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POLLINATORS DIVERSITY AND BUMBLEBEE ABUNDANCE IN RAWALPINDI/ISLAMABAD AND NARAN KAGHAN VALLEY, PAKISTAN

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A B S T R A C T

Indigenous bumblebee *Bombus haemorrhoidalis*, the only *Bombus* of Lower Northern Pakistan plays a significant role in wild floral pollination. Present study compared the relative abundance and diversity of *B. haemorrhoidalis* with other insect pollinators. Monthly population level field surveys were conducted from Rawalpindi/Islamabad and Naran Kaghan Valley during 2012 and 2013. Hymenopteran insect pollinators were the most abundant taxa with six species followed by Lepidoptera with five. *Syrphus* species (Dipteran) were recorded with maximum abundance after *B. haemorrhoidalis* from all study locations. Pollinator diversity indices were at their highest in Naran and F9 Park (Islamabad) areas. Such ecological information are important for possible utilization in further biological experimentations, commercial pollination services and environmental conservation. This study also focuses the importance to conserve the only *Bombus* species in these areas.

Keywords: *Bombus haemorrhoidalis*; Pollinator diversity; Relative abundance; Naran Kaghan

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INTRODUCTION

World's 3000 species of agricultural crops require pollination and pollination by insects and other sources is a requirement for about 90% of flowering plants (Ollerton, 1999). Different crops vary in their pollination requirements and thus their dependence on insect pollinators. Insect pollinators are most diverse group of pollinators, comprise more than twenty five thousand bee species belonging to order Hymenoptera (Kevan and Phillips, 2001). Abundance and diversity of insect pollinators is beneficial to the yield of numerous crops and fruits and about one third of human food depends on insect pollination (Kremen et al., 2002; McGregor, 1976). Hymenoptera, Diptera and Lepidoptera are dominant group of insect pollinators with the highest abundance in Lower Northern Pakistan and in Indian Kashmir (Avdhesh and Alexander, 1998).

Bees include a variety of hymenopterans insects, major groups includs Apis and non-Apis bees, which are important for crop pollination (Gardner and Ascher, 2006). Bumblebees are major Hymenopteran pollinators with excellent speed of pollination and buzzing to explode the pollen sacs, having the ability to forage at low temperature and in harsh conditions (Heinrich, 1979). Bumblebees are among the most efficient bee pollinators in wild and managed crops with more than 250 known species worldwide mostly from Northern hemisphere (Paul, 1991).

Northern Pakistan has very distinctive and rich fauna and flora especially the bumblebees that help in ecosystem conservation (Barbattini, 1994; Pittoni, 1939). Major work done on bumblebees dates back to early twentieth century and needs more diverse studies about relationship of bumblebees with flora of this area. Some plants are pollinated only by the single species of bumblebees (Rathcke and Jules, 1993). From Northern Pakistan thirteen *Bombus* species has been observed during pollination activities both in agricultural and non-agricultural lands. These four most dominant species are

B. asiaticus, *B. avinoviellus*, *B. biroi* and *B. haemorrhoidalis* and were found most efficient pollinators of this area (Sabir et al., 2008; Suhai et al., 2009).

Local bumblebee (*B. haemorrhoidalis* Smith) species belongs to Himalayan and South East Asian countries (Paul, 1991) and also reported from Pakistan (Richards, 1929). In India, it has been recorded as sole pollinator of large cardamom and other crops (Deka et al., 2011). This species is dominant in five agricultural habitat of northern Pakistan (Sabir et al., 2008) and is the sole species of lower northern Pakistan including, Rawalpindi, Islamabad and Murree hills ranging from 542-1986 m altitude which pollinate twenty four plant species of thirteen plant families in wild and managed crops in this region (Sheikh et al., 2014). Keeping in view the importance of bumblebee, this study was designed to calculate the abundance of *Bombus haemorrhoidalis* and diversity of common pollinators in this area.

MATERIALS AND METHODS

The relative abundance and diversity of indigenous bumblebee, *Bombus haemorrhoidalis* Smith in comparison with common insect pollinators utilizing similar floral hosts were monitored from two different topographical areas of Northern Pakistan during two consecutive years of 2012 and 2013. These locations were further divided into sub-locations according to topography, vegetation, altitude and latitude.

Study areas

Two different areas from Northern Pakistan including Rawalpindi-Islamabad and Naran Kaghan valley were chosen based on different flora, topography, altitude, latitude and environmental conditions. Longitude, altitude and latitude were measured with Garmin e-trex 10 GPS device (Table 1).

Table 1. Global positions of study locations and sub-locations.

