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Diversity and Distribution of Syrphid Fly Communities in Temperate Fruit Orchard of Kashmir, India

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ABSTRACT

Keywords

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The studies on the biodiversity of aphidophagous syrphid flies were made in temperate fruit ecosystem including apple, pear, peach and plum orchards of Kashmir during 2013 and 2014. Nineteen species of syrphid flies belongs to 2 sub families, 4 tribes and 12 genera were identified from fruit orchards of Kashmir. Among these, *Eristalis tenax* followed by *Eoseristalis cerealis*, *Eristalis interruptus* and *Episyrphus balteatus* were pre-dominant species of syrphid flies in fruit orchards of Kashmir. Among all orchards, the highest distribution and relative abundance of syrphid flies were recorded in apple orchard followed by pear orchard and lowest in peach orchard. Species diversity of aphidophagous syrphid flies were recorded greater in fruit orchard of Harwan of district of Srinagar and Species richness of aphidophagous syrphid flies were recorded greater in fruit orchard of Warpora of district of Baramullah of Kashmir.

Introduction

Syrphids (Diptera: Syrphidae) are one of the most important predators of aphids and are known to regulate the prey population effectively (Ssymank *et al.*, 2008). They are commonly known as hoverflies, flower flies or sunflies owing to their peculiar behaviour of hovering in sun over the flowers to feed on pollen and nectar (Kevan, 2002). The family syrphidae includes nearly 6000 species worldwide (Pape and Evenhuis, 2013; Miranda *et al.*, 2013). In India, predatory syrphidae is represented by 312 species (Ghorpade, 1981) and from western Himalaya; India recoded 169 species of

syrphid flies (Shah *et al.*, 2014). Among the predators of aphids, more important ones are the ladybird beetle (Coleoptera: Coccinellidae) and hoverflies (Diptera: Syrphidae). Although a considerable amount of research has been conducted on the Biodiversity, biology, preying potential and ecology of the coccinellids and Chrysoperla (Khan *et al.*, 2007; Khan and Mir 2008; Khan, 2009; Khan *et al.*, 2009; Khan, 2010; Mushtaq and Khan, 2010a, b; Shah and Khan, 2013, 2014); the syrphids, as a group have been somewhat neglected (Ghorpade, 1981). However, the management of syrphidae in

biological and integrated control is not an easy task because of their relatively high ecological demands in the environment (Mengual and Thompson 2011). Among the important predators of aphid, syrphids play a dominant role next to coccinellids (Khan *et al.*, 2016). However, not much attention has been paid to make studies on syrphids in agro ecosystem (Hopper *et al.*, 2011).

The identification and knowledge of hoverflies has helped to farmer about their predatory role, as pollinator, harmless to plants/crops and despite their mimicry of the black and yellow stripes of wasps, which serves to ward off predators (Haenke *et al.*, 2009). Farmer was suggested for better and safe utilization of insecticides against predatory syrphids in sustainable manner in horticulture of Kashmir (Abrol, 1993). There was need in today's context to reduce pesticide usage on the world's crop and optimize natural bio-control (Hopper *et al.*, 2011). Hence, the question of information pertaining to biodiversity and successful utilization of syrphid flies in today's context of pest management is not yet explored due to sole reliance on chemical control. It seems that we are far away in taking the advantages of the nature. Keeping in view that above fact, an endeavour would be to go a step ahead in respect to exploring distribution and diversity of aphidophagous syrphid fly in fruit orchard of Kashmir to support the sustainable pest management.

Materials and Methods

The studies on the biodiversity of aphidophagous syrphid were made in fruit orchard including the main fruit crops of these states are apple, pear, peach and plum during 2013 and 2014. The observations were recorded weekly in different crops from Srinagar and Baramulla District of Kashmir. Three locations viz., Shalimar, Harwan and

Gulab Bagh of district Srinagar and Wagoora, Mamoosa, Warpora of district Baramulla were selected for the sampling of syrphid flies of fruit orchard of Kashmir from April to September 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). Each stroke of sweep-net will a complete oscillation and was repeated five times randomly from five different places of field.

Hand picking

The maggots (larvae) population was 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

Relative abundance

The relative abundance was calculated by using the formula:

$$R = n_i/N * 100$$

Where, R is the relative abundance (%), “ n_i ” is the number of individual of the i th species and “N” is the total number of specimens.

Ecological indices for quantitative analysis

Quantitative estimation of individual species 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) is calculated by taking the number of each species, the proportion each species is of the total number of individual, and sums the proportion times the natural log of the proportion for each species. Since this is a negative number, we then take the negative of the negative of this sum. The higher the number, the higher is the species diversity. In the ideal situation, one should compare population that is the same size in numbers of individuals.

$$H = -\sum p_i \ln p_i$$

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. All statistical analyses were performed by using the R-software (R Development Core Team, 2015).

