

Pollinator Diversity and Relative Abundance of Insect Visitors on Apple Crop in Kullu Hills of Western Himalaya India



Zoology

KEYWORDS : Insect pollinator, Diversity, Relative abundance, Apple, Kullu hills.

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ABSTRACT

*Studies on diversity and relative abundance of various insect visitors to apple crop was made by collecting them in different orchards located at Bhalogi (1400 m), Baskhola (1580 m) and Dhamadhar (1810 m) of Kullu hills of Western Himalaya. Insect diversity studies showed that apple flowers were visited by 39 species of insects belonging to 6 orders and 19 families of class Insecta. Of these, 18 species belonged to Hymenoptera, 9 to Diptera, 6 to Lepidoptera, 3 to Coleoptera, 2 to Hemiptera and 1 to order Thysanoptera. Analyses of data on relative abundance of different insect visitors revealed that Indian hive bee, *A. cerana* was the most abundant insect visitor to apple flowers in all the three experimental orchards i.e. Bhalogi (17.63%), Baskhola (18.21%) and Dhamadhar (20.21%). Other important hymenopterans at Bhalogi, Baskhola and Dhamadhar orchards were European honey bee, *A. mellifera* (14.93%, 15.97% and 14.51%), *Bombus tunicatus* (2.04%, 3.09% and 2.53%) and *Ceratina simillima* (4.19%, 2.40% and 4.21%). Besides, hymenopterans, dipterans also constituted an important group of insect pollinators.*

INTRODUCTION

Pollination is an essential pre-requisite for fertilization and fruit/seed set. If there is no pollination, there will be no fertilization and no fruits or seeds will be formed. The crops that are fertilized by pollen of same plant are self-compatible, whereas, there are certain other crops which are self-incompatible that cannot be fertilized by their own pollen, but require compatible pollen from different variety of the same crop. Therefore, these crops require cross-pollination, as adequately fertilized flowers produce fruits susceptible to primitive fruit fall (McGregor, 1976; Free, 1993). It is estimated that about 85% of the world's flowering plant species depend upon animals, mostly insects for pollination (Ollerton *et al.*, 2011) and the total annual economic value of crop pollination worldwide is about \$153billion (Gallai *et al.*, 2009). Losey and Vaughan (2006) and Mattu (2013) emphasized that flower-visiting insects provide an important ecosystem function to global crop production through their pollination services. The rapid spread of human habitation is affecting the available natural habitats through urbanization and other land-use practices, putting pressure on ecosystem services delivered by wild pollinators.

The cultivation of apple in India was initiated by the Britishers in 1870, when the European missionaries introduced apple cultivars which were for the first time planted in Kullu hills of Himachal Pradesh. Later delicious apple cultivars were introduced from California and planted in Kotgarh area of district Shimla in Himachal Pradesh (Keulemans *et al.*, 1996). In recent years, apple has emerged as the leading cash crop amongst temperate fruit crops. It alone accounts for 48% of area under all fruits and 78% of total fruit production. The area covered under apple production increased from 35,076 ha in 1975-76 to 99,564 ha in 2009-10 registering an annual growth of 3.14% during this period (Singh *et al.*, 2012). During the last few years, the production of apple per hectare has come down inspite of increase in area under apple cultivation. So, there is a need for changed strategies and look for other possible inputs such as full use of under-utilized and eco-friendly resources like bee pollination for increasing apple production in state (Verma and Jindal, 1997; Mattu *et al.*, 2012b; Mattu and Mattu, 2013; Mattu, 2014).

Of all the insects honey bees are the most important pollinators in apple orchards in the Himalayan region and they form a vast majority of pollinating insects (Free, 1993). However, very little is known about the role of different insect visitors including honeybees in pollinating various horticultural crops in India especially Himachal Pradesh (Mishra *et al.*, 1976; Mattu and Verma, 1985; Verma, 1990; Mattu *et al.*, 1996, 2006; Kumar, 1997; Raj *et al.*, 2012).

Therefore, present investigation was conducted in order to know the diversity and relative abundance of different insect species visiting apple crop in Kullu hills of Western Himalaya.

