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Diversity of Insect Pollinators in Pir Panjal Biodiversity Park Rajouri, Jammu and Kashmir

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Abstract

The Himalayas are the world's highest mountain range, and its biodiversity has attracted researchers' curiosity. Regarding the variety of plants with special reference to pollination, insect pollinators are the major focus of research. The Pir Panjal range is a collection of mountains in the lower Himalayan area home to a diverse range of wildlife, including insect pollinators. Therefore, an investigation was conducted in Pir Panjal Biodiversity Park, the Baba Ghulam Shah Badshah University (BGSBU), Rajouri, and Jammu and Kashmir, to develop a list of insect pollinators in the study area for future reference. Consequently, we identified 25 species of insect pollinators that were seasonal in nature, with Hymenoptera having the most insect pollinators. In contrast, insect orders like Diptera and Lepidoptera had the least number of species observed. Basically, any change in landscape, land use pattern, or deforestation will have an adverse effect on insect pollinators when it comes to species diversity richness. The loss of endemism and the extinction of species, especially floral variety, may influence the diversity of pollinating insects. As a result, altering the vegetation mix around a study site may help to preserve pollinators.

***Key words*:** Diversity, Insect pollinators, Species richness, Species abundance

Panjal Range is a large range of mountains in the Lesser Himalayan region running from the east to the west, spanning the Indian states of Himachal Pradesh, Punjab Jammu and Kashmir, and Pakistan's Azad Kashmir. Elevations range from 4,600 to 13,500 feet (1,400 to 4,100 m). The Himalayas gradually gain altitude as they ascend towards the Dhauladhar and Pir Panjal ranges. Pollination is one of the most critical processes in maintaining and promoting biodiversity. Pollinators and pollination are critical for food production and human livelihoods, and directly link wild ecosystems with agricultural production systems. Pollination, an essential ecosystem service provided by insect pollinators, is many times taken for granted, and little attention is paid to the need to conserve and enhance pollinator diversity in crop ecosystems. Pollination can be greatly improved if there are enough suitable pollinators available during flowering time. The essential ecosystem service of pollination provided by insects is often taken for granted and little effort is generally applied to conserving and enhancing the diversity of insects in crop ecosystems. Hymenoptera, Lepidoptera, and Diptera are the three major orders of insect pollinators. Insect pollinators play a crucial role in improving the productivity of cross-pollinated crops. The availability of a sufficient number of suitable pollinators during flowering time is essential for achieving optimum pollination. Pollination by animals (insects, birds, and mammals) accounts for about 87 percent of all plant species. The ratio might reach 94 percent in tropical areas [1]. The output inspecting method was used to determine the number of bug pollinators. A total of 470 insect pollinators were recorded during light days from 8 a.m. until 10 a.m. and 2 p.m. to 4 p.m., recording 43 species from three orders (Hymenoptera, Diptera, and Lepidoptera) [2]. About 87 percent of all plant species are pollinated by animals (insects, birds, and mammals). [1] estimate that the ratio could reach 94 percent in tropical areas. In three key apple-producing districts: Baramulla, Pulwama, and Shopian, 970 bug specimens from two primary insect orders were collected during the blooming season (March-April) of apple trees [3]. During the bloom season of apple trees (March-April) in three key apple-producing districts, namely Baramulla, Pulwama, and Shopian [3], 970 specimens of two primary insect orders (Hymenoptera and Diptera) were collected.

