www.biodicon.com Biological Diversity and Conservation

ISSN 1308-5301 Print; ISSN 1308-8084 Online BioDiCon 2/1 (2009) 1-9

Geographic distributional patterns of the genus *Bombus* (Bombini, Apidae: Hymenoptera) in northern Pakistan

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Abstract

The distributional patterns of the species of genus *Bombus* were analyzed by using cluster analysis which grouped the sites into three main geographical groups. Cluster 1 comprised of two sites i.e., Samgam and Doarian as these sites were located in the same ecological region i.e., Himalayan moist temperate forest. Cluster 2 consists of Sermik and Rama showing similar patterns of occurrence as dry temperate coniferous and steppic forest adjoin with alpine dry steppe regions while cluster 3 represented by four sites which was further divided into two sub groups viz., Naltar, Gilgit and Darkot, Hunza. Naltar and Gilgit both located in steppic forest and alpine dry steppe. Similarly sub group Darkot, Hunza belong to same ecological region i.e., alpine meadows and sub- alpine scrub. A total of 13 species of genus *Bombus* were grouped in to three clusters. Cluster 1 was represented by species (*B. (Sibricobombus) asiatics* Morawitz, *B. (Bombus) tunicatus* Smith, *B. (Pyrobombus) subtypicus* Skorikov and *B. (Subterraneobombus) melanurus* Lepletier). These species were more or less evenly distributed in sampling sites and have wide ecological amplitude. *B. (Pyrobombus) biroi* Vogt, *B. (Bombus) lucorum* Linnaeus, *B. (Melanobombus) semenovianus* Skorikov and *B. (Mendacibombus) marussinus* Skorikov formed cluster 2. These species are less evenly distributed while cluster 3 was consisted of five species viz., *B. (Melanobombus) rufofasciatus* Smith, *B. (Alpigenobombus) kashmirensis* Friese, *B. (Orientalibombus) haemmorrhoidalis* Smith, *B. (Mendacibombus) himalayanus* Skorikov and *B. (Mendacibombus) avinoviellus* Skorikov. These species are moderately distributed in the sampling areas with narrow ecological range as compared to cluster 1. These patterns reflect the complex geographic history of the fauna in the region.

Key words: Cluster analysis, Distributional patterns, Genus *Bombus*, Geography, Northern Pakistan

1. Introduction

The Northern Pakistan covers overall Northern Areas (NA), Azad Jammu & Kashmir (AJK), the upper region of North West Frontier Province (NWFP) including Chitral and some parts of the central and northern regions of Pakistan and is endowed with a great variety of flora and fauna owing to its diverse array of altitude, rainfall and climate. It is among the regions where the earth's biological wealth is most distinctive and rich (Malcolm et al., 2002). Three famous mountain ranges viz., Himalayas, the Karakorum and the Hindukush which are one of the largest mountainous regions of the world extends over an area of 132700 km^2 and lies between 34^o 0′ to 36^{o}50′ N and 71^o 12′ to 75^{o}0′ E (Hashmi and Shafiullah, 2003) give rise to a unique blend of habitats and biological communities (Sheikh, 2000). This region represents one of the world's biologically richest ecosystems. This is due to the extreme altitudinal differences and associated flora and fauna and nowhere in the world can such diversity be seen as in this region (Anonymous, 1993).

Pollinators play a pivotal role in flowering plant reproduction and fruit set for agricultural and wild plant communities (Buchmann and Nabhan, 1996; Accorti, 2000) and bumblebees provide a vital ecological service in this regard (Sabir et al., 2007). In recent years many bumblebee (Bombus) species have shown serious declines in