Results and Discussion

The important report from this study is that annual changes in the syrphid complex are considerable, both qualitatively and quantitatively (Hagvar and Nielson, 2007). This is important which ecological studies on syrphid fauna are carried out for one season only. A reason why certain species dominating one year are absent other years can be weather conditions, food, and density dependent factors may also influence the annual variation (Gilbert, 2005). In present study a total of 2844 individuals of 19 species belong to 13 genera from 4 tribes and two sub families of hoverflies were recorded in fruit orchards of Kashmir in the study period during 2013 and 2014. The details of distribution, relative abundance, species diversity and species richness of aphidophagous syrphid flies were recorded in apple, pear, plum and peach orchards of 6 locations and two districts of Kashmir are as under:

Distribution of syrphid flies

In fruit ecosystem, 19 species of syrphid flies were recorded during 2013. Out of 19 species, 15, 12, 7, and 9 species were recorded in apple, pear, plum and peach ecosystem of Shalimar; 16, 13, 8 and 7 species of syrphid fly were recorded in apple, pear, plum and peach ecosystems of Harwan; 14, 3, 9 and 8 species were recorded in apple, pear, plum

and peach ecosystem of Gulabagh of Srinagar district during 2013 (Table 1). In district Baramullah; 15, 14, 9 and 8 species were recorded in apple, pear plum and peach ecosystem of Wagoora; 14, 10, 6 and 5 species from apple, pear, plum and peach ecosystem of Mamoosa; 17, 10, 9 and 9 species were recorded in apple, pear, plum and peach ecosystem of Warpora, respectively during 2013. Among all species, *Eristalis tenax* was the most distributed species followed by *Eoseristalis cerealis* and *Episyrphus balteatus* were recorded during 2013 in fruit ecosystem. Species of sub-family Eristalinae were more distributed in fruit ecosystem as compared to sub-family Syrphidae; only two species viz., *Episyrphus balteatus* and *Sphaerophoria scripta* were evenly distributed in fruit ecosystem during 2013.

In 2014, 18 species of syrphid flies were recorded. *Syritta* sp was least distributed species in fruit ecosystem during 2013 and was not recorded during 2014 in fruit ecosystem (Table 2). Out of 18 species, 17, 15, 9 and 8 species were recorded from apple, pear, plum and peach ecosystems of Shalimar; 15, 12, 12 and 7 species were recorded in Harwan of same fruit ecosystem, respectively. In Gulabagh, 16 species from apple, 13 species from pear and plum and 9 species from peach ecosystem of Srinagar district were recorded during 2014. In Baramullah district, 17, 10, 9 and 10 species were recorded from apple, pear, plum and peach ecosystems of wagoora; 16, 14, 11 and 11 species from Mamoosa and 14, 12, 9 and 7 species from warpora location in apple, pear, plum and peach ecosystem, respectively during 2014. Among all species, *Eristalis tenax* followed by *Eoseristalis cerealis*, *Eristalis interruptus* and *Episyrphus balteatus* were more evenly distributed during 2014. The sub-family Eristalinae included maximum population as compared to sub-family Syrphidae; *Copestylum* sp. and *Syrphus* sp.

were least distributed species of syrphid fly in fruit ecosystem during 2014. Species belonging to the subfamily Eristalinae (2285 individuals) are most distributed species in all locations and orchards of Kashmir (Similar to the result found by Frank, 1999). Most of aphid species in the study habitats appeared in May and June, suggesting that larval diet is also very important in determining population dynamics of aphidophagous species (Naderloo and Rad, 2014). The result indicated that in the study areas, the most distributed species are *E. tenax* (L) followed by *E. cerealis* (Fabricius) and *E. interruptus* (Harris) of subfamily Eristalinae. In sub family Syrphinae, *E. balteatus* and *S. scripta* are the most distributed species in all orchards and locations of Kashmir. These species have adopted and distributed to a wide range of geographic area and cropping pattern, therefore, they can be consider as the most successful hoverflies species (Speight, 2008; Naderloo and Rad, 2014). Among four orchards, most of syrphidflies were recorded in apple orchard in both the year followed by pear orchard and with the concern of location the most distributed location was Wagoora followed by Shalimar.

Relative abundance of syrphid flies

Among all 19 species, highest mean population of *E.tenax* (14.69%) followed by *E.interruptus* (11.84%), *E.lineata* (9.77%), *E.aeneus* (9.63%) and *Episyrphus balteatus* (9.20%) were recorded in fruit orchard of Kashmir during 2013. Least population (0.99%) of *Copestylum* sp. followed by *syritta* sp (1.71%) and *Syrphus* sp. (1.78%) were recorded in fruit ecosystem during 2013. The population of *E.tenax* was recorded highest in almost all fruit crops including Apple, Pear, Plum and peach in different location of district Shalimar and Baramullah and Gulabagh location of district Srinagar, the *E. tenax* was not observed in peach orchard.

In some crops the other abundant species, *E.interruptus* was not observed viz., peach crop in Gulabagh location of district Srinagar, plum and peach crop of Mamoosa and peach crop of location Warpora of district Baramullah during, 2013. Among all fruit crops, the syrphid flies were observed highest in apple orchards followed by pear orchard.

