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Importance of Weed Flora in Maintaining Pollinator Diversity: An Overview from University of Agricultural Sciences Bangalore, India

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Abstract

Weed plants are very important components of agro-ecosystems especially nutrient availability, nutrient cycling and agro ecological diversity. The weeds also provide floral rewards for many pollinators and promote diversity. In this study 24 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 67 insect visitors associated with them by considering Simpson diversity index (SDI), Simpson's Index of Diversity (SID), Shannon-Wiener index (H') and Jaccard index (JI), and also their interrelationship among themself. Site I, highest SID was 0.92 on *Lantana camara* of and least of 0.66 on *Commelina benghalensis* and *Stachytarpheta indica*. Whereas, highest H' was 1.13 on *Lantana camara* and least of 0.56 on *Solanum nigrum* L. In Site II and in Site III, it was found that SID was highest with values of 0.91 and 0.94 respectively on *Lantana camara* and least in *Convolvulus arvensis* L and *Solanum nigrum* L. Weed plants *Lantana camara*, *Alternanthra echinate*, *Emilia sonchifolia*, *Tridax procumbens*, *Commelina benghalensis* and *Leucas urticaefolia* showed greater association with pollinators diversity. Thus weeds can support pollinators' diversity even during the floral dearth period and promote agrobiodiversity. Taking this into view, weed plants can be supported to grow on roadside or fallow lands, also proper planned establishment on field margins to support pollinator fauna.

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Introduction

The developmental co-evolution of insect pollinators with angiosperms happened during cretaceous period, advance in terms of pollination and prime factor for succession (Hu *et al*., 2008). Pollination results in the evolution of species and enriches biodiversity in agriculture as well as natural ecosystems (Eswarappa *et al*., 2001; Sajjanar *et al*., 2002). Pollinators played a major role in achieving food production through sustainable agriculture. Intensive changes in agricultural practices leads to decline of bees and other pollinators. Changes in the land use system, loss and fragmentation of habitat, monoculture systems, introduction of exotic organisms and injudicious pesticide uses leads to the decline of pollinators diversity (Aguilar *et al*., 2006; Biesmeijer *et al*., 2006; Garibaldi *et al*., 2011). Lack of field marginal vegetation and removal of weed plants showed hampering effect on bees and pollinator diversity (Gibson *et al*., 2006; Van Emden, 1964).

Weeds are anthropocentrically undesired plants which compete for nutrients, space and water with the crop plants (Baker, 1974). Most of the weed plants are nuisance to mankind but considered as a good source of nectar and pollen to the pollinators during dearth periods. The weeds play a major role in maintaining beneficial insect survivorship in agriculture ecosystem (Bretagnolle and Gaba, 2015). In agroecosystems, crops shows specific blooming patterns and thus unable to provide pollen and nectar continuously which could be supplemented by flowering weeds (Steffan-Dewenter *et al*., 2005).

Weeds support many arthropods communities, support granivores, support insect diversity and provide flora for insects (Van Emden, 1963; Marshall *et al*., 2003). Weeds play a major role in maintaining the persistence and survival of wild flora and improving the socio-cultural values of landscapes (Richards, 2001; Rollin *et al*., 2013). Association of the pollinators and crop plants were usually well studies but studies on pollinators interaction with weed plants are still scarce. In-depth studies about the association of pollinators and weed plants will surely maintain the agro-ecosytem diversity. 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 University of Agricultural Sciences, Bangalore, during autumn season 2021-22 (October to January). Geographically Bangalore is locate in southern India on the Deccan Plateauat 12.58 N latitude, 7.34 E longitude and 900 m altitude and known as the Silicon Valley of India.

The monsoon starts from third week of June and terminates by mid of September with annual rainfall about 960 mm. The driest month is January, with 4 mm of rainfall. The greatest amount of precipitation occurs in October, with an average of 147 mm. April is the warmest month of the year and the temperature in April averages 26.6°C.

The lowest average temperatures in the year occur in December, which is around 20.1 °C with an annual average temperature of 22.9 °C. The month with the highest relative humidity is August (79.24 %). The month with the lowest relative humidity is March (41.49 %). The month with the most rainy days is July (20.47 days) and the month with the fewest rainy days is February (1.33 days).

