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Hymenopteran Floral Visitors as Recorded from an Agro-Ecosystem Near Bikaner, Rajasthan

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Abstract - Hymenoptera is one of the most diverse orders of insects, including over 115,000 described species. Some are phytophagous (plant-feeding), while others are herbivorous, predatory, or even parasitic. Hymenoptera distribution is often dependent on their food supply for eg., bees pollinate flowers and require habitats with flowering plants. Hymenoptera are important to the balancing and functioning of most ecosystems on the planet. These are also one of the most beneficial insects for the human economy. Not only do bees pollinate many of our crops, but they also produce goods such as wax any honey. Parasitic wasps are often the most successful way to control pest insects as biological control agents. The present study was therefore planned to observe and document hymenopteran pollinators existing in the vicinity of Bikaner (Rajasthan) and to monitor some of their activities. Thirteen species of hymenopterans belonging to seven families were found to visit the flowers of various crops cultivated in the agro-ecosystem during the present study.

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HYMENOPTERAN FLORAL VISITORS AS RECORDED FROMAN AGRO-ECOSYSTEM NEAR BIKANER, RAJASTHAN

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Hymenopteran Floral Visitors as Recorded from an Agro-Ecosystem Near Bikaner, Rajasthan

Harshwardhan Bhardwaj[α], Parul Thaker[α] & Meera Srivastava[α]

Abstract - Hymenoptera is one of the most diverse orders of insects, including over 115,000 described species. Some are phytophagous (plant-feeding), while others are herbivorous, predatory, or even parasitic. Hymenoptera distribution is often dependent on their food supply for eg., bees pollinate flowers and require habitats with flowering plants. Hymenoptera are important to the balancing and functioning of most eco-systems on the planet. These are also one of the most beneficial insects for the human economy. Not only do bees pollinate many of our crops, but they also produce goods such as wax any honey. Parasitic wasps are often the most successful way to control pest insects as biological control agents.

The present study was therefore planned to observe and document hymenopteran pollinators existing in the vicinity of Bikaner (Rajasthan) and to monitor some of their activities. Thirteen species of hymenopterans belonging to seven families were found to visit the flowers of various crops cultivated in the agro-ecosystem during the present study. Maximum floral visitors (13 spp. belonging to 7 families) were documented on marigold, followed by mustard (9 spp. belonging to 5 families), ridged gourd (7 spp. belonging to 5 families), bottle gourd (6 spp. belonging to 4 families), brinjal (4 spp. belonging to 2 families), pumpkin (3 spp. belonging to 3 families), radish (5 spp. belonging to 3 families). Most number of hymenopteran species were documented during the month of January (12) followed by December (10), February (10), November (9), September (8) and October (7).The major hymenopteran visitors observed during the present study were *Apis mellifera, Scolia specifica* and *Xylocopa fenestreta*.

I. Introduction

Pollinators, including insects play a crucial role in reproduction of flowering plants and in the production of most fruits and vegetables.The relationship between pollinators and flowering plants is one of the mutually beneficial relationships in the natural world. Without the assistance of pollinators, most plants cannot reproduce. Different pollinators prefer different types of flowers. Studying the relationships between flowers and their pollinators is thus very useful to help maintain endangered species. 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 plat 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.

Hymenoptera is one of the most diverse orders of insects, including over 115,000 described species. Some are phytophagous (plant-feeding), while others are herbivorous, predatory, or even parasitic. Hymenoptera distribution is often dependent on their food supply for eg., bees pollinate flowers and require habitats with flowering plants. Hymenoptera are important to the balancing and functioning of most eco-systems on the planet. These are also one of the most beneficial insects for the human economy. Not only do bees pollinate many of our crops, but they also produce goods such as wax any honey. Parasitic wasps are often the most successful way to control pest insects as biological control agents.

The present study was therefore planned to observe and document hymenopterans as pollinators existing in the vicinity of Bikaner (Rajasthan) and to monitor some of their activities.

II. The Study Area

The state of Rajasthan is the largest state of Indian republic located between 23°3' to 20'13 N latitude and 69°30' to 78°17'C longitudes and the area under study falls in the Indian desert near Bikaner situated in Western Rajasthan along the international border. The agro-ecosystem Vallabh Garden Agriculture Farm surveyed during the present study lies 10 km away from Bikaner, at Gharsisar village. It is a crop field where seasonal crops are grown. It is irrigated by sewage water.

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III. Methodology

The crop field comprised of different crops during the study period. As the study concentrated on hymenopteran pollinators, 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. Visit of a particular hymenopteran species to a specific flower was documented and expressed as number of visits/man/h.The hymenopteran insect visitors to different flowering crops were surveyed and collected every week from September 2008 to February 2009. For the study, the field area was divided into five stations from where the hymenopteran visitors on flowers were collected. Sweep net was used for insect collection. The hymenopterans collected by the above method were transferred to killing bottles, killed and preserved. Large winged hymenopteran 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.

IV. Observations and Results

During the study period the crops cultivated in the agro-ecosystem included marigold, bottle gourd, ridged gourd, pumpkin, mustard, radish and brinjal. Crops, their flowering period and floral characteristics have been presented in Table 1.

a) Crops and their hymenopteran visitors

The flowers of marigold (*Tagetes erecta*), a member of family Compositae, were visited by all the 13 species documented during the present study. *Apis mellifera* were the major forms (57.20%) followed by *Polistes sp.* (9.55%), *Scolia specifica* (9.00%), *Xylocopa fenestreta* (6.23%), *Megachile* sp. (4.70%), *Sphex sp.* (4.15%), *Polistes carolina* (3.87%), *Pompilus* sp. (1.80%), Potter wasp (1.38%), *Coelioxys capitatus* and *Xylocopa virginica* (0.96% each), *Bembix* sp. and *Xanthopimpla stemmator* (0.27% each). *Lagenaria siceraria or* bottle gourd flowers were visited by six species viz *S. specifica* (37.42%), *Polistes sp.* (22.08%), *X. fenestrata* (20.85%), *X. stemattor* (13.49%), *A. mellifera* (4.90%), and *X. virginica* (1.22%). One of the major cucurbit crops cultivated in the agro-ecosystem studied was *Luffa cylindrica* from the flowers of which eight insect species were collected viz., *A. mellifera* (35.96%), *X. fenestreta* (27.19%), *S. specifica* (16.66%), *Polistes sp.* and *Sphex sp.* (7.01% each), *P. carolina* (3.07%), *X. virginica* (2.19%) and *X. stemattor* (0.87%).Yet another vegetable species cultivated in the agricultural field was pumpkin *Cucurbita maxima*.The flowers of pumpkin were visited by three species viz *A. mellifera* (94.64%), *S. specifica* (3.57%) and Potter wasp (1.78%).Of the total thirteen species documented during the present study, nine species viz., *Bembix* sp. (33.61%), *A. mellifera* (22.68%), *Megachile* sp. (19.32%), *Polistes sp.* and Potter wasp (5.78%), *S. specifica* (4.95%), *X.virginica* (4.20%), *X.fenestreta* (1.68%) and *Sphex sp.* (1.65%) were found to visit the mustard flowers (*Brassica campestris)* belonging to family Brassicaceae. *Solanum melongena* belonging to family Solanaceae was visited by five species viz. *X.fenestrete* (40.00%), *A.mellifera* (24.00%), *X. viriginica* (16.00%), *S.specifica* (12.00%) and *C.capitatus* (8.00%).The flowers of radish *Raphanus sativus* were visited by five species viz. *A. mellifera* (40.62%), *Megachile* sp. (34.37%), *Polistes sp.* (15.62%), *C. capitatus* (6.25%) and *X. fenestreta (*3.12%).