Out of two sub-families, the abundance of Eristalinae (72.7 %) was higher than the syrphidae (27.3 %) in all locations, orchards and districts during 2013 (Table 3). In sub-family Eristalinae, the most abundant species was *E. tenax* (14.7 %) followed by *Eoseristalis cerealis* (11.8 %) and under the sub-family: Syrphinae; *Episyrphus balteatus* (9.2 %) followed by *Sphaerophora scripta* (6.7 %) were recorded in fruit orchards during 2013. Among sub-family: Eristalinae; *Copestylum sp.* followed *Syricta sp* were found least abundant while as in sub-family syrphinae, the least abundant species was syrphus sp. followed by *Eupeodus corolla* during 2013 (Table 3). With the concern of different fruit orchard, least abundance of syrphid species and their number was recorded in peach orchard while as highest abundant and higher species was recorded in apple orchard during 2013.

In 2014, the highest abundance specie was also *E. tenax* (12.3%) followed by *E.interruptus* (10.5%), *Eoseristalis cerealis* (9.7%) and *Episyrphus balteatus* (8.6%) in fruit orchard of Kashmir. Out of two sub-families, the abundance of Eristalinae (72.8 %) was higher than the syrphidae (27.2 %) in all locations, orchards and districts during 2014. In second year, *Syricta sp.* was not recorded and least abundant species of syrphid fly was *Helophilus sp* (2.2%) followed by *Copestylum sp.* (2.4%) in sub family- Eristalinae and *Eupeodus corolla* (2.9%) followed by *Scaeva pyrastris* (3.12%) during 2014. Out of total 18 species, most of the species of syrphid fly was recorded in

apple orchard of all location and least species was recorded in peach ecosystem during 2014, which was quite similar to 2013. The composition of different species of sub-family –Eristalinae was ranged between 53.2% (plum orchards in Mamoosa) to 83.33% (plum orchard in Gulabagh) as compared to sub-family Syrphus which was 16.67% (plum orchard in Gulabagh) to 46.88% (plum orchard in Mamoosa) during 2014. In sub-family- Eristalinae, the highest abundant species was *Eristalis tenax* (12.28%) followed by *E.interruptus* (10.52%) and *Eoseristalis cerealis* (9.67%) while as least abundant species was *Palpada sp.* (2.17%) followed by *Helophilus sp.* (2.25%).

In subfamily- syrphidae, the highest abundant species was *Episyrphus balteatus* (8.56%) followed by *Sphaerophora scripta* (6.46%) and *Sphaerophora bengalensis* (3.31%) during 2014 (Table 4). Among the predatory Syrphidae, the *Eristalis tenax* (13.5 %) was found most abundant syrphid species followed by *Eoseristalis cerealis* (10.7%), *E.interruptus* (10.1%) and *Episyrphus balteatus* (8.9 %) 2012 to 2013 (Figure 1), while as *Syricta sp.* followed by *Helophilus sp.* and *Syrphus sp.* were recorded as least abundant during 2013 and *Palpada sp.* followed by *Copestylum sp.* during 2014. In last year, *Syricta sp.* was not recorded in fruit ecosystem. Most of the species were recorded abundant in apple orchard followed by pear orchard during both the years. Similar observation was recorded by Trzeinski and Piekarska-Boniecka (2013) and reported that the apple orchard had a higher abundance of aphids attracting syrphid flies.

Species diversity and richness of syrphid flies

The parameter of abundance of syrphid flies in fruit ecosystem during 2013 and 2014 was shown in table 5.

