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# Food plants and bionomics of indigenous Bumblebee, *Bombus haemorrhoidalis* Smith in Rawalakot, Azad Jammu and Kashmir of Pakistan

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**Abstract**

Bumblebees are important pollinators in both wild and commercial crops with increased use in enclosed farming system of the imported. *Bombus haemorrhoidalis* Smith is only *Bombus* species of Rawalakot and there is need to study its life cycle and floral host range to conserve it in future. From three locations of Rawalakot monthly surveys were conducted to collect and observe the bumblebees and its floral host for two years 2012 and 2013. Forty two floral host plants of nineteen plants families were recorded from three new locations. Asteraceae family was found with maximum floral host plants with higher bumblebee workers observed during August-September while male and daughter queens in October-November months. Drastic temperature drop in the month of December resulted in negligible observation records. Floral host range, seasonal distribution and relative abundance of this bumblebee species might be helpful for its future application in possible pollinator rearing program. Eco-biological interaction of this important insect pollinator also values its ecological role of this zone.

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## Introduction

Plant-pollinators interaction is one of most imperative type of plant-animal interactions. Pollinators visit flowers due to many reasons which may be nectar feeding, pollen collection and warmth. The pollination of flowering plants by animals in both cultivated and wild plants represents a vital ecosystem service of enormous value to humanity and enhances fruit setting in 75% of the world's leading food crops (Klein *et al.*, 2007). Floral diversity has great effect on pollinator-plant interaction and numbers of plant species are positively correlated with the diversity of pollinators and their population (Bawa, 1990). Diversity of flowering plants plays governing role to determine the type and population of pollinators (Backman and Tiainen, 2002; Collinge *et al.*, 2003). Insects the most diverse group of pollinators, comprise more than twenty five thousand bee species belonging to order Hymenoptera (Kevan and Phillips, 2001). Bumblebees are among the most efficient bee pollinators with more than 250 known species worldwide mostly from Northern hemisphere (Williams, 1991). Their efficiency is mainly due to high flower visitation speed at low temperature, buzz pollination and solitary colony structure. These characteristics make them more reliable pollinators than others including honeybees (Kaftanoglu, 1999) and are considered suitable for enclosed pollination services (Heinrich, 1979a).Their status is considered as the most plentiful and evident of flower visitors providing the vital ecosystem services of pollination in both wild and agricultural cropping systems (Corbet *et al.*, 1991).

Intensive cropping systemsparticularly greenhouse cultivation has increased the demand of bumblebees to meet crop pollination needs (Griffiths and Robberts, 1996). Different species (*Bombus terrestris, B. impatiens, B. occidentalis* and *B. ignitus*) have been reared on mass level and used throughout the world (Velthuis and Doorn, 2006; Imran *et al.*, 2017). In enclosed greenhouse farming, bumblebee facilitated pollination has been reported to yield high economic returns in Solanaceous crops like tomato, pepper and eggplant.

In the high altitude regions of Himalaya, these bees are important natural pollinators of cultivated and wild flowering plants (Williams, 1991) and play key role in ecological services in Northern Pakistan (Sabir *et al.*, 2007). Foraging activity of bumblebees has been recorded from 160 floral host plants (Raina,, 2011) in Hamalayan region. Recently, we have reported their 24 floral hosts belonging to 13 plant families in lower Northern Pakistan and 10 families from Naran Kaghan Valley, Pakistan(Sheikh *et al.*, 2014 & 2015).

Thirteen bumblebee species with *B. haemorrhoidalis*, *B. asiaticus*, *B. avinoviellus*, and *B. biroi* from Northern Pakistan were reported from Northern Pakistan (Suhail*et al.*, 2009). Five species including *B. subtypicus, B. kashmirensis, B. trifasciatus, B. rufofasciatus* and *B. haemorrhoidalis* were recorded for the first time from Naran Kaghan valley, Pakistan(Sheikh *et al.*,2014). However, in lower northern region of Pakistan (Murree and Margalla Hills) only one bumblebee species, *B. haemorrhoidalis* was found (Sheikh *et al.*,2014 & 2015). This species has also been found in India as a sole pollinator of large cardamom and other crops (Deka *et al.*, 2011). In this region, there is no specific study on *B. haemorrhoidalis*, however, competition of this species for floral resources in relation to other pollinators was another focal objective. This might help in conservation of bumblebee and facilitating ecological and biological interaction with other insect pollinators of Azad Kashmir, Pakistan.

