



STUDY ON DIVERSITY, DISTRIBUTION AND RELATIVE ABUNDANCE OF INSECT POLLINATORS ON *FYGOPYRUM ACUTATUM* (LEHM.) MANSF. EX K. HAMMER IN DIFFERENT ALTITUDINAL POPULATIONS OF SHIMLA HILLS, WESTERN HIMALAYA.

Entomology

Madhu Rana Department of Biosciences, Himachal Pradesh University, Shimla, 171005 India

Mahender Singh Thakur Department of Biosciences, Himachal Pradesh University, Shimla, 171005 India

ABSTRACT

Fagopyrum acutatum (Lehm.) Mansf. ex K. Hammer, is an herbaceous perennial wild species of *Fagopyrum* belonging to Family Polygonaceae. The study on diversity, distribution, and relative abundance of various insect pollinators was carried out by collecting insect pollinators in different localities i.e. Vikasnagar (1831m), Summer Hill (2088m), Dhalli (2155m), Parshal (2279m), Theog (2135m), Matiyana (2419m), Fagu (2576m), and Kufri (2609m) in Shimla hills of Western Himalaya. The present investigation revealed that *Fagopyrum acutatum* (Lehm.) Mansf. ex K. Hammer flowers were visited by 57 species of insect pollinators belonging to 5 orders and 21 families of class insecta, of these, 28 species belonged to Diptera, 10 to Hymenoptera, 15 to Lepidoptera, 2 to Coleoptera and 2 to Hemiptera. From various localities, it has been observed that dipterans were the most abundant insect pollinators in all eight localities i.e. Vikasnagar (47.18%), Summer Hill (69.79%), Dhalli (40.72%), Parshal (44.09%), Theog (57.28%), Matiyana (45.67%), Fagu (57.01%), and Kufri (54.29%) followed by Lepidoptera in Vikasnagar (37.46%), Summer Hill (22.79%), Dhalli (40.67%), Parshal (31.73%), Theog (27.79%), Matiyana (33.32%), Fagu (34.53%), and Kufri (33.51%) and Hymenoptera in Vikasnagar (14.09%), Summer Hill (6.04%), Dhalli (11.84%), Parshal (21.18%), Theog (14.90%), Matiyana (18.81%), Fagu (5.10%), and Kufri (8.49%).

KEYWORDS

Diversity; Distribution; Relative abundance; Insect pollinators; *Fagopyrum acutatum*

INTRODUCTION

Fagopyrum acutatum (Lehm.) Mansf. ex K. Hammer, locally mentioned as Perennial buckwheat and grows as a tall, thinly branched herb. The species is widely dispersed in the Himalayas from Bhutan, Kashmir, Myanmar, Nepal, Sikkim and Vietnam in between the altitudinal ranges of 1500–3400 m. It has triangular arrow-shaped elongated pointed leaves and white unisexual flowers on one side on the long inflorescence branches.

The herb in the Himalayas is considered to be of excessive medicinal and economic value. From there leaves decoction is prepared which is used by the locals in the treatment of snake and insect bites, infections, inflammations, dysmenorrhea and traumatic injuries. The whole plant is anodyne, carminative, febrifuge, anthelmintic, antiphlogistic, anti-spasmodic and anti-hypertensive. Its leaves are used like spinach that is rich in rutin and are eaten raw or cooked, boiled or steamed. Plant seeds which are rich in vitamin B6 are dried and ground into powder and the powder is used as a cereal for patients suffering from gluten allergy (Gupta *et al.*, 2018).

Considering its medicinal importance, the present study was carried out on the diversity, distribution, and relative abundance of insect pollinators of *Fagopyrum acutatum* (Lehm.) Mansf. ex K. Hammer in 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 *Fagopyrum acutatum* (Lehm.) Mansf. ex K. Hammer.

MATERIAL AND METHODS

The present investigation was carried out on insect pollinators of *Fagopyrum acutatum* (Lehm.) Mansf. ex K. Hammer in different localities of Shimla Hills, Western Himalaya. The present studies were conducted during the flowering season i.e. from July to October, in the years 2018 to 2021. The experimental sites where these studies were conducted are Vikasnagar (1831m), Summer Hill (2088m), Dhalli (2155m), Parshal (2279m), Theog (2135m), Matiyana (2419m), Fagu (2576m), and Kufri (2,609m).

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

The relative abundance of different insect pollinators on *Fagopyrum acutatum* (Lehm.) Mansf. ex K. Hammer was determined in terms of their visit per 500 flowers/10 minutes (Verma and Chauhan, 1985). 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). The species diversity and relative

abundance were analyzed statistically from the collected data (Snedcor and Cochran, 1967). 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.

RESULTS AND DISCUSSION

Diversity and distribution studies conducted on insect pollinators of *Fagopyrum acutatum* (Lehm.) Mansf. ex K. Hammer revealed a total of 56 species recorded from different altitudes of Shimla hills, Western Himalaya. Of these 56 species, 28 belonged to the order Diptera, 10 to Hymenoptera, 14 to Lepidoptera, 2 to Coleoptera, and 2 to Hemiptera. It was observed that dipteran were the most dominant represented by 7 families viz., Syrphidae, Tachinidae, Calliphoridae, Sciaridae, Bibionidae, Sarcophagidae and Simuliidae, and out of these 28 species, 14 species belongs to family Syrphidae (*Eristalis himalayensis*, *Eristalis cerealis*, *Eristalis tenax*, *Melanostoma orientale*, *Syrphid pipiens*, *Sphaerophoria* (*Sphaerophoria*) *indiana*, *Eristalinus* (*Eristalinus*) *megacephalus*, *Eristalinus* (*Eristalinus*) *arvorum*, *Episyrphus* (*Episyrphus*) *balteatus*, *Eumerus aurifrons*, *Platycheirus albimanus*, *Eristalinus* (*Eristalinus*) *paria*, *Volucella peleterii*, *Erystalis arbustorum* and *Eristalis obscura*); 8 to Tachinidae (*Gymnosoma sylvaticum*, *Nowickia marklini*, *Tachina sacontata*, *Estheria petiolata*, *Tachina fera*, *Tachina magnicornis*, *Tachina lurida* and *Carcelia tibialis*); 2 to Calliphoridae (*Calliphora vomitoria* and *Lucilia papuensis*), *Sciara indica* belongs to Sciaridae, *Bibio hortulanoides* to Bibionidae, *Sarcophaga fuscicauda* to Sarcophagidae, and *Simulium tormentor* to Simuliidae.

