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Akhtar Ali Khan
Division of Entomology,
Sher-e-Kashmir University of
Agricultural sciences and
Technology of Kashmir,
Shalimar, Srinagar-190025,
Jammu and Kashmir, India

Effect of insecticides on biodiversity of aphidophagous syrphid flies in fruit ecosystem of Kashmir

Akhtar Ali Khan

Abstract

The effect of insecticides on biodiversity of aphidophagous syrphid flies were studied in managed/sprayed (where spray schedule followed) and unmanaged/unsprayed (where spray schedule not followed) fruit orchards of apple, pear and peach of Kashmir. Out of 1237 individual of syrphid flies, 66.29% was recorded from unsprayed and 34.71% from sprayed fruit orchards during 2013 while out of 1404 individual of syrphid flies, 71.22% were recorded from unsprayed and 28.78% from sprayed fruit of Kashmir during 2014. In fruit ecosystem, out of 19 species, highest population of *Eristalis tenax* followed by *Eoseristalis cerealis* were recorded in unsprayed fruit orchards which was also high in sprayed but the percentages were decline in sprayed fruit orchards of Kashmir during both years. Distribution of syrphid flies was recorded highest in unsprayed fruit orchards as compared to insecticidal sprayed fruit orchards caused of the adverse impact on syrphid flies population and its abundance. The sprayed fruit orchards exhibited poor species diversity and less distribution of syrphid flies in fruit ecosystem of Kashmir.

Keywords: Abundance, biodiversity, distribution, effect of insecticides, fruit orchards

Introduction

The family Syrphidae includes nearly 6000 species worldwide. In India, predatory Syrphidae is represented by 312 species^[1]. Syrphids (Diptera: Syrphidae) are one of the most important predators of aphids and are known to regulate the prey population effectively^[2]. 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^[3]. Among the predators of aphids, more important ones are the lady bird 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, the syrphids, as a group have been somewhat neglected^[4]. 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^[5, 6, 7]. Among the important predators of aphid, syrphids play a dominant role next to coccinellids^[8, 9]. Many scientists evaluated the bio-control potential of syrphid fly larvae against various aphid pests on apple like *Dysaphis plantaginea*^[7, 10] and *E. lanigerum*^[11, 12] and reported positive results. The potential of *Episyrphus balteatus* De Geer as a biological control agent for aphids on several crops has been the subject of several studies, summarized by Amiri- Jami *et al* (2014)^[13].

The use of pesticides in agriculture, parasites, habitat loss and fragmentation, have all been linked to pollinator decline^[14, 15, 16, 17]. Agricultural intensification, of which an increased use of pesticides is an integral part, is often argued to be a key driver of pollinator decline^[18]. The application of pesticides can directly affect particularly susceptible species. The loss or reduction in abundance of a species can subsequently indirectly affect other trophic levels, within the ecological network of which they are a part^[19, 20]. The present study explored how the distribution, abundance, species diversity and richness of syrphid fly and number of visits to fruit orchards were affected by the application of an insecticide in fruit orchards of Kashmir.

Material 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 and peach during 2013 and 2014.

Correspondence
Akhtar Ali Khan
Division of Entomology,
Sher-e-Kashmir University of
Agricultural sciences and
Technology of Kashmir,
Shalimar, Srinagar-190025,
Jammu and Kashmir, India

The observations were recorded weekly in different unsprayed and sprayed fruit 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.

