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FLORAL HOST PLANT RANGE OF SYRPHID FLIES (SYRPHIDAE: DIPTERA) UNDER NATURAL CONDITIONS IN SOUTHERN PUNJAB, PAKISTAN

ASIF SAJJAD AND SHAFQAT SAEED

Department of Plant Protection, University College of Agriculture, Bahauddin Zakariya University, Multan, Pakistan.

Abstract

Syrphid flies are very important group of insects in ecosystem from viewpoint of pollination and biological control. Floral host preference of 15 most abundant syrphid fly species was assessed towards 11 agricultural and 40 non-agricultural plant species in 28 families under natural field conditions. *Coriandrum sativum*, *Cirsium arvense*, *Launaea procumbens*, *Prosopis juliflora*, *Allium cepa*, *Ranunculus muricatus* and *Daucus carota* were visited by maximum number of syrphid fly species (≥9). *Eristalinus aeneus*, *Ischiodon scutellaris* and *Episyrphus balteatus* were the most frequent floral visitors and also visited maximum number of plant species. There was a positive relationship between abundance of syrphid fly species and the amount of available floral resources along the flowering weeks. Fifteen syrphid most preferred plant species were identified including 8 agricultural and 7 non-agricultural plant species. *Parkinsonia aculeata* and *Mangifera indica* were the most preferred plant species by syrphid flies among agricultural and non-agricultural plant species, respectively. Most of the syrphid fly species preferred white and yellow colored actenomorphic flowers.

Introduction

Pollination and biological control are one of the most important ecosystem services delivered by insects for human beings (Potts *et al*., 2006). Both the abundance and diversity of pollinators have generally been documented as beneficial to the yield of numerous crops (Talavera *et al*., 2001; Kremen *et al*., 2002). Bees is the only taxon which is considered thoroughly in this context (Jauker & Wolters, 2008) and very little work has been done on fly (Diptera) pollinators (Ssymank *et al*., 2008). Flower flies are a very important group of insects because their services to ecosystems are twofold i.e., their larvae are important natural enemies of herbivorous arthropods and their adults are pollinators of many of the crops and wild plants (Tooker *et al*., 2006; Ghahari *et al*., 2008). It is estimated that their importance as predator is equal to that of parasitoids, pathogenic fungi, lady birds and lacewings (Ankersmit *et al*., 1986). Adults of hover flies consume floral nectar for energy and pollen for protein, lipids and vitamins (Faegri & Pijl, 1979). These floral resources enhance longevity and fecundity of adult hoverflies (Shahjhan, 1968). This nutritional dependence on floral resources suggests that artificial planting of the most attractive nutrition plants, might help to conserve hover flies for the better biological control of herbivorous pests (Heimpel & Jervis, 2005). Colley & Luna (2000) called it "beneficial insectary planting" when we intentionally introduce flowering plants into agricultural ecosystems to increase pollen and nectar resources required by Syrphids. Therefore, the effective biological control by using beneficial insectary plants needs a complete knowledge of floral host range of biological control agents (Colley & Luna, 2000; Tooker *et al*., 2006). Furthermore, most of the investigations of predator foraging have been made taking into account prey-host-relationships exclusively and have overlooked non-prey food (Jervis & Kidd, 1996).

Correspondence E-mail: bumblebeepak@gmail.com
+92-61-9210002; +92-300-6358432

Most of the work has been done on intentionally introduced insectary plants from conservation point of view (Lovei *et al*., 1992; Colley & Luna, 2000) but the complete knowledge of Syrphid-plant associations is still lacking as adult hoverflies exhibit a high degree of selectivity in flowers from which they feed (Lovie *et al*., 1993; Lunau & Wacht, 1994).

Floral preferences vary from species to species. Some species are highly specialized feeders while others are highly generalized feeders (Haslett, 1989). This floral attractiveness may be due to many factors like flower color and shape, pollen and nectar availability (Sutherland *et al*., 1999), shelter and availability of prey (Colley & Luna, 2000).

Goulson & Wright (1998) observed marked floral constancy in *Episyrphus balteatus* and *Syrphus ribesii* when foraging in a mixed plant community. Several flowering plants have been evaluated by researchers as insectary plants in different regions of the world (Colley & Luna, 2000; Robertson, 1929; Tooker *et al*., 2006; Juker & Wolters, 2008; Lovei *et al*., 1993). The native flora and fauna vary in different geographical areas of the world or even within the same geographical area depending upon latitude, altitude, climate and geological and soil characteristics.

The objective of this study was to document:

1. The floral host plant range of native syrphid fly species in southern Punjab.
2. The most preferred plant species by syrphid flies under natural conditions.
3. The relationship between availability of floral resources (number of flowering plant species and average flower density per week) and the abundance of syrphid flies.
4. Whether the abundance of syrphid flies is influenced by their species diversity or not.