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.

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 insects 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, University of Agriculture Sciences, Bangalore.

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 three 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 December in 2021.

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 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), and Shannon-Wiener index (H'). 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:

$H' = -\Sigma Pi \ln(Pi)$, 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. The most widely used index for an estimation of Beta diversity is Jaccard Index (JI), which is measured by using the equation:

JI (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.

Results and Discussion

Insect visitors on different weed flora

A total of 68 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 is as follows: Hymenoptera (41 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 0.92 on *L. camara* and least 0.66 on *C. benghalensis* and *Stachytarpheta indica*. Whereas, highest H' was 1.13 on *L. camara* and least of 0.56 on *Solanum nigrum* L. In Site II and in Site III it was found that SID was highest 0.91 and 0.94 on *L. camara* and least in *Convolvulus arvensis* L and *Solanum nigrum* L 0.57 and 0.56 respectively. Similar fashion was followed by H' with results 1.03 and 1.06 on *L. camara* and least on *Solanum nigrum* L 0.47 and 0.49, respectively. Thus the above result reveal that *L. camara* support high diversity and abundance of pollinators' visitation, compared to other weed species. Whereas, *C. benghalensis* and *Stachytarpheta indica*. 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 following weed species; *Celosia argentia*, *Emilia sonchifolia*, *Tridax procumbens*, *Parthenium histiroporus*, *Ipomoea cairica*, *Cleome monophylla*, *Croton sparasiflovux* and *Desmodium trifolium*. 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 67 insect visitors were recorded on 24 weed plants, which were further categorized based on pollination efficiency and their visiting relationship with host plant (Table 3). The order wise categorization includes, Hymenopterans, Dipterans, Lepidopterans and Coleopterans. Among 67 insect visitors 41 species were found to be belonging to order Hymenoptera (Table 3 and Figure 1); with *Apis cerana* F., *Apis dorsata* F., *Apis florea* F., *Apis mellifera* L. and *Tetragonula iridipennis* Smith as major generalist pollinators. 7 species of Dipterans (Table 3 and Figure 2) were observed during study period mainly belonging to the family Syrphidae, they were *Eristalinus sp*., *Episyrphus sp*., *Mesembrius sp*., *Sphaerophoria sp*. and *Syrphus sp*. It was observed that 16 species of insect visitors were from Lepidoptera (butterflies) belonging to families mainly Hesperiidae, Nymphalidae and Pieridae. Butterflies include *Ampitta diascorides* F., *Pelopidas mathias* F., *Spialia galba* F., *Castalius rosimon* (F)., *Pseudozizeeria maha* Kollar., *Ariadne merione* F., *Danaus chrysippus* L., *Danaus genutia* C., *Phalanta phalanta* D., *Ypthima cantliei* N., *Graphium sarpendon* L., *Papilio demoleus* L., *Delias eucharis* D., *Eurema hecabe* L., *Pareronia hippia* F. and *Pieris brassicae* L. Coleopterans include species like, *Hycleus sp*., *Cetonia sp*. and *Raphidopalpa foveicollis* Lucas considered as insect pest visitors.