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abundance and marked contractions in many parts of the world (Rasmont, 1995; Buchmann and Nabhan, 1996; Westrich, 1996; Kevan and Phillips, 2001). There has been growing concern about the decline of natural populations of several bumblebee species in many parts of the world and many researchers think that their populations are exposed to strong unfavourable pressure because of human activities (Osborne et al., 1991). This decline may culminate in the local extinction of species which has already been recorded in various parts of the world (Rasmont, 1995; Kevan and Phillips, 2001). As the most distinctive and rich faunal and floral wealth of earth is in northern Pakistan so there is dire need to study its fauna particularly the key groups like bumblebees which play a pivotal role in conservation of ecosystems (Corbet et al., 1991; Banaszak, 1992; Barbattini, 1994; Porrini, 1999). The plight of our bumblebee fauna deserves particular attention because their loss will have negative consequences for different habitats. Owing to already scarce information, knowing bumblebees is thus extremely important to improve the pollination of our cultivated crops, to restore native plants (Sabir et al., 2008) and to evaluate the degree of deterioration of certain areas. So the main aim of this study is to investigate the geographical patterns of bumblebees in northern Pakistan.

2. Materials and methods

The studies on geographical distribution of bumblebees were conducted in the northern Pakistan, during two consecutive years 2006 and 2007. Bumblebees were searched for and caught when they landed on or right after leaving the flowers with entomological handnet despite other methods of sampling (Dafni, 1992) not only because it is an easy handling method but it also allows assessing the frequency of specific flowers visited (Quaranta et al., 2004). The data were collected on the basis of altitudinal succession of forage plants and their associated bumblebees. The bumblebees were identified up to the species level by following Williams, 1991 while the plant material (flowers) etc., was identified with the help of available literature (Stewart, 1982 and Malik and Farooq, 1984) and "Flora of Pakistan" (series 1- 204) edited by S. I. Ali and E. Nasir.

Cluster analysis (CA) was used for grouping of data set on the basis of spatial similarities (Kent and Coker, 1992; Angeler et al., 2007; Sánchez-Carrillo et al., 2007 and Qadir et al., 2008). The distributional data set was subjected to CA to identify clusters of the sampling sites indicating their similarity based on geographical similarities in the study area. CA was performed on the presence/ absence data of bumblebees studied at different sampling sites over the whole period. Euclidean distances were chosen as a measure of similarity that uses analysis of variance to evaluate the distances between clusters, attempting to minimize the sum squares of any two clusters that can be formed at each step (Kent and Coker, 1992 and Qadir et al., 2008).

