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Diversity of insect-pests and their natural enemies in cauliflower under mid hills of Himachal Pradesh

Shikha Sharma, SC Verma, PL Sharma and RS Chandel

Abstract

The present experiment was carried out at the research farm of Department of Entomology, Dr Y S Parmar University of Horticulture and Forestry, Nauni, Solan, Himachal Pradesh during 2017-2018. During the experimental period a total of 14 species of insect pests of cauliflower viz. cabbage butterfly (*Pieris brassicae*), white cabbage butterfly (*Pieris rapae*), diamondback moth (*Plutella xylostella*), tobacco caterpillar (*Spodoptera litura*), cutworm (*Agrotis ipsilon*), golden wing moth (*Thysanoplusia orichalcea*), cabbage web worm (*Hellula undalis*), flea beetle (*Phyllotreta sp.*), painted bugs (*Bagrada cruciferarum* and *Eurydema pulchrum*), green potato bug (*Nizara viridula*), cabbage aphid (*Brevicoryne brassicae*), green peach aphid (*Myzus persicae*), greenhouse whitefly (*Trialeurodes vaporariorum*) were recorded. In the present study a total of fourteen species of natural enemies on insect pests of cauliflower were recorded, out of which 10 were predators and 4 parasitoids. Among predators 4 were coccinellids viz. *Coccinella septempunctata*, *Hippodamia variegata*, *Oenopia Sauzeti* and *Oenopia kirbyi*, five were syrphids viz. *Episyrphus balteatus*, *E. frequens*, *Syrphus pyrastris*, *Metasyrphus confrator*, *Sphaerophoria Indiana* and one was chrysopid is *Crysoperla zastrowisillemi*. Whereas, parasitoids recorded were *Cotesia glomerata* parasitizing the larva of *Pieris brassicae* and *Pieris rapae*, *Diadegma Semiclausam* parasitizing the larva of *Plutella xylostella*, *Diadegma Collaris* parasitizing the pupa of *Plutella xylostella* and *Diaeretiella rapae* parasitizing the cabbage aphid. *Coccinella septumpunctata* was the most abundant predator with relative proportion of 74.55 and 52.98 per cent during 2017 and 2018, respectively. The parasitization of *Plutella xylostella* by *D. Semiclausam* was 28.94 per cent and 30.77 per cent during 2017 and 2018, respectively. *Cotesia glomerata* was the most abundant parasitoid with relative proportion of 42.43 and 57.58 per cent during 2017 and 2018, respectively.

Keywords: Insect pests, natural enemies, predators, parasitoids, parasitisation, relative proportion

Introduction

Cauliflower (*Brassica oleracea* L. var. *botrytis*) is the most important crop grown for table as well as for seed purpose. India is the second largest producer of cauliflower with annual production of 8499 thousand metric tonnes from an area of 452 thousand hectares (Anonymous, 2017) [1]. In the state of Himachal Pradesh, total area under cauliflower is 5.31 thousand hectares with annual production of 124.33 thousand tonnes (Anonymous, 2017) [1]. It is grown as main season as well as off-season crop in mid and high hills which brings lucrative returns to the growers of the state (Ghosh, 2017) [2]. The cauliflower crop is attacked by various insect-pests. Among these the major insect-pests are cabbage aphid, *Brevicoryne brassicae* (L.), cabbage butterfly, *Pieris brassicae* L., diamondback moth, *Plutella xylostella* L. and painted bug, *Bagrada cruciferarum* Kirk., cabbage head borer, *Hellula undalis* F. and tobacco caterpillar, *Spodopteralitura* (F.) (Bhatia, 1986; Bhatia and Gupta, 2003; Kumar *et al.*, 2014 and Meghana *et al.*, 2018) [3-6]. The damage caused to cauliflower by *B. brassicae* is both direct and indirect. According to Khan *et al.* (2015) [7] cabbage aphid causes 35-75 per cent yield losses. Cabbage aphid also acts as the vector for viruses causing blackening spot in cauliflower, cauliflower mosaic and cabbage viruses A and B (Kaul, 1998) [8]. The larvae of *P. Brassicae* skeletonize leaves and also bore the heads of cauliflower with faecal excreta. The newly hatched larvae feed on outer epidermis of leaves giving cellophane like appearance. Sood (1992) [9] reported that a single caterpillar of *P. brassicae* reduces the yield to a maximum of 1.79 per cent at curd formation. The yield loss due to *P. xylostella* in cauliflower was reported as 34.4 per cent. (Kaul, 1998) [8].

