Diversity of Hymenpteran pollinators in Kashmir region

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Abstract: Studies were undertaken to explore the diversity of Hymenopteran pollinators at different sites/ agro-ecosystems of Kashmir region so as to cover its all areas viz. Southern, Central and Northern. Out of the total 448 specimens collected, majority (60%) were collected in pre noon survey and 40% at post noon survey. 9 species belonging to 5 genera and three families, were collected. The calculated values of all diversity indices showed that the lowest diversity was shown in the areas which were with weeded orchards and surrounded by the disturbed surroundings as compared to those having natural surroundings' with less human interference and diverse floral resources.

1. Introduction

Pollination is one of the most important mechanisms to promote biodiversity and to sustain life on Earth. Pollination also benefits society by increasing food security and improving livelihoods (Khan and Khan, 2004). Pollinators are extremely diverse, with more than 16,000 pollinator bee species (Hymenoptera: Apidae) have been described worldwide (Michener, 2000; Kevan, 2003). Insect pollination mostly bees is necessary for the pollination of 75% of all crops that are used directly for human food worldwide (Potts et al 2010). The ecological relationship of the pollinators was recognized long before by Knutson et al. (1990) that cross pollination is the only means of maintaining the ecological diversity. The self pollinated plants if cross pollinated there would be improvement in both fruit yield and size (Gautier-Hion and Maisels, 1994; Free, 1993). It is estimated that bees accomplish for more than eighty percent of the insect pollination. Yields of fruit, legumes and vegetable seeds often have been doubled or tripled by providing adequate number of bees for pollination (McGregor, 1976). The wild bees including bumble bees, leaf-cutting bees, alkali bees and carpenter bees and the social bees like honeybees have various modifications in their morphology which make them efficient pollinators. Globally, the annual contribution of pollinators to the agricultural crop has been estimated at about US$54 billion (Buchmann and Nabhan 1996; Kenmore and Krell, 1998). So the Hymenopteran pollinators determine the economy of the people. In Kashmir about 65% of population depends on agriculture so their economy and livelihood depend on insect pollinators especially Hymenopteran insects which account for 80% of crop pollination. Because of its moderate temperate climatic conditions the Kashmir valley is the home for a diverse Hymenopteran fauna but no attempt for its assessment has been done so far except a few scattered reports. So an attempt has been made by selecting various sites in valley to assess the diversity of pollinating Hymenopteran fauna.

Table 1. Blooming months of various plants in Kashmir region

Common Name	Latin Name	Blooming Months
Almond	*Prunus amygdalus*	March to April
Plum	*Prunus species*	April to May
Apple	*Pyrus malus*	April to May
Cherry	*Prunus avium*	April to May
Peach	*Prunus persica*	April to May
Mustard	*Brasica nigra*	April to May
Radish	*Raphanus sativus*	April to May
Coriander	*Coriandrum sativum*	May
Cucumber	*Cucumis sativus*	June to October

2. Material and Methods
Field survey

Field surveys were undertaken in some selected locations like Botanical Garden and vegetable garden Batapora in District Srinagar, Fruit orchard in District Baramullah ,a crop field in District Kulgam, a vegetable garden and a fruit orchard in District Shopian of Kashmir. The sites were selected on the bases of richness in flora and hence were rich in pollinator fauna also. The detailed survey of these sites was conducted from early spring to early winter for the year 2013-2014. The occurrence and distribution of pollinators varies with the topographic change. The flowering period of major fruit plants and vegetable seed plants is given in (Table 1). At each location roving survey was taken up twice in 15 days. In roving survey, the occurrence of pollinators was assessed by taking observations on five randomly selected plants. The hymenopterans pollinators in orchard ecosystem were sampled by using two methods; 1) by sweep net ($30 \times 60 \times 45$ cm) and 2) hand picking through net (where sweeping couldn't work).In sweep net practice, twenty-five sweeps were made diagonally across each canopy and samples were placed in separate plastic vials. A total of 12 samples were taken from each site at different time. The collection obtained from hand picking was taken out after every 72 h from the previous collection. But the time of their activity in the field and their proportion in different localities was only possible to determine through sweep net collection in different times of the day. A maximum number of pollinator's activity was also observed during the full bloom and fruit setting because at full bloom more food is available in the form of nectar and pollen. In order to study the proportion of each species within the local community, species diversity was computed based on Shannon- Wiener formula, also called the Shannon's index or Shannon- Wiener index H= -sum(pi log[pi]) (Humphries et al., 1996), where H is the Shannon-Wiener (1963) biodiversity index; Pi is the proportion of each species in the sample (relative abundance); log e Pi is the natural log of Pi; and S is the number of species in the pollinators community.

