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Distribution, Relative Abundance, Species Diversity and Richness of Syrphid Flies in Floricultural Ecosystem of Kashmir, India

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A B S T R A C T

The extensive study on biodiversity of aphidophagous syrphid flies were made in daffodil, Rose, chrysanthemum and wild flowers (including Dandelion, Fennel and Black Berry) of floriculture ecosystem of Kashmir during 2013 to 2014 and a total of 21 species were recorded. Among all, the *Eristalis tenax* (11.57% and 9.80%) was found most distributed and abundant syrphid species followed by *Eoseristalis cerealis* (10.49% and 9.00%) and *Eupeodus corolla* (9.12% and 7.63%) while as *Syritta sp*. (0.82% and 1.17%) followed by *Palpada sp*. (1.49% and 2.02%) were least distributed and abundant species of syrphid fly in daffodil, Rose, chrysanthemum and wild flowers (including Dandelion, Fennel and Black Berry) of floricultural ecosystem of all locations in Kashmir during 2013 and 2014, respectively. The species diversity was measured by the using Shannon-Wiener biodiversity index (H) and species richness by using Margalef's richness index (Da) during 2013 and 2014. The highest mean species diversity (H^1) of syrphid flies was found in Harwan of district Srinagar with 2.935 and the highest species richness (Da) was observed in Mamoosa of district Baramullah with 3.584 and 3.611 in Shalimar of district Srinagar of floricultural ecosystem of Kashmir.

Introduction

Flies are common flower visitors. Species from at least 86 families of Diptera have been observed visiting flowers, and over eleven hundred species of plants from 172 families have been reported as having their flowers visited by flies (Kearns, 2002; Khan and Riyaz, 2017; this is undoubtedly an underestimate of the actual number). The systematic study of the family Syrphidae has gradually progressed from the 17th century and presently 6,107 species under 209 genera reported from the world (Pape and Evenhuis, 2013, Miranda *et al.*, 2013). In India, 357 species under 14 tribes of three subfamilies are reported (Ghorpade, 2014; Mitra *et al.*, 2015).

Syrphinae and Milesiinae are the two most important sub families of the family Syrphidae. Most of the hoverflies are important pollinators of the many flowers. Larval stage of the many species of the hoverflies is also predator of the aphid and some other pests (Gilbert, 1981; Khan *et al.*, 2016; Khan, 2017; Khan and Riyaz, 2017). Larvae of hoverflies have different feeding modes like saprophagous, aphidophagous, zoophagous and phytophagous (Sommaggio,

1999). While the adults are the flower visitors they can visit large number of flowers in one day. Adult hoverflies feed on plant nectar for energy while the requirement of protein is fulfilled by feeding on pollens (Mitra *et al.,* 2005; 2008). Nector and pollen also increases their egg laying capacity and life of the adult dipterans (Khan and Hanif, 2016). Some of the hoverflies species (Syrphidae) are also considered as very important pollinators of different crops.

Pollination and biological control are one of the most important ecosystem services delivered by insects for human beings (Potts *et al.,* 2006, Khan *et al.,* 2016, Khan, 2017a,b,). 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). However, there has been relatively little research on the flower flies pollination compared with bee species (Mitra *et al.,* 2005, 2010 and 2013). Bees is the only taxon which is considered thoroughly in this context (Jauker and 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 and 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 and Jervis, 2005). Colley and 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 and 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 and Kidd, 1996). The aim of present study, explore the distribution, relative abundance, species diversity and richness of syrphid flies for utilization as pollinator and biological control agents in floriculture ecosystem of Kashmir

Materials and Methods

Study area

In floricultural ecosystem, biodiversity of syrphid flies were studied in two district and three respective locations viz., Srinagar (Shalimar, Harwan and Gulabagh) and Baramullah (Wagoora, Mamoosa and Warpora) of Kashmir during 2013 and 2014. In each location, four flower crops viz., daffodil, Rose, chrysanthemum and wild flowers (including Dandelion, Fennel and Black Berry) were chosen for study of distribution, relative abundance, species diversity and species richness in floricultural ecosystem of Kashmir during 2013 and 2014.

Method of sampling

Two sampling methods were used, the detail as follows:

Sweep net

In sweep net method, adult syrphids were collected by making double stroke sweeps by insect collection net (Diameter 32 cm and handle 92 cm) was repeated five times randomly from five different places of floriculture ecosystem.

Hand picking

The maggots (larvae) populations were recorded on the basis of population per plant. The maggots were collected into plastic tube by hand picking method.

Preservation and identification

The collected samples were identified upto the species level with the help of literature and confirm by experts.

The larvae were reared up to adult stage in separate labelled rearing cages by providing fresh aphids every day. After adult emergence, the adults were preserved dry and grouped into different categories based on morphological features and counted.

Statistical analysis

Ecological indices for quantitative analysis

Quantitative estimation of individual species in floriculture ecosystem was made using the data derived from field survey. Species richness (Da) was calculated using Margalef's richness index and species diversity was calculated by using Shannon-Wiener diversity index by using the data.

Margalef's richness index

The simplest measure of species diversity is the number of species or species richness and was calculated after Margalef's (1968).

$$Da = (S-1)/\log e N$$

Where, Da=Margalef's richness index, S=Number of species, and N=total number of individuals.

Shannon-Wiener diversity index

The Shannon Wiener diversity index (Shannon, 1948) provides a good learning tool for computing two distinct habitats of floriculture of Kashmir. It combines two quantifiable measures, the species richness (the number of species within the community) and the species equitability (how even are the number of individual species). It is computed by using following equation;

$$H = -\sum pi \ln pi$$

Where,

H=Shannon-Wiener diversity index

Pi = the observed proportion of a particular species.