Painted bug, *B. cruciferarum* causes physical damage to the crop by feeding on both surfaces of the leaves and presumably inject saliva to aid in breaking down the inner leaf tissue (Palumbo and Natwick, 2010) ^[10].

In the state of Himachal Pradesh, cauliflower is being grown throughout the year in one or the other parts of the region. One of the most serious constraints for production loss in this crop is due to insect pests. Insect pests are of prime importance as they cause serious economical damage in cauliflower crop. The damage caused by the insect pests affects cauliflower crop both qualitatively as well as quantitatively resulting in low returns to the farmers. In order to protect their crop from the losses caused by insect pests, the farmers are mostly dependent on the application of various insecticides. However, using insecticides indiscriminately has led to various issues like contamination of the harvested produce with pesticides residues, health hazards, development of resistance, outbreaks and resurgence of pests and deleterious effects on natural enemies.

Natural enemies play an important role in suppression of insect pests of cauliflower (Manyangarirwa, 2009) ^[11]. In Himachal Pradesh, *Aphidius* sp. was reported to parasitize 2.9 - 38.0 per cent cabbage aphid at Solan (Kotwal *et al.*, 1984; Dhiman and Kumar, 1985) ^[12, 13]. At Palampur, *Diaeretella rapae* (M'Intosh) parasitized 8.62 to 11.02 per cent *B. brassicae* on rapeseed (Raj and Sharma, 1993) ^[14]. Parasitization of aphids by *D. rapae* on cauliflower varied from 1 to 7.4 per cent during January to April at Solan (Gupta *et al.*, 2007) ^[15]. Verma and Makhmoor (1987) ^[16] have reported various species of syrphid *viz.* *Scaeva pyrastris* (Linn.), *Episyrphus balteatus* (Oeg.), *Metasyrphus confrater* (Wied.), *M. corollae* (Fabr.), *Betasyrphus serarius* (Wied.), *Ischiodon scutellaris* (Fabr.), *Sphaerophoria indiana* (B. igot), *Melanosloma* sp. prob., *M. univittatum* (Wied.) and *Eupeodesl atilunulalus* (Collins) preying upon *B. brassicae* in mid-hill region of Himachal Pradesh.

According to Sharma *et al.* (2015) ^[17] predators like lady bird beetles (*Coccinella septempunctata* L., *Cheilomenes sexmaculata* F. and *Hippodamia variegata* Goeze) were predominant in Himachal Pradesh. *C. septempunctata* was found to be the most abundant species accounting for 47.3 per cent of the adult count followed by *A. variegata* (26.2%) (Sharma and Verma, 1993) ^[18]. Whereas, among hymenopteran parasitoids, *Diadegma fenestralis* (Holm.), *Diadromus collaris* (Gravenhorst) and *Cotesia* spp. were the dominant species of diamondback moth (Bhalla and Dubey, 1986; Devi and Raj, 1995; Chauhan *et al.*, 1997 and Devi *et al.*, 2004) ^[19-22]. *Cotesia glomerata* (L.), *Polistes ilebreus* (F.) and *Serratia. Marcescens* Bizio were also reported to be associated with different stages of *P. brassicae* in Himachal Pradesh (Gupta, 1984; Kakar and Sharma, 1991) ^[23,24]. Sood and Bhalla (1996) ^[25] reported *C. Glomerata* L. and *Hyposoter ebeninius* (Gravenhorst) as major parasitoids causing mortality in cabbage butterfly. Sood *et al.* (2011) ^[26] also mentioned *C. Glomerata* L. as an efficient parasitoid of *P. brassicae* at Palampur. Most of the reports on the natural enemy complex of insect pests of cauliflower are not recent. Furthermore, with changing climatic and farming practices, the insect pests and their natural enemy diversity is expected to change. Therefore, the present study was carried out to study the diversity and abundance of insect-pests and their natural enemies in cabbage ecosystem under mid hills of Himachal Pradesh.