Table.1 List of weed flora

S. No.	Scientific name	Family	Common name	Life span
1	*Celosia argentia*	Amaranthaceae	Cocks comb	A
2	*Achyranthus aspera*	Amaranthaceae	Chafe flower	A
3	*Alternanthera sesilis*	Amaranthaceae	Kaki weed	A
4	*Emilia sonchifolia*	Asteraceae	Lilac tasselflower	A
5	*Tridax procumbens*	Asteraceae	Tridax daisy	A
6	*Parthenium histiroporus*	Asteraceae	Congress weed	A
7	*Achanthospermum hispida*	Asteraceae	Bristly starbur	A
8	*Conyza ambiqua*	Asteraceae	Butterweed	A
9	*Bidens pilosa*	Asteraceae	Spanish needle	A
10	*Commelina benghalensis* L.	Commelinaceae	Tropical spiderwort	P
11	*Convolvulus arvensis* L.	Convolvulaceae	Field bindweed	P
12	*Ipomoea cairica* (L.)	Convolvulaceae	Messina creeper	P
13	*Luffa echinata* Roxb.	Cucurbitaceae	Bitter sponge gourd	
14	*Solanum nigrum* L.	Solanaceae	Black nightshade	P
15	*Lantana camara* L.	Verbanaceae	Common lantana	P
16	*Cleome monophylla*	Capparidaceae	Spindle pod	A
17	*Cyperus rotundus*	Cyperaceae	Nutsedge	P
18	*Croton sparasiflovux*	Euphorbiaceae		A
19	*Euphorbia hirta*	Euphorbiaceae	Asthma-plant	A
20	*Leucas urticaefolia*	Lamiaceae		A
21	*Desmodium trifolium*	Leguminaceae	Creepingtick trefoil	A
22	*Mimosa pudica*	Leguminaceae	Touch me not	A
23	*Borreria hispida*	Rubiaceae	False buttonweed	A
24	*Stachytarpheta indica*	Verbanaceae	Indian snakeweed	A

A: Annual; P: Perennial

Fig.1 General view of the GKVK campus where the investigation was conducted.

Table.2 Diversity of insect visitors on different weed flora

SI. 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	*Tetragonula iridipennis* Smith	Apidae	Stingless bee
6	*Amegilla zonata* (L.)	Apidae	Blue-banded bee
7	*Ceratina propinqua* C.	Apidae	Small carpenter bee
8	*Ceratina simillima* Smith	Apidae	Small carpenter bee
9	*Xylocopa aestuans* (L.)	Apidae	Carpenter bee
10	*Xylocopa latipes* D.	Apidae	Carpenter bee
11	*Thyreus sp.*	Apidae	Cuckoo bee
12	*Ceratina binghami* Cockerell, 1908	Apidae	Small carpenter bee
13	*Ceratina hieroglyphica* Smith, 1854	Apidae	Small carpenter bee
14	*Tetralonia* (*Thygatina*) *macroceps*	Apidae	
15	*Thyreus histrio* (Fabricius, 1775)	Apidae	
16	*Thyreus massuri* (Radoszkowski, 1893)	Apidae	
17	*Ctenonomia sp.*	Halictidae	Sweat bee
18	*Halictus sp.*	Halictidae	Sweat bee
19	*Pseudapis sp.*	Halictidae	Sweat bee
20	*Lasioglossum sp.*	Halictidae	Sweat bee
21	*Nomia iridescens* Smith	Halictidae	Sweat bee
22	*Nomia elliotii* Smith	Halictidae	Sweat bee
23	*Braunsapis sp.*	Halictidae	
24	*Hoplonomia westwoodi* (Gribodo, 1894)	Halictidae	
25	*Pachynomia sp.*	Halictidae	
26	*Scolia hirta*	Halictidae	
27	*Seladonia sp.*	Halictidae	
28	*Coelioxis sp.*	Megachilidae	Cuckoo bee
29	*Lithurgus sp.*	Megachilidae	Leafcutter bee
30	*Pseudoanthidium sp.*	Megachilidae	Leafcutter bee
31	*Coelioxys basalis* Smith, 1875	Megachilidae	
32	*Coelioxys confusus* Smith, 1854	Megachilidae	
33	*Lithurgus atratus* Smith, 1853	Megachilidae	
34	*Megachile anthracina* Smith, 1853	Megachilidae	
35	*Megachile bicolor* (Fabricius, 1781)	Megachilidae	
36	*Megachile cephalotes* Smith, 1853	Megachilidae	
37	*Campsomeriella collaris* (F.)	Scoliidae	Scoliid wasp
38	*Phalerimeris sp.*	Scoliidae	Scoliid wasp
39	*Antepipona sp.*	Vespidae	Potter wasp
40	*Eumenes sp.*	Vespidae	Potter wasp
41	*Rhynchium brunneum* (F.)	Vespidae	Potter wasp
Diptera			
42	*Erythroplurus sp.*	Bombyliidae	Bumble fly
43	*Hermetia sp.*	Stratiomyidae	Black soldier fly