Locations	Sub-Locations	Altitude	Global positioning
Rawalpindi/Islamabad	Lake View Park	542 m	33° 43′ 05.16″ N 73° 08′ 00.22″ E
	F-9 Park	564 m	33° 42′ 35.01″ N 73° 01′ 21.72″ E
	Bara-Kahu	679 m	33° 45′ 14..57″ N 73° 11′ 19.72″ E
Naran Kaghan Valley	Mahandri	1673 m	34° 41′ 40.56″ N 73° 34′ 27.09″ E
	Kaghan	2095 m	34° 46′ 40.81″ N 73° 31′ 31.80″ E
	Naran	2772 m	34° 55′ 25.86″ N 73° 46′ 00.99″ E

Rawalpindi and Islamabad are located in the range of Margalla hills with sub-humid to subtropical climate and rainfall is received from both monsoon and western climatic turbulence (Fatimah and Ahmad, 2012). Naran Kaghan valley is located in district Mansehra, Khyber Pakhtunkhwa province and entire area is formed by high spurs of mountains along both side of the river Kunhar flowing in North-East to South-West direction (Khan et al., 2009).

Rawalpindi/Islamabad and Naran Kaghan Valley were further classified into three sub-locations. Rawalpindi/Islamabad included Lake View Park, F9 Park and Bara Kahu areas while Naran Kaghan Valley included Mahandari, Kaghan and Naran areas.

Relative Abundance of Indigenous Bumblebee, *Bombus haemorrhoidalis* Smith In Comparison With Other Insect Pollinators and their Diversity Indices

Relative abundance of indigenous bumblebee, *B. haemorrhoidalis* in comparison of other common insect pollinators was measured on monthly basis during the field monitoring surveys at all sub-locations of Rawalpindi/Islamabad and Naran Kaghan Valley. Numbers of individuals of *B. haemorrhoidalis* with other common pollinator species were recorded at 9 to 11am in the morning and afternoon during 2-5pm (any reference for their peak activity at these times or of insect pollinators). Monthly abundance of indigenous bumblebee was measured to determine the population variation throughout the year. Diversity of each sub-location was calculated by using three species diversity indices and for each year was also

determined and compared. These indices were calculated to compare the diversity of different locations and sub-locations.

1. The formula given by Margalef (1958) was used to calculate Shannon species diversity index (H) based on Shannon-Wiener function as:

$H = \Sigma Pi (lnPi)$

Where $Pi = Ni/N$

Ni = Total number of individuals in a species

N = Total number of individuals in all species

2. Evenness (j) was calculated to estimate the equitability component of diversity using the formula (Pielou, 1975):

$J = H/log10S$

Where H= Shannon species diversity index

S = total number of species

3. The following formula was used to calculate the Simpson's index of diversity:

$D = \sum (n / N)^2$

Where N= Total number of individuals of all species

n= Number of individuals of a species

RESULTS

Pollinators Species Composition Belonging to Different Insect Orders during Two Years (2012 and 2013)

In both years (2012 and 2013), Hymenopterans were recorded with maximum (53%) population of insect pollinators followed by Diptera (30%) and Lepidoptera with (17%) populations, respectively (Figure1).

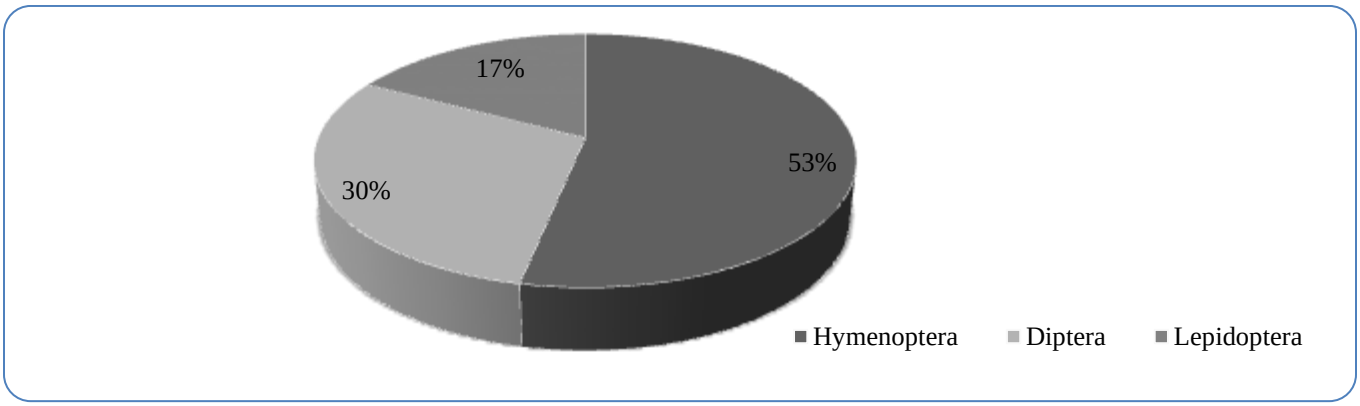

Figure 1. Species composition of pollinators belonging to different insect orders from all study locations during two years (2012 and 2013).