Table.1 Distribution of Syrphid flies in fruit orchards of Kashmir during 2013

Sub-family, species	Distribution of Syrphid species in fruit ecosystem of Kashmir (in number)																								Total
	Shalimar				Srinagar				Gulabagh				Wagoora				Baramullah				Warpora				
	A	B	C	D	A	B	C	D	A	B	C	D	A	B	C	D	A	B	C	D	A	B	C	D	
Sub-Family: Eristalinae																									
<i>Eristalinusaeneus</i> (Scopoli)	8	7	-	2	10	10	5	-	10	8	5	5	15	8	-	5	-	5	3	3	5	5	-	2	121
<i>Eristalinus</i> sp.	5	-	-	4	5	2	-	-	-	-	4	-	7	-	-	5	6	2	2	-	-	-	1	1	44
<i>Eristalis arbustorum</i> (L.)	5	2	-	3	6	-	2	-	-	3	2	-	8	5	2	-	4	2	-	5	5	4	-	4	62
<i>Eoseristalis cerealis</i> (Fabricius)	16	8	5	-	15	10	4	-	15	8	5	4	15	8	3	5	13	5	-	4	10	5	4	4	166
<i>Eristalis tenax</i> (Linnaeus)	25	10	5	3	20	8	5	2	15	8	4	-	20	7	4	5	15	10	5	5	15	5	5	5	206
<i>Eristalis interruptus</i> (Poda)	10	10	5	3	10	8	5	2	10	5	4	-	15	5	4	4	10	10	-	-	10	4	3	-	137
<i>Eristalis linaeta</i> (Harris)	-	5	-	-	5	4	-	3	-	-	-	-	5	6	-	4	3	-	4	-	3	-	-	-	42
<i>Eristalis</i> sp.	3	-	2	-	4	-	2	-	5	-	3	-	5	2	-	-	3	-	-	-	3	-	-	-	32
<i>Palpada</i> sp.	-	-	-	-	3	2	-	-	3	2	-	3	4	-	-	-	3	2	-	3	4	-	-	-	29
<i>Helophilus trivittatus</i> Weid	10	8	-	3	-	7	5	3	10	-	6	-	10	6	4	5	10	-	-	-	8	6	3	2	106
<i>Helophilus</i> sp.	-	-	-	-	5	3	-	-	5	-	-	-	-	4	2	-	-	5	-	-	-	-	-	-	24
<i>Syritasp.</i>	-	-	-	-	-	-	-	-	3	-	-	3	-	-	2	-	-	-	-	2	2	-	-	2	14
<i>Copestylum</i> sp.	5	-	-	-	4	-	-	-	5	-	-	-	4	-	-	-	8	-	-	3	5	-	2	-	36
Sub total	87	50	17	18	87	54	28	10	81	34	33	15	108	51	21	33	75	41	14	25	70	29	18	20	1019
Sub-Family: Syrphinae																									
<i>Episyrphus balteatus</i> (De Geer)	20	5	3	-	15	8	2	1	10	7	-	4	10	8	-	-	15	-	-	6	10	3	2	-	129
<i>Eupeodus corolla</i> (Fabricius)	5	3	-	2	4	-	-	-	-	-	-	2	-	5	2	-	-	-	-	-	5	3	2	-	33
<i>Scaeva pyrastris</i> (Linnaeus)	5	3	-	3	-	4	-	-	8	-	-	4	-	-	-	-	9	-	-	-	5	2	-	-	43
<i>Sphaerophoria bengalensis</i> Mac.	5	3	2	-	6	3	-	-	6	3	2	-	7	2	-	-	6	4	3	-	5	-	-	2	59
<i>Sphaerophoria scripta</i> (L.)	5	5	3	2	5	4	-	3	6	-	-	3	8	2	-	5	15	3	2	-	10	4	4	5	94
<i>Syrphus</i> sp.	5	-	-	-	4	-	-	2	-	-	-	-	5	3	2	-	-	-	-	-	4	-	-	-	25
Sub total	45	19	8	7	34	19	2	6	30	10	2	13	30	20	4	5	45	7	5	6	39	12	8	7	383
Total individuals	132	69	25	25	121	73	30	16	111	44	35	28	138	71	25	38	120	48	19	31	109	41	26	27	1402
Total Species	15	12	7	9	16	13	8	7	14	8	9	8	15	14	9	8	14	10	6	5	17	10	9	9	19

A=Apple, B= Pear, C=Plum, D=Peach

