ENTOMON 42(4): 275-282 (2017)
Article No. ent. 42403

Insect pollinators, their diversity, foraging behaviour and relative abundance on litchi, okra and sarson

Joginder Singh[1], Neelima R Kumar[2] and Anita Devi[*]

Department of Zoology, Panjab University, Chandigarh 160014, India
Email: anitakadian23@gmail.com

ABSTRACT: The study focused on the importance of the role of insects as pollinators with reference to the fruit crop *Litchi chinensis* Sonn. (Litchi) and the vegetable crops *Abelmoschus esculentus* (L.) Moench (Okra) and *Brassica campestris* (L) var.(Sarson). The studies envisaged the diversity, relative abundance, foraging rate and foraging duration of important pollinators on the target crops. The studies revealed that the diversity of insect pollinators was crop specific. Honey bees were dominating the scene and were the most efficient pollinators of most crops. The exotic honey bee *A. mellifera* outscored the other pollinators where it was present. This could be explained on the basis of domestication and migration of this bee in the field areas. It was also observed that the diversity of insect pollinators on crops studied showed definite decline, when compared to earlier studies.

KEY WORDS: Okra, litchi, sarson, insect pollinators, diversity

INTRODUCTION

It is necessary to enhance the yield of crops under cultivation and also to maintain the diversity of flora and fauna thereby assuring sustainability of agricultural productivity. For this insects are an indispensible component of sustainable agriculture, natural ecosystem balance and a pollution free environment. They provide the best free ecosystem service by way of pollination of our crop plants. The insects and the plants have a mutualistic relationship and have coevolved during the long course of evolution. The beneficial aspects of this association are immense. Pollination by insects is thought to be the main reproductive mechanism in 78% of flowering plants and is essential for maintaining plant genetic diversity. Klein *et al*. (2007) observed that 87 per cent of the leading global food crops were dependent upon animal pollination, while 13 per cent crops did not rely upon animal pollination. Thapa (2006) reported 50 species of insects visiting flowers of 17 different species of selected crops during flowering period. The visiting preferences of insects to flowers of different crops differed among the crop species and insect species as well. To increase food production the yield per unit area under cultivation has to increase. Pollinators and beekeeping are a very important bio input which can contribute greatly in this direction (Singh and Kumar, 2009; Kumar, 2002; Kumar and Kumar, 2000; Verma *et al*., 2002). A consistent pollination service is one of the key factors supporting agricultural production but land use and flowering practices also have substantial impact on pollinators.

The insect visitors of a variety of crop plants have been studied and the role of individual species

* Author for correspondence

emphasized in some instances (Free, 1993; Sihag, 1991; Kumar and Kumar, 1997a, b, 1998). Honey bees are efficient pollinators because of modification of their body parts and their behavior like hairy bodies that readily pick up pollen grains and corbiculate, legs vegetarian diet, flower visiting habits and visit to many flowers of the same species during a single trip thus affecting pollination (Delaplane *et al.,* 2000; Partap, 2003; Bhalchandra *et al*., 2014). Heard (1999) reported that in the tropics, stingless bees (Apidae: Meliponini) were the effective pollinators of several crop species and contributed to the pollination of others. Evidence is still lacking for many plant species. Although a large amount of research has been devoted to test the ability of a few non *Apis* bees as pollinators of commercially important crops (Richards, 1993, 1995a, b; Rahman and Chopra, 1994; Cane *et al*., 1996), data are inconclusive to effectively support the adoption of a series of non *Apis* pollinators in many areas of agriculture.

MATERIALS AND METHODS

Studies on *Litchi chinensis* Sonn. (Litchi) were done in the month of March-April, at Pinjore Garden, Chandigarh. *Abelmoschus esculentus* (L.) Moench (Okra) was studied in field/grooves at village Tasoli near Chandigarh in the months of June-July and studies on *Brassica campestris* L. var. Sarson were conducted during the full blooming period of crops *i.e* in the month of February-March, at village Togan near Chandigarh. For all above said crops observations were taken three times in a week for a period of five weeks

The insects visiting the flowers of the crop under study were collected by sweeping a hand net. Collections were made during the blossoming period of crop/trees every two hours between 9:00 to 5:00 hrs; few visitors observed on the bloom at any other time of the day were also captured. Collected insects were killed in a glass bottle fumigated with ethyl acetate. These were stretched on a thermocol sheet, dried and preserved in insect cabinets. The preserved insects were identified by comparison with reference collection in the entomology laboratory of the Department of Zoology, Panjab University, Chandigarh, with the help of taxonomic keys and were also got identified by taxonomists in the parent department and in the Zoology Department of Punjabi University, Patiala.

