International Journal of Advanced Research in Biological Sciences
ISSN: 2348-8069
www.ijarbs.com
DOI: 10.22192/ijarbs Coden: IJARQG(USA) Volume 3, Issue 9 - 2016

Research Article

DOI: 10.22192/ijarbs.2016.03.09.007

Pollination potential: A comparative study of various hymenopteran insects pollinating some economically important crops in Kashmir

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Abstract

The present study was carried out in some districts of South and Central Kashmir, during blooming season 2013/2014 to investigate the comparative pollination potential of various hymenopterous insects. For this purpose some crops on the basis of their agricultural/ horticultural or medicinal importance were selected. The contribution of pollination potential of honeybees, bumble bees, carpenter bees, mining bees and wasps was calculated in pollinating a particular crop on the basis of the their abundance and the pollen load carried on their body. The results showed that among the selected crops, almost 80% were found to be mainly pollinated by honeybees i.e. honeybees constitute their major pollinators.

Keywords: Hymenopterous, pollinators, horticultural, abundance, pollen load.

Introduction

Hymenoptera is a diverse group of insects including bees, wasps and ants. Bees and wasps are of great economic importance for their essential role in pollination of a great variety of crops. Pollination is one of the most important mechanisms in the maintenance and promotion of biodiversity and in general, life on earth. It involves the transfer of genetic information between plants through pollen. Many ecosystems; including agroecosystems, depend on the pollinator diversity to maintain overall biological diversity. The various Hymenopteran insects have different pollination potential. Pollination also benefits society by increasing food security and improving livelihoods (Khan and Khan, 2004). Pollinators are extremely diverse, with more than 25000 pollinator bee species (Hymenoptera: Apidae) have been described worldwide (Michener, 2000; Kevan, 2003).

The ecological relationship of the pollinators was recognized long before by Knutson *et al.*, (1990) that cross pollination are the only means of maintaining the ecological diversity.

Pollination is an ecosystem process that has evolved over millions of years to benefit both flowering plants and pollinators. Pollinators visit flowers for many reasons, including feeding, pollen collection and warmth. When pollinators visit flowers, pollen are rubbed and dropped onto the flowers. Co-evolution of flowering plants and their pollinators started about 225 million years ago (Price, 1975). Stone carvings and bricks from the palace of Assyrian kings as early as 800 B.C. depict the significance of pollen and pollination of fruits that pollination enhances quality and yield of seeds and fruits.

Kashmir valley being an ideal place due to its moderate climatic conditions harbors a rich diversity of Hymenopteran fauna and the economy which depends largely on agriculture, has a direct dependence to a maximum extent on the pollination service they perform. So, the aim of the present study was to investigate the comparative pollination potential of various Hymenopterous insects.

Materials and Methods

Study area and sites

The collection sites were fixed in some districts of South and Central Kashmir, for the monitoring and collection purpose. In South Kashmir, a fruit orchard of 25×20m^2 dimensions in Shopian district and a vegetable garden of the same dimensions in Kulgam district were selected. In Central Kashmir's Srinagar district two sites University garden of area 50×10m^2 and Vegetable garden of area 25×20m^{2}in Batapora were selected. These sites were selected on the basis of the rich diversity of flora and hence the pollinator fauna was abundantly available over there.

Sampling of pollinator abundance

Some crops (Table 1) at the selected sites were chosen for their agricultural/ horticultural and medicinal importance, to work upon. The abundance of the pollinators, which constitutes one of the determining factors of their pollination potential, was sampled during the blooming period of the crop. Five readings were taken during the blooming season of the particular crop. During the survey 10 plants of a crop and 5 branches of a fruit plant were selected for the observation purpose. The observation of the different bees and wasps visiting the plants was carried out for 10-15 minutes of every hour from 8:00AM to 17:00 PM. Then the mean of 5 observations was taken to be the mean abundance of the various pollinators visited that crop or fruit plant.

Table 1.List of selected crops.

