



Study on diversity, distribution and relative abundance of insect pollinators on *Valeriana jatamansi* Jones in different altitudinal populations of Shimla hills, western Himalaya

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Abstract

Valeriana jatamansi Jones is a perennial medicinal herb that belongs to the family Caprifoliaceae. In India, this species is on the verge of extinction due to the over-exploitation of its roots/rhizomes from its natural habitat to meet the burgeoning industrial demand. Therefore, a study on diversity, distribution, and relative abundance of various insect pollinators of *Valeriana jatamansi* Jones was carried out by collecting insect pollinators in different localities i.e. Tara Devi (1,927 m), Dhalli (2,155 m), Chaura Maidan (2,100 m), Fagu (2,576 m), Matiyana (2,419 m), Kufri (2,609 m), Kharapather (2,703 m) and Kupper (2,850 m) in Shimla hills of Western Himalaya. Diversity and distribution study showed that *Valeriana jatamansi* Jones flowers were visited by 51 species of insects pollinators belonging to 5 orders and 12 families of class Insecta, of these, 33 species belonged to Diptera, 4 to Hymenoptera, 9 to Lepidoptera, 3 to Coleoptera and 2 to Hemiptera. During the relative abundance study, it has been observed that dipterans were the most abundant insect pollinators in all eight localities i.e. Tara Devi (80.14%), Kufri (92.62%), Kharapather (82.73%), Kupper (82.91%), Matiyana (63.2%), Fagu (91.10%), Dhalli (84.97%), Chaura Maidan (87.59%) followed by hymenopterans in Tara Devi (14.04%), Kharapather (9.81%), and Kupper (8.49%), lepidopterans in Kufri (2.95%), Matiyana (12.41%), Fagu (5.44%) and Dhalli (5.67%) and coleopterans in Chaura Maidan (5.50%).

Keywords: insect pollinators, *Valeriana jatamansi*

Introduction

Valeriana jatamansi Jones is a medicinal and aromatic plant of Himalaya. It has become a threatened and endangered plant species and is included in the endangered category by IUCN (Maurya *et al.*, 2017) [1]. *V. jatamansi* Jones is a perennial medicinal herb that belongs to the family Caprifoliaceae (initially it was a separate family Valerianaceae; APG, 2009; APG III, 2011) [2, 3], commonly known as Indian valerian (English), Mushkbala (Kashmiri), Sughanthdawal, or Tagar (Sanskrit) (Raina and Srivastava, 1992) [4], is a native of Himalaya with extent distribution from Afghanistan to southwest China, India, Nepal, Bhutan, Myanmar, and Burma. *V. jatamansi* has a relatively high level of genetic diversity and therefore has greater environmental adaptability. The adaptability is also demonstrated by the distribution of this species, which extends between a wide altitudinal range of 1000 to 3000-meter elevation, and is generally preferred to grow on hill slopes, moist places, damp woods, ditches, and along streams (Rather *et al.*, 2012; Jugran *et al.*, 2013) [5, 6]. The flowering and fruiting time for the species is March–June (Jugran *et al.*, 2013) [6]. In the Himalayan region, this species grows frequently under the canopy of *Quercus leucotricophora*, *Pinus roxburghii*, mixed forests, and grassy habitats.

In India, this species is at the edge of extinction due to the over-exploitation of its roots and rhizomes of its natural habitation to meet the increasing industrial demand. The industrial demand for this plant is increasing daily for phytopharmaceutical and essential oil-based products. Moreover, *V. jatamansi* has also been reported as a psychopharmacological agent (Mishra, 2004; Violon and Vercruyse, 1983; Ernst, 2010) [7, 8, 9] and is highly effective

against leprosy (Kaur *et al.*, 1999) [10], epilepsy and hysteria (Wagner *et al.*, 1980) [11], nerve diseases (Diapher and Hindwarch, 2004) [12], scorpion bite (Chopra *et al.*, 1956) [13], cholera (Pande and Shukla, 1993) [14], anxiolytic properties (You *et al.*, 2012) [15], and curing Lewy body dementia (Bagchi and Hooper, 2011) [16]. *V. jatamansi* dried rhizomes are also employed in perfumes, hair oil, and incense (Bhattacharjee, 2008; Kirtikar and Basu, 1975; Prakash and Mahrotra, 1994) [17, 18, 19]. Roots are acrid and bitter and are used as carminative, laxative, and hypnotic. Considering its endangered category and medicinal importance, the present study was carried out on the diversity, distribution, and relative abundance of insect pollinators of *V. jatamansi* Jones in the Shimla hills of Western Himalaya. The greatest service provides to mankind by insects is the pollinators of flowers which otherwise will not set fruits or seeds. Pollinators provide an essential ecosystem service that results in the outcrossing and sexual reproduction of many plants including *V. jatamansi*.

Material and methods

The present investigation was carried out on insect pollinators of *Valeriana jatamansi* in different localities of Shimla Hills, Western Himalaya. The present studies were conducted during the flowering season i.e. from March to May, in the years 2018 to 2021. The experimental sites where these studies were conducted are Tara Devi (1,927 m), Dhalli (2,155 m), Chaura Maidan (2,100 m), Fagu (2,576 m), Matiyana (2,419 m), Kufri (2,609 m), Kharapather (2,703 m) and Kupper (2,850 m).