The value of H near zero would indicate that every species in the sample is the same. A value near 4.6 would indicate that the numbers of individuals are evenly distributed between all the species. Values in the middle are ambiguous which an obvious flaw of this index is and, thus, care is taken when using this index.

Results and Discussion

Distribution of syrphid fly

In floricultural ecosystem, 21 species of syrphid flies were recorded during 2013. Out of 21 species, 16, 17, 15, and 21; 19, 18, 16 and 21; 9, 10,14 and 21 species were recorded from Daffodil, rose, chrysanthemum and wild flowers in Shalimar, Harwan and Gulabagh

respectively of district Srinagar while as 9, 12,17 and 19; 12, 12, 11 and 21; 10, 9, 13 and 19 were recorded from Daffodil, rose, chrysanthemum and wild flowers in Wagoora, Mamoosa and Warpora respectively of district Baramullah during 2013 (Table 1). Among all species, *Eristalis tenax* was the most distributed species followed by *Eoseristalis cerealis, Eupeodus corolla* and *Eristalis interruptus* were recorded during 2013 in floricultural ecosystem of Kashmir. Species of subfamily- Eristalinae; *Eristalis tenax, Eoseristalis cerealis* and *Eristalis interruptus* were found most distributed species of syrphid fly while as *Syritta* sp., *Palpada* sp. and *Eristalinus* sp. were least distributed species and other species were more or less evenly distributed in floricultural ecosystem of Kashmir during 2013. In subfamily- Syrphinae; *Eupeodus corolla, Sphaerophoria scripta* and *Sphaerophoria bengalensis* were most abundant distributed species of syrphid flies while as *Syrphus* sp., *Scaeva pyrastri* and *Epistrophe grossularia* were found least distributed in floricultural ecosystem of Kashmir during 2013.

In 2014, Out of 21 species, 17, 15, 18, and 19; 14, 15, 11 and 21; 16, 13,13 and 19 species were recorded from Daffodil, rose, chrysanthemum and wild flowers in Shalimar, Harwan and Gulabagh respectively of district Srinagar while as 14, 16,15 and 19; 14, 13, 11 and 18; 12, 14, 15 and 18 species were recorded from Daffodil, rose, chrysanthemum and wild flowers in Wagoora, Mamoosa and Warpora respectively of district Baramullah during 2014 in floricultural ecosystem of Kashmir (Table 2). Among all species, *Eristalis tenax* followed by *Eoseristalis cerealis, Eupeodus corolla* and *Sphaerophoria scripta* were found most distributed while as *Syritta* sp., *Palpada* sp. and *Eristalinus* sp. were least distributed species and other species were more or less evenly distributed in floricultural ecosystem of Kashmir during 2014. In sub- family- Eristalinae: *Eristalis tenax* followed by *Eoseristalis cerealis, Eristalis interruptus* and *Eristalinus aeneus* were found most distributed while as *Syritta* sp., *Palpada* sp. an d *Eristalinus* sp. were least distributed species in floricultural ecosystem of Kashmir during 2014. In sub-family – Syrphinae; *Eupeodus corolla* followed by *Sphaerophoria scripta* and *Sphaerophoria bengalensis* were most abundant distributed species of syrphid flies while as *Syrphus* sp., *Scaeva pyrastri* and *Epistrophe grossularia* were found least distributed in floricultural ecosystem of Kashmir during 2014.

Mitra *et al.,* 2015 was review and recorded 357 species of hoverflies, more than 100 species are restricted in India out of which 22.13 % represented the Jammu and Kashmir. Khan and Hanif (2016) reported 16 species from Chakwal, Pakistan and Khan and Riyaz (2017) reported 19 species of syrphid flies from fruit orchards of Kashmir and these findings has quite similar to our findings. In present study the *Eristalis tenax* followed by *Eoseristalis cerealis, Eristalis interruptus* and *Eristalinus aeneus* were found most distributed syrphid fly species. According to Khan and Riyaz (2017) the distribution of *Eristalis tenax* followed by *Eoseristalis cerealis, Eristalis interruptus* and *Eristalinus balteatus* was found quit similar to present findings and variations were due to climatic variation and ecology of area (Ssmank *et al.,* 2008; Sajjad *et al.,* 2010)

Relative abundance of syrphid flies

In floricultural ecosystem, among 21 species, highest mean population of *E. tenax* (11.57%) followed by *Eoseristalis cerealis* (10.49%), *Eupeodus corolla* (9.12%), and *E. aeneus* (7.56%) were recorded in floricultural ecosystem of Kashmir during 2013. Least population (0.82%) of *Syritta sp* followed by

Palpada sp (1.49%) and *Eristalinus* sp. (1.52%) were recorded in floricultural ecosystem during 2013. The population of *E. tenax* was recorded highest in almost all floricultural crops including Daffodil, rose, chrysanthemum and wild flowers in different location of district Srinagar and Baramullah. Among all floricultural crops, the syrphid flies were observed highest in wild flowers followed by Rose crop in floricultural ecosystem of Kashmir during 2013. The mean population of syrphid flies were taken from the Daffodil, rose, chrysanthemum and wild flowers crops in two districts with three respective locations viz., Srinagar (Shalimar, Harwan and Gulabagh) and Baramullah (Wagoora, Mamoosa and Warpora) of floricultural ecosystem of Kashmir during 2013. The population of *E. tenax* was recorded highest in almost all floricultural crops including Daffodil, rose, chrysanthemum and wild flowers crops in different location of district Shalimar and Baramullah (Table 3).

