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Evaluating the association of pollinators' diversity with scrubland weed flora

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Abstract
In agro ecosystem, along with crops weed plants are observed. These weeds can act as a source of floral rewards, for pollinators' survivability. In this study 14 weed species in uninhabited land (Site I), semi-cultivated land (Site II) and cultivated land ecosystem (Site III) were studied to know the diversity and abundance of insect visitors associated with them by considering Simpson diversity index (SDI), Shannon-Wiener index (H') and Jaccard index (JI), and also their interrelationship among themself. Where weed plants like *Lantana camara* L., *Alternanthera ficoides* (L.), *Ageratum conyzoides* L., *Luffa echinata* Roxb. and *Celosia argentea* L. showed greater association with pollinators diversity. Thus weeds can support pollinators' diversity even during the floral dearth period of the region. Taking this into view, weed plants can be supported to grow on roadside or fallow lands, also proper planned establishment on bunds in agriculture land can be followed to support pollinator fauna.

Keywords: Insect pollinators, weed plants, diversity and abundance, conservation

Introduction
Worlds' ecology with its dynamic ecosystem, led to the developmental co-evolution of insects as pollinators on plants (angiosperms) during cretaceous period. Early cretaceous period was supremely advance in terms of pollination, the prime factor for succession, as insects were active source of pollinators of angiospermic plants. Thus, pollination results in the maintenance of generation in a species and also its biodiversity abundance in ecosystem of agriculture and natural ecosystem [15].

The sustainability for human race through agriculture is also achieved by the integration of pollinators in food production and survivability. But intensive change in agricultural activity from past half-century has bloomed to decline in bees' population and other insect pollinators. Many factors, like change in land use system, loss and fragmentation of habitat, introduction of exotic organisms, and injudicious pesticide uses are involved in commercial mode of agriculture. Along with this, the removal of weed plants which provide forage for pollinators in agro ecosystem are a major factor, which greatly showed hampering effect on bee diversity [8, 13].

Weeds are anthropocentrically undesirable plants out of their place [3, 4]. Though these cause nuisance to mankind but are considered to be main food source for many animals particularly pollinators that depend upon rare plant species [9]. They play a positive role in enhancing beneficial insect survivorship in agricultural ecosystem [18, 19]. In agro ecosystem the crops show blooming in mass but at some specific time period only and thus unable to supply pollen and nectar continuously, which the pollinators require for their survival. During such periods the flowering weeds may supplement the demand of pollinators [7].

Weed flora has predominant role in production of seeds for granivores, maintenance of species genotype and providing flora for insects [5, 12]. Bees involved in pollination of crop depends on its floral reward for their diet, either mass flowering crops as mono flora at specific time of crop period or weeds as multi flora, but more constantly, spatially and temporally [14]. The ecological link in between plant resources and insect biology which make entomologist to declare that, weeds play major role in maintaining the persistence and survival of wild flora and improving the socio-cultural values of landscapes.

Pollinators and the host plant are intertwined with each other and they provide a natural way of co-existence with which, various angiospermic plants getting flourished. But the studies of pollinator's activity on weed plants are scarce. Weeds being a natural hub for nutritive source of food with respect to entomophilous invertebrates, thus, in-depth studies are required for the

support of both weed-pollinator associations. The present study is dealing on various weed species and their interaction with diversity of insect pollinators.

Materials and Methods

The study was conducted at Govind Ballabh Pant University of Agriculture and Technology, Pantnagar, during autumn season of 2018-19. Geographically Pantnagar is located at foot hills of "Sivalik" range of Himalaya at 29^0 N latitude, 79.30^0 E longitude and 243.84 m altitude. It lies in ***terai*** belt of Uttarakhand state of India. The monsoon starts from third week of June and terminates by mid of September with annual rainfall about 1450 mm and average pH value of soil is 7.2 to 7.4. The temperature variation is very large, as summer temperature maxima of around 42 to 45^0 C while in winter it falls to 2 to 4^0 C with an average relative humidity highest in June to July around (70±85%) and lowest in the month of April to May (35±40%).

Study material

Weed flora: Following species of the weed plants available at three study sites were observed regularly during their respective blooming periods for associated insect pollinators.

List of weed flora

S. No.	Scientific name	Family
1.	*Alternanthera ficoides* (L.)	Amaranthaceae
2.	*Celosia argentea* L.	Amaranthaceae
3.	*Ageratum conyzoides* L.	Asteraceae
4.	*Bidens pilosa* L.	Asteraceae
5.	*Caesulia axillaris* Roxb.	Asteraceae
6.	*Tridax procumbens* L.	Asteraceae
7.	*Commelina benghalensis* L.	Commelinaceae
8.	*Convolvulus arvensis* L.	Convolvulaceae
9.	*Ipomoea cairica* (L.)	Convolvulaceae
10.	*Merremia hederacea* Burm. f.	Convolvulaceae
11.	*Luffa echinata* Roxb.	Cucurbiteceae
12.	*Physalis angulata* L.	Solanaceae
13.	*Solanum nigrum* L.	Solanaceae
14.	*Lantana camara* L.	Verbanaceae

To study the diversity and abundance of insect pollinators

The insect visitors on the flowers of different weed species were recorded for their diversity and were further categorized according to their flower visit.