Materials and Methods

Study sites: The study was made in the Southern Irrigated Zone of Punjab, Pakistan (Anon., 1980). Climate of the area is sub-tropical with a hot summer and cold winter; the mean daily maximum and minimum temperatures are in the range of 38 to 50^{o}C and 8 to 12^{o}C, respectively with the mean monthly summer rainfall *ca.* 18mm. Geographically, it is an alluvial plain with fertile soil deposited by the flood regime of the rivers through thousands of years. Most of the land is cultivated and irrigated by canals or underground waters. A variety of crops are grown but cotton and wheat rotation mostly is the tradition. We focused on three cities of Southern irrigated zone of Punjab for our objectives i.e., Multan, Muzafargarh and Khanewal. Muzafargarh is situated 40 Km in west of Multan and Khanewal is 50 Km in the east. In Multan city, we chose two localities, a planted forest of 20 hectares and an experimental farm in Bahauddin Zakariya University (BZU) campus and the other one in the research farm of Cotton Research Station (CRS). In CRS, other than crop plants, we also investigated unmanaged margins of watercourses having a variety of wild plants. In Muzafargarh, we selected the river bank of the Chanab where we focused on the least disturbed area by human beings along the river verges and some adjacent agricultural landscape. In Khanewal city, we selected a wildlife sanctuary (7212 hectares) and adjacent agricultural lands for study. We attributed planted forest and unmanaged river or watercourse verges as semi-natural landscape and wildlife sanctuary area as natural landscape.

Plant species and floral units: We investigated all available plant species (crops, trees, shrubs and annual weeds) that were flowering during the full course of our study (Third week of February to 2nd week of May, 2008). As different plant species had different kind of inflorescence types, we defined the floral units for each plant species separately (Table 2) and counted syrphid flies from these floral units.

Table 1. Particulars about the areas of study during spring 2008

Sites/Cities	GPS Latitude, Longitudes	Altitude feet	Code	Habitat type
Bahauddin Zakariya, University Campus, Multan	30.277, 071.507	373 ± 19	a	Semi-natural and Agricultural landscapes
Wildlife Sanctuary Perowal, Khanewal	30.364, 072.030	430 ± 17	b	Natural landscape
Central Cotton Research Station, Multan	30.151, 071.448	370 ± 14	c	Semi-natural and agricultural landscapes
River Chanb, Muzafargarh	30.045, 071.167	357 ± 12	d	Semi-natural landscape

Floral abundance: We estimated the floral abundance by randomly selecting and tagging 15 plants per plant species and counting the total number of floral units/plant each week.

Identification of plant and syrphid fly species: Plant species were identified by local taxonomist (Acknowledgements). The nomenclature of plant species was followed according to latest database updated by The International Plant Names Index (2008). This database is available on the internet http://www.ipni.org. One of the plant species was identified only up to genus level (*Convolvulus* sp.).

Syrphid fly species were identified up to genus level by using standard keys (Vockeroth, 1996) and species were identified by the experts (Acknowledgements). The nomenclature of syrphidae was followed according to the Biosystematics Database of the World Diptera (Thompson, 2004).

Syrphid visitor censuses: In semi-natural and natural habitats we used random walks in the study areas and considered only single plant species at one time during its anthesis. Fifteen plants of each species were randomly selected and each plant was observed for 1 minute. In this way there was a total of 15 minute observation per plant species in one census. For agricultural crop species, 15 plants were selected randomly in each census from the margins of the fields.

For each plant, we counted the number of visiting individuals per syrphid fly species by visual observations. Weekly census of each flowering plant species was made from the very beginning to the end of its flowering period. When we started our observations (third week of February, 2008), some of the plant species were already in flower and similarly, at the end of our study (2^{nd} week of May, 2008) some other plant species were still flowering.

Data analysis: To find the relationship between availability of floral resources (number of flowering plant species and average number of floral units per week) on the abundance of syrphid flies, we used simple linear regression analysis between availability of floral resources and average abundance of syrphid flies along the observation weeks. We also used linear regression analysis between number of syrphid fly species and total syrphid abundance per week to assess whether the diversity of syrphid flies affects their abundance or not. To find the most attractive plant species for syrphid flies, we ranked plant species based on syrphid visiting frequencies per plant species and number of syrphid fly species per plant species using Kruskal-Walis test (Anon., 2001) and selected 15 top ranked plant species as insectary plants.

Table 2. Plant species, sites observed and sampling efforts on given plant species during spring 2008.