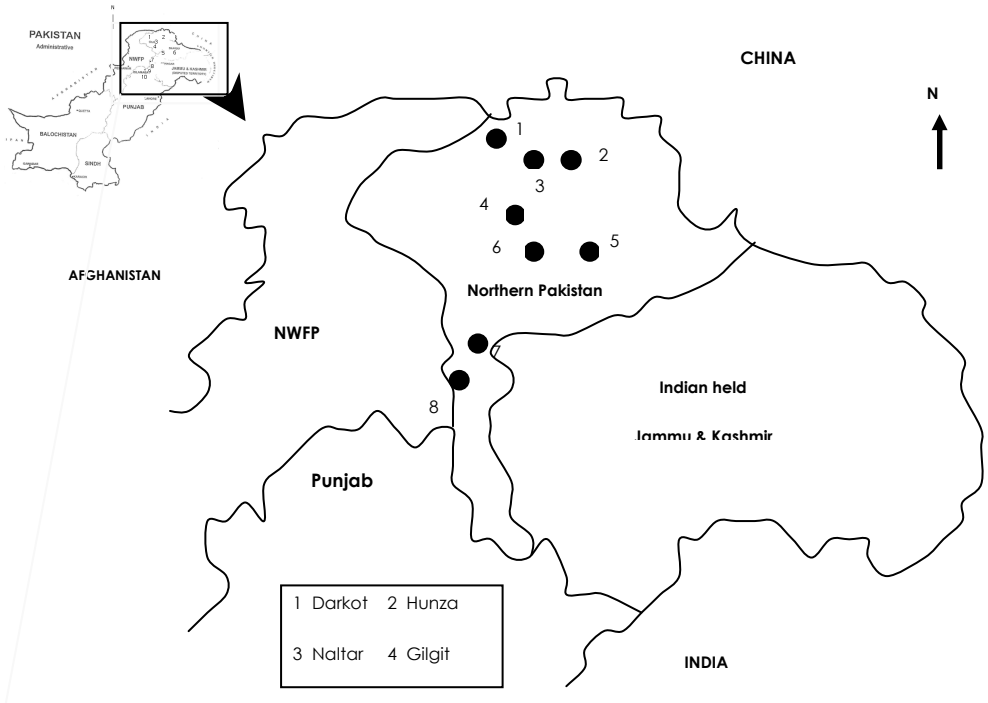

Figure 1. Sampling sites in the northern Pakistan.

3. Results

It is evident (Table 1) that bumblebees of genus *Bombus* in the northern Pakistan consist of 13 species represented by 9 subgenera which are confined in the area ranging from 2291 to 5344m above sea level (a.s.l).

Table 1. Binary (presence/ absence) data of genus *Bombus* in northern Pakistan.

Bumblebees *(Genus, Sub genus, Species)*	Geographical Distribution							
	Hunza	Rama	Darkot	Gilgit	Naltar	Doarian	Samgam	Sermik
B. (Mendacibombus) avinoviellus Skorikov	-	-	-	+	+	`+	+	-
B. (Mendacibombus) himalayanus Skorikov	-	-	+	-	+	+	+	-
B. (Mendacibombus) marussinus Skorikov	+	-	+	-	+	-	-	-
B. (Orientalibombus) haemmorrhoidalis Smith	-	-	-	-	-	+	+	-
B. (Subterraneobombus) melanurus Lepletier	+	+	+	+	+	-	-	+
B. (Alpigenobombus) kashmirensis Friese	+	-	+	-	-	+	+	-
B. (Pyrobombus) subtypicus Skorikov	-	+	+	-	+	-	-	+
B. (Pyrobombus) biroi Vogt	-	-	+	-	-	-	-	-
B. (Bombus) tunicatus Smith	+	+	+	+	+	+	+	+
B. (Bombus) lucorum Linnaeus	-	-	+	+	+	-	-	-
B. (Sibricobombus) asiatics Morawitz	+	-	+	+	+	+	+	+
B. (Melanobombus) semenovianus Skorikov	+	-	+	+	+	-	-	-
B. (Melanobombus) rufofasciatus Smith	+	+	+	-	-	+	+	-

3.1 Distribution of Bumblebees

Cluster analysis (CA) performed on the bumblebees' data set to evaluate geographical variations among different sampling sites. CA grouped the sites into three main geographical groups. Cluster 1 comprised of two sites i.e., Samgam and Doarian. This is because of the fact that these sites were located in the same ecological region i.e., Himalayan moist temperate forest. Cluster 2 consists of Sermik and Rama showing similar patterns of occurrence of genus *Bombus* as both ecological regions (Dry temperate coniferous and steppic forest and alpine dry steppe, respectively) adjoin there. Cluster 3 represented by four sites which was further divided into two sub groups viz., Naltar, Gilgit and Darkot, Hunza. Naltar and Gilgit both located in steppic forest and alpine dry steppe. Similarly sub group Darkot, Hunza belong to same ecological region i.e., permanent snow, alpine meadows and sub- alpine scrub.