Diversity Observation regarding the diversity of insect pollinator associated with weed flora was recorded. Insect pollinators of particular weed species were collected by aerial net of 30 cm diameter ring by sweeping net on weed flora. Captured insect were killed by using ethyl acetate and preserved as dry specimen, which were further used in species identification.

Identification of the specimen was done by comparing with previously identified specimen in the Department of Entomology, Govind Ballabh Pant University of Agriculture and Technology, Pantnagar.

Abundance: Observations on abundance of different pollinators was recorded as number of visitors/plant/5 minutes from five randomly selected plants. The abundance data was collected by three observations per day, at two hourly intervals (morning: 8.00- 9.00am; afternoon: 12.00-1.00pm; evening: 4.00-5.00pm), twice a week, from first week of September till last week of November in 2018.

Three sites were studied here - Site I: it was an un-cultivated and an uninhabited by human ecosystem, where wild flora was available in abundant; Site II: medium or semi-cultivated land and human inhabitation in adjacent area and Site III: in this ecosystem, highly cultivated land with bee flora and maintenance of domesticated bee hives (*Apis mellifera*) was carried.

Analysis of diversity and abundance: This was carried out by calculating parameters like, Species or alpha diversity of the location was estimated using Simpson's diversity Index (SDI) [17], and Shannon-Wiener index (H') [16]. SDI is an estimation of diversity which takes into account the number of species present, as well as the relative abundance of each species. SDI can be calculated by using the formula,

$$D = \Sigma n (n-1)/ N (N-1)$$

Where n=total number of organisms of a particular species and N=total number of organisms of all species. Subtracting the value of Simpson's index from 1, gives Simpson's Index of Diversity (SID).

Shannon-Wiener index (H') is one more diversity index which will be calculated by formula:

$$H' = -\Sigma Pi \ln(Pi), \text{ where } Pi = S/N;$$

Where S=number of individuals of one species, N=total number of all individuals in the sample, ln=logarithm to base e. The higher the value of H', constitute the diversity, higher.

Beta diversity is an evaluation of how different (or similar) ranges of habitats are in terms of the variety of species found in them [11]. The most widely used index for an estimation of Beta diversity is Jaccard Index (JI) [10], which is measured by using the equation:

$$JI \text{ (for two sites)} = j / (a+b-j),$$

Where j= the number of species found common to both location A and B, a= the number of species in location A and b= the number of species in location B. We assumed the data to be normally distributed and adopted parametric statistics for comparing the sites.

Result

Insect visitors on different weed flora

A total of 61 insect species were recorded to visit flowers of different weed plant species in the study area (Table 1). Considering the species richness, order wise categorization of the insect visitors follows as: Hymenoptera (25 species), Lepidoptera (22 species), Diptera (9 species), Coleoptera (4 species) and Thysanoptera (1 species).

Diversity and abundance of insect visitors on different weed flora

Insect visitors' diversity and abundance study on three locations revealed (Table 2) that, in Site I, highest SID was 0.91 on *L. camara* of and least of 0.66 on *C. benghalensis*. Whereas, highest H' was 1.11 on *L. camara* and least of 0.58 on *I. cairica*. In Site II and in Site III it was found that SID was highest of 0.89 and 0.90 on *L. camara* and least in *P. angulata* of 0.57 and 0.57 respectively. Similar fashion was followed by H' with results 1.05 and 1.08 on *L. camara* and least on *P. angulata* of 0.40 and 0.42, respectively. Thus the

above result reveal that *L. camara* support high diversity and abundance of pollinators' visitation, then compare to other weed species. Whereas, *P. angulata* has showed least diversity and abundance of pollinators' visitation.

Comparison on species similarity in between the three sites taken in pairs was carried out using Jaccard's index (Table 2). It was noticed that 100 percent species similarities between Site I and Site II, Site II and Site III and also, Site III and Site I in the weed species, *A. ficoides, B. pilosa, C. axillaris, T. procumbens, C. arvensis, I. cairica, L. echinata.* This outcome could be due to abundance of these weeds in bunds, road side, and fallow land of respective location.

Interrelationship between insect visitors and weed flora

A total of 61 insect visitors were recorded on 14 weed plants, which were further categorized based on pollination efficiency and their visiting relationship with host plant (Table 3). The categorization includes, generalist pollinators, occasional pollinators, specific pollinators, Pests and unknown status.