Species richness (Ma)

To assess the diversity of the population and its distribution among the particular species, this index was calculated (Pielou, 1975).

Ma=S-1Log e N

Where, S is the total number of species collected and N is the total number of individuals in all the species.

Species evenness (H)

Species evenness was calculated to estimate the equitability component of diversity to understand the similarity in abundance of different species. (Pielou, 1969); H′= C {log10N - 1⁄NΣ (log10 nr log10)} Where, H is the Shannon-Wiener Richness index and S is the number of species in the community.

Simpson's diversity index

This accounts for both richness and proportion (per cent) of each species in the local community. The index has been defined in three different ways (Simpson, 1949);

Simpson's index (D): This denotes the probability that two randomly selected individuals in the community belong to the same species. The form of the Simpson's index used was:

S
C = Σ {ni (ni-1)⁄N (N-1)}
I=1

Where, "ni" is the number of individuals in the" ith" species and "N" is the total number of individual in the sample. The form of the Nakamura's index used was:

S
RI = ΣRi⁄S (M - I)
r = i

Where, "S" is the number of investigated species of insects; "M" is the number of rank of abundance (0, 1, 2, 3… M - I) and "R" is the rank value of "ith" species in the sample.

Rank abundance values

In biodiversity study, there are mainly four categories to be worked out; abundance, richness, evenness and dominance. As here the species dominance of pollinators during the flowering period was to be studied to solve the rank abundance value. This was done by taking the sum of individual species found throughout the crop period and ranks were given based on the dominance of hymenopterans species.

3. Results
Bee pollinators in the selected sites

Field surveys for collection of the bees were carried out during from April 2013. The specimens were identified up to species level. A total of nine species belonging to five genera that fall in three families, were identified. The abundance, richness and evenness (equitability) of pollinators found in each sampled site and total abundance of each species and total abundance of species collected from all sampled sites are in accordance with Jasara et al. (2000) and Jasara and Rafi (2008) who have carried out such survey in fruit orchards of Himalayan foot hills. Abundance, richness and evenness (equitability) of the Hymenopteran pollinator bees was found at peak during blooming periods of these sites. Previously, Verma and Pertap (1993) also highlighted the impact of mountain pollinators during spring

from Himalayan region.The surveys were carried out in two sessions in a day viz. Am session or before noon session and PM session or afternoon session.

Ante-meridian (before noon) collection surveys

During ante-meridian (A.M.) collection, a total of two hundred and fifty (150) specimens was collected from all sampled orchards of which is the 60.94% of the total collected specimens in both ante-meridian (A.M.) and postmeridian (P.M.). It showed that Hymenopteran pollinator bees prefer to visit flowers during ante-meridian (A.M.) phase as compared to post-meridian (P.M.) phase of the day time because of moderate weather conditions and widely open corolla of flowers. There was no significant difference in abundance, richness and evenness (equitability) of then Hymenopteran pollinator bees found in all these sites at post-meridian taxa collected at post-meridian which is in accordance with that of Louadi and Doumandji (1998).

Post-meridian (after noon) collection surveys

During post-meridian (P.M.) collection, a total of fifty (50) specimens were collected from all sampled orchards; that is the 39.06% of the total specimens collected in both ante-meridian (A.M.) and post-meridian (P.M.). This indicated that Hymenopteran pollinator bees less preferred to visit flowers during post-meridian (P.M.) phase as compared to ante-meridian (A.M.) phase of the day time. Abundance, richness and evenness (equitability) of the Hymenopteran pollinator bees found in all sites at postmeridian (P.M.) are diagrammatically represented in Figure 1. Table 3 shows the collective rank list along with the list of taxa collected at post-meridian from different collection sites. Yields of fruit, legumes and vegetable seeds often have been doubled or tripled by providing adequate number of bees for pollination. Shannon's diversity index in perturbed situations are usually higher (Pileou, 1975). During the present study, four (4) diversity indices namely; Shannon-Wiener's diversity index along with its equitability component, Margalef's index, Simpson's index and Nakamura and Toshima's index were used for the calculation of abundance, richness and evenness (equitability). The calculated values and comparison of calculated values of four diversity indices for each sampled sites are given in Table 4. The calculated values of this index in different selected sites ranged from 2.262 (vegetable garden Shopian) to 2.945 (Botanical Garden Srinagar).

