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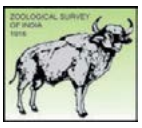

Bumble bee, *Bombus haemorrhoidalis* Smith, 1852 (Apoidea: Hymenoptera)- a significant Pollinator and Bio-indicator species of the lower Shiwalik ranges in the Western Himalayan states of India

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Abstract

This study has been carried out to find out the role of the bumble bee, *Bombus haemorrhoidalis* as a significant pollinator and Bio-indicator species in the ecosystems of the lower Shiwalik ranges in the Western Himalayan states of India during 2019-22. The *Bombus haemorrhoidalis* was the only dominant species of the genus *Bombus* ranging in the selected study area. This species was recorded as very active and pollinating in the winter period during harsh environmental conditions. The *B. haemorrhoidalis* has a great role in pollinating the flowers of *Solanum melongena, Cajanus cajan*, *Cucumis sativus, Cucurbita maxima* in agricultural fields and *Ocimum tenuiflorum*, *Helianthus annus* in cultivated gardens *Mesosphaerum suaveolens*, *Vitex negundo*, *Eremostachys superba, Justicia adhatoda, Impatiens glandulifera*, *Tecoma stans*, and *Lantana camara etc* in wild in the study area.

Keywords: Bumble bee, *Bombus haemorrhoidalis*, Hymenoptera, Pollinator, Western-Himalaya, India.

Introduction

The Western Himalayas is one of the most diverse ecosystems in the world. The rich bio-diversity of this mountainous region provides suitable habitats for bumble bees. There are about 250 species of bumble bees reported around the world, out of which 48 species so far reported from India (Saini *et al.,* 2015). The bumble bees belongs to the high land and distributed mostly in temperate regions in the world as they are cold-adapted species (Williams, 1991). Bumble bees are the important bio-indicators of the Himalayan ecosystem as they indicate the health of an ecosystem and the presence of specific components in the habitats. These bees are distinct by their black and yellow body hairs present in the bands over the abdomen, the hindlegs of female bees are modified into corbicula surrounded by the hair to collect pollen. Their long proboscis and fuzzy body make them more efficient pollinators and they also visited more numbers of flowers per minute as compared to honey bees. They follow unique buzzy foraging behavior to pollinate flowers, as they produce very distinctive vibrational sounds that extract pollen from the anther of the flower. With their hairy body and legs, they transfer pollen to the stigma of the flower and fertilise the flowering plants. These insects pollinate wild, agricultural and horticultural plants which are not pollinated by honey bees (Wahengbam *et al.,* 2019). *B. haemorrhoidalis* is an active pollinator in western Himalayan ecosystems, its distribution range starts from 500-1800m. This species is observed as the most significant pollinator to maintain the germplasm of many floral species in the mountain regions, due to the presence of very limited pollinators of other faunal groups in the winter season. These distinct characteristics make them efficient pollinators in the Himalayan ecosystem.

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Material and Methods

Study Area

The present study was conducted in the selected 20 localities of the Lower Shiwalik ranges in the Western Himalayan States of India (10 selected localities each in Himachal Pradesh and Uttarakhand). The field collection has been done by sweep net sampling method between the altitude of 565-1224m during different seasons of 2019-22. The vegetation in the Shivalik foothills is dominated by Sub-tropical coniferous and broad-leaf forests. The samplings were conducted in the different localities of the study area to assess the presence of *B. haemorrhoidalis* and its floral resources present in the different habitats such as agricultural, barren horticultural lands and grasslands.