Out of two sub-families, the abundance of Eristalinae was higher than the Syrphidae in all locations, flowers and districts during 2013. In sub-family Eristalinae, the most abundant species was *Eristalis tenax* (11.57%) followed by *Eoseristalis cerealis* (10.49%) while as *Syritta* sp. (0.82%) and *Palpada* sp. (1.49%) were found least abundant and under the sub-family: Syrphinae; *Eupeodus corolla* (9.12%) followed by *Sphaerophoria scripta* (6.42%) and *Sphaerophora bengalensis* (5.05%) were recorded abundant while as *Syrphus sp*. (2.47%), *Scaeva pyrastri* (2.38%) and *Epistrophe grossularia* (4.03%) were found least abundant in floricultural ecosystem of Kashmir during 2013 (Table 3).

In 2014, the highest abundance species was also *E. tenax* (9.80%) followed by *Eoseristalis cerealis* (9.00%), *Eupeodus corolla* (7.63%), and *Sphaerophoria scripta* (7.10%) were recorded in floricultural ecosystem of Kashmir during 2014. Least population (1.17%) of *Syritta* sp followed by *Palpada* sp (2.02%) and *Helophilus* sp. (2.10%) were recorded in floricultural ecosystem during 2014.

Out of total 21 species, most of the species of syrphid fly was recorded in wild flowers of all locations during 2014, which was quite similar to 2013. In sub-family- Eristalinae, the highest abundant species was *Eristalis tenax* (9.80%) followed by *Eoseristalis cerealis* (9.00%), *E. interruptes* (6.71%) and while as least abundant species was *Syritta* sp. (1.17%) followed by *Palpada* sp. (2.02%) and *Helophilus* sp. (2.10%).

In subfamily- Syrphinae, the highest abundant species were *Eupeodus corolla* (7.63%) followed by *Sphaerophora scripta* (7.10%) and *Sphaerophora bengalensis* (5.52%) in floricultural ecosystem of Kashmir during 2014.

During both years, the *Eristalis tenax* was found most abundant syrphid species followed by *Eoseristalis cerealis* and *Eupeodus corolla* while as *Syritta sp*. followed by *Palpada sp*. were least abundant species of syrphid fly in floricultural ecosystem of Kashmir (Tables 3 and 4). Syrphids are generally selective of the floral resources that they utilize, but some species are more specialized than others, and males are more selective than females (Gilbert 1981; Shaw and Taylor 1986; Haslett 1989b; Cowgill *et al.*, 1993). Large, hairy flower flies such as *Eristalis tenax* L. and *Lasiopticus* [Scaeva] *pyrastri* L. often contain pollen of numerous plant species in their crops (Holloway, 1976), so they appear to exhibit little flower constancy, although their migratory behaviour could be responsible for some of this diversity and abundance.

Table.1 Distribution of Syrphid flies in major flowers of Kashmir during 2013

Sub-family, species	Distribution of Syrphid flies in Floriculture Ecosystem of Kashmir (in number)																								Total
	Srinagar												Baramullah												
	Shalimar				Harwan				Gulabagh				Wagoora				Mamoosa				Warpora				
	Daff.	Ro	Chry	WFs	Daff.	Ro	Chry	WFs	Daff.	Ro	Chry	WFs	Daff.	Ro	Chry	WFs	Daff.	Ro	Chry	WFs	Daff.	Ro	Chry	WFs	
Sub-Family: Eristalinae																									
Eristalinus taeniops (Wied.)	5	-	-	5	4	3	2	6	3	-	-	2	4	2	2	-	2	-	-	4	-	-	3	3	50
Eristalinu sparia Bigot	3	2	-	5	3	-	2	3	-	-	-	4	-	-	3	4	3	-	2	4	-	-	-	5	43
Eristalinus aeneus (Scopoli)	6	4	6	10	7	8	4	9	4	6	3	8	2	5	3	8	-	-	5	10	3	3	6	10	130
Eristalinus sp.	2	2	-	6	2	3	3	5	-	-	-	3	-	-	-	4	2	-	-	4	-	-	-	-	36
Eristalis arbustorum (L.)	5	4	3	6	3	2	-	7	-	-	3	4	-	4	-	6	3	2	-	5	4	-	6	8	75
Eoseristalis cerealis (Fabicius)	8	7	6	15	6	9	5	15	9	6	5	12	7	4	5	11	6	5	7	9	-	4	6	13	180
Eristalis tenax (Linnaeus)	4	9	8	15	5	7	7	12	-	9	8	14	8	9	6	14	3	9	8	13	4	8	6	15	201
Eristalis interruptus (Poda)	3	5	7	15	2	5	3	16	-	-	2	13	-	8	7	11	-	5	9	14	2	4	7	13	151
Eristalis sp.	2	4	-	6	3	-	-	9	2	2	-	5	-	-	3	6	-	3	2	5	2	3	-	9	66
Palpada sp.	-	-	2	4	2	2	-	5	-	-	-	4	2	-	2	-	-	-	-	5	2	-	-	3	33
*Helophilus trivittatus*Weid	3	6	5	10	4	6	3	8	2	7	5	11	-	5	6	8	3	-	-	6	5	7	3	12	125
Helophilus sp.	-	-	-	5	-	2	3	6	-	-	3	6	-	-	-	5	-	-	2	5	-	-	-	6	43
Syritta sp.	-	-	-	5	-	2	-	6	-	-	2	4	-	-	-	4	-	-	-	3	-	-	-	-	26
Sub total	41	43	37	107	41	49	32	107	20	30	31	90	23	37	37	81	22	24	35	87	22	29	37	97	1159
Sub-Family:Syrphinae																									
Epistrophe grossulariae (Meigen)	3	5	4	8	2	4	2	7	-	5	4	7	3	2	2	5	-	-	2	5	2	-	2	4	78
Episyrphusbalteatus(De Geer)	3	6	5	10	2	5	4	9	-	3	2	13	-	5	5	8	2	5	-	10	-	-	2	4	103
Eupeodu s corolla (Fabricius)	7	9	8	12	6	7	8	15	3	4	2	13	5	-	7	14	5	4	3	7	5	7	2	10	163
Scaeva pyrastri (Linneaus)	-	4	3	7	2	-	-	6	3	-	-	5	-	-	3	6	2	2	-	5	-	-	-	6	54
Sphaerophoria bengalensis Mac.	5	3	4	12	3	2	2	10	2	2	-	10	3	4	3	9	-	3	4	7	-	3	2	13	106
Sphaerophoria indiana Bigot	-	4	5	12	3	2	6	13	4	-	3	8	-	4	2	8	-	2	-	4	-	3	2	9	94
Sphaerophoria scripta (Linnaeus)	5	6	5	13	4	3	5	10	-	4	9	12	4	3	8	11	2	3	2	7	-	-	4	9	129
Syrphus sp.	-	3	3	6	3	2	-	5	-	-	2	5	-	-	2	4	3	2	-	6	2	-	-	4	52
Sub total	23	40	37	80	25	25	27	75	12	18	22	73	15	18	32	65	14	21	11	51	9	13	14	59	779
Total individuals	64	83	74	187	66	74	59	182	32	48	53	163	38	55	69	146	36	45	46	138	31	42	51	156	1938
Total species	15	17	15	21	19	18	15	21	9	10	14	21	9	12	17	19	12	12	11	21	10	9	13	19	21

