

# Diversity, Distribution and Relative Abundance of Insect Pollinators on Apple Crop in Shimla Hills of Western Himalaya India

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**Abstract:** Diversity, distribution and relative abundance of various insect visitors of apple crop was investigated and carried out by collecting flower visitors in different orchards located at Padola (2200 m), Kalzar (2514 m) and Jarol (2648m) in Shimla hills of Western Himalaya. Insect diversity studies showed that apple flowers were visited by 41 species of insects belonging to 5 orders and 16 families of class Insecta. Of these, 13 species belonged to Hymenoptera, 17 to Diptera, 8 to Lepidoptera, 2 to Coleoptera and 1 to order Thysanoptera. Analyses of data on relative abundance of different insect visitors revealed that Indian hivebee, *A. cerana* was the most abundant insect visitor to apple flowers in all the three experimental orchards i.e. Padola (29.23%), Kalzar (29.43%) and Jarol (28.82%). European honey bee, *A. mellifera* (18.59%, 17.23% and 16.74%) and *Bombus tunicatus* (2.02%, 2.04% and 1.98%) were other important hymenopterans at Padola, Kalzar and Jarol orchards. Besides, hymenopterans, dipterans also constituted an important group of insect pollinators.

**Keywords:** Insect pollinator, Relative abundance, Apple, Honeybee, Shimla hills

## 1. Introduction

Pollination provides an essential ecosystem service that contributes to the maintenance of biodiversity and ensures the survival of plant species including crop plants. For one out of every three bites eaten, one can thank a bee, butterfly, bat, bird or other pollinator. Any loss of biodiversity is a matter of public concern, but losses of pollinating insects may be particularly troublesome because of the potential effects on plant reproduction and hence on food supply security. Many agricultural crops and natural plant populations are dependent upon pollination and often on the services provided by wild, unmanaged, pollinator communities (Free, 1993; Kluser and Peduzzi, 2007).

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 \$153 billion (Gallai *et al.*, 2009). 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. Other agronomic practices like manuring, pesticides, fertilizers etc. are quite cost effective and these may not yield the desired results without the use of managed and unmanaged pollinators for enhancing the productivity levels of different crops by pollination.

In recent years, apple has emerged as the leading cash crop amongst temperate fruit crops in Himalayan belt. 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).

Honeybees derive their food in the form of pollen and nectar, which are the raw materials of beekeeping industry. This collection of pollen and nectar from flowering plants by bees is known as 'foraging behavior'. In the Himalayan region Honey bees are the most important pollinators in apple orchards 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; Kumar, 1997; Mattu and Bhagat, 2015). Therefore, present investigation was conducted in order to know the diversity, distribution and relative abundance of different insect species visiting apple crop in Shimla hills of Western Himalaya.

## 2. Material and Methods

Research investigations were carried out on diversity, distribution and relative abundance of various insect visitors of apple crop, by collecting them in different orchards located at Padola (2200 m), Kalzar (2514 m) and Jarol (2648 m) of Shimla hills of Western Himalaya. These apple orchards had more than 200 trees belonging to Golden delicious, Red delicious, Royal delicious and Red Gold varieties. All these collections were made during the months of March-April, when the orchards were in full bloom. Almost equal number of working hours were spent in each

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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

Pollinator diversity studies showed that apple flowers were visited by 41 species of insects belonging to 5 orders and 16 families of class Insecta. Of these, 13 species belonged to Hymenoptera, 17 to Diptera, 8 to Lepidoptera, 2 to Coleoptera and 1 to order Thysanoptera (Table 1). It was observed that Hymenoptera was represented by 6 families viz., Apidae, Vespidae, Halictidae, Andrenidae, Formicidae and Pteromalidae with species like *Apis cerana*, *A. mellifera*, *Bombus haemorrhoidalis*, *B. tunicatus*, *Andrena* sp., *Halictus dasygaster*, *Camponotus* sp., *Vespa mandarina*, *V. velutina* etc. Of the dipterans, species like *Musca domestica*, *Eristalis tenax*, *E. himalyensis*, *Metasyrphus corollae*, *Episyrphus* sp., *Fannia domestica*, *Dolichopus* sp., *Calliphora vicina* etc. spread over families Syrphidae, Cordiluridae, Calliphoridae and Dolichopodidae were recorded as pollinators of apple crop. However, lepidopterans were represented by only 8 species belonging to families Pieridae, Nymphalidae and Noctuidae. Order Coleoptera was represented by two families i.e. Coccinellidae and Chrysomelidae. In addition, a single species of thrips belonging to order Thysanoptera was also recorded as pollinator of apple crop in Shimla hills (Table 1).