Among 61 insect visitors 18 species were found to be generalist pollinator mainly belonging to order Hymenoptera namely (Table 3 and Figure 1), *Apis cerana* F., *Apis dorsata* F., *Apis florea* F., *Apis mellifera* L., *Amegilla zonata* (L.), *Ceratina propinqua* C., *Ceratina simillima* Smith, *Tetragonula iridipennis* Smith, *Xylocopa aestuans* (L.), *Xylocopa latipes* D., *Ctenonomia* sp., *Halictus* sp., *Pseudapis* sp., *Lasioglossum* sp., *Nomia iridescens* Smith, *Nomia elliotii* Smith, *Lithurgus* sp., and *Pseudoanthidium* sp. 13 species of occasional pollinators (Table 3 and Figure 2) were observed during study period mainly belonging to the family Scoliidae and Vespidae of Hymenoptera and syrphidae of Diptera, they were *Thyreus* sp., *Coelioxis* sp., *Campsomeriella collaris* (F.), *Phalerimeris* sp., *Antepipona* sp., *Eumenes* sp., *Rhynchium brunneum* (F.), *Erythroplurus* sp., *Eristalinus* sp., *Episyrphus* sp., *Mesembrius* sp., *Sphaerophoria* sp. and *Syrphus* sp. It was observed that 25 species of insect visitors under specific pollinators in which majority were from Lepidoptera (butterflies). Specific pollinators includes insect species like, *Hermetia* sp., Nose flies (Unidentified sp.), Picture winged flies (Unidentified sp.), *Ampitta diascorides* F., *Pelopidas mathias* F., *Spialia galba* F., *Castalius rosimon* (F)., *Catochrysops strabo* F., *Pseudozizeeria maha* Kollar., *Talicada nyseus* G., *Ariadne merione* F., *Danaus chrysippus* L., *Danaus genutia* C., *Hypolimnus bolina* L., *Junonia almanac* L., *Phalanta phalanta* D., *Ypthima cantliei* N., *Graphium sarpendon* L., *Papilio demoleus* L., *Papilio polytes* L., *Catopsilia pyranthe* L., *Delias eucharis* D., *Eurema hecabe* L., *Pareronia hippia* F. and *Pieris brassicae* L. Whereas, 4 species of insect pest visitors were recorded, namely *Hycleus* sp., *Cetonia* sp., *Raphidopalpa foveicollis* Lucas and Thrips (Unidentified sp.). One insect species with unknown status belongs to family Curculionidae.

When floral range was calculated it was found that, 18 species of generalist pollinator had 62 associations with 14 weed plants was observed. In case of occasional pollinators it was observed that 32 interrelation between 13 species occasional of pollinators and 14 weed plants, was observed.

When all 61 species of insect visitors were compared for host range, it was observed that *A. mellifera* was having highest foraging plant range of 11 weed plants followed by *A. cerana* with 9 weed plants. Among occasional pollinators *Eristalinus* sp. was found to be associated with 6 weed plants.

Amid 14 weed plants, *L. camara* was recorded to support 20 species of insect visitors. But majority of insect visitors were specific pollinators. Both *A. ficoides* and *A. conyzoides* were recorded to be visited by 15 species of insect visitors followed by *L. echinata* with 13 species, whereas, *C. axillaris* and *C. argentea* aided 12 species of insect visitor respectively. Weed plants *L. camara, A. ficoides, A. conyzoides, L. echinata, C. axillaris* and *C. argentea* showed their potential in conservation of pollinators' diversity.

Discussion

This study shows that weed plant can successfully support the diversified pollinators' species that visit them for floral rewards. Fourteen weed species studied here show the interrelationship with 61 species of the insect visitors, thus prove the efficiency in attracting the various species towards them. As weeds show positive role in encouraging beneficial insect survivorship in agro-ecosystem was reported by, van Emden (1963, 1965). In agro-ecosystem pollinators play a crucial role in the regulation and multiplication of the weed plants by pollination activity, thus help in the balance of the food chain in the ecosystem was mentioned in the studies carried out by Aguilar *et al.,* (2006) and Bretagnolle and Gaba (2015). As there is a 50 percent reduction in the weed species diversity from past 70 years due to inappropriate use of weedicide, which in turn has led to the depletion of the insect species visiting them was reported by Carvalheiro *et al.,* (2011). Thus, the above study emphasize for the conservation of the pollinators *vis-à-vis* weed in the natural niches is must to maintain the sustainability of both pollinators and weeds in the ecosystem, similar was studied by Aguilar *et al.,* (2012).

Interrelationship among the insect visitors and weed species proves the network of food preferences by the pollinators in the natural ecosystem. This interrelationship is mainly dependent on the presence and distribution of weed species in the given region, also the desirability of weed flora by the insect pollinators' species [6, 7].