The following parameters were considered for making observations:

Pollinators' diversity was observed as the number of different species of insects visiting the crop. The insects on a particular crop were caught with a sweep net as described above.

Relative abundance from five randomly selected areas of 1mx1m size was taken in case of field crops and 5 equal sized branches in case of fruit crops. The number of insects of each species visiting the flower were recorded for 5 minutes in the selected areas and observations were taken three times in a day between 09:00-11:00hrs, 12:00-02:00hrs, 3:00-5:00hrs during the full bloom of the crop.

Foraging behaviour was assessed by recording Foraging rate and Foraging duration. Foraging rate was determined by recording the number of flowers visited per minute by each type of insect. Observations were recorded between 09:00-11:00 h, 12:00-02:00 h, 3:00-5:00 h and were repeated five times during each interval. Foraging duration as the time spent by each insect species on one flower (in seconds) was recorded with the help of a stopwatch. Observations were recorded three times a day viz., 09:00-11:00 h, 12:00-02:00 h, 3:00-5:00 h and repeated five times during each period.

Data pertaining to relative abundance, foraging rate, foraging duration were statistically analysed using factorial randomized block design.

RESULTS AND DISCUSSION

The litchi fruit crop, *Litchi chinensis* Sonn, is a medium sized, round topped, evergreen subtropical tree bearing pendent clusters of rosy pink fruits. The aromatic succulent flesh around the seed forms the relished edible part. India is now second largest producer of litchi being next only to China. The

plant bears three types of flowers male, female and bisexual. The flowers require transfer of pollen by insects. The inflorescence was observed to be visited by nine species of insects. The little honey bee *Apis florea* was the most abundant pollinator (6.26/m of branch/5min.). Scelionid bee (3.93/m of branch/5min.) *Episyrphus balteatus* (3.2/m of branch/5min.) and *A. cerana* (1.53/m of branch/5min.) were the other important visitors observed during the present investigation. *Pieris canidia* and *Coccinella septumpunctata* were infrequent visitors (Table 1 and 2). It was observed that *Episyrphus balteatus* visited maximum number of flowers per minute (11.93±0.42) followed closely by the native honey bees. It was interesting to note that the European honey bee showed relatively less number of visits (9.86± 0.50) as compared to the native honey bees (Table 3). Time spent per flower was also highest in case of *Episyrphus* (Table 4).

Table 1. Diversity of insect pollinators on *Litchi chinensis* Sonn. (Litchi)

S. No.	Name of Insect	Order	Family
1.	*Episyrphus balteatus*	Diptera	Syrphidae
2.	*Apis florea*	Hymenoptera	Apidae
3.	*Apis cerana*	Hymenoptera	Apidae
4.	*Pieris canidia*	Lepidoptera	Pieridae
5.	*C. septumpunctata*	Coleoptera	Coccinellidae
6.	*Scelionid bee*	Hymenoptera	Scelionidae
7.	*Apis. Mellifera*	Hymenoptera	Apidae
8.	*Apis dorsata*	Hymenoptera	Apidae
9.	*Eristalis sp.*	Diptera	Syrphidae

Abelmoschus esculentus (L.) Moench, Okra (Bhindi) is grown throughout the tropical and warm temperature regions of the world for its fibrous pods full of seeds, which when picked young are eaten as vegetables. Results of investigations carried out on *Abelmoschus esculentus* showed that the crop was visited by ten species of insects (Table 5 and 6). There are very few reports available on the pollination requirements and pollinators of Okra. The data available suggested that though the flowers were self fertile, there was improvement in seed and fruit set as a result of cross pollination by insects (Njoya *et al*., 2005). Sharma (2004) in his studies conducted in Himachal Pradesh observed *Ceratina sexmaculatus*, *Megachile* sp., *Xylocopa* sp and *Bombus* sp. to be foraging on Okra bloom. Njoya *et al*. (2005) have, however, reported that though *Xylocopa* visited Okra bloom, it did not contribute to pollination. High foraging rates were exhibited by *A. cerana* (16.0 flowers/min) and *Papilio demoleus* (15.73 flowers/ min) during the present study (Table 7). These species were therefore important for the pollination of Okra. *Megachile* sp. and *Halictus* sp. were rated as efficient pollinators by Njoya *et al*. (2005). The native honey