44	*Eristalinus sp*.	Syrphidae	Hoverflies
45	*Episyrphus sp*.	Syrphidae	Hoverflies
46	*Mesembrius sp*.	Syrphidae	Hoverflies
47	*Sphaerophoria sp*.	Syrphidae	Hoverflies
48	*Syrphus sp*.	Syrphidae	Hoverflies
Lepidoptera			
49	*Ampittia diascorides* F.	Hesperiidae	Skipper
50	*Pelopidas mathias* F.	Hesperiidae	Dark small-branded swift
51	*Spialia galba* F.	Hesperiidae	Indian grizzled skipper
52	*Castalius rosimon* (F).	Lycaenidae	Common Pierrot
53	*Pseudozizeeria maha* Kollar.	Lycaenidae	Pale grass blue
54	*Ariadne merione* F.	Nymphalidae	Common castor butterfly
55	*Danaus chrysippus* L.	Nymphalidae	Plain tiger
56	*Danaus genutia* C.	Nymphalidae	Striped tiger
57	*Phalanta phalanta* D.	Nymphalidae	Common leopard
58	*Ypthima cantliei* N.	Nymphalidae	Four ring butterfly
59	*Graphium sarpendon* L.	Papilionidae	Common bluebottle
60	*Papilio demoleus* L.	Papilionidae	Lime butterfly
61	*Delias eucharis* D.	Pieridae	Common Jezebel
62	*Eurema hecabe* L.	Pieridae	Common grass yellow
63	*Pareronia hippia* F.	Pieridae	Common wanderer
64	*Pieris brassicae* L.	Pieridae	Cabbage butterfly
Coleoptera			
65	*Hycleus sp*.	Meloidae	Blister beetle
66	*Cetonia sp*.	Scarabaeidae	Chaffer beetle
67	*Raphidopalpa foveicollis* Lucas	Chrysomelidae	Red pumpkin beetle

Table.3 Diversity of insect visitors

SI. No.	Weed species	Indicies	Location		
			Site 1	Site 2	Site 3
1	*Celosia argentia*	SID	0.82	0.81	0.78
		H’	0.87	0.85	0.85
		JI	1	1	1
2	*Achyranthus aspera*	SID	0.80	0.79	0.84
		H’	0.88	0.87	0.93
		JI	0.93	0.86	0.80
3	*Alternanthera echinata*	SID	0.78	0.87	0.88
		H’	1.02	0.93	0.96
		JI	1	0.91	0.91
4	*Emilia sonchifolia*	SID	0.88	0.82	0.75
		H’	0.84	0.82	0.73
		JI	1	1	1
5	*Tridax procumbens*	SID	0.85	0.86	0.82
		H’	0.92	0.94	0.86
		JI	1	1	1
6	*Parthenium histiroporus*	SID	0.84	0.82	0.75
		H’	0.84	0.82	0.73
		JI	1	1	1
7	*Achanthospermum hispida*	SID	0.80	0.79	0.84
		H’	0.88	0.87	0.93
		JI	0.93	0.86	0.80
8	*Conyza ambiqua*	SID	0.76	0.77	0.85
		H’	0.81	0.84	0.93
		JI	0.91	0.87	0.86
9	*Bidens pilosa*	SID	0.76	0.78	0.75
		H’	0.69	0.72	0.68
		JI	0.87	0.87	0.75
10	*Commelina benghalensis* L.	SID	0.66	0.80	0.73
		H’	0.73	0.64	0.83
		JI	0.83	1	0.83
11	*Convolvulus arvensis* L.	SID	0.69	0.57	0.56
		H’	0.59	0.40	0.42
		JI	0.88	1	0.88
12	*Ipomoea cairica* (L.)	SID	0.85	0.85	0.84
		H’	0.90	0.89	0.87
		JI	1	1	1
13	*Luffa echinata* Roxb.	SID	0.77	0.78	0.68
		H’	0.67	0.69	0.54
		JI	0.83	0.67	0.81
14	*Solanum nigrum* L.	SID	0.69	0.57	0.56
		H’	0.56	0.47	0.49
		JI	0.84	1	0.83
15	*Lantana camara* L.	SID	0.92	0.91	0.94
		H’	1.13	1.03	1.06

