International Journal of Science and Research (IJSR)
ISSN (Online): 2319-7064
Index Copernicus Value (2013): 6.14 | Impact Factor (2013): 4.438

Effect of Changing Landscapes on Diversity, Distribution and Relative Abundance of Insect Pollinators on Apple Crop in Northwest Himalayas

V. K. Mattu[1], Thakur Bhagat[2]

[1]Sociobiology and Behavioural Ecology Research Lab

[2]Department of Biosciences, Himachal Pradesh University, Shimla (H.P.)-171005, India

Abstract: ***Pollinator diversity studies were conducted on apple bloom in terms of diversity, distribution and relative abundance of insect pollinators, in twenty orchards located at different landscapes of Kullu hills of the Northwest Himalayas. Apple orchards were selected in such a manner that, of these, ten were far away from the natural habitat (i.e. forest), whereas, other experimental orchards were located nearer to natural habitat.These studies revealed that apple flowers were visited by 44 species of insects belonging to 6 orders and 18 families of class Insecta. Hymenopterans and dipterans were the most abundant insect pollinators on apple bloom in all the experimental orchards. Relative abundance studies indicated that Indian hive bee, A. cerana was the most abundant insect visitors to this crop followed by European bee, A. mellifera. However, relative abundance of wild bees was comparatively less in orchards away from natural habitat than those nearer to it. Besides hymenopterans and dipterans, other important insect visitors to apple bloom were lepidopterans such as Pieris canidia, Pieris brassicae; coleopterans like Coccinella sp. and hemiptera like Adolenda typicaie. Present studies on diversity, distribution and relative abundance of different pollinators on apple bloom showed that hymenopterans were the most abundant insect pollinators on apple bloom at different landscapes, moreover, it was also observed that diversity and relative abundance of majority of insect pollinators was higher in those orchards which were nearer to natural habitat than those away from natural habitat.***

Keywords: Diversity, relative abundance, pollinators, natural habitat

1.Introduction

Pollination involves the transfer of pollen grains from male to female part of flower with the help of abiotic and biotic pollen dispersing agents. Wind, water and gravity are the important abiotic agents, whereas, insects, birds, bats and small mammals are the primary biotic agents (4). Various insect groups which are of prime significance in pollination of agricultural and horticultural crops are Hymenoptera, Diptera, Lepidoptera, Coleopteran and Thysanoptera. Of these, Hymenopterans are the most important insect pollinators because of their high energy requirements and tendency for collecting provisions for their brood in the form of pollen and nectar. Honeybees, bumble bees and solitary bees are some of the most important pollinators belonging to order Hymenoptera (9, 22, 12, 19). Among hymenopterans, honeybees are considered as the most efficient pollinators of cultivated crops because of their floral fidelity, potential for long working hours, presence of pollen basket, maintainability of high population, micromanipulation of flowers and adaptability to different climatic conditions. Further, honeybees can be domesticated, marked and transported from one place to another (30, 13, 16).

Pollination of different agricultural and horticultural crops by animals is an essential ecosystem service. It is estimated that about 85% of the world's flowering plants depend upon animals, mostly insects for pollination (24) and the total annual economic value of crop pollination worldwide is about $153 billion (5). (11) and (14) emphasized that flower-visiting pollinators provide an important ecosystem function to global crop production through their pollination services. However, 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. Therefore, in future emphasis has to be given on full use of under-utilized and eco-friendly resources like bee pollination (32, 20, 17, 15).

Many investigators have studied the pollination ecology of horticultural crops in relation to *A. mellifera* L. pollination in Europe, North America, South America and Australia (9, 22, 4). However, a little is known about the role of Indian hive bee, *Apis cerana* F. in pollinating fruit crops especially temperate fruit crops (18, 30, 21, 25). Therefore, present investigation was conducted in order to know the effect of changing landscapes on diversity, distribution and relative abundance of insect pollinators on apple crop in Kullu hills of the Northwest Himalayas.

2.Methodology

Present investigations were conducted on apple (*Malus domestica* Borkh) crop in twenty orchards located at different landscapes in Kullu hills of Himachal Pradesh during the months of March-April, 2013 when these orchards were in full bloom. Out of twenty experimental orchards, ten were located far away from the natural habitat (i.e. forest), whereas, other orchards were nearer to it.

Studies on diversity, distribution and relative abundance of various insect visitors to apple flowers were made by selecting trees at random, almost in the middle of orchards, on the basis of their size, age, flowering stage and number of branches. Relative abundance of different insect visitors was determined in terms of their visits per 500 flowers/10

minutes. 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 a particular day (29).