Daff = Daffodil, Ro= Rose, Chry = Chrysanthemum, WFs= Wild flowers, Number of samples= 120 sweeps in each flower crops of each locations, Sampling method=sweep net method, Sampling time=April to September at weekly interval

Table.2 Distribution of Syrphid flies in major flowers of Kashmir during 2014

Sub-family, species	Distribution of Syrphid flies in major flowers of Kashmir (in number)																								Total
	Srinagar												Baramullah												
	Shalimar				Harwan				Gulabagh				Wagoora				Mamoosa				Warpora				
	Daff.	Ro	Chry	WFs	Daff.	Ro	Chry	WFs	Daff.	Ro	Chry	WFs	Daff.	Ro	Chry	WFs	Daff.	Ro	Chry	WFs	Daff.	Ro	Chry	WFs	
Sub-Family: Eristalinae																									
Eristalinus taeniops (Wied.)	-	4	2	3	5	2	-	3	3	2	-	-	3	-	-	3	6	4	3	-	2	2	-	2	49
Eristalinus paria Bigot	2	2	3	-	4	-	-	3	5	4	-	2	4	-	3	2	3	2	-	-	4	-	2	-	45
Eristalinus aeneus (Scopoli)	4	3	4	8	6	5	3	12	3	4	3	8	7	3	4	10	3	4	3	12	-	6	3	9	127
Eristalinus sp.	-	-	2	-	4	3	-	2	3	-	4	2	2	2	-	2	2	2	4	2	-	4	3	-	43
Eristalis arbustorum (L.)	6	3	4	3	4	3	2	5	3	2	-	2	4	2	3	-	-	4	-	5	2	4	3	4	68
Eoseristalis cerealis (Fabicius)	9	5	4	13	7	6	-	15	8	-	8	10	8	9	5	12	-	8	6	14	7	5	6	11	176
Eristalis tenax (Linnaeus)	6	4	7	15	7	7	4	10	6	8	5	13	7	6	5	13	5	6	4	13	8	9	6	14	188
Eristalis interruptus (Poda)	-	5	6	8	-	6	4	12	-	-	4	9	4	5	6	10	4	6	8	10	-	6	7	8	128
Eristalis sp.	-	6	-	4	-	3	4	8	4	-	3	7	-	3	2	7	2	-	-	6	4	3	-	8	74
Palpada sp.	2	3	-	3	-	-	4	3	3	-	-	5	-	4	3	-	2	-	-	3	-	-	-	4	39
*Helophilus trivittatus*Weid	4	4	6	8	3	5	-	9	-	8	6	10	3	4	7	9	4	2	-	7	3	4	8	12	126
Helophilus sp.	2	-	3	4	2	-	-	5	3	-	4	6	-	-	3	7	-	-	-	3	-	-	3	2	47
Syritta sp.	2	-	-	2	-	-	3	6	-	-	-	3	2	2	-	4	-	-	-	2	-	-	-	-	26
Sub total	37	39	41	71	42	40	24	93	41	28	37	77	44	40	41	79	31	38	28	77	30	43	41	74	1136
Sub-Family Syrphinae																									
Epistrophe grossulariae (Meigen)	4	3	2	7	-	6	-	8	3	7	3	9	-	-	4	6	3	2	-	4	-	-	4	6	81
Episyrphusbalteatus (De Geer)	3	5	5	8	-	7	4	8	-	6	-	11	-	6	7	9	-	7	-	8	-	3	2	6	105
Eupeodu s corolla (Fabricius)	8	6	5	14	5	6	6	15	7	2	6	5	4	2	-	13	8	4	6	3	6	4	-	13	148
Scaeva pyrastri (Linneaus)	4	-	4	6	-	-	3	4	2	3	-	7	-	3	3	5	-	-	4	6	7	-	3	6	70
Sphaerophoria bengalensis Mac.	6	4	5	11	3	4	-	8	-	4	5	7	4	-	5	7	6	-	4	3	9	-	3	14	112
Sphaerophoria indiana Bigot	4	-	4	12	3	6	-	7	4	5	4	8	-	5	-	10	4	-	-	6	-	4	6	9	101
Sphaerophoria scripta (Linnaeus)	5	7	4	14	3	-	5	8	10	4	4	-	8	3	6	7	12	-	4	-	8	4	-	15	131
Syrphus sp.	2	-	-	4	5	3	-	6	2	-	-	8	4	3	-	4	-	3	2	4	5	2	3	6	66
Sub total	36	25	29	76	19	32	18	64	28	31	22	55	20	22	25	61	33	16	20	34	35	17	21	75	814
Total individuals	73	64	70	147	61	72	42	157	69	59	59	132	64	62	66	140	64	54	48	111	65	60	62	149	1950
Total Species	17	15	17	19	14	18	14	21	16	16	16	19	14	16	15	19	14	13	14	18	12	14	15	18	20