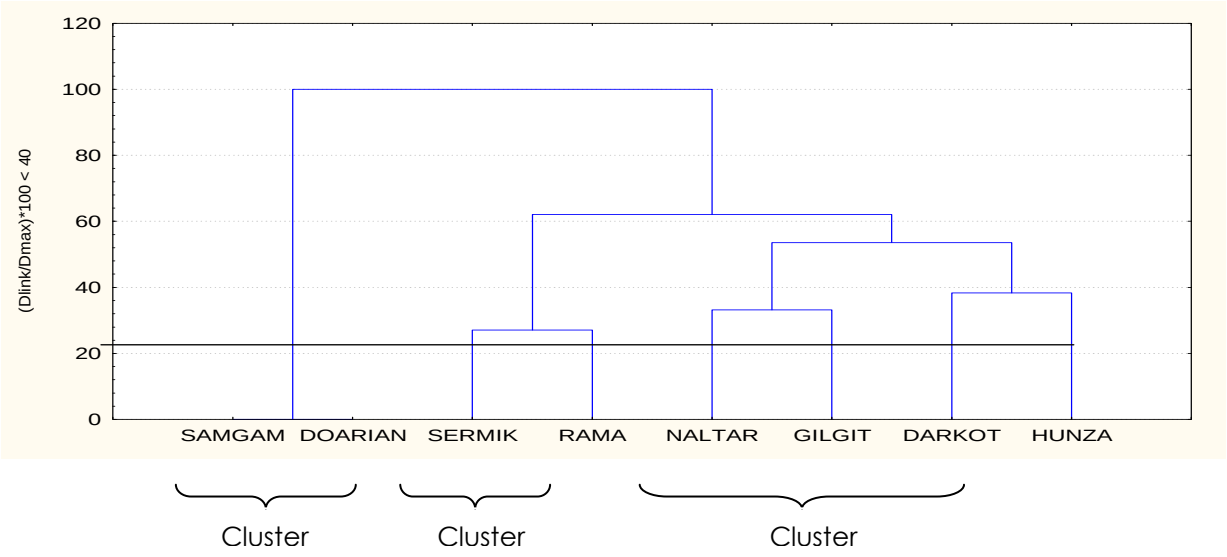

Figure 2. Dendrogram showing different clusters of sampling sites on the basis of abundance data of genus *Bombus* in northern Pakistan.

A total of 13 species of genus *Bombus* (Table 1) were grouped in to three clusters (Fig. 2) on the basis of presence/ absence data. Cluster 1 was represented by species (*B. (Sibricobombus) asiatics* Morawitz, *B. (Bombus) tunicatus* Smith, *B. (Pyrobombus) subtypicus* Skorikov and *B. (Subterraneobombus) melanurus* Lepletier). Theses species were more or less evenly distributed in sampling sites and have wide ecological amplitude. *B. (Pyrobombus) biroi* Vogt, *B. (Bombus) lucorum* Linnaeus, *B. (Melanobombus) semenovianus* Skorikov and *B. (Mendacibombus) marussinus* Skorikov formed cluster 2. These species are less evenly distributed while cluster 3 was consisted of five species viz., *B. (Melanobombus) rufofasciatus* Smith, *B. (Alpigenobombus) kashmirensis* Friese, *B. (Orientalibombus) haemmorrhoidalis* Smith, *B. (Mendacibombus) himalayanus* Skorikov and *B. (Mendacibombus) avinoviellus* Skorikov. These species are moderately distributed in the sampling areas with narrow ecological range as compared to cluster 1.