Relative abundance of *Bombus haemorrhoidalis* Smith in comparison with other insect pollinators at sub-locations of Rawalpindi/Islamabad

The most abundant pollinator was *B. haemorrhoidalis* (20.29, 18.65 and 19.92%) followed by *Syrphus* sp. (16.71, 17.47 and 13.58%) at Lake View Park, F9 Park and Bara-Kahu, respectively. *A. cingulata* was (0.98, 0.93 and 0.72%) minimum at Lake View Park, F9 Park and Bara-Kahu, respectively. At Lake View Park, relative abundance of four insect pollinators including *Papilio demoleus*, *A. cerana*, *L. sericata* and *A. dorsata* ranged between 6.33 to 13.71% while other seven pollinators not exceeded of 6.11%. At F9 Park, relative abundance of seven pollinators, *P. demoleus*, *Pieris brassicae*, *Danaus plexippus*, *V. orientalis*, *Xylocopa* sp., *A. cerana* and *L. sericata* ranged between 5.28 to12.29% but other three not exceeded from 4.31%. At Bara-Kahu, five pollinators including *A. cerana*, *A. dorsata*, *V. orientalis*, *Syrphus* sp. and *L. sericata* ranged between 7.85-13.89% while other five were less than 6.63% (Table 2).

Relative abundance of *Bombus haemorrhoidalis* Smith in comparison with other insect pollinators at sub-locations of Naran Kaghan Valley

At Mahandari, *B. haemorrhoidalis* was the highest (26.87%) in relative abundance followed by *Syrphus* sp. (16.52%) which shows almost same pattern as for Rawalpindi/Islamabad locations observed. Relative abundance of other pollinators i.e., *X.* sp., *A. cerana*, *A. dorsata* and *L. sericata* ranged from 5.14-11.24%. Other seven pollinators at sub-location not exceeded more than 4.80% and minimum abundant pollinator was *A. cingulata* (1.31%). *B. haemorrhoidalis* was again the most abundant (28.22%) pollinator at Kaghan followed by *Syrphus* sp. (15.47%). Relative abundance of other pollinators at Kaghan was less than 11.37% and *H. fuciformis* was the least abundant. At Naran, relative abundance of four pollinators, *Xylocopa* sp., *A. cerana*, *A. cingulata* and *A. dorsata* ranged between 5.15-11.20%. Abundance of other seven pollinators was less than 4.51%. *B. haemorrhoidalis*

(28.85%) remained the highest abundant pollinator followed by *Syrphus* sp. (15.07%) (Table 2).

Comparison of diversity indices of Rawalpindi/Islamabad, Rawalakot and Naran Kaghan Valley in the year 2012 and 2013

From Naran Kaghan Valley in 2012, maximum Shannon and Evenness indices (1.311 and 1.117) were observed followed by Rawalpindi/Islamabad with Shannon index (0.911). In case of Simpson index, Rawalpindi/Islamabad area was richer in diversity (0.885) than that of Naran (0.876) (Table 3). In 2013, Naran Kaghan Valley was again found with highest Shannon and Evenness indices (0.988 and 0.890) followed by Rawalpindi/Islamabad with (0.966 and 0.840). In case of Simpson index, maximum index was found at Rawalpindi/Islamabad (0.910) followed by Naran Kaghan Valley (0.855) (Table 3).

Table 2. Relative abundance of *Bombus haemorrhoidalis* Smith in comparison with other pollinators in different locations of Rawalpindi/Islamabad and Naran Kaghan.

Pollinator Species (insect order)	Rawalpindi/ Islamabad			Naran Kaghan		
	Lake View	F9 Park	Bara-Kahu	Mahandari	Kaghan	Naran
	Relative abundance	Relative abundance	Relative abundance	Relative abundance	Relative abundance	Relative abundance
Bombus haemorrhoidalis (Hymenoptera)	20.29	18.65	19.92	26.87	28.22	28.85
Apis dorsata (Hymenoptera)	13.71	4.31	12.62	11.15	11.37	11.20
Apis cerana (Hymenoptera)	9.81	10.96	7.85	8.38	7.48	7.47
Xylocopa spp (Hymenoptera)	6.11	8.10	6.63	5.41	5.34	5.15
Amegilla cingulata (Hymenoptera)	0.98	0.93	0.72	1.31	1.43	1.52
Vespa orientalis (Hymenoptera)	4.15	6.67	8.00	4.47	4.86	4.91
Syrphus spp (Diptera)	16.71	17.47	13.58	16.52	15.47	15.07
Lucilia sericata (Diptera)	10.32	12.29	13.89	11.24	11.02	10.77
Danaus spp (Lepidoptera)	3.57	5.92	4.95	3.78	3.72	3.62
Pieris brassicae (Lepidoptera)	3.62	5.28	4.20	3.18	2.39	3.08
Papilio demoleus (Lepidoptera)	6.33	5.45	3.61	4.80	4.69	4.51
Phobis trite (Lepidoptera)	2.043	2.23	2.73	1.44	2.02	2.08
Hemaris fuciformis (Lepidoptera)	1.29	1.66	1.24	1.39	1.39	1.62