In Kashmir Himalayan apple orchards, a study assessed the relative numbers and types of natural insect pollinators. Researchers at Perowal (Central Agriculture Zone, southern Punjab, Pakistan) studied the seasonal variation of pollinators in relation to abundance and diversity in an ecosystem where average maximum and minimum temperatures range from 19.4 to 43.3°C and 5°C to 31.3°C respectively. Several insect pollinators (Diptera and Hymenoptera) were satisfied. According to the results of the study, flies and bees were active all year while wasps stopped breeding when temperatures dropped below 20 °C during December-February (winter). There were 42 different fly species representing 10 different

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families. The most abundant fly species were Euphumosiasp, E. aeneus, and Musca domestica. Spring and summer were both the seasons of the highest bee abundance and richness, respectively [4]. Within the Kashmir valley, 21 species of insects (Hymenoptera, Diptera, and Lepidoptera) belonging to 12 families and three orders (Hymenoptera, Diptera, and Lepidoptera) were identified among apple orchards [5]. Around 80% of plant species in Kashmir are being pollinated by honeybees. A comparative study was done on various Hymenopteran insects pollinating some economically significant crops in Kashmir [6]. Studying pollinators in 21 different crops over several years, this study quantifies the temporal variability observed. Based on data from 43 studies across six continents, researchers found that the diversity of pollinators is associated with greater inter-annual stability of pollinator communities, and variability in pollinator abundance is primarily driven by the three most dominant species. In tropical regions, levels of pollinator species richness fluctuate more than in temperate regions, highlighting the importance of recognizing wild pollinator diversity in agricultural landscapes to maintain pollinator persistence across seasons to protect biodiversity and crop pollination services [7].

Flora of Rajouri

Taxonomic information about many regions of the Himalayas, which is considered a biodiversity hotspot [8], is still lacking. As a result, the Botanical Survey of India has recognized Jammu and Kashmir (J&K) as one of the least explored floristically in the Western Himalaya [9]. In terms of its biogeography, the Jammu and Kashmir Union Territory is divided into two different provinces: the subtropical Jammu and the predominantly temperate Kashmir. There is a great deal of floristic diversity in the union territory due to the wide range of habitats found throughout these provinces. Many botanists, both foreign and domestic, have been interested in the country's flora for the past two centuries. In Hooker's [10] and Stewart's (1972) illustrious works, many of its plants are cited. A great deal of floristic diversity can be found in Jammu province of the state of J & K. In the past three decades, several taxonomic studies have been conducted on this province's floristic diversity. Taxonomic details are provided in Vol. 2 of Sharma and Kachroo's Flora of Jammu and adjacent areas, published in 1981-82. As well as illustrations in Vol. 1. An overview of the flora of Trikuta hills, as well as the surroundings of Shri Vaishno Devi Shrine, was provided by Kapur and Sarin [11]. In 1998, Swami and Gupta published Flora of Udhampur district, a useful work on the higher plants of this area. The Chenab Valley's flowering plants and the floristic richness of the Doda, Kishtwar, and Ramban districts have been cataloged by Bhellum and Magotra [12]. Vir Jee *et al*. [13]; Dar *et al*. [14]; and Malik *et al*. [15] report that Rajouri and Poonch are probably the least studied districts of the Jammu province in terms of their flora, with scanty information available [16-20]. There is no inventory of plants occurring in these two districts in any of these publications. They are preliminary short communications. Below is the list of floral resources from which insect pollinators were collected (Table 1).

Table 1 List of different floral resources of insect pollinators in Rajouri BGSBU

Common name	Scientific name	Family
Mustard	*Brassica nigra*	Brassicaceae
Rangoon creeper	*Quisqualis indica* L.	Combretaceae
Pear	*Pyrus communis* L.	Rosaceae
Apple	*Malus pumila*	Rosaceae
Small bugloss	*Anchusa arvensis*	Boranginaceae
Peach	*Prunus persica*	Rosaceae
Amla	*Phyllanthus emblica*	Phyllanthaceae

Study area and locations

Preliminary surveys of different insect pollinators have been conducted in the Pir Panjal Biodiversity Park at BGSB University Rajouri. In the state of Jammu and Kashmir, Rajouri. Geographically, climatically, and culturally, BGSBU is one of the most diverse. Large trees, bushy shrubs, long grasses, and small hills provide shelter to butterflies in the lush green vegetation. Because of the abundance of nectar, suitable food plants for laying eggs, and open sunny space, the area is home to many species of pollinators. There is a subtropical climate in the southern part of the study area and a temperate climate in the northern mountain fringes. Temperatures range from 7 degrees in winter to 37 degrees in summer. The area receives an average of 500 millimeters of rainfall each year. The Center for Biodiversity Studies comprises the Lead Botanical Garden, which is being developed over an area of about 437 acres. Out of this area, a leading botanic garden is being developed over an area of 10 acres. The park is rich in flora and fauna and has dense Chirr pine forests.