The effect of insecticides on biodiversity of aphidophagous syrphid flies were studied in managed/sprayed (where spray schedule followed) and unmanaged/unsprayed (where spray schedule not followed) viz., fruit orchards of apple, pear and peach of Kashmir during 2013 and 2014. Samples were collected from sprayed fruit ecosystem where sprayed schedule as per the recommendation of Sher-e-Kashmir University of Agricultural sciences and Technology of Kashmir, Shalimar, Srinagar-190025, Jammu and Kashmir, India were followed and compared with unsprayed fruit ecosystem where sprayed schedule as per the recommendation of this university were not followed for at least 3 years. The important insecticides and acaricides are recommended are Horticultural mineral oil, Dimethoate 30 EC, Clothianidon 50 WDG, Methyl-o-deneton 25 EC, Quinolphos 25 EC, Abamectin 1.8 EC, Fenpyroximate 5EC, Milbemecctin 1 EC, Chlorpyrifos 20 EC, Thiochorpid 240SC, Phosalone 25 EC, Ethion 50 EC and Herbal etc.

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 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

Relative abundance

The relative abundance was calculated by using the formula:

$$R = \frac{n_i}{N} * 100$$

Where, R is the relative abundance (%), "ni" is the number of individual of the ith 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) [21].

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

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 [22] 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 [23].

Results and Discussion

In fruit ecosystem, 66.29% of syrphid flies were recorded from unsprayed and 34.71% from sprayed fruit orchards of Kashmir during 2013 while as 71.22 % were recorded from unsprayed and 28.78% from sprayed fruit of Kashmir during 2014. Details of effect of insecticides on distribution, abundance, species diversity and species richness of syrphid flies in fruit ecosystem of Kashmir are described as under:

Effect of insecticides on distribution of syrphid flies in fruit ecosystem of Kashmir

The total number of individual syrphid flies was 1237, out of which 820 were recorded from unsprayed and 417 were recorded from sprayed orchards of fruit ecosystem (apple, pear and peach) of Kashmir during 2013. In unsprayed and sprayed fruit ecosystem, out of 19 species, 16, 12, 11, and 16, 10, 5 were recorded from unsprayed and sprayed orchards of apple, pear and peach, respectively in Shalimar; 14,12,11 and 14, 12, 10 from unsprayed and sprayed orchards of apple, pear and peach, respectively in Harwan and 11, 11, 11 and 7, 10, 13 from unsprayed and sprayed orchards of apple, pear and peach, respectively in Gulabagh locations of district Srinagar while as 15, 10,12 and 13, 9,11 from unsprayed and sprayed orchards of apple, pear and peach, respectively in Wagoora; 10, 14, 15 and 10, 13, 14 from Mamoosa and 12, 13, 11 and 10,13, 6 species recorded from unsprayed and sprayed orchards of apple, pear and peach, respectively in Warpora location of district Baramullah during 2013 (Table 1). The highest individuals of syrphid flies were recorded from the unsprayed apple orchards of district Srinagar followed by the unsprayed pear orchards of district Srinagar in fruit ecosystem of Kashmir during 2013. Among all species, *Eristalis tenax* was the most distributed species followed by *Eoseristalis cerealis*, *Eristalis interruptus* and *Eristalinus aeneus* in unsprayed fruit ecosystem of Kashmir while as *Eristalis tenax* followed by *Eoseristalis cerealis*, *Eristalis interruptus* and *Episyrphus balteatus* were recorded most distributed in sprayed fruit orchards of Kashmir during 2013. The least distributed species of syrphid fly were *Syritta sp.* followed by *Syrphus sp.* and *Scaeva pyrastris* in unsprayed fruit orchards (apple, pear and peach) where as *Syritta sp.*