S. No.	Common name	Scientific name
1	Mustard	*Brassica nigra*
2	Apple	*Malus pumila*
3	Pear	*Pyrus communis*
4	Peach	*Prunus persica*
5	Onion	*Allium cepa*
6	Pumpkin	*Cucurbita maxima*
7	Cucumber	*Cucumis sativus*
8	Sunflower	*Helianthus annuus*
9	Tomato	*Lycopersicon esculentum*
10	Spanish Broom	*Spartium junceum*

Sampling of pollinators for pollen loads

The bees and wasps collecting pollen were trapped randomly and anaesthetized with ethyl acetate vapors. 5 readings each containing 10 bees or wasps, were taken. To measure their pollen load, the insects were weighed using a single pan electronic balance. The weight of the bees or wasps was noted down. Later the pollens were brushed from their body and weight was again determined. The difference in the weight was considered to be weight of pollen. Mean of the five readings (each reading containing 10 insects) was taken for calculating the pollination efficiency of the respective pollinators.

Pollination Efficiency

Pollination potential/Pollination importance value (PIV) of the Hymenopteran pollinators was assessed by using the formula as per the method adopted by Sharma (1990) and Tepedino *et al*., (2011).

$$\text{Pollination Importance Value (PIV)} = \frac{\text{Mean pollinator abundance X Mean Pollen load}}{100}$$

Statistical analysis

The field manual data obtained was subjected to analysis of variance (ANOVA) through MS-EXCEL 2007 &PRIMER software.

Results and Discussion

Mustard (*Brassica nigra*)

The pollination importance value (PIV) of various Hymenopteran insects in mustard crop was found to be *Apis* spp. (17.68±0.5); *Xylocopa* spp. (5.75±0.45); *Bombus* spp. (1.76 ±0.03); *Andrena* spp. (2.32±0.3) and wasps (1.00±0.03) (Table 2/ p≤0.01).

Table 2. Comparative account of Pollination potential of various Hymenopteran Insects in some Crops

Crops	Mean Abundance (MA), Mean Pollen Load (mg) (MPL) and Pollination Importance Value (PIV) with Standard Deviations (±) of various Hymenopteran Pollinators														
	***Apis* spp.**			***Xylocopa* spp.**			***Bombus* spp.**			***Andrena*s pp.**			**WASPS**		
	MA	**MPL**	**PIV**	**MA**	**MPL**	**PIV**	**MA**	**MPL**	**PIV**	**MA**	**MPL**	**PIV**	**MA**	**MPL**	**PIV**
Mustard	9.3 ± 1.98	188 ± 0.04	17.68^{e} ±0 .57	1.74± 1.26	330± 0.05	5.75^{d}± 0.43	1.02± 0.24	180± 0.05	1.76^{b}± 0.03	1.0± 0.16	90± 0.01	2.32^{c}± 0.30	0.63± 0.25	120± 0.02	1.00^{a}± 0.03
Apple	14.78 ± 1.62	144 ± 0.008	21.2^{e} ± 0.16	1.36± 0.42	354± 0.03	4.82^{d}± 0.17	0.88± 0.39	202± 0.02	1.74^{b}± 0.06	0.86± 0.08	94± 0.08	2.2^{c}± 0.01	0.34± 0.26	158± 0.01	1.02^{a}± 0.03
Pear	7.0 ± 1.10	132 ± 0.02	9.24^{e} ± 0.21	0.54± 0.13	250± 0.02	1.22^{d}± 0.03	0.19± 0.01	208± 0.013	1.00^{b}± 0.03	1.2± 0.29	90± 0.01	1.06^{c}± 0.02	0.26± 0.24	114± 0.01	0.30^{a}± 0.02
Peach	8.42 ± 2.16	156 ± 0.08	13.13^{e} ± 0.3	0.54± 0.23	234±0 .015	1.23^{c}± 0.04	0.8±0. 01	220± 0.02	1.76^{d}± 0.03	0.74± 0.16	98± 0.004	0.72^{b}± 0.01	0.26± 0.20	142± 0.02	0.36^{a}± 0.03
Onion	12.76 ± 2.92	142 ± 0.01	17.68^{e} ± 0.33	0.74± 0.37	320± 0.04	2.42^{d}± 0.15	0.30± 0.13	220± 0.03	1.00^{c}± 0.03	0.84± 0.2	94± 0.008	0.76^{b}± 0.01	0.48± 0.21	132± 0.02	0.48^{a}± 0.04
Pumpkin	8.6 ± 0.95	134 ± 0.03	11.58^{e} ± 0.32	0.70± 0.16	226± 0.01	1.5^{d}± 0.04	0.5± 0.18	232±0. 03	1.16^{c}± 0.04	1.04± 0.19	88± 0.01	0.88^{b}± 0.01	0.5±0.4	136± 0.02	0.68^{a}± 0.04
Cucumber	7.4 ± 1.23	154 ± 0.008	11.33^{e} ± 0.15	0.54± 0.08	224± 0.025	1.21^{d}± 0.02	0.28± 0.17	216± 0.01	0.56^{c}± 0.03	0.38± 0.08	94± 0.008	0.35^{b}± 0.008	0.28± 0.19	120± 0.01	0.28^{a}± 0.01
Sunflower	7.4 ± 1.26	158 ± 0.01	12.46^{e} ± 0.24	0.44± 0.26	198± 0.008	0.86^{d}± 0.05	0.28± 0.25	210± 0.01	0.59^{c}± 0.05	0.6± 0.18	90± 0.01	0.52^{b}± 0.01	0.22± 0.14	112± 0.013	0.25^{a}± 0.016
Tomato	1.22 ± 0.43	160 ± 0.02	1.92^{d} ± 0.06	0.56± 0.21	232± 0.02	1.25^{c}± 0.05	2.06± 0.48	198± 0.02	4.01^{e}± 0.06	0.46± 0.18	96± 0.05	0.44^{b}± 0.01	0.3± 0.10	122± 0.02	0.36^{a}± 0.01
Spanish Broom	0.98 ± 0.32	162 ± 0.01	1.45^{d} ± 0.05	3.26± 1.61	242± 0.01	8.5^{e}± 0.41	0.38± 0.22	164± 0.021	0.59^{b}± 0.03	0.96± 0.27	88± 0.016	0.80^{c}± 0.007	0.26± 0.19	132± 0.02	0.36^{a}± 0.02