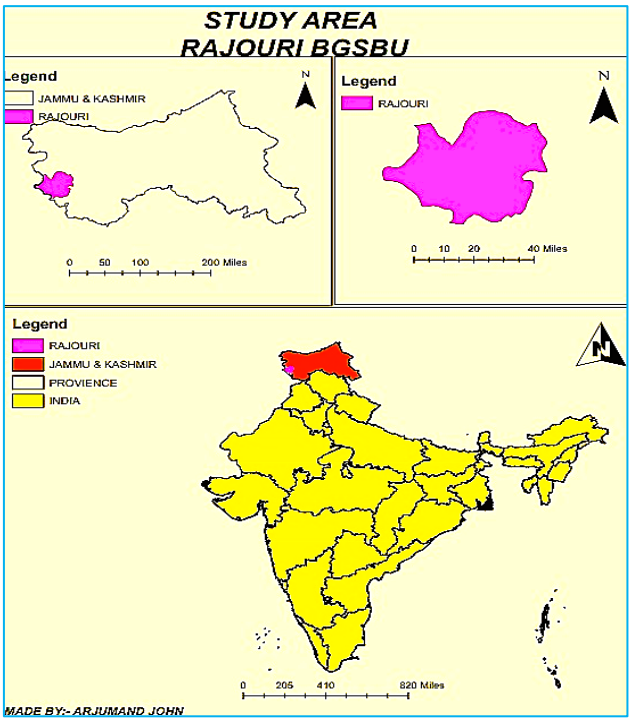


Fig 1 Study area map

MATERIALS AND METHODS

Method of study

The preserved and identified specimens were examined and the specimens apparently resembling each other were grouped together. They were identified based on the keys available [21-23] and further confirmed by comparing them with the identified specimens in NPC. Michener's [22] standard nomenclature was utilized to describe pilosity, sculptures, and genitalia, among other things. In the description, the term 'pilosity' referred to the type and organization of hairs, while 'sculptures' referred to punctures, depressions, and patterns on the cuticle. The freshly caught bees were frequently covered in pollen or nectar spillage, which disguised the morphological characteristics. To clean the specimens, the bee working group's bee wash procedure was used. The bees were cleaned with tap water, then a combination of warm water and dishwashing

liquid (a drop in 100ml), and then wiped with tissue paper. Thereafter, 95 percent alcohol was added to dehydrate the specimens, and they were blotted again. After 45 minutes, the specimens were put on a paper towel, which was gently folded to eliminate any moisture that remained on the specimens. Finally, the specimens were dried using a low-speed air blower. In a wet chamber between moist filter sheets, old or dry specimens were relaxed.

Table 2 Equipment's required during the study process

S. No.	Material required
1	Olympus microscope
2	Insect collecting net
3	Killing jar/bottle
4	Paper envelopes
5	Entomological pins
6	Stretching board / spreading board and relaxing jar
7	Ordinary pins
8	Forceps
9	Scissors
10	Insect cabinet/display case
11	Ethyl acetate
12	Naphthalene balls and phenol
13	Labels
14	Camera (Nikon)

Insect collection net

The pollinators were collected through an insect collection net with a telescopic handle consisting of a strong wire ring (diagram 30 cm). The net slowly moves until it is within range of the insect, then it is swung upwards while the lever is turned such that the net spins over and the seized insects cannot escape. If in case the pollinator is sitting on the ground, then bring the net over the pollinator, raise the end of it so that the pollinator can fly to the closed top and immediately close the mouth of the net by hand so that the captured insect cannot escape.