The relative abundance of different insect pollinators on *V. jatamansi* was determined in terms of their visit per 500

flowers/10 minutes (Verma and Chauhan, 1985) [20]. The observation was recorded during 0900-1000, 1200-1300, and 1500-1600 hours of a day and the average count at these hours gives an abundance of insect pollinators for that particular day (Mattu and Kumar 2016; Southwood, 1978) [21, 22]. The species diversity and relative abundance were analyzed statistically from the collected data (Snedcor and Cochran, 1967) [23]. In the same way, family number, family percentage, order number, and order percentage were calculated for all the sites of insect collection and the results were tabulated.

$$\text{Relative Abundance of Species} = \frac{\text{Total number of individuals of species A}}{\text{Total number of individuals of all species}} \times 100$$

Results and discussion

Diversity and distribution studies of insect pollinators of *Valeriana jatamansi* Jones revealed a total of 51 species from different areas of Shimla hills, Western Himalaya, of these 51 species, 33 belonged to the order Diptera, 4 to Hymenoptera, 9 to Lepidoptera, 3 to Coleoptera, and 2 to Hemiptera.

It was observed that dipteran were the most dominant represented by 4 families viz., Syrphidae, Tachinidae, Calliphoridae and Bombyliidae, of these 26 species belongs to family Syrphidae (*Parasyrphus lineolus*, *Syrphus torvus*, *Syrphus vitripennis*, *Eristalis himalayensis*, *Eristalis cerealis*, *Eristalis tenax*, *Melanostoma orientale*, *Melanostoma mellinum*, *Melanostoma scalare*, *Syrphid pipiens*, *Sphaerophoria (Sphaerophoria) indiana*, *Chrysotoxum baphyrus*, *Eupeodes (Metasyrphus) latifasciatus*, *Eupeodes luniger*, *Dasysyrphus lenensis*, *Scaeva pyrastris*, *Eristalinus (Eristalinus) megacephalus*, *Eristalinus (Eristalinus) arvorum*, *Episyrphus (Episyrphus) balteatus*, *Meliscaevia cinctella*, *Rhingia (Rhingia) laticincta*, *Eumerus aurifrons*, *Platycheirus albimanus*, *Platycheirus nigrofemoratus*, *Eristalinus (Eristalinus) paria*, and *Brachyopa notata*); 3 to Tachinidae (*Gymnosoma sylvaticum*, *Nowickia marklini*, and *Tachina sacontala*); 2 to Calliphoridae (*Calliphora vomitoria* and *Lucilia papuensis*) and Bombyliidae (*Bombylius major* to Bombyliidae).

Among the four hymenopterans species, two species i.e. *Apis cerana* and *Apis mellifera* belong to the family Apidae and *Lasioglossum minutissimum* and *Megachilidae* sp. to family Halictidae and *Megachilidae* respectively were found to visit *V. jatamansi* flowers. Order Lepidoptera was represented by 9 species i.e. *Heliophorus sena*, *Heliophorus androcles*, *Celastrina lavendularis*, *Celastrina huegleli* (Lycaenidae), *Pieris canidia*, *Belenois aurota*, *Eurema hecabe*, *Eurema laeta* (Pieridae), and *Neptis mahendra* (Nymphalidae). However, in order Coleoptera, 3 insect pollinator species of the family Coccinellidae were recorded i.e. *Oenopia sexareata*, *Hippodamia variegata*, and *Coccinella septempunctata*. Hemiptera was represented by 2 pollinator species i.e. *Orthops scutellatus* and *Pinalitus rubricatus* of the family Miridae. Among all these, dipterans were the most abundant pollinators comprising 33 species visiting *V. jatamansi* (Table I).

Different investigators have reported numbers of pollinators on many medicinal plants and fruit crops in Western Himalayas. Thakur and Katoch (2022) [24] recorded a total of 29 insect pollinators on two medicinal plants i.e. *Bergenia ciliata* (Haw.) Sternb. and *Vinca major* (Linnaeus) in different localities of Shimla hills, of these 29 insect

pollinator species, 8 have been collected on *Bergenia ciliata* (Haw.) Sternb. belongs to 3 orders i.e. Coleoptera, Hymenoptera, and Diptera, whereas 24 species have been reported and collected on *Vinca major* (L.) under four orders i.e. Coleoptera, Hymenoptera, Lepidoptera, and Diptera. Kumar (1995) [25] described thirty species of insect pollinators on almond bloom in Shimla hills, belonging to 5 orders and 17 families of class Insecta. Relative abundance studies on almonds indicated that *Apis cerana* was the most abundant species followed by *A. mellifera* and *Halictus dasygaster*. Whereas, Kumar (1997) [26] documented that apple flowers were visited by 49 insect species in the Himalayan belt. Similarly, Mattu and Nirala (2016) [27] studied that apple flowers were visited by 41 species of insect pollinators in Shimla hills which belong to 5 orders and 16 families of class Insecta. Chauhan *et al.* (2021) [28] recorded 23 species of insect pollinators of mango from Kyarda Doon valley of district Sirmour, Himachal Pradesh, of these, 11 species belonged to Diptera, 6 to Coleoptera, 4 to Hymenoptera, and 2 to Hemiptera. Similarly, Thakur and Poonam (2022) [29] recorded 25 species of insect pollinators of *Punica granatum* L. belonging to 4 orders and 11 families of class Insecta from a different area of Himachal Pradesh.