Different Superscripts showing the significant data

The Fig. 1 shows that the among the all Hymenopteran insects that visit the crop bloom (mustard), *Apis* spp. has the maximum pollination value and constitutes its main pollinators. At the time, when mustard crop was in full bloom i.e., March-April, the *Apis* spp. was in abundance as compared to other Hymenopterans and hence constituted the main visitors of the crop. Besides they had specialized pollen collecting structure (corbicula) present on their legs, which added to their efficiency as pollen carriers. These features made them the efficient and main pollinators of the crop. The findings were in agreement with Kulkerni and Dhanarkar (1998), who concluded the same results.

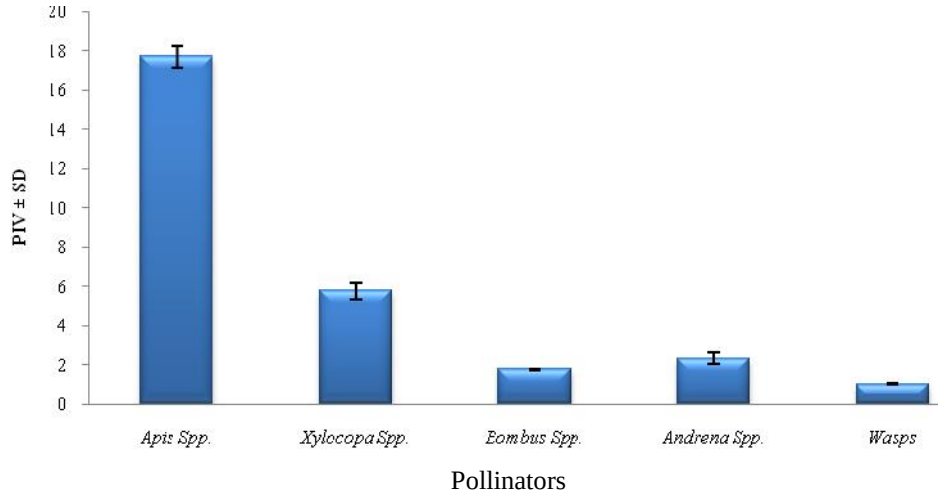

Fig. 1. Pollination Importance Value of various Hymenopteran insects in Mustard crop

Apple (*Maluspumila*)

In case of apple the PIV of the insects was found to be *Apis* spp. (21.2± 0.16); *Xylocopa* spp. (4.82± 0.17); *Bombus* spp. (1.74±0.06); *Andrena* spp. (2.2±0.01) and wasps (1.02±0.03) (Table 2/ p≤0.03).