Killing bottle/ jar

Insect pollinators were simply killed in one of the easiest ways by using a killing jar. It was prepared by placing a one-to-two-inch layer of absorbent material (Plaster of Paris) on the bottom of the jar, a small amount of ethyl acetate was introduced and allowed to absorb. Blotters were put on top of the absorbent material and sealed. The lower part of the jar was covered with masking tape to protect it from sunlight and extend the power of the killing jar. Captured pollinators were placed in a killing jar for an extended period until they died.

Entomological pins

Insect pins vary in diameter and length and are numbered 0, 1, 2, 3, 4, 5, etc. The entomological pin was carefully inserted through the right side of the thorax. The thorax was pinched with a pin so that the pin was inserted through it. Approximately 3/8 inch of the pin should be visible over the insect's body.

Stretching board / spreading board

The spreading board consists of the groove in the middle, the body of the insect is placed on the board, and it varies in width for different-sized insects, gently press the wings down so they spread out flat, then put a thin strip of paper over each wing and pin the ends of the stripe to the board this will hold the wings flat until they dry out. The drying process may take up to two weeks.

Sampling methods

The findings presented here are based on a random survey carried out from March – 2018 to August – 2018. The total area of Pir Panjal Biodiversity Park was surveyed from morning to 04:00 p.m. usually, the period between 08:00 a.m. and 11:00 a.m. is considered as the peak time for most of the insect pollinator activity. Insect pollinators were photographed from different angles as often as possible to obtain sufficient photographs to enable the positive identification of species. Photographs were taken with a high-resolution digital camera. Pollinators were primarily identified directly in the field with the help of field guides followed by photography and capture. The collection was restricted to those specimens that could not be identified directly. In such cases, the pollinators were collected through an insect collection net with a telescopic handle consisting of a strong wire ring (diameter 30 cm). They were killed by pinching their thorax by taking proper care or killing the small specimen with ethyl acetate and finally placing it in the proper envelope. The collected specimens were placed in a hot air oven for about 1 hr. at 40 degree and later transferred to relaxing chambers for 24 hours containing moist absorbent cotton and a few drops of phenol to avoid any fungal growth. Later, the specimens were pinned with entomological pins of different sizes according to the size of the specimen. The pinned specimens were put on the stretching board after relaxing their wings, abdomen, and legs. The preserved and identified specimens were examined and the specimens that appeared similar to each other were grouped together. They were identified based on the keys available [21-23] and further confirmed by comparing them with the identified specimens in NPC. Michener's [22] standard nomenclature was utilized to describe pilosity, sculptures, and genitalia, among other things. The freshly caught pollinators were frequently covered in pollen or nectar spillage, which disguised the morphological characteristics. To clean the specimens, the pollinator working group's wash procedure was used. The pollinators (bees) were cleaned with tap water, then a combination of warm water and dishwashing liquid (a drop in 100ml), and then wiped with tissue paper. A solution of 95 percent alcohol was added to dehydrate the specimens, and they were blotted again. After 45 minutes, the specimens were put on a paper towel, which was gently folded to eliminate any moisture that remained on the specimens. Finally, the specimens were dried using a low-speed air blower. Wet chambers were used to relax old or dry specimens between moist filter sheets. Specimens were morphologically studied at Baba Ghulam Shah Badshah University Rajouri's Department of Zoology. The specimens were taken to the laboratory and sorted (both geographically and crop-wise), stretched, pinned, tagged, housed in insect collecting boxes, and prepared for morphometric research. A stereo-zoom microscope was used to record various morphological findings (OLYMPUS, SZX16).

The diversity of insect pollinators was assessed by Shannon-Weiner diversity index (H')

The Shannon Weiner diversity index was calculated by the formula given by Marg Alef [24]:

$$H' = -\sum pi \ln pi$$

Where, pi=Ni/N, Ni=total number of individuals in a species, and N=total number of individuals in all species.