Materials and Methods

Raising of the crop

The crop of cauliflower was raised by transplanting 26 days old seedlings of cauliflower (*Brassica oleracea* L. Var *botrytis* cv. Sweta). The seedlings were transplanted during two consecutive years i.e. on December 28, 2016 and December 22, 2017. The planting distance was kept as 60 X 45 cm i.e. 60 cm distance was maintained between the row to row and 45 cm between plant to plant. The crop was grown as per recommended package of practices of vegetable crops, Dr. YS Parmar University of Horticulture and Forestry, Nauni, Solan (Anonymous, 2014) ^[27].

Biodiversity of natural enemies associated with major insect-pests of cauliflower

Collection of natural enemies

Collection of natural enemies was done periodically from the cauliflower, cabbage and mustard crops in the field. The predators were collected with the help of sweep nets, insect collection tubes and jars depending upon the habitat. Predators collected from different localities were killed and preserved in insect collection cabinet after proper labelling. The different life stages of the host were also collected periodically from the cauliflower crop. Collected hosts were reared in the laboratory at 25±0.5 °C and 70±5 per cent relative humidity for emergence of parasitoids.

Identification of the natural enemies

Predators

Predators were collected from the experimental field. Collected predators were examined under stereo zoom binocular microscope. Examination was done carefully for all morphological details. The collected predators were identified on the basis of available literature and reference collection maintained in the Biological Control Laboratory of Department of Entomology, Dr. YS Parmar university of Horticulture and Forestry Nauni, Solan, Himachal Pradesh.

Parasitoids

Preparation of slides

Temporary and permanent mounting

The temporary mounting of specimens was done in Hoyer's medium (Willoughby and Kosztarab, 1974) ^[28]. Permanent mounts were prepared as per method of (Noyes, 1982 and Khan *et al.*, 2005) ^[29-30]. In some specimens the body parts were dissected and mounted separately to examine different morphological characters for identification. The specimens were examined under stereo-zoom microscope.

Diversity index: Diversity indices like Shannon diversity index, maximum diversity, species evenness and species dominance was calculated as per procedure given by Shannon (1948) ^[31] which is described as under:

- Shannon diversity index (H) = $-\sum p_i \log_e p_i$ where p_i = fraction of i^{th} species
- Maximum diversity (H_{max}) = $\log_e k$; k= total number of species
- Species evenness (J) = H/H_{max}
- Species dominance (D) = $1-J$

Per cent parasitization: The number of parasitized aphid was recorded on weekly basis to determine per cent parasitism. The predators were recorded on the transplanted

plants in the experimental field. The per cent parasitization of the aphid by its parasitoid was calculated by using the equation of Root and Skelsey (1969) [32]:

Statistical analysis: The data obtained after identifying the parasitoid were used to calculate the percent parasitization by each species and the relative proportion of each species.