For collection of different insect pollinators, following methods were used: Hand picking; sweeping; beating; aerial netting and aspirator method and standard techniques were followed for the preservation of insect pollinators belonging to different orders such as Hymenoptera; Diptera; Lepidoptera; Coleoptera and Thysanoptera (1, 6, 8). Later on pollination data was analysed statistically (28).

3.Results

Pollinator diversity studies conducted in twenty experimental orchards showed that apple flowers were visited by 44 species of insects belonging to 6 orders and 18 families of class Insecta. Of these, 19 species belonged to Hymenoptera, 11 to Diptera, 8 to Lepidoptera, 3 to Coleoptera, 2 to Hemiptera and 1 to order Thysanoptera (Table 1).

Indian hive bee, *A. cerana* was the most abundant insect visitor to apple flowers in all the twenty experimental orchards investigated i.e. orchards away from natural habitat (17.02±0.72, 17.35%) and orchards nearer to natural habitat (19.20±0.51, 19.50%). Other important hymenopterans in orchards away from and nearer to natural habitat were: European bee, *A. mellifera* (14.40±0.51, 14.68%, and 15.31±0.32, 15.41%), *Bombus tunicatus* (2.10±0.12, 2.14% and 2.40±0.04, 2.43%) and *Ceratina simillima* (3.20±0.40, 3.36% and 4.04±0.01, 4.10%). However, wild bees like *Andrena* sp., *Megachile lenata* and *Megachile umbripan* were other important hymenopterans which were present only in those orchards which were nearer to natural habitat (0.18±0.21, 0.19%; 0.13±0.02, 0.14% and 0.24±0.05, 0.25%) (Tables 2, 3).

Among dipterans, *Musca domestica* (6.28±0.43, 6.40% and 4.20±0.02, 4.42%), *Episyrphus balteatus* (10.55±0.61, 10.72% and 12.89±0.12, 13.53%), and *Eristalis tenax* (7.21±0.52, 7.35% and 8.70±0.09, 9.25%) were the most important pollinators in orchards away from and nearer to natural habitat respectively. Other important dipterans in orchards away from and nearer to natural habitat were: *Calliphora vicina* (3.56±0.70, 3.65%, and 4.33±0.02, 4.35%) and *lucilia* sp. (3.80±0.21, 3.84% and 2.22±0.02, 2.23%) (Tables 2, 3).

Regarding lepidopteran pollinators, *Pieris brassicae* and *Pieris canidia* were the important insect species present in orchards away from natural habitat (6.36±0.21, 6.48% and 6.22±0.06, 6.34%) and orchards nearer to natural habitat (7.80±0.11, 7.92% and 7.03±0.24, 7.15%). Whereas, *Coccinella septumpunctata* and *Altica* sp. (0.90±0.10, 0.92% and 0.20±0.02, 0.21%) were the important coleopteran pollinators in orchards away from and nearer to natural habitat respectively. *Adolenda typicae* and *Nysius* sp. were the important hemipteran pollinators recorded in orchards away from natural habitat (0.40±0.20, 0.41% and 0.15±0.01, 0.15%), whereas thrips belonging to order Thysanoptera was present in orchards nearer to natural habitat only (0.50 ± 0.03, 0.51%) (Tables 2, 3).

Present results thus suggest that hymenopterans and dipterans were the most abundant insect pollinators of apple crop in orchards away from natural habitat (43.19%, 38.79%) as well as in orchards nearer to natural habitat (45.81%, 39.29%). Among all pollinators studied, both species of honeybees i.e. *A. cerana* and *A. mellifera* were the most predominant visitors to apple crop. However, wild bees like *Ceratina simillima*, *Xylocopa fenestrata*, *Halictus* sp. and *Nomia elliotii* were comparatively less in population in orchards far away from natural habitat (3.36%, 0.81%, 1.73% and 1.63%) than those nearer to it (4.10%, 1.03%, 2.66% and 2.41%) (Tables 2, 3).

4.Discussion

4.1 Diversity and Distribution Studies

Pollinator diversity studies on apple bloom revealed the presence of 44 species of insect pollinaors with maximum species belonging to Hymenoptera (19 species) followed by Diptera (11 species), Lepidoptera (8 species), Coleoptera (3 species), Hemiptera (2 species) and Thysanoptera (1 species) (Table 1). Earlier, (31) 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. A similar survey by (7) in North Korea revealed a total of 88 species of pollinators on apple, pear and peach flowers. Recent pollinator diversity studies by (19) and (25) also showed that apple flowers were visited by 46 species of insects belonging to 5 orders and 17 families of class Insecta in the Himalayan belt.