Simpson diversity index

$$D = 1 - \sum pi^2$$

Evenness (E)

Is the measure of the relative abundance of each species in a habitat and shall be calculated by using the formula Pileous 1975):

E=H/lnS

Where;

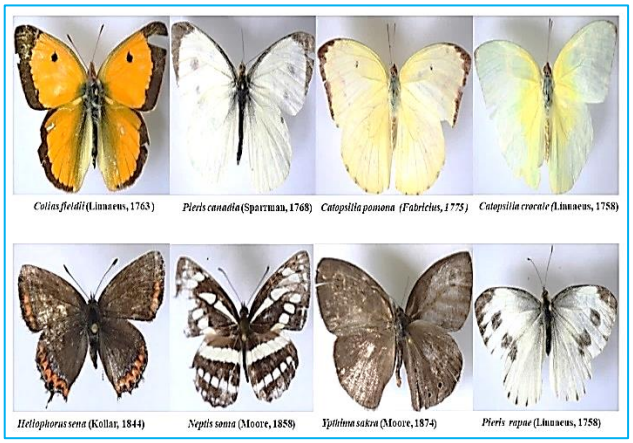
H is the Shannon index and S is the total number of species present.

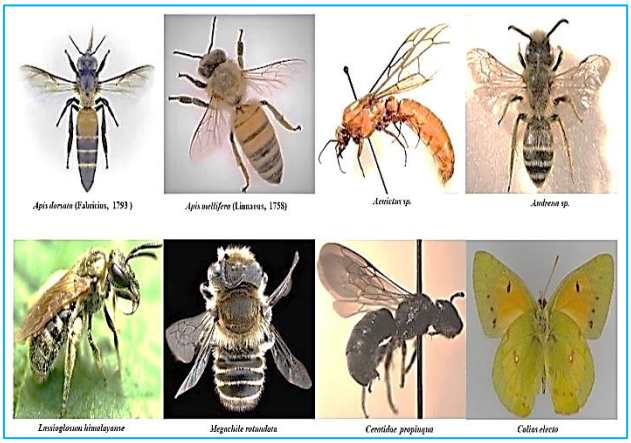
RESULTS AND DISCUSSION

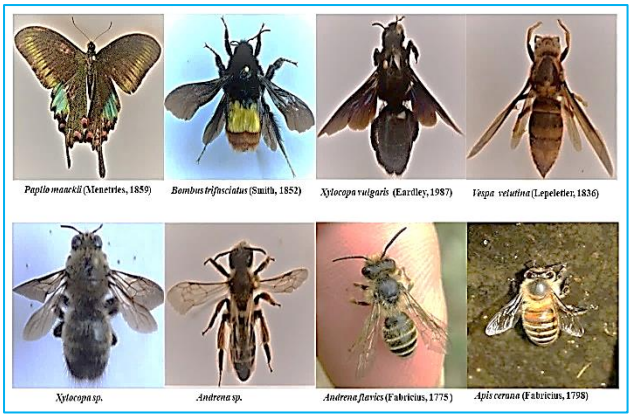
A total of twenty-five species of insect pollinators were identified from the collection sites falling in three orders, thirteen families, and twenty-one genera. Among Hymenoptera 10 species were recorded in 8 genera. Among Lepidoptera, thirteen species were identified in nine genera. Among Dipterans two species were identified in 2 genera. My findings are in accordance with Parry *et al*. [3] who studied the pollinator diversity of apple orchards in the Kashmir Himalaya. Ganie *et al.* [25] studied the native insect pollinators in apple orchards under different management practices in the Kashmir valley (Table 3). Foraging activity (Emergence, peak, and cessation time) of different insect pollinators was also assessed (Table 5). The early initiation time was first observed in case of *Apis cerana* (7:17±0.03), followed by *Xylocopa fenestrate* (7:20±0.002), *Apis mellifera* (8:13±0.005), *Lassioglossum himalayanse* (8:13±0.005), *Andrena flaviups* (8:13±0.005), *Apis dorsata* (9:11±0.004), *Vespa velutina* (9:15±0.04). The peak time for *Apis cerana* was observed to be (12:00-13:15), followed by *Xylocopa fenestrate* (11:30-12:30), *Apis mellifera* (14:00-15:00), *Lassioglossum himalayanse* (11:00-12:30), *Andrena flaviups* (11:00-12:30), *Apis dorsata* (12:00-14:00), *Vespa velutina* (10:00-12:30). Similarly, the early cessation was found in case of *Lassioglossum himalayanse* (16:11±0.004), followed by the *Andrena flaviups* and *Xylocopa fenestrate* (16:19±0.019), *Vespa velutina* (17:10±0.005), *Apis mellifera* (17:20±0.002), *Apis dorsata* (18:13±0.005), *Apis cerana* (18:19±0.019). A simple measure of relative dominance status is described which we have termed the Dominance Index: First, we select a study area, and after this, we record the dominance index of different orders, as shown in (Fig 2). The highest Dominance Index was shown by the order Hymenoptera; (*Apis cerana*, *Apis mellifera* and *Apis dorsata*) followed by the *Diptera* and then Lepidoptera.