b) Preference and rhythmicity of hymenopteran visitors

During the present study insect species belonging to following hymenopteran families were reckoned from the agro-ecosystem studied:

c) Apidae

This family was represented by three species which included *A. mellifera*, *X. fenestreta and X. virginica*. *A. mellifera* was documented throughout the period of study as presented in Table 2. It was found to visit the flowers of all the crops cultivated in the agriculture field and has been presented in Table 3. *A. mellifera* was found to prefer the capitulum of *T. erecta* on which its visits ranged from 40 v/m/h in the month of October to 121 v/m/h in the month of November. It was documented as a rare form on flowers of *Lagenaria* in the month of September, making only 8 visits /m/h. The flowers of *Luffa* were also frequented by this bee during September (10v/m/h) and October (72v/m/h). On flowers of *Cucurbita* it was noted in the months of November and December, visiting them at the rate of 35 and 18v/m/h, respectively. During January and February they were also documented on flowers of mustard making 6 and 12v/m/h respectively. The bee was also observed on *Solanum* making 5v/m/h and 1 v/m/h in November and December respectively, whereas on radish it was found to visit the flowers at the rate of 5v/m/h and 8v/m/h in the months of January and February respectively (Table 4.).

X. fenestreta was also observed throughout the study period as presented in Table 2. It was found to visit the flowers of all crops cultivated in the agriculture field except *Cucurbita* during the period of study and has been presented in Table 3. *X. fenestreta* was found to prefer the flowers of *Luffa* on which its visits ranged between 30-32 v/m/h in the month of September and October, and documented as a rare form on flowers of radish in the month of January making only 1v/m/h. The

head of *Tagetes* were also visited by the bee making 29v/m/h, 12v/m/h and 4v/m/h in the months of December, January and February respectively. On flowers of *Lagenaria* it was noted in the months of September, October and November, visiting them at the rate of 5v/m/h, 17v/m/h and 12v/m/h respectively. The bee was a rare visitor to the flowers of *Brassica* crop making 2v/m/h in the month of February. On the flowers of *Solanum* it was documented during November and January making 2 v/m/h and 8 v/m/h and respectively. Over all, on keen observation it was noted that when the flowering period of *Luffa* was going on, the insect preferred it more, but afterwards it shifted to the capitulums of *Tagetes* and flowers of *Lagenaria* (Table 5.).

Another species, *X. virginica* was also observed throughout the study period as presented in Table 2. It was found to visit the flowers of all crops, except *Cucurbita* and *Raphanus* cultivated in the agriculture field during the period of study and has been presented in Table 3. *X. virginica* was found to prefer the flowers of *Luffa* on which it was observed to visit 5v/m/h in the month of September. It rarely visited the head of *Tagetes* making a single visit in the month of February, and 4 and 2v/m/h in the months of November and January respectively. This bee rarely visited the flowers of *Lagenaria only* at the rate of 2v/m/h in the month October. On *Brassica* flowers, the bee was noted to make 2 and 3 v/m/h in the months of December and February respectively. On flowers of *Solanum* the insect was observed to visit 4v/m/h in the month of January (Table 6.).

d) Vespidae

This family was represented by three species which included *Polistes sp.*, *P.carolina* and an unidentified species of potter wasp. *Polistes sp.* was documented through out the study period as presented in Table 2. It was found to visit the flowers all crops except *Cucurbita* and *Solanum* present in the agriculture field during the study period as presented in Table 3. *Polistes sp.* was found to prefer the capitulum of *Tagetes* on which its maximum visits were noted in the month of November making 38 v/m/h, while in October, December, January and February the visits were 14, 8, 2 and 7v/m/h respectively. It was found rarely on the flowers of *Raphanus* making 2v/m/h in the month of February and 3v/m/h in the month of January. The flowers of *Lagenaria* were visited by this wasp, making 24 v/m/h in September while 12 v/m/h in October. On *Luffa* flowers, the wasp was observed only in September making 16v/m/h. On the flowers of *Brassica* the insect visits were observed to be 4v/m/h and 3v/m/h in the months of January and February respectively. It was further noted that *Polistes sp.* preferred the flowers of *Lagenaria* the most, but as soon as the flowering period of this crop ended the preference shifted towards the flowers of *Tagetes* (Table 7.). *P.carolina* was rarely documented during the study period as presented in Table 2. It was found to visit only the head of *Tagetes* and flowers of *Luffa* crop present in the agriculture field as presented in Table 3. *P.carolina* was found to prefer the heads of *Tagetes* on which its visits ranged from 7v/m/h in the month of October to 21v/m/h in the month of November. The wasp made its least visits on the flowers of *Luffa* making 2v/m/h in the month of September and on the same crop 5v/m/h was noted in the month of October (Table 8.).