The results (Fig. 2) showed that the maximum contribution in pollinating the apple was of *Apis* spp. Our results were otherwise to the findings of Khan and Khan (2004) which showed that the wild bees like leaf cutting bees, *Megachile rotunda* and *Andrena* spp. constituted the main pollinators. Our findings deviated their findings for the reason that the excessive pesticide use and loss of appropriate nesting habitat had reduced the number of wild bee pollinators leaving most of the pollination for commercial orchards dependent on honeybees.

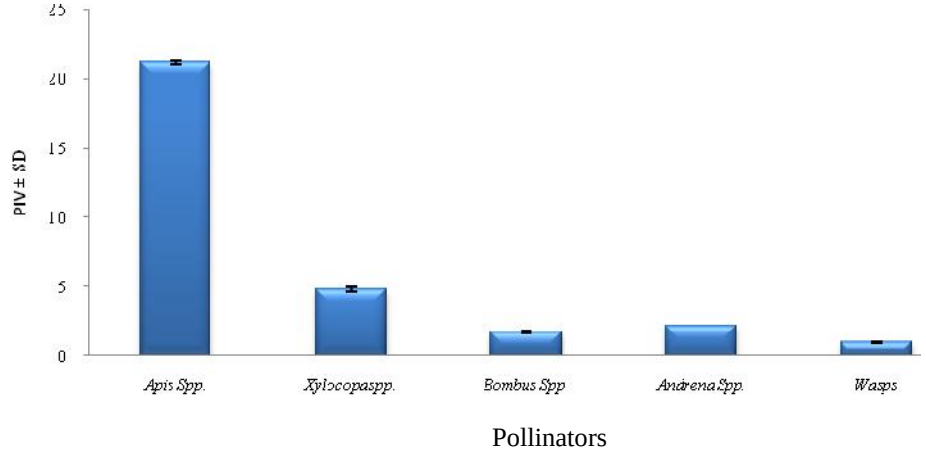

Fig.2. Pollination Importance Value of various Hymenopteran insects in Apple

Pear (*Pyrus communis*)

In case of pear the PIV of insects was found to be *Apis* spp. (9.24±0.21); *Xylocopa* spp. (1.22±0.03); *Bombus* spp. (1.76±0.03); *Andrena* spp. (1.06±0.02) and wasps (0.36±0.01) (Table 2/ p≤0.05).

The results (Fig. 3) showed that the *Apis* spp. performs the major role in pollination of this fruit plant. The more abundance of *Apis* spp. during its blooming season as compared to other Hymenoptera and the tender nature of flower which could easily bear the weight of only *Apis* spp. made them the main visitors of these plants. The same conclusions were drawn by McGregor (1976) and Currie (1992) out of their work.

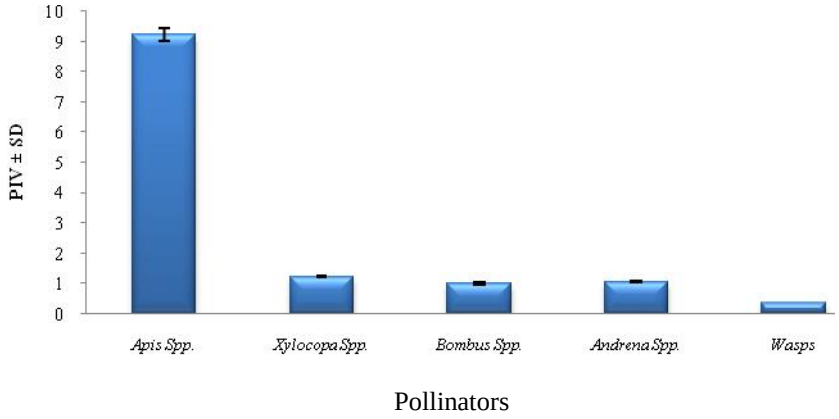

Fig.3. Pollination Importance Value of various Hymenopteran insects in Pear

Peach (*Prunus persica*)

In peach plants the PIV of insects was found to be *Apis* spp. (13.13±0.3); *Xylocopa* spp. (1.23±0.04); *Bombus* spp. (0.29±0.03); *Andrena* spp. (0.72±0.01) and wasps = (0.03±0.03) (Table 2/ p≤0.05).