## Materials and methods

*Study area*

Present study was conducted at Rawalakot and its surrounding areas in Azad Kashmir, Pakistan for two consecutive years (2012-2013). Rawalakot lies in the north-east of Pakistan under foothills of great Himalayas in the Poonch Division. Altitude of study area lies between 1400m to1860m and its landscape is mainly hilly and mountainous with valleys (Table 1). It is characterized by moderate climate with annual rainfall between 500–2000 mm. Mean average low and high temperatures are 23.2 and 33.1°C (Nazar and Mahmood, 2011).

Study area was divided into three sub-locations as Poonch University area, Paniola and Namnoota constituting different landscapes and vegetation pattern. Field surveys were conducted on monthly basis from March to December. Entomological hand nets were used for collection of bumblebee samples, by walking through transect of each sub-location falong roadside, crops, forest and surroundings of field crops (Dafni, 1992).

*Floral host and abundance*

Foraging behavior was studied on different floral plant species (weeds, ornamental plants, cultivated crops) by following modified bee walk transect method (Banaszak, 1980). Abundance and seasonal distribution of different castes of *B. haemorrhoidalis* of queens, workers and males were recorded. Relative abundance of other pollinators in comparison to *B. haemorrhoidalis* was also recorded at the same time. All the field visits were made in sunny days by avoiding rainy or windy days. All the plant species

visited by *B. haemorrhoidalis* were recorded as floral hosts of bumblebees. Host plants were ranked from high to low as the visiting rate by bumblebees at different sites.

*Data analysis*

Garmin e-trex 10 GPS device was used to record longitude, latitude and altitude of all study sites. Collected data was analyzed by using Staisitcs 8.1 software. All the collected specimens were pinned, preserved in wooden boxes and deposited in the Biosystematics Laboratory, Department of Entomology, Pir Mehr Ali Shah Arid Agriculture University Rawalpindi, Pakistan.

**Results**

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

Hymenoptera order including six pollinator species were most abundant followed by Diptera including two species and Lepidoptera including five species at Poonch University area, Paniola and Namnoota, respectively. At Poonch University surroundings area, relative abundance of four insect pollinators including *Luciliasericata, Syrphus* sp.,*Apis cerana* and *B. haemorrhoidalis* ranged from 13.3-18.5%. *Phobis trite*, *Danaus* spp., *Pieris brassicae* and *Vespa orientalis* were from 5.08-9.02%. Remaining five pollinators i.e., *Apis dorsata*, *Xylocopa* spp. *Amegillac ingulata* and *Hemaris fuciformis fuciformis* were less than 2.89% reflecting their rarity in this sub-locality. *B. haemorrhoidalis* was the most abundant with 18.57% relative abundance at this sub-locality.

**Table 1.** Global Positions of Study locations and sub-locations.

| Locations | Altitude | Global positioning |
|---|---|---|
| Poonch University | 1614 m | 33° 50′ 48.25″ N<br>73° 46′ 28.10″ E |
| Paniola | 1438 m | 33° 55′ 13.70″ N<br>73° 41′ 12.65″ E |
| Namnoota | 1864 m | 33° 51′ 11.61″ N<br>73° 49′ 09.16″ E |

At Paniola, *Syrphus* sp. was higher in abundance (21.94%) followed by *B. haemorrhoidalis* (17.76%). Relative abundance of three pollinators i.e., *V. orientalis*, *L. sericata* and *A. cerana* ranged from 10.82-17.59%. Other eight pollinators did not exceed 3.68% and *A. cingulate* was the least abundant (0.45%) in this sub-locality.

*B.haemorrhoidalis* was the most abundant pollinator (19.12%) followed by *A. cerana* (19.05%) at Namnoota. Relative abundance of three pollinators i.e., *V. orientalis*, *L. sericata* and *Syrphus* spp. ranged from 9.99-16.25%. Other eight pollinators at this sub-location not exceeded 4.64% (Table 2).