Potter wasp belonging to family Vesipidae which was rarely documented in the agriculture field as presented in Table 2 was found to visit only the flowers of *Tagetes, Cucurbita and Brassica* as presented in Table 3. This species was found to prefer the flowers of *T. erecta* on which its visits ranged from 7v/m/h in the month of December to 2v/m/h and 1 v/m/h in the months of November and January respectively. It was documented rarely on the flowers of *Cucurbita* in the month of December making only 1 v/m/h. On the flowers of *Brassica* it was seen to make 3v/m/h in the month of January and 4v/m/h in the month of February (Table 9.).

e) Megachilidae

This family was represented by two species which included *Megachile* sp. and *Coelioxys capitatus. Megachile* sp. was rarely documented during the study period as presented in Table 2. It was found to visit the flowers of only three crops *viz., Tagetes, Brassica and Raphanus* cultivated in the agriculture field during the period of study, as presented in Table 3. This member was found to prefer the flowers of *Tagetes* on which its visits ranged from 16v/m/h in the month of January to 18v/m/h in the month of February. It was found rarely on the flowers of *Raphanus* in the month of February making 4v/m/h where as on same flowers 7v/m/h were noted in the month of January. The flowers of *Brassica* were also frequented by this member, making 12v/m/h in the month of January and 11v/m/h in the month of February (Table 10.). Another member belonging to the same family which was observed during the study period was *Coelioxys capitatus* which was also rarely documented during the study period as presented in Table 2. It was found to visit the flowers of three crops namely, *Tagetes, Solanum* and *Raphanus* as presented in Table 3. *C. capitatus* was observed to prefer the flowers of *Tagetes* on which its visits in the month of February were 5 visits /m/h, where as it was rarely documented on the same crop and on flowers of *Raphanus* in the months of December to February. During February they were also documented on flowers of *Solanum*, making 2v/m/h (Table 11.).

f) Scoliidae

Scolia specifica was the only wasp representative of this family documented from the crop field. It was observed nearly in all the months of study,

as presented in Table 2. It was found to visit the flowers of all the crops except *Raphanus* and has been presented in Table 3. *S.specifica* was found to prefer the flowers of *Luffa* on which its visits were noted to be 38v/m/h in September. On flowers of *Cucurbita* it was documented as a rare form making only 2v/m/h in the month of December. The capitulum of *Tagetes* was also frequented by this wasp, visits ranging from 32v/m/h during October to 2v/m/h in the month of February. The flowers of *Lagenaria* were also visited by this wasp making 35v/m/h during September and 26v/m/h during October respectively. On flowers of *Brassica* it was noted in the month of February, visiting them at the rate of 6v/m/h, while on flowers of *Solanum* making 3v/m/h in the month of November. Overall, it was noted that it highly preferred to visit the flowers of *Lagenaria and Luffa* (Table 12.).

g) Sphecidae

Two members belonging to this family documented from the study area were *Sphex sp*. and *Bembix sp.* Former was documented throughout the study period where as the latter was noted only during January and February as presented in Table 2. Both the species were found to visit the flowers of two crops namely *Tagetes and Brassica* while *Sphex* sp. also visited the flowers of *Luffa*, cultivated in the crop field during the study period and has been presented in Table 3. *Sphex sp*. was found to prefer the flowers of *Tagetes* on which its visits ranged from 1-18 v/m/h, maximum visits were noted in the month of November. The flowers of *Luffa* were also frequented by this wasp making 4v/m/h during September and 12v/m/h during October. On flowers of *Brassica* it was noted only in the month of January, visiting them at the rate of 2v/m/h. It was further noted that with the end of flowering period of *Luffa* in November the insect diverted towards the head of *Tagetes* (Table 13.). *Bembix* sp. belonging to this family was rarely documented as presented in Table 2. It was found to visit only the head of *Tagetes* and flowers of *Brassica* crop cultivated in the agriculture field during the study period as presented in Table 3.This species was found to prefer the flowers of *Brassica* on which its visits ranged from 27v/m/h in the month of January to 13 v/m/h in the month of February. It was documented as a rare form on heads of *Tagetes* in the month of January making only 2 visits /m/h (Table 14.).

h) Pompilidae

Only one member *Pompilus* sp. belonging to this family was reckoned during the present study.This member was a rare visitor, documented only during three months as presented in Table 2. It was found to visit the head of *Tagetes* crop only and has been presented in Table 3. The visits ranged from 1 to 7v/m/h from November to January (Table 15.).

i) Ichneumonidae

Xanthopimpla stemattor was only representative of this family documented from the crop field, as presented in Table 2. Occurrence of this wasp was documented on the flowiers of three crops which were *Tagetes, Lagenaria and Luffa* as presented in Table 3. *X.stemattor* was found to prefer the flowers of *Lagenaria* on which its visits were noted to be 22v/m/h in the months of September, while on *Luffa* it made only 2v/m/h in the same month. It was rarely found on flowers of *Tagetes* making single visit v/m/h in the months of December and January (Table 16.).

V. Discussion

a) The hymenopteran visitors

Thirteen species viz., *Apis mellifera, Xylocopa fenestreta and Xylocopa virginica* belonging to family Apidae; *Polistes sp., P.carolina* and an unidentified species of Potter wasp belonging to family Vespidae; *Coelioxys capitatus* and *Megachile sp.* of the family Megachilidae; *Scolia specifica* belonging to family Scoliidae; *Sphex sp.* and *Bembix sp.* belonging to family Sphecidae; *Pompilus sp.* belonging to family Pompilidae; and *Xanthopimpla stemattor* belonging to family Ichneumonidae were documented on the flowers of various crops present in the agro-ecosystem during the present study.

Apis mellifera was one of the major forms reckoned throughout the study period in large numbers. It was found to visit the flowers of all the crops cultivated in the agro- ecosystem. Overall, in relation to crops, the honeybee *A. mellifera* preferred flowers of marigold followed by ridged gourd, mustard, pumpkin, bottle gourd, radish and brinjal.

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. The present findings also get support from the work of Omar (1988) who reported *A. mellifera* as pollinator of *C. sativum*. Maria & Zenon (2004) and Bruce et al. (2002) reported *Tagetes* to be visited by honeybee *Apis* which also corroborate the present findings. Agarwal & Rastogi (2008) also noticed hymenopterans on the flowers of *L. cylindrica*. Morimoto et al. (2004) observed honeybee *A. mellifera* as active floral visitor of *L. siceraria*. Alan & Bradley (1966) and Agbagwa et al. (2007) considered *A. mellifera* as natural pollinator of pumpkin. Singh et al. (2006) reported that most of the insect pollinators of *Brassica* crops belong to *Apis* species. *A. mellifera, A. dorsata* and *A. cerena* as floral visitors of mustard were also observed by Povada et al. (2004). Partap (1999) suggested *A. cerena* and *A. mellifera* as the most practical pollinators for mustard crop. 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. *A. mellifera* as important pollinator of brinjal has been suggested by Partap (1999), Hiwkawa (2004) and Miyamoto (2006).