Again the results (Fig. 4) in this case showed *Apis* spp. to be the main pollinators. The peach (and almond) bloom in early spring when temperature is low and only the honeybee pollinators are available in abundance (Lema, 1998). This makes the peach plants dependent on honeybees more than the other type of bees for their pollination, and hence honeybees featured to be the main pollinators of these plants. Our findings were in consonance with those of McGregor (1976).

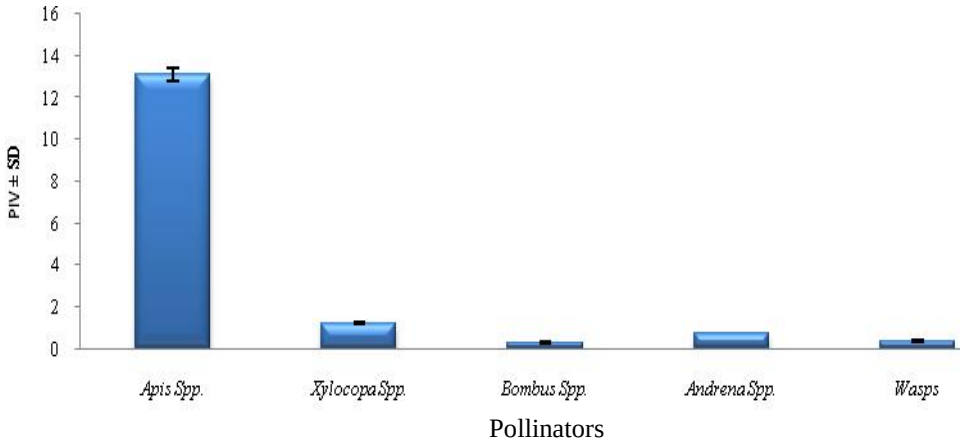

Fig.4. Pollination Importance Value of various Hymenopteran insects in Peach

Onion (*Allium cepa*)

The PIV of various pollinators in case of onion was found to be *Apis* spp. (17.68±0.3); *Xylocopa* spp. (2.42± 0.1); *Bombus* spp. (0.30±0.03); *Andrena* spp. (0.76± 0.01) and wasps (0.40± 0.04) (Table 2/ p≤0.02).

The onion flowers are protandrous so only cross pollination occurs (Lema, 1998).The cross pollination occurred through insects and wind also contributed in it. Among the insects honey bees constituted the main pollinators. Onion seeds are a rich source of pollen and nectar which attracts the honeybees. So more abundantly visiting honeybees constitute the more efficient pollinators of onion as compared to other insect visitors (Fig. 5). Bohart (1970) and Caron *et al.*,(1975) got the same results.

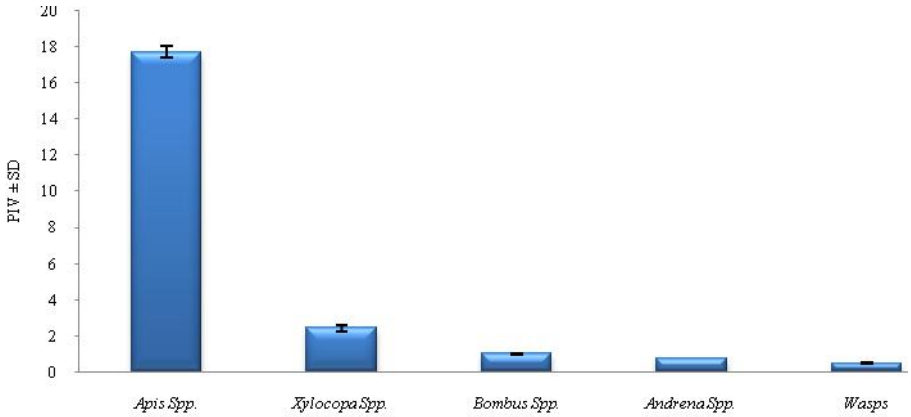

Fig.5. Pollination Importance Value of various Hymenopteran Insects in Onion

Pumpkin (*Cucurbita maxima*)

In case of pumpkin the PIV of various Hymenopteran insect pollinators was observed to be *Apis* spp. (11.58±0.32); *Xylocopa* spp. (0.77±0.04); *Bombus* spp. (0.68±0.04); *Andrena* spp. (0.88±0.01) and wasps (0.60± 0.04) (Table 2/ p≤0.02).