Results and Discussion

Diversity of natural enemies of insect-pests of cauliflower

Fourteen species of insect pests belonging to 13 genera and 8 families have been recorded on cauliflower under mid-hills of Himachal Pradesh (Table 1). The insect pests recorded were cabbage butterfly (*Pieris brassicae* (L.)), cabbage butterfly (*Pieris rapae* (L.)), diamondback moth (*Plutella xylostella* L.), tobacco caterpillar (*Spodoptera litura* (Fabricius)), cutworm (*Agrotis ipsilon* (Hufnagel)), golden wing moth (*T. orichalcea* (Fabricius)), cabbage web worm (*Hellula undalis* (Fabricius)), flea beetle (*Phyllotreta* sp), painted bugs (*Bagrada cruciferarum* Kirkaldy and *Euretdyma pulchrum* (Westwood)), green potato bug (*Nezara viridula* L.), cabbage

aphid (*Brevicoryne brassicae* (L.)), green peach aphid (*Myzus persicae* (Sulzer)), greenhouse whitefly (*Trialeurodes vaporariorum* Westwood) (Table 1).

In the present study, fourteen species of insect pests of cauliflower crop and fourteen species of natural enemies associated with insect pests of cauliflower under mid hill conditions were recorded. Similar to present study, Bhatia (1986) [33] recorded *P. xylostella*, *P. brassicae*, *P. rapae*, *S. litura*, *A. ipsilon*, *T. orichalcea*, *B. cruciferarum*, *E. pulchrum* *F* and *B. brassicae* in Himachal Pradesh. The present study also corroborates the findings of Rattan *et al.* (2007) [33] who recorded *B. brassicae*, *P. brassicae* and *P. xylostella* at Solan under the mid hill conditions of Himachal Pradesh. Similarly Mahendran (2015) [34] recorded *P. xylostella*, *P. brassicae*, *Trichoplusiani*, *Lipaphis erysimi* (Kaltenbach), *M. persicae* as dominant insect pests of cauliflower crop. Bhat (2018) [35] also reported diamondback moth (*P. xylostella*), cutworms, green peach aphid (*M. persicae*), *T. orichalcea*, *P. brassicae*, *P. rapae*, *A. ipsilon* and *Helicoverpa armigera* (Hubner) were the abundant insect pests of cauliflower in Kashmir, India.

Table 1: Insect - pests associated with cauliflower crop during 2017-18

S.N.	Common Name	Scientific Name	Order and Family	Damaging stages
1	Cabbage butterfly	<i>Pieris brassicae</i> (L.)	Lepidoptera: Pieridae	Caterpillar
2	Small white butterfly	<i>Pieris rapae</i> (L.)	Lepidoptera: Pieridae	Caterpillar
3	Diamondback moth	<i>Plutella xylostella</i> (L.)	Lepidoptera: Plutellidae	Caterpillar
4	Tobacco caterpillar	<i>Spodoptera litura</i> (F)	Lepidoptera: Noctuidae	Caterpillar
5	Cutworm	<i>Agrotis ipsilon</i> (Hufnagel)	Lepidoptera: Noctuidae	Caterpillar
6	Golden wing moth	<i>Thysanoplusia orichalcea</i> (F.)	Lepidoptera: Noctuidae	Caterpillar
7	Cabbage head borer	<i>Hellulaundalis</i> (Fabricius)	Lepidoptera: Crambidae	Caterpillar
8	Flea beetle	<i>Phyllotreta</i> sp.	Chrysomelidae: Coleoptera	Adult
9	Painted bug	<i>Bagrada cruciferarum</i> Kirkaldy	Hemiptera: Pentatomidae	Nymph and adult
10	Painted bug	<i>Eurydema pulchrum</i> (Westwood)	Hemiptera: Pentatomidae	Nymph and adult
11	Green potato bug	<i>Nezaraviridula</i> (L.)	Hemiptera: Pentatomidae	Nymph and adult
12	Cabbage aphid	<i>Brevicoryne brassicae</i> (L.)	Hemiptera: Aphididae	Nymph and adult
13	Green peach aphid	<i>Myzus persicae</i> (Sulzer)	Hemiptera: Aphididae	Nymph and adult
14	Greenhouse whitefly	<i>Trialeurodes vaporariorum</i> Westwood	Hemiptera: Aleyrodidae	Nymph and adult