Number of samples= 120 sweeps in each fruit crops of each locations

Sampling method=sweep net method

Sampling time=15th April to 15th September at weekly interval

Table.2 Distribution of Syrphid flies in fruit orchards of Kashmir during 2014

Sub-family, species	Distribution of Syrphid fly species in fruit ecosystem of Kashmir (in number)																								Total
	Shalimar				Srinagar				Gulabagh				Wagoora				Baramullah				Warpora				
	A	B	C	D	A	B	C	D	A	B	C	D	A	B	C	D	A	B	C	D	A	B	C	D	
Sub-Family: Eristalinae																									
<i>Eristalinus aeneus</i> (Scopoli)	6	5	-	3	9	8	4	2	11	7	5	4	11	9	1	3	-	5	2	3	4	6	-	1	109
<i>Eristalinus sp.</i>	7	2	-	-	5	4	3	-	10	-	-	4	5	-	-	3	7	3	2	2	4	-	-	-	61
<i>Eristalis arbustorum</i> (Linnaeus)	8	3	2	-	5	2	-	-	4	2	-	-	10	5	3	4	5	2	-	-	5	4	-	3	67
<i>Eoseristalis cerealis</i> (Fabricius)	18	5	6	-	10	-	-	-	16	12	4	3	15	6	-	6	12	4	5	5	10	4	3	-	148
<i>Eristalis tenax</i> (Linnaeus)	27	13	5	5	16	10	-	-	13	6	5	-	24	9	3	5	14	8	-	-	12	7	5	4	191
<i>Eristalis interruptus</i> (Poda)	14	8	5	4	12	6	7	5	15	2	4	-	13	7	5	3	10	4	4	-	9	4	-	3	144
<i>Eristalis linaeta</i> (Harris)	5	-	4	2	-	4	3	6	5	7	2	3	8	4	-	-	5	-	-	2	-	4	-	-	64
<i>Eristalis sp.</i>	6	3	-	-	5	-	3	-	4	2	2	-	5	-	-	4	4	2	2	3	-	3	2	2	52
<i>Palpada sp.</i>	-	4	-	-	-	2	3	-	4	2	3	-	6	-	-	-	3	2	-	4	2	-	-	-	35
<i>Helophilus trivittatus</i> Weid	14	5	3	4	10	5	8	2	8	-	6	4	6	2	3	-	8	2	-	2	6	3	2	-	103
<i>Helophilus sp.</i>	5	-	-	-	7	2	-	2	7	-	2	-	5	-	2	-	4	2	-	-	3	-	-	-	41
<i>Copestylum sp.</i>	7	2	-	-	4	-	-	2	-	-	2	2	5	-	-	-	3	2	-	2	-	-	2	-	33
Sub Total	117	50	25	18	83	43	35	19	97	40	35	20	113	42	17	28	75	34	17	19	57	37	14	13	1048
Sub-Family: Syrphinae																									
<i>Episyrphus balteatus</i> (De Geer)	22	4	2	-	13	5	-	-	15	5	2	2	10	-	6	-	16	4	5	2	8	4	5	3	133
<i>Eupeodus corolla</i> (Fabricius)	6	2	2	-	4	-	4	-	5	2	2	-	4	-	-	2	-	-	3	2	3	2	-	-	43
<i>Scaeva pyrastris</i> (Linnaeus)	6	3	-	-	5	-	2	2	-	-	-	-	8	4	3	-	4	-	2	-	6	-	2	-	47
<i>Sphaerophoria engalensis</i> Mac.	5	4	-	2	-	-	2	-	8	4	3	-	4	2	-	2	5	2	-	-	4	-	3	-	50
<i>Sphaerophoria scripta</i> (L.)	5	6	4	2	8	4	4	-	5	3	-	2	6	4	2	3	8	4	2	3	6	4	-	2	87
<i>Syrphus sp.</i>	5	-	-	2	4	2	-	-	3	2	-	3	-	-	-	-	4	2	3	2	-	-	2	-	33
Sub total	49	19	8	6	34	11	12	2	36	16	7	7	32	10	17	7	37	12	15	9	27	10	12	5	394
Total	166	69	33	24	117	54	42	21	133	56	42	27	145	52	35	35	112	46	32	28	84	47	26	18	1442
Total Species	17	15	9	8	15	12	12	7	16	13	13	9	17	10	9	10	16	14	11	11	14	12	9	7	18