Again in this crop/vegetable *Apis* spp. constitute main pollinators(Fig. 6). The honey bees were abundantly visiting the flowers of pumpkin as compared to other Hymenopteran insects and hence constitute efficient pollinators of this crop. The results were in consonance with the findings of Tepedino (1981) who found honeybees as the main and most efficient pollinators of pumpkin and squash. The reason for *Apis* bees to make frequent visits of the crop was that, its nectar provides them some essential lipids and proteins (Schippers, 1997).

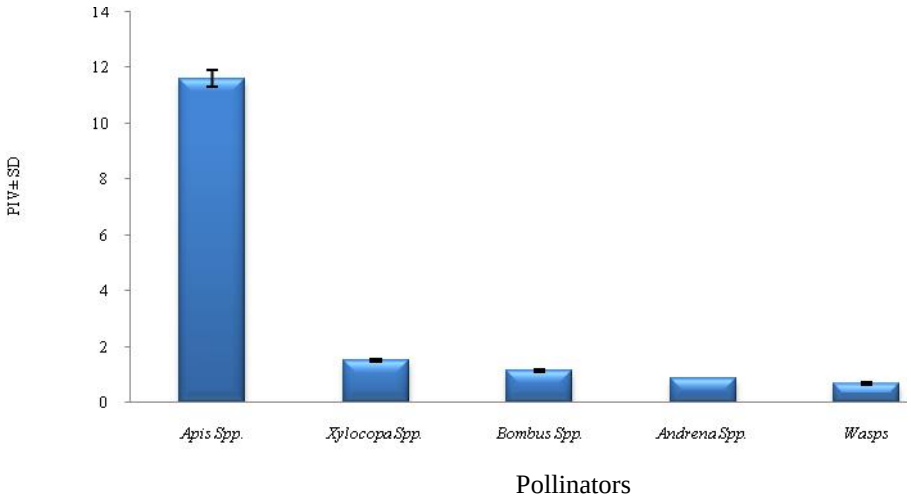

Fig.6. Pollination Importance Value of Hymenopteran insects in Pumpkin

Cucumber (*Cucumi ssativus*)

The contribution of the various flower visitors of cucumber was found to be *Apis* spp. (11.33±0.15); *Xylocopa* spp.(1.21±0.02); *Bombus* spp. (0.56±0.03); *Andrena* spp.(0.35±0.08) and wasps (0.2±0.01) (Table 2/ p≤0.02).

Cucumbers are not rich source of pollen or nectar but are being readily visited by the insects if no more attractive plants are nearby. The results (Fig. 7) showed that *Apis* was the main pollinator of cucumber which was in agreement with Tew and Caron 1988. The reason for frequent visitation of honeybees to cucurbitacea was the same i.e. availability of essential lipids and proteins (Schippers, 1997).

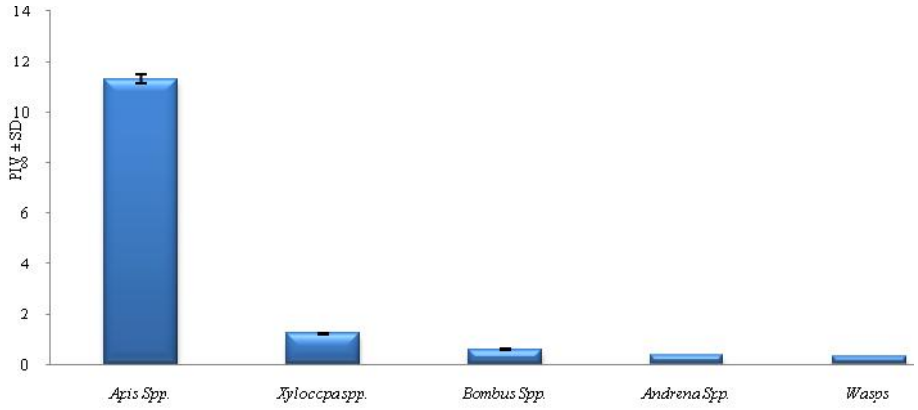

Fig. 7. Pollination Importance Value of Hymenopteran insects in cucumber

Sunflower (*Helianthus annuus*)

As per the observation the PIV of insects in sunflower was as *Apis* spp. (12.46±0.2); *Xylocopa* spp. (0.86±0.05); *Bombus* spp. (0.59±0.05); *Andrena* spp. (0.52±0.01) and wasps (0.25 ±0.01) (Table 2/ p≤0.02).