Table 3. Comparison of diversity indices of Rawalpindi/Islamabad, Rawalakot and Naran Kaghan Valley during the year 2012 and 2013.

Locations	Shannon Index		Simpson Index		Evenness	
	2012	2013	2012	2013	2012	2013
Rawalpindi/Islamabad	1.00	0.966	0.885	0.910	0.903	0.840
Naran Kaghan Valley	1.31	0.988	0.876	0.855	1.117	0.890

Overall comparison of diversity indices of different locations of Rawalpindi/Islamabad and Naran Kaghan Valley during the years 2012 and 2013

Comparison of indices for both years (2012 and 2013) for both Naran and F9 Park were the highest for Shannon index (1.03 and 1.00) with maximum Simpson and Evenness indices found at Naran. Mahandari area of Naran Kaghan Valley was recorded with the least (0.956, .0855 and .0858) Shannon, Simpson and Evenness indices for both years (2012 and 2013). All other localities were found with insignificant variations for all three indices (Table. 4).

Table 4. Overall Comparison of diversity indices of sub-locations locations of Rawalpindi/Islamabad, Rawalakot and Naran Kaghan Valley during 2012-2013.

Location	Sub-location	Shannon Index	Simpson Index	Evenness
	Lake View Park	0.987	0.877	0.886
Rawalpindi/Islamabad	F9 Park	1.00	0.884	0.903
	Bara-Kahu	0.999	0.883	0.897
	Mahandari	0.956	0.858	0.858
Naran Kaghan Valley	Kaghan	0.956	0.855	0.858
	Naran	1.03	0.893	0.959

DISCUSSION

Insect pollinators are known as key players as floral main pollinators sources in nature. Among these insects, some species have been used as crop pollinators in commercial economic crops to boost increase in their yield. Bumblebees are important pollinator of crops like tomato, cucumber, pepper, strawberries etc. in both managed and open fields (Heinrich, 1979).

Present study supports Hymenoptera to be the most abundant insect pollinators order including six insect pollinating species present in natural habitats in present study. Lepidoptera with five and Diptera with two insect pollinator species at all locations of Rawalpindi/Islamabad and Naran Kaghan valley were also important. Hymenopteran insect pollinators have been observed as the major pollinator group followed by Lepidoptera and Diptera in Rawalakot, Azad Jammu and Kashmir previously (Sheikh et al., 2015). Indian Kashmir region had also found Hymenoptera to be the most abundant pollinators group with nine species (Sharma and Abrol, 2005) and Himachel Himalaya with Hymenoptera followed by Diptera, Lepidoptera and Coleoptera (Raj and Mattu, 2014).

In present study, we found *B. haemorrhoidalis* the most abundant insect pollinator at all locations of Rawalpindi/ Islamabad and Naran Kaghan valley. This status of *B. haemorrhoidalis* was also observed in Lower Northern Pakistan (Sheikh et al., 2014). In case of Rawalakot, this bumblebee species was also found as major pollinator in wild condition in comparison with other common pollinators (Sheikh et al., 2015). In central Himalayas of India, *B. haemorrhoidalis* was found most abundant and only *Bombus* pollinator throughout the Himalayas at different altitudes. It was also recorded only Bombus pollinator in large caradomom (Sinu et al., 2011).

Results about diversity of pollinator shows that highest Shannon index, Simpson and Evenness indices were recorded from Naran and F9 Park. These results may be due to diverse and vast wild floral range in Naran which consist high altitudes area with condense vegetation pattern having favorable weather conditions for pollinators. High diversity of insect pollinators in F9 Park due to managed ornamental flowers with divers range having full attractions for pollinators. Overall Naran Kaghan valley was found with maximum pollinator's diversity because this area is full of wild vegetation's with vast floral range. This area also has favorable habitats for pollinators with good ideal weather conditions.

AUTHORS' CONTRIBUTIONS

All authors contribute equally for collection, conducting experiment, data collection and analyses in this manuscript.

CONFLICT OF INTEREST

The authors have no conflicts of interest to declare. All co-authors have seen and agree with the contents of the manuscript and there is no financial interest to report.

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