During the present study bees were observed during November – December which is in conformation with earlier study of Sekhar & Gowda (2006) who also 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. *A. mellifera* was documented throughout the study period, it showed a great increase in the month of November and this trend was noticed upto December. In January and Februray it was noted in less number. Grombene – Guaratini et al. (2004) while studing the reproductive biology of *Bidens* (Asteraceae) suggested that the composition of the pollinator community changes during a year and between sites, hymenopterans being one of the most frequent visitors of this species. During the present study also honeybees were documented on marigold flowers a member of Asteraceae, from October to February, major visits being during November, December and January, and during rest of the months they shifted to other crops. Sekhar & Gowda (2006) noted bees from June to December on sunflower, on *Bidens* from January to May and on *Aster* during September and October. Singh et al. (2006) suggested most of the insect pollinators of *Brassica* crops belong to *Apis* species. They observed an average of 15.04, 7.71 flower visits/minute by *A. mellifera* and *A. dorsata* respectively.

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.

Xylocopa fenestreta and *X. virginica* were the two carpenter bees documented during the present study on the eleven crops cultivated in the field, pumpkin was not visited by these species, while mustard, marigold, bottle gourd and ridged gourd flowers were visited by both the species. *X.virginica* species was rarely documented on the flowers of *Tagetes*. Earlier *X. fenestreta* as flower visitor of *Helianthus annuus* a member of Asteraceae was reported by Singh et al. (2000). The present findings also get support from the work of Carrek & Williams (2002) who found 16 families of Hymenoptera to visit the flowers of *Tagetes*. On flowers of *Luffa, X. fenestreta* was observed as a major visitor, while, *X. virginica* as a rare form. During the present study, *X. fenestreta* was collected from the umbels of radish and mustard flowers. The present findings are in conformation with the reports of Thapa (2006) and Hannan (2007) who 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).

Overall, the choicest flower of *Xylocopa sp.* based on the present observations could be concluded as *Luffa cylindrica*, a yellow and scentless flower, probably high in pollen content. 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).

Xylocopa fenestreta was noted throughout the study period. It was noted on the flowers of *L. siceraria*, *C. maxima, R. sativus* and *S. melongena*. Except *Luffa,* on all flowers its visitation was noticed to range between 1–29v/man/h. On *Luffa* flowers it was noted in good numbers making 30-32 visits/man/h from September to October. *X. virginica* was noted on the flowers of *Tagetes, Lagenaria, Luffa, S.melongena* and *Brassica* and its visitation was from 1 to 5 visits man/h. On *Luffa* it was noticed only during September. 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.

Polistes sp., P.carolina and potter wasp were the three members belonging to family Vespidae which were documented on the flowers of various crops cultivated in the agro-ecosystem during the present study. All the three wasps were found in good numbers to visit the flowers of *Tagetes.* Flowers of *Luffa cylindrica* were visited by *Polistes sp. and P.carolina*. Only *Polistes sp.* was found to visit the flowers of *L. siceraria*, *R. sativus* and *B. campestris* while flowers of *C. maxima* were visited by *Potter wasp* but *S. melongena* flowers were visited by none of them. The present findings get support from the earlier reports by different workers who suggested *Polistes spp.* as flower visitors. These include Defni & Ducas (1986) who recorded *Polistes gellicus* as pollinator of *Urginea maritima* (Liliaceae), Hannan (2007)

who found *Polistes* to visit *Sesamum* flowers. Tangmitcharoen et al. (2006) noted *P. stigma* as potential pollinator of teak flowers or inflorescence. Milk weed has been found to be pollinated by *Polistes* as reported by Kephart (1983), Ivey et al. (2003) and Robert et al. (1994). During the present study while *Polistes sp.* was noticed nearly throughout the study period, *P.carolina* was found during September to November. Both the wasps were found in good numbers in the month of November. The population density of *Polistes sp.* was also found to be high in the months of September, October and November. According to Martin (1993) *Polistes sp.* are very common floral visitors of *Acacia* with little pollen movement. Valdivia & Niemeyar (2006) also reported *Polistes buyssoni* as diurnal floral visitor. Wasp as a floret visitor of Asteraceae was documented by Tooker & Hanes (2000). Patt (2000) found that umbels such as coriander, dill, fennel, caraway are very attractive beneficial insects like wasp. Dunne (2001) also observed that lovage attracts wasps. Visitation rate of *P.carolina* was noticed from 1–21 visits/man/h. The flowers of *Luffa* were visited by the wasp during September and October. The highest visits were noticed to be 21visits/ man/h on *Tagetes* and minimum of 2visits/man/h on the flowers of *Luffa*. While *Polistes sp.* visited 1–38 visits/man/h on different crops and peak visitation was noticed in the month of November on the flowers of *Tagetes.*

Scolia specifica a member of family Sphecidae was also a major wasp found to visit flowers of various crops cultivated in the agro-ecosystem during the present study. It was found to prefer flowers of *Lagenaria,* followed by *Tagetes, Luffa, Brassica, Solanum and Cucurbita*. *S. duvia* as insect pollinator of milk weed, *Scolia sp.* as flower visitors of *Sesamum* and *S. ruficeps* as potential pollinators of teak flowers were suggested by Ivey et al. (2006) respectively, which corroborate the present findings. It was noted throughout the study period. Its maximum numbers were noted in the month of September when it visited the flowers of *Luffa* at the rate of 469 visits / man/ h. According to Martin (1993) members of family Scoliidae are common, patrolling underneath flowering plants. Yamazaki & Kato (2003) also reported scolid wasp as a good pollinator of some plants in the grassland ecosystem. Reddi & Reddi (1983) observed *Scolia cruenta* as pollinators of *Jatropha gossypiifolia* (Euphorbiaceae).

Sphex sp. and *Bembix sp.* belonging to family Sphecidae were collected from different flowers during the present study. *Sphex sp*. was found to visit flowers of *Luffa, Tagetes* and *Brassica,* whereas *Bembix sp.* visited only the Head of *Tagetes* and flowers of *Brassica.* Thapa (2006) also reported *Sphex sp.* as pollinator of various crops. Kephart (1983), Robert et al. (1994) and Ivey et al. (2003) reported *Sphex sp.* as pollinator of milkweed. Visitation rate of *Sphex sp.* was noticed to be between 1–18 visits / man / h on different crops throughout the study period.