Daff = Daffodil, Ro= Rose, Chry = Chrysanthemum, WFs= Wild flowers, Number of samples= 120 sweeps in each flower crops of each locations, Sampling method=sweep net method, Sampling time=April to September at weekly interval

Table.3 Relative abundance of Syrphid flies in major flowers of Kashmir during 2013

Sub-family, species	Abundance of Syrphid flies in major flowers of Kashmir *(%)*																										Total mean
	Srinagar													Baramullah													
	Shalimar				Harwan				Gulabagh					Wagoora				Mamoosa				Warpora				Mean	
	Daff.	Ro	Chry	WFs	Daff.	Ro	Chry	WFs	Daff.	Ro	Chry	WFs	Mean	Daff.	Ro	Chry	WFs	Daff.	Ro	Chry	WFs	Daff.	Ro	Chry	WFs		
Sub-Family: Eristalinae																											
Eristalinus taeniops (Wied.)	7.81	-	-	2.67	6.06	4.05	3.38	2.29	9.37	-	-	1.22	**3.15**	10.52	3.63	2.89	-	5.55	-	-	2.89	-	-	5.88	1.92	**2.77**	2.96
Eristalinus paria Bigot	4.68	2.40	-	2.67	4.54	-	3.38	1.64	-	-	-	2.45	**1.81**	-	-	4.34	2.73	8.33	-	4.34	2.89	-	-	-	3.20	**2.15**	1.98
Eristalinus aeneus (Scopoli)	9.37	4.81	8.10	5.34	10.6	10.81	6.77	4.94	12.5	12.5	5.66	4.90	**8.02**	5.26	9.09	4.34	5.47	-	-	10.86	7.24	9.67	7.14	11.76	6.41	**7.10**	7.56
Eristalinus sp.	3.12	2.40	-	3.20	3.03	4.05	5.08	2.74	-	-	-	1.84	**2.11**	-	-	-	2.73	5.55	-	-	2.89	-	-	-	-	**0.93**	1.52
Eristalis arbustorum (L.)	7.81	4.81	4.05	3.20	4.54	2.70	-	3.84	-	-	5.66	2.45	**3.25**	-	7.27	-	4.10	8.33	4.44	-	3.62	12.90	-	11.76	5.12	**4.79**	4.02
Eoseristalis cerealis (Fabicius)	12.5	8.43	8.10	8.02	9.09	12.16	8.47	8.24	28.12	12.5	9.43	7.36	**11.03**	18.42	7.27	7.24	7.53	16.66	11.11	15.21	6.52	-	9.52	11.76	8.33	**9.96**	10.49
Eristalis tenax (Linnaeus)	6.25	10.84	10.81	8.02	7.57	9.45	11.86	6.59	-	18.75	15.0	8.58	**9.47**	21.0	16.36	8.69	9.58	8.33	20.0	17.39	9.42	12.90	19.0	11.76	9.61	**13.67**	11.57
Eristalis interruptus (Poda)	4.68	6.02	9.45	8.02	3.03	6.75	5.08	8.79	-	-	3.77	7.97	**5.29**	-	14.54	10.14	7.53	-	11.11	19.56	10.14	6.45	9.52	13.72	8.33	**9.25**	7.27
Eristalis sp.	3.12	4.81	-	3.20	4.54	-	-	4.94	6.25	4.16	-	3.06	**2.84**	-	-	4.34	4.10	-	6.66	4.34	3.62	6.45	7.14	-	5.76	**3.53**	3.18
Palpada sp.	-	-	2.70	2.13	3.03	2.70	-	2.74	-	-	-	2.45	**1.31**	5.26	-	2.89	-	-	-	-	3.62	6.45	-	-	1.92	**1.67**	1.49
*Helophilus trivittatus*Weid	4.68	7.22	6.75	5.34	6.06	8.10	5.08	4.39	6.25	14.58	9.43	6.74	**7.05**	-	9.09	8.69	5.47	8.33	-	-	4.34	16.12	16.66	5.88	7.69	**6.85**	6.95