Table 2. Relative abundance (number of insects/m^2/5min.) of pollinators on Litchi

Sl No.	Name of insect	Time of observation In hours			Grand mean	(PSs) = Nij/NjxS
		9-11AM	12-02PM	3-5PM		
1	*Episyrphus balteatus*	7.2±7.98	0.8±0.84	1.6±2.61	3.2±3.49	1.663
2	*Apis florea*	5.4±4.67	11.0±7.04	2.4±1.52	6.26±4.37	3.254
3	*Apis cerana*	2.2±1.48	1.6±1.14	0.8±1.79	1.53±0.70	0.795
4	*Pieris canidia*	0.8±1.10	0.2±0.45	0.2±0.45	0.4±0.35	0.207
5	*Coccinella septumpunctata*	2.0±1.41	0.2±0.45	0.00±0.00	0.73±1.10	0.379
6	*Scelionid bee*	5.0±2.55	3.6±2.19	3.2±3.03	3.93±0.95	2.043
7	*Apis. mellifera*	0.2±0.45	0.4±0.55	0.00±0.00	0.2±0.20	0.103
8	*Apis dorsata*	0.2±0.45	1.0±1.41	1.2±1.30	0.8±0.53	0.415
9	*Eristalis sp.*	0.00±0.00	0.60±0.89	0.2±0.45	0.26±0.31	0.135
Mean		2.55	2.15	1.06	1.92	

F ($p \leq 0.001$) for number of insects: Significant and F ($p \leq 0.001$) for day hours: Significant

Table 3. Foraging rate (number of flowers visited/minute) of pollinators on Litchi

Sl No.	Name of insect	Time of observation In hours			Grand mean	(PSs) = Nij/NjxS
		9-11AM	12-02PM	3-5PM		
1	*Episyrphus balteatus*	11.8±2.28	12.4±3.91	11.6±1.82	11.93±0.42	1.303
2	*Apis florea*	11.8±5.22	11.0±2.12	10.2±1.64	11.0±0.80	1.201
3	*Apis cerana*	11.4±3.44	12.4±1.67	11.0±3.16	11.6±0.72	1.267
4	*Pieris canidia*	7.0±3.74	5.4±1.67	10.6±4.62	7.66±2.66	0.836
5	*Coccinella septumpunctata*	1.0±0.00	1.2±0.45	1.2±0.45	1.13±0.12	0.123
6	*Scelionid bee*	6.8±2.95	7.2±1.10	8.0±1.22	7.33±0.61	0.800
7	*Apis. mellifera*	9.8±2.17	10.4±2.79	9.4±2.51	9.86±0.50	1.077
8	*Apis dorsata*	14.8±2.17	10.4±5.57	10.2±5.26	11.66±2.72	1.274
9	*Eristalis sp.*	11.2±1.64	10.0±1.73	9.4±1.14	10.20±0.92	1.114
	Mean	9.51	8.89	9.07	9.16	

Table 4. Foraging Duration (time spent in seconds/flower) of pollinators on Litchi

Sl No.	Name of insect	Time of observation In hours			Grand mean	(PSs) = Nij/NjxS
		9-11AM	12-02PM	3-5PM		
1	*Episyrphus balteatus*	19.4±11.92	13.0±3.54	21.0±9.30	17.80±4.23	42.694
2	*Apis florea*	5.0±2.74	2.4±0.55	3.6±1.82	3.66±1.30	207.639
3	*Apis cerana*	6.6±2.97	5.0±2.55	7.4±1.14	6.33±1.22	120
4	*Pieris canidia*	8.0±4.95	11.4±2.61	11.6±6.35	10.33±2.02	73.568
5	*Coccinella septumpunctata*	14.8±8.41	22.4±9.02	13.8±6.72	17.00±4.70	44.703
6	*Scelionid bee*	6.8±5.54	6.4±2.88	10.0±5.43	7.73±1.97	98.313
7	*Apis. mellifera*	4.2±2.17	5.8±1.30	9.0±2.12	6.33±2.44	120.050
8	*Apis dorsata*	14.0±5.15	10.2±4.97	10.4±6.43	11.53±2.14	65.911
9	*Eristalis sp.*	3.6±2.07	2.4±1.14	5.2±2.59	3.73±1.40	203.742
	Mean	9.16	8.78	10.22	9.39	