Among the hymenopteran's species, four species i.e. *Apis cerana*, *Apis mellifera*, *Bombus ardens* and *Bombus tunicatus* belongs to the family Apidae, *Eumenes atrophicus* and *Vespa flaviceps* to Vespidae, and *Lasioglossum minutissimum* (Halictidae), *Andrena fulvida* (Andrenidae), *Tenthredo omissa* (Tenthredinidae), and *Sphex argentatus* to Sphecidae respectively were found to visit *Fagopyrum acutatum* (Lehm.) Mansf. ex K. Hammer flowers.

Order Lepidoptera was represented by 14 species i.e. *Heliophorus sena*, *Heliophorus androcles*, *Lycaena pavana*, *Celastrina lavendularis*, and *Celastrina huegleri* (Lycaenidae), *Pieris canidia*, *Belenois aurota*, *Eurema hecabe*, *Eurema laeta*, *Eurema brigitta* and *Colias electo fieldii* (Pieridae), *Neptis mahendra* and *Argynnis childreni* (Nymphalidae), *Dodona durga* (Riodinidae) *Pterodactyla felderi* (Callidulidae). However, in the order Coleoptera, only 2 insect pollinator species of the family Coccinellidae were recorded i.e. *Holotrichia parallela* and *Coccinella septempunctata*. Hemiptera was also represented by only 2 pollinator species i.e. *Orthops scutellatus* and *Pinalitus rubricatus* of the family Miridae. Among all these, dipterans were the most abundant pollinators comprising 28 species

visiting *Fagopyrum acutatum* (Lehm.) Mansf. ex K. Hammer (Table I).

Different investigators have reported numbers of pollinators on many medicinal plants and fruit crops in the Western Himalayas. Thakur and Katoch (2022) 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) 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*. Similarly, Mattu and Nirala (2016) 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) 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. Thakur and Kumari (2022) 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.

Table 1: Systematic list of insect pollinators of *Fagopyrum acutatum* from different areas of Himachal Pradesh

Order	Family	Genus/Species	
Diptera	Syrphidae	<i>Eristalis tenax</i> (Linnaeus, 1758)	
		<i>Eristalis himalayensis</i> Brunetti, 1908	
		<i>Eristalis cerealis</i> Fabricius, 1805	
		<i>Syrirta pipiens</i> (Linnaeus, 1758)	
		<i>Sphaerophoria</i> (<i>Sphaerophoria</i>) <i>indiana</i> Bigot, 1884	
		<i>Episyrphus</i> (<i>Episyrphus</i>) <i>balteatus</i> (De Geer, 1776)	
		<i>Eristalinus</i> (<i>Eristalinus</i>) <i>megacephalus</i> (Rossi, 1794)	
		<i>Eristalinus</i> (<i>Eristalinus</i>) <i>arvorum</i> (Fabricius 1787)	
		<i>Volucella peletieri</i> Macquart, 1834	
		<i>Eumerus aurifrons</i> (Wiedermann, 1824)	
		<i>Platycheirus albimanus</i> (Fabricius, 1781)	
		<i>Eristalinus</i> (<i>Eristalinus</i>) <i>paria</i> (Bigot, 1880)	
		<i>Eristalis arbustorum</i> (Linnaeus, 1758)	
		<i>Eristalis obscura</i> (Loew, 1866)	
		Tachinidae	<i>Gymnosoma sylvaticum</i> Zimin, 1966
			<i>Nowickia marklini</i> (Zetterstedt, 1838)
			<i>Tachina sacontata</i> Wakler, 1849
			<i>Estheria petiolata</i> (Bonsdorff, 1866)
			<i>Tachina fera</i> (Linnaeus, 1761)
	<i>Tachina magnicornis</i> (Zetterstedt, 1844)		
	<i>Tachina lurida</i> (Fabricius, 1781)		
	Calliphoridae	<i>Carcelia tibialis</i> (Robineau-Desvoidy, 1863)	
		<i>Calliphora vomitoria</i> (Linnaeus, 1758)	
		<i>Lucilia papuensis</i> Macquart, 1843	
	Sciaridae	<i>Sciara indica</i> Walker, 1856	
	Bibionidae	<i>Bibio hortulanoides</i> Brunetti, 1911	
	Sarcophagidae	<i>Sarcophaga fuscicauda</i> Böttcher 1912	
	Simuliidae	<i>Simulium tormentor</i> Adler, Currie & Wood, 2004	
	Hymenoptera	Apidae	<i>Apis cerana</i> Fabricius, 1793
			<i>Apis mellifera</i> Linnaeus, 1758
			<i>Bombus ardens</i> (Smith, 1879)
			<i>Bombus tunicatus</i> Smith, 1852
Halictidae		<i>Lasioglossum minutissimum</i> (Kirby 1802)	
Vespidae		<i>Eumenes atropicus</i> (Fabricius 1798)	
		<i>Vespa flaviceps</i> (Smith, 1870)	
Andrenidae		<i>Andrena fulvida</i> Schenck, 1853	
Tenthredinidae		<i>Tenthredo omisssa</i> (Förster, 1844)	
Sphexidae		<i>Sphex argentatus</i> Fabricius, 1787	