Coelioxys capitatus and *Megachile sp.*, members belonging to family Megachilidae were collected from different flowers during the present study. *C. capitatus* was found to visit flowers of *Tagetes, R. sativus,* and *S. melongena* where as *Megachile sp.* preffered the head of *Tagetes* and flowers of *Raphanus* and *Brassica*. Peak visitation of *Coelioxys* was observed on the flowers of *T. erecta* in the month of February and it was noted as 5 visits/man /h. On the flowers of *Lagenaria, Luffa, Cucurbita* and *Brassica* it was never documented during the present study. Tybirk (1992) also observed *Coelioxys* as the pollinators of African *Acacias* which supports the present findings.

Pompilus sp., another hymenopteran belonging to family Pompilidae was documented visiting only the capitulum of *T. erecta* cultivated in the agriculture farm during the present study. It was noted from November to January. Its visits on the head of *Tagetes* ranged from 1-7 visits/m/h. *Pompilus sp*. as a floret visitor of Asteraceae was documented by Tooker & Hanes (2000) which gives support to the present study.

Xanthopimpla stemattor, another hymenopteran belonging to family Ichneumonidae was documented visiting flowers of different crops cultivated in the agricultural farm during the present study. It was documented from September to January. In September it was found to visit the flowers of *L.siceraria* at the rate of 19–22 visits/man/h. Although it was also noticed on flowers of *Luffa* and *Tagetes*, but on these it was a rare form.

According to Roubik (1989) hymenopterans are responsible for 67–93% of the floral visits. Total pollination activities, over 80% are performed by insects, and bees contribute nearly 80% of the total insect pollination and therefore, they are considered the best pollinators, supporting the present findings. Sievers (1948) also reported hymenopterans as visitors of chervil flowers. Hymenopterans as pollinators of plants belonging to family Asteraceae were noted by Noronha & Gottsberger (1980); Arroyo et al. (1982); Sazima & Machado (1983); Abbot & Irwin (1988); Herrera & Iwata (1990). Hymenopterans were noted as pollinators of carrot an umbelliferous plant by Ahmed & Aslam (2002). Hymenopterans were noted on the heads of *Mikania* by Cerena (2004).

b) The hymenopteran visitors in relation to crops

Marigold (Tagetes erecta)

During the present study marigold heads, were visited by thirteen species belonging to seven families. *A. mellifera* were the major visitors while, the others which included *S. specifica, Sphex sp., Polistes sp., P. carolina, X. fenestreta, X. virginica, C. capitatus, Xanthopimpla stemattor, Bembix sp., Potter wasp, Megachile sp. and Pompilus sp.* were rare visitors. The

present findings are in conformation with the work of Gange & Smith (2005) who suggested hymenopterans as pollinators of *T. erecta*. Maria & Zenon (2004) in their study also found that the *Tagetes* was visited by hymenopterans including *A. mellifera.* Ten bumble bee species were reckoned by Lall (2003) visiting *T. patula*. Honeybee *Apis* and wasp *Helictus* on flowers of *T. erecta* were also noted by Bruce et al. (2002) which corroborate the present findings. In a study done by Singh et al. (2000) on *Helianthus annuus,* a member of Asteraceae, the honeybees *A. mellifera, A. dorsata* and *A. florea* were found to constitute 42.2% of the total insects visiting the capitula. They also documented *X. fenestreta* as the flower visitor of *H. annuus.* Radford et al. (1979) also reported *A. mellifera* as the most frequent floral visitor to flowering sunflower while, Panda et al. (1996) observed *A.cerena* and *A.dorsata* besides, *A. mellifera* as predominant visitors to sunflowers. Puskadija et al. (2005) also noted honeybees as visitors of sunflower head. The present findings also get support from the earlier work of Carrek & Williams (2002) who found sixteen families of hymenoptera including bumble bees to visit the flowers of *Tagetes*. Five hymenopteran floral visitors to heads of sunflower were observed by Nderitu et al. (2008), while, Arya et al. (1994) noted twelve bee species visiting sunflower. According to several other authors (Noronha & Gottsberger, 1980; Arroyo et al., 1982; Sazima & Machado, 1983; Abbot & Irwin, 1988; Herrera, 1990; Iwata, 1990 & 1992) the members of Asteraceae are pollinated by several insect groups and Hymenoptera is also one of them. Honeybees *Apis mellifera* were found to produce at least 150% more seeds in family Asteraceae as reported by Mamood et al. (1990). Cerana (2004) noticed hymenopterans on heads of *Mikania* while, Roitman (1999) documented them on capitula of *Grindelia covasii,* both belonging to Asteraceae. Thapa (2006) has also reported honeybees as good pollinators of various Asteraceae plant like *Cynara scolymus, Cichorium intiybus, Helianthus annuus* etc. Wasp as a floret visitor of Asteraceae was documented by Tooker & Hanes (2000) which gives support to the present study wherein, five wasp species were documented.

c) Bottle gourd (Lagenaria siceraria)

During the present study six species belonging to four families were found to visit the flowers of bottle gourd.The flowers were visited by six species viz. *A. mellifera, X. fenestreta, X.virginica, X.stemattor, Polistes sp.* and *S. specifica.* Earlier Morimoto et al. (2004) also observed honeybee *A. mellifera* as active flower visitors of *L. siceraria* in Kenya which is in support of the present findings. Fomekong et al. (2008) also reported *A. mellifera* to be a pollinator of cucurbitaceous plant. *A. mellifera* as a dominant species visiting flowers of Cucurbitaceae was also reported by Rust et al. (2003). In all, 43 species of bees were collected from the flowers of *E. elaterium* a member of Cucuritaceae, of which 33 bee species were found to carry pollen. The present findings also get support from the findings of Valdivia & Niemeyer (2006) who also documented *A. mellifera* and *Polistes buyssoni* to visit flowers of cucurbit *Escallonia myrtoidea.* Besides these, 16 other hymenopteran species were reported to visit these flowers by them. While studying the pollination ecology of *Citrullus lanatus* a cucurbit, Njorage et al. (2004) found that this species depends heavily on *A. mellifera* for pollination. Other pollinators identified were *Xylocopa* bees, halicted bees and hypotrigona bees which corroborate the present findings.

d) Ridged gourd (Luffa cylindrica)