Table 1: Diversity of insect visitors on different weed flora

Sl. No.	Insect species	Family	Common name
Hymenoptera			
1.	*Apis cerana* F.	Apidae	Indian honey bee
2.	*Apis dorsata* F.	Apidae	Rock bee
3.	*Apis florea* F.	Apidae	Little bee
4.	*Apis mellifera* L.	Apidae	Italian bee
5.	*Amegilla zonata* (L.)	Apidae	Blue-banded bee
6.	*Ceratina propinqua* C.	Apidae	Small carpenter bee
7.	*Ceratina simillima* Smith	Apidae	Small carpenter bee
8.	*Tetragonula iridipennis* Smith	Apidae	Stingless bee
9.	*Thyreus* sp.	Apidae	Cuckoo bee
10.	*Xylocopa aestuans* (L.)	Apidae	Carpenter bee
11.	*Xylocopa latipes* D.	Apidae	Carpenter bee

12.	*Ctenonomia* sp.	Halictidae	Sweat bee
13.	*Halictus* sp.	Halictidae	Sweat bee
14.	*Pseudapis* sp.	Halictidae	Sweat bee
15.	*Lasioglossum* sp.	Halictidae	Sweat bee
16.	*Nomia iridescens* Smith	Halictidae	Sweat bee
17.	*Nomia elliotii* Smith	Halictidae	Sweat bee
18.	*Coelioxis* sp.	Megachilidae	Cuckoo bee
19.	*Lithurgus* sp.	Megachilidae	Leafcutter bee
20.	*Pseudoanthidium* sp.	Megachilidae	Leafcutter bee
21.	*Campsomeriella collaris* (F.)	Scoliidae	Scoliid wasp
22.	*Phalerimeris* sp.	Scoliidae	Scoliid wasp
23.	*Antepipona* sp.	Vespidae	Potter wasp
24.	*Eumenes* sp.	Vespidae	Potter wasp
25.	*Rhynchium brunneum* (F.)	Vespidae	Potter wasp
Diptera			
26.	*Erythroplurus* sp.	Bombyliidae	Bumble fly
27.	Unidentified sp.	Rhiniidae	Nose flies
28.	*Hermetia* sp.	Stratiomyidae	Black soldier fly
29.	*Eristalinus* sp.	Syrphidae	Hoverflies
30.	*Episyrphus* sp.	Syrphidae	Hoverflies
31.	*Mesembrius* sp.	Syrphidae	Hoverflies
32.	*Sphaerophoria* sp.	Syrphidae	Hoverflies
33.	*Syrphus* sp.	Syrphidae	Hoverflies
34.	Unidentified sp.	Ulidiidae	Picture winged flies
Lepidoptera			
35.	*Ampitta diascorides* F.	Hesperiidae	Skipper
36.	*Pelopidas mathias* F.	Hesperiidae	Dark small-branded swift
37.	*Spialia galba* F.	Hesperiidae	Indian grizzled skipper
38.	*Castalius rosimon* (F).	Lycaenidae	Common Pierrot
39.	*Catochrysops strabo* F.	Lycaenidae	Forget-me-not
40.	*Pseudozizeeria maha* Kollar.	Lycaenidae	Pale grass blue
41.	*Talicada nyseus* G.	Lycaenidae	Red Pierrot
42.	*Ariadne merione* F.	Nymphalidae	Common castor butterfly
43.	*Danaus chrysippus* L.	Nymphalidae	Plain tiger
44.	*Danaus genutia* C.	Nymphalidae	Striped tiger
45.	*Hypolimnus bolina* L.	Nymphalidae	Great eggfly
46.	*Junonia almana* L.	Nymphalidae	Peacock pansy
47.	*Phalanta phalanta* D.	Nymphalidae	Common leopard
48.	*Ypthima cantliei* N.	Nymphalidae	Four ring butterfly
49.	*Graphium sarpendon* L.	Papilionidae	Common bluebottle
50.	*Papilio demoleus* L.	Papilionidae	Lime butterfly
51.	*Papilio polytes* L.	Papilionidae	Common Mormon
52.	*Catopsilia pyranthe* L.	Pieridae	Mottled emigrant
53.	*Delias eucharis* D.	Pieridae	Common Jezebel
54.	*Eurema hecabe* L.	Pieridae	Common grass yellow
55.	*Pareronia hippia* F.	Pieridae	Common wanderer
56.	*Pieris brassicae* L.	Pieridae	Cabbage butterfly
Coleoptera			
57.	*Hycleus* sp.	Meloidae	Blister beetel
58.	*Cetonia* sp.	Scarabaeidae	Chaffer beetle
59.	*Raphidopalpa foveicollis* Lucas	Chrysomelidae	Red pumkin beetle
60.	Unidentified sp.	Curculionidae	Weevil
Thysanoptera			
61.	Unidentified sp.	Thripidae	Thrips