Studies on the apple bloom revealed that both *Apis cerana* and *A. mellifera* were almost equally distributed in all the orchards. Besides honey bees, other important hymenopteran visitors to apple bloom were: *Ceratina simillima*, *Bombus tunicatus* and *Xylocopa fenestrata* (Table 1). Present investigation also supports the earlier findings of (3) and (19) who also observed *Bombus* sp., *Halictus* sp., *Ceratina* sp. and *Xylocopa* sp. visiting apple flowers in Solan and Shimla hills respectively. Moreover, present studies showed that wild bees like *Andrena* sp., *Megachile lenata* and *Megachile umbripan* were present only in orchards nearer to natural habitat. These results corroborate the earlier findings of (10) who also observed that pollination services from wild bees were significantly and positively related to natural habitats.

Besides hymenopterous insects, apple flowers were also visited by many dipteran species like *Episyrphus balteatus*, *Eristalis tenax*, *Musca domestica*, *Fannia domestica*, and *Calliphora vicina* etc. in all the experimental orchards (Table 1). These observations are in accordance with the observations of earlier workers like (23) and (31), who also found *Eristalis* sp. and syrphid flies as the frequent visitors to apple crop in Shimla hills, whereas, (7) observed syrphid flies as the dominant visitors to apple flowers in North Korea. Recently, (25) and (15) also observed that *A. mellifera*, *A. cerana*, syrphids, butterflies and coleopterans

are the major pollinators of apple crop in the Himalayan region.

4.2 Relative Abundance Studies

Relative abundance studies on apple crop indicated that Indian hive bee, *A. cerana* was the most abundant insect visitor to apple crop followed by European bee, *A. mellifera* in all the orchards away from and nearer to natural habitat (Tables 2, 3). These results are in conformity with the earlier observations of (23), (30) and (13), who also observed that honeybees constituted a major proportion of insect pollinators on apple crop in Shimla hills. Similarly, (22) and (4) have also reported honeybees as the important pollinators of apple and other temperate fruit crops in Europe and United States. Recently, (25) found *A. cerana* and *A. mellifera* as most important insect visitors on apple bloom in Himachal Himalaya.

Other important hymenopteran visitors to apple bloom were: *Bombus tunicatus, Ceratina simillima, Xylocopa fenestrata* and *Halictus* sp. which were also relatively more abundant in orchards nearer to natural habitat than orchards away from it. Similar survey by (26) also found that coffee fields near natural habitat had more native bee visitation rate than in fields further away. Recently, (19) also reported *Bombus* sp., *Halictus* sp. and *Xylocopa fenestrata* in good proportion on different mountain fruit crops in Himachal Pradesh.

Besides hymenopteran, dipteran and lepidopteran species like *Episyrphus baltatus, Eristalis tenax, Pieris brassicae* and *Pieris canidia* were comparatively more abundant in orchards nearer to natural habitat than orchards away from it. Present results are in agreement with earlier observations of (2) who reported more abundance of dipteran species in areas nearer to natural habitats than urban and agriculture areas in Poland.

Thus present pollination studies revealed that hymenopterans were most abundant insect pollinators on apple bloom in Kullu hills of the Northwest Himalayas. Recently, (25) and (15) also reported hymenopterans and dipterans as the most important insect pollinators on apple and other temperate fruit crops in Himalayan belt. Moreover, it was also observed that diversity and relative abundance of majority of insect pollinators was higher in those orchards which were nearer to natural habitat than those away from natural habitat. These results are in accordance with the findings of (27) who also found that pollinator richness and visitation rates on crop decline with increasing distance from natural habitats.

5.Acknowledgments

The authors are thankful to the Chairman (V.K. Mattu), Department of Biosciences, Himachal Pradesh University, Shimla for providing the necessary facilities and for encouragements. Thanks are also due to the University Grants Commission (UGC), New Delhi for providing the financial assistance in the form of UGC-JRF (Thakur Bhagat).