Data contained in Table 2 reveal that a total of fourteen species of natural enemies were associated with different insect pests of cauliflower out of which ten were predators and four of parasitoids. Out of the ten predators recorded four were coccinellids *viz.* *Coccinella septempunctata* L., *Hippodamia variegata* (Goeze), *Oenopia. Sauzeti* (Mulsant) and *O. kirbyi* (Mulsant), five were syrphids *viz.* *Episyrphus balteatus* (De Geer), *Eupeodes frequens* (Matsumura), *Scaeva pyrastris* (L.), *Metasyrphus confrator* (Wiedemann), *Sphaerophoria indiana* Bigot and one was chrysopid: *Chrysoperla zastrowisillemi* (Esbén-Peterson). The parasitoid species recorded were *Cotesia glomerata* (L.) parasitizing the larva of *P. brassicae* and *P. rapae*. *Diadegma semiclausum* (Hellen) parasitizing the larva of *P. xylostella*, *Diadromus collaris* (Gravenhorst) parasitizing the pupae of *P. xylostella* and *D. rapae* (Mc' Intosh) parasitizing the cabbage aphid (Table 2). Present study reports a rich diversity of natural enemies of insect pests of cauliflower in Solan area of H.P.

and these results corroborate the findings of Sharma *et al.* (2017) [36] and Verma and Makhmooor (1987) [37] who reported nine species of aphid ophagous syrphids, *viz.* *S. pyrastris*, *E. balteatus*, *M. confrator*, *M. corollae*, *Betasyrphus serarius* (Wied.), *I. scutellaris*, *S. indiana*, *Melanosloma* sp., *M. univittatum* (Wied.) and *E. latilunulalus* (Collins) associated with *B. brassicae* on cauliflower in Solan. Natural enemies recorded in the present studies were relatable to the earlier findings (Shlyakhovoi and Bobonich, 1975; Kadamshoev, 1983; Thakur *et al.* 1989; Alam, 1992; Santos *et al.*, 2000) [38-42] who reported *D. semiclausum*, *Cotesia* sp, *C. septempunctata* L., *C. carnea* (Steph.), *M. corolla*, (*Syrphuscorollae*), *E. balteatus* and *D. rapae*. Earlier *C. plutellae* and *D. semiclausum* and *D. collaris* have also been reported from diamondback moth in Tamil Nadu, India (Isfahani, 2010; Razmi *et al.*, 2011; Debbarma *et al.*, 2017) [43-45].

Table 2: Natural enemies associated with insect-pests of cauliflower during 2017-2018

S. No.	Common Name	Scientific Name	Order and Family	Prey/host
Predator				
1	Ladybird beetle	<i>Coccinella septempunctata</i> Linnaeus	Coleoptera: Coccinellidae	Aphid
2	Variegated ladybird	<i>Hippodamia variegata</i> (Goeze)	Coleoptera: Coccinellidae	Aphid
3	Ladybird beetle	<i>Oenopiasauzeti</i> (Mulsant)	Coleoptera: Coccinellidae	Aphid
4	Ladybird beetle	<i>Oenopiakirbyii</i> (Mulsant)	Coleoptera: Coccinellidae	Aphid