Of the total number of species documented during the present study, eight species viz., *S. specifica, A. mellifera, X. fenestreta, X. virginica, Sphex sp., X. stemattor* and *Polistes sp.* belonging to five different families were found to visit the flowers of ridged gourd during the present study. The present findings are in conformation with the studies done by Agarwal & Rastogi (2008) who also noticed hymenopterans on the flowers of *Luffa cylindrica.* Singh et al. (2000) also recorded members belonging to family Braconidae on cucurbit plant *Luffa cylindrica.* The members of Formicidae on *Luffa* were documented by Okoli et al. (2008). Thapa (2006) reported hymenopterans like bumble bee *Bombus,* golden wasp *Vespa magnifica* and oriental wasp *Vespa orientalis* as pollinators of sponge gourd. Earlier Baskaran & Eswaran (2004) also observed *Apis dorsata* and *A. florea* as pollinators of another gourd *Momordica charantia* which corroborate the present findings.

e) Pumpkin (Cucurbita maxima)

During the present study, three species belonging to three families were observed on flowers of pumpkin during the present study.The hymenopterans visiting the flowers of pumpkin were *S. specifica, A. mellifera* and Potter wasp. Earlier most of the authorities have considered honeybees to play a major role in pollination of *Cucurbita,* which include the works of Pammel & Bach (1894), Jones & Rosa (1928), Jones & Emsweller (1934), Whitaker & Davis (1962), Battaglini (1969), Langridge (1952), Nevkryta (1953), Robinson (1952), Sandulac (1959), Verdieva & Ismalilova (1960) and Wolfenbarger (1962), while, Michel Bacher et al. (1964) and Hurd (1966) gave credit to both honeybees as well as wild bees and thus support the present findings. Alan & Bradley (1966) have also considered bumble bees, carpenter bees, squash bees and honeybees including *A. mellifera* as natural pollinators of pumpkin. Canto Aquliar & Parra – Ptavla (2000) evaluated the pollination efficiency of *Peponapis limitaris* and *A. mellifera* in *Cucurbita moschata* in Mexico and found that *P. limitaris* to be more efficient than *A. mellifera.* Thapa (2006) has also reported *A. cerena* and *Helophilus trivittatus* as insect visitors of *C. maxima* which corroborate the present findings. Agbagwa *et al.,* (2007) also considered *A. mellifera* to play an essential

role in pollination of *C. moschata* in Nigeria. Fomekong et al. (2008) reported *A. mellifera* to be a pollinator of Cucurbitaceae plant.

f) Mustard (Brassica campestris)

Nine species belonging to five families were documented on the flowers of *Brassica campestris* during the present study.These were *A. mellifera, X. fenestreta, X. virginica, Polistes sp., S. specifica, Sphex sp., Bembix sp.,* Potter wasp *and Megachile sp.* of which, *Apis mellifera* was the most frequent visitor. The present findings are in conformation with the earlier reports of Singh et al. (2006) who also found that most of the insect pollinators of *Brassica* crops belonged to *Apis* species. In another study, *A. florea* was noted to out number the visitation on *Brassica* followed by *A. mellifera* and *A. dorsata* by Singh et al. (2004). Jhajj et al. (1996) also found the foraging frequency of various bee species as *A. mellifera > A. dorsata > A. florea* on raya and brown sarson. A total of 859 flower visitors on mustard were observed by Poveda et al. (2004), most abundant of which were the honeybees *A. mellifera, A. dorsata, A. cerena. Xylocopa* and *Megachile sp.* have been reported to be flower visitors of *Brassica* by Hannan (2007) which also supports the present observations. According to Partap (1999), *A.cerena* and *A. mellifera* are the most practical for mustard crop pollination. Langridge & Goodman (1975) also reported honeybees as efficient pollinators of *B. campestris*. Perveen et al. (2000) also suggested *A. mellifera* to cause a significant increase in quantity and quality of *B. campestris* in Pakistan. Honeybees as important pollinators of *B. napus* and *B.rapa* was observed by Pritsch (2000), while, Mohar & Jay (1988) observed honeybees to visit and pollinate *B. campestris* more as compared to *B. napus*. Honeybees are attracted towards mustard flowers and are of great benefit to *B. hirta* and *B. juncea* was suggested by Free & Spancer (1963). An increase in the yield of rape and white mustard due to honeybee *A.mellifera* was noted by Kontensky (1959). Manning & Boland (2000) also emphasized on the significance of *A. mellifera* in pollination of *B. napus* in Western Australia. Thapa (2006) reported *A. mellifera, A. cerena, A. dorsata, Bombus sp., Xylocopa, Sphex sp.* and *Chlorion sp.* as insect pollinators of *B. campestris* which corroborate the present findings.

g) Brinjal (Solanum melongena)

The flowers of *S. melongena* were found to be visited by five species belonging to three families viz. *A. mellifera, S. specifica, X. fenestreta, X. virginica and C. capitatus* during the present study which gets support from the observations of Miyamoto (2006) who also observed *A. mellifera* as pollinators of egg plant. According to Partap (1999) *A. cerena* and *A. mellifera* are most practical for brinjal crop pollination. Bumble bees *Bombus terrestris* have been suggested to be effective pollinators of *S. melongena* by Buczkowska et al. (2000) and Kowalska (2003), while, Hikawa (2004) suggested *A. mellifera* to be economically important pollinator as compared to *B. terrestris*. *A. mellifera* and *B. terrestris* as pollinators of *S. melongena* was also reported by Vanden (1994). Wild bees can be equal or better pollinators than *A. mellifera* for important agricultural crops such as Solanaceae was suggested by O' Toole (1993). Two solitary bees *Xylocopa caffra* and *Macronomia rufipes* were identified as effective pollinators of egg plant by Gemmill – Herren& Ochienj (2008). Amoako & Yeboah – Gyan (2000) found *A. mellifera* and *Xylocopa* to be important pollinators of *S. melongena*. Thapa (2006) reported *Bombus sp., Chlorion sp., Vespa magnifica, V. orientalis, Xylocopa sp.* and *Polistes sp.* as floral visitors of brinjal which support the present findings in a way that, both honeybee and wasps were documented on flowers of brinjal.

h) Radish (Raphanus sativus)

The flowers of *R. sativus* were found to be visited by five species viz., *A. mellifera, X. fenestreta, Polistes sp., Megachile sp. and C. capitatus* belonging to three different families. The present findings are in conformation with the studies done by Free & Williams (1973) who also noticed bumble bees visiting Brussels sprout flowers of family *Brassicaceae* comprising 98% of visitors in Egypt (Hussein and Abden- Aal, 1982) and 99% in New Zealand (Forster et al.; 1973). Eariler most of the authorities have considered honey bees to play a major role in pollination of radish, which include the works of Raula (1972), Dhaliwal and Sharma (1973), which support the present findings. From Indian sub-continent *A. cerena, A.dorsata and A. florae* are all important visitors on *Brassica olererecea*, a member of *Brassicacea* as reckoned by Singh et al. (2004). Thapa (2006) has also reported *A. mellifera, A. cerena, A. dorsata, Xylocopa and Sphex sp.* as insect pollinators of *R. sativus*. Singh et al. (2006) recorded that most of the insect pollinators of *Brassica* crops belong to *Apis* species which also supports the present observations. Conner and Rush (2008) also reported about the effect of flower size and number on *A. mellifera* visitation on wild radish. Bumble bees preffered white coloured flowers of wild radish was reported by Key (1978) which corroborate the present findings.