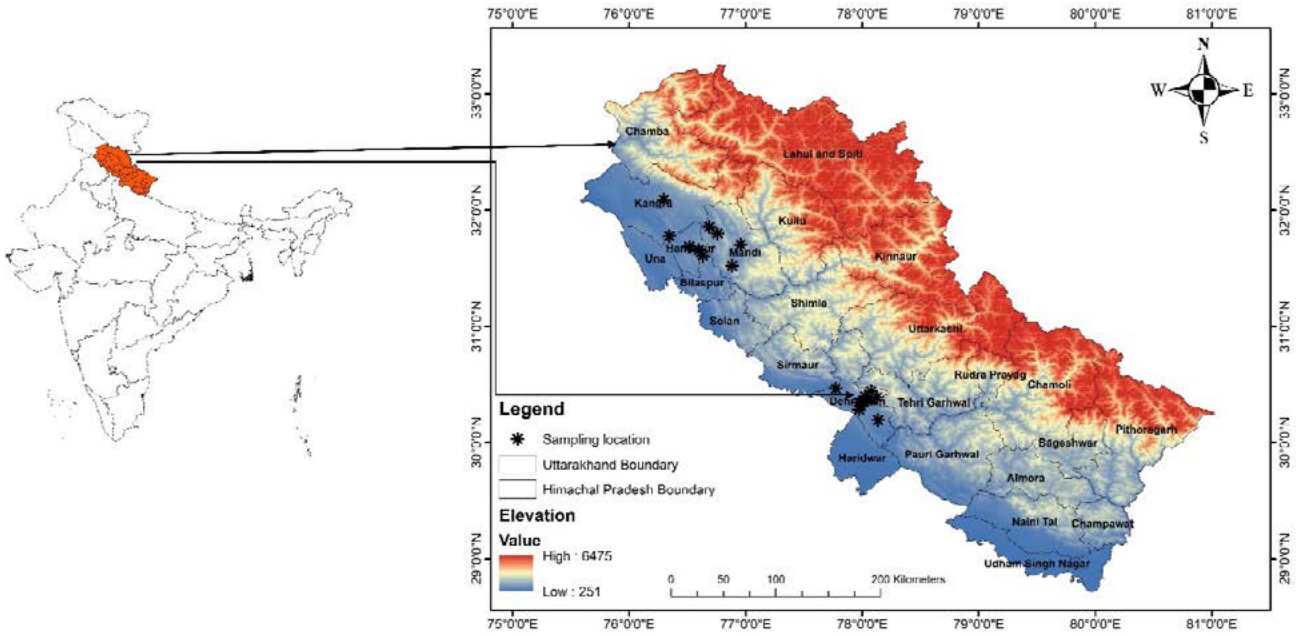

Figure 1. Map showing the study area for sampling of Bumblebee specimens from Shiwalik ranges in Himachal Pradesh and Uttarakhand states.

Sampling Methodology

The bumble bee's specimens were collected and recorded pollinating different flowering plants throughout the year 2019-22 in different localities of the study area. The survey has been conducted between the altitude of 565-1224m during different seasons, *i.e.* pre-monsoon (January–June), monsoon (July–September), and post-monsoon (October–January) from 8am-5pm in pre-monsoon and monsoon periods and from 8am-4pm in the post-monsoon periods due to short light hours. The collection has been done by using the sweep net of nylon. Specimens were killed in jars after capturing which were charged with ethyl-acetate fumes. Insect mounting has been done with the insect stretcher and with different size of entomological pins (sizes 1, 2, and 3) after mounting an artificially incubated chamber with a yellow light bulb was used for 2-3 days to dry the stretched specimens in discontinuous light hours. Then these processed specimens were transferred to fumigated entomological boxes. For the genitalia dissection male abdomen segments were dipped inside KOH solution for 24 hours and with the help of forceps genitalia pulls out and wasted solution was discarded. All the specimens of the bumble bee were examined under a Luxeo 4Z stereomicroscope and digitally photographed using Nikon digital camera D7500. For the identification, keys given in Bingham, 1897; Williams, 1991; Michener, 2007; Saini *et al.,* 2015 were followed and the identification of floral plants was made using the keys by Pusalkar and Srivastava, 2018.