Helophilus sp.	-	-	-	2.67	-	2.70	5.08	3.29	-	-	5.66	3.68	**1.92**	-	-	-	3.42	-	-	4.34	3.62	-	-	-	3.84	**1.26**	1.59
Syritta sp.	-	-	-	2.67	-	2.70	-	3.29	-	-	3.77	2.45	**1.24**	-	-	-	2.73	-	-	-	2.17	-	-	-	-	**0.40**	0.82
Sub total	**64.06**	**51.81**	**50.00**	**57.22**	**62.12**	**66.22**	**54.37**	**58.79**	**62.50**	**62.50**	**58.49**	**55.25**	**58.49**	**60.56**	**67.29**	**53.56**	**55.54**	**61.14**	**53.37**	**76.38**	**63.04**	**70.94**	**69.05**	**72.52**	**62.22**	**64.37**	**61.40**
Sub-Family:Syrphinae																											
Epistrophe grossulariae (Meigen)	4.68	6.02	5.40	4.27	3.03	5.40	3.38	3.84	-	10.41	7.54	4.29	**4.85**	7.89	3.63	2.89	3.42	-	-	4.34	3.62	6.45	-	3.92	2.56	**3.22**	4.03
Episyrphusbalteatus(De Geer)	4.68	7.22	6.75	5.34	3.03	6.75	6.77	4.94	-	6.25	3.77	7.97	**5.28**	-	9.09	7.24	5.47	5.55	11.11	-	7.24	-	-	3.92	2.56	**4.34**	4.81
Eupeodus corolla (Fabricius)	10.93	10.84	10.81	6.41	9.09	9.45	13.55	8.24	9.37	8.33	3.77	7.97	**9.06**	13.15	-	10.14	9.58	13.88	8.88	6.52	5.07	16.12	16.66	3.92	6.41	**9.19**	9.12
Scaeva pyrastri (Linneaus)	-	4.81	4.05	3.74	3.03	-	-	3.29	9.37	-	-	3.06	**2.61**	-	-	4.34	4.10	5.55	4.44	-	3.62	-	-	-	3.84	**2.15**	2.38
Sphaerophoria bengalensis Mac.	7.81	3.61	5.40	6.41	4.54	2.70	3.38	5.49	6.25	4.16	-	6.13	**4.65**	7.89	7.27	4.34	6.16	-	6.66	8.69	5.07	-	7.14	3.92	8.33	**5.45**	5.05
Sphaerophoria indiana Bigot	-	4.01	6.75	6.41	4.54	2.70	10.16	7.14	12.5	-	5.66	4.90	**5.39**	-	7.27	2.89	5.47	-	4.44	-	2.89	-	7.14	3.92	5.76	**3.31**	4.35
Sphaerophoria scripta (Linnaeus)	7.81	7.22	6.75	6.95	6.06	4.05	8.47	5.49	-	8.33	16.98	7.36	**7.12**	10.52	5.45	11.59	7.53	5.55	6.66	4.34	3.62	-	-	7.84	5.76	**5.73**	6.42
Syrphus sp.	-	3.61	4.05	3.20	4.54	2.70	-	2.74	-	-	3.77	3.06	**2.30**	-	-	2.89	2.73	8.33	4.44	-	4.34	6.45	-	-	2.56	**2.64**	2.47
Sub total	**35.94**	**48.19**	**50.00**	**42.78**	**37.88**	**33.78**	**45.63**	**41.21**	**37.50**	**37.50**	**41.51**	**44.75**	**41.51**	**39.45**	**32.71**	**46.42**	**44.46**	**38.86**	**46.63**	**23.62**	**36.96**	**29.06**	**30.95**	**27.48**	**37.78**	**36.03**	**38.60**
Total individuals	**64**	**83**	**74**	**187**	**66**	**74**	**59**	**182**	**32**	**48**	**53**	**163**	**1085**	**38**	**55**	**69**	**146**	**36**	**45**	**46**	**138**	**31**	**42**	**51**	**156**	**853**	**1938**
Total species	**15**	**17**	**15**	**21**	**19**	**18**	**15**	**21**	**9**	**10**	**14**	**21**		**9**	**12**	**17**	**19**	**12**	**12**	**11**	**21**	**10**	**9**	**13**	**19**		**21**