The relative abundance studies revealed that dipterans were the most prominent insect visitors on *V. jatamansi* in all localities i.e. Tara Devi (81.64%) Chaura Maidan (81.82%), Dhalli (84.97%), Fagu (87.41%), Kufri (91.21%), Matiyana (64.34%), Kharapather (82.97%) and Kupper (82.91%) followed by hymenopterans, lepidopterans, coleopterans, and hemipterans. During this period, 33 dipterans were recorded, of which 26 belongs to family Syrphidae, 4 to Tachinidae, 2 to Calliphoridae, and one to Bombyliidae. Insect pollinators belonging to the family Syrphidae were the most common in all the localities i.e. Tara Devi (79.47%), Chaura Maidan (81.82%), Dhalli (81.76%), Fagu (82%), Kufri (90.09%), Matiyana (61.28%), Kharapather (79.29%) and Kupper (74.43%) followed by family Tachinidae, Calliphoridae and Bombyliidae (Table 2,3,4).

Maximum abundance of dipterans was observed in Kufri (91.21%) followed by Fagu (87.41%), Dhalli (84.97%), Kharapather (82.97%), Kupper (82.91%), Chaura Maidan (81.82%), Tara Devi (81.64%) and Matiyana (64.34%). Similarly, the maximum number of insect pollinators belonging to the family Syrphidae was observed in Kufri (90.09%) (Table 2,3,4).

Among all the insect pollinators, *Sphaerophoria (Sphaerophoria) indiana* was the most abundant insect visitor on *V. jatamansi* flowers in six out of eight localities i.e. Tara Devi (10.17±5.98, 32.98%), Kharapather (4±0.89, 11.05%), Kupper (2.83±1.72, 16%), Matiyana, (3.67±0.82, 13.51%), Fagu (13.33±1.37, 19.70%), and Dhalli (15.83±3.87, 23.39%) and also found among the common visitors at Chaura Maidan (5.33±1.63, 19.38%) and Kufri (5.33±0.52, 9.06%) (Table 2,3,4). *Rhingia (Rhingia) laticincta* which was the most abundant insect pollinator visited flowers of *V. jatamansi* in Kufri (10.17±2.64, 17.28%) and Chaura maidan (5.5±1.22, 22.75%) and among most common visitors in Tara Devi (8.5±4.59, 27.57%) and Dhalli (10.67±2.34, 15.76%) (Table 2,3,4).

Important dipterans pollinators of *V. jatamansi* which were observed in all locations are *Parasyrphus lineolus* (Tara Devi, 2.69%), (Kufri, 4.24%), (Kharapather, 10.14%), (Matiyana, 1.21%), (Kupper, 1.87%), (Fagu, 0.74%), (Dhalli, 1.48) and (Chaura Maidan, 7.27%); *Melanostoma*

mellinum (Tara Devi, 4.86%), (Kufri, 5.10%), (Khadapather, 5.52%), (Matiyana, 9.20%), (Kupper, 4.69%), (Fagu, 12.56%), (Dhalli, 3.69%) and (Chaura Maidan 1.82%); *Meliscaevia cinctella* (Tara Devi 3.24%), (Kufri, 1.69%), (Khadapather, 1.38%), (Matiyana, 3.68%),

(Kupper, 4.70%), (Fagu 4.18%), (Dhalli, 1.48%) and (Chaura maidain,1.82%) and *Syritta pipiens* (Tara Devi, 2.17%), (Kufri, 2.83%), (Khadapather, 1.85%), (Matiyana, 1.84%), (Kupper 2.83%), (Dhalli, 1.48%) and (Chaura Maidan, 3.64%) (Table 2,3,4).

Table 1: Systematic list of insect pollinators of *Valeriana jatamansi* from different areas of Himachal Pradesh