		JI	0.98	0.96	0.98
16	*Cleome monophylla*	SID	0.70	0.71	0.69
		H’	0.58	0.60	0.58
		JI	1	1	1
17	*Cyperus rotundus*	SID	0.77	0.78	0.68
		H’	0.67	0.69	0.54
		JI	0.83	0.67	0.82
18	*Croton sparasiflovux*	SID	0.88	0.88	0.87
		H’	0.96	0.96	0.95
		JI	1	1	1
19	*Euphorbia hirta*	SID	0.77	0.78	0.68
		H’	0.67	0.69	0.54
		JI	0.83	0.67	0.85
20	*Leucas urticaefolia*	SID	0.81	0.78	0.84
		H’	0.89	0.85	0.93
		JI	0.92	0.86	0.82
21	*Desmodium trifolium*	SID	0.84	0.82	0.75
		H’	0.84	0.82	0.73
		JI	1	1	1
22	*Mimosa pudica*	SID	0.80	0.79	0.84
		H’	0.88	0.87	0.93
		JI	0.94	0.86	0.80
23	*Borreria hispida*	SID	0.79	0.83	0.82
		H’	0.84	0.81	0.83
		JI	0.91	0.83	0.79
24	*Stachytarpheta indica*	SID	0.66	0.80	0.75
		H’	0.72	0.61	0.85
		JI	0.81	1	0.89

Table.4 Interrelationship between insect visitors and weed flora.

SI. No.	Insect species	Weed species																							Total
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	
Hymenoptera																									
1	*Apis cerana* F.	-	-	+	+	+	-	-	-	+	+	-	+	+	+	-	-	-	-	+	+	-	+	-	-	11
2	*Apis dorsata* F.	-	-	+	+	-	-	-	-	+	+	-	-	-	+	+	-	-	-	-	+	-	+	-	-	8
3	*Apis florea* F.	+	-	+	+	-	-	-	-	-	+	-	-	-	+	+	-	-	-	-	-	-	+	-	-	7
4	*Apis mellifera* L.	-	-	+	+	+	-	-	-	-	+	-	-	-	+	+	-	-	-	-	-	-	+	-	-	7
5	*Tetragonula iridipennis* Smith	+	-	+	+	+	-	-	-	-	+	-	-	-	+	-	-	-	-	-	+	-	+	-	-	8
6	*Amegilla zonata* (L.)	-	+	-	-	+	-	-	-	-	-	+	-	-	-	-	+	-	-	-	+	-	-	-	-	5
7	*Ceratina propinqua* C.	+	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	3
8	*Ceratina simillima* Smith	-	+	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-	+	4
9	*Xylocopa aestuans* (L.)	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	2
10	*Xylocopa latipes* D.	+	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	2
11	*Thyreus sp*.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-	1
12	*Ceratina binghami* Cockerell, 1908	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1
13	*Ceratina hieroglyphica* Smith, 1854	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	2
14	*Tetralonia* (*Thygatina*) *macroceps*	-	+	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	3
15	*Thyreus histrio* (Fabricius, 1775)	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1
16	*Thyreus massuri* (Radoszkowski, 1893)	-	-	-	-	+	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	2
17	*Ctenonomia sp*.	+	-	-	-	-	-	-	-	-	-	+	-	-	+	-	-	-	-	-	-	-	-	-	-	3
18	*Halictus sp.*	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1
19	*Pseudapis sp.*	-	-	-	-	+	-	-	-	-	+	-	-	-	-	-	-	+	+	-	-	-	+	-	-	5
20	*Lasioglossum sp.*	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-	2