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Table1: Crops cultivated in Vallabh Garden Agriculture Farm, Bikaner and their floral characteristics

Crop	Botanical Name	Family	Inflorescence	Scent	Colour	Self or Cross pollination	Flowering period
Marigold	*Tagetes erecta*	Compositae/ Asteraceae	Head or Capitulum	Scented	Yellowish orange	Self/Cross	October to February
Bottle gourd	*Lagenaria siceraria*	Cucurbitaceae	Solitary	Scentless	White or Creamish	Cross	September to October
Ridged gourd	*Luffa cylindrica*	Cucurbitaceae	Solitary	Scentless	Yellow	Cross	September to October
Pumpkin	*Cucurbita maxima*	Cucurbitaceae	Solitary	Scentless	Yellow	Cross	November to December
Radish	*Raphanus sativus*	Brassicaceae	Racemose	Aromatic	Purplish white	Self/Cross	January to March
Mustard	*Brassica campestris*	Brassicaceae	Corymbose raceme	Aromatic	Yellow	Self/Cross	January to February
Brinjal	*Solanum melongena*	Solanaceae	Solitary	Scentless	Purple	Cross	November to December

Table 2 : Hymenopteran floral visitors observed in Vallabh Garden Agriculture Farm, Bikaner (September 2008 - February 2009)

Hymenopteran visitors	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.
FAMILY: APIDAE						
Apis mellifera	++	++++	++++	++++	+++	+++
Xylocopa fenestreta	++	++	++	++	++	+
Xylocopa virginica	+	+	+	+	+	+
FAMILY: VESPIDAE						
Polistes sp.	++	++	++	+	+	++
Polistes Carolina	+	++	++	-	-	-
Potter wasp	-	-	+	+	+	+
FAMILY: MEGACHILIDAE						
Megachile sp.	-	-	-	-	++	++
Coelioxys capitatus	-	-	-	+	+	+
FAMILY: SCOLIIDAE						
Scolia specifica	+++	+++	++	+	+	+
FAMILY: SPHECIDAE						
Sphex sp.	+	++	++	+	+	+
Bembix sp.	-	-	-	-	++	++
FAMILY: POMPILIDAE						
Pompilus sp.	-	-	+	+	+	-
FAMILY: ICHNEUMONIDAE						
Xanthopimpla stemattor	++	-	-	+	+	-

0-10 = +, 10-50 = ++, 50-100 = +++, 100-200 = ++++.

Table 3 : Hymenopteran visitors on flowers of different crops in Vallabh Garden Agriculture Farm, Bikaner

Hymenopteran visitors	*Tagetes erecta* (marigold)	*Lagenaria siceraria* (bottle gourd)	*Luffa cylindrica* (ridged gourd)	*Cucurbita maxima* (pumpkin)	*Brassica campestris* (mustard)	*Solanum melongena* (brinjal)	*Raphanus sativus* (radish)
Family : Apidae							
Apis mellifera	+++	+	++	++	++	+	+
Xylocopa fenestreta	++	++	++	-	+	+	+
Xylocopa virginica	+	+	+	-	+	+	-
Family : Vespidae							
Polistes sp.	++	++	+	-	+	-	+
Polistes carolina	++	-	+	-	-	-	-
Potter wasp.	+	-	-	+	+	-	-
Family : Megachilidae							
Megachile sp.	++	-	-	-	++	-	+
Coelioxys capitatus	+	-	-	-	-	+	+
Family: Scoliidae							
Scolia specifica	++	++	++	+	+	+	-
Family: Sphecidae							
Sphex sp.	++	-	+	-	+	-	-
Bembix sp.	+	-	-	-	++	-	-
							....
Family: Pompilidae							
Pompilus sp.	+	-	-	-	-	-	-
Family: Ichneumonidae							
Xanthopimpla stemattor	+	++	+	-	-	-	-

+=1 to 10 visits/m/h, ++=11 to 50 visits /m/h, +++=51 to 100 visits /m/h,

Table 4 : Occurrence (No./man/h) of *Apis mellifera* (Family: Apidae) on flowers of different crops in Vallabh Garden Agriculture Farm, Bikaner

S. No.	Crop	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.
1	*Tagetes erecta*	-	40	121	117	92	43
2	*Lagenaria siceraria*	8	-	-	-	-	-
3	*Luffa cylindrica*	10	72	-	-	-	-
4	*Cucurbita maxima*	-	-	35	18	-	-
5	*Raphanus sativus*	-	-	-	-	5	8
6	*Brassica campestris*	-	-	-	-	6	21
7	*Solanum melongena*	-	-	5	1	-	-

Table 5 : Occurrence (No./man/h) of *Xylocopa fenestreta* (Family: Apidae) on flowers of different crops in Vallabh Garden Agriculture Farm, Bikaner

S. No.	Crop	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.
1	*Tagetes erecta*	-	-	-	29	12	4
2	*Lagenaria siceraria*	5	17	12	-	-	-
3	*Luffa cylindrica*	32	30	-	-	-	-
4	*Cucurbita maxima*	-	-	-	-	-	-
5	*Raphanus sativus*	2	-	-	-	1	0
6	*Brassica campestris*	-	-	-	-	-	2
7	*Solanum melongena*	-	-	2	-	8	-

Table 6 : Occurrence (No./man/h) of *Xylocopa virginica* (Family: Apidae) on flowers of different crops in Vallabh Garden Agriculture Farm, Bikaner

S. No.	Crop	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.
1	*Tagetes erecta*	-	-	4	-	2	1
2	*Lagenaria siceraria*	-	2	-	-	-	-
3	*Luffa cylindrica*	5	-	-	-	-	-
4	*Cucurbita maxima*	-	-	-	-	-	-
5	*Raphanus sativus*	-	-	-	-	-	-
6	*Brassica campestris*	-	-	-	2	-	3
7	*Solanum melongena*	-	-	-	-	4	-