followed by *Scaeva pyrastris*, *Eupeodus corolla* and *Sphaerophoria bengalensis* in sprayed fruit orchards of Kashmir during 2013. The distribution of syrphid flies were recorded from two sub families-Eristalinae and Syrphinae. Out of two sub families, Species of subfamily- Eristalinae; *Eristalis tenax*, *Eoseristalis cerealis* and *Eristalis interruptus* were found most distributed species of syrphid fly while as *Syrpita sp.*, *Palpada sp.* and *Eristalinus lineata* were recorded as least distributed species in unsprayed fruit orchards of Kashmir. In sprayed fruit orchards (apple pear and peach), *Eristalis tenax*, *Eoseristalis cerealis* and *Eristalis interruptus* were found most distributed species of syrphid fly where as *Syrpita sp.*, *Copestylun sp.* and *Eristalinus sp.* were least distributed species of Kashmir during 2013. In subfamily-Syrphinae; *Sphaerophoria scripta* followed by *Sphaerophoria indiana* and *Episyrphus balteatus* were most abundant distributed species of syrphid flies, while as *Syrphus sp.*, *Scaeva pyrastris* and *Eupeodus corolla* were found least distributed in unsprayed fruit orchards of Kashmir and in sprayed fruit orchards, *Episyrphus balteatus* followed by *Sphaerophoria scripta* and *Sphaerophoria indiana* were recorded most distributed while as *Scaeva pyrastris* followed by *Syrphus sp.* and *Eupeodus corolla* were found least distributed during 2013 (Table 1).

In 2014, a total of 18 species of syrphid flies were recorded from unsprayed and sprayed fruit orchards of Kashmir (Table 2). Out of 18 species, 16, 15, 12, and 15, 9, 10 were recorded from unsprayed and sprayed orchards of apple, pear and peach, respectively in Shalimar; 15,13,13 and 7, 9, 7 from unsprayed and sprayed orchards orchards of apple, pear and peach, respectively in Harwan and 14, 12, 16 and 11, 6, 13 from unsprayed and sprayed orchards of apple, pear and peach, respectively in Gulabagh area of district Srinagar while as 13, 14,12 and 12, 10,6 from unsprayed and sprayed orchards of apple, pear and peach, respectively in Wagoora; 16, 10, 15 and 13, 6, 9 from Mamoosa and 17, 15, 16 and 11, 10, 13 species recorded from unsprayed and sprayed orchards of apple, pear and peach, respectively in Warpora location of district Baramullah during 2014 (Table 2). The highest individuals of syrphid flies were recorded from the unsprayed apple orchards of district Srinagar followed by the unsprayed pear orchards of district Srinagar in fruit ecosystem of Kashmir during 2014. Among all species, *Eristalis tenax* were the most distributed species followed by *Eristalinus sp.* and *Eoseristalis cerealis* in unsprayed and sprayed fruit ecosystem of Kashmir but with the concerned of population in unsprayed orchards were high as compared to sprayed orchards during 2014. The least distributed species of syrphid fly were *Syrphus sp.* followed by *Eristalis sp.* and *Eristalinus lineata* in unsprayed where as *Syrphus sp.*, *Eristalinus lineata* and *Eristalis sp.* in sprayed fruit orchards of Kashmir during 2014. The distribution of syrphid flies were recorded from two sub families-Eristalinae and Syrphinae. Out of two sub families, species of subfamily- Eristalinae; *Eristalis tenax* followed by *Eristalinus aeneus* were found most distributed species of syrphid fly while as *Eristalis sp.*, and *Eristalinus lineata* were recorded least distributed in unsprayed fruit orchards of Kashmir. In sprayed fruit orchards, *Eristalis tenax* followed by *Eristalinus aeneus*, *Eristalinus sp.* and *Eristalis arbustorum* were found most distributed species of syrphid fly where as *Eristalinus lineata*, *Eristalis sp.* and *Palpada sp.* were least distributed species of Kashmir during 2014. In subfamily- Syrphinae; *Sphaerophoria scripta* followed by *Episyrphus balteatus* and *Sphaerophoria bengalensis* were most distributed species of syrphid flies, while as *Syrphus sp.*,

Sphaerophoria indiana and *Eupeodus corolla* were found least distributed in unsprayed fruit orchards of Kashmir and in sprayed fruit orchards, *Sphaerophoria scripta* followed by *Episyrphus balteatus* and *Sphaerophoria bengalensis* were recorded most distributed while as *Syrphus sp.* followed by *Sphaerophoria indiana* and *Eupeodus corolla* were found least distributed during 2014 (Table 2). Comparisons have been made between sprayed and unsprayed fields aiming to quantify the benefits of restricting pesticide application for syrphid fly services [24, 25]. A review by Richards (2001) [18] on the effects of declines in syrphid fly biodiversity in fruit orchards to be one of the most common factors behind a reduction in pollination services, although no evidence was found for pesticides specifically.