Order	Family	Fauna/ Insect species
Diptera	Syrphidae	<i>Parasyrphus lineolus</i> (Zetterstedt, 1843)
		<i>Syrphus torvus</i> (Osten Sacken, 1875)
		<i>Syrphus vitripennis</i> Meigen, 1822
		<i>Eristalis himalayensis</i> Brunetti, 1908
		<i>Eristalis cerealis</i> Fabricius, 1805
		<i>Eristalis tenax</i> (Linnaeus, 1758)
		<i>Melanostoma orientale</i> (Wiedermann, 1824)
		<i>Melanostoma mellinum</i> (Linnaeus, 1758)
		<i>Syritta pipiens</i> (Linnaeus, 1758)
		<i>Melanostoma scalare</i> (Fabricius 1794)
		<i>Sphaerophoria (Sphaerophoria) indiana</i> Bigot, 1884
		<i>Chrysotoxum baphyrus</i> Walker, 1849
		<i>Eupeodes (Metasyrphus) latifasciatus</i> Macquart, 1829
		<i>Eupeodes luniger</i> (Meigen, 1822)
		<i>Dasysyrphus lenensis</i> Bagatshanova, 1980
		<i>Scaeva pyrastris</i> (Linnaeus, 1758)
		<i>Meliscaevia cinctella</i> (Zetterstedt, 1843)
		<i>Eristalinus (Eristalinus) arvorum</i> (Fabricius 1787)
		<i>Episyrphus (Episyrphus) balteatus</i> (De Geer, 1776)
		<i>Platycheirus nigrofemoratus</i> (Kanervo, 1934)
	<i>Rhingia (Rhingia) laticincta</i> Brunetti, 1907	
	<i>Eumerus aurifrons</i> (Wiedermann, 1824)	
	<i>Platycheirus albimanus</i> (Fabricius, 1781)	
	<i>Eristalinus (Eristalinus) paria</i> (Bigot, 1880)	
	<i>Eristalinus (Eristalinus) megacephalus</i> (Rossi, 1794)	
	<i>Brachyopa notata</i> Osten Sacken, 1875	
	Tachinidae	<i>Gymnosoma sylvaticum</i> Zimin, 1966
		<i>Nowickia marklini</i> Zetterstedt, 1838
<i>Tachina sacontala</i> Walker, 1849		
<i>Estheria petiolata</i> (Bonsdorff, 1866)		
Calliphoridae	<i>Calliphora vomitoria</i> (Linnaeus, 1758)	
	<i>Lucilia papuensis</i> Macquart, 1843	
Bombyliidae	<i>Bombylius (Bombylius) major</i> Linnaeus, 1758	
Hymenoptera	Apidae	<i>Apis cerana</i> Fabricius, 1793
		<i>Apis mellifera</i> Linnaeus, 1758
	Halictidae	<i>Lasioglossum minutissimum</i> (Kirby 1802)
	Megachilidae	<i>Megachilidae</i> sp.
Coleoptera	Coccinellidae	<i>Coccinella septempunctata</i> (Linnaeus 1758)
		<i>Hippodamia variegata</i> (Goeze, 1777)
		<i>Oenopia sexareata</i> (Mulsant, 1853)
Hemiptera	Miridae	<i>Pinalitus rubricatus</i> (Fallen, 1807)
		<i>Orthops scutellatus</i> Uhler, 1877
LEPIDOPTERA	Pieridae	<i>Pieris canidia</i> (Sparrman, 1768)
		<i>Belenois aurota</i> (Fabricius 1793)
		<i>Eurema laeta</i> Boisduval, 1836
		<i>Eurema hecabe</i> (Linnaeus, 1758)
	Nymphalidae	<i>Neptis mahendra</i> Moore, 1872
		<i>Heliophorus sena</i> (Kollar 1844)
	Lycaenidae	<i>Heliophorus androcles</i> (Westwood, 1851)
		<i>Celastrina lavendularis</i> (Moore, 1877)
		<i>Celastrina huegeli</i> (Moore, 1882)

Table 2: Relative abundance of different insect pollinators visiting *Valeriana Jatamansi* Jones flowers from Tara Devi, Chaura Maidan, and halli localities of Shimla hills. (No. of insects/500 flowers/10 minutes)