*Floral host range of Bombus haemorrhoidalis Smith from Rawalakot during 2012 and 2013*

From Rawalakot, 42 plant species belonging to 19plant families were recorded as floral host plants of *B. haemorrhoidalis*. Out of which, 10 species belonged to family Asteraceae, 5 species each to Fabaceae and Cucurbitaceae.Lamiaceae and Malvaceae were recorded with three plant species each. Acanthaceae, Convovulaceae, and Solanaceae families were recorded with two plant species each. From plant families including Balsaminaceae, Bignoniaceae, Cisteraceae, Ebenaceae, Iridaceae, Myrtaceae, Plantaginaceae, Rosaceae, Ranunculaceae, Verbenaceae and Violaceae, one floral host plant was observed from each family.

**Table 2.** Relative abundance of *Bombus haemorrhoidalis* Smith in comparison with other pollinators of different locations of Rawalakot.

| Pollinator Species | Poonch University Area | | Paniola | | Namnoota | |
|---|---|---|---|---|---|---|
| | Number | Relative abundance | Number | Relative abundance | Number | Relative abundance |
| *Bombus haemorrhoidalis* (Hymenoptera) | 1688 | 18.57 | 1514 | 17.76 | 1570 | 19.12 |
| *Apis dorsata* (Hymenoptera) | 112 | 1.23 | 118 | 1.38 | 96 | 1.16 |
| *Apis cerana* (Hymenoptera) | 1342 | 14.76 | 1499 | 17.59 | 1565 | 19.05 |

| | | | | | | |
|---|---|---|---|---|---|---|
| *Xylocopa* sp. (Hymenoptera) | 161 | 1.77 | 82 | 0.962 | 65 | 0.791 |
| *Amegilla cingulata* (Hymenoptera) | 42 | 0.462 | 39 | 0.457 | 65 | 0.791 |
| *Vespa orientalis* (Hymenoptera) | 832 | 9.15 | 922 | 10.82 | 821 | 9.99 |
| *Syrphus* sp. (Diptera) | 1688 | 18.57 | 1817 | 21.94 | 1335 | 16.25 |
| *Lucilia sericata* (Diptera) | 1213 | 13.35 | 1257 | 14.75 | 1328 | 16.17 |
| *Danaus plexippus* (Lepidoptera) | 479 | 5.27 | 305 | 3.57 | 381 | 4.64 |
| *Pieris brassicae* (Lepidoptera) | 664 | 7.30 | 314 | 3.68 | 308 | 3.75 |
| *Papilio demoleus* (Lepidoptera) | 263 | 2.89 | 205 | 2.40 | 222 | 2.70 |
| *Phobis trite* (Lepidoptera) | 462 | 5.08 | 292 | 3.42 | 328 | 3.99 |
| *Hemaris fuciformis fuciformis* (Lepidoptera) | 140 | 1.54 | 103 | 1.20 | 127 | 1.54 |

Four plant species from two families, Asteraceae and Verbenaceae were recorded as major host for bumblebee, fourteen plants as medium host and twenty five plants were recorded as minor hosts (Table 3).

*Monthly abundance of Bombus haemorrhoidalis Smith at Rawalakot*

At surroundings of Poonch University areas, maximum number of *B. haemorrhoidalis* was recorded in September followed by August. Very low population was observed in March, April and November and no population in December, January and February. At Namnoota, Paniola and their surrounding areas, its population trend was similar to that of Poonch University area (Fig. 1).

*Seasonal biological variations of Bombus haemorrhoidalis workers, males and daughter queens at three sub-locations of Rawalakot*

At all sub-locations (Poonch University, Paniola and Namnoota) of Rawalakot, variable emergence of queens from winter diapause was observed from March to May with maximum numbers in April. Workers were recorded throughout from June to October with highest population in September. Males and daughter queens were observed in September to October and October to November, respectively. In October, there was highest population of males and least of workers. There was no population of workers; males and queens from December to February at all three sub-locations of Rawalakot (Fig. 2).