The Fig. 8 shows the major contribution in pollination of this oil seed plant is that of *Apis* species. The responsible factors are bright colouration of the flowers, Abundance of pollen and nectar which attract the honeybees in abundance. The flowers had so lose pollen that they did not need a special sit of the insects like *Bombus* and *Xylocopa* to draw out the pollen. The abundance and foraging behavior of *Apis* spp. made them the major insect pollinators of this crop. Similar results were found by Rajasri *et al.*, (2007).

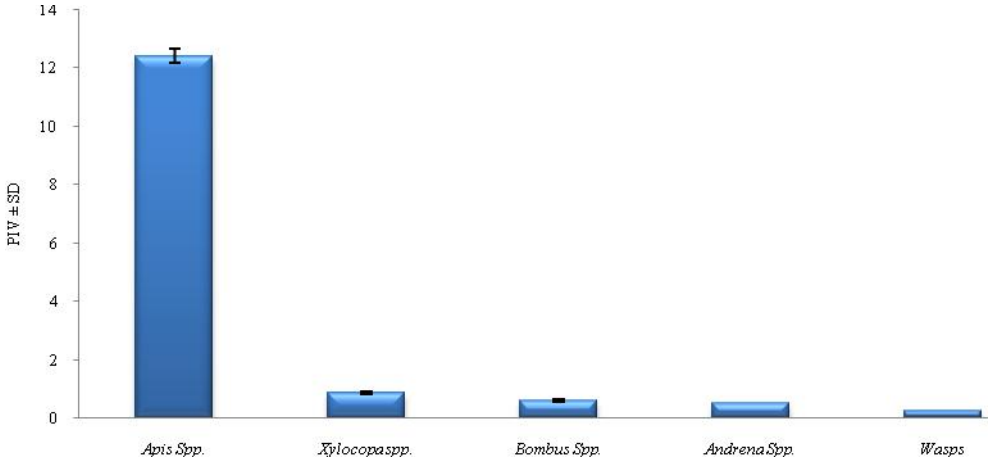

Fig.8. Pollination Importance Value of Hymenopteran insects in Sunflower

Tomato (*Lycopersicon esculentum*)

The observation showed the PIV of various pollinators in case of tomato as *Apis* spp. (1.92±0.06); *Xylocopa* spp. (1.25±0.05); *Bombus* spp, (4.01±0.06); *Andrena* spp. (0.43±0.01) and wasps (0.3±0.01) (Table 2 /p≤0.02).

Tomato stigmas were pollinated when the flower was shaken by wind or insects. The pollen grains in tomato were enclosed inside the anther, the bees other than bumble bees *Bombus* spp. were not that much able to buzz-pollinate the tomato. The *Bombus* vibrated over the flower (buzz-pollination) and opened the pollen from anther to transfer them to stigma. So the behavior of the bumble bees it is which makes them the major pollinators of tomato (Fig. 9). McGregor (1976) also found *Bombus* to be the main pollinators of tomato.