References

[1] Arora, G.S. 1990. *Collection and preservation of animals (Lepidoptera)*. Zoological Survey of India, Calcutta, 131- 138.
[2] Bankowska, R. 1980. Fly communities of the family Syrphidae in natural and anthropogenic habitats of Polland. *Memorabilia Zoologica*, **33**: 3 – 93.
[3] Dashad, S.S. 1989. Pollination studies on apple (*Malus domestica* Borckh) with particular reference to the role of honeybees. Ph.D. Thesis, Dr. Y.S. Parmar University of Horticulture and Forestry, Solan, H.P. India.
[4] Free, J.B. 1993. Insect Pollination of Crops. Academic Press, London.
[5] Gallai, N., Salles, J.M., Settele, J. and Vaissiere, B.E. 2009. Economic valuation of the vulnerability of world agriculture confronted with pollinator decline, Ecological Economics, **68**: 810 - 821.
[6] Ghosh, A.K. 1990. *Collection and preservation of animals*. Zoological Survey of India, Calcutta, 71-80.
[7] Hong, K.J., Lee, S.H. and Choi, K.M. 1989. Flower visiting insects on the flowers of pear, peach and apple trees in Suwon. *Korean. J. Apic.* 4: 16-24.
[8] Jonathan, J.K. 1990. *Collection and preservation of animals (Hymenoptera)*. Zoological Survey of India, Calcutta, 147-150.
[9] Kozin, R.B. 1972. Pollination of entomophilous crops by bees. Amrind Pub. Co. Pvt., New York.
[10] Kremen, C., William, N.M., Bugg, R.L., Fay, J.P. and Thorp, R.W., 2004. The area requirements of an ecosystem service: crop pollination by native bee communities in California, *Ecology Letters*, **7**: 1109 – 19.
[11] Losey, J. E. and Vaughan, M. 2006. The economic value of ecological services provided by insects. BioScience **56**: 311–323.
[12] Mattu, N., Sharma, R.M., Mattu, V.K. and Sharma, M. 2006. Diversity, Abundance and Foraging Activity of insect Pollinators on *Pyrus communis* Linn. In: Biodiversity and Environment (Eds.: Pandey B.N. and Kulkarni G.K.). A.P.H. Pub., New Delhi, 13-28.
[13] Mattu, N. and Mattu, V.K. 2010. Pollinator Diversity, Beekeeping and Sustainable Mountain Crop Productivity. In "Advances in Entomology" (ed. Singh, J and Kumar, A). New Delhi: Kanishka Publishers, pp.37-51.
[14] Mattu, V.K. 2013. Pollinator Friendly Management Practices in Himachal Himalayas. In "Vignettes of Himachal Himalayas- Vol 2". Satyam Publishing House, New Delhi, pp 75-99.
[15] Mattu, V.K. 2014. Role of honeybees and other pollinators in crop productivity and impacts of climate change. Wkshp. on Promotion of Honey Beekeeping in Haryana**,** Panchkula, pp. 56-74.
[16] Mattu, V.K. and Mattu, N. 2007. Conservation and Management of Pollinators for Sustainable Horticulture in Himachal Himalaya. Institute of Integrated Himalayan Studies (UGC Centre of Excellence), HP Univ., Shimla. 128 pages.
[17] Mattu, V.K. and Mattu, N. 2013. Mountain perspectives and modern Beekeeping Technology. *Himalayan Studies Journal* 4: 103-114.