Different investigators have reported different number of pollinators on various temperate fruit crops. For example, Verma and Chauhan (1985) observed 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. A similar survey in North Korea by Hong *et al.* (1989) revealed a total of 88 species of pollinators on apple, pear and peach flowers, whereas, Kumar (1997) recorded that apple flowers were visited by 49 insect species in the Himalayan belt. Similarly, Thapa (2006) observed the presence of 50 species of insect pollinators on flowers of different crops in Nepal and found that honeybees contributed 80 % of the total insect pollination. 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.

Present studies 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., Padola (14.64±0.54, 29.23%),

Kalzar (13.70±0.71, 29.43%) and Jarol (12.68±0.64, 28.82%). Other important hymenopterans at Padola, Kalzar and Jarol were European honeybee, *A. mellifera* (9.24±0.21, 18.59%, 8.35±0.44, 17.23% and 8.12±0.52, 16.74%), *Bombus tunicatus* (0.72±0.06, 2.02%, 0.71±0.06, 2.04% and 0.69±0.03, 1.98%) and *Vespa velutina* (0.28±0.01, 0.55%, 0.27±0.01, 0.49% and 0.29±0.01, 0.42%) Among Dipterans, *Musca domestica* (7.42±0.21, 13.25%, 7.26±0.09, 13.72% and 7.20±0.08, 14.12%) and *Eristalis tenax* (3.42±0.09, 4.94%, 3.42±0.04, 4.97% and 3.42±0.08, 5.02%) were the most important pollinators at Padola, Kalzar and Jarol orchards respectively. Moreover, *Heliothis armegera* and *Pieris canidia* were important lepidopteran pollinators present at Padola (1.62±0.05, 2.42% and 0.52±0.07, 0.40%), Kalzar (1.57±0.08, 2.36% and 0.50±0.02, 0.41%) and Jarol (1.52±0.19, 2.44% and 0.49±0.03, 1.01%) orchards, *Coccinella* sp. (0.62±0.04, 1.40%, 0.62±0.04, 1.43% and 0.59±0.04, 0.34%) was the only coleopteran pollinator at Padola, Kalzar and Jarol orchards respectively. However, thrips belonging to order Thysanoptera were present at Padola (0.79±0.04, 1.38%), Kalzar (0.82±0.02, 1.68%) and Jarol (0.74±0.03, 1.57%) orchards (Tables 2-4).

Based on present studies it is suggested that hymenopterans and dipterans were the most abundant insect pollinators of apple at Padola (52.00%, 41.00%), Kalzar (50.76%, 43.05%) and Jarol (49.42%, 45.60%) orchards.

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 wild bees also visited apple flowers in good number. Similarly, Dashad (1989) and Kumar (1997) also found the hymenopterans and dipterans as the most predominant insect species on apple crop in Shimla hills. A number of recent studies have suggested that both domesticated and wild native bees play an important role in crop pollination (Winfree *et al.* 2007). Recently, Mattu *et al.* (2012a) and Mattu and Bhagat (2015) reported *Xylocopa fenestrata*, *Halictus* sp., *Bombus* sp., *Camponotus* sp. and *Vespa* sp. in good proportion on apple crop in Himachal Pradesh.

Analyses of data on pollinator diversity and relative abundance of insect visitors on apple bloom it is observed that Hymenopterans were most abundant insect pollinators on apple bloom in Shimla hills of Western Himalayas. These results were 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 Mattu and Bhagat (2015) who also found hymenopterans as the most important insect pollinators on apple bloom in Himachal Pradesh.