Order	Family	Genus/ Species	Locality: Tara Devi				Locality: Chaura maidan				Locality: Dhalli									
			Mean ±S.E.	Population %	Family %	Order %	Mean ±S.E.	Population %	Family %	Order %	Mean± S.E.	Population%	Family %	Order %						
Diptera	Syrphidae	<i>Parasyrphus lineolus</i> (Zetterstedt)	0.83±0.75	2.69	79.47	81.64	2±1.09	7.27	81.82	81.82	1±1.26	1.48	81.76	84.97						
		<i>Syrphus torvus</i> (Osten Sacken)																		
		<i>Syrphus vitripennis</i> Meigen						0.33±0.52			1.2						0.67±0.82	0.99		
		<i>Eristalis himalayensis</i> Brunetti															0.5±0.84	0.74		
		<i>Eristalis cerealis</i> Fabricius	0.5±0.55	1.62				0.67±0.82			2.44						0.33±0.52	0.49		
		<i>Eristalis tenax</i> (Linnaeus)	0.33±0.52	1.07				0.5±0.55			1.82						0.33±0.52	0.49		
		<i>Melanostoma orientale</i> (Wiedermann)						0.83±1.17			3.02						2.5±1.87	3.69		
		<i>Melanostoma mellinum</i> (Linnaeus)	1.5±1.05	4.86				0.5±0.86			1.82						2.5±1.87	3.69		
		<i>Syrirta pipiens</i> (Linnaeus)	0.67±0.82	2.17				1±0.89			3.64						1±1.09	1.48		
		<i>Melanostoma scalare</i> (Fabricius)						0.67±0.52			2.44						1.83±1.17	2.70		
		<i>Sphaerophoria (Sphaerophoria) Indiana</i> Bigot	10.17±5.98	32.98				5.33±1.63			19.38						15.83±3.87	23.39		
		<i>Chrysotoxum baphyrus</i> Walker						1.17±1.17			4.25						0.17±0.41	0.25		
		<i>Eupeodes (Metasyrphus) latifasciatus</i> Macquart						0.5±0.55			1.82						0.33±0.52	0.49		
		<i>Eupeodes luniger</i> (Meigen)	1±0.89	3.24				1.33±0.82			4.84						0.67±0.82	0.99		
		<i>Dasysyrphus lenensis</i> Bagatshanova															0.67±1.21	0.99		
		<i>Scaeva pyrastris</i> (Linnaeus)															0.5±0.84	0.74		
		<i>Meliscaevia cinctella</i> (Zetterstedt)	1±0.89	3.24				0.5±0.55			1.82						1±0.89	1.48		
		<i>Eristalinus (Eristalinus) arvorum</i> (Fabricius)															0.67±0.82	0.99		
		<i>Episyrphus (Episyrphus) balteatus</i> (De Geer)															11.5±2.17	16.99		
		<i>Platycheirus nigrofemoratus</i> (kanerv)															0.33±0.52	0.49		
	<i>Rhingia (Rhingia) laticincta</i> Brunetti	8.5±4.59	27.57		5.5±1.22	20				10.67±2.34	15.76									
	<i>Eumerus aurifrons</i> (Wiedermann)																			
	<i>Platycheirus albimanus</i> (Fabricius)									1.5±1.38	2.22									
	<i>Eristalinus (Eristalinus) paria</i> (Bigot)									0.33±0.52	0.49									
	<i>Eristalinus (Eristalinus) megacephalus</i> (Ross)									0.5±0.84	0.74									
	<i>Brachyopa notata</i> Osten Sacken																			
	Tachinidae	<i>Gymnosoma sylvaticum</i> Zimin			2.17															
		<i>Estheria petiolate</i> (Bonsdorff)	0.67±0.82	2.17																
<i>Nowickia marklini</i> Zetterstedt																				
<i>Tachina sacontala</i> Walker																				
Calliphoridae	<i>Calliphora vomitoria</i> (Linnaeus)									0.67±0.82	0.99	2.47								
	<i>Lucilia papuensis</i> Macquart									1±0.89	1.48									
Bombyliidae	<i>Bombylius (Bombylius) major</i> Linnaeus									0.5±0.84	0.74	0.74								
Hymenoptera	Apidae	<i>Apis cerana</i> Fabricius	2±1.41	6.49	11.90	12.97	0.5±0.55	1.82	3.64	9.09	0.83±0.75	1.23	2.96	4.44						
		<i>Apis mellifera</i> Linnaeus	1.67±0.82	5.41											1.17±0.75	1.73				
	Halictidae	<i>Lasioglossum minutissimum</i> (Kirby)	0.33±0.52	1.07	1.07		1±0.63	3.64	3.64		0.67±0.82	0.99	0.99							
	Megachilidae	<i>Megachilidae</i> spp.					0.5±0.55	1.82	1.82		0.33±0.52	0.49	0.49							
Coleoptera	Coccinellidae	<i>Coccinella septempunctata</i> (Linnaeus)	0.33±0.52	1.07	1.07	1.07	0.5±0.55	2.07	4.84	4.84	1±1.09	1.48	3.45	3.45						
		<i>Hippodamia variegata</i> (Goeze)													0.83±0.98	1.23				
		<i>Oenopia sexareata</i> (Mulsant)													0.33±0.52	1.36	0.5±0.55	0.74		
Hemiptera	Miridae	<i>Pinalitus rubricatus</i> (Fallen)	0.83±0.98	2.69	2.69	2.69	0.67±1.03	2.77	4.25	4.25	0.5±0.55	0.74	1.48	1.48						

Lepidoptera	Pieridae	<i>Orthops scutellatus</i> Uhler					0.5±0.84	2.07			0.5±0.84	0.74			
		<i>Pteris canidia</i> (Sparrman)	0.5±0.84	1.62	1.62	1.62					0.5±0.84	0.74	0.99	5.67	
		<i>Belenois aurota</i> (Fabricius)													
		<i>Eurema laeta</i> Boisduval													
	<i>Eurema hecabe</i> (Linnaeus)														
	Nymphalidae	<i>Neptis mahendra</i> Moore			1.62	1.62					0.17±0.41	0.25	0.25	4.43	
	Lycaenidae	<i>Heliophorus sena</i> (Kollar)										1±1.26			1.48
		<i>Heliophorus androcles</i> (Westwood)										0.5±0.84			0.74
		<i>Celastrina lavendularis</i> (Moore)										0.33±0.82			0.49
		<i>Celastrina huegleri</i> (Moore)								1.17±1.17	1.73				

* Each value is an overall average for an insect species S.E. = Standard error about the mean

