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Distribution of Bumblebee, *Bombus haemorrhoidalis* Smith, and its Association with Flora in Lower Northern Pakistan

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Abstract.- Prevalence and floral host plant range of indigenous *Bombus* pollinators are considered to be important alternatives than the imported species. Commercial enclosed farming has increased the use of the bumblebees as economically important pollinators for high economic return and offseason crops. Indigenous bumblebee species has been considered important to rear and use for such pollination services than imported bumblebees to avoid possible environmental and pest problems. *Bombus haemorrhoidalis* Smith, the only bumblebee species of this region, was collected at monthly interval from different non-agricultural and agricultural flora of Margalla and Murree hills of Pakistan during 2011-12. Plant species for floral host plant resources, variation in seasonal population and distribution with different climatic regions of this indigenous bumblebee were observed. Twenty four plant species of thirteen plant families were found as floral host plants visited for nectar and pollens with seven new localities ranging from 542-1986 m altitude. The most commonly visited plant family was Asteraceae. Reproductive stages including males and daughter queens were observed from October to December. Prevalence of queen, workers and males differ from parks to forests with altitude. Workers were observed active in early and late day hours to avoid harsh climate of June to August. Present study provides the possible available floral host plants, variation in its availability of different life stages and possible distribution for future utilization in possible alternate pollinator rearing programs. It also focuses on the ecological and biological interaction of the only bumblebee pollinators of this agro-ecological zone of Pakistan.

Key words: Indigenous bumblebee, *Bombus haemorrhoidalis*¸floral plants, distribution, Northern Pakistan.

INTRODUCTION

Bumblebees are important pollinators belonging to insect order Hymenoptera. High speed of pollination, vibration to burst the pollen sacs and efficiency to forage at low temperature and light makes them the most reliable and efficient pollinators (Heinrich, 1979; Abrol, 2012). Increased world human population stresses the use of such crop pollinators especially for commercial crops grown under intensive cultivation (Griffiths and Robberts, 1996). Crops like tomato, pepper, cucumber, strawberries etc under plastic tunnel and systematic hydroponics farms need such pollinators to get low cost constituents (Abak *et al*., 1997; Kwon and Saeed, 2003). Pollination by these important contributors help in better fruit production, weight, size and other chemical characters to get cost effective production (Klein *et al*., 2007; Aizen *et al*., 2008).

Different *Bombus* species like *Bombus terrestris*, *B. impatiens*, *B. occidentalis* and some others have been utilized for commercial pollination of different crops worldwide (Kwon and Saeed, 2003; Velthuis and van Doorn, 2006; Klein *et al*., 2007). These species are quite costly to import and hinder their use for crops pollination (Asada and Ono, 2000; Velthuis and van Doorn, 2006). They also results in different problems like competing with local species of pollinators especially *Bombus* for food, nest sites and other resources (Couvillon *et al*., 2010). Possible replacement of the local species with the introduced ones may result in changes in flora visited by the indigenous species. These changes due to accidental release or escape of introduced *Bombus* species in local environment has been observed in different parts of the world (Stout and Goulson, 2000). These escaped individuals can

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Table I.- Collection locations in Margalla and Murree Hills of Pakistan.

Location	Altitude a.s.l.	Global positioning	Major vegetation type
Lake view Park	542 m	33° 43' 05.16 N 73° 08' 00.22 E	Ornamental plants and weeds
Pir Sohawa	1146 m	33 45 35.62 N 73 04 10.03 E	Dense forest
Sunny bank Apple Research Station	1986 m	33 55 01.53 N 73 23 32.82 E	Apple orchard, weeds, ornamentals
Shahdra	679 m	33 46 38.11 N 73 10 17.58 E	Dense forest
Daman-e-koh	726 m	33 44 20.66 N 73 03 23.70 E	Ornamentals, weeds and dense forest
F-9 park	564 m	33 42 35.01 N 73 01 21.72 E	Ornamental plants and weeds
Murree forest	1454 m	33 54 31.35 N 73 21 06.76 E	Dense forest and weeds

Source: Google Earth® online

also transfer their diseases and pests which might be new to our environment (Whittington and Winston, 2003).