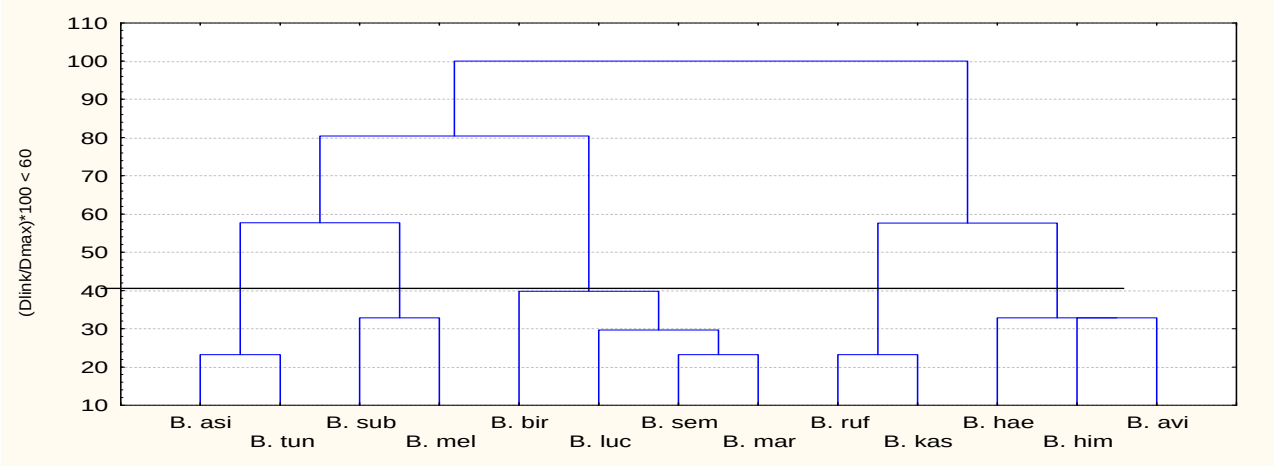

Figure 3. Cluster analysis showing association of genus *Bombus* in northern Pakistan.

B. asi (*B. asiatics* Morawitz), B. tun (*B. tunicatus* Smith), B. sub (*B. subtypicus* Skorikov), B. mel (*B. melanurus* Lepletier), B. bir (*B. biroi* Vogt), B. luc (*B. lucorum* Linnaeus), B. sem (*B. semenovianus* Skorikov), B. mar (*B. marussinus* Skorikov), B. ruf (*B. rufofasciatus* Smith), B. kas (*B. kashmirensis* Friese), B. hae (*B. haemmorrhoidalis* Smith), B. him (*B. himalayanus* Skorikov) and B. avi (*B. avinoviellus* Skorikov)

4. Conclusions

The genus *Bombus* Latreille belongs to the monotpic tribe Bombini (Hymenoptera: Apidae), comprising 239 know species the world over (Williams, 1985, 1998). *B. (Mendacibombus) avinoviellus* Skorikov and *B. (Mendacibombus) himalayanus* Skorikov are west Himalayan species (Williams, 1991). *B. (Mendacibombus) marussinus* Skorikov is a central Asian species also recorded from Pakistan and Kashmir (Williams, 1991)- the Hindu Kush (Reinig, 1940, Tkalců, 1969) and the Pamir (Skorikov, 1910; Reinig, 1930; Skorikov, 1931).

B. (Orientalibombus) haemmorrhoidalis Smith is a Himalayan and South East Asian species (Williams, 1991). It is also known from Kashmir and Pakistan (Richards, 1929; Frison, 1933), Assam (Bingham, 1897, Richards, 1929), south eastern Tibet (Wang, 1988), Sikkim (Friese, 1918; Richards, 1929, 1930; Frison 1935), Darjiling Bengal (Friese, 1918; Richards, 1929; Frison, 1933, 1935), Nepal (Richards, 1929; Frison, 1935; Tkalců. 1974b), Uttar Pradcsh (Richards, 1929; Frison, 1935), Himachal Pradesh (Smith, 1879; Richards, 1929; Frison, 1933, 1935), Vietnam (Tkalců, 1968), Laos (Richards, 1929, Tkalců, 1968), Thailand (Sakagami & Yoshikawa, 1961; Tkalců, 1968); Burma (Frison, 1933, 1935, Skorikov, 1938; Tkalců, 1968, 1989), Yunnan (Wang, 1987).

B. (Subterraneobombus) melanurus Lepletier is a widespread, but primarily central Asian species (Williams, 1991) also known to occur from Pakistan (Frison, 1935), the Hindu Kush (Reinig, 1940; Richards, 1951; Tkalců, 1969), Kashmir, Xinjiang [Kunlun Shan] (Morawitz, 1886), the Hindu Raj, Karakoram. Ladakh, Zanskar, Great Himalaya and Pir Panjal ranges, in montane coniferous forest, alpine scrub and steppe and in high, subtropical scmi-dcscrt (Williams, 1985), Tibet (Richards, 1928b, 1930; Wang, 1982), Mongolia (Pittioni, 1939; Skorikov, 1933a; Bischoff, 1936; Tkalců,