Table 3: Relative abundance of different insect pollinators visiting *Valeriana Jatamansi* Jones flowers from Kufri, Fagu, and Matiyana Localities of Shimla hills. (No. of insects/500 flowers/10 minutes)

Order	Family	Genus Species	Locality: Kufri			Locality: Fagu			Locality: Matiyana					
			Mean ±S.E.	Population %	Family%	Order %	Mean ±S.E.	Population%	Family%	Order %	Mean ±S.E.	Population %	Family %	Order %
Diptera	Syrphidae	<i>Parasyrphus lineolus</i> (Zetterstedt)	2.5±0.96	4.24	90.09	91.21	0.5±0.55	0.74	82	87.41	0.33±0.52	1.21	61.28	64.34
		<i>Syrphus torvus</i> (Osten Sacken)	0.17±0.40	0.28			0.17±0.41	0.25			1.17±0.75	4.31		
		<i>Syrphus vitripennis</i> Meigen	2±1.41	3.40			0.83±1.33	1.23						
		<i>Eristalis himalayensis</i> Brunetti	0.67±0.82	1.13			0.33±0.82	0.49			0.33±0.82	1.21		
		<i>Eristalis cerealis</i> Fabricius	1.67±1.63	2.83			2.67±1.50	3.95			0.83±0.75	3.05		
		<i>Eristalis tenax</i> (Linnaeus)	2.5±1.38	4.24			5±2.61	7.39			0.5±0.84	1.84		
		<i>Melanostoma orientale</i> (Wiedermann)	3.33±0.82	5.66			6.17±2.79	9.12			1±0.89	3.68		
		<i>Melanostoma mellinum</i> (Linnaeus)	3±1.26	5.10			8.5±3.94	12.56			2.5±0.55	9.20		
		<i>Syritta pipiens</i> (Linnaeus)	1.67±0.82	2.83			1.83±0.75	2.70			0.5±0.84	1.84		
		<i>Melanostoma scalare</i> (Fabricius)	3±0.63	5.10			2±0.89	2.95			0.83±1.17	3.05		
		<i>Sphaerophoria (Sphaerophoria) Indiana</i> Bigot	5.33±0.52	9.06			13.33±1.37	19.70			3.67±0.82	13.51		
		<i>Chrysotoxum baphyrus</i> Walker					0.67±0.82	0.99						
		<i>Eupeodes (Metasyrphus) latifasciatus</i> , Macquar					0.33±0.52	0.49						
		<i>Eupeodes luniger</i> (Meigen)	3.83±0.75	6.51			0.83±0.98	1.23			0.17±0.41	0.63		
		<i>Dasysyrphus lenensis</i> Bagatshanova	1.33±1.21	2.26			0.67±0.82	0.99			0.33±0.52	1.21		
		<i>Scaeva pyrastris</i> (Linnaeus)	0.5±0.83	0.85			0.83±0.75	1.23			0.5±0.84	1.84		
		<i>Meliscaevia cinctella</i> (Zetterstedt)	1±1.26	1.69			2.83±1.33	4.18			1±1.26	3.68		
		<i>Eristalinus (Eristalinus) arvorum</i> (Fabricius)	0.5±0.55	0.85			0.17±0.41	0.25						
		<i>Episyrphus (episyrphus) balteatus</i> (De Geer)	9±2.36	15.29			4.83±1.83	7.14			2±0.89	7.36		
		<i>Platycheirus nigrofemoratus</i> (kanervo)					0.33±0.82	0.49						
		<i>Rhingia (Rhingia) laticincta</i> Brunetti	10.17±2.64	17.8			0.5±0.84	0.74						
		<i>Eumerus aurifrons</i> (Wiedermann)					0.33±0.52	0.49			0.33±0.52	1.21		
		<i>Platycheirus albimanus</i> (Fabricius)					0.67±0.82	0.99						
		<i>Eristalinus (Eristalinus) paria</i> (Bigot)					1±1.26	1.48						
		<i>Eristalinus (Eristalinus) megacephalus</i> (Rossi)	0.83±0.75	1.41			0.17±0.41	0.25			0.33±0.52	1.21		
		<i>Brachyopa notata</i> Osten Sacken												
	Tachinidae	<i>Gymnosoma sylvaticum</i> Zimin	0.33±0.52	0.56	1.12	1.12	0.5±0.84	0.74	2.22	2.22			3.05	
	<i>Estheria petiolate</i> (Bonsdorff)													
	<i>Nowickia marklini</i> Zetterstedt	0.33±0.52	0.56	0.33±0.52			0.49							