Effect of insecticides on relative abundance of syrphid flies in fruit ecosystem of Kashmir

Out of total number of 1237 specimen collected, 66.29% were recorded from unsprayed and 34.71% from sprayed fruit orchards of Kashmir during 2013. In fruit ecosystem, among 19 species of syrphid fly, highest mean population of *E. tenax* (8.00%) followed by *Eoseristalis cerealis* (6.95%), *Eristalis interruptus* (6.95%) and *E. aeneus* (5.82%) were recorded in unsprayed fruit orchards of Kashmir while as *E. tenax* (3.72%) followed by *Eoseristalis cerealis* (3.15%), *Eristalis interruptus* (3.15%) and *Episyrphus balteatus* (2.99%) were recorded from sprayed fruit orchards of Kashmir during 2013. Least populated species of syrphid fly were *Syrpita sp.* (1.21%) followed by *Syrphus sp.* (1.78%) and *Scaeva pyrastris* (1.94%) were recorded in unsprayed fruit orchards of Kashmir where as *Syrpita sp.* (0.40%) followed by *Scaeva pyrastris* (0.81%) and *Syrphus sp.* (0.89%) were recorded from sprayed fruit orchards of Kashmir during 2013 (Table 26). The population of *E. tenax* was recorded highest in almost all fruit crops including apple, pear and peach in two districts of Kashmir viz., Srinagar and Baramullah of unsprayed and sprayed fruit ecosystem of Kashmir. Among all fruit crops, the syrphid flies were observed highest in unsprayed apple orchards followed by pear orchards of district Srinagar in fruit ecosystem of Kashmir during 2013. The mean population of syrphid flies was calculated from the unsprayed and sprayed apple, pear and peach crops in two districts viz., Srinagar and Baramullah (Table 3). Out of two sub-families, the abundance of Eristalinae (47.70%) was higher than the Syrphinae (18.59%) in unsprayed and it was 23.61 % and 11.10 % in sprayed orchards during 2013 (Table 3). In sub-family Eristalinae, the most abundant species was *Eristalis tenax* (8.00%) followed by *Eoseristalis cerealis* and *Eristalis interruptus* with (6.95%) while as *Syrpita sp.* (1.21%) and *Helophilus trivittatus* (2.02%) were found least abundant in unsprayed fruit orchards of Kashmir where as in sprayed fruit orchards; *Eristalis tenax* (3.72%) followed by *Eoseristalis cerealis* and *Eristalis interruptus* with (3.15%) were recorded most abundant while as *Syrpita sp.* (0.40%) and *Copestylun sp.* (1.13%) were least abundant recorded species of syrphid fly in fruit ecosystem of Kashmir during 2013. In sub family-Syrphinae; *Sphaerophoria scripta* (4.04%) and *Sphaerophora bengalensis* (3.15%) were recorded most abundant while as *Syrphus sp.* (1.78%) and *Scaeva pyrastris* (1.94%) were least abundant species of syrphid fly recorded from unsprayed fruit orchards of Kashmir where as in sprayed fruit orchards; *Episyrphus balteatus* (2.99%) followed by *Sphaerophoria scripta* (1.78%) and *Sphaerophoria Indiana* (1.46%) were recorded most abundant while as *Scaeva pyrastris* (0.81%) and *Syrphus sp.* (0.89%) were found least abundant in fruit

ecosystem of Kashmir during 2013 (Table 3).