The other orchards yielded values in between the above-mentioned figures (2.262 to 2.945). The calculated values showed that there is no big difference (0.921) and (0.988) in the richness and evenness of Shannon- Wiener's diversity index,

which meant that the Hymenopteran pollinator bees are well distributed in all these orchards. However, the maximum diversity value was calculated from the Botanical Garden Srinagar (2.945) and minimum diversity value was calculated from the vegetable garden Shopian (2.262).

Table 2. Specific, generic and family wise distribution of specimens collected from the sites

Family	Genus	Species	Number
Apidae	*Apis*	*cerana indica*	2
		Melifera	
	Xylocopa	*Dissimilis*	2
		Rufescens	
	Bombus	*Tunicatus*	2
		Kashmirensis	
Vespidae	*Vespa*	*Orientalis*	2
		Velutina	
Megachillidae	*Osmia*	*Cornifrons*	1

Shannon's equitability (H)

Shannon's equitability index measures the evenness (equitability) of the calculated species in the sample or sampling area (Shannon, 1963). The calculated values of the Shannon's equitability index 'H' in sampled sites ranged from 0.875 (vegetable garden Batapora) to 0.988 (Fruit orchard Shopian). Out of the four selected sites, the similarity and differences in calculated values were not significantly different in pollinators' number as well in the fruit yields. This uniform distribution indicated the equitability of the Hymenopteran pollinators (Table 2). The evenness and richness of the pollinators are coinciding in values from two diversity indexes - Shannon-Wiener's diversity index and Shannon's equitability index 'J' which support normal distribution of the pollinators' species indicating less diverse pattern in the study area of monoculture.

Margalef's index

Margalef's index is used to measure the richness of the species distributed in the sample or sampling area (Margalef, 1969). This index is used frequently in the biological data. The calculated values of the Margalef's index in the surveyed sites ranged from 1.298 (vegetable garden Bataporas (Srinagar) to 1.671 (Fruit orchard Shopian). (Table4). The yielded values of this index from all the sampled sites indicated that there was no any big difference in the richness of Hymenopteran pollen orchards of the Valley.

Simpson's index

The calculated values of the Simpsons' index from sampled sites were calculated as: 0.959

(vegetable garden Shopian) and the remaining sampled sites as 0.999. The yielded values of this index indicated that the abundance of fruit orchard Baramullah was slightly higher than remaining other sampled sites.

Nakamura's index (RI)

Nakamura and Toshima's index measures the richness of the species. The calculated value of Nakamura (RI) index ranged from 0 to 1. If the value tends to zero, the diversity will increase (Nakamura and Toshima, 1995). The calculated values of the Nakamura's index (RI) from sampled sites calculated as: fruit orchard Shopian (0.642), vegetable garden Batapora as 0.700, fruit orchard Baramullah as 0.666 and vegetable garden Shopian as 0.666, crop field kulgam 642, University garden 0.642 and Botanical Garden as 0.666. The yielded values of this index indicated that the diversity was more or less same at all sites (Table 4).

Table3. Rank and abundance list of taxa collected from various sites

Rank	Name of taxa	Abundance	Fruit orchard Shopian	Vegetable garden Shopian	Crop field Kulgam	Fruit Orchard Baramullh	University garden	Vegetable garden Batapora Srinagar	Botanical Garden University
1	*Apis cerana*	97	12	13	25	12	11	0	14
2	*Apis melifera*	84	9	11	18	11	12	13	10
3	*Xylocopa dissimils*	69	9	11	14	6	8	10	11
4	*Xylocopa rufescens*	58	10	9	8	5	9	8	9
5	*Bombus tunicatus*	57	9	15	9	6	5	7	6
6	*Bombus kashmerensis*	44	7	8	8	5	6	8	4
7	*Vespa orientalis*	37	5	8	9	4	6	3	2
8	*Vespa velutina*	7	0	0	7	0	0	0	0
9	*Osmia cornifrons*	5	5	0	0	0	0	0	0
Total		N=448	N=66	N=75	N=98	N=49	N=57	N=47	N=56

Table 4. Value of diversity indices from different sites

Name of the site	Shannon-Weiner's index (H)	Margalef's index (Ma)	Simpson's Index (D)	Nakamura's Index (RI)
Fruit orchard Shopian	0.982	1.671	0.999	0.642
Crop field Kulgam	0.921	1.527	0.965	0.642
Vegetable garden shopian	0.988	1.389	0.959	0.666
Fruit orchard in Baramullah	0.958	1.542	0.999	0.666
University garden	0.982	1.671	0.999	0.642
Vegetable garden Batapora Srinagar	0.875	1.298	0.999	0.700
Botanical Garden Srinagar	2.932	1.490	0.999	0.666

4. Conclusion

The calculated values of all the indices from the entire sampled commercial fruit orchards showed that despite some differences in the total number of individuals (abundance) there was no big difference in the richness and evenness of Hymenopteran pollinator bees in the selected sites which cover all the three viz., Southern, central and Northern areas of Kashmir valley.