Daff = Daffodil, Ro= Rose, Chry = Chrysanthemum, WFs= Wild flowers (including Dandelion, Fennel and Black Berry), Number of samples= 120 sweeps in each flower crops of each locations, Sampling method=sweep net method, Sampling time=April to September at weekly interval

Table.4 Relative abundance of Syrphid flies in major flowers of Kashmir during 2014

Sub-family, species	Abundance of Syrphid flies in major flowers of Kashmir (%)																									
	Srinagar												Mean	Baramullah												Mean	Total
	Shalimar				Harwan				Gulabagh					Wagoora				Mamoosa				Warpora					
	Daff.	Ro	Chry	WFs	Daff.	Ro	Chry	WFs	Daff.	Ro	Chry	WFs		Daff.	Ro	Chry	WFs	Daff.	Ro	Chry	WFs	Daff.	Ro	Chry	WFs		
Sub-Family: Eristalinae																											
Eristalinus taeniops (Wiedemann)	-	6.25	2.85	2.04	8.19	2.77	-	1.91	4.34	3.38	-	-	2.64	4.68	-	-	2.14	9.37	7.40	6.25	-	3.07	3.33	-	1.34	3.13	3.00
Eristalinus paria Bigot	2.73	3.12	4.28	-	6.55	-	-	1.91	7.24	6.77	-	1.51	2.84	6.25	-	4.54	1.42	4.68	3.70	-	-	6.15	-	3.22	-	2.49	2.67
Eristalinus aeneus (Scopoli)	5.47	4.68	5.71	5.44	9.83	6.94	7.14	7.64	4.34	6.77	5.08	6.06	6.25	10.93	4.83	6.06	7.14	4.68	7.40	6.25	10.81	-	10.0	4.83	6.04	6.58	6.41
Eristalinus sp.	-	-	2.85	-	6.55	4.16	-	1.27	4.34	-	6.77	1.51	2.28	3.12	3.22	-	1.42	3.12	3.70	8.33	1.80	-	6.66	4.83	-	3.01	2.64
Eristalis arbustorum (L.)	8.21	4.68	5.71	2.04	6.55	4.16	4.76	3.18	4.34	3.38	-	1.51	4.04	6.25	3.22	4.54	-	-	7.40	-	4.50	3.07	6.66	4.83	2.68	3.60	3.82
Eoseristalis cerealis (Fabicius)	12.32	7.81	5.71	8.84	11.47	8.33	-	9.55	11.59	-	13.55	7.57	8.06	12.5	14.51	7.57	8.57	-	14.81	12.5	12.61	10.76	8.33	9.67	7.38	9.93	9.00
Eristalis tenax (Linnaeus)	8.21	6.25	10.0	10.20	11.47	9.72	9.52	6.36	8.69	13.55	8.47	9.84	9.35	10.93	9.67	7.57	9.28	7.81	11.11	8.33	11.71	12.30	15.0	9.67	9.39	10.23	9.80
Eristalis interruptus (Poda)	-	7.81	8.57	5.44	-	8.33	9.52	7.64	-	-	6.77	6.81	5.07	6.25	8.06	9.09	7.14	6.25	11.11	16.66	9.0	-	10.0	11.29	5.36	8.35	6.71
Eristalis sp.	-	9.37	-	2.72	-	4.16	9.52	5.09	5.79	-	5.08	5.30	3.91	-	4.83	3.03	5.0	3.12	-	-	5.40	6.15	5.0	-	5.36	3.15	3.53
Palpada sp.	2.73	4.68	-	2.04	-	-	9.52	1.91	4.34	-	-	3.78	2.42	-	6.45	4.54	-	3.12	-	-	2.70	-	-	-	2.68	1.62	2.02
*Helophilus trivittatus*Weid	5.47	6.25	8.57	5.44	4.91	6.94	-	5.73	-	13.55	10.16	7.57	6.21	4.68	6.45	10.60	6.42	6.25	3.70	-	6.30	4.61	6.66	12.90	8.05	6.38	6.30
Helophilus sp.	2.73	-	4.28	2.72	3.27	-	-	3.18	4.34	-	6.77	4.54	2.65	-	-	4.54	5.0	-	-	-	2.70	-	-	4.83	1.34	1.53	2.10
Syritta sp.	2.73	-	-	1.36	-	-	7.14	3.82	-	-	-	2.27	1.44	3.12	3.22	-	2.85	-	-	-	1.80	-	-	-	-	0.91	1.17
Sub total	50.68	60.93	58.53	48.30	68.79	55.55	57.12	59.23	59.42	47.46	62.75	58.33	57.33	68.71	64.56	62.14	56.48	48.45	70.33	58.34	69.33	46.18	71.69	66.17	49.61	61.01	58.26
Sub-Family Syrphinae																											
Epistrophe grossulariae (Meigen)	5.47	4.68	2.85	4.76	-	8.33	-	5.09	4.34	11.86	5.08	6.81	4.93	-	-	6.06	4.28	4.68	3.70	-	3.60	-	-	6.45	4.02	2.73	3.83
Episyrphusbalteatus (De Geer)	4.10	7.81	7.14	5.44	-	9.72	9.52	5.09	-	10.16	-	8.33	5.61	-	9.67	10.60	6.42	-	12.96	-	7.20	-	5.0	3.22	4.02	4.92	5.30
Eupeodu s corolla (Fabricius)	10.95	9.37	7.14	9.52	8.19	8.33	14.28	9.55	10.14	3.38	10.16	3.78	8.73	6.25	3.22	-	9.28	12.5	7.40	12.5	2.70	9.23	6.66	-	8.72	6.53	7.63
Scaeva pyrastri (Linneaus)	5.47	-	5.71	4.08	-	-	7.14	2.54	2.89	5.08	-	5.30	3.18	-	4.83	4.54	3.57	-	-	8.33	5.40	10.76	-	4.83	4.02	3.85	3.52
Sphaerophoria bengalensis Macqaurt	8.21	6.25	7.14	7.48	4.91	5.55	-	5.09	-	6.77	8.47	5.30	5.43	6.25	-	7.57	5.0	9.37	-	8.33	2.70	13.84	-	4.83	9.39	5.60	5.52
Sphaerophoria indiana Bigot	5.47	-	5.71	8.16	4.91	8.33	-	4.45	5.79	8.47	6.77	6.06	5.34	-	8.06	-	7.14	6.25	-	-	5.40	-	6.66	9.67	6.04	4.10	4.72
Sphaerophoria scripta (Linnaeus)	6.84	10.93	5.71	9.52	4.91	-	11.90	5.09	14.49	6.77	6.77	-	6.91	12.5	4.83	9.09	5.0	18.75	-	8.33	-	12.30	6.66	-	10.06	7.30	7.10
Syrphus sp.	2.73	-	-	2.72	8.19	4.16	-	3.82	2.89	-	-	6.06	2.54	6.25	4.83	-	2.85	-	5.55	4.16	3.60	7.69	3.33	4.83	4.02	3.92	3.23
Sub total	49.32	39.05	41.47	51.70	31.21	44.45	42.84	40.73	40.58	52.54	37.25	41.67	42.67	31.29	35.44	37.86	43.52	51.55	29.66	41.66	30.66	53.82	28.31	33.83	50.29	38.99	41.74
Total individuals	73	64	70	147	61	72	42	157	69	59	59	132	1005	64	62	66	140	64	54	48	111	65	60	62	149	945	1950
Total Species	17	15	17	19	14	18	14	21	16	16	16	19		14	16	15	19	14	13	14	18	12	14	15	18		20