MATERIAL AND METHODS

Studies on diversity and relative abundance of various insect visitors to apple crop was made by collecting the flower visitors in different orchards located at Bhalogi (1400 m), Baskhola (1580 m) and Dhamadhar (1810 m) of Kullu hills of Western Himalaya. These apple orchards had more than 200 trees belonging to Royal delicious, Red Gold, Golden delicious and Red delicious varieties. All these collections were made during the months of March-April, when the orchards were in full bloom. Almost equal numbers of working hours were spent in each orchard. Relative abundance of different insect visitors was determined in terms of their visits per 500 flowers/10 minutes (Verma and Chauhan, 1985). The observations were recorded during 0900-1000, 1200-1300 and 1500-1600 hours of a day and average counts at these hours gave abundance of an insect pollinator for the particular day (Southwood, 1978).

For collection of different insect species, following methods were used: Hand picking; sweeping; beating; aerial netting and aspirator method and standard methods were followed for the preservation of insect pollinators belonging to different orders such as Hymenoptera; Diptera; Lepidoptera; Coleoptera and Thysanoptera (Arora, 1990; Ghosh, 1990; Jonathan, 1990). Pollination data was analysed statistically (Snedcor and Cochran, 1993).

RESULTS AND DISCUSSION

Insect diversity studies showed that apple flowers were visited by 39 species of insects belonging to 6 orders and 19 families of class Insecta. Of these, 18 species belonged to Hymenoptera, 9 to Diptera, 6 to Lepidoptera, 3 to Coleoptera, 2 to Hemiptera and 1 to order Thysanoptera (Table 1). It was observed that Hymenoptera was represented by 7 families *viz.*, Apidae, Halictidae, Megachilidae, Andrenidae, Vespidae, Pteromalidae and Formicidae with species like *Apis cerana*, *A. mellifera*, *Bombus tunicatus*, *B. haemorrhoidalis*, *Megachile lenata*, *Vespa mandarina*, *V. velutina*, *Andrena* sp., *Halictus dasygaster*, *Camponotus* sp. etc. Of the dipterans, species like *Eristalis tenax*, *E. himalyensis*, *Episyrphus balteatus*, *Metasyrphus corollae*, *Musca domestica*, *Fannia domestica*, *Calliphora vicina*, *Dolichopus* sp. etc. spread over families Syrphidae, Cordiluridae, Calliphoridae and Dolichopodidae were recorded as pollinators of apple crop. However, lepidopterans were represented by only 6 species belonging to families Nymphalidae, Pieridae, Noctuidae and Lycaenidae. Order Coleoptera was

represented by two families i.e. Coccinellidae and Chrysomelidae, whereas, Hemiptera was represented by only one family Cixiidae. In addition, a single species of thrips belonging to order Thysanoptera was also recorded as pollinator of apple crop in some orchards of Kullu hills (Table1).

Present studies are in accordance with the work of earlier investigators who have also recorded a variety of pollinators on apple crop in different parts of the continent. For example, Verma and Chauhan (1985) recorded 44 species of insect pollinators on apple bloom in Shimla hills, of which 16 belonged to Hymenoptera, 11 to Diptera, 9 to Lepidoptera, 7 to Coleoptera and 1 to Hemiptera, whereas, Kumar (1988) recorded 16 species of bees visiting apple bloom in Solan area of Himachal Pradesh. A similar survey by Hong *et al.* (1989) revealed a total of 88 species of pollinators on apple, pear and peach flowers in North Korea, whereas, Kumar (1997) observed that apple flowers were visited by 49 insect species in the Himalayan belt. Recent pollinator diversity studies by Mattu *et al.*, (2012a) and Raj *et al.*, (2012) also showed that apple flowers were visited by 46 species of insects belonging to 5 orders and 17 families of class Insecta.