A=Apple, B= Pear, C=Plum, D=Peach

Number of samples= 120 sweeps in each fruit crops of each locations

Sampling method=sweep net method

Sampling time=15th April to 15th September at weekly interval

Table.3 Relative abundance of Syrphid flies in fruit orchards of Kashmir during 2013

Sub-family, species	Abundance of Syrphid flies in fruit ecosystem of Kashmir (%)																								Total Mean		
	Srinagar												Baramullah														
	Shalimar				Harwan				Gulabagh				Mean	Wagoora				Mamoosa				Warpora				Mean	
A	B	C	D	A	B	C	D	A	B	C	D		A	B	C	D	A	B	C	D	A	B	C	D			
Sub-Family: Eristalinae																											
<i>Eristalinusaeneus</i> (Scopoli)	6.1	10.1	-	8.0	8.3	13.7	16.6	-	9.0	18.2	14.3	17.8	10.2	10.8	11.3	-	13.2	-	10.4	15.8	9.7	4.6	12.2	-	7.4	8.0	9.6
<i>Eristalinus</i> sp.	3.8	-	-	16.0	4.1	2.7	-	-	-	-	11.4	-	3.2	5.1	-	-	13.2	5.0	4.2	10.5	-	-	-	3.8	3.7	3.2	3.1
<i>Eristalis arbustorum</i> (L.)	3.8	2.9	-	12.0	4.9	-	6.7	-	-	6.8	5.7	-	3.6	5.8	7.04	8.0	-	3.3	4.2	-	16.1	4.6	9.7	-	14.8	6.1	4.4
<i>Eoseristalis cerealis</i> (Fabricius)	12.1	11.9	20.0	-	12.4	13.7	13.3	-	13.51	18.8	14.3	14.3	10.8	10.8	11.3	12.0	13.1	10.8	10.4	-	12.9	9.2	12.2	15.4	14.8	11.1	11.8
<i>Eristalis tenax</i> (Linnaeus)	18.9	14.6	20.0	12.0	16.5	10.9	16.6	12.5	13.51	18.8	11.4	-	13.8	14.9	9.8	16.0	13.1	12.5	20.8	26.3	16.1	13.7	12.2	19.2	18.5	16.0	14.7
<i>Eristalis interruptus</i> (Poda)	7.6	14.5	20.0	12.0	8.3	10.9	16.6	12.5	9.0	11.4	11.4	-	11.2	10.8	7.1	16.0	10.5	8.3	20.8	-	-	9.2	9.7	11.5	-	8.7	9.8
<i>Eristalis linaeta</i> (Harris)	-	7.2	-	-	4.1	5.5	-	18.8	-	-	-	-	2.9	3.6	8.4	-	10.5	2.5	-	21.1	-	2.7	-	-	-	2.7	3.0
<i>Eristalis</i> sp.	2.3	-	8.0	-	3.3	-	6.7	-	4.50	-	6.8	-	2.6	3.6	2.8	-	-	2.5	-	-	-	2.7	-	-	-	1.0	2.3
<i>Palpada</i> sp.	-	-	-	-	2.5	2.7	-	-	2.70	4.54	-	10.7	1.9	2.9	-	-	-	2.5	4.2	-	9.7	3.9	-	-	-	2.0	2.1
<i>Helophilus trivittatus</i> Weid	7.8	11.69	-	12.0	-	9.6	16.6	18.7	9.0	-	17.1	-	8.5	7.2	8.4	16.0	13.2	8.3	-	-	-	7.3	14.6	11.5	7.4	8.0	7.5
<i>Helophilus</i> sp.	-	-	-	-	4.1	4.1	-	-	4.50	-	-	-	1.1	-	5.6	8.0	-	-	10.4	-	-	-	-	-	-	2.0	1.7
<i>Syrpita</i> sp.	-	-	-	-	-	-	-	-	2.70	-	-	10.7	1.1	-	-	8.0	-	-	-	-	6.4	1.8	-	-	7.4	2.0	0.9
<i>Copestylum</i> sp.	3.9	-	-	-	3.3	-	-	-	4.50	-	-	-	0.9	2.9	-	-	-	6.7	-	-	9.7	4.6	-	7.7	-	2.6	2.5
Sub total	65.9	72.5	68.0	72.0	71.9	74.0	93.3	62.5	73.0	77.3	94.3	53.5	72.5	78.3	71.8	84.0	86.8	62.5	85.4	73.7	80.6	64.2	70.7	69.2	74.1	73.4	72.7
Sub-Family: Syrphinae																											
<i>Episyrphus balteatus</i> (De Geer)	15.1	7.2	12.0	-	12.4	10.9	6.7	6.3	9.0	15.9	-	14.3	9.2	7.2	11.3	-	-	12.5	-	-	19.4	9.2	7.3	7.7	-	6.2	9.2
<i>Eupeodus corolla</i> (Fabricius)	3.8	4.3	-	8.0	3.3	-	-	-	-	-	-	7.1	2.2	-	7.1	8.0	-	-	-	-	-	4.6	7.3	7.7	-	3.0	2.3
<i>Scaeva pyrastris</i> (Linnaeus)	3.8	4.3	-	12.0	-	5.5	-	-	7.20	-	-	14.3	3.9	-	-	-	-	7.5	-	-	-	4.6	4.9	-	-	1.4	3.1
<i>Sphaerophoria bengalensis</i> Mac.	3.8	4.3	8.0	-	4.9	4.1	-	-	5.40	6.8	5.7	-	3.5	5.1	2.8	-	-	5.0	8.3	15.8	-	4.6	-	-	7.4	4.1	4.2
<i>Sphaerophoria scripta</i> (L.)	3.8	7.2	12.0	8.0	4.1	5.5	-	18.7	5.40	-	-	10.8	6.3	5.8	2.8	-	13.2	12.5	6.3	10.5	-	9.2	9.7	15.4	18.5	8.0	6.7
<i>Syrphus</i> sp.	3.8	-	-	-	3.3	-	-	12.5	-	-	-	-	1.6	3.6	4.2	8.0	-	-	-	-	-	3.9	-	-	-	1.6	1.8
Sub total	34.1	27.5	32.0	28.0	28.1	26.0	6.7	37.5	27.0	22.7	5.7	46.5	27.5	21.7	28.2	16.0	13.2	37.5	14.6	26.3	19.4	35.8	29.3	30.8	25.9	26.6	27.3
Total individuals	132	69	25	25	121	73	30	16	111	44	35	28	709	138	71	25	38	120	48	19	31	109	41	26	27	733	1402
Total Species	15	12	7	9	16	13	8	7	14	8	9	8		15	14	9	8	14	10	6	5	17	10	9	9		19

A=Apple, B= Pear, C=Plum, D=Peach

Number of samples= 120 sweeps in each fruit crops of each locations

Sampling method=sweep net method

Sampling time=15th April to 15th September at weekly interval

Table.4 Relative abundance of Syrphid flies in fruit orchards of Kashmir during 2014