Plant Species	Families	Shorts	Sites observed	No. of censes	Floral units	No. of syrphid species observed
Sesuvium sesuvioides	Aizoaceae	*Sesses*	a b	2	Inflorescence/plant	1
Mangifera indica	Anacardiaceae	*Manind*	a c	3	Inflorescences/5 ft^2	8
Coriandrum sativum	Apiaceae	*Corsat*	a c	7	Umbels/plant	11
Daucus carota	Apiaceae	*Daucar*	c	7	Umbels/plant	10
Torilis japonica	Apiaceae	*Torjap*	a c	3	Umbels/plant	4
Calotropis procera	Asclepiadaceae	*Calpro*	a c d	6	Flowers/5ft^2	5
Asphodelus tenuifolius	Asphodelaceae	*Aspten*	a b	5	Flowers/plant	2
Sonchus asper	Asteraceae	*Sonasp*	a d	10	Flowers/plant	8
Cirsium arvense	Asteraceae	*Cirarv*	a c	7	Flowers/plant	9
Launaea procumbens	Asteraceae	*Laupro*	a c	9	Flowers/plant	9
Ageratum conyzoides	Asteraceae	*Agecon*	a	8	Flowers/5ft^2	7
Helianthus annuus	Asteraceae	*Halann*	a d	3	Flowers/5 plants	4
Conyza bonariensis	Asteraceae	*Conbon*	a c	4	Flowers/plant	4
Carthamus persicus	Asteraceae	*Carper*	a	3	Flowers/plant	1
Pulicaria crispa	Asteraceae	*Pulcri*	a	6	Flowers/plant	3
Heliotropium europaeum	Boraginaceae	*Heleur*	a b c	6	Inflorescence/plant	5
Brassica campestris	Brassicaceae	*Bracom*	a c	5	Flowers/plant	7
Malcolmia africana	Brassicaceae	*Malafr*	a b	5	Flowers/plant	2
Raphanus sativus	Brassicaceae	*Rapsti*	c	2	Flowers/plant	9
Capparis decidua	Capparidaceae	*Capdec*	a	5	Flowers/2ft^2	4
Spergula arvensis	Caryophyllaceae	*Spearv*	a b	2	Flowers/plant	2
Stellaria media	Caryophyllaceae	*Stemed*	a c	2	Flowers/plant	2
Chenopodium album	Chenopodiaceae	*Chealb*	a c	6	Inflorescences/plant	4
Convolvulus arvensis	Convolvulaceae	*Conarv*	a d	10	Flowers/plant	8
Convolvulus sp.	Convolvulaceae	*Conv* sp.	a	8	Flowers/plant	5
Cucumis prophetarum	Cucurbitaceae	*Cucpro*	a c	2	Flowers/plant	1

Table 2. (Cont'd.).

Plant Species	Families	Shorts	Sites observed	No. of censes	Floral units	No. of syrphid species observed
Momordica charantia	Cucurbitaceae	*Momcha*	a c	3	Flowers/5 ft^2	3
Cucumis sativa	Cucurbitaceae	*Cucsat*	a	2	Flowers/plant	1
Euphorbia helioscopia	Euphorbiaceae	*Euphel*	a b d	4	Flowers/plant	4
Chrozophora tinctoria	Euphorbiaceae	*Chrtin*	a	2	Flowers/plant	1
Prosopis juliflora	Fabaceae	*Projul*	a b	7	Flowers/3ft^2	10
Albizia procera	Fabaceae	*Albpro*	a	3	Flowers/3ft^2	5
Dalbergia sissoo	Fabaceae	*Dalsis*	a c	3	Flowers/3ft^2	3
Leucaena leucocephala	Fabaceae	*Leuleu*	a	4	Flowers/3ft^2	5
Parkinsonia aculeata	Fabaceae	*Paracu*	a	4	Flowers/3ft^2	8
Melilotus indica	Fabaceae	*Melind*	c d	6	Flowers/plant	2
Centaurium pulchellum	Gentianaceae	*Cenpul*	a	5	Flowers/plant	6
Allium cepa	Liliaceae	*Allcep*	c	5	Umbels/plant	10
Abutilon indicum	Malvaceae	*Abuind*	a b	10	Flowers/plant	5
Malvastrum coromandelianum	Malvaceae	*Malvcor*	a c	7	Flowers/plant	7
Grewia subinaequalis	Malvaceae	*Gresub*	a	3	Flowers/plant	7
Marsilea minuta	Marsiliaceae	*Marmin*	a b c	7	Flowers/3ft^2	5
Melia azedarach	Meliaceae	*Melaze*	c d	2	Flowers/3ft^2	3
Eucalyptus camaldulensis	Myrtaceae	*Euccam*	a b	2	Flowers/3ft^2	6
Anagallis arvensis	Primulaceae	*Anaarv*	a c d	7	Flowers/plant	1
Ranunculus muricatus	Ranunculaceae	*Ranmur*	a c	5	Flowers/plant	9
Ziziphus jujuba	Rhamnaceae	*Zizjuj*	a c	2	Flowers/3ft^2	3
Citrus medica	Rutaceae	*Citrmed*	a c	2	Flowers/5ft^2	5
Solanum surattense	Solanaceae	*Solsur*	a d	3	Flowers/plant	1
Lantana camara	Verbenaceae	*Lancam*	a	1	Inflorescences/5ft^2	1
Tribulus terrestris	Zygophyllaceae	*Triter*	a b	2	Flowers/plant	3