Thirteen *Bombus* species from northern Pakistan has been observed under agricultural and non-agricultural areas with four most dominant species including *B. asiaticus, B. avinoviellus, B. biroi* and *B. haemorrhoidalis* (Suhail *et al.*, 2009; Makhdoom, 2011). Presence of local indigenous *Bombus* species in Margalla and Murree hills for their natural occurrence, host range and distribution under different plant situations were planned to see if there is some alternate indigenous species to get utilized. This was attempted to find the possible and easily available *Bombus* species for crop pollination, which are most acclimatized to our environments.

MATERIALS AND METHODS

Host range, new localities and spatial and temporal distribution of bumblebees were conducted in Margalla and Murree hills of northern Pakistan during 2011-12 on monthly basis. Bumblebees were observed from different natural habitats including parks, mountains and rangelands of seven different locations. These bumblebees were collected with the help of Entomological net and identified as worker, male or queen on the basis of their morphological characters (Dafni, 1992). Their numbers visiting in different parts of survey time and locations were made. Altitude and latitude details were identified using Google Earth for their possible floral host plants and host range. Samples of these bumblebees and flowering plants visited were kept for identification at species level (Malik and Farooq, 1984; Williams, 1991).

Bumblebees were collected during early morning to early evening hours by walking transect method. Monthly observations from the selected locations were made throughout the year and differences in their sexual and foraging worker bees

Taxonomic characteristics have been given for clear elaboration of indigenous bumblebee species. Interaction of bumblebees and flowering plants visited were estimated. Plant species has been classified on the basis of minor, medium and major pollinating hosts for future easy collection of the studied bumblebees on the basis of their visitation rate by these bees. Location based variation of different stages as worker, male and queen observations helped to develop their possible life cycle under field conditions and elaborated as graphs for all the locations under observation.

RESULTS

Collected bumblebees showed diverse range of its collection sites with diverse environments and climatic regions providing the successful establishment and survival in the nature (Table I). It

was observed from 540 to 2000 meters altitude in managed and natural mountainous landscapes. Their foraging plants mainly included weeds, ornamental, dense forest trees and some cultivated crops (Table I).

The bumblebees were collected from seven different locations throughout the year on monthly basis (Fig. 1). Hibernated queens started emerging in March to April with most prominent collection observed from the lake view surrounding. Early workers were observed in April and most commonly in May which started increasing and reached at peak during July to September (Fig. 1). Workers were observed foraging actively in early and late day hours to avoid harsh climate of June to August and reproductive stages including males and daughter queens were observed from October to December. Daughter queens were the most difficult to capture due to their high altitude flight patterns (Fig. 1).

Bumblebee populations were observed foraging for nectar and pollen more prominently in open managed parks than natural forest areas at Daman-e-koh, Pir Sohawa, Shahdra, and Murree forest areas. They were more in numbers at managed park of lake view and its surroundings where *Lantana camara* is the most common weed flowering from March to November and other wild plants species (Fig. 1).

Twenty four plant species belonging to thirteen different plant families were observed as host plants in seven new localities ranging from 540-2000 m altitude (Table II). The families of plants visited for nectar and pollens belonged to Asteraceae, Cisteraceae, Cucurbitaceae, Ebenaceae, Fabaceae, Iridaceae, Lamiaceae, Malvaceae, Myrtaceae, Plantaginaceae, Rosaceae, Solanaceae and Verbenaceae. The most commonly visited plants included *Zinnia* sp., *Gladiolus* sp. and *Lantana camara* belonging to the families Asteraceae, Iridaceae and Verbenaceae, respectively (Table II). *Lantana* (wild type spanish flag) was the most commonly observed weed in all the locations and even used as ornamental plant in some of the parks under observation. The least number of bees were observed in Margalla hills which might be due to the intensive presence of forest trees and little flowering vegetation to forage by these bees. Wild daisy (*Bellis perennis*) was observed to be the most common wild flowering plant present on Murree foothills with common visitation of the observed bumblebee species. From cultivated plant species, sunflower, cucumber and muskmelon were also the source of their visitation for nectar as well as pollens whereas amaltas (golden shower tree) was the common wild tree with medium level of the bumblebee visitation. However, it was difficult to collect the bees due to their flowering at inaccessible height.