[18] Mattu, V.K. and Verma, L.R. 1985. Studies on annual foraging cycle of *Apis cerana indica* F. in Shimla hills of northwest Himalayas. *Apidologie* 16: 1-18.
[19] Mattu, V.K., Hem Raj and Mattu, N. 2012a. Pollinator diversity and relative abundance studies on apple crop in Shimla Hills, Himachal Pradesh. *HP Univ. J.* 1(2): 130-135.
[20] Mattu, V.K., Hem Raj and Thakur, M.L. 2012b. Foraging behavior of honeybees on apple crop and its variation with altitude in Shimla Hills of Western Himalaya, India. *International Journal of Science and Nature* 3(1): 296-301.
[21] Mattu, V.K., Sharma, N., Kumar, D. and Kumar, L. 1996. Pollination Ecology of Stone Fruit Crops in Himachal Pradesh, India. Rec. Adv. Biosc. & Ocean., 75-88.
[22] McGregor, S.F. 1976. Insect pollination of cultivated crop plants. U.S. Dept. Agric. Handbook, 496.
[23] Mishra, R.C., Dogra, G.S. and Gupta, P.R. 1976. Some observations on insect pollinators of apple. *Indian Bee J.* **38**: 20-22.
[24] Ollerton, J., Winfree, R. and Tarrant, S. 2011. How many flowering plants are pollinated by animals? *Oikos*, **120**: 321-326.
[25] Raj, H., Mattu, V.K. and Thakur, M.L. 2012. Pollinator diversity and relative abundance of insect visitors on apple crop in Shimla hills of western Himalaya, India. *International Journal of Science and Nature* 3 (3): 507-513.
[26] Ricketts, T.H., Dailly, G.C., Ehrlich, P.R. and Michener, C.D. 2004. Economic value of tropic forest to coffee production. *Proceedings of the National Academy of Science*, U.S.A., **101**(34): 12579 - 82.
[27] Ricketts, T.H., Regetz, J., Dewenter, I.S., Cunningham, S.A., Kremen, C., Bogdanski, A., Herren, B.G., Greenleaf, S.S., Klein, A.M., Mayfield, M.M., Morandin, L.A., Ochieng, A. and Viana, B.F. 2008. Landscape effects on crop pollination services: are there general patterns? *Ecological Letters*, **11**: 499 – 515.
[28] Snedcor, G.W. and Cochran, W.G. 1993. Statistical methods. *Oxford and IBH Publishing Company, New Delhi.*
[29] Southwood, T.R.E. 1978. *Ecological methods.* Chapman and Hall, London.
[30] Verma, L.R. 1990. *Beekeeping in integrated mountain development: Economic and Scientific perspectives.* Oxford and IBH Publ., New Delhi.
[31] Verma, L.R. and Chauhan, P. 1985. Distribution, abundance and diversity of insect pollinators in apple orchards of Shimla hills. Indian J. Ecol. 12: 286-292.
[32] Verma, L.R. and Jindal, K.K. 1997. *Fruit crops pollination*. Kalyani Publishers, Ludhiana, India.

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*	20	*Eristalis tenax*	31	*Neptis* sp.	39	*Coccinella repanda*	42	*Adolenda typicaie*	Thrips
2	*Apis mellifera*	21	*Episyrphus balteatus*	32	*Vanessa cardui*	40	*Coccinella septumpunctata*	43	*Nysius* sp.	
3	*Ceratina smaragdula*	22	*Eristalis himalyansis*	33	*Vanessa cashmirensis*		Family **Chrysomelidae**			
4	*C. simillima*	23	*Metasyrphus corolla*		Family **Pieridae**	41	*Altica* sp.			
5	*Bombus tunicatus*	24	*Eristalis cerealis*	34	*Pieris brassicae*					
6	*B. haemorridalis*	25	*Eristalis arvorum*	35	*Gonepteryx rhamni*					
7	*Anthophora* sp.		Family **Cordiluridae**	36	*Pieris canidia*					
8	*Xylocopa fenestrata*	26	*Musca domestica*		Family **Noctuidae**					
	Family **Vespidae**	27	*Fannia domestica*	37	*Agrotis ipsilon*					
9	*Vespa velutina*		Family **Calliphoridae**		Family **Lycaenidae**					
10	*Vespa mandrina*	28	*Calliphora vicina*	38	*Heliophorus androcles*					
11	*Vespa auraria*	29	*Lucilia* sp.							
12	*Vespa flaviceps*		Family **Dolichopodidae**							
	Family **Megachilidae**	30	*Dolichopus* sp.							
13	*Megachile umbripan*									
14	*Megachile lenata*									
	Family **Halictidae**									
15	*Nomia elliotii*									
16	*Nomia westwoodi*									

17	*Halictus dasygaster*									
	Family **Andrenidae**									
18	*Andrena* sp.									
	Family **Formicidae**									
19	*Camponotus* sp.									

Table 2: Relative abundance of different insect pollinators visiting apple bloom at orchards away from natural habitat.
No. of insects/500 flowers/10 minutes