Results

A total of 51 species of flowering plants in 28 families were observed for syrphid fly species. Of the plant species, 8 (15%) belonged to Asteraceae, 6 (12%) to Fabaceae, 3 each (6%) to Cucurbitaceae, Apiaceae and Brassicaceae; the remaining plant families were represented by one or two species ($\leq$4%). Of the recorded plant species, 11 were agricultural crops (Agronomic or Horticultural crops) (Table 2) and the remaining 40 plant species were wild plants, shrubs or trees. Only 9 plant species (*Euphorbia helioscopia, Brassica campestris, Malcolmia africana, Asphodelus tenuifolius, Stellaria media, Coriandrum sativum, Raphanus sativus, Marsilea minuta* and *Melilotus indica*) were already flowering before we started our observations.

On all the plant species 1443 individuals of 15 syrphid species were recorded during the total observation period of 59 hours (Table 2). Among the syrphids, 5 species belonged to the genus *Eristalinus* (*E. aeneus, E. laetus, E. taeniops, E. arvorum and E. quadristriatus*), and the remaining species i.e., *Episyrphus balteatus, Syritta pippins, Ischiodon scutellaris, Eristalis tenax*, *Melanostoma* sp., *Sphaerophoria bengalensis, Scaeva latimaculata, Eupeodes corollae*, *Paragus serratus and Mesembrius bengalensis* were single in their genera. Only 7 out of 16 syrphid species were aphidophagous i.e., *E. balteatus, I. scutellaris, Melanostoma* sp., *S. bengalensis*, *S. latimaculata*, *E. corollae* and *P. serratus*.

The plant species which were visited by the greatest number of syrphid species ($\geq$9 species) included (Table 2) *C. sativum*, *Daucus carota* from Apiaceae, *Allium cepa* from Liliaceae, *Cirsium arvense* and *Launaea procumbens* from Asteraceae, *Prosopis juliflora* from Fabaceae and *Ranunculus muricatus* from Ranunculaceae. Among the syrphid species (Table 2), *E. aeneus*, *I. scutellaris*, *E. balteatus* visited the highest number of plant species i.e., 34, 36 and 37, respectively. Whereas, *M. bengalensis* and *S. pipiens* visited only a few plant species i.e. 4 and 5 respectively.

The most abundant syrphid species included *E. aeneus,* followed by *I. scutellaris* and *E. balteatus* having total numbers of 229, 301 and 329 individuals, respectively. *M bengalensis* and *S. pippins* were the rarest floral visitors with the abundance of only 8 and 4 individuals, respectively. The number of flowering plant species and their floral units increased in the last week of February (start of spring) and attained their peak (23 flowering plant species with an average of 157 floral units) in 3rd week of March (Fig. 1). The abundance of syrphid species also increased with the availability of floral resources (number of flowering plants and their average flower density) and attained its peak (279 individuals) in 2nd week of April. As the floral resources started decreasing in 2nd week of April, syrphid abundance also decreased until the 2nd week of May (last observation week) i.e., 22 individuals.

There was a positive linear relationship between number of flowering plant species and syrphid abundance per week (Fig. 3). A similar positive linear relationship was also observed between average flower density and syrphid abundance per week (Fig. 2).

Among 15 most preferred plant species by Syrphid flies (ranked by Kruskal-Walis test; χ^2=107.78 , df = 49, p=0.000), 8 were grown as agricultural crops including 2 tree species (*Mangifera indica* and *Citrus medica*), one shrub (*Grewia asiatich*) and five annual crop species (*Raeahnus stivus*, *Momordica charantia*, *Helianthus annuus, A. cepa* and *C. sativum*). The remaining 7 plant species were non-agricultural including 4 tree species (*Parkinsonia aculeata, Capparis decidua, Dalbergia sissoo* and *Eucalyptus camaldulensis*) and three annual weed species (*L. procumbens, Ageratum conyzoides* and *C. arvensis*). Most of the plant species had yellow or white flowers except *A. conyzoides*, *C. arvensis* and *C. deciduas* having purple and pink flowers.