B. haemorrhoidalis can be distinguished from other species by having thoracic pubescence black; large individuals (queen: 33±2mm; male: 25±1.6mm and worker: 20±4.4mm) with large wings (33±0.7mm queen; 25±1.3mm male and 20±3.2mm workers); forewing 2.2 times longer than wider in queen and 3 times in male and workers. Terga1-2 was bright yellow and 3-5 orange red with workers similar in coloration but quite smaller in size and thinner than queens. Male with pale fulvous red pubescence and has sooty-black pubescence mixed with pale hairs on the legs. Antennal segment 3 was 1.5 times the length of segment 4.

DISCUSSION

Different bee species play vital role in pollination and survival of plant species in nature. Some species have been used for crops pollination and increase in yields to meet their food requirements for humans and the economic value of the crops. Bumblebees are used under enclosed farming of crops especially vegetables and fruits. Their natural population depends on plant species composition, flowering patterns and abundance.

The lowest altitude where these bumblebees were observed is around 540 m altitude which is from the parks of Rawalpindi area. However, another species, *B. terrestris* widely used in commercial crop pollination has been observed from zero altitude in the east Mediterranean region showing their diverse climatic adaptations (Gurel *et al*., 2008). Their absence in our areas below this level might be due to the harsh summer in the subtropical environment and in the range observed might be due to their mountainous region with harsh winter months to meet their hibernation needs. This represents to be their