Table 5. Diversity of insect pollinators on Okra/Bhindi

S. No.	Name of Insect	Order	Family
1.	*Eristalis* sp.	Diptera	Syrphidae
2.	*Pieris canidia*	Lepidoptera	Pieridae
3.	*Papilio demoleus*	Lepidoptera	Papilionidae
4.	*R. flavolineatum*	Hymenoptera	Eumenidae
5.	*Polistes hebraeus*	Hymenoptera	Vespidae
6.	*Apis dorsata*	Hymenoptera	Apidae
7.	*Apis cerana*	Hymenoptera	Apidae
8.	*Apis florea*	Hymenoptera	Apidae
9.	*Apis. Mellifera*	Hymenoptera	Apidae
10.	*Megachile* sp.	Hymenoptera	Megachilidae

bee species spent highest time per visit on Okra bloom (Table 8).

Brassica campestris L. var. Sarson is a typical winter season crop of the sub tropical to temperate regions. It is cultivated for its seeds that yield oil and leaves that are used as vegetable. It is a major source of nectar for honey bees. Reports on the pollinator diversity of *Brassica* in India are well spread over a long period of time and provide valuable information on insect pollinators decline particularly under the changed agro forest scenario following advent of *A. mellifera* (Singh and Kumar, 2003; Singh and Kumar, 2007). During the present studies on pollinating species of *Brassica*

Table 6. Relative abundance (number of insects/m^2/5min.) of pollinators on Okra/Bhindi

Sl No.	Name of insect	Time of observation In hours			Grand mean	(PSs) = Nij/NjxS
		0900-1100	1200-1400	1500-1700		
1	*Eristalis* sp.	1.2±2.17	1.0±1.41	0.8±0.84	1.0±0.20	1.420
2	*Pieris canidia*	0.4±0.55	0.4±0.89	0.2±0.45	0.33±0.12	0.468
3	*Papilio demoleus*	1.2±1.30	0.2±0.45	0.2±0.45	0.53±0.58	0.752
4	*R. flavolineatum*	0.8±1.30	0.4±0.89	0.6±1.34	0.6±0.20	0.852
5	*Polistes hebraeus*	2.8±1.92	1.0±1.73	0.6±0.89	1.46±1.17	2.073
6	*Apis dorsata*	0.4±0.89	1.2±1.30	0.4±0.55	0.66±0.46	0.937
7	*Apis cerana*	0.6±1.34	1.4±1.67	1.0±1.73	1.0±0.40	1.420
8	*Apis florea*	0.2±0.45	0.2±0.45	1.6±1.14	0.66±0.81	0.937
9	*A.mellifera*	0.2±0.45	0.4±0.89	0.6±0.89	0.40±0.20	0.537
10	*Megachile* sp.	0.4 ±0.89	0.4±0.89	0.4±0.89	0.40±0.00	0.568
	Mean	0.82	0.66	0.64	0.70	

F (p=0.222) for number of insects: insignificant, F (p=0.270) for day hours: insignificant, PSs- Performance Score=Nij/Nj x S

Table 7. Foraging rate (number of flowers visited/minute) of pollinators on Okra/Bhindi

Sl No.	Name of insect	Time of observation In hours			Grand mean	(PSs) = Nij/NjxS
		0900-1100	1200-1400	1500-1700		
1	*Eristalis* sp.	4.4±2.07	4.0±1.22	7.0±2.24	5.13±1.63	0.603
2	*Pieris canidia*	14.0±6.67	17.4±1.95	15.4±6.88	15.60±1.71	1.835
3	*Papilio demoleus*	19.4±1.34	10.8±3.35	17.0±6.32	15.73±4.44	1.851
4	*R. flavolineatum*	3.4±1.14	4.2±1.92	4.2±1.92	3.93±0.46	0.462
5	*Polistes hebraeus*	6.0±2.45	6.4±2.70	4.4±2.30	5.60±1.06	0.659
6	*Apis dorsata*	4.8±3.11	5.4±2.79	6.8±3.42	5.66±1.03	0.666
7	*Apis cerana*	12.6±5.27	18.6±2.61	16.8±2.28	16.0±3.08	1.883
8	*Apis florea*	5.2±2.95	5.0±2.24	7.0±2.65	5.73±1.10	0.674
9	*A.mellifera*	10.0±3.61	8.4±4.51	9.6±3.21	9.33±0.83	1.098
10	*Megachile* sp.	2.0±1.73	2.6±2.07	2.2±1.30	2.26±0.31	0.265
	Mean	8.18	8.28	9.04	8.49	

Table 8. Foraging duration (time spent in seconds/flower) of pollinators on Okra/Bhindi