In 2014, out of total number of 1404 specimen collected, 71.22% were recorded from unsprayed and 28.78% from sprayed fruit of Kashmir during 2014. Among 18 species of syrphid fly, highest mean population of *E. tenax* and *E. aeneus* with (6.27%) followed by *Eristalinus sp.* (5.34%), *Eoseristalis cerealis* (5.27%) and *Sphaerophoria scripta* (5.27%) were recorded in unsprayed fruit of Kashmir while as *E.tenax* (2.92%) followed by *E. aeneus* (2.85%), *Eristalinus sp.* (2.28%), *Eristalis arbustorum* and *Sphaerophoria scripta* both with (2.22%) were recorded from sprayed fruit orchards of Kashmir during 2014. Least abundant species of syrphid flies were *Syrphus sp.* (1.92%) followed by *Eristalis sp.* (2.35%) and *Eristalis lineate* (2.42%) were recorded in unsprayed fruit orchards of Kashmir while as *Syrphus sp.* (0.57%) followed by *Eristalis sp.* (0.71%) and *Sphaerophoria indiana* (0.85%) were recorded from sprayed fruit orchards of Kashmir during 2014 (Table 4). The abundance of *E. tenax* was recorded highest in almost all fruit crops including apple, pear and peach in two districts viz., Srinagar and Baramullah of unsprayed and sprayed fruit ecosystem of Kashmir. Among all fruit crops, the syrphid flies were observed highest in unsprayed pear orchards (73.74%) of district Srinagar followed by peach orchard (73.04%) of district Baramullah in fruit ecosystem of Kashmir during 2014. Out of two sub-families, the abundance of Eristalinae with 48.43% and 19.44% in unsprayed and sprayed orchards respectively was higher than the Syrphinae with 22.79% and 28.78% in unsprayed and sprayed orchards respectively during 2014 (Table 4). In sub-family Eristalinae, the most abundant species was *Eristalis tenax* (6.27%) followed by *Eoseristalis cerealis* (6.27%) and *Eristalinus sp.* with (5.34%) while as *Eristalis sp.* (2.35%) and *Eristalis lineate* (2.42%) were found least abundant in unsprayed fruit orchards of Kashmir where as in sprayed fruit orchards; *Eristalis tenax* (2.92%) followed by *Eristalinus aeneus* (2.85%) and *Eristalinus sp.* (2.28%) were recorded most abundant while as *Eristalis lineate* (0.64%) and *Eristalis sp.* (0.71%) were least abundant recorded species of syrphid fly in fruit ecosystem of Kashmir during 2014. In sub family- syrphinae; *Sphaerophoria scripta* (5.20%) and *Episyrphus balteatus* (4.34%) were recorded most abundant while as *Syrphus sp.* (1.92%) and *Sphaerophoria indiana* (2.49%) were least abundant species of syrphid fly recorded from usprayed fruit orchards of Kashmir where as in sprayed fruit orchards; *Sphaerophoria scripta* (2.22%) followed by *Episyrphus balteatus* (1.78%) and *Sphaerophoria bengalensis* (1.35%) were recorded most abundant while as *Syrphus sp.* (0.57%) and *Sphaerophoria indiana* (0.85%) were found least abundant in fruit ecosystem of Kashmir during 2014 (Table 4).

During both years, the *Eristalis tenax* was found most abundant syrphid species followed by *Eoseristalis cerealis* and *Eristalinus aeneus* in unsprayed fruit orchards of Kashmir. Distribution of syrphid flies was highest in unsprayed fruit orchards as compared to insecticidal spray in fruit orchards caused of the adverse impact on syrphid flies population and its abundance. (Table 3 and 4). The results of the study indicated that the impact of the insecticide on the

dominant structure of the syrphid community was not very strongly displayed as compared to insecticides free orchards. This fact was also reported in other similar researches [26, 27].