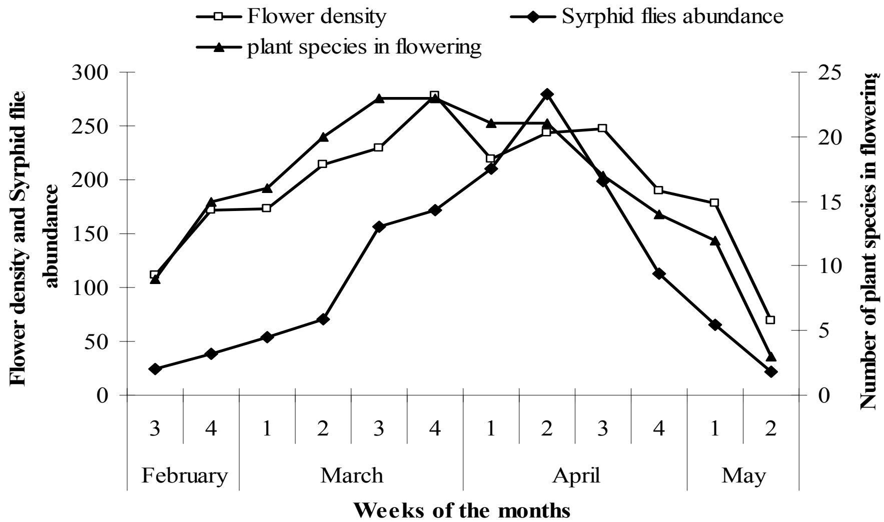

Fig 1. Variation in syrphid flies abundance and availability of floral resources along the flowering weeks of spring, 2008 at Southern Punjab, Pakistan.

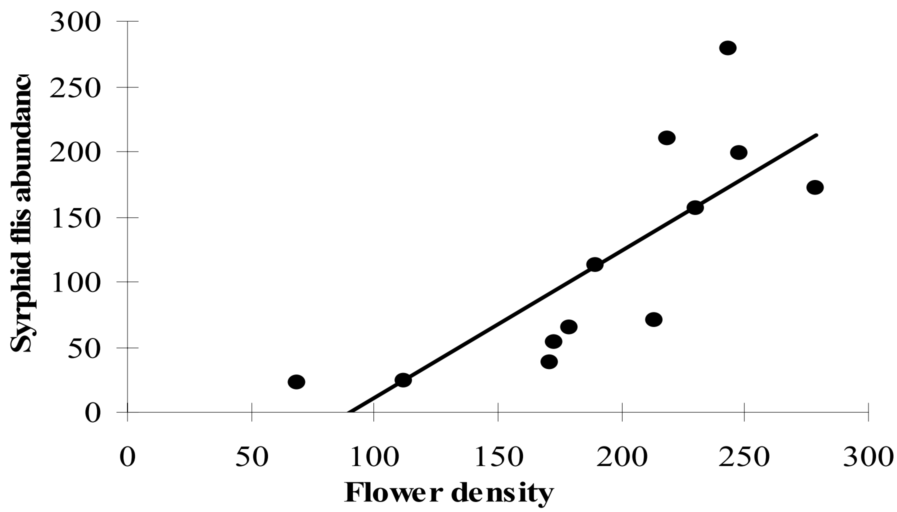

Fig 2. Relationship between syrphid flies abundance and flower density per week during spring 2008 at Southern Punjab, Pakistan. Best fit regression equation: Y= -102 + 1.13X, r^2=0.618, P= 0.002.

P. aculeata was ranked highest (avg. rank=189.0) followed by *M. indica* (avg. rank=183.8). *P. aculeata* is mostly grown as ornamental tree which flowers irregularly the year around but in our experiment it flowered from 2nd week of March to 2nd week of April. Out of 15 top ranked plant species, 9 flowered in different weeks of March (Table 3). Two of these plant species i.e., *L. procumbens* and *M. charantia* started flowering in 3rd week of March and were still in flower when we stopped field observations (2nd week of May).

It was also observed that syrphid species preferred mostly the actenomorphic flowers. Only three preferred plants species had zygomorphic flowers. Among the 15 top ranked plant species, *D. sissoo*, *M. charantia* and *C. deciduas* were visited by only a few number of syrphid species i.e., 3, 3 and 4, respectively. However these syrphid species were greater in abundances as we ranked plant species based on syrphid fly visitation frequencies. *E. balteatus* was the most common visitor in these three plant species.

The relationship between number of syrphid species and their abundance per plant suggests a linear positive relationship between the two (Fig. 4).