Analyses of data on relative abundance of different insect visitors revealed that Indian hive bee, *A. cerana* was the most abundant insect visitor to apple flowers in all the three experimental orchards i.e., Bhalogi (18.20±0.72, 17.63%), Baskhola (17.80±0.52, 18.21%) and Dhamadhar (19.80±0.51, 20.21%). Other important hymenopterans at Bhalogi, Baskhola and Dhamadhar were European honeybee, *A. mellifera* (15.41±0.51, 14.93%, 15.60±0.10, 15.97% and 14.18±0.32, 14.51%), *Bombus tunicatus* (2.11±0.12, 2.04%, 3.02±0.02, 3.09% and 2.48±0.04, 2.53%) and *Ceratina simillima* (4.32±0.40, 4.19%, 2.34±0.01, 2.40% and 4.12±0.01, 4.21%) and *Vespa velutina* (0.38±0.11, 0.37%, 0.24±0.01, 0.25% and 0.17±0.02, 0.17%) Among Dipterans, *Musca domestica* (7.18±0.43, 6.96%, 5.82±0.07, 5.96% and 4.23±0.02, 4.32%), *Eristalis balteatus* (10.65±0.61, 10.32%, 8.41±0.01, 8.36% and 7.39±0.12, 7.56%) and *Eristalis tenax* (6.11±0.52, 5.92%, 6.33±0.03, 6.48% and 5.71±0.09, 5.84%) were the most important pollinators at Bhalogi, Baskhola and Dhamadhar orchards respectively. Moreover, *Pieris brassicae* and *Pieris canidia* were important lepidopteran pollinators present at Bhalogi (5.56±0.04, 5.38% and 7.02±0.06, 6.80%), Baskhola (6.83±0.04, 6.99% and 7.62±0.12, 7.80%) and Dhamadhar (5.83±0.11, 5.96% and 7.08±0.04, 7.24%) orchards, *Coccinella* sp. (0.61±0.22, 1.56%, 2.04±0.11, 2.08% and 0.62±0.13, 0.63%) was the only coleopteran pollinator at Bhalogi, Baskhola and Dhamadhar orchards respectively. *Adolenda typicae* and *Nysius* sp. were important hemipteran

pollinators recorded at Baskhola (0.09±0.20, 0.09% and 0.24±0.08, 0.25%) orchards, however, thrips belonging to order Thysanoptera were present at Bhalogi (0.24±0.01, 0.23%) and Dhamadhar (0.48±0.03, 0.49%) orchards (Tables 2-4).

Based on present studies it is suggested that hymenopterans and dipterans were the most abundant insect pollinators of apple at Bhalogi (43.92%, 40.48%), Baskhola (45.01%, 35.60%) and Dhamadhar (47.86%, 35.28%) orchards.

The higher population of *A. cerana* in experimental apple orchards (Tables 2-4) may be due to its being native species and thus having better adaptability to local environmental conditions. These results are in conformity with the earlier observations of Mishra *et al.* (1976); Verma (1990) and Mattu and Mattu (2010) who also reported that honeybees constituted a major proportion of insect pollinators on apple crop in Shimla hills and *Bombus* sp. also visited apple flowers in good number. Similarly, Verma and Chauhan (1985), Dashad (1989) and Kumar (1997) also found the hymenopterans and dipterans as the most predominant insect species on apple crop in Shimla hills. Recently, Mattu *et al.* (2012a) and Raj *et al.* (2012) reported *Bombus* sp., *Vespa* sp., *Halictus* sp., *Xylocopa fenestrata* and *Camponotus* sp. in good proportion on different mountain fruit crops in Himachal Pradesh.

Based on present studies on pollinator diversity and relative abundance of insect visitors on apple bloom it is suggested that Hymenopterans were most abundant insect pollinators on apple bloom in Kullu hills of Western Himalayas. These results are in accordance with earlier findings of Mattu and Mattu (2007) who also found hymenopterans (78.89%) as the most important insect pollinators on almond bloom, whereas, hymenopterans (44.50%) and dipterans (49.37%) were almost equally abundant on peach bloom in Shimla and Solan hills respectively. Present results also support the recent findings of Raj *et al.* (2012) who also found hymenopterans as the most important insect pollinators on apple bloom in Himachal Himalaya.

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Table 1: Insect species visiting apple flowers with their taxonomic status

	Order HYMENOPTERA		Order DIPTERA		Order LEPIDOPTERA		Order COLEOPTERA		Order HEMIPTERA		Order THYSANOPTERA
	Family Apidae		Family Syrphidae		Family Nymphalidae		Family Coccinellidae		Family Cixiidae		Family Thripidae
1.	Apis cerana	19.	Episyrphus balteatus	28.	Vanessa cardui	34.	Coccinella septumpunctata	37.	Adolenda typicae	39.	Thrips
2.	Apis mellifera	20.	Eristalis tenax	29.	Vanessa cashmirensis	35.	Coccinella repanda	38.	Nysius sp.		
3.	Ceratina simillima	21.	Eristalis himalyansis		Family Pieridae		Family Chrysomelidae				
4.	C. smaragdula	22.	Metasyrphus corollae	30.	Pieris brassicae	36.	Altica sp.				
5.	Bombus tunicatus		Family Cordiluridae	31.	Pieris canidia						
6.	B. haemorrhoidalis	23.	Musca domestica		Family Noctuidae						
7.	Xylocopa fenestrata	24.	Fannia domestica	32.	Agrotis ipsilon						
8.	Anthophora sp.		Family Calliphoridae		Family Lycaenidae						