Table 2: Diversity and abundance of insect pollinators on weed flora

	Weed species	**Indicies**	**Location**		
			Site I	**Site II**	**Site III**
1	*Alternanthera ficoides* (L.)	SID	0.82	0.81	0.80
		H’	0.87	0.85	0.82
		JI	1	1	1
2	*Celosia argentea* L.	SID	0.78	0.87	0.88
		H’	1.02	0.93	0.96
		JI	1	0.916	0.916
3	*Ageratum conyzoides* L.	SID	0.80	0.79	0.84
		H’	0.88	0.87	0.93
		JI	0.93	0.86	0.80

4	*Bidens pilosa* L.	SID	0.84	0.82	0.75
		H'	0.84	0.82	0.73
		JI	1	1	1
5	*Caesulia axillaris* Roxb.	SID	0.88	0.88	0.86
		H'	0.97	0.98	0.95
		JI	1	1	1
6	*Tridax procumbens* L.	SID	0.85	0.86	0.82
		H'	0.92	0.94	0.86
		JI	1	1	1
7	*Commelina benghalensis* L.	SID	0.66	0.80	0.73
		H'	0.73	0.64	0.83
		JI	0.833	1	0.833
8	*Convolvulus arvensis* L.	SID	0.85	0.85	0.84
		H'	0.90	0.89	0.87
		JI	1	1	1
9	*Ipomoea cairica* (L.)	SID	0.70	0.71	0.69
		H'	0.58	0.60	0.58
		JI	1	1	1
10	*Merremia hederacea* Burm. f.	SID	0.76	0.78	0.75
		H'	0.69	0.72	0.68
		JI	0.875	0.875	0.75
11	*Luffa echinata* Roxb.	SID	0.88	0.88	0.87
		H'	0.96	0.96	0.95
		JI	1	1	1
12	*Physalis angulata* L.	SID	0.69	0.57	0.56
		H'	0.59	0.40	0.42
		JI	0.8	1	0.8
13	*Solanum nigrum* L.	SID	0.77	0.78	0.68
		H'	0.67	0.69	0.54
		JI	0.83	0.67	0.8
14	*Lantana camara* L.	SID	0.91	0.89	0.90
		H'	1.11	1.05	1.08
		JI	0.95	0.9	0.95

Table 3: Interrelationship between insect visitors and weed flora.

S. No.	Insect visitors	Weed species													Total
		P1	P2	P3	P4	P5	P6	P7	P8	P9	P10	P11	P12	P13	P14	
Generalist pollinator																
1.	*Apis cerana* F.	-	+	-	-	+	+	+	+	+	+	+	+	-	-	9
2.	*Apis dorsata* F.	-	+	-	-	+	-	+	+	-	-	-	-	-	-	4
3.	*Apis florea* F.	-	-	-	+	-	-	-	-	-	-	-	-	+	-	2
4.	*Apis mellifera* L.	-	+	+	+	+	+	-	+	+	+	+	+	+	-	11
5.	*Amegilla zonata* (L.)	-	-	-	-	-	-	-	+	+	+	+	+	-	+	6
6.	*Ceratina propinqua* C.	-	-	-	-	+	+	+	-	-	+	+	-	-	-	5
7.	*Ceratina simillima* Smith	-	-	-	-	-	-	-	+	-	-	+	-	+	-	3
8.	*Tetragonula iridipennis* Smith	-	-	-	-	-	-	-	-	-	-	+	-	-	-	1
9.	*Xylocopa aestuans* (L.)	-	-	-	-	-	-	-	-	-	-	-	-	-	+	1
10.	*Xylocopa latipes* D.	-	-	-	-	-	-	-	-	+	-	-	-	-	-	1
11.	*Ctenonomia* sp.	-	-	-	-	+	-	-	-	-	-	+	-	-	-	2
12.	*Halictus* sp.	-	-	-	-	-	-	-	+	+	-	-	-	-	-	2
13.	*Pseudapis* sp.	-	-	-	-	-	+	-	-	-	-	-	-	-	-	1
14.	*Lasioglossum* sp.	-	-	-	-	-	-	-	-	-	-	-	+	+	-	2
15.	*Nomia iridescens* Smith	+	-	-	-	+	+	-	-	-	+	-	-	+	-	5
16.	*Nomia elliotii* Smith	-	-	+	-	-	-	+	-	-	-	-	-	-	+	3
17.	*Lithurgus* sp.	-	-	-	-	+	-	-	-	-	-	-	-	-	-	1
18.	*Pseudoanthidium* sp.	+	-	-	-	-	+	-	-	+	-	-	-	-	-	3
Total Generalist pollinator/ host		2	3	2	2	7	6	4	6	6	5	7	4	5	3	62
Occasional pollinator																
19.	*Campsomeriella collaris* (F.)	+	+	-	-	-	-	-	-	-	-	-	-	-	-	2
20.	*Phalerimeris* sp.	-	-	-	+	-	-	-	-	-	-	-	-	-	-	1
21.	*Thyreus* sp.	-	+	-	+	-	+	-	-	-	-	-	-	-	+	4
22.	*Coelioxis* sp.	+	+	-	-	+	-	-	+	-	+	-	-	-	-	5
23.	*Antepipona* sp.	-	-	-	-	-	-	-	-	-	+	-	-	-	-	1
24.	*Eumenes* sp.	+	-	-	-	-	-	-	-	-	-	-	-	-	-	1
25.	*Rhynchium brunneum* (F.)	+	-	-	-	-	-	-	-	-	-	-	-	-	-	1
26.	*Erythroplurus* sp.	-	-	+	-	-	-	-	-	-	-	-	-	-	-	1
27.	*Eristalinus* sp.	+	+	+	+	+	-	-	+	-	-	-	-	-	-	6