Sub-family, species	Abundance of Syrphid flies in fruit ecosystem of Kashmir (%)																								Total Mean			
	Shalimar				Srinagar Harwan				Gulabagh				Mean	Wagoora				Baramullah Mamoosa				Warpora				Mean		
	A	B	C	D	A	B	C	D	A	B	C	D		A	B	C	D	A	B	C	D	A	B	C			D	
Sub-Family: Eristalinae																												
<i>Eristalinus aeneus</i> (Scopoli)	3.6	7.2	-	12.5	7.7	14.8	9.5	9.5	8.3	12.5	11.9	14.8	9.4	7.6	17.3	3.6	8.6	-	10.9	6.3	10.7	4.8	12.8	-	5.5	7.3	8.3	
<i>Eristalinus</i> sp.	4.2	2.9	-	-	4.3	7.4	7.1	-	7.5	-	-	14.8	4.0	3.4	-	-	8.6	6.2	6.5	6.3	7.1	4.8	-	-	-	-	3.6	3.8
<i>Eristalis arbustorum</i> (L.)	4.8	4.3	6.0	-	4.3	3.7	-	-	3.0	3.6	-	-	2.5	6.9	9.6	10.7	11.4	4.5	4.3	-	-	5.9	8.5	-	16.6	6.5	4.5	
<i>Eoseristalis cerealis</i> (Fabricius)	10.8	7.2	18.2	-	8.5	-	9.5	-	12.0	21.4	9.5	11.1	9.0	10.3	11.5	-	17.1	10.7	8.7	15.6	17.8	11.9	8.5	11.5	-	10.3	9.7	
<i>Eristalis tenax</i> (Linnaeus)	16.3	18.8	15.2	20.8	13.7	18.5	-	-	9.8	10.7	11.9	-	11.3	16.5	17.3	10.7	14.3	12.5	17.4	-	-	14.3	14.9	19.2	22.2	13.3	12.3	
<i>Eristalis interruptus</i> (Poda)	8.4	11.6	15.2	16.6	10.2	11.1	16.7	23.8	11.3	3.6	9.5	-	11.5	8.9	13.5	17.8	8.6	8.9	8.7	12.5	-	10.7	8.5	-	16.6	9.6	10.5	
<i>Eristalis linaeta</i> (Harris)	3.0	-	12.1	8.3	-	7.4	7.1	28.8	3.7	12.5	4.8	11.1	8.2	5.5	7.7	-	-	4.5	-	-	7.1	-	8.5	-	-	2.8	5.5	
<i>Eristalis</i> sp.	3.6	4.3	-	-	4.3	-	7.1	-	3.0	3.6	4.8	-	2.5	3.4	-	-	11.4	3.6	4.3	6.2	10.8	-	6.4	7.7	-	5.4	4.0	
<i>Palpada</i> sp.	-	5.8	-	-	-	3.7	7.1	-	3.0	3.6	7.1	-	2.5	4.1	-	-	-	2.7	-	6.2	-	4.8	4.2	-	-	2.0	2.2	
<i>Helophilus trivittatus</i> Weid	8.4	7.2	9.1	16.6	8.5	9.2	19.1	9.5	6.0	-	14.3	14.8	10.2	4.1	3.8	10.7	-	7.1	4.3	-	7.1	7.1	6.4	7.7	-	5.0	7.5	
<i>Helophilus</i> sp.	3.0	-	-	-	6.0	3.7	-	9.5	5.3	-	4.8	-	2.7	3.4	-	7.1	-	3.5	4.3	-	-	3.6	-	-	-	1.8	2.2	
<i>Copestylum</i> sp.	4.2	2.9	-	-	3.4	-	-	9.5	-	-	4.7	7.4	2.7	3.4	-	-	-	2.6	4.3	-	7.1	-	-	7.7	-	2.1	2.4	
Sub Total	70.4	72.5	75.7	75.8	75.0	70.9	79.6	90.5	72.9	71.4	83.3	74.0	76.7	77.9	80.8	60.7	80.0	66.9	73.9	53.1	67.9	67.9	78.8	53.8	72.2	66.7	72.7	
Sub-Family: Syrphinae																												
<i>Episyrphus balteatus</i> (De Geer)	13.2	5.8	6.1	-	11.1	9.1	-	-	11.3	8.9	4.8	7.4	6.5	6.9	-	21.4	-	14.3	8.7	15.6	7.1	9.5	8.6	19.2	16.6	10.7	8.6	
<i>Eupeodus corolla</i> (Fabricius)	3.6	2.9	6.1	-	3.4	-	9.5	-	3.7	3.6	4.8	-	3.1	2.7	-	-	5.7	-	-	9.4	7.1	3.6	4.3	-	-	2.7	2.9	
<i>Scaeva pyrastris</i> (Linnaeus)	3.6	4.3	-	-	4.3	-	4.8	9.5	-	-	-	-	2.2	5.5	7.7	10.7	-	3.6	-	6.2	-	7.1	-	7.7	-	4.0	3.1	
<i>Sphaerophoria engalensis</i> Mac.	3.0	5.8	-	8.3	-	-	4.7	-	6.0	7.1	7.1	-	3.5	2.7	3.8	-	5.7	4.5	4.3	-	-	4.8	-	11.5	-	3.1	3.3	
<i>Sphaerophoria scripta</i> (L.)	3.0	8.9	12.1	8.3	6.8	7.4	9.4	-	3.7	5.3	-	7.4	6.1	4.1	7.7	7.2	8.6	7.1	8.7	6.3	10.7	7.1	4.3	-	11.1	7.0	6.4	
<i>Syrphus</i> sp.	3.0	-	-	8.3	3.4	3.7	-	-	2.2	3.6	-	11.1	2.9	-	-	-	-	3.6	4.3	9.4					2.7	2.8		
Sub total	30.6	27.5	24.3	24.2	25.0	29.1	20.4	9.5	27.1	28.6	16.7	26.0	23.3	22.1	19.2	39.3	20.0	33.1	26.1	46.9	32.1	32.1	21.2	46.2	27.8	33.3	27.3	
Total individuals	166	69	33	24	117	54	42	21	133	56	42	27	784	145	52	28	35	112	46	32	28	84	47	26	18	658	1442	
Total Species	17	15	9	8	15	12	12	7	16	13	13	9	17	10	9	10	16	14	11	11	14	12	9	7	18		18	