5	Green lace wing	<i>Chrysoperlazastrowisillemi</i> (Esben-Peterson)	Neuroptera: Chrysopidae	Aphid
6	Marmalade hoverfly	<i>Episyrphusbalteatus</i> (De Geer)	Diptera: Syrphidae	Aphid
7	Hoverfly	<i>Eupeodesfrequens</i> (Matsumura)	Diptera: Syrphidae	Aphid
8	Pied hoverfly	<i>Scaevapyrastris</i> (Linnaeus)	Diptera: Syrphidae	Aphid
9	Hoverfly	<i>Metasyrphusconfrator</i> (Wiedemann)	Diptera: Syrphidae	Aphid
10	Hoverfly	<i>Sphaerophoriaindana</i> Bigot	Diptera: Syrphidae	Aphid
Parasitoid				
1	Braconid wasp	<i>Cotesiaglomerata</i> (L.)	Hymenoptera: Braconidae	Cabbage butterfly
2	Ichneumon wasp	<i>Diadegmasemiclausam</i> (Hellen)	Hymenoptera: Ichneumonidae	Diamondback moth
3	Ichneumon wasp	<i>Diadromuscollaris</i> (Gravenhorst)	Hymenoptera: Ichneumonidae	Diamondback moth
4	Braconid wasp	<i>Diaeretiellarapae</i> (McIntosh)	Hymenoptera: Braconidae	Cabbage aphid

Diversity of natural enemies

Diversity of natural enemies of insect-pests of cauliflower was also studied and the results are presented below:

Diversity of predators

Coccinella. Septempunctata was the most abundant predator comprising of 74.55 and 52.98 per cent of the total predator during 2017 and 2018, respectively (Table 3). The second

most abundant predator was *H. variegata* with relative proportion of 17.39 and 42.21 per cent during 2017 and 2018, respectively. The minimum relative proportion was of *O. kirbyii* (0.16%) during 2017, whereas, during 2018 the relative proportion of *O. sauzeti* was minimum with 0.15 per cent. Present findings corroborate the findings of Sanjhata (2015) [46] and Sharma *et al.* (2017) [36] who also reported the dominance of *C. septempunctata*.

Table 3: Abundance of predators of insect pests of cauliflower during 2017 and 2018

S. No.	Scientific name	Relative proportion (%)	
		2017	2018
1	<i>Coccinellaseptempunctata</i>	74.56	52.98
2	<i>Hippodamiavariegata</i>	17.39	42.21
3	<i>Oenopiasauzeti</i>	0.32	0.15
4	<i>Oenopiakirbyii</i>	0.16	-
5	<i>Chrysopellazastrowisillemi</i>	0.81	0.58
6	<i>Episyrphusbalteatus</i>	3.06	1.75
7	<i>Eupeodesfrequens</i>	1.77	1.31
8	<i>Scaevapyrastris</i>	0.97	0.71
9	<i>Metasyrphusconfrator</i>	0.64	0.31
10	<i>Sphaerophoriaindana</i>	0.32	-
	Total	100	100

It is evident from Table 4 that Shannon index (H) was 0.86, maximum diversity (H_{max}) was 2.30, species evenness (J) was 0.38 and 62 per cent of the species (Dominance = 0.62) i.e. six species viz. *C. septempunctata*, *H. variegata*, *E. balteatus*, *E. frequens*, *S. pyrastris* and *C. zastrowisillemi* dominated the predatory complex of insect pests of cauliflower during 2017. Whereas, during 2018, the Shannon index (H) was 0.92,

maximum diversity (H_{max}) was 2.08, species evenness (J) was 0.44 and 56 per cent of the species (Dominance = 0.56) i.e. five species viz. *C. septempunctata*, *H. variegata*, *E. balteatus*, *E. frequens* and *S. pyrastris* dominate the predatory complex. Shah and Khan (2014) [47] recorded the Shannon index and species evenness of coccinellids as 1.75 and 0.84 on cauliflower crop.