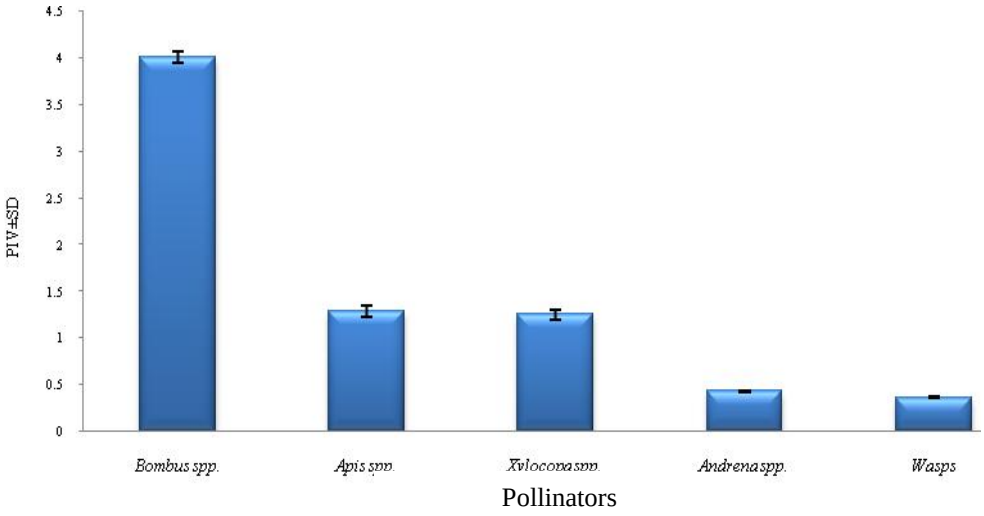

Fig.9. Pollination Impotance Value of Hymenopteran insects in Tomato

Spanish Broom (*Spartium junceum*)

The PIV of various insects in *S. junceum* was found to be *Apis* spp. (1.45±0.05); *Xylocopa* spp. (8.5±0.41); *Bombus* spp. (0.59±0.03); *Andrena* spp. (0.80±0.007); Wasps (0.36 ±0.02) (Table 2/ p≤0.02).

The *Xylocopa* spp. was clearly observed (Fig. 10) to be the main pollinators of this leguminous plant. The leguminous plants have usually the strong flowers and the weak insects like *Apis* often fail to draw any nectar or pollen from it. There is a correlation between the morphometric traits of plant and insect (particularly the wing and keel). So the features like strong body and the ability of *Xylocopa* spp. to cut the base of corolla off to enter the flower to draw nectar and pollen, made them the most efficient and main pollinators of this plant. Cardoba (2011) had worked on it and got the same results.

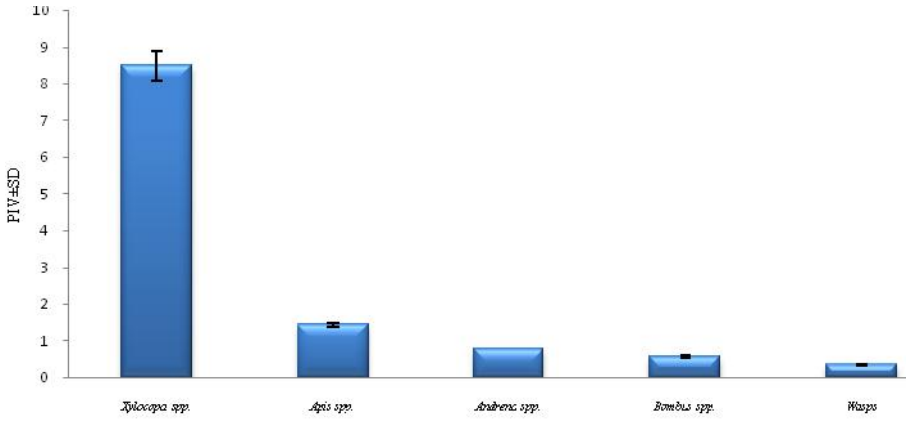

Fig.10. Pollination Importance Value of Spanish Broom (*Spartiumjunceum)*

Conclusion

The results showed that majority of the selected crops (8 of 10) are mainly pollinated by *Apis*spp.All the bees and wasps, due to their foraging habit, different food preferences, specialized structures and behavior, play an essential role in pollinating different crops. The *Apis* spp. because of their abundant population, special morphological characters like hairy body and pollen basket diverse food preference (nectar and pollen from numerous floral resources), constitute the most efficient and major group of crop pollinators (Singh *et al.*, 1999; Bosch *et al.*, 2006).

Pollinators provide an essential ecosystem service that contributes to the maintenance of biodiversity and ensures the survival of plant species including crop plants. The decline of natural insect pollinators has been a major concern so the scientists and other workers of this field are always busy in finding the alternatives, one of the solutions to this problem is the management of bee colonies for pollination purpose.

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DOI:10.22192/ijarbs.2016.03.09.007	

How to cite this article:
Fehmeeda Akhter, Abdul Lateef Khanday & S. Tariq Ahmad. (2016). Pollination potential: A comparative study of various hymenopteran insects pollinating some economically important crops in Kashmir. Int. J. Adv. Res. Biol. Sci. 3(9): 50-59.