Effect of insecticides on Species diversity and richness of syrphid flies in fruit ecosystem of Kashmir

The data pertaining to species abundance of the syrphid flies in fruit orchards (apple, pear and peach) of Kashmir is presented in Table 5 and the parameters of abundance 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 (Da). The parameters were calculated from two districts with three respective locations viz., Srinagar (Shalimar, Harwan and Gulabagh) and Baramullah (Wagoora, Mamoosa and Warpora) in unsprayed and sprayed fruit ecosystem of Kashmir during 2013 and 2014. Data depicted that the highest species diversity (H) of syrphid flies with 2.818 were recorded in the Wagoora location of district Baramullah and 2.770 in Shalimar location of district Srinagar in unsprayed fruit orchard of followed during 2013 and 2014 respectively while as least diversity (H) (2.676) in the Mamoosa of district Baramullah and 2.379 in the Harwan location of district Srinagar were recorded in sprayed fruit orchards of Kashmir during 2013 and 2014 respectively. The highest total mean diversity (H') of syrphid flies was calculated with 2.755 in unsprayed fruit orchard of Wagoora location of district Baramullah while as least mean diversity (H') with 2.575 in sprayed fruit orchards of Harwan location of district Srinagar of Kashmir (Table 5).

The highest Margalef's richness index (Da) was observed in sprayed fruit orchards as compared to unsprayed fruit orchards of Kashmir during 2013 and 2014. The highest Margalef's richness index (Da) was recorded (4.433) in Gulabagh location of district Srinagar and 4.186 in Warpora location of district Baramullah in sprayed fruit ecosystem of Kashmir during 2013 and 2014 respectively. The least Margalef's richness index (Da) was calculated as 3.647 in Warpora location of district Baramullah and 3.227 in Shalimar area of district Srinagar in unsprayed fruit ecosystem of Kashmir during the year 2013 and 2014 respectively. The highest mean Margalef's richness index (Da') of syrphid flies was calculated as 4.231 in Wagoora area of district Baramullah in sprayed fruit orchards while as least mean Margalef's richness index 3.407 in unsprayed fruit orchards of Shalimar location of district Srinagar of Kashmir. The lower species richness of flower visiting syrphid fly, observed in the fields sprayed earlier in the season, was consistent with the expectation of insecticides being harmful to pollinators. There was, however, no decrease in visitation in the second sampling round in the field sprayed twice between rounds. Indeed, the species richness and diversity was greatest in the fields of unsprayed as compared to sprayed fruit orchards during both years. It may be that spraying earlier in the season is more harmful to flower visiting insects, or that insects that are active earlier in the season are more susceptible to the toxic effects of insecticide [28].

Table 1: Distribution of Syrphid flies in sprayed and unsprayed fruit orchards of Kashmir during 2013