Table 3 Insect pollinators identified from Pir Panjal biodiversity park BGSBU Rajouri

S. No.	Order	Family	Scientific name	Common name	Author / year
1	Hymenoptera	Apidae	*Bombus trifascitus*	Three banded bumble bees	Smith 1852 [26]
2	Hymenoptera	Apidae	*Xylocopa fenestrate*	Carpenter bees	Eardley 1987 [27]
3	Hymenoptera	Apidae	*Apis cerana*	Asiatic honeybee	
4	Hymenoptra	Apidae	*Apis mellifera*	European honeybee	Linnaeus 1758 [28]
5	Hymenoptra	Apidae	*Apis dorsata*	Gaint honeybee	Fabricius 1793 [29]
6	Hymenoptera	Vespidae	*Vespa velutina*	Asian hornet	Lepeletier 1836
7	Hymenoptera	Formicidae	*Aenictus sp.*	Large army ant	Paraenictus Wheeler 1929, Typhlatta Smith 1857 [30-31]
8	Hymenoptera	Helictidae	*Losioglosum himalayanse*	Sweet bee	Bingham 1898 [32]
9	Hymenoptera	Megachalidae	*Megachile rotundata*	Leaf cutting bee	Fabricius 1787 [33]
10	Hymenoptera	Andranidae	*Andrena flavicps*	Yellow legged minning bee	Fabricius 1775 [34]
11	Hymenoptera	Ceratidae	*Ceratina propinqua*	Small carpenter bee	Cameron 1897 [35]
12	Diptera	Calliophoridae	*Calliphora vicina*	Blue blowfly	Robineau-Desvoidy 1830 [36]
13	Diptera	Sarcophagidae	*Sarcophaga spec.*	Flesh flies	Meigen 1826 [37]
14	Lepidoptera	Pieridae	*Pieris rapae*	Small cabbage white	Linnaeus 1758 [28]
15	Lepidoptera	Pieridae	*Pieris canadia*	Indian cabbage white	Sparrman 1768
16	Lepidoptera	Pieridae	*Catopsilia Pomona*	Common emigrant	Fabricius 1775 [38]
17	Lepidoptera	Papilionidae	*Papilio demoleus*	Lemmon butterfly	Linnaeus 1758 [28]
18	Lepidoptera	Papilionidae	*Papilio maackii*	Alpine black swallow tail	Menetries 1859
19	Lepidoptera	Pieridae	*Catopsilia pyranthe*	Lemmon emigrant	Linnaeus 1758 [28]
20	Lepidoptera	Pieridae	*Catopsilia Pomona*	Encyclopedia of life	Fabricius 1775 [38]
21	Lepidoptera	Pieridae	*Colias electo*	Clouded emigrant	Linnaeus 1763 [39]
22	Lepidoptera	Pieridae	*Colias romanovia*	Clouded yellows	Grum -Grshimalio 1885
23	Lepidoptera	Nymphalidae	*Ypthima sckra*	Himalayan five ring	Moore 1874
24	Lepidoptera	Nymphalidae	*Neptis suma*	Sullied sailer	Moore 1858
25	Lepidoptera	Lycaenidae	*Heliophorus sena*	Sorrel sapphire	Kollar 1844