21	*Nomia iridescens* Smith	-	-	-	+	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	+	-	-	-	3
22	*Nomia elliotii* Smith	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1
23	*Braunsapis sp.*	-	-	-	-	-	+	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	2
24	*Hoplonomia westwoodi* (Gribodo, 1894)	-	-	-	-	-	-	-	+	-	+	-	-	-	-	+	-	-	-	-	-	-	-	-	-	3
25	*Pachynomia sp.*	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1
26	*Scolia affinis* Guérin-Méneville, 1830	-	-	+	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2
27	*Seladonia sp.*	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	2
28	*Coelioxis sp.*	-	-	-	+	-	-	-	-	-	-	+	-	-	-	-	+	-	-	-	-	-	-	-	-	3
29	*Lithurgus sp.*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	1
30	*Pseudoanthidium sp.*	+	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-	3
31	*Coelioxys basalis* Smith, 1875	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1
32	*Coelioxys confusus* Smith, 1854	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	2
33	*Lithurgus atratus* Smith, 1853	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1
34	*Megachile anthracina* Smith, 1853	-	-	+	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	+	+	-	-	4
35	*Megachile bicolor* (Fabricius, 1781)	-	-	-	-	+	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	2
36	*Megachile cephalotes* Smith, 1853	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1
37	*Campsomeriella collaris* (F.)	-	-	-	-	-	+	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2
38	*Phalerimeris sp.*	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-	2
39	*Antepipona sp.*	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1
40	*Eumenes sp.*	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	+	-	-	-	-	-	-	-	-	2
41	*Rhynchium brunneum* (F.)	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1
Diptera																										
42	*Erythroplurus sp.*	-	+	-	-	-	-	-	-	-	-	+	-	-	-	+	-	-	-	-	-	-	-	-	-	3
43	*Hermetia sp.*	-	-	-	-	+	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	2
44	*Eristalinus sp.*	-	-	-	-	-	-	-	-	+	-	-	-	-	+	-	-	-	-	-	+	-	-	-	-	3

45	*Episyrphus sp.*	-	-	-	+	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	2
46	*Mesembrius sp.*	-	-	-	-	-	+	-	-	-	-	-	-	-	-	+	-	-	+	-	-	-	-	-	3
47	*Sphaerophoria sp.*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	1
48	*Syrphus sp.*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	1
Lepidoptera																									
49	*Ampitta diascorides* F.	-	-	+	-	-	-	+	-	-	-	-	-	+	-	+	-	-	-	-	-	-	-	-	4
50	*Pelopidas mathias* F.	-	-	-	-	-	-	-	-	-	-	+	-	-	+	+	-	-	-	-	-	-	-	-	3
51	*Spialia galba* F.	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	1
52	*Castalius rosimon* (F).	-	-	-	-	+	-	-	-	+	-	-	-	-	-	+	-	-	-	-	-	-	-	-	3
53	*Pseudozizeeria maha* Kollar.	+	-	-	-	-	-	--	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	2
54	*Ariadne merione* F.	-	-	-	+	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	2
55	*Danaus chrysippus* L.	-	-	-	-	-	-	-	-	-	+	-	-	+	-	-	-	-	-	+	-	-	-	-	3
56	*Danaus genutia* C.	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	+	-	-	-	-	-	-	2
57	*Phalanta phalanta* D.	-	-	-	-	-	-	-	+	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	2
58	*Ypthima cantliei* N.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-	1
59	*Graphium sarpendon* L.	-	+	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	2
60	*Papilio demoleus* L.	-	-	-	-	+	-	-	-	-	-	-	+	-	-	+	-	-	-	-	-	-	-	-	3
61	*Delias eucharis* D.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	+	-	-	-	+	3
62	*Eurema hecabe* L.	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1
63	*Pareronia hippia* F.	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-	2
64	*Pieris brassicae* L.	-	-	-	-	-	+	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	+	-	3
Coleoptera																									
65	*Hycleus sp.*			+							+														2
66	*Cetonia sp.*																						+		1
67	*Raphidopalpa foveicollis* Lucas									+															1
		8	8	14	13	12	6	3	3	8	12	7	5	6	9	15	5	5	4	5	7	4	10	3	4	

Weed species:1.*Celosia argentia*, 2. *Achyranthus aspera*, 3. *Alternanthera echinate*, 4. *Emilia sonchifolia*, 5. *Tridax procumbens*, 6. *Parthenium histiroporus*, 7. *Achanthospermum hispida*, 8. *Conyza ambiqua*, 9. *Bidens Pilosa*, 10. *Commelina benghalensis* L., 11. *Convolvulus arvensis* L., 12. *Ipomoea cairica* (L.), 13. *Luffa echinata Roxb*., 14. *Solanum nigrum* L., 15. *Lantana camara* L., 16. *Cleome monophyla*, 17. *Cyperus rotundus*, 18. *Croton sparasiflovux*, 19. *Euphorbiahirta*, 20. *Leucas urticaefolia*, 21. *Desmodium trifolium*, 22. *Mimosa pudica*, 23. *Borreria hispida*, 24. *Stachytarpheta indica*