Order/Family	Genus/Species	Mean ± S.E.	Population Percentage	Family Percentage	Order Percentage
HYMENOPTERA					43.19
Apidae	*Apis cerana*	17.02* ± 0.72	17.35	38.34	
	Apis mellifera	14.40 ± 0.51	14.68		
	Bombus tunicatus	2.10 ± 0.12	2.14		
	Ceratina simillima	3.20 ± 0.40	3.36		
	Xylocopa fenestrate	0.80 ± 0.03	0.81		
Halictidae	*Halictus dasygaster*	1.70 ± 0.12	1.73	3.36	
	Nomia elliotii	1.60 ± 0.10	1.63		
Vespidae	*Vespa auraria*	0.50 ± 0.01	0.51	1.49	
	Vespa mandrina	0.54 ± 0.17	0.56		
	Vespa velutina	0.41 ± 0.11	0.42		
DIPTERA					38.79
Cordyluridae	*Musca domestica*	6.28 ± 0.43	6.40	10.03	
	Fannia donestica	3.30 ± 0.31	3.63		
Syrphidae	*Episyrphus balteatus*	10.55 ± 0.61	10.72	18.07	
	Eristalis tenax	7.21 ± 0.52	7.35		
Calliphoridae	*Calliphora vicina*	3.56 ± 0.70	3.65	7.49	
	Lucilia sp.	3.80 ± 0.21	3.84		
Dolichopodidae	*Dolichopus* sp.	3.14 ± 0.13	3.20	3.20	
LEPIDOPTERA					14.69
Pieridae	*Pieris brassicae*	6.36 ± 0.21	6.48	12.82	
	Pieris canidia	6.22 ± 0.06	6.34		
Noctuidae	*Agrotis ipsilon*	1.27 ± 0.11	1.30	1.30	
Nymphalidae	*Neptis* sp.	0.50 ± 0.01	0.51	0.57	
COLEOPTERA					2.77
Coccinellidae	*Coccinella repanta*	1.81 ± 0.22	1.85	2.77	
	Coccinella septumpunctata	0.90 ± 0.10	0.92		
HEMIPTERA	*Adolenda typicaie*	0.40 ± 0.20	0.41	0.56	0.56
Cixiidae	*Nysius* sp.	0.15 ± 0.01	0.15		

* 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 orchards nearer to natural habitat.
No. of insects/500 flowers/10 minutes

Order/Family	Genus/Species	Mean ± S.E.	Population Percentage	Family Percentage	Order Percentage
HYMENOPTERA					45.81
Apidae	*Apis cerana*	19.20* ± 0.51	19.50		
	Apis mellifera	15.31 ± 0.32	15.41		
	Bombus tunicatus	2.40 ± 0.04	2.43	40.16	
	Ceratina smaragdula	0.10 ± 0.01	0.11		
	Ceratina simillima	4.04 ± 0.01	4.10		
Halictidae	*Halictus dasygaster*	2.65 ± 0.02	2.66	5.07	
	Nomia elliotii	2.40 ± 0.11	2.41		
Andrenidae	*Andrena* sp.	0.18 ± 0.21	0.19	0.19	
Megachilidae	*Megachile lenata*	0.13 ± 0.02	0.14	0.39	
	Megachile umbripan	0.24 ± 0.05	0.25		
DIPTERA					39.29
Cordyluridae	*Musca domestica*	4.20 ± 0.02	4.42	6.95	
	Fannia domestica	2.40 ± 0.01	2.53		
Syrphidae	*Episyrphus balteatus*	12.89 ± 0.12	13.53		
	Eristalis tenax	8.70 ± 0.09	9.25	23.55	
	Eristalis cerealis	0.53 ± 0.10	0.55		
	Eristalis arvorum	0.21 ± 0.03	0.22		

Calliphoridae	*Calliphora vicina*	4.33 ± 0.02	4.35	6.58	
	Lucilia sp.	2.22 ± 0.02	2.23		
Dolichopodidae	*Dolichopus* sp.	2.20 ± 0.08	2.21	2.21	
LEPIDOPTERA					
Pieridae	*Pieris brassicae*	7.80 ± 0.11	7.92	15.07	
	Pieris canidia	7.03 ± 0.24	7.15		15.70
Lycaenidae	*Heliophorus* sp.	0.40 ± 0.09	0.42	0.42	
Nymphalidae	*Vanessa cashmirensis*	0.20 ± 0.02	0.21	0.21	
COLEOPTERA					
Coccinellidae	*Coccinella repanta*	0.41 ± 0.13	0.42	0.42	
Chrysomelidae	*Altica* sp.	0.20 ± 0.02	0.21	0.21	0.63
THYSANOPTERA	Thrips	0.50 ±0.03	0.51	0.51	0.51

Author Profile

Dr. V.K. Mattu, Chairman Department of Biosciences, Himachal Pradesh University, Shimla, Address : Department of Biosciences, Himachal Pradesh University Shimla-171005, Himachal Pradesh, India.

Thakur Bhagat, Research Fellow, Department of Biosciences, Himachal Pradesh University, Shimla, Address: Department of Biosciences, Himachal Pradesh University Shimla-171005, Himachal Pradesh, India.