Coleoptera	Coccinellidae	<i>Coccinella septempunctata</i> (Linnaeus 1758)
	Scarabaeidae	<i>Holotrichia parallela</i> (Motschulsky, 1854)
Hemiptera	Miridae	<i>Orthops scutellatus</i> Uhler, 1877
		<i>Pinalitus rubricatus</i> (Fallen, 1807)
Lepidoptera	Lycaenidae	<i>Heliophorus sena</i> (Kollar 1844)
		<i>Heliophorus androcles</i> (Westwood, 1851)
		<i>Lycaena pavana</i> (Kollar, 1848)
		<i>Celastrina huegeli</i> (Moore, 1882)
		<i>Celastrina lavendularis</i> (Moore, 1877)
		<i>Pieris canidia</i> (Sparrman, 1768)
	Pieridae	<i>Belenois aurota</i> (Fabricius 1793)
		<i>Eurema hecabe</i> (Linnaeus, 1758)
		<i>Eurema laeta</i> Boisduval, 1836
		<i>Eurema brigitta</i> (Cramer, 1780)
		<i>Colias electo fieldii</i> Ménétriés, 1855
	Nymphalidae	<i>Neptis mahendra</i> Moore, 1872
		<i>Argynnis childreni</i> Gray, 1831
Riodinidae	<i>Dodona durga</i> (Kollar & Redtenbacher, 1844)	
Callidulidae	<i>Pterodecta felderi</i> (Bremer, 1864)	

The relative abundance studies revealed that dipterans were the most prominent insect visitors on *Fagopyrum acutatum* (Lehm.) Mansf. ex K. Hammer in all eight localities i.e. Vikasnagar (47.18%), Summer Hill (69.79%), Dhalli (40.72%), Parshal (44.09%), Theog (57.28%), Matiyana (45.67%), Fagu (57.01%), and Kufri (54.29%) followed by lepidopterans, hymenopterans, coleopterans, and hemipterans. During this period, 28 dipterans were recorded; of which 14 belong to the family Syrphidae, 8 to Tachinidae, 2 to Calliphoridae, and one species each to Sciaridae, Bibionidae, Sarcophagidae and Simuliidae. Insect pollinators belonging to the family Syrphidae were the most common in all the localities i.e. Vikasnagar (47.18%), Summer Hill (59.73%), Dhalli (30.50%), Parshal (38.83%), Theog (47%), Matiyana (33.35%), Fagu (44.14%), and Kufri (48.60%) followed by family Tachinidae, Calliphoridae, Sciaridae, Bibionidae, Sarcophagidae and Simuliidae (Table 2,3,4,5).

Maximum abundance of dipterans was observed in Summer Hill (69.79%) followed by Theog (57.28%), Fagu (57.01%), Kufri (54.29%), Vikasnagar (47.18%), Matiyana (45.67%), Parshal (44.09%) and Dhalli (40.72%). Similarly, the maximum number of insect pollinators belonging to the family Syrphidae was observed in Summer Hill (59.73%). (Table 2,3,4).

During this period, it has been observed that *Eristalis tenax* and *Eristalis cerealis* were the most abundant pollinators of *Fagopyrum acutatum* (Lehm.) Mansf. ex K. Hammer plant at all eight localities i.e. Vikasnagar (4.17±1.47, 11.02%; 4.5±2.43, 11.89%), Summer Hill (4±1.26, 16.11%; 3.17±1.17, 12.76%), Dhalli (1.5±1.76, 7.63%; 1±1.26, 5.08%), Parshal (3.33±1.97, 11.75%; 3.33±2.06, 11.75%), Theog (4.33±1.63, 11.10%; 1.67±1.21, 4.28%), Matiyana (1.67±0.82, 5.39%; 1.83±0.75, 5.90%), Fagu (4.33±1.86, 10.43%; 5.5±1.05, 13.25%) and Kufri (3.17±1.72, 8.97%; 1.67±1.21, 4.73%).

Other important dipteran pollinators of *Fagopyrum acutatum* (Lehm.) Mansf. ex K. Hammer, observed were *Syrirta pipiens*, *Episyrphus* (*Episyrphus*) *balteatus*, *Eristalinus* (*Eristalinus*) *arvorum*, *Eristalinus* (*Eristalinus*) *paria* at all 8 localities i.e. Vikasnagar (4.41%; 1.77%; 9.70%; 7.06%), Summer Hill (11.40%; 3.84%; 2.70%; 13.41%), Dhalli (2.54%; 1.68%; 3.41%; 2.54%), Parshal (1.16%; 1.76%; 2.36%; 5.89%), Theog (1.28%; 2.13%; 1.72%; 7.69%), Matiyana (2.68%; 3.77%; 3.77%; 1.61%), Fagu (0.79%; 2%; 1.20%; 4.82%), and Kufri (3.76%; 6.59%; 5.66%; 4.73%) respectively (Table 2,3,4,5).

Besides above mentioned other dipteran insect pollinator species which were also observed during study period includes *Tachina sacontata* (Summerhill, 4.02%), (Dhalli, 2.54%), (Theog, 0.44%), (Parshal, 1.16%), (Fagu, 1.20%), (Matiyana, 2.16%); *Estheria petiolata* (Summer hill, 4.02%), (Dhalli, 0.86%), (Theog, 1.28%) (Parshal, 1.16%), (Fagu, 1.20%) (Matiyana, 1.06%); *Eristalis himalayensis* (Theog, 0.85%) (Parshal, 0.60%), (Fagu, 3.61%), (Kufri, 2.35%), (Matiyana, 1.61%); *Sphaerophoria* (*Sphaerophoria*) *indiana* (Theog, 4.28%), (Parshal, 1.76%), (Fagu, 1.61%), (Kufri, 1.41%), (Matiyana, 2.16%); *Eumerus aurifrons* (Theog, 1.72%), (Fagu, 0.41%) (Kufri, 1.41%), (Matiyana, 1.61%); *Gymnosoma sylvaticum* (Theog, 0.44%), (Fagu, 1.20%), (Kufri, 0.48%), (Matiyana, 1.06%); *Tachina fera* (Theog, 1.72%), (Fagu, 2%), (Kufri, 1.41%), (Matiyana,

1.06%); *Tachina lurida* (Theog., 1.28%), (Fagu, 1.20%), (Kufri, 1.89%), (Matiyana, 1.61%); *Lucilia papuensis* (Theog, 1.72%), (Fagu, 1.20%), (Kufri, 1.41%), (Matiyana, 2.16%); *Eristalinus (Eristalinus) megacephalus* (Theog, 7.26%), (Fagu, 0.79%), (Kufri, 7.56%), (Matiyana, 0.55%) (Table 2,3,4,5).