Fig.2 Description of A) *Celosia argentia*; B) *Achyranthus aspera*; C) *Alternanthera sesilis*; D) *Emilia sonchifolia*; E) *Tridax procumbens*; F) *Parthenium histiroporus*; G) *Achanthospermum* hispida; H) *Conyza ambiqua*; I) *Bidens pilosa*; J) *Commelina benghalensis* L.; K) *Convolvulus arvensis* L.; L) *Ipomoea cairica* (L.); M) *Luffa echinata* Roxb.

Fig.3 Description A)*Solanum nigrum* L.; B) *Lantana camara* L.; C) *Cleome monophyla*; D) *Cyperus rotundus*; E) *Croton sparasiflovux*; F)*Euphorbia hirta*; G) *Leucas urticaefolia*; H) *Desmodium trifolium*; I) *Mimosa pudica*; J) *Borreria hispida*; K) *Stachytarpheta indica.*

Fig.4 Description of 1)*Apis cerena* F. 2) *Apis dorsata* F. 3) *Apis florea* F 4) *Apis mellifera* L. 5) *Tetragonula iridipennis* Smith 6)*Amegilla zonata* (L.) 7) *Ceratina propinqua* C. 8) *Ceratina simillima* Smith 9) *Xylocopa aestuans* (L.) 10) *Xylocopa latipes* D. 11) *Thyreus sp*. 12) *Ceratina binghami* Cockerell 13)*Ceratina hieroglyphica* Smith 14) *Tetralonia* (*Thygatina*) *macroceps* 15) *Thyreus histrio* (Fabricius) 16) *Thyreus massuri* 17) *Ctenonomia sp*. 18) *Halictus sp*. 19) *Pseudapis sp*. 20) *Lasioglossum sp*. 21) *Nomia iridescens* Smith 22) *Nomia elliotii* Smith 23) *Braunsapis sp*. 24) *Hoplonomia westwoodi*

1 *Apis cerena* F.

2*Apis dorsata* F.

3*Apis florea* F

4*Apis mellifera* L.

5*Tetragonula iridipennis* Smith

6*Amegilla zonata* (L.)

7*Ceratina propinqua* C.

8*Ceratina simillima* Smith

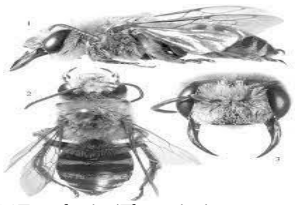
9*Xylocopa aestuans* (L.)

10*Xylocopa latipes* D.

11*Thyreus sp*.

12*Ceratina binghami* Cockerell

13*Ceratina hieroglyphica* Smith



14*Tetralonia* (*Thygatina*) *macroceps*

15*Thyreus histrio* (Fabricius)

16*Thyreus massuri*

17*Ctenonomia sp*.

18*Halictus sp*.

19*Pseudapis sp*.

20*Lasioglossum sp*.

21*Nomia iridescens* Smith

22*Nomia elliotii* Smith

23*Braunsapis sp*.

24*Hoplonomia westwoodi*

Fig.5 Description of 25) *Pachynomia sp*. 26) *Scolia hirta* 27) *Seladonia sp*. 28) *Coelioxis sp*. 29) *Lithurgus sp*. 30) *Pseudoanthidium sp*. 31) *Coelioxys basalis* Smith 32) *Coelioxys confusus* Smith 33) *Lithurgus atratus* Smith 34) *Megachile anthracina* Smith 35) *Megachile bicolor* 36) *Megachile cephalotes* 37) *Campsomeriella collaris* (F.) 38) *Phalerimeris sp*. 39) *Antepipona sp*. 40) *Eumenes sp*. 41) *Rhynchium brunneum* (F.) 42) *Erythroplurus sp*. 43) *Hermetia sp*. 44) *Eristalinus sp*. 45) *Episyrphus sp*. 46) *Mesembrius sp*. 47) *Sphaerophoria* 48) *Syrphus sp*.