Table 3. Fifteen most preferred plants species ranked by Kruskal-Walis test ($df = 49$, $\chi^2=107.78$, $p=0.000$).

Plant species	Flower color	Average rank	Symmetry (A/Z)*	Flowering weeks (week/month)
Parkinsonia aculeata	Yellow	189.0 (1)	Z	2/3 to 2/4
Mangifera indica	Yellow	183.8 (2)	A	4/3 to 2/4
Eucalyptus camaldulensis	White	173.2 (3)	A	2/4 to 4/4
Coriandrum sativum	Yellow	170.9 (4)	A	4/2 to 1/4
Grewia subinaequalis	Yellow	160.0 (5)	A	2/4 to 4/4
Capparis decidua	Pink	149.4 (13)	Z	4/3 to 4/4
Dalbergia sissoo	White+Yellow	141.3 (6)	Z	3/4 to 1/4
Allium cepa	White	140.0 (7)	A	4/3 to 4/4
Momordica charantia	Yellow	138.5 (9)	A	3/4 to 2/5
Raphanus stivus	White	137.1 (10)	A	3/2 to 3/3
Cirsium arvense	Purple	132.9 (11)	A	2/3 to 4/4
Helianthus annuus	Yellow	129.5 (8)	A	3/4 to 1/5
Launaea procumbens	Yellow	125.1 (14)	A	3/3 to 2/5
Citrus medica	White	124.2 (12)	A	1/3 to 2/3
Ageratum conyzoides	Purple	110.6 (15)	A	3/3 to 1/5

* A=actenomorphic, Z= zygomorphic

Discussion

In this study the maximum available native and exotic flowering plants of the area were assessed for syrphid preference. Fifty two percent of the flowering plant community was composed of the family Asteraceae. This is the largest family of vascular plants (Rahman *et al*., 2008). Plant species of the family Asteraceae mostly flower in spring and some flower throughout the year. Roberston (1929) recroded 25% Asteraceae among 257 native floral host plants of Syrphidae in Illinois, USA. Some of the Asteraceae i.e., *Calendula officinalis* and *Tagetes patula*, have been described as insectary plants (Colley & Luna, 2000) and others i.e., *Pulicaria dysenterica*, *Eupatorium cannabinum* and *Lapsana communis* etc., have used in floral constancy studies of *E. balteatus* and *S. ribesii* (Goulson & Wright, 1998).

Most of the studies on floral host preference among Syrphid species have been done on non-agricultural plants particularly annual weeds (Freitas & Sazima, 2003; Goulson & Wright, 1998), but only a few crop plant species have been focused. We assessed the relative attractiveness of Syrphidae on 11 agricultural crop plants (Agronomic and Horticultural) and found 7 plant species among the 15 most preferred plants by Syrphidae. The knowledge of host preference could be helpful in making some strategy for intercropping i.e., highly preferred crops can be intercropped with low preferred plants for the good pollination of the later. For example, *C. sativum* can easily be inter-cropped with many other crops like carrot and canola etc.

Most of the syrphid fly species were aphidophagous in this study. These aphidophagous species play a vital role in biological control of wheat, canola and rice. The maximum number of syrphid fly species visited *C. sativum*, *C. arvensis*, *L. procumbens*, *P. juliflora*, *A. cepa*, *R. muricatus* and *D. carota*. All these plant species have easily accessible nectar and pollen resources. Many syrphid species have relatively shorter mouth parts and mostly prefer those flowers having open florets and easy access to nectar and pollen (Faegri & Vander Pijl, 1997).