	Family Halictidae	25.	Calliphora vicina	33.	Heliophorus androcles						
9.	Halictus dasygaster	26.	Lucilia sp.								
10.	Nomia elliotii		Family Dolichopodidae								
11.	Nomia westwoodi	27.	Dolichopus sp.								
	Family Megachilidae										
12.	Megachile lenata										
13.	Megachile umbripan										
	Family Andrenidae										
14.	Andrena sp.										
	Family Vespidae										
15.	Vespa mandrina										
16.	Vespa velutina										
	Family Pteromalidae										
17.	Chalcid sp.										
	Family Formicidae										
18.	Camponotus sp.										

Table 2: Relative abundance of different insect pollinators visiting apple bloom at Bhalogi orchard. No. of insects/500 flowers/10 minutes

Order/Family	Genus/Species	Mean \pm S.E.	Population Percentage	Family Percentage	Order Percentage
HYMENOPTERA					
Apidae	Apis cerana	18.20* \pm 0.72	17.63	40.53	43.92
	Apis mellifera	15.41 \pm 0.51	14.93		
	Bombus tunicatus	2.11 \pm 0.12	2.04		
	Ceratina simillima	4.32 \pm 0.40	4.19		
	Xylocopa fenestrata	1.80 \pm 0.03	1.74		
Halictidae	Halictus dasygaster	0.72 \pm 0.02	0.70	2.29	43.92
	Nomia elliotii	1.64 \pm 0.05	1.59		
Megachilidae	Megachile lenata	0.54 \pm 0.01	0.52	0.52	43.92
Vespidae	Vespa mandrina	0.22 \pm 0.17	0.21	0.58	
	Vespa velutina	0.38 \pm 0.11	0.37		
DIPTERA					
Cordyluridae	Musca domestica	7.18 \pm 0.43	6.96	10.19	40.48
	Fannia domestica	3.34 \pm 0.31	3.24		
Syrphidae	Eristalis balteatus	10.65 \pm 0.61	10.32	19.99	
	Eristalis tenax	6.11 \pm 0.52	5.92		
	Eristalis himalayansis	2.18 \pm 0.12	2.11		
	Metasyrphus corollae	1.24 \pm 0.09	1.23		
	Melanostomata	0.45 \pm 0.02	0.48		
Calliphoridae	Calliphora vicina	4.66 \pm 0.30	4.51	8.23	
	Lucilia sp.	3.84 \pm 0.21	3.72		
Dolichopodidae	Dolichopus sp.	2.14 \pm 0.13	2.07	2.07	
LEPIDOPTERA					
Pieridae	Pieris brassicae	5.56 \pm 0.04	5.38	12.19	14.01
	Pieris canidia	7.02 \pm 0.06	6.80		
Noctuidae	Agrotis ipsilon	1.17 \pm 0.11	1.33	1.33	
Nymphalidae	Vanessa cardui	0.51 \pm 0.01	0.49	0.49	
COLEOPTERA					
Coccinellidae	Coccinella repanta	1.61 \pm 0.22	1.56	1.56	1.56
THYSANOPTERA	Thrips	0.24 \pm 0.01	0.23	0.23	0.23

* 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 apple bloom at Baskhola orchard. No. of insects/500 flowers/10 minutes