**Table 3.** Floral host plants of *Bombus haemorrhoidalis* Smith form Rawalakot and its surroundings.

| Host plants | Scientific name | Family | Status* |
|---|---|---|---|
| Globe thistle | *Echinops echinatus* | Asteraceae | Major |
| Mary thistle | *Silybum marianum* | Asteraceae | Major |
| Wild daisy | *Bellis perennis* | Asteraceae | Medium |
| Lesser knapweed | *Centaurea nigra* | Asteraceae | Minor |
| Centaurea blue | *Centaurea cyanus* | Asteraceae | Minor |
| Sunflower | *Helianthus annuus* | Asteraceae | Medium |
| Blue Thistle | *Carduus sp* | Asteraceae | Minor |
| Saw-wort | *Saussurea spp* | Asteraceae | Minor |
| Zinnia | *Zinnia sp* | Asteraceae | Major |
| Daisy | *Chrysanthemum leucanthemum* | Asteraceae | Minor |
| Brachychiton | *Brachychiton diversifolius* | Asteraceae | Minor |
| Dicliptera sp. | *Dicliptera roxburghiana* | Acanthaceae | Minor |
| Baikhar | *Adhatoda zeylanica* | Acanthaceae | Major |
| Sichuan Gold | *Impatiens sp* | Balsaminaceae | Minor |
| Yellow bells | *Tecoma stans* | Bignoniaceae | Medium |
| Cucumber | *Cucumis sativus* | Cucurbitaceae | Medium |

| | | | |
|---|---|---|---|
| Musk melon | *Cucurbita pepo* | Cucurbitaceae | Medium |
| Tori | *Luffa cylindrica* | Cucurbitaceae | Medium |
| Field bindweed | *Convolvulus arvensis* | Convolvulaceae | Minor |
| Pink morning glory | *Ipomoea carnea* | Convolvulaceae | Minor |
| Rock rose | *Cistaceae sp* | Cisteraceae | Minor |
| Persimmon | *Diospyros kaki* | Ebenaceae | Minor |
| Kachnar | *Bauhinia variegate* | Fabaceae | Minor |
| Amaltas | *Cassia fistula* | Fabaceae | Medium |
| Lupin flower | *Lupinus sp* | Fabaceae | Minor |
| Black locust | *Robinia pseudoacacia* | Fabaceae | Medium |
| Clover | *Trifolium repens* | Fabaceae | Medium |
| Gladiolus | *Gladiolus sp.* | Iridaceae | Medium |
| Sage | *Salvia officinalis* | Lamiaceae | Minor |
| Dead-nettle white | *Lamium sp* | Lamiaceae | Minor |
| Pudina | *Mentha piperita* | Lamiaceae | Minor |
| Okra | *Abelmoschus esculentus* | Malvaceae | Minor |
| Hollyhock | *Alcea rosea* | Malvaceae | Minor |
| Rose of Sharon | *Hibiscus syriacus* | Malvaceae | Medium |
| Sleeping beauty | *Oxalis corniculata* | Oxalidaceae | Minor |
| Fox glove pink | *Digitalis sp* | Plantaginaceae | Medium |
| Apple | *Malus domestica* | Rosaceae | Medium |
| Butter cup | *Ranunculus muricatus* | Ranunculaceae | Minor |
| Tomato | *Solanum lycopersicum* | Solanaceae | Minor |
| Brinjal | *Solanum melongena* | Solanaceae | Minor |
| Lantana | *Lantana camara* | Verbenaceae | Major |
| Banafsha | *Vioila pilosa* | Violaceae | Medium |

*Major, medium and minor host classified on the basis of bumblebee visitation rate

**Discussion**

Insects play an important role in pollination and endurance of plants in nature. Among these insects, some species have also been used as crop pollinators on commercial basis to increase the crop yield. Bumblebees are being used worldwide under enclosed cropping system especially for vegetable and fruit crops pollination. Natural population of bumblebee depends on plant species composition, flowering patterns and abundance in a particular area (Heinrich, 1979).

*Abundance*

In our study, six insect species belonging to order Hymenoptera proved the most abundant guild of insect pollinators at all sub-locations of Rawalakot. The same order (Hymenoptera) was found to be the most abundant group of insect pollinators in Indian occupied Kashmir (Kumar and Lall, 1998: Abrol and Sharma, 2005) with nine insect species (Abrol and Sharma, 2005). Lepidoptera (five species) and Diptera (two species) were recorded as next more abundant orders. These findings are partially in accordance with those reported by Raj and Mattu (2014) in Himachal Himalaya, where Hymenoptera was the most abundant pollinator group followed by Diptera, Lepidoptera and Coleoptera. We found *B. haemorrhoidalis* as the only and most abundant *Bombus* pollinator at all sub-locations of Rawalakot which is also with the same status in Margalla and Murree hills of Pakistan (Sheikh *et al.*, 2014). Sinu *et al.* (2011) also reported it to be the most important and common pollinator at different altitudes in central Himalayas of India.