Among lepidopterans, five species belonging to the family Lycaenidae were also recorded from Vikasnagar, Summer Hill, Dhalli, Parshal, Theog, Matiyana, Fagu and Kufri viz. *Heliophorus sena* (4.5±2.51, 11.89%; 0.83±1.17, 3.34%; 1±1.26, 5.08%; 1.33±1.75, 4.69%; 2.5±1.97, 6.41%; 1.67±1.21, 5.39%; 2±1.41, 4.82%; 1.33±1.37, 3.76%), *Heliophorus androcles* (3.17±1.60, 8.37%; 0.83±1.33, 3.34%; 2±0.89, 5.66%); 1.5 ±1.05, 5.29%; 1.5±0.84, 3.85%; 1±1.26, 3.23%; 2.83±1.83, 6.82%; 2.67±2.06, 7.56%), *Lycaena pavana* (2.17±1.33, 5.73%; 1±1.09, 4.02%; 1.83±0.75, 9.30%; 1.5±0.55, 5.29%; 1.67±1.21, 4.28%; 1.33±1.03, 4.29%; 2.67±1.97, 6.43%; 2±0.89, 5.66%), *Celastrina huegeli* (1.67±1.37, 4.41%; 0.83±0.98, 3.34%; 2.17±1.17, 11.03%; 2.33±1.37, 8.22%; 2.17±1.47, 5.56%; 1.83±0.98, 5.90%; 2.67±1.97, 6.43%; 1.83±0.98, 5.18%) and *Celastrina lavendularis* (1.83±0.98, 4.84%; 1.17±0.98, 4.71%; 1.83±0.98, 9.30%; 1.83±1.33, 4.46%; 2.17±1.17, 5.56%; 1.5±0.84, 4.84%; 2.5±1.64, 6.02%; 1.67±0.81, 4.73%). Other important lepidopterans of family Pieridae recorded were *Pieris canidia*, *Belenois aurota*, *Eurema hecabe*, *Eurema laeta*, and *Eurema brigitta*.

Among hymenopterans, 10 species were recorded viz. *Apis cerana*, *Apis mellifera*, *Bombus ardens*, *Bombus tunicatus*, *Eumenes atrophicus*, *Vespula flaviceps*, *Lastioglossum minutissimum*, *Andrena fulvida*, *Tenthredo omissa*, *Sphex argentatus* (Table 2,3,4). In order coleopterans 2 species i.e. *Coccinella septempunctata* and *Holotrichia parallela* were also observed as insect pollinators (Table 2,3,4,5).

Based on present studies, it was observed and concluded that dipterans were the most abundant insect pollinators on *Fagopyrum acutatum* (Lehm.) Mansf. ex K. Hammer, from different localities of Western Himalaya and observed that *Eristalis tenax* and *Eristalis cerealis* was the most abundant dipteran pollinators followed by Lepidopterans such as *Heliophorus sena*, *Heliophorus Androcles*, *Lycaena pavana*, *Celastrina huegeli*, *Celastrina lavendularis*. Similarly, a study conducted by Jacquemart *et al.* (2007) demonstrated 49 different insect species, belonging to 18 families were recorded on buckwheat (*Fagopyrum esculentum* Moench). Dipterans and hymenopterans were the major visitors, among hymenopterans *Apis mellifera* L and in dipterans, syrphid flies were the most abundant insect pollinators.

Similarly, Aryal *et al.* (2016) study on buckwheat (*Fagopyrum esculentum* Moench.) in Chitwan, Nepal found that wasps, *Apis dorsata*, *Apis mellifera*, *Apis cerana*, *Andrena* sp., *Synoecca* sp., *Chalcid* sp., *Formica* sp., *Syrphus* sp. and various dipterans, coleopterans, and lepidopterans were the flower visitors of buckwheat. In 2001 Goodman *et al.*, observed that honeybees (*Apis mellifera*) play an important role in the pollination of buckwheat cv. Manor., bees covered 80% of insect visitors to this crop, and other insect pollinators are ladybirds, hoverflies, drone flies (*Eristalis* sp.), blowflies (Calliphoridae), cabbage white butterflies (*Pieris rapae*), small bush flies and native bees.

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Table 2: Relative abundance of different insect pollinators visiting *Fagopyrum acutatum* (Lehm.) Mansf.ex K flowers at Summer Hill and Vikasnagar, Shimla Hills. (No. of insects/500 flowers/10 minutes)