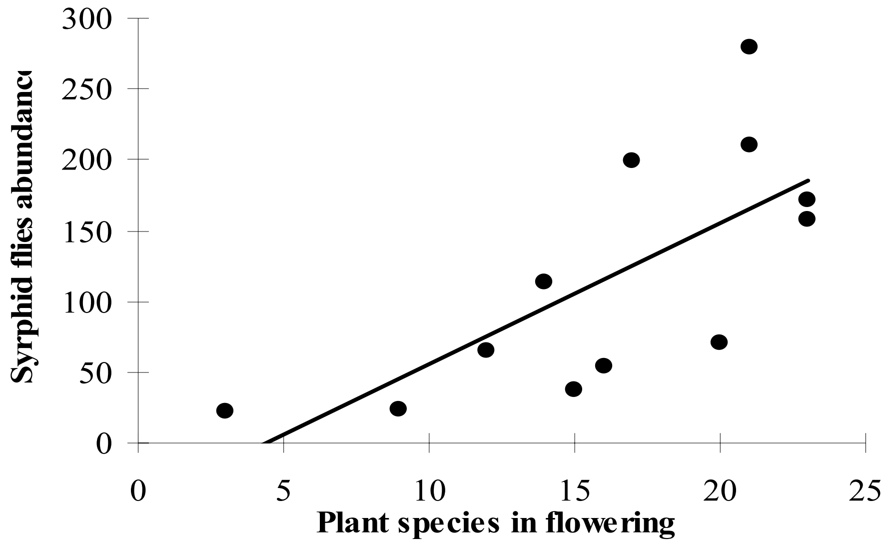

Fig. 3. Relationship between syrphid flies abundance and plant species in flowering per week during spring 2008 at Southern Punjab, Pakistan: Best fit regression equation Y= 10.2+ 0.50X, r^2=0.505, P= 0.01.

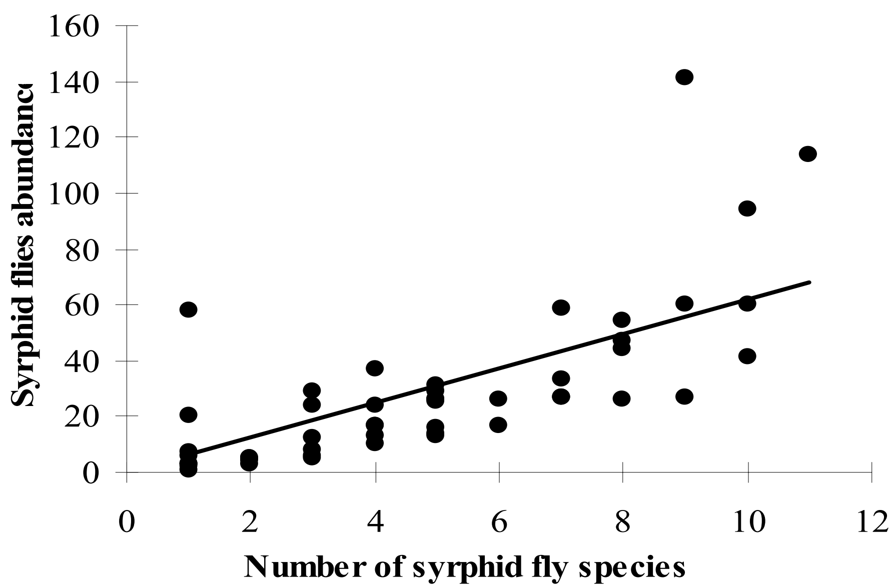

Fig 4. Relationship between number of syrphid fly species and their abundance per week during spring 2008 at Southern Punjab, Pakistan. Best fit regression equation: Y= - 6.05 + 7.10X, r^2=0.523, P= 0.000.

The results of the present study suggest that *E. aenus*, *I. scutellaris* and *E. balteatus* visited the maximum number of plant species. It was also observed that these three syrphid species had maximum abundances among all the 15 syrphid species. It seems that these species have successfully evolved according to their native habitat. *E. balteatus*, *I. scutellaris* and *E. corollae* have been documented as the most common syrphid species in many parts of the world (Saleem *et al*., 2001; Macleod, 1999; Jauker & Wolters, 2008; Ghahari *et al*., 2008). This reflects the high degree of co-evolution and generalization in their host feeding preferences as each geographically distinct area has a different set of floral resources. A marked floral constancy has also been observed in foraging behavior of syrphids (Goulson & Wright, 1998). Floral constancy may affect the observations under natural conditions. Therefore in our study, we randomly selected different plants at a remarkable distance from each other in different habitats.

Table 4. Total season, bipartite pollination matrix, Southern Punjab, Pakistan. Matrix entries are total number of syrphid fly species visitors observed in the flowers of different plant species during 59 hours of observation.

Plant species	**Syrphid fly species**															**Total syrphids observed**
	Episyrphus balteatus	***Eristalinus aeneus***	***Eupeodes corollae***	***Sphaerophoria bengalensis***	***Ischiodon scutellaris***	***Eristalinus laetus***	***Eristalis tenax***	***Eristalinus arvorum***	***Eristalinus quadristriatus***	***Melanostoma* sp.**	***Eristalinus taeniops***	***Syritta pipiens***	***Paragus serratus***	***Scaeva latimaculata***	***Mesembrius bengalensis***	
	(35)	**(37)***	**(24)**	**(29)**	**(37)**	**(21)**	**(8)**	**(11)**	**(8)**	**(12)**	**(9)**	**(4)**	**(8)**	**(6)**	**(5)**	
Sesses	8	4		5	1					2						20
Manind	7	5	7		20	4		4	6						1	54
Corsat	22	55	3	4	11	5		3	2		3			4	2	114
Calpro	4	5		3	11	8										31
Heleur	5	4			5	10		2								26
Capdec	6			5	22								4			37
Spearv	3			1	1											5
Stemed			2		2											4
Chealb	4			4	6					3						17
Sonasp	5	3	1	8	4		2			2			1			26
Cirarv	8	26	2	5	10	3	2		2					2		60
Laupro	14	20	5	72	24			2		2		1	1			141
Agecon	10	14	6	7	11	4				7						59
Halann	5	3				13					3					24
Conbon	5			2						9		1				17
Carper		3														3
Pulcri		9					1						2			12
Conarv	4	14	6	4	9	4		2	1							44
Conv sp.		15		5	5	2		2								29
Bracom	4	4	5	2	8	3		1								27