	Calliphoridae	<i>Tachina sacontala</i> Walker					0.67±0.82	0.99			0.83±0.98	3.05			
		<i>Calliphora vomitoria</i> (Linnaeus)					1.33±0.82	1.96	2.70						
		<i>Lucilia papuensis</i> Macquart					0.5±0.84	0.74							
	Bombyliidae	<i>Bombylius (Bombylius) major</i> Linnaeus	0.17±0.41	0.28	0.28		0.33±0.52	0.49	0.49						
Hymenoptera	Apidae	<i>Apis cerana</i> Fabricius	0.67±0.82	1.13	1.97	3.40	0.67±0.82	0.99	1.73	3.70	0.83±0.75	3.05	5.52		
		<i>Apis mellifera</i> Linnaeus	0.5±0.55	0.84			0.5±0.84	0.74			0.67±0.82	2.47			
	Halictidae	<i>Lasioglossum minutissimum</i> (Kirby)	0.33±0.52	0.56	0.56		1±1.09	1.48	1.48		1.33±1.21	4.89	4.89		
		Megachilidae	<i>Megachilidae</i> spp.	0.5±0.55	0.84		0.84	0.33±0.52	0.49		0.49	0.5±0.55	1.84	1.84	
Coleoptera	Coccinellidae	<i>Coccinella septempunctata</i> (Linnaeus)	0.83±0.98	1.41	2.26	2.26	0.83±0.98	1.23	2.46	2.46	0.83±0.98	3.05	7.36		
		<i>Hippodamia variegata</i> (Goeze)	0.5±0.84	0.84			0.83±0.98	1.23			0.67±0.52	2.47			
		<i>Oenopia sexareata</i> (Mulsant)									0.5±0.84	1.84			
Hemiptera	Miridae	<i>Pinalitus rubricatus</i> (Fallen)					0.67±1.03	0.99	0.99	0.99					
		<i>Orthops scutellatus</i> Uhler													
Lepidoptera	Pieridae	<i>Pieris canidia</i> (Sparrman)	0.5±0.84	0.84	0.84	2.84	0.67±0.82	0.99	2.23	5.19	0.17±0.41	0.63	4.89		
		<i>Belenois aurota</i> (Fabricius)					0.17±0.41	0.25			0.33±0.52	1.21			
		<i>Eurema laeta</i> Boisduval					0.5±0.55	0.74			0.33±0.52	1.21			
		<i>Eurema hecabe</i> (Linnaeus)					0.17±0.41	0.25			0.5±0.84	1.84			
	Nymphalidae	<i>Neptis mahendra</i> Moore						0.17±0.41	0.25		0.25				15.94
		<i>Heliophorus sena</i> (Kollar)	0.83±0.98	1.41	1.98		0.83±0.98	1.23	2.96		1.17±1.17	4.30	11.04		
		<i>Heliophorus androcles</i> (Westwood)					0.83±0.75	1.23			0.83±0.75	3.05			
		<i>Celastrina lavendularis</i> (Moore)	0.17±0.41	0.28			0.17±0.41	0.25			0.83±1.33	3.05			
<i>Celastrina huegleri</i> (Moore)	0.17±0.41	0.28	0.17±0.41	0.25		0.17±0.41	0.63								

* Each value is an overall average for an insect species S.E. = Standard error about the mean

Table 4: Relative abundance of different insect pollinators visiting *Valeriana Jatamansi* Jones flowers from Kharapather and Kupper Localities of Shimla hills. (No. of insects/500 flowers/10 minutes)

Order	Family	Genus Species	Locality: Kharapather				Locality: Kupper			
			Mean±S.E.	Population%	Family %	Order %	Mean±S.E.	Population%	Family %	Order %
Diptera	Syrphidae	<i>Parasyrphus lineolus</i> (Zetterstedt)	3.67±1.03	10.14	79.29	82.97	0.33±0.52	1.87	74.43	82.91
		<i>Syrphus torvus</i> (Osten Sacken)	2.17±1.17	5.99			0.67±0.82	3.79		
		<i>Syrphus vitripennis</i> Meigen	1.17±0.75	3.23						
		<i>Eristalis himalayensis</i> Brunetti								
		<i>Eristalis cerealis</i> Fabricius	0.33±0.82	0.91						
		<i>Eristalis tenax</i> (Linnaeus)	0.5±0.83	1.38						
		<i>Melanostoma orientale</i> (Wiedermann)	1.67±0.82	4.61			0.67±0.82	3.79		
		<i>Melanostoma mellinum</i> (Linnaeus)	2±0.89	5.52			0.83±0.98	4.69		
		<i>Syritta pipiens</i> (Linnaeus)	0.67±0.82	1.85			0.5±0.84	2.83		
		<i>Melanostoma scalare</i> (Fabricius)	1.17±1.17	3.23			0.67±0.82	3.79		
		<i>Sphaerophoria (Sphaerophoria) Indiana</i> Bigot	4±0.89	11.05			2.83±1.72	16.00		
		<i>Chrysotoxum baphyrus</i> Walker								
		<i>Eupeodes (Metasyrphus) latifasciatus</i> , Macquart								
		<i>Eupeodes luniger</i> (Meigen)	1.17±0.75	3.23						
		<i>Dasyrphus lenensis</i> Bagatshanova	1.17±0.75	3.23						
		<i>Scaeva pyrastris</i> (Linnaeus)	0.83±0.75	2.29						
		<i>Meliscaevia cinctella</i> (Zetterstedt)	0.5±0.55	1.38			0.83±0.98	4.70		
		<i>Eristalinus (Eristalinus) arvorum</i> (Fabricius)	0.83±0.75	2.29						
<i>Episyrphus (Episyrphus) balteatus</i> (De Geer)	2.17±0.75	5.99	2.33±1.37	13.18						