1974a), the Tien Shan (Skorikov, 1931; Bischoff, 1936; Panfilov, 1957), the Pamir (Skorikov, 1912, 1931; Reinig, 1930, 1934; Bischoff, 1931), Nepal (Tkalců, 1974b), Sikkim (Richards, 1928b, 1930), Qinghai (Morawitz, 1886; Skorikov, 1912; Panfilov, 1957; Tkalců, 1961; Wang, 1982), Gansu (Bischoff, 1936), Inner Mongolia (Skorikov, 1933a), Shanxi (Yasumatsu, 1951), Caucasus (Skorikov, 1931) and Turkey (Skorikov, 1931; Reinig, 1971).

B. (Alpigenobombus) kashmirensis is Tibetan species known from Kashmir- the Hindu Raj, Ladakh, Zanskar. Great Himalaya and Pir Panjal ranges (Williams, 1991), Tibet (Richards, 1930; Wang, 1982), Nepal (Tkalců, 1974b; Gansu (Morawitz, 1880; Bischoff, 1936), Qinghai (Morawitz, 1886; Bischoff, 1936; Wang, 1982), Sichuan (Morawitz, 1890; Skorikov, 1933b; Wang, 1982), Guangxi (Wang, 1982).

B. (Pyrobombus) subtypicus Skorikov is a central Asian species (Williams, 1991). It is known from Kashmir (Williams, 1985), the Hindu Kush (Reinig, 1934, 1940; Richards, 1951; Tkalců, 1969), Pakistan (Tkalců, 1989), the Tien Shan (Morawitz, 1880; Skorikov, 1914, 1931; Krüger, 1943) and the Pamir (Reinig, 1930, 1934; Skorikov, 1931).

B. (Pyrobombus) biroi Vogt is a central Asian species (Williams, 1991) also known from the Hindu Kush (Reinig, 1934, 1940; Tkalců, 1969), Kashmir- Hindu Raj, Ladakh, Zanskar, Great Himalaya, Pir Panjal ranges, Mt. Apharwat. Rumbak (Zanskar ranges), Panichar near Suru and Tungri (Williams, 1985), the Tien Shan (Vogt, 1911; Skorikov, 1931; Krüger, 1943 and the Pamir (Cockerell, 1922; Reinig, 1930, 1934; Skorikov, 1931).

B. (Bombus) tunicatus Smith is a Himalayan species (Williams, 1991) also known from Pakistan (Frison, 1933, 1935), Kashmir- southern side of the Great Himalayan Range, the Pir Panjal range, Jhelum valley watershed (Vale of Kashmir and the Kishanganga valley), Hindu Kush (Tkalců, 1969), Indian plains and Calcutta (Dover, 1922), Sikkim (Bingham, 1897; Friese, 1918; Skorikov, 1933b), Uttar Pradesh (Bingham, 1897; Frison, 1935), Himachal Pradesh (Friese, 1909; Cockerell, 1917; Frison, 1935) and Nepal (Tkalců, 1974b).