28.	*Episyrphus* sp.	-	+	+	-	+	-	-	-	-	-	-	-	-	-	3
29.	*Mesembrius* sp.	+	-	-	+	+	-	+	-	-	-	-	-	-	-	4
30.	*Sphaerophoria* sp.	+	-	-	-	-	-	-	+	-	-	-	-	-	-	2
31.	*Syrphus* sp.	-	+	-	-	-	-	-	-	-	-	-	-	-	-	1
Total Occasional pollinator/ host		7	6	3	4	4	1	1	3	0	2	0	0	0	1	32
Specific pollinators																
32.	*Hermetia* sp.	-	-	-	-	-	+	-	-	-	-	-	-	-	-	1
33.	Unidentified sp. (Nose flies)	-	+	+	-	-	-	-	-	-	+	+	-	-	+	5
34.	Unidentified sp. (Picture winged flies)	+	-	-	-	-	-	-	-	-	-	-	-	-	-	1
35.	*Ampitta diascorides* F.	+	-	-	-	-	-	-	-	-	-	-	-	-	+	2
36.	*Pelopidas mathias* F.	+	+	-	+	+	+	-	+	+	-	+	-	-	-	8
37.	*Spialia galba* F.	+	-	-	-	-	-	-	-	-	-	-	-	-	-	1
38.	*Castalius rosimon* (F).	+	-	-	-	-	-	-	-	-	-	-	-	-	-	1
39.	*Catochrysops strabo* F.	-	-	+	-	-	-	-	-	-	-	-	-	-	+	2
40.	*Pseudozizeeria maha* Kollar.	-	-	+	-	-	-	+	-	-	-	-	-	-	-	2
41.	*Talicada nyseus* G.	-	-	+	-	-	-	-	-	-	-	-	-	-	-	1
42.	*Ariadne merione* F.	-	-	-	-	-	-	-	-	-	-	-	-	-	+	1
43.	*Danaus chrysippus* L.	-	-	+	-	-	-	-	-	-	-	-	-	-	+	2
44.	*Danaus genutia* C.	-	-	-	-	-	-	-	-	-	-	-	-	-	+	1
45.	*Hypolimnus bolina* L.	-	-	-	-	-	-	-	-	-	-	-	-	-	+	1
46.	*Junonia almana* L.	-	-	+	-	-	-	-	-	-	-	-	-	-	-	1
47.	*Phalanta phalanta* D.	-	-	+	-	-	-	-	-	-	-	-	-	-	+	2
48.	*Ypthima cantliei* N.	-	-	-	+	-	+	-	-	-	-	-	-	-	-	2
49.	*Graphium sarpendon* L.	-	-	-	-	-	-	-	-	-	-	-	-	-	+	1
50.	*Papilio demoleus* L.	-	-	-	-	-	-	-	-	-	-	-	-	-	+	1
51.	*Papilio polytes* L.	-	-	-	-	-	-	-	-	-	-	-	-	-	+	1
52.	*Catopsilia pyranthe* L.	-	-	-	-	-	+	-	-	-	-	-	-	-	-	1
53.	*Delias eucharis* D.	-	-	-	-	-	-	-	-	-	-	-	-	-	+	1
54.	*Eurema hecabe* L.	-	-	+	-	-	+	-	-	-	-	-	-	-	+	3
55.	*Pareronia hippia* F.	-	-	-	-	-	-	-	-	-	-	-	-	-	+	1
56.	*Pieris brassicae* L.	-	-	+	+	-	+	-	-	-	-	-	-	-	+	4
Pest insect																
57.	*Hycleus* sp.	-	-	-	-	-	-	-	-	-	-	-	+	+	-	2
58.	*Cetonia* sp.	-	+	-	-	-	-	-	-	-	-	-	-	-	-	1
59.	*Raphidopalpa foveicollis* Lucas	-	-	-	-	-	-	-	-	-	-	+	-	-	-	1
60.	Unidentified sp. (Thrips)	+	-	+	-	-	-	-	-	-	-	-	-	-	+	3
Unknown status																
61.	Unidentified sp. (Weevil)	-	-	-	-	-	-	-	-	-	-	+	-	-	-	1
Total insect visitors/ plant		15	12	15	9	12	13	6	10	7	8	11	5	6	20	-