		<i>Platycheirus nigrofemoratus</i> (Kanervo)	1.5±1.05	4.15			1.5±1.05	8.48		
		<i>Rhingia (Rhingia) laticincta</i> Brunetti								
		<i>Eumerus aurifrons</i> (Wiedermann)								
		<i>Platycheirus albimanus</i> (Fabricius)	2.33±1.75	6.16			1.67±1.37	9.45		
		<i>Eristalinus (Eristalinus) paria</i> (Bigot)	0.83±0.98	2.29						
		<i>Eristalinus (Eristalinus) megacephalus</i> (Ross)								
		<i>Brachyopa notata</i> Osten Sacken					0.33±0.52	1.87		
	Tachinidae	<i>Gymnosoma sylvaticum</i> Zimin			1.38				8.48	
		<i>Estheria petiolate</i> (Bonsdorff)								
		<i>Nowickia marklini</i> Zetterstedt								
	Calliphoridae	<i>Tachina sacontala</i> Walker	0.5±0.54	1.38			0.83±1.17	4.70		
		<i>Calliphora vomitoria</i> (Linnaeus)					0.67±0.82	3.79		
		<i>Lucilia papuensis</i> Macquart	0.83±0.98	2.29	2.29					
	Bombyliidae	<i>Bombylius (Bombylius) major</i> Linnaeus								
Hymenoptera	Apidae	<i>Apis cerana</i> Fabricius	0.67±0.82	1.85	5.09	9.68			8.49	
		<i>Apis mellifera</i> Linnaeus	1.17±0.75	3.23						
	Halictidae	<i>Lasioglossum minutissimum</i> (Kirby)	1.33±1.21	3.68	3.68		1±1.26	5.66		5.66
	Megachilidae	<i>Megachilidae</i> sp.	0.33±0.52	0.91	0.91		0.5±0.84	2.83		2.83
Coleoptera	Coccinellidae	<i>Coccinella septempunctata</i> (Linnaeus)	0.33±0.52	0.91	0.91	0.91	0.33±0.52	1.87	1.87	1.87
		<i>Hippodamia variegata</i> (Goeze)								
		<i>Oenopia sexareata</i> (Mulsant)								
Hemiptera	Miridae	<i>Pinalitus rubricatus</i> (Fallen)					0.67±0.82	3.79	3.79	3.79
		<i>Orthops scutellatus</i> Uhler								
Lepidoptera	Pieridae	<i>Pieris canidia</i> (Sparrman)				5.53			2.94	
		<i>Belenois aurota</i> (Fabricius)								
		<i>Eurema laeta</i> Boisduval, 1836								
		<i>Eurema hecabe</i> (Linnaeus)								
	Nymphalidae	<i>Neptis mahendra</i> Moore								
	Lycaenidae	<i>Heliophorus sena</i> (Kollar)	0.67±0.82	1.85	5.53			0.52±1.21		2.94
<i>Heliophorus androcles</i> (Westwood)										
<i>Celastrina lavendularis</i> (Moore)		0.33±0.52	0.91							
		<i>Celastrina huegeli</i> (Moore)	1±1.26	2.76						

* Each value is an overall average for an insect species S.E. = Standard error about the mean

Among hymenopterans, 4 species were recorded viz., *Lasioglossum minutissimum*, *Megachilidae* sp, *Apis cerana* and *Apis mellifera* (Table 2,3,4). During the study period 9 species of lepidopterans were observed which belongs to the family Lycaenidae (*Heliophorus sena*, *Heliophorus androcles*, *Celastrina lavendularis* and *Celastrina huegleli*); Pieridae (*Pieris canidia*, *Belenois aurota*, *Eurema laeta*, *Eurema hecabe*) and Nymphalidae (*Neptis mahendra*) (Table 2,3,4). In order coleopterans 3 species i.e. *Coccinella septempunctata*, *Hippodamia variegata*, and *Oenopia sexareata* were also observed as insect pollinators (Table 2,3,4).

Based on present studies, it was observed and concluded that dipterans were the most abundant insect pollinators on *V. jatamansi* from different localities of Shimla hills, Western Himalaya and *Sphaerophoria* (*Sphaerophoria*) *indiana* was the most abundant insect pollinator. Diversity and distribution studies are in accordance with the earlier observations viz., Jugran *et al.* (2013)^[30] observed that the highest number of insect species visiting *Valeriana* flower were from the order Diptera i.e. 13 species, followed by 2 hymenopterans, 3 lepidopterans and 2 species belonging to other minority groups. Similarly, Badoni and Arya (2022)^[31] study shows that dipterans species such as *Eristalis tenax*, *Episyrphus balteatus* and *Eristalis cerealis* were the most abundant insect pollinators of three medicinal plant species of genus *Berberis* (*B. chitria*, *B. lycium* and *B. asiatica*) in Western Himalayas.

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