B. (Bombus) lucorum Linnaeus is most widespread of all bumblebee species, but it is not quite circumpolar (Williams, 1991). It is recorded from Pakistan, Kashmir- the Hindu Kush (Reinig, 1940), Hindu Raj, Karakoram ranges, southern side of the Great Himalaya range, the Pir Panjal range, in the upper montane coniferous forest and in subalpine scrub (Williams, 1985), Nepal (Tkalců, 1974b), Sikkim (Friese, 1918), Tibet (Krüger, 1951, 1958; Panfilov, 1957; Wang, 1982, I988), Yunnan (Wang, 1987), Sichuan (Wang, 1982), Gansu (Bischoff, 1936; Krüger, 1951, 1958), in central Asia its distribution reaches southwards to the Tien Shan (Morawitz, 1880; Skorikov. 1931; Krüger, 1954; Panfilov. 1957, 1981), the Pamir (Reinig, 1930, 1934; Skorikov, 1931; Krüger, 1951, 1958; Panfilov, 1981), Turkey and the Caucasus (Krüger, 1951; Panfilov, 1981; Rasmont, 1984) to the Elburz (Rasmont, 1984) and from across the northern U.S.S.R. (Krüger, 1951; Panfilov, 1981) to Mongolia (Morawitz, 1880; Vogt, 1909; Krüger, 1954, 1958; Tkalců, 1974a; Panfilov, 1981). Inner Mongolia (Reinig, 1936; Panfilov, 1981; Wang, 1982), Heilongjiang (Krüger, 1954, 1958), North Korea (Kim & Ito, 1987), Hokkaido in Japan (Tkalců, 1962; Sakagami & Ishikawa, 1969) and Kamchatka (Bischoff, 1930; Krüger, 1951; Panfilov, 1981), Europe (Krüger, 1951; LØken. 1973; Alford, 1975; Rasmont, 1984) and from Alaska almost to Hudson Bay (Milliron, 1971).

B. (Sibricobombus) asiatics Morawitz is a central Asian and Tibetan species (Williams, 1991) also found in the Hindu Kush (Reinig, 1940; Richards, 1951; Tkalců, 1969), Kashmir- Hindu Raj, Karakoram, Ladakh and Zanskar ranges and from across the Great Himalayan range from the northern side to at least as far as Gumri (Williams, 1985), Nepal (Tkalců, 1974a), Tibet (Richards, 1930; Wang, 1982), Mongolia (Vogt, 1909), the Altai (Skorikov, 1931), the Tien Shan (Morawitz, 1875, 1880; Vogt, 1911; Skorikov, 1931; Panfilov, 1957), the Pamir (Friese, 1931; Reinig, 1930, 1934; Skorikov, 1931), Qinghai (Bischoff, 1936; Tkalců, 1961; Wang, 1982) and Gansu (Bischoff, 1936).

B. (Melanobombus) semenovianus Skorikov is a central Asian species (Williams, 1991). It is known from Pakistan (Frison, 1935) and Kashmir (Hindu Raj, Karakoram, Ladakh, Zanskar, Great Himalaya ranges, Dras (Williams, 1991) and the Hindu Kush (Reinig, 1940; Richards, 1951; Tkalců, 1969).

B. (Melanobombus) rufofasciatus Smith is a peri- Tibetan and also know from Kashmir- Hindu Raj, Great Himalaya, Pir Panjal ranges, Wangal valley, Sangisfaid valley, Mt. Apharwat, Khilanmarg, Mt. Apharwat, Kishanganga valley, Great Himalaya range and Batakush (Williams, 1991), Arunachat Pradesh (Friese, 1918), Uttar Pradesh

(Richards, 1928a, 1930) Sikkim (Bingham, 1897; Friese, 1918), Gansu (Morawitz, 1880; Bischoff, 1936), Qinghai (Morawitz, 1886; Tkalců, 1961; Wang, 1982), Tibet (Friese, 1918; Richards, 1928a, 1930; Wang, 1982, 1988), Sichuan (Morawitz, 1890; Wang, 1982) and Nepal (Tkalců, 1974b).

As the economy of the northern Pakistan, despite tourism is mainly based on subsistence production of agricultural and horticultural crops in the form of a mountain agricultural landscape. Farmers always create their fields at the expense of forest cover and use a variety of methods to do so and burning is the most probable ancient way to obtain pastures and land for crops (Sheikh, 2000). Such anthropogenic activities are continuously deteriorating natural resources such as reduction in vegetation cover, deforestation, intensive cropping and habitat fragmentation which not only reduce the biodiversity but also a permanent threat for bumblebees' fauna and their conservation. Present study was the first effort to document the recent distribution of bumblebees' fauna keeping in view their conservation.

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(Received for publication 28 December 2008)