Table 4. (Cont'd.).

Malafr		4				1										5
Rapsti	4	25	5	7	11	3	1							1	1	58
Cucpro		6														6
Momcha	5	3				13					3					24
Cucsat		3														3
Euphel	5	3			4							1				13
Chrtin		3														3
Projul	14	6	1	7	19	2				7	2		1	1		60
Albpro		2		2	8		1	3								16
Dalsis	8		4		17											29
Leuleu	1	9		4	9						2					25
Paracu	28		11	30	5	6				4			2	1		87
Cenpul	4	4	1	2	4					2						17
Aspten		2	1													3
Allcep	3	17	2	2	9	4	1		1	1				1		41
Abuind	7	4		5	9						1					26
Malvcor	7	3	3	4	5					2			3			27
Gresub	9	6	3	3	9	1					2					33
Marmin	3	2	2	6	1											14
Melaze	2		3		3											8
Melind			1		3											4
Anaarv					7											7
Euccam		5	1	2		3		9	6							26
Ranmur	2	4	4	3	11		1	1		1						27
Zizjuj	1					3		1								5
Citrmed	1				3	5			2		2					13
Solsur					1											1
Daucar	23	29	7	9	11	5	2		4		2				2	94
Torjap	2	1		3	4											10
Lancam															2	2
Triter		4										1	1			6
Total	**243**	**329**	**86**	**216**	**303**	**102**	**11**	**30**	**24**	**42**	**20**	**4**	**15**	**10**	**8**	**1443**

* In parenthesis given is the total number of plant species visited by that particular syrphid fly species

Among the syrphid fly species, *M. benganlensis* and *S. pipiens* had the lowest abundance and visited only a few plant species i.e., 5 and 4, respectively. In nature, the pollinators having more generalized feeding relationships are more successful as compared to specialized relationships (Waser *et al*., 1996). *M. bengalensis* is an oriental species which needs investigations for its biology and *S. pipeins* is distributed in many parts of the world. Roberston (1929) documented *S. pipiens* as the most frequent floral visitor of Carlinbvill, USA. Both the species were very rare in our observations. The abundance of a particular insect species primarily depends upon the availability of nesting or breeding places (Richards, 2001) e.g., *S. pipeins* breeds in decaying vegetable matters (Heiss, 1938) and prefers low growing shrubs with dense and small white flowers.

There was a positive linear relationship between the floral resources and the abundance of syrphid flies. Insects and plants have been co-evolved through millions of years (Waser *et al*., 1996). Syrphid flies have evolved their life cycle and visitation patterns with the flowering patterns of plant species (Freitas & Sazima, 2003). In the oriental region, most of the flowering occurs in the spring season and syrphids are also the characteristic for the spring season. In hot and arid parts of Asia, syrphids are very rarely observed in the whole summer and winter. On the other hand, variations in temperature and day length due to change in seasons also influence the abundance and diversity of the insects (Dolezal *et al*., 2007). We also observed a positive relationship between number of syrphid species and their abundance per week. This means that abiotic (availability of prey and floral resources) or biotic (Temperature, day length etc.) factors have equally affected the abundance and diversity of syrphid species along the flowering weeks.

P. aculeata is an exotic tree which is native to southwestern United States. There is a lot of variation in the timing of flowering in *P. aculeata*. The general pattern is that flowering occurs in the warmer months after winter and seed pods develop soon afterwards. In our field study it flowered in the month of February and March only. All the 15 top ranked plants flowered in different weeks of the months. We can use the knowledge of flowering periods in the development of conservation strategies. *C. sativum* has also been proved to be an insectary plant (Colley & Luna, 2000) and our findings are similar. Hoverflies were clearly better attracted to white and yellow flowers then to others as 80% of the top ranked plants had yellow or white flowers. Flower color may influence the choice of feeding plants. Cowgill (1989) and Sutherland *et al*., (1999) also documented yellow colour as the most attractive for hoverflies.

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