Weed species: P1. *Alternanthera ficoides* (L.), P2. *Celosia argentea* L., P3. *Ageratum conyzoides* L., P4. *Bidens pilosa* L., P5. *Caesulia axillaris* Roxb., P6. *Tridax procumbens* L., P7. *Commelina benghalensis* L., P8. *Convolvulus arvensis* L., P9. *Ipomoea cairica* (L.), P10. *Merremia hederacea* Burm. f., P11. *Luffa echinata* Roxb., P12. *Physalis angulata* L., P13.*Solanum nigrum* L and P14. *Lantana camara* L.
T- Total weed plants visited by insect species

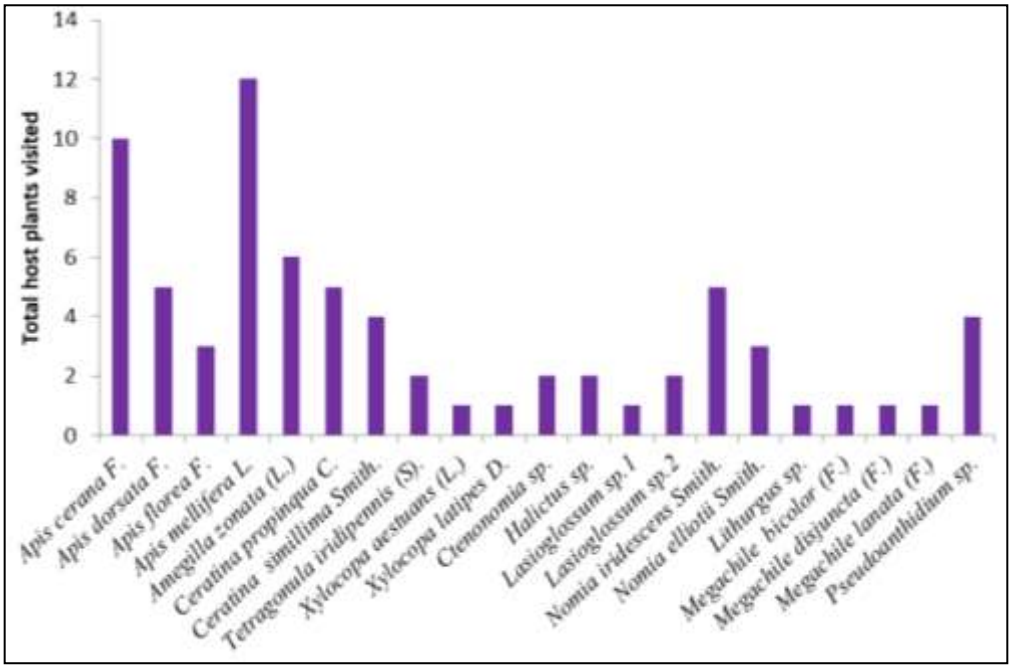

Fig 1: Interrelationship between generalist pollinator and weed flora

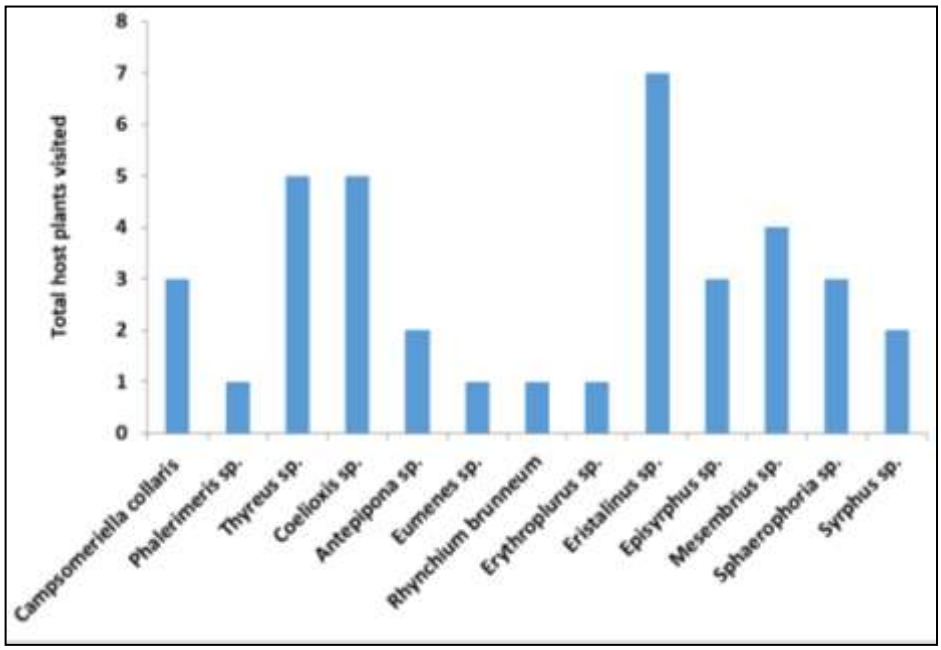

Fig 2: Interrelationship between occasional pollinators and weed flora

Conclusion

The results of the study revealed that the weed plants serve as a source of food to many species of insect pollinators which require pollen / and nectar for their own survival and to provision their brood. Therefore, weed species play important role in sustaining the populations of social and wild bees that provide vital pollination services for maintenance of biodiversity and enhancing crop yields. Farmers should be convinced with proper information to conserve weed flora in roadside, scrubland, fallow land, wasteland and other human uninhabited areas. In order to achieve optimum pollination services in farming landscapes, agronomic strategies to encourage weeds beneficial to pollinators should be designed and practiced. This can be achieved by the establishment of weedy hedge-rows in intensive agricultural areas, which can attract and conserve many native pollinators since besides providing pollen and nectar for adults; they supply the substrates that provide shelter and nesting sites for various insect pollinator species.

References

1. Aguilar R, Ashworth L, Galetto L, Aizen MA. Determinants of plant reproductive susceptibility to habitat fragmentation: review and synthesis through a meta-analysis. Ecology Letters 2006;9:968-980.
2. Aguilar R, Ashworth L, Calvin˜o A, Quesada M. What is left after sex in fragmented forests: assessing the quantity and quality of progeny of Prosopis caldenia (Fabaceae) an endemic tree from central Argentina. Biological Conservation 2012;152:81-89.
3. Baker HG. The evolution of weeds. Annual Review of Ecology and Systematics 1974;5:1-24.