Order	Family	Genus/Species	Locality: Summerhill				Locality: Vikasnagar				
			Mean±S.E.	Percent population	Family percent	Order percent	Mean±S.E.	Percent population	Family percent	Order percent	
Diptera	Syrphidae	<i>Eristalis tenax</i> (Linnaeus, 1758)	4±1.26	16.11	59.73	69.79	4.17±1.47	11.02	47.18	47.18	
		<i>Eristalis himalayensis</i> Brunetti, 1908									
		<i>Eristalis cerealis</i> Fabricius, 1805	3.17±1.17	12.76			4.5±2.43	11.89			
		<i>Syrpita pipiens</i> (Linnaeus, 1758)	2.83±1.47	11.40			1.67±0.52	4.41			
		<i>Sphaerophoria (Sphaerophoria) indiana</i> Bigot, 1884									
		<i>Episyrphus (Episyrphus) balteatus</i> (De Geer, 1776)	0.83±0.75	3.34			0.67±0.52	1.77			
		<i>Eristalinus (Eristalinus) megacephalus</i> (Rossi, 1794)									
		<i>Eristalinus (Eristalinus) arvorum</i> (Fabricius 1787)	0.67±0.52	2.70			3.67±1.97	9.70			
		<i>Volucella peleterii</i> Macquart, 1834									
		<i>Eumerus aurifrons</i> (Wiedermann, 1824)									
		<i>Platycheirus albimanus</i> (Fabricius, 1781)									
		<i>Eristalinus (Eristalinus) paria</i> (Bigot, 1880)	3.33±1.86	13.41			2.67±1.86	7.06			
		<i>Eristalis arbustorum</i> (Linnaeus, 1758)									
		<i>Eristalis obscura</i> (Loew, 1866)					0.5±0.55	1.32			
		Tachinidae	<i>Gymnosoma sylvaticum</i> Zimin, 1966			10.07					
			<i>Nowickia marklini</i> (Zetterstedt, 1838)								
	<i>Tachina sacontata</i> Wakler, 1849		1± 0.89	4.02							
	<i>Estheria petiolata</i> (Bonsdorff, 1866)		1±0.89	4.02							
	<i>Tachina fera</i> (Linnaeus, 1761)										
	<i>Tachina magnicornis</i> (Zetterstedt, 1844)		0.5±0.84	2.01							
Calliphoridae	<i>Tachina lurida</i> (Fabricius, 1781)										
	<i>Carcelia tibialis</i> (Robineau-Desvoidy, 1863)										
	<i>Calliphora vomitoria</i> (Linnaeus, 1758)										
		<i>Lucilia papuensis</i> Macquart, 1843									

	Sciaridae	Sciara indica Walker, 1856									
	Bibionidae	Biblio hortulanoides Brunetti, 1911									
	Sarcophagidae	Sarcophaga fuscicauda Böttcher 1912									
	Simuliidae	Simulium tormentor Adler, Currie & Wood, 2004									
Hymenoptera	Apidae	Apis cerana Fabricius, 1793				6.04	3.33±1.63	8.80	11.89	14.09	
		Apis mellifera Linnaeus, 1758					1.17±1.17	3.09			
		Bombus ardens (Smith, 1879)									
		Bombus tunicatus Smith, 1852									
	Halictidae	Lasioglossum minutissimum (Kirby 1802)									
		Eumenes atrophicus (Fabricius 1798)			2.01					1.32	
	Vespididae	Vespa flaviceps (Smith, 1870)	0.5±0.84	2.01				0.5±0.84	1.32		
		Andrena fulvida Schenck, 1853	0.33±0.52	1.33	1.33						
	Tenthredinidae	Tenthredo omissa (Förster, 1844)	0.67±0.82	2.69	2.69			0.33±0.52	0.87	0.87	
Sphexidae		Sphex argentatus Fabricius, 1787									
Coleoptera	Coccinellidae	Coccinella septempunctata (Linnaeus 1758)	0.33±0.52	1.33	1.33	1.33					
		Scarabaeidae	Holotrichia parallela (Motschulsky, 1854)								
Hemiptera	Miridae	Orthops scutellatus Uhler, 1877									
		Pinalitus rubricatus (Fallen, 1807)									
Lepidoptera	Lycaenidae	Heliophorus sena (Kollar 1844)	0.83±1.17	3.34	18.77	22.79	4.5±2.51	11.89	35.26	37.46	
		Heliophorus androcles (Westwood, 1851)	0.83±1.33	3.34			3.17±1.60	8.37			
		Lycaena pavana (Kollar, 1848)	1±1.09	4.02			2.17±1.33	5.73			
		Celastrina huegeli (Moore, 1882)	0.83±0.98	3.34			1.67±1.37	4.41			
		Celastrina lavendularis (Moore, 1877)	1.17±0.98	4.71			1.83±0.98	4.84			
	Pieridae	Pieris canidia (Sparman, 1768)	0.5±0.84	2.01	2.01		0.83±0.75	2.19	2.19		
		Belenois aurota (Fabricius 1793)									
		Eurema hecabe (Linnaeus, 1758)									
		Eurema laeta Boisduval, 1836									
	Nymphalidae	Eurema brigitta (Cramer, 1780)									
		Colias electo fieldii Ménétriés, 1855									
		Neptis mahendra Moore, 1872			2.01						
		Argynnis childreni Gray, 1831	0.5±0.84	2.01							
		Riodinidae	Dodona durga (Kollar & Redtenbacher, 1844)								
Callidulidae	Pterodecta felderi (Bremer, 1864)										

* 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 visiting Fygyopyrum acutatum (Lehm.) Mans.ex K flowers at Theog and Parshal, Shimla Hills. (No. of insects/500 flowers/10 minutes)

Order	Family	Genus/Species	Locality: Theog			Locality: Parshal				
			Mean±S.E.	Percent population	Family percent	Order percent	Mean±S.E.	Percent population	Family percent	Order percent
Diptera	Syrphidae	Eristalis tenax (Linnaeus, 1758)	4.33±1.63	11.10	47	57.28	3.33±1.97	11.75	38.83	44.09
		Eristalis himalayensis Brunetti, 1908	0.33±0.52	0.85			0.17±0.41	0.60		
		Eristalis cerealis Fabricius, 1805	1.67±1.21	4.28			3.33±2.06	11.75		
		Syritta pipiens (Linnaeus, 1758)	0.5±0.84	1.28			0.33±0.52	1.16		
		Sphaerophoria (Sphaerophoria) indiana Bigot, 1884	1.67±1.21	4.28			0.5±0.84	1.76		
		Episyrphus (Episyrphus) balteatus (De Geer, 1776)	0.83±0.75	2.13			0.5±0.84	1.76		
		Eristalinus (Eristalinus) megacephalus (Rossi, 1794)	2.83±1.47	7.26						
		Eristalinus (Eristalinus) arvorum (Fabricius 1787)	0.67±0.82	1.72			0.67±1.21	2.36		
		Volucella peleterii Macquart, 1834	0.5±0.84	1.28						