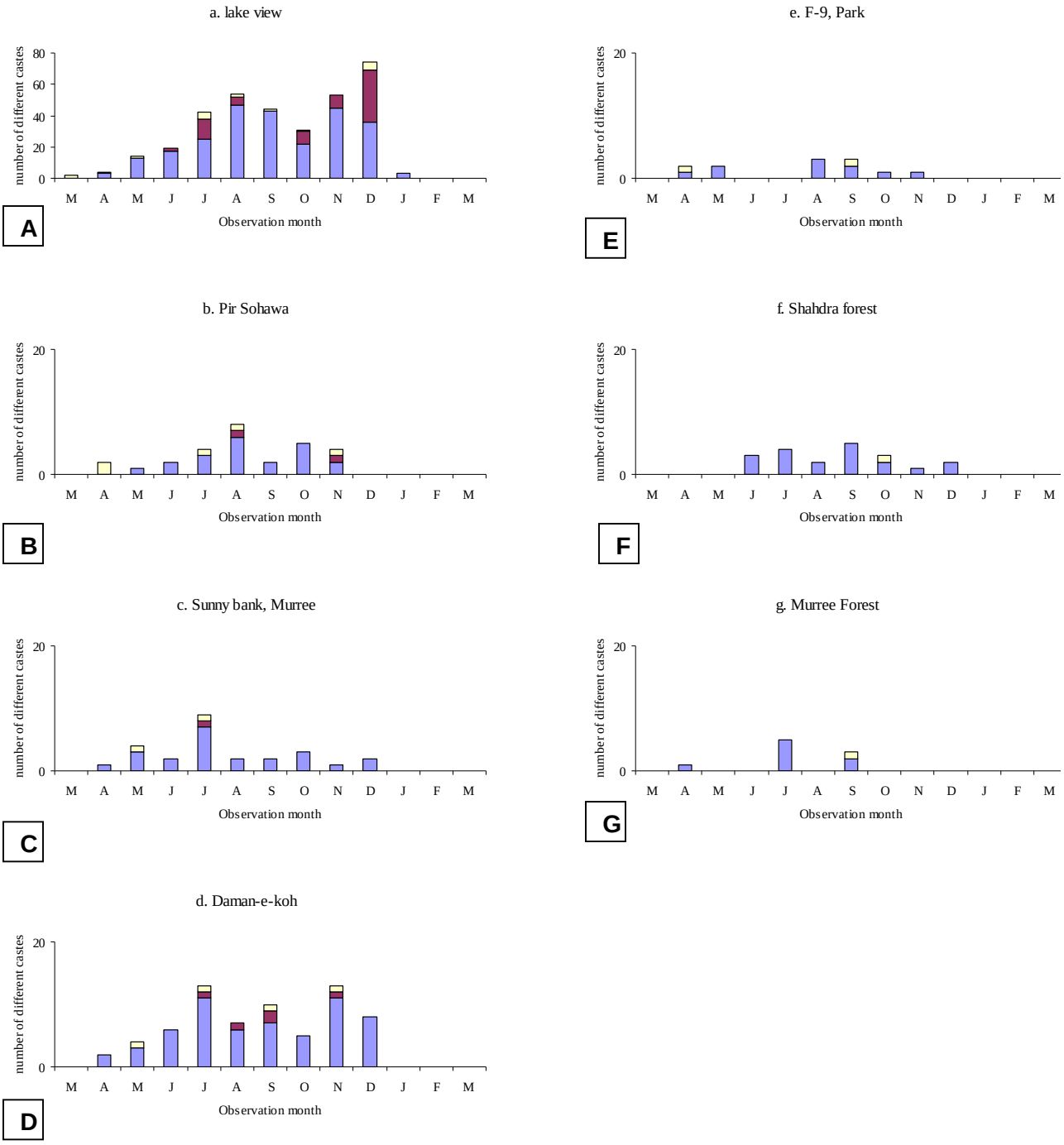

Fig. 1. Seasonal biological variation of local bumblbee, *Bombus haemorrhoidalis* Smith workers, males and queens under different landscapes for the year 2011-12 (the bar with three divisions shows queens, males and workers from top to bottom.

specific needs of certain temperature range and other climatic parameters. Another species *B. atratus* from Java, however, has been reported throughout the year with presence of reproductives (Michener and Amir, 1977). Their numbers were more in rainy climate rather than dry, however, their

Table II.- Plant species visited by *Bombus haemorrhoidalis* form Margalla and Murree hills, Pakistan throughout the year 2011-12.

Family	Plants	Scientific name	Status*	Flowering time	Location
Asteraceae	Zinnia	*Zinnia sp*	Major	Jul-Aug	Murree, F-9 Park
Asteraceae	Wild daisy	*Bellis perennis*	Medium	Mar-Oct	Murree
Asteraceae	Lesser knapweed	*Centaurea nigra*	Minor	Jul-Aug	Murree, Pir Sohawa
Asteraceae	Centaurea blue	*Centaurea cyanus*	Minor	Jul-Aug	Margalla
Asteraceae	Sunflower	*Helianthus annuus*	Medium	Apr-May	Rawalpindi, AAUR
Asteraceae	Blue Thistle	*Carduus sp*	Minor	Jun-Sep	Rawalpindi, Pir Sohawa
Cisteraceae	Rock rose	*Cistaceae sp*	Minor	Jul-Aug	Islamabad, Murree
Cucurbitaceae	Cucumber	*Cucumis sativus*	Medium	Jul-Aug	Rawalpindi, Murree
Cucurbitaceae	Musk melon	*Cucurbita pepo*	Medium	Jul-Aug	Rawalpindi, Murree
Ebenaceae	Persimmon	*Diospyros kaki*	Minor	Mar-Apr	Murree
Fabaceae	Kachnar	*Bauhinia variegate*	Minor	Mar-Apr	Margalla, AAUR
Fabaceae	Amaltas	*Cassia fistula*	Medium	Jul-Aug	Rawalpindi, Margalla
Fabaceae	Lupin flower	*Lupinus sp*	Minor	Jul-Aug	Murree
Iridaceae	Gladiolus	*Gladiolus sp.*	Major	Jul-Aug	Murree, F-9 Park
Lamiaceae	Sage	*Salvia officinalis*	Minor	Jul-Aug	Pir Sohawa, Murree
Lamiaceae	Dead-nettle white	*Lamium sp*	Minor	Jul-Aug	Margalla hills
Malvaceae	Okra	*Abelmoschus esculentus*	Minor	Mar-Jun	Rawalpindi, AAUR
Malvaceae	Hollyhock	*Alcea rosea*	Minor	Jul-Aug	Murree, Pir Sohawa
Myrtaceae	Guava	*Psidium guajava*	Minor	Mar-Apr	Rawalpindi
Plantaginaceae	Fox glove pink	*Digitalis sp*	Minor	Jul-Aug	Murree
Rosaceae	Apple	*Malus domestica*	Minor	Mar-Apr	Murree
Solanaceae	Tomato	*Solanum lycopersicum*	Minor	Mar-Jun	Rawalpindi, AAUR
Solanaceae	Brinjal	*Solanum melongena*	Minor	Mar-Jun	Rawalpindi, AAUR
Verbenaceae	Lantana	*Lantana camara*	Major	Mar-Dec	Margalla

AAUR, Arid Agriculture University Rawalpindi Campus.
*Major, medium and minor host classified on the basis of bumblebee visitation rate.

greater numbers was also observed to be due to favorable environmental conditions for their collection. Present studies, however, were performed on monthly basis and such possibility can be excluded for its collection and observation in the specified region under study.