Order/Family	Genus/Species	Mean ± S.E.	Population Percentage	Family Percentage	Order Percentage
HYMENOPTERA					
Apidae	<i>Apis cerana</i>	17.80* ± 0.52	18.21	40.09	45.01
	<i>Apis mellifera</i>	15.60 ± 0.10	15.97		
	<i>Bombus tunicatus</i>	3.02 ± 0.02	3.09		
	<i>Ceratina similima</i>	2.34 ± 0.01	2.40		
	<i>Arthophora</i> sp.	0.41 ± 0.03	0.42		
Halictidae	<i>Nomia westwoodi</i>	2.26 ± 0.20	2.31	3.52	
	<i>Nomia elliotii</i>	1.18 ± 0.03	1.21		
Megachilidae	<i>Megachile umbripan</i>	0.52 ± 0.09	0.53	0.53	
Vespidae	<i>Vespa mandrina</i>	0.60 ± 0.02	0.62	0.87	
	<i>Vespa velutina</i>	0.24 ± 0.01	0.25		
DIPTERA					
Cordyluridae	<i>Musca domestica</i>	5.82 ± 0.07	5.96	9.15	35.60
	<i>Fannia domestica</i>	3.12 ± 0.12	3.19		
Syrphidae	<i>Eristalis balteatus</i>	8.41 ± 0.01	8.36	19.47	
	<i>Eristalis tenax</i>	6.33 ± 0.03	6.48		
	<i>Eristalis cerealis</i>	3.01 ± 0.02	3.08		
	<i>Eristalis himalyansis</i>	1.14 ± 0.11	1.17		
Calliphoridae	<i>Calliphora vicina</i>	3.45 ± 0.16	3.53	6.70	
	<i>Lucilia</i> sp.	3.10 ± 0.10	3.17		
Dolichopodidae	<i>Dolichopus</i> sp.	0.27 ± 0.13	0.28	0.28	
LEPIDOPTERA					
Pieridae	<i>Pieris brassicae</i>	6.83 ± 0.04	6.99	14.79	17.31
	<i>Pieris canidia</i>	7.62 ± 0.12	7.80		
Noctuidae	<i>Agrotis ipsilon</i>	2.01 ± 0.04	2.05	2.05	
Nymphalidae	<i>Vanessa cardui</i>	0.26 ± 0.09	0.47	0.47	
COLEOPTERA					
Coccinellidae	<i>Coccinella septempunctata</i>	2.04 ± 0.11	2.08	2.08	2.08
HEMIPTERA					
Cixiidae	<i>Adolenda typicae</i>	0.09 ± 0.20	0.09	0.34	0.34
	<i>Nysius</i> sp.	0.24 ± 0.08	0.25		

Table 4: Relative abundance of different insect pollinators visiting apple bloom at Dhamadhar orchard. No. of insects/500 flowers/10 minutes

Order/Family	Genus/Species	Mean ± S.E.	Population Percentage	Family Percentage	Order Percentage
HYMENOPTERA					
Apidae	<i>Apis cerana</i>	19.80* ± 0.51	20.21		47.86
	<i>Apis mellifera</i>	14.18 ± 0.32	14.51		
	<i>Bombus tunicatus</i>	2.48 ± 0.04	2.53	43.75	
	<i>Bombus haemorrhoidalis</i>	2.24 ± 0.13	2.29		
	<i>Ceratina simillima</i>	4.12 ± 0.01	4.21		
Halictidae	<i>Halictus dasygaster</i>	3.02 ± 0.02	3.09		
	<i>Nomia westwoodi</i>	1.45 ± 0.11	1.48	3.57	
Formicidae	<i>Componotus</i> sp.	0.16 ± 0.21	0.16	0.16	
Vespidae	<i>Vespa velutina</i>	0.17 ± 0.02	0.17	0.38	
	<i>Vespa mandrina</i>	0.21 ± 0.05	0.21		

DIPTERA					
Cordyluridae	Musca domestica	4.23 ± 0.02	4.32	7.88	
	Fannia domestica	3.48 ± 0.01	3.56		
Syrphidae	Eristalis balteatus	7.39 ± 0.12	7.56		
	Eristalis tenax	5.71 ± 0.09	5.84		
	Eristalis himalyansis	3.76 ± 0.02	3.99	20.06	
	Melanostomata	1.55 ± 0.10	1.58		
	Scaeva pyrastris	1.22 ± 0.03	1.26		35.28
Calliphoridae	Calliphora vicina	3.83 ± 0.30	3.91		
	Lucilia sp.	3.12 ± 0.02	3.19	7.10	
Dolichopodidae	Dolichopus sp.	0.24 ± 0.08	0.24	0.24	
LEPIDOPTERA					
Pieridae	Pieris brassicae	5.83 ± 0.11	5.96	13.20	
	Pieris canidia	7.08 ± 0.04	7.24		
Noctuidae	Agrotis ipsilon	1.07 ± 0.009	1.09	1.09	14.57
Nymphalidae	Vanessa cashmirensis	0.28 ± 0.02	0.28	0.28	
COLEOPTERA					
Coccinellidae	Coccinella repanta	0.62 ± 0.13	0.63	0.63	0.63
THYSANOPTERA	Thrips	0.48 ± 0.03	0.49	0.49	0.49

* Each value is an overall average for an insect species

S.E. = Standard error about the mean

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