4. Baker HG, Stebbins GL. The genetics of colonizing species. New York, USA: Academic Press 1965.
5. Biesmeijer JC, Roberts SPM, Reemer M, Ohlemueller R, Edwards M, Peeters T, *et al*. Parallel declines in pollinators and insect-pollinated plants in Britain and the Netherlands. Science 2006;313:351-354.
6. Bretagnolle V, Gaba S. Weeds for bees? Agronomy for Sustainable Development 2015;35:891-909.
7. Carvalheiro LG, Garibaldi LA, Dewenter IS, Kremen C, Bommarco R, Cunningham SA, *et al*. Stability of pollination services decreases with isolation from natural areas despite honey bee visits. Ecology Letters 2011;14(10):1062-1072.
8. Dewenter IS, Potts SG, Packer L. Pollinator diversity and crop pollination services are at risk. Trends in ecology and evolution 2005;20(12):651-652.
9. Gibson RH, Nelson IL, Hopkins GW, Hamlett BJ, Memmott J. Pollinator webs, plant communities and the conservation of rare plants: arable weeds as a case study. Journal of Applied Ecology 2006;43:246-257.
10. Jaccard P. The distribution of the flora in the alpine zone. New Phytologist 1912;11:37-50.
11. Magurran EA. Ecological Diversity and its Measurement. Croom Helm, Australia 1988, 215.
12. Marshall EJP, Brown VK, Boatman ND, Lutman PJW, Squire GR, Ward LK. The role of weeds in supporting biological diversity within crop fields. Weed research 2003;43(2):77-89.
13. Richards AJ. Does low biodiversity resulting from modern agriculture practice affect crop pollination and yield ?. Annals of Botany 2001;88:165-172.
14. Rollin O, Bretagnolle V, Decourtye A. Differences of floral resource use between honey bees and wild bees in an intensive farming system. Agriculture, Ecosystems & Environment 2013;179:78-86.
15. Shusheng H, Dilcher DL, Jarzen DM, Taylor DW. Early steps of angiosperm–pollinator coevolution. Proceedings of the National Academy of Sciences of the United States of America 2008;105(1):240-245.
16. Shannon CE, Wiener W. The Mathematical Theory of Communication, University of Illinois Press, Urbana 1949, 177.
17. Simpson EH. Measurement of species diversity. Nature 1949;163:688.
18. Van Emden HF. The role of uncultivated land in the biology of crop pests and beneficial insects. *Scientia Horticulturae* 1965;17:121-136.
19. Van Emden HF. Observations of the effects of flowers on the activity of parasitic Hymenoptera. Entomologist's Monthly Magazine 1963;98:265-270.