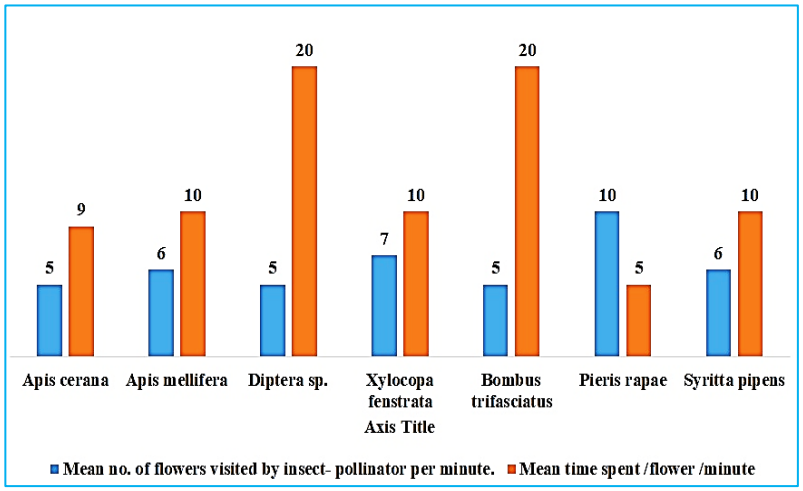


Fig 3.1 Foraging activities of different insect pollinators in BGSBU Pir-Panjal Biodiversity Park

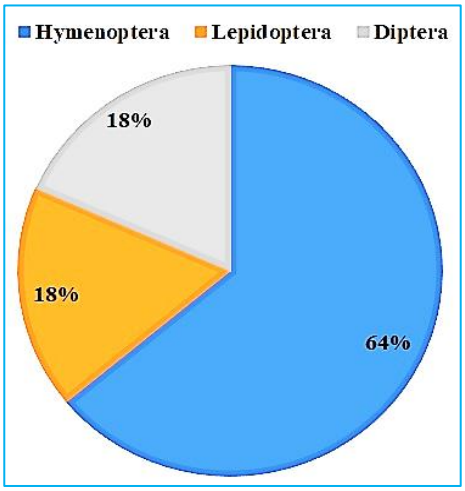


Fig 3.2 Dominance index (Evenness)

Table 4 Diversity of Insect Pollinators from different regions of Rajouri Jammu and Kashmir UT

	BGSBU Campus	Dhauladhar	Darhal	Sunderbani	Thanna mandi	Nowshera
Taxa_S	25	25	25	25	25	25
Individuals	920	563	487	425	388	452
Dominance_D	0.09809	0.1215	0.1022	0.09711	0.06857	0.1371
Simpson_1-D	0.9019	0.8785	0.8978	0.9029	0.9314	0.8629
Shannon_H	2.615	2.592	2.702	2.788	2.926	2.645
Evenness_e^H/S	0.5469	0.5343	0.5963	0.6499	0.7464	0.5635
Margalef	3.517	3.79	3.878	3.966	4.026	3.926
Equitability_J	0.8125	0.8053	0.8394	0.8661	0.9091	0.8218