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

Order HYMENOPTERA	Order DIPTERA	Order LEPIDOPTERA	Order COLEOPTERA	Order THYSANOPTERA
<b>Family Apidae</b> 1. <i>Apis cerana</i> 2. <i>Apis mellifera</i> 3. <i>Bombus tunicatus</i> 4. <i>Bombus haemorrhoidalis</i> 5. <i>Xylocopa</i> sp. <b>Family Vespidae</b> 6. <i>Vespa mandarina</i> 7. <i>Vespa velutina</i> 8. <i>Polistes maculipennis</i> <b>Family Halictidae</b> 9. <i>Halictus dasygaster</i> 10. <i>Halictus</i> sp. <b>Family Andrenidae</b> 11. <i>Andrena</i> sp. <b>Family Formicidae</b> 12. <i>Camponotus</i> sp. <b>Family Pteromalidae</b> 13. <i>Chalcid</i> sp.	<b>Family Syrphidae</b> 14. <i>Eristalis tenax</i> 15. <i>Eristalis himalayensis</i> 16. <i>Eristalis cerealis</i> 17. <i>Eristalis angustimarginalis</i> 18. <i>Eristalis arvorum</i> 19. <i>Metasyrphus corolla</i> 20. <i>Episyrphus</i> sp. 21. <i>Scaeva pyrastris</i> 22. <i>Melanostoma</i> sp. <b>Family Cordiluridae</b> 23. <i>Musca domestica</i> 24. <i>Musca</i> sp. 25. <i>Fannia domestica</i> 26. <i>Orthelia</i> sp. 27. <i>Scathophaga stereoraria</i> <b>Family Calliphoridae</b> 28. <i>Calliphora vicina</i> 29. <i>Lucilia</i> sp. <b>Family Dolichopodidae</b> 30. <i>Dolichopus</i> sp.	<b>Family Pieridae</b> 31. <i>Pieris canidia</i> 32. <i>Pieris</i> sp. <b>Family Nymphalidae</b> 33. <i>Pyrameis indica</i> 34. <i>Vanessa cashmirensis</i> 35. <i>Neptis</i> sp. <b>Family Noctuidae</b> 36. <i>Heliothis</i> sp. 37. <i>Agrotis flammatra</i> 38. <i>Agrotis</i> sp.	<b>Family Coccinellidae</b> 39. <i>Coccinella septumpunctata</i> <b>Family Chrysomelidae</b> 40. <i>Altica</i> sp.	<b>Family Thripidae</b> 41. <i>Thrips</i>

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

Family	Genus/Species	Mean ± S.E.	Percentage Population	Family Percentage	Order Percentage
<b>HYMENOPTERA</b>					
Apidae	<i>Apis cerana</i>	14.64* ± 0.54	29.23	50.91	52.00
	<i>Apis mellifera</i>	9.24±0.21	18.59		
	<i>Bombus tunicatus</i>	0.72±0.06	2.02		
	<i>Bombus haemorrhoidalis</i>	0.59±0.02	1.07		
	<i>Camponotus</i> sp.	0.21±0.03	0.54	0.54	
Vespidae	<i>Vespa velutina</i>	0.28±0.01	0.55	0.55	
<b>DIPTERA</b>					
Cordyluridae	<i>Musca domestica</i>	7.42±0.21	13.25	13.25	
Syrphidae	<i>Eristalis anqustimarginalis</i>	4.03±0.14	7.19		41.00
	<i>Episyrphus</i> sp.	3.33±0.11	5.00	2.03	
	<i>Eristalis tenax</i>	3.42±0.09	4.94		
	<i>Eristalis himalayensis</i>	2.21±0.08	4.90		
Calliphoridae	<i>Calliphora</i> sp.	0.79±0.05	1.35	2.39	
	<i>Lucilia</i> sp.	0.59±0.03	1.04		
Dolichopodidae	<i>Dolichopus</i> sp.	1.90±0.03	3.22	3.22	
<b>LEPIDOPTERA</b>					
Noctuidae	<i>Heliothis armigera</i>	1.62±0.05	2.42	2.42	
Pieridae	<i>Pieris canidia</i>	0.52±0.07	0.40	1.40	
Nymphalidae	<i>Pyrameis indica</i>	0.31±0.05	0.32	0.32	4.14
<b>COLEOPTERA</b>					
Coccinellidae	<i>Coccinella</i> sp.	0.62±0.04	1.40	1.40	1.40
<b>THYSANOPTERA</b>	<i>Thrips</i>	0.79±0.04	1.38	1.38	1.38