Daff = Daffodil, Ro= Rose, Chry = Chrysanthemum, WFs= Wild flowers (including Dandelion, Fennel and Black Berry), Number of samples= 120 sweeps in each flower crops of each locations, Sampling method=sweep net method, Sampling time=April to September at weekly interval

Table.5 Parameter of abundance of Syrphid flies in major flowers of Kashmir (2013-2014)

Districts	Sites	S		N		Diversity (H)		Richness (D_a)		Mean Diversity (H)	Mean Richness (D_a)
		2013	2014	2013	2014	2013	2014	2013	2014		
Srinagar	Shalimar	21	21	408	254	2.818	2.843	3.327	3.611	2.830	3.469
	Harwan	21	21	381	332	2.900	2.970	3.365	3.445	2.935	3.405
	Gulabagh	21	21	296	319	2.827	2.894	3.214	3.469	2.860	3.341
Baramullah	Wagoora	21	21	308	332	2.835	2.895	3.490	3.445	2.865	3.467
	Mamoosa	21	21	265	277	2.820	2.841	3.584	3.556	2.830	3.570
	Warpora	21	21	280	308	2.738	2.754	3.549	3.490	2.746	3.519

S = Total number of species collected
N = Total number of individuals in all the species.
H = Shannon-Wiener biodiversity index
Da= Species Richness

On the other hand, studies have shown that the smaller, sparsely hairy Syrphidae species (especially of the genera Melanostoma and Platycheirus) that visit reputedly anemophilous plants are relatively constant to at most two families of plants (Goot and Grabandt, 1970; Holloway, 1976; Leereveld, 1982). In present study, *Eristalis tenax* was found most abundant syrphid species followed by *Eoseristalis cerealis* and *Eupeodus corolla* while as *Syritta sp*. followed by *Palpada sp*. were least abundant species of syrphid fly in floricultural ecosystem of Kashmir which was similar to Khan and Riyaz (2017) findings and was reported that the *Eristalis tenax* followed by *Eoseristalis cerealis, Eristalis interruptus* and *Episyrphus balteatus* were pre-dominant species of syrphid flies in fruit orchards of Kashmir. Other authors like Mitra *et al.*, (2005) also reported the quite similar abundance syrphid flies.

Species diversity and richness of syrphid flies

The parameters of abundance of syrphid flies in floricultural ecosystem of Kashmir during 2013 and 2014 are shown in table 5 and the parameters included species diversity and species richness. The species diversity was measured by the using Shannon-Wiener biodiversity index (H) and species richness by using Margalef's richness index (Dmg). The parameters were calculated from two districts with three respective locations viz., Srinagar (Shalimar, Harwan and Gulabagh) and Baramullah (Wagoora, Mamoosa and Warpora) in floricultural ecosystem of Kashmir during 2013 and 2014.Data depicted that the highest species diversity (H) of syrphid flies with 2.900 and 2.970 were recorded in the Harwan location of district Srinagar during 2013 and 2014 respectively while as least species diversity (H) with 2.738 and 2.754 observed in the Warpora of district Baramullah during 2013and 2014 respectively. The highest mean species diversity ($H^{!}$) of syrphid flies was found in Harwan of district Srinagar with 2.935 of floricultural ecosystem of Kashmir during the year 2013 and 2014 (Table 5).

The highest Species richness (Da) was observed in Mamoosa of district Baramullah with 3.584 and 3.611 in Shalimar of district Srinagar during 2013 and 2014 respectively. The least species richness (Da) was calculated as 3.214 in Gulabagh area of Srinagar district during the year 2013. In 2014, least species richness ($Dmg^{!}$) was calculated as 3.445 in Harwan and Wagoora areas of district Srinagar and Baramullah respectively. The highest mean species richness of syrphid flies were observed as 3.570 in Mamoosa area of district Baramullah of floricultural ecosystem of Kashmir during the year 2013 and 2014 (Table 5). According to Shannon-wiener's diversity index (H') the calculated values showed that there is a big difference in the diversity of area which means the syrphid flies are not well scattered in all chosen locations of two districts of Kashmir due to varying topography, type of orchards and availability of aphids (Arif *et al.*, 2014; Khan and Riyaz, 2017). The yielded values of Margalaf's richness index (Dmg) shown that richness of syrphid flies in the study area is not significantly different except Warpora location. Species diversity was low in areas with intensive human activity, and those species that occurred in these areas were generalists with broad ranges and good colonizing abilities. In contrast, undisturbed areas had more species and a higher representation of specialists (Bankowska, 1981; Ssymank, 2002).

The extensive study on biodiversity of aphidophagous syrphid flies were made in agro ecosystem of Kashmir during 2013 to 2014 and a total of 21 species of syrphid files

were recorded from floriculture ecosystem of Kashmir. Among all species, *Eristalis tenax* was the most distributed and abundant species followed by *Eoseristalis cerealis, Eupeodus corolla* and *Eristalis interruptus* were recorded during both years while as *Syritta sp*. followed by *Palpada sp*. were least abundant species of syrphid fly in floricultural ecosystem of Kashmir. The highest mean species diversity (H^{l}) of syrphid flies was found in Harwan of district Srinagar with 2.935 of floricultural ecosystem of Kashmir during the year 2013 and 2014. The highest mean species richness of syrphid flies were observed as 3.570 in Mamoosa area of district Baramullah of floricultural ecosystem of Kashmir during the year 2013 and 2014.

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