These bumblebees have established an interaction with their wild host plants for centuries to meet their pollen and nectar needs. Previously no work has shown the foraging range of this bumblebee species. Presence of perennials and annual plants throughout the observation range showed their preference of different plant species belonging to different families. However, perennials showed higher preference due to their ability to produce more nectar and pollens based on their longer growth periods (Fussel and Corbet, 1992). Flower morphology, color and scent are important in cues to meet their pollen and nectar needs by the bees (Stone *et al*., 2003; Cnaani *et al*., 2006). Choice of flowers as minor, medium or major source of visitation by these bumblebees might be due to variation of sucrose concentration to decrease their foraging time with maximum reward (Cnaani *et al*., 2006). The collection of the food resources has been considered as important factor for their survival and fecundity (Raine *et al*., 2006). Honeybees and bumblebees keep the record of suitable host plants for food reserves and develop interactive responses with their quick learning abilities (Ali *et al*., 2014). Body size of the foraging bumblebees been observed as important factor in foraging competitiveness yet *B. haemorrhoidalis* workers showed non-significant size variation but longer beak size than *B. terrestris* workers (Ings *et al*., 2005). Pollen collected by bumblebees can also help to identify the food supply for these important pollinators. Teper (2006) Identified the foraging plants of *B. terrestris* by pollen analysis from the bumblebee feces showed 56 pollen grains types from 28 plant families with most of the pollens collected from the entomophilous plants (Teper,

2006). Previously observed 29 pollen sources comprised a diverse source for this protein necessary to build the cells, breed their young ones and use as a food (Teper, 2004). Such a long floral host range provides suitable development of interactions for long term survival for the bumblebee pollinators. Food, nest sites and other resources may be shared or competed with exotic *Bombus* species imported for pollination as observed previously in different parts of the world (Couvillon *et al*., 2010; Stout and Goulson, 2000; Whittington and Winston, 2003).

Biological cycle of *B. haemorrhoidalis* showed a single generation per year (Fig. 1), however, it lasted longer than *B. terrestris* observed previously where diapause period was longer than for the observed species lasting no longer than three months (personal observations). They also observed one generation per year in the coastal Mediterranean region. Different environmental factors including temperature, moisture, photoperiod and availability of food are also very important limiting factors for their normal colony development. Variation in temperature may also hinder their foraging potential when used for crop pollination (Kwon and Saeed, 2003). Under natural field conditions, these factors not only activate diapause but also help to wake up and initiate the colony which must be synchronized with flowering plant species (Wuellner, 1999; Danks, 2007). Decrease in rainfall can also be an important factor for plant development and flower phenology ultimately affecting the visiting insect pollinators (Ogaya and Penuelas, 2007) and it was mainly responsible to break the aestivation in bumblebee queens (Rasmont *et al*., 2005).

Present studies highlighted the importance of this only bumblebee species of this region observed at different altitudes and habitats. Its seasonal distribution in different locations with different flora showed diverse floral host range for collection of nectar and pollens. It has established interaction with certain plant species as a major source of pollination. There existed quite variable population trends of the three castes of this species at the seven locations with maximum population at Lake View Park and Daman-e-koh. Further detailed studies focusing the floral needs, nesting behavior and laboratory rearing conditions are desired for this species to serve under controlled farming systems and benefit the cultivated plant species of economic value.

CONCLUSIONS

Bombus haemorrhoidalis Smith visitation was observed on twenty four plants with diverse plant families as floral resources. These floral plants were the main source for provision of nectar and pollens present in wild and managed parks. The range of the only observed species, *B. haemorrhoidalis* was quite diverse and the most commonly visited plants belonged to family Asteraceae. However, plants with longer available floral resources were visited more than short season flowering. Sexual including daughter queens and males were more in fall during October to November after which the mated queen burrow the soil and diapause to avoid harsh winter months. Prevalence of queen, workers and males differ from parks to forests with altitude and floral composition.

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