In present study, forty-two plants belonging to nineteen plant families were recorded from sub locations of Rawalakot as floral hosts of *B. haemorrhoidalis*. Sheikh *et al.* (2014) reported twenty-four host plants belonging to thirteen plants families from Margalla and Murree hills of Pakistan from Northern areas of Pakistan which shows relatively more plant diversity from the Murree and Margalla hills than the present under study locations. Similarly, Sabir (2011) reported twenty-three floral plants belonging to thirteen families as host plants of *B. haemorrhoidalis* from other higher altitude Northern regions of the Pakistan.

*Floral host range*

Plants belonging to Asteraceae family proved the most visited floral hosts followed by those of Fabaceae and Lamiaceae. Three species from Asteraceae (*Echinops echinatus,*

*Silybummarianum*and *Zinnia* spp.) and one (*Lantana camara*) from Verbenaceae remained as major floral hosts for bumblebees. These findings are in accordance with Sheikh *et al.*, (2014). Previously we reported Asteraceae as comprising of major floral hosts of *B. haemorrhoidalis* in Margalla and Murree hills and Naran-Kaghan valley of Pakistan (Sheikh *et al.* 2014, 2015). This plant family Asteraceae has also been the most foraged plant family by bumblebees in other Northern areas of Pakistan (Suhail *et al.*, 2009).