\* 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 Kalzar orchard.  
 No. of insects/500 flowers/10 minutes

Family	Genus/Species	Mean ± S.E.	Percentage Population	Family Percentage	Order Percentage
<b>HYMENOPTERA</b>					
Apidae	<i>Apis cerana</i>	13.70±0.71	29.43		
	<i>Apis mellifera</i>	8.35±0.44	17.23	49.82	50.76
	<i>Bombus tunicatus</i>	0.71±0.06	2.04		
	<i>Bombus haemorrhoidalis</i>	0.62±0.01	1.12		
Formicidae	<i>Camponotus</i> sp.	0.15±0.02	0.45	0.45	
Vespidae	<i>Vespa velutina</i>	0.27±0.01	0.49	0.49	
<b>DIPTERA</b>					
Cordyluridae	<i>Musca domestica</i>	7.26±0.09	13.72	13.72	
Syrphidae	<i>Eristalis anqustimarginalis</i>	3.97±0.12	7.37		
	<i>Episyrphus</i> sp.	3.42±0.09	6.10		43.05
	<i>Eristalis tenax</i>	3.42±0.04	4.97	23.34	
	<i>Eristalis himalayensis</i>	2.24±0.09	4.90		
Calliphoridae	<i>Calliphora</i> sp.	0.77±0.02	1.42	2.44	
	<i>Lucilia</i> sp.	0.50±0.01	1.02		
Dolichopodidae	<i>Dolichopus</i> sp.	1.95±0.06	3.55	3.55	
<b>LEPIDOPTERA</b>					
Noctuidae	<i>Heliothis armigera</i>	1.57±0.08	2.36	2.36	
Pieridae	<i>Pieris canidia</i>	0.50±0.02	0.41	0.41	3.08
Nymphalidae	<i>Pyrameis indica</i>	0.31±0.02	0.31	0.31	
<b>COLEOPTERA</b>					
Coccinellidae	<i>Coccinella</i> sp.	0.62 ± 0.04	1.43	1.43	1.43
<b>THYSANOPTERA</b>	<i>Thrips</i>	0.82 ± 0.02	1.68	1.68	1.68

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

Family	Genus/Species	Mean ± S.E.	Percentage Population	Family Percentage	Order Percentage
<b>HYMENOPTERA</b>					
Apidae	<i>Apis cerana</i>	12.68±0.64	28.82		
	<i>Apis mellifera</i>	8.12±0.52	16.74	48.60	49.42
	<i>Bombus tunicatus</i>	0.69±0.03	1.98		
	<i>Bombus haemorrhoidalis</i>	0.59±0.02	1.06		
Formicidae	<i>Camponotus</i> sp.	0.11±0.03	0.40	0.40	
Vespidae	<i>Vespa velutina</i>	0.29±0.01	0.42	0.42	
<b>DIPTERA</b>					
Cordyluridae	<i>Musca domestica</i>	7.20±0.08	14.12	14.12	
Syrphidae	<i>Eristalis anqustimarginalis</i>	3.77±0.08	7.49		
	<i>Episyrphus</i> sp.	3.31±0.11	5.55		45.60
	<i>Eristalis tenax</i>	3.42±0.08	5.02	22.98	
	<i>Eristalis himalayensis</i>	2.21±0.06	4.92		
Calliphoridae	<i>Calliphora</i> sp.	1.83±0.05	3.84	5.26	
	<i>Lucilia</i> sp.	0.48±0.02	1.42		
Dolichopodidae	<i>Dolichopus</i> sp.	1.70±0.04	3.24	3.24	
<b>LEPIDOPTERA</b>					
Noctuidae	<i>Heliothis armigera</i>	1.52±0.19	2.44	2.44	
Pieridae	<i>Pieris canidia</i>	0.49±0.03	1.01	1.01	3.76
Nymphalidae	<i>Pyrameis indica</i>	0.29±0.02	0.31	0.31	
<b>COLEOPTERA</b>					
Coccinellidae	<i>Coccinella</i> sp.	0.59±0.04	0.34	0.34	0.34
<b>THYSANOPTERA</b>	<i>Thrips</i>	0.74±0.03	1.57	1.57	1.57

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