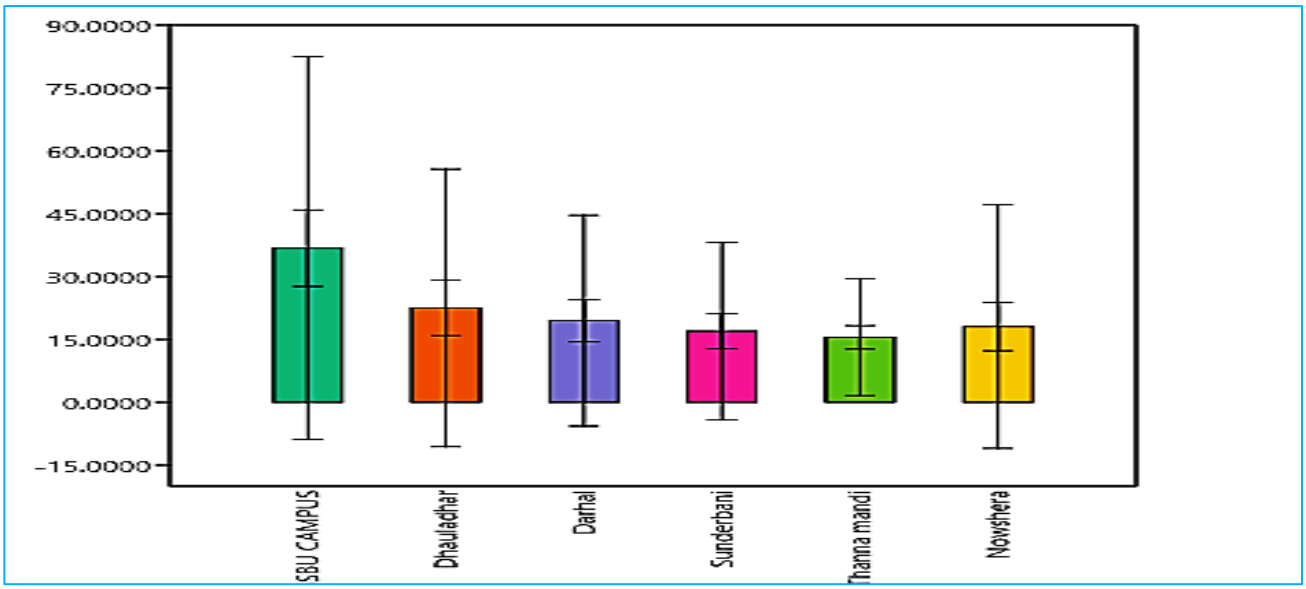


Fig 4 BOX PLOT of pollinator diversity

Table 5 Foraging activity (Emergence, peak, and cessation time) of different insect pollinators in BGSBU Pir Panjal biodiversity

Insect pollinators or visitors	Mean population foraging time (Hours)		
	Initiation	Peak	Cessation
Apis cerana	7:17 ± 0.03	12:00 – 13:15	18:19 ± 0.019
Xylocopa fenestrate	7:20 ± 0.002	11:30 – 12:30	16:19 ± 0.019
Apis mellifera	8:13 ± 0.005	14:00 – 15:00	17:20 ± 0.002
Lassioglossum himalayanse	8:13 ± 0.005	11:00 – 12:30	16:11 ± 0.004
Andrena flaviups	8:13 ± 0.005	11:00 – 12:30	16:19 ± 0.019
Apis dorsata	9:11 ± 0.004	12:00 – 14:00	18:13 ± 0.005
Vespa velutina	9:15 ± 0.04	10:00 – 12:30	17:10 ± 0.005

CONCLUSION

The study area supported a rich diversity of insect pollinators accounting wide variety of plants (Floral Resources) which provide them with an ideal breeding habitat. My study revealed 25 species of insect pollinators within the BGSBU campus, as they are specific to different seasons and this survey was done for one year. The present study is an attempt to prepare a list of insect pollinators in the study area which will be subjected to continuous updating for future reference. It was observed that Hymenoptera were the most insect pollinator species and had the highest number of individual species observed during the study, and insect orders like Diptera and Lepidoptera had the least member of species observed during the survey. The study site houses a rich diversity of insect pollinators mainly attributed to the micro-habitat available within the eco-forest. Any change in the landscape, land use pattern, or loss of vegetation in the habitat is harmful to the diversity of insect pollinators in terms of species richness and leads to a potential loss of endemism and endangerment. The diversity of insect pollinators depends upon the floral diversity. So, the conservation of insect pollinators would be possible by the enhancement of the vegetation composition of habitats around the study area.

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