		Eumerus aurifrons (Wiedermann, 1824)	0.67±0.82	1.72						
		Platycheirus albimanus (Fabricius, 1781)	0.5±0.84	1.28						
		Eristalinus (Eristalinus) paria (Bigot, 1880)	3±1.41	7.69			1.67±1.50	5.89		
		Eristalis arbustorum (Linnaeus, 1758)					0.5±0.55	1.76		
		Eristalis obscura (Loew, 1866)	0.83±0.98	2.13						
	Tachinidae	Gymnosoma sylvaticum Zimin, 1966	0.17±0.41	0.44	6.44					4.09
		Nowickia marklini (Zetterstedt, 1838)	0.5±0.84	1.28			0.5±0.84	1.76		
		Tachina sacontala Walker, 1849	0.17±0.41	0.44			0.33±0.52	1.16		
		Estheria petiolata (Bonsdorff, 1866)	0.5±0.84	1.28			0.33±0.52	1.16		
		Tachina fera (Linnaeus, 1761)	0.67±1.21	1.72						
		Tachina magnicornis (Zetterstedt, 1844)								
		Tachina lurida (Fabricius, 1781)	0.5±0.84	1.28						
		Carcelia tibialis (Robineau-Desvoidy, 1863)								
	Calliphoridae	Calliphora vomitoria (Linnaeus, 1758)	0.5±0.84	1.28	3					
		Lucilia papuensis Macquart, 1843	0.67±0.82	1.72						
	Sciaridae	Sciara indica Walker, 1856								
	Bibionidae	Biblio hortulanoides Brunetti, 1911								
	Sarcophagidae	Sarcophaga fuscicauda Böttcher 1912								
	Simuliidae	Simulium tormentor Adler, Currie & Wood, 2004	0.33±0.52	0.85	0.85		0.33±0.52	1.16	1.16	
Hymenoptera	Apidae	Apis cerana Fabricius, 1793	1.33±0.82	3.41	7.67	14.90	2.33±1.21	8.22	18.81	21.18
		Apis mellifera Linnaeus, 1758	0.83±0.75	2.13			2.5±1.64	8.82		
		Bombus ardens (Smith, 1879)	0.5±0.84	1.28			0.33±0.82	1.16		
		Bombus tunicatus Smith, 1852	0.33±0.52	0.85			0.17±0.41	0.60		
	Halictidae	Lasioglossum minutissimum (Kirby 1802)	0.83±0.98	2.13	2.13		0.67±1.03	2.36	2.36	
	Vespidae	Eumenes atrophicus (Fabricius 1798)	0.33±0.52	0.85	4.26					
		Vespula flaviceps (Smith, 1870)	1.33±1.21	3.41						
	Andrenidae	Andrena fulvida Schenck, 1853								
	Tenthredinidae	Tenthredo omissa (Förster, 1844)	0.33±0.52	0.85	0.85					
Sphecidae	Sphex argentatus Fabricius, 1787									
Coleoptera	Coccinellidae	Coccinella septempunctata (Linnaeus 1758)	0.33±0.52	0.85	0.85	0.85	0.67±0.52	2.36	2.36	2.36
	Scarabaeidae	Holotrichia parallela (Motschulsky, 1854)								
Hemiptera	Miridae	Orthops scutellatus Uhler, 1877							1.76	1.76
		Pinalitus rubricatus (Fallen, 1807)					0.5±1.22	1.76		
Lepidoptera	Lycaenidae	Heliophorus sena (Kollar 1844)	2.5±1.97	6.41	25.67	27.79	1.33±1.75	4.69	29.97	31.73
		Heliophorus androcles (Westwood, 1851)	1.5±0.84	3.85			1.5 ±1.05	5.29		
		Lycaena pavana (Kollar, 1848)	1.67±1.21	4.28			1.5±0.55	5.29		

		Celastrina huegeli (Moore, 1882)	2.17±1.47	5.56			2.33±1.37	8.22		
		Celastrina lavendularis (Moore, 1877)	2.17±1.17	5.56			1.83±1.33	4.46		
Pieridae		Pieris canidia (Sparman, 1768)	0.17±0.41	0.44	2.13		0.5±0.84	1.76	1.76	
		Belenois aurota (Fabricius 1793)	0.33±0.52	0.85						
		Eurema hecabe (Linnaeus, 1758)								
		Eurema laeta Boisduval, 1836								
		Eurema brigitta (Cramer,1780)	0.33±0.52	0.85						
		Colias electo fieldii Ménétrics, 1855								
	Nymphalidae		Neptis mahendra Moore, 1872							
		Argynnis childrenI Gray, 1831								
Riodinidae		Dodona durga (Kollar & Redtenbacher, 1844)								
Callidulidae		Pterodecta felderi (Bremer, 1864)								

* 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 visiting Fygyopyrum acutatum (Lehm.) Mans.ex K flowers at Fagu and Kufri, Shimla Hills. (No. of insects/500 flowers/10 minutes)