Table 7 : Occurrence (No./man/h) of *Polistes sp.* (Family: Vespidae) on flowers of different crops in Vallabh Garden Agriculture Farm, Bikaner

. No.	Crop	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.
1	*Tagetes erecta*	-	14	38	8	2	7
2	*Lagenaria siceraria*	24	12	-	-	-	-
3	*Luffa cylindrica*	16	-	-	-	-	-
4	*Cucurbita maxima*	-	-	-	-	-	-
5	*Raphanus sativus*	-	-	-	-	3	2
6	*Brassica campestris*	-	-	-	-	4	3
7	*Solanum melongena*	-	-	-	-	-	-

Table 8 : Occurrence (No./man/h) of *Polistes carolina* (Family: Vespidae) on flowers of different crops in Vallabh Garden Agriculture Farm, Bikaner

S. No.	Crop	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.
1	*Tagetes erecta*	-	7	21	-	-	-
2	*Lagenaria siceraria*	-	-	-	-	-	-
3	*Luffa cylindrica*	2	5	-	-	-	-
4	*Cucurbita maxima*	-	-	-	-	-	-
5	*Raphanus sativus*	-	-	-	-	-	-
6	*Brassica campestris*	-	-	-	-	-	-
7	*Solanum melongena*	-	-	-	-	-	-

Table 9 : Occurrence (No./man/h) of Potter wasp (Family: Vespidae) on flowers of different crops in Vallabh Garden Agriculture Farm, Bikaner

S. No.	Crop	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.
1	*Tagetes erecta*	-	-	2	7	1	-
2	*Lagenaria siceraria*	-	-	-	-	-	-
3	*Luffa cylindrica*	-	-	-	-	-	-
4	*Cucurbita maxima*	-	-	-	1	-	-
5	*Raphanus sativus*	-	-	-	-	-	-
6	*Brassica campestris*	-	-	-	-	3	4

Table 10 : Occurrence (No./man/h) of *Megachile sp.* (Family: Megachilidae) on flowers of different crops in Vallabh Garden Agriculture Farm, Bikaner

S. No.	Crop	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.
1	*Tagetes erecta*	-	-	-	-	16	18
2	*Lagenaria siceraria*	-	-	-	-	-	-
3	*Luffa cylindrica*	-	-	-	-	-	-
4	*Cucurbita maxima*	-	-	-	-	-	-
5	*Raphanus sativus*	-	-	-	-	7	4
6	*Brassica campestris*	-	-	-	-	12	11
7	*Solanum melongena*	-	-	-	-	-	-

Table 11 : Occurrence (No./man/h) of *Coelioxys capitatus* (Family: Megachilidae) on flowers of different crops in Vallabh Garden Agriculture Farm, Bikaner

S. No.	Crop	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.
1	*Tagetes erecta*	-	-	-	1	1	2
2	*Lagenaria siceraria*	-	-	-	-	-	-
3	*Luffa cylindrica*	-	-	-	-	-	-
4	*Cucurbita maxima*	-	-	-	-	-	-
5	*Raphanus sativus*	-	-	-	-	1	1
6	*Brassica campestris*	-	-	-	-	-	-
7	*Solanum melongena*	-	-	-	-	-	2

Table 12 : Occurrence (No./man/h) of *Scolia specifica* (Family: Scoliidae) on flowers of different crops in Vallabh Garden Agriculture Farm, Bikaner

S. No.	Crop	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.
1	*Tagetes erecta*	-	32	21	5	5	2
2	*Lagenaria siceraria*	35	26	-	-	-	-
3	*Luffa cylindrica*	38	-	-	-	-	-
4	*Cucurbita maxima*	-	-	-	2	-	-
5	*Raphanus sativus*	-	-	-	-	-	-
6	*Brassica campestris*	-	-	-	-	-	6
7	*Solanum melongena*	-	-	3	-	-	-

Table 13 : Occurrence (No./man/h) of *Sphex sp.* (Family: Sphecidae) on flowers of different crops in Vallabh Garden Agriculture Farm, Bikaner

S. No.	Crop	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.
1	*Tagetes erecta*	-	1	18	3	7	1
2	*Lagenaria siceraria*	8	-	-	-	-	-
3	*Luffa cylindrica*	4	12	-	-	-	-
4	*Cucurbita maxima*	-	-	-	-	-	-
5	*Raphanus sativus*	-	-	-	-	-	-
6	*Brassica campestris*	-	-	-	-	2	-
7	*Solanum melongena*	-	-	-	-	-	-

Table 14 : Occurrence (No./man/h) of *Bembix sp.* (Family: Sphecidae) on flowers of different crops in Vallabh Garden Agriculture Farm, Bikaner

S. No.	Crop	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.
1	*Tagetes erecta*	-	-	-	-	2	-
2	*Lagenaria siceraria*	-	-	-	-	-	-
3	*Luffa cylindrica*	-	-	-	-	-	-
4	*Cucurbita maxima*	-	-	-	-	-	-
5	*Raphanus sativus*	-	-	-	-	-	-
6	*Brassica campestris*	-	-	-	-	27	13
7	*Solanum melongena*	-	-	-	-	-	-

Table 15 : Occurrence (No./man/h) of *Pompilus* sp. (Family: Pompilidae) on flowers of different crops in Vallabh Garden Agriculture Farm, Bikaner

S. No.	Crop	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.
1	*Tagetes erecta*	-	-	5	7	1	-
2	*Lagenaria siceraria*	-	-	-	-	-	-
3	*Luffa cylindrica*	-	-	-	-	-	-
4	*Cucurbita maxima*	-	-	-	-	-	-
5	*Raphanus sativus*	-	-	-	-	-	-
6	*Brassica campestris*	-	-	-	-	-	-
7	*Solanum melongena*	-	-	-	-	-	-

Table 16 : Occurrence (No./man/h) of *Xanthopimpla stemattor* (Family:Ichneumonidae) on flowers of different crops in Vallabh Garden Agriculture Farm, Bikaner

S. No.	Crop	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.
1	*Tagetes erecta*	-	-	-	-	1	1
2	*Lagenaria siceraria*	22	-	-	-	-	-
3	*Luffa cylindrica*	2	-	-	-	-	-
4	*Cucurbita maxima*	-	-	-	-	-	-
5	*Raphanus sativus*	-	-	-	-	-	-
6	*Brassica campestris*	-	-	-	-	-	-
7	*Solanum melongena*	-	-	-	-	-	-

Shaded a rea in tables indicating crop period

Shaded area in tables indicating flowering period.