25*Pachynomia sp*.

26*Scolia hirta*

27*Seladonia sp*.

28*Coelioxis sp*.

29*Lithurgus sp*.

30*Pseudoanthidium sp*.

31*Coelioxys basalis* Smith

32*Coelioxys confusus* Smith

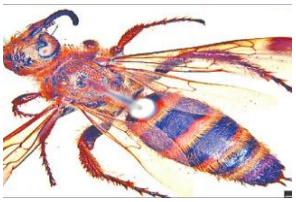
33*Lithurgus atratus* Smith

34*Megachile anthracina* Smith

35*Megachile bicolor*

36*Megachile cephalotes*

37*Campsomeriella collaris* (F.)



38*Phalerimeris sp*.

39*Antepipona sp*.

40*Eumenes sp*.

41*Rhynchium brunneum* (F.)

42*Erythroplurus sp*.

43*Hermetia sp*.

44*Eristalinus sp*.

45*Episyrphus sp*.

46*Mesembrius sp*.

47*Sphaerophoria sp*.

48*Syrphus sp*.

Fig.6 Description of49) *Ampittia diascorides* F. 50) *Pelopidas mathias* F 51) *Spialia galba* F. 52) *Castalius rosimon* (F). 53) *Pseudozizeeria maha* Kollar. 54) *Ariadne merione* F. 55) *Danaus chrysippus* L. 56) *Danaus genutia* C. 57) *Phalanta phalanta* D. 58) *Ypthima cantliei* N. 59) *Graphium sarpendon* L. 60) *Papilio demoleus* L. 61) *Delias eucharis* D. 62) *Eurema hecabe* L. 63) *Pareronia hippia* F. 64) *Pieris brassicae* L. 65) *Hycleus sp*. 66) *Cetonia sp.* 67) *Raphidopalpa foveicollis* Lucas

49*Ampittia diascorides* F.

50*Pelopidas mathias* F.

51*Spialia galba* F.

52*Castalius rosimon* (F).

53*Pseudozizeeria maha* Kollar.

54*Ariadne merione* F.

55*Danaus chrysippus* L.

56*Danaus genutia* C.

57*Phalanta phalanta* D.

58*Ypthima cantliei* N.

59*Graphium sarpendon* L.

60*Papilio demoleus* L.

61*Delias eucharis* D.

62*Eurema hecabe* L.

63*Pareronia hippia* F.

64*Pieris brassicae* L.

65*Hycleus sp*.

66Cetonia sp.

67*Raphidopalpa foveicollis* Lucas

When floral range was calculated it was found that, 41 species of Hymenopteran pollinators had 119 associations with 24 weed plants. In case of Dipteran pollinators it was observed that there were15 interrelation between 7 species of pollinators and 24 weed plants.

When all 61 species of insect visitors were compared for host range, it was observed that *A. cerana* was having highest foraging plant range of 11 weed plants followed by *A. dorsata* and *Tetragonula iridipennis* Smith with 8 weed plants respectively. Both *Apis florea* and *Apis mellifera* were found to be associated with 7 weed plants.

Amid 24 weed plants, *L. camara* was recorded to support 15 species of insect visitors followed by *Alternanthera echinate* (14 species) and *Emilia sonchifolia* (13 species). Both *Tridax procumbens* and *Commelina benghalensis* were recorded to be visited by 12 species of insect visitors followed by *Leucas urticaefolia* with 10 species. Weed plants *L. camara*, *Alternanthra echinate*, *Emilia sonchifolia*, *Tridax procumbens*, *Commelina benghalensis* and *Leucas urticaefolia* showed their potential in conservation of pollinators' diversity.

This study shows that weed plants can successfully support the diversified pollinators' species that visit them for floral rewards. 14 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 which 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 emphasizes 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 study was conducted 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 (Deeksha *et al*., 2021). 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.

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 feed 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.

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