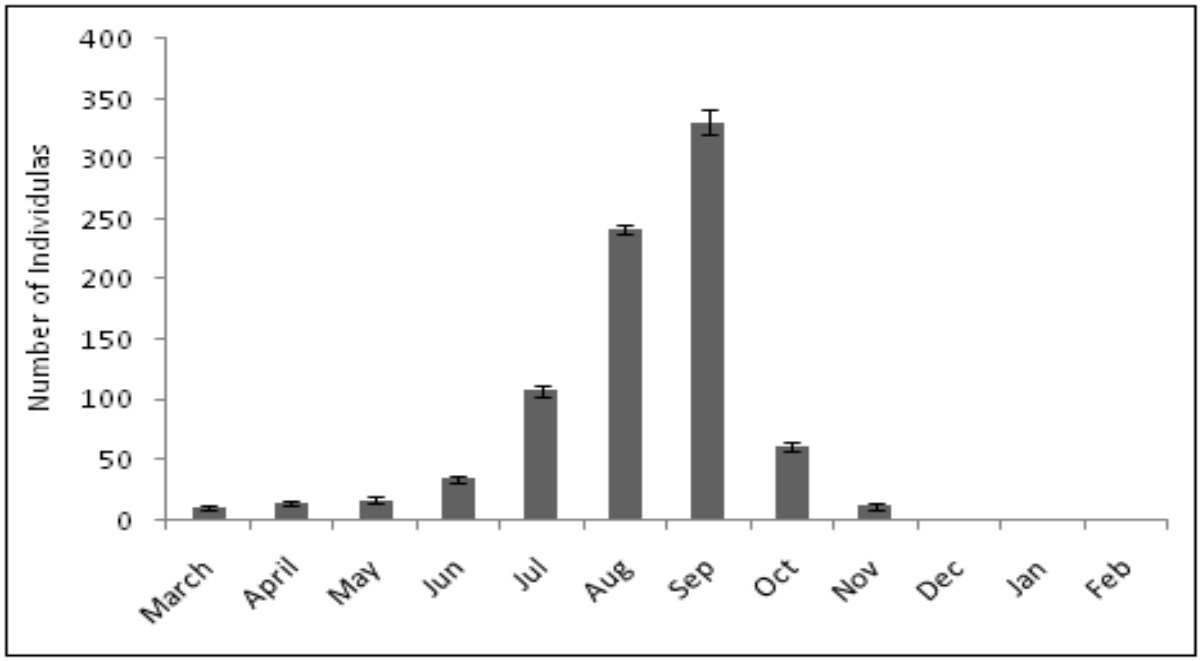


**Fig. 1.** Monthly abundance of *Bombus haemorrhoidalis* Smith at Rawalakot for the years 2012-2013.

Highest population of *B. haemorrhoidalis* at all sub-locations of Rawalakot was observed in August-September while the lowest in October-November. Bumblebee population was not recorded in these locations from December to February which may be due to completion of colony cycle and queens hibernation in severe winter. Maximum population in August and September may be due to rapid developmental stage of colony cycle in nature because of favorable temperature. Comparable results were observed in August-September in Margalla and Murree hills of Pakistan regarding their population (Sheikh *et al.*, 2014). Comparatively lower population in October to November might be due to end of colony cycle in this region. Bumblebee queens were recorded from March to May, this may be due to emergence of hibernating queens in early spring who started foraging in these months for building their nests.

Maximum workers were recorded in August and September; it may be due to development stage of colony of bumblebee in nature. Daughter queens and males were in October and November because sexuals of bumblebee produced at the end of colony cycle. Similarly, at Margalla and Murree hills queens were observed from March to May, maximum workers were in August and September and sexuals including daughter queens and males were observed in October and November (Sheikh *et al.*, 2014).

**Conclusion**

From above results, it can be concluded that in all sub-locations of Rawalakot, only one bumblebee (*B. haemorrhoidalis*) species was recorded foraging 42 host plants belonging to 20 plants families. Asteraceae was recorded as the major host plants family for this indigenous bumblebee species.

Queens of bumblebee were found form March to April, maximum population of workers in August and September and sexuals in October and November months.

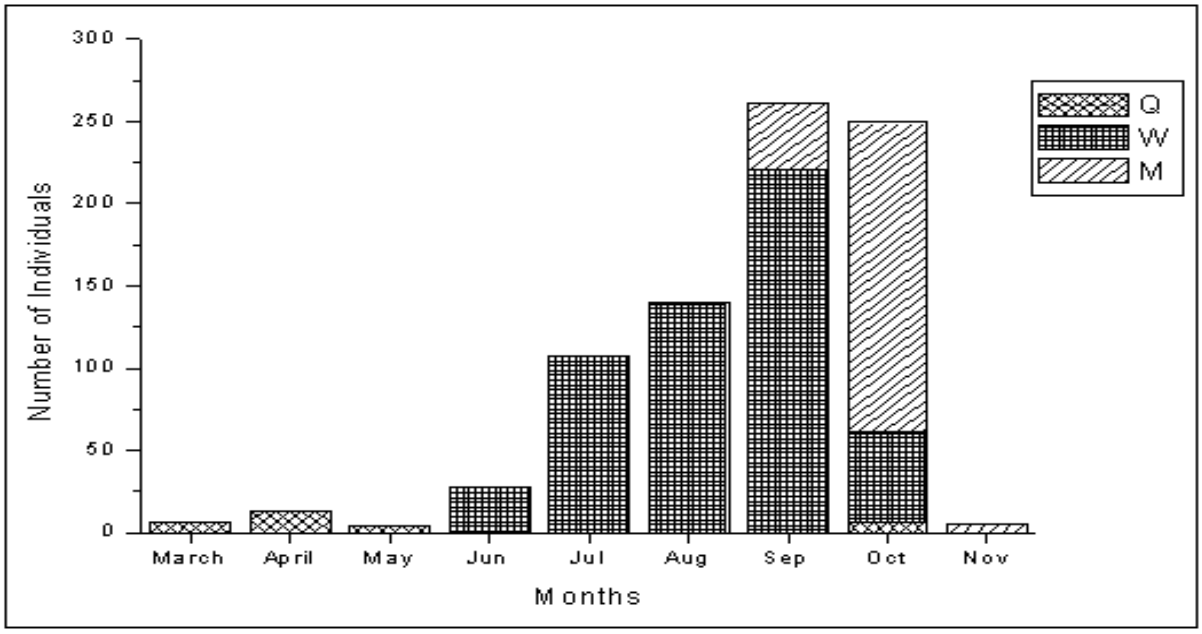


**Fig. 2.**Seasonal biological variation of local bumblebee, *Bombus haemorrhoidalis* Smith workers, males and queens at Rawalakot and (each bar with three divisions show males, worker and queens from top to bottom).

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