Results & Discussion

Systematic Account

Order HYMENOPTERA

Superfamily APOIDEA

Family APIDAE

Subfamily APINAE

Tribe Bombini

Genus *Bombus* Latreille, 1802

Species *haemorrhoidalis* Smith, 1852

Bombus orientalis Smith, 1854

Bombus buccinatoris Smith, 1879

Orientalibombus haemorrhoidalis semialbopleuralis Tkalcu, 1974

Orientalibombus haemorrhoidalis cinnameus Tkalcu, 1989

Orientalibombus montivolans semivicinus Tkalcu, 1991

B. haemorrhoidalis hive has three different casts, male (drone), female (worker) and single queen, queen is the one who lays the fertile eggs in the colony and maintains its population. Adults in the hive feed on nectar and larvae feeds on a mixture of pollen and honey to get energy (Williams, 1991). *B. haemorrhoidalis* is an important bio-indicator, it indicates the health of the ecosystem and diversity of the ecosystem as it is a specific pollinator to specific flowers (**Table 1).** The bumble bee species have long tongue length and they can easily reach the stigma of a flower with a long corolla, while short tongue bee has to bite the corolla of a flower to reach the stigma. Hence, long-tongue pollinators can not be replaced by honey bees (Free and Williams, 1973; Rasmont, 1988). This species was the only dominant species of genus *Bombus* ranging between this altitude in the study area. It has great efficiency to survive in extreme cold conditions and also can fly at high wind speed. As the temperature decreases in the winter season, this species has been recorded as one of those species which remains active and pollinates in the late winter period during the harsh environmental conditions. It was reported foraging in the dawn and dusk hours; their peak activities were reported from 8am-10am and 4pm-6pm and they were found least active during the afternoon. The maximum species richness of this species was reported in the Post-Monsoon period. The Bumble bee population is declining worldwide due to integrated-agricultural practices such as the use of pesticides, fungicides, herbicides; habitat degradation; habitat fragmentation; forest fire; outbreaks of invasive species and climate changes (Goulson *et al.,* 2008 and Tamburini *et al.,* 2021). The increase in hot wave frequency can predict the local extinction of bumble bee species (Soroye *et al.,* 2020). The conservation of bumble bees will help us in the sustaining of natural resources and it is also important for ecosystem functioning or food security. As it is an important bio-indicator species it indicates the health and presence of specific floral components in an ecosystem. So this indicator species will help in conserving all the species within that region. The evaluation of indicator species within a particular biogeographic region can provide information about the status of declining species within communities and can also give information about conservation strategies for complete communities (Birkhofer *et al.,* 2018). Therefore, more earnest efforts are required for the conservation of this species, their habitats and floral resources to conserve the entire ecosystem in any geographical area.

Table 1: Nectar plants of *B. haemorrhoidalis* recorded in the study area (Foraging ecology).

Sl. No.	Botanical name	Common name	Blooming period	Wild/Cultivated/Invasive
Family: Acanthaceae				
1.	*Justicia adhatoda* L.	Basuti	Throughout year	Wild
Family: Asteraceae				
2.	*Dahlia coccinea* Cav.	Dahlia	June-November	Cultivated
3.	*Tithonia rotundifolia* (Mill.)	Red sunflower	November- December	Cultivated
4.	*Helianthus annuus* L.	Common- Sunflower	June-October	Cultivated
5.	*Cirsium arvense* (L.)	Field thistle	March- April	Wild

Sl. No.	Botanical name	Common name	Blooming period	Wild/Cultivated/Invasive
Family: Balsaminaceae				
6.	*Impatiens glandulifera* Royle	Himalayan balsam	September-December	Wild
Family: Bignoniaceae				
7.	*Tecoma stans* (L.)	Yellow trumpet	Throughout year	Cultivated
Family: Convolvulaceae				
8.	Ipomoea purpurea (L.)	Morning-glory	October- December	Wild
Family: Cucurbitaceae				
9.	*Cucurbita maxima* Duchesne	Pumpkin	November-December	Cultivated
10.	*Cucumis sativus* L.	Cucumber	June- August	Cultivated
Family: Lamiaceae				
11.	*Vitex negundo* L.	Chaste tree	September–December	Wild
12.	*Mesosphaerum suaveolens* (L.)	Pignut	September–December	Wild
13.	*Eremostachys superba* (Van Mooli)	Golden Himalayan Spike	March-April	Wild and Cultivated
Family: Leguminaceae				
14.	*Glycine max* (L.)	Soyabean	April-June	Cultivated
15.	*Trifolium resupinatum L.*	Persian clover	November- March	Cultivated
Family: Solanaceae				
16.	*Solanum melongena* (L.)	Brinjal	June–October	Cultivated
Family: Verbenaceae				
17.	*Lantana camara* L.	Lantana	Throughout year	Invasive
Family:Malvaceae				
18.	*Hibiscus mutabilis* L.	Cotton- rose	October- January	Cultivated