A=Apple, B= Pear, C=Plum, D=Peach

Number of samples= 120 sweeps in each fruit crops of each locations

Sampling method=sweep net method

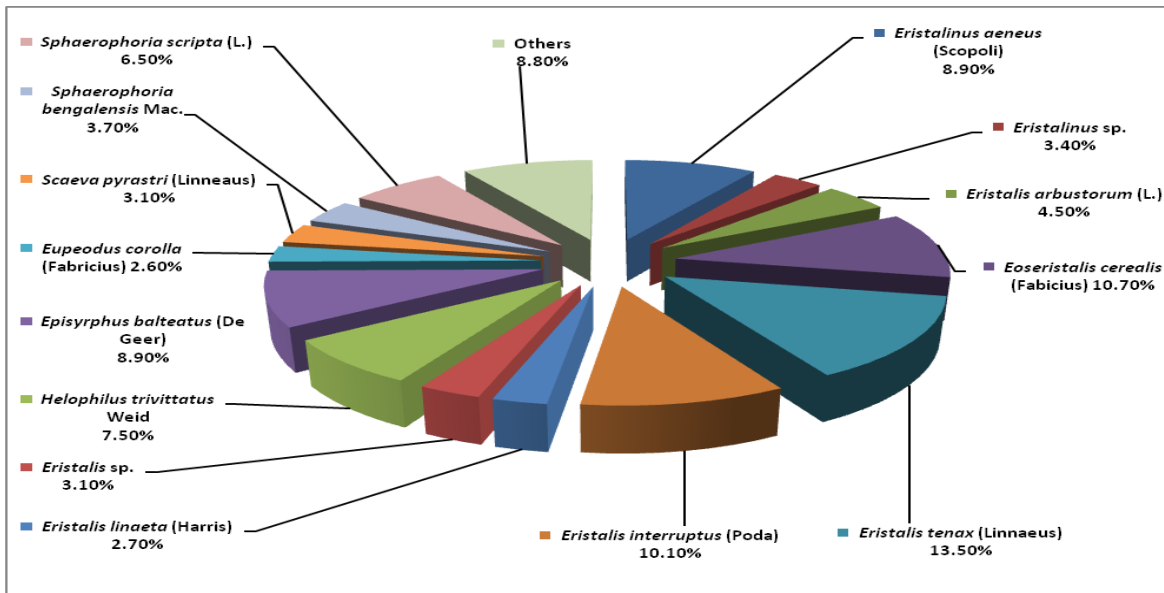
Sampling time=15th April to 15th September at weekly interval

Table.5 Parameter of abundance of Syrphid flies in fruit ecosystem of Kashmir (2013-2014)

Districts	Sites	S		N		Diversity (H)		Richness (D _{mg})		Mean Diversity (H)	Mean Richness (D _{mg})
		2013	2014	2013	2014	2013	2014	2013	2014		
Srinagar	Shalimar	19	18	251	292	2.521	2.637	3.257	2.994	2.579	3.125
	Harwan	19	18	240	254	3.331	2.609	3.284	3.070	2.970	3.177
	Gulabagh	19	18	218	258	2.513	2.659	3.342	3.061	2.586	3.201
Baramullah	Wagoora	19	18	272	260	2.633	2.641	3.210	3.057	2.637	3.133
	Mamoosa	19	18	218	218	2.617	2.700	3.342	3.157	2.658	3.249
	Warpora	19	18	203	175	2.605	2.634	3.387	3.291	2.619	3.339

S = Total number of species collected; N = Total number of individuals in all the species.
 H = Shannon-Wiener biodiversity index; D_{mg}= Species Richness

Fig.1 The share of species dominant in the Syrphidae community in the temperate fruit orchards of Kashmir during 2013-14



The data depicted that the highest species diversity (3.331) of syrphid flies was recorded in Harwan location of district Srinagar followed by Wagoora location of district Baramullah while as least diversity (2.513) observed at Gulabagh followed by Shalimar (2.521) during 2013. In 2014, the species diversity was highest observed in Mamoosa (2.700) followed by Gulabagh (2.659) and least at Harwan (2.609) followed by Shalimar (2.637) location of district Srinagar. Species richness was highest (3.387) was observed in

Warpora followed by Mamoosa of district Baramullah and least (3.210) of same district in location of Warpora during 2013. In 2014, it was observed least in Shalimar (2.994) followed by Wagoora (3.057) while as highest species richness was observed in Warpora (3.291) followed by Mamoosa (3.157) in fruit orchard of Kashmir.

The mean diversity of syrphid flies were highest (2.970) was observed in Harwan location of district Srinagar while as least diversity was observed in Shalimar (2.579) of

same district. The mean species richness was observed highest (3.339) in Warpora while as least richness was observed in Warpora location of Baramullah district of fruit orchard of Kashmir. 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 syrphidflies 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). The yielded values of Margalaf's richness index (D_{mg}) shown that richness of syrphid flies in the study area is not significantly different except Warpora location.

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