Sl No.	Name of insect	Time of observation In hours			Grand mean	(PSs) = Nij/NjxS
		0900-1100	1200-1400	1500-1700		
1	*Eristalis* sp.	11.8±7.40	13.2±5.07	7.8±6.02	10.93±2.80	78.956
2	*Pieris canidia*	8.4±5.94	8.4±4.16	6.8±4.55	7.86±0.92	109.796
3	*Papilio demoleus*	2.4±1.67	4.6±3.03	2.0±1.00	3.00±1.40	287.666
4	*R. flavolineatum*	10.0±3.81	4.8±2.39	6.4±3.65	7.06±4.81	122.237
5	*Polistes hebraeus*	8.2±2.86	5.8±2.49	8.2±2.86	7.40±1.39	116.621
6	*Apis dorsata*	12.8±5.17	13.2±4.32	7.0±5.10	11.00±3.47	78.454
7	*Apis cerana*	9.8±6.65	8.4±4.34	16.0±7.71	11.40±4.04	75.701
8	*Apis florea*	11.6±6.23	10.4±1.67	11.8±2.86	11.26±0.76	76.642
9	*A.mellifera*	13.8±7.01	9.0±3.87	15.2±4.15	12.66±3.25	68.167
10	*Megachile* sp.	2.4±1.14	3.0±2.92	5.8±2.28	3.73±1.81	231.367
	Mean	9.12	8.08	8.70	8.63	

campestris, the crop was observed to be visited by eight species of insects (Table 9). It is important to note that *A. mellifera* outnumbered all other species during the present study and was higher in abundance (6.4 bees/m^2/5 min.) as compared to the native honey bees (1.80, 1.66 and 1.80 bees/m^2/5min for *A. dorsata*, *A. cerana* and *A. florea* respectively) (Table 10). Similar observations were made by Kumar and Kumar. (1998) on related toria crop. In their studies *A. mellifera* predominated the wild bees and made 58.94% of total visits, whereas *A. ilerda*, *H. catullus*, one solitary bee and *H. spendidulus* constituted 20.40, 11.92, 4.88 and 3.80% of total bees respectively (Kumar and Kumar. 1998). Wild bees were conspicuous by their absence during the present studies while dipterans were present.

Table 9. Diversity of pollinators on *Brassica campestris*

S. No.	Name of Insect	Order	Family
1.	*Apis dorsata*	Hymenoptera	Apidae
2.	*Apis cerana*	Hymenoptera	Apidae
3.	*Apis florea*	Hymenoptera	Apidae
4.	*Apis. Mellifera*	Hymenoptera	Apidae
5.	*Eristalis sp.*	Diptera	Syrphidae
6.	*Episyrphus balteatus*	Diptera	Syrphidae
7.	*Pieris canidia*	Lepidoptera	Pieridae
8.	*Junonia almanac*	Lepidoptera	Nymphalidae

Table 10. Relative Abundance (Number of insects/m^2/5min.) of pollinators on Sarson

Sl No.	Name of insect	Time of observation			Grand mean	(PSs) = Nij/NjxS
		In hours				
		9-11AM	12-02PM	3-5PM		
1	*Apis dorsata*	3.8±1.64	0.2±0.45	1.4±0.89	1.80±1.86	1.168
2	*Apis cerana*	2.8±1.10	1.8±1.30	0.4±0.89	1.66±1.48	1.077
3	*Apis florea*	2.2±1.30	0.00±0.0	0.2±0.45	0.80±1.26	0.519
4	*Apis. mellifera*	0.4±0.8	9.2±2.79	9.6±7.86	6.4±6.66	4.155
5	*Eristalis sp.*	0.4±0.5	0.00±0.0	0.2±0.45	0.20±0.41	0.129
6	*Episyrphus balteatus*	0.4±0.89	1.2±1.1	1.0±1.22	0.86±1.06	0.558
7	*Pieris canidia*	0.4±0.55	0.8±0.84	0.00±0.00	0.40±0.63	0.259
8	*Junonia almana*	0.4±0.8	0.00±0.0	0.2±0.4	0.20±0.56	0.129
Mean		1.35	1.65	1.62	1.54	

F ($p \leq 0.001$) number of insects : significant, F ($p \leq 0.001$) for day hours : significant

Table 11. Foraging rate (Number of flowers visited/minute) of pollinators on Sarson