Order	Family	Genus/Species	Locality: Fagu				Locality : Kufri					
			Mean±S.E.	Percent population	Family percent	Order percent	Mean±S.E.	Percent population	Family percent	Order percent		
Diptera	Syrphidae	Eristalis tenax (Linnaeus, 1758)	4.33±1.86	10.43	44.14	57.01	3.17±1.72	8.97	48.60	54.29		
		Eristalis himalayensis Brunetti, 1908	1.5±1.76	3.61			0.83±0.75	2.35				
		Eristalis cerealis Fabricius,1805	5.5±1.05	13.25			1.67±1.21	4.73				
		Syritta pipiens (Linnaeus, 1758)	0.33±0.82	0.79			1.33±1.03	3.76				
		Sphaerophoria (Sphaerophoria) indiana Bigot, 1884	0.67±0.94	1.61			0.5±0.84	1.41				
		Episyrphus (Episyrphus) balteatus (De Geer, 1776)	0.83±0.75	2			2.33±1.63	6.59				
		Eristalinus (Eristalinus) megacephalus (Rossi, 1794)	0.33±0.52	0.79			2.67±2.07	7.56				
		Eristalinus (Eristalinus) arvorum (Fabricius 1787)	0.5±0.84	1.20			2±2.28	5.66				
		Volucella peleiterii Macquart, 1834	1.33±0.81	3.20								
		Eumerus aurifrons (Wiedermann, 1824)	0.17±0.41	0.41			0.5±0.84	1.41				
		Platycheirus albimanus (Fabricius, 1781)					0.5±0.55	1.41				
		Eristalinus (Eristalinus) paria (Bigot, 1880)	2±1.26	4.82			1.67±1.03	4.73				
		Eristalis arbustorum (Linnaeus,1758)	0.83±0.75	2								
		Eristalis obscura (Loew, 1866)										
		Tachinidae		Gymnosoma sylvaticum Zimin, 1966	0.5±0.84	1.20	8.02		0.17±0.41	0.48	4.27	
				Nowickia marklini (Zetterstedt, 1838)								
Tachina sacontata Wakler, 1849	0.5±0.84			1.20								
Estheria petiolata (Bonsdorff, 1866)	0.5±0.84			1.20								
Tachina fera (Linnaeus, 1761)	0.83±0.98			2			0.5±0.55	1.41				
Tachina magnicornis (Zetterstedt, 1844)							0.17±0.41	0.48				
Tachina lurida (Fabricius, 1781)	0.5±0.55			1.20			0.67±0.82	1.89				
Carcelia tibialis (Robineau-Desvoidy, 1863)	0.5±0.84			1.20								

	Calliphoridae	Calliphora vomitoria (Linnaeus, 1758)			1.20				1.41	
		Lucilia papuensis Macquart, 1843	0.5±0.84	1.20			0.5±0.84	1.41		
	Sciaridae	Sciara indica Walker, 1856								
	Bibionidae	Biblio hortulanoides Brunetti, 1911	1.17±1.84	2.82	2.82					
	Sarcophagidae	Sarcophaga fuscicauda Böttcher 1912	0.17±0.41	0.41	0.41					
Hymenoptera	Apidae	Apis cerana Fabricius, 1793	0.33±0.82	0.79	4.52	6.13	0.5±0.84	1.41	7.56	8.49
		Apis mellifera Linnaeus, 1758	0.17±0.41	0.41			1±0.63	2.83		
		Bombus ardens (Smith, 1879)	0.67±0.82	1.66			0.67±0.82	1.90		
		Bombus tunicatus Smith, 1852	0.67±0.82	1.66			0.5±0.55	1.41		
	Halictidae	Lasioglossum minutissimum (Kirby 1802)	0.33±0.82	0.79	0.79		0.33±0.52	0.93	0.93	
		Vespidae	Eumenes atrophicus (Fabricius 1798)			0.41				
	Vespa flaviceps (Smith, 1870)		0.17±0.41	0.41						
	Andrenidae	Andrena fulvida Schenck, 1853								
	Tenthredinidae	Tenthredo omissa (Förster, 1844)								
	Sphecidae	Sphex argentatus Fabricius, 1787	0.17±0.41	0.41	0.41					
Coleoptera	Coccinellidae	Coccinella septempunctata (Linnaeus 1758)	0.5±0.84	1.20	1.20	2.41	0.83±1.33	2.35	2.35	3.76
	Scarabaeidae	Holotrichia parallela (Motschulsky, 1854)	0.5±0.84	1.20	1.20		0.5±0.84	1.41	1.41	
Hemiptera	Miridae	Orthops scutellatus Uhler, 1877								
		Pinalitus rubricatus (Fallen, 1807)								
Lepidoptera	Lycaenidae	Heliophorus sena (Kollar 1844)	2±1.41	4.82	29.71	34.53	1.33±1.37	3.76	26.89	33.51
		Heliophorus androcles (Westwood, 1851)	2.83±1.83	6.82			2.67±2.06	7.56		
		Lycaena pavana (Kollar, 1848)	2.67±1.97	6.43			2±0.89	5.66		
		Celastrina huegeli (Moore, 1882)	2.33±0.82	5.61			1.83±0.98	5.18		
		Celastrina lavendularis (Moore, 1877)	2.5±1.64	6.02			1.67±0.81	4.73		
	Pieridae	Pieris canidia (Sparman, 1768)	0.33±0.82	0.79	2.82		0.5±0.55	1.41	6.14	
		Belenois aurota (Fabricius 1793)								
		Eurema hecabe (Linnaeus, 1758)	0.17±0.41	0.41			0.5±0.84	1.41		
		Eurema laeta Boisduval, 1836	0.5±0.84	1.20			0.67±0.82	1.90		
		Eurema brigitta (Cramer, 1780)	0.17±0.41	0.41			0.5±0.55	1.41		
		Colias electo fieldii Ménétrés, 1855								
	Nymphalidae	Neptis mahendra Moore, 1872	0.33±0.52	0.79	0.79					
		Argynnis childreni Gray, 1831								
	Riodinidae	Dodona durga (Kollar & Redtenbacher, 1844)								
	Callidulidae	Pterodecta felderi (Bremer, 1864)	0.5±0.84	1.20	1.20		0.17±0.41	0.48		

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

Table 5: Relative abundance of different insect pollinators visiting Fygyopyrum acutatum (Lehm.) Mansf. ex K flowers at Matiyana and Dhalli, Shimla Hills. (No. of insects/500 flowers/10 minutes)