Table 4: Diversity index of predators of cauliflower during year 2017 and 2018

Diversity indices	Year	
	2017	2018
Shannon Index	0.86	0.92
H_{max}	2.30	2.08
Evenness (J)	0.38	0.44
Dominance (D)	0.62	0.56

Diversity of parasitoids

Data contained in the Table 5 reveal that the parasitoids, *C. glomerata* were recorded from *P. brassicae*, *P. rapae* and *D. semiclausam* and *D. collaris* from *P. xylostella*. Among these *D. semiclausam* was the most dominant resulting in 28.94 and 30.77 per cent parasitization during 2017 and 2018, respectively. Other two parasitoid i.e. *C. glomerata* and *D. collaris* resulted 19.84 per cent and 21.05 per cent parasitization during 2017, and 20.80 and 23.07 per cent parasitization during 2018, respectively. *C. glomerata*, *D. semiclausam* and *D. collaris* shared 42.43, 33.33 and 24.24 per cent of the total parasitization during 2017 and 57.58,

24.24 and 18.18 per cent during 2018, respectively. In the present findings maximum parasitization of *P. xylostella* was recorded with *D. semiclausam* followed by *D. collaris*. These findings find support from the results of Razmi *et al.* (2011) [44] and Bhat (2018) [35] who recorded that parasitism by *D. semiclausam* and *C. glomerata* was 10 per cent and 5 per cent to their respective host pest. Sood *et al.* (1995) [48] reported that the mortality of *P. brassicae* larvae was caused by hymenopteran parasitoids, *C. glomeratus* and *Hyposotere beninus* (Gravenhorst) which ranged between 3.9- 23.6 per cent.

Table 5: Diversity of parasitoids of cauliflower during year 2017 and 2018

S. No.	Parasitoid	Host insect	Parasitization (%)		Relative proportion (%)	
			Year			
			2017	2018	2017	2018
1	<i>C. glomerata</i>	<i>P. brassicae</i>	5.55	8.33	42.43	57.58
		<i>P. rapae</i>	14.29	12.50		
2	<i>D. semiclausam</i>	<i>P. xylostella</i>	28.94	30.77	33.33	24.24
3	<i>D. collaris</i>	<i>P. xylostella</i>	21.05	23.07	24.24	18.18

It is evident from the Table 6 that during 2017, the Shannon index (H) was 0.61, maximum diversity (H_{max}) was 1.10, species evenness (J) was 0.54 and 46 per cent of the species (Dominance = 0.46) i.e. one species (*C. glomerata*) dominated the parasitoid complex. During 2018, diversity indices viz. the Shannon index (H), maximum diversity (H_{max}), species evenness (J) and dominance (D) were 0.63, 1.09, 0.79 and 0.21, respectively. This indicates that 21 per cent of the species i.e one species (*C. glomerata*) the larval parasitoid of *P. brassicae* dominated the parasitoid complex and other two i.e., *D. semiclausam* and *D. Collaris* were evenly distributed. Similar to present studies Nelly *et al.* (2010) [49] recorded that diversity index of parasitoid on lepidopterans larvae on cauliflower was 3.40.

Table 6: Diversity indices of parasitoid during year 2017 and 2018

Diversity indices	Year	
	2017	2018
Shannon Index	0.60	0.63
H_{max}	1.10	1.09
Evenness (J)	0.54	0.79
Dominance (D)	0.46	0.21

Conclusion

In the present study, fourteen species of insect pests of cauliflower namely *P. brassicae*, *P. rapae*, *P. xylostella*, *S. litura*, *A. ipsilon*, *T. orichalcea*, *H. undalis*, *Phyllotreta* sp, *B. cruciferarum*, *E. pulchrum*, *N. viridula*, *B. brassicae*, *M. persicae* and *T. Vaporarorium* were recorded. During the study period fourteen species of natural enemies of insect pests of cauliflower *C. septempunctata*, *H. variegata*, *O. sauzeti* and *O. kirbyi*, *E. balteatus*, *E. frequens*, *S. pyrastris*, *M. confrator*, *S. Indiana*, *C. zastrowisillemi*, *C. glomerata*, *D. semiclausam*, *D. Collaris* and *D. Rapae* were recorded on different insect pests of cauliflower. *Coccinella septempunctata* was the most abundant predator and *D. Rapae* the most abundant parasitoid of cabbage aphid. A hyperparasitoid, *Pachyneuron aphidis*.

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