Sl No.	Name of insect	Time of observation			Grand mean	(PSs) = Nij/NjxS
		In hours				
		9-11AM	12-02PM	3-5PM		
1	*Apis dorsata*	20.8±2.68	14.2±1.30	14.8±2.17	16.6±3.66	1.679
2	*Apis cerana*	19.2±2.28	14.8±2.68	14.6±2.61	16.2±3.21	1.634
3	*Apis florea*	2.6±1.52	2.8±1.10	3.6±2.88	3.0±1.88	0.303
4	*Apis. mellifera*	14.2±1.79	12.8±1.92	14.4±2.30	13.8±2.00	1.396
5	*Eristalis sp.*	13.8±2.49	9.6±7.44	13.4±3.78	12.26±5.04	0.1240
6	*Episyrphus balteatus*	2.0±0.71	2.0±0.71	2.0±0.71	2.0±0.65	0.202
7	*Pieris canidia*	7.4±4.10	12.0±1.00	10.2±1.30	9.86±3.06	0.997
8	*Junonia almana*	5.0±5.79	4.4±2.88	6.6±4.88	5.33±4.43	0.539
Mean		10.62	9.07	9.95	9.88	

F ($p \leq 0.001$) number of insects : significant, F ($p \leq 0.001$) for day hours : significant

Table 12. Foraging duration (Time spent in seconds/flower) of pollinators on Sarson

Sl No.	Name of insect	Time of observation In hours			Grand mean	(PSs) = Nij/NjxS
		9-11AM	12-02PM	3-5PM		
1	*Apis dorsata*	2.6±1.52	4.2±3.35	1.8±0.84	2.86±2.26	251.132
2	*Apis cerana*	6.4±7.70	10.6±6.43	7.4±7.80	8.13±7.03	88.344
3	*Apis florea*	20.4±14.26	17.0±4.47	46.0±15.97	27.8±17.78	25.835
4	*Apis. mellifera*	1.4±0.55	2.2±0.84	1.8±0.84	1.8±0.77	399.022
5	*Eristalis sp.*	2.4±0.55	2.2±1.64	9.8±1.48	4.8±3.85	149.633
6	*Episyrphus balteatus*	40.2±13.33	30.4±16.12	44.2±18.95	38.2±17.15	18.772
7	*Pieris canidia*	3.8±1.79	2.4±0.89	6.8±7.46	4.33±4.54	165.875
8	*Junonia almana*	1.2±0.45	2.2±2.17	2.0±1.73	1.8±1.56	399.022
Mean		9.8	8.9	14.97	11.22	

F ($p \leq 0.001$) number of insects : significant, F ($p \leq 0.001$) for day hours : significant

Balachandran *et al*. (2014) observed that *Apis dorsata* had highest visitations on *Utricularias* i*mpatiens* and *Flacourtia indica*, whereas *Trigona* preferred *Eriocaulons* especially in the absence of *A. mellifera.* A significant finding during the present studies was that the native honey bee *A. dorsata* and *A. cerana* were better performer than *A. mellifera* with respect to foraging rate (Table 11and 12). Further *A. dorsata* and *A. cerana* are cold hardy (Verma *et al.* 2002) and were therefore observed to become active on these winter season flowers earlier in the day (9:00-11:00hrs) as compared to *A. mellifera* which started foraging comparatively later (12:00-2:00 hrs). However the exotic honey bee *A. mellifera* outscored the native bees in pollinating efficiency on the basis of abundance.

The area around Chandigarh particularly, the *Brassica* fields are extensively exploited for honey harvesting by bee keepers who migrate *A. mellifera* colonies to the plains for this purpose. This accounts for the high population of *A. mellifera* observed in this crop. Similar trend is also available in the studies of Kumar and Kumar. (1997a). According to them *A. mellifera* was the most abundant visitor to toria bloom in the mid hills. Based on pollination indices, they reported *A. mellifera* followed by *A. ilerida* to be the most efficient pollinator on toria bloom.

The studies revealed that the diversity of insect pollinators was crop specific. Honey bees were dominating the scene and were the most efficient pollinators of most crops. The exotic honey bee *A. mellifera* outscored the other pollinators where it was present. This could be explained on the basis of domestication and migration of this bee in the field areas. It was also observed that the diversity of insect pollinators on crops studied showed definite decline, when compared to earlier studies.

ACKNOWLEDGEMENTS

The authors acknowledge the assistance and facilities provided by Department of Zoology and UGC CAS-II at various stages of this research work and there are no conflicts of interest.

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(Received 12 July 2017; revised ms accepted 05 September 2017; published 06 December 2017)