Order	Family	Genus/Species	Locality: Matiyana			Locality: Dhalli				
			Mean±S.E	Percent population	Family percent	Order percent	Mean±S.E.	Percent population	Family percent	Order percent
Diptera	Syrphidae	Eristalis tenax (Linnaeus, 1758)	1.67±0.82	5.39	33.35	45.67	1.5±1.76	7.63	30.50	40.72
		Eristalis himalayensis Brunetti, 1908	0.5±0.55	1.61						
		Eristalis cerealis Fabricius, 1805	1.83±0.75	5.90			1±1.26	5.08		
		Syritta pipiens (Linnaeus, 1758)	0.83±0.98	2.68			0.5±0.55	2.54		
		Sphaerophoria (Sphaerophoria) Indiana Bigot, 1884	0.67±0.82	2.16						
		Episyrphus (Episyrphus) balteatus (De Geer, 1776)	1.17±0.41	3.77			0.33±0.52	1.68		
		Eristalinus (Eristalinus) megacephalus (Rossi, 1794)	0.17±0.41	0.55						

		Eristalinus (Eristalinus) arvorum (Fabricius 1787)	1.17±1.17	3.77			0.67±0.82	3.41			
		Volucella peleterii Macquart, 1834	0.5±0.84	1.61							
		Eumerus aurifrons (Wiedermann, 1824)	0.5±0.84	1.61							
		Platycheirus albimanus (Fabricius, 1781)	0.83±0.98	2.68							
		Eristalinus (Eristalinus) paria (Bigot, 1880)	0.5±0.84	1.61			0.5±0.8	2.54			
		Eristalis arbustorum (Linnaeus, 1758)					1±1.26	5.08			
		Eristalis obscura (Loew, 1866)					0.5±0.55	2.54			
	Tachinidae	Gymnosoma sylvaticum Zimin, 1966	0.33±0.52	1.06	8.03				3.41		
		Nowickia marklini (Zetterstedt, 1838)	0.33±0.82	1.06							
		Tachina sacontata Wakler, 1849	0.67±0.82	2.16			0.5±0.84	2.54			
		Estheria petiolata (Bonsdorff, 1866)	0.33±0.82	1.06			0.17±0.41	0.86			
		Tachina fera (Linnaeus, 1761)	0.33±0.52	1.06							
		Tachina magnicornis (Zetterstedt, 1844)									
		Tachina lurida (Fabricius, 1781)	0.5±0.84	1.61							
		Carcelia tibialis (Robineau-Desvoidy, 1863)									
	Calliphoridae	Calliphora vomitoria (Linnaeus, 1758)	0.33±0.51	1.06	3.23		0.5±0.84	2.54	2.54		
		Lucilia papuensis Macquart, 1843	0.67±1.21	2.16							
	Sciaridae	Sciara indica Walker, 1856	0.33±0.52	1.06	1.06		0.17±0.41	0.86	0.86		
	Bibionidae	Bibio hortulanoides Brunetti, 1911									
	Sarcophagidae	Sarcophaga fuscicauda Böttcher 1912					0.67±0.82	3.41	3.41		
	Simuliidae	Simulium tormentor Adler, Currie & Wood, 2004									
Hymenoptera	Apidae	Apis cerana Fabricius, 1793	1±0.89	3.23	8.06	18.81	1±1.26	5.08	8.49	11.84	
		Apis mellifera Linnaeus, 1758	0.5±0.55	1.61			0.67±0.8	3.41			
		Bombus ardens (Smith, 1879)	0.5±0.55	1.61							
		Bombus tunicatus Smith, 1852	0.5±0.84	1.61							
	Halictidae	Lasioglossum minutissimum (Kirby 1802)	1.17±1.17	3.77	3.77						
	Vespidae	Eumenes atrophicus (Fabricius 1798)					0.33±0.82	1.68	3.35		
		Vespula flaviceps (Smith, 1870)					0.33±0.52	1.68			
Andrenidae	Andrena fulvida Schenck, 1853	1.5±1.64	4.84	4.84							
Tenthredinidae	Tenthredo omissa (Förster, 1844)	0.33±0.52	1.06	1.06							
Sphecidae	Sphex argentatus Fabricius, 1787	0.33±0.82	1.06	1.06							
Coleoptera	Coccinellidae	Coccinella septempunctata (Linnaeus 1758)	0.67±1.21	2.16	2.16	2.16	0.83±0.75	4.22	4.22	4.22	
	Scarabaeidae	Holotrichia parallela (Motschulsky, 1854)									
Hemiptera	Miridae	Orthops scutellatus Uhler, 1877					0.17±0.41	0.86	2.54	2.54	
		Pinalitus rubricatus (Fallen, 1807)					0.33±0.82	1.68			
Lepidoptera	Lycaenidae	Heliophorus sena (Kollar 1844)	1.67±1.21	5.39	23.64	33.32	1±1.26	5.08	38.13	40.67	
		Heliophorus androcles (Westwood, 1851)	1±1.26	3.23			0.67±0.82	3.41			
		Lycaena pavana (Kollar, 1848)	1.33±1.03	4.29			1.83±0.75	9.30			
		Celastrina huegeli (Moore, 1882)	1.83±0.98	5.90			2.17±1.17	11.03			
		Celastrina lavendularis (Moore, 1877)	1.5±0.84	4.84			1.83±0.98	9.30			
	Pieridae	Pieris canidia (Sparman, 1768)	0.67±0.82	2.16	7		0.5±0.84	2.54	2.54		
		Belenois aurota (Fabricius 1793)	0.17±0.41	0.55							
		Eurema hecabe (Linnaeus, 1758)	0.5±0.84	1.61							
		Eurema laeta Boisduval, 1836	0.5±0.55	1.61							
		Eurema brigitta (Cramer, 1780)	0.33±0.52	1.06							
		Colias electo fieldii Ménétrés, 1855									

	Nymphalidae	Neptis mahendra Moore, 1872			1.06					
		Argynnis childrenI Gray, 1831	0.33±0.52	1.06						
	Riodinidae	Dodona durga (Kollar & Redtenbacher, 1844)	0.5±0.84	1.61	1.06					
	Callidulidae	Pterodecta felderi (Bremer, 1864)								

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

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