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References

1. Ambrose, J.D., Kevan, P.G. Reproductive biology of rare Carolinian plants with regard to management. In: G.M. Allen, G.F.J. Eagles & S.D. Price (Eds). Conserving Carolinian Canada: Conservation Biology in the Deciduous Forest Region. University of Waterloo Press 1990: pp. 281-290

2. Bohart, G.E. Management of wild bees for the pollination of crops. Annual Review of Entomol 1972: 17: 287- 312.

3. Buchmann, S.L., Nabhan, G.P. The Forgotten Pollinators. Island Press Washington, D.C., U.S.A 1996: p. 292.

4. Free, J.B. Insect pollination of crops. 2nd edition, Academic press, London 1993.

5. Gautier-Hion A, Maisels, F. mutualism between a leguminous and large African monkeys as pollinators. Behavioural Ecology1994

6. Hingston AB, McQillan PB. Does the recently introduced bumblebee, *Bombus terrestris* (Apidae) threaten Australian ecosystems. Australian J. Ecol1998: 23: 539-549.

7. Jasara A W, Ashfaq S, Kasi AM. Apple pollination in Balochistan Pakistan. National Arid land Development and Research Institute, Ministry of Food, Agricultural and Livestock, Islamabad 2000: p. 33.

8. Jasara AW, Rafi MA.Pollination management of apricot as a livelihood source in northern areas. Pak. J. Agric. Agricultural Engineering and Veterinary Science 1994: 24: 34-40.

9. Kearns, C.A., Innouye, D.W., Waser, N.M. Endangered mutualisms; the conservation of plant-pollinator interactions. Annual Review Ecol. Syst1998: 29: 83-112.

10. Kevan, PG. Pollinators as bio indicators of the state of the environment: species, activity and diversity. Agriculture, Ecosystems & Environment 1999: 74: 373-393.

11. Kevan, P.G. Pollination: Plinth, pedestal, and pillar for terrestrial productivity. The why, how, and where of pollination protection, conservation, and promotion. In: C.S. Stubbs and F.A. Drummond [eds] Bees and Crop Pollination–Crisis, Crossroads, Conservation. Thomas Say Publication of the Entomological Society of America, Lanham, Maryland, U.S.A2011: pp. 7-68.

12. Kevan, P.G. Pollination for the 21st century: integrating pollinator and plant inter dependence. In: K. Strickler and J.H. Cane [eds] For Nonnative Crops, Whence Pollinators of the Future. Thomas Say Publication of the Entomological Society of America, Lanham, Maryland, U.S.A2003: pp. 181-204.

13. Kevan, P.G.,Clark, E.A and Thomas, V. Insect pollinators and sustainable agriculture. Am. J. Alternative Agric1990: 5: 13-22.

14. Kenmore P, Krell R. Global perspectives on pollination in agriculture and agro-ecosystem management. International workshop on the conservation and sustainable use of pollinators in Agriculture with emphasis on Bees October 7-9 Sao Paulo, Barazil 1998.

15. Khan M R, Khan M R. The role of honey bees *Apis mellifera* L. (Hymenoptera: Apidae) in pollination of apple. Pak. J. Biol. Sci 2004: 7: 359-362.

16. Knutson, R.D., Taylor, R.G., Penson, B.J., Smith, G.E. Economic impacts of reduced chemical use. Knutson and Associates, College Station, Texas 1990: pp 30- 31.

17. Louadi, K., Doumandji, S. Diversity and gathering activity of bees (Hymenoptera: Apoidea) in a therophyte lawn in Constantine (Algeria). Canadian Entomologist1998: 130: 691-702.

18. Margalef, S.R. Diversity and stability: A practical proposal: a model of instars-dependence. Brookhaven Symposium of Biology 1969: 22: 25-37.

19. McGregor, S. E. Insect pollinators of cultivated crop plants. United State Department of Agriculture, Agriculture Hand book 1976: p. 496.

20. Michener C D. The bees of the world. The Johns Hopkins University Press 2000.

21. Potts, S.G., Biesmejer, J.C., Kremen, C., Neumann, O., Schweiger and Kunin. Global Pollinator declines: trends, impacts and drivers. Trends in Ecological and Evolution 2010: 25:345-353.

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