Figure 2. Floral resources of *B. haemorrhoidalis* in western Himalayas, India.

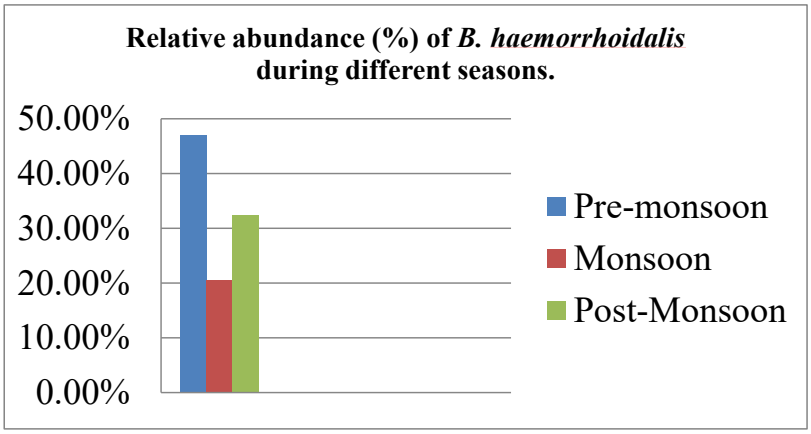

Figure 3. Relative abundance (%) of *B. haemorrhoidalis* during different seasons.

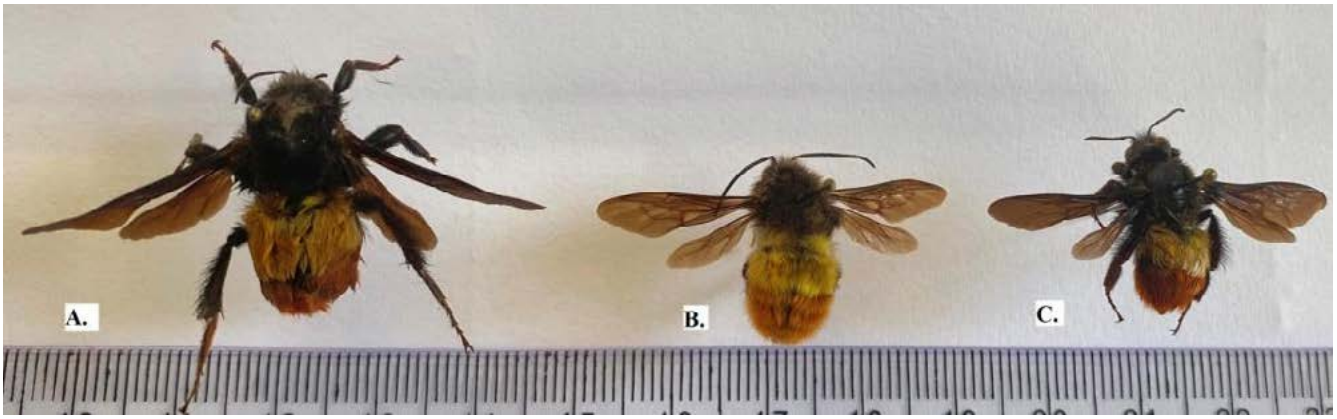

Figure 4. A. Queen B. Drone ( ) C. Worker ( )

Figure 5. Male genitalia of *B. haemorrhoidalis*

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