Sub-family, species	Distribution of Syrphid flies in sprayed and unsprayed fruit orchards of Kashmir (in number)																												Total										
	Srinagar														Baramullah																								
	Shalimar						Harwan				Gulabagh				Wagoora				Mamoosa						Warpora														
	Apple		Pear		Peach		Apple		Pear		Peach		Apple		Pear		Peach		Apple		Pear		Peach		Apple		Pear				Peach								
US	S	US	S	US	S	US	S	US	S	US	S	US	S	US	S	US	S	US	S	US	S	US	S	US	S	US	S	US	S	US	S								
Sub-Family: Eristalinae																																							
<i>Eristalinus aeneus</i> (Scopoli)	6	2	4	3	-	-	1	1	8	2	7	3	3	2	-	-	8	2	6	2	3	2	10	5	5	3	-	-	3	2	-	-	2	1	6	3	72	33	
<i>Eristalinus sp.</i>	3	2	-	-	-	-	3	2	2	1	-	-	-	-	3	2	-	-	4	3	-	-	4	1	-	-	3	3	2	-	1	1	-	-	3	-	28	15	
<i>Eristalis arbustorum</i> (L.)	3	2	-	-	3	-	5	2	-	-	3	1	-	-	2	2	-	-	4	2	-	-	7	2	3	2	-	-	1	1	6	3	4	1	3	2	44	20	
<i>Eoseristalis cerealis</i> (Fabricius)	8	4	4	3	3	2	-	-	11	4	5	3	3	1	-	-	6	2	7	3	4	2	2	1	10	3	7	2	3	2	7	4	2	1	4	2	86	39	
<i>Eristalis tenax</i> (Linnaeus)	13	5	3	2	2	-	12	3	5	4	4	3	2	-	3	2	12	4	3	2	3	2	-	-	9	6	4	3	2	3	12	3	6	2	4	2	99	46	
<i>Eristalis interruptus</i> (Poda)	8	2	7	3	3	2	9	2	5	3	2	-	8	2	3	2	2	2	3	2	3	1	-	-	8	5	5	4	6	2	8	4	-	-	6	3	86	39	
<i>Eristalis linaeta</i> (Harris)	-	-	3	2	-	-	4	2	-	-	2	2	3	-	-	-	2	1	-	-	3	2	3	2	-	-	2	2	2	1	-	-	3	2	-	-	27	16	
<i>Eristalis sp.</i>	2	1	-	-	3	1	-	-	2	1	-	-	3	2	-	-	2	2	4	3	-	-	2	1	-	-	1	1	2	1	2	2	3	1	2	2	28	18	
<i>Palpada sp.</i>	-	-	3	2	-	-	4	2	1	1	4	1	-	-	2	1	-	-	2	2	1	1	-	-	2	1	1	1	3	2	2	2	-	-	-	-	25	16	
<i>Helophilus trivittatus</i> Weid	5	3	4	2	-	-	2	1	-	-	6	4	-	-	3	2	6	3	-	-	7	2	3	2	2	2	5	3	-	-	4	3	2	2	3	-	52	29	
<i>Syritta sp.</i>	-	-	-	-	-	-	-	-	3	2	-	-	3	-	-	-	1	1	-	-	1	1	-	-	2	-	-	-	2	-	1	1	-	-	2	-	15	5	
<i>Copestylum sp.</i>	3	2	-	-	2	2	-	-	3	2	-	-	-	-	2	2	-	-	6	2	-	-	3	1	-	-	4	1	-	-	2	-	3	2	-	-	28	14	
Sub total	51	23	28	17	16	7	40	15	40	20	33	17	25	7	18	13	39	17	39	21	25	13	34	15	41	22	32	20	26	14	45	23	25	12	33	14	590	292	
Sub-Family:Syrphinae																																							
<i>Episyrphus balteatus</i> (De Geer)	10	6	3	2	-	-	6	3	7	1	-	-	2	-	-	-	5	3	-	-	7	2	-	-	2	2	-	-	5	1	-	-	6	2	-	38	37		
<i>Eupeodus corolla</i> (Fabricius)	3	2	3	-	2	-	2	2	-	-	-	-	-	2	1	-	3	2	2	-	-	-	-	-	-	4	3	3	2	-	-	2	-	-	-	-	25	13	
<i>Scaeva pyrastris</i> (Linnaeus)	4	1	-	-	3	-	2	2	-	-	-	-	2	1	-	-	3	2	-	-	2	-	-	3	2	-	-	3	1	-	-	2	1	-	-	-	24	10	
<i>Sphaerophoria bengalensis</i> Mac	4	1	2	-	3	-	2	2	-	-	6	2	-	-	2	2	-	-	3	1	-	-	6	2	-	-	3	2	-	-	1	1	-	-	-	-	32	13	
<i>Sphaerophoria indiana</i> Bigot	4	1	3	2	1	1	-	-	4	2	-	-	4	2	3	1	-	-	4	3	-	-	4	2	-	-	5	1	2	1	-	-	3	2	2	-	39	18	
<i>Sphaerophoria scripta</i> (L.)	3	2	3	2	2	-	3	2	2	2	2	1	3	-	6	2	-	-	6	2	-	-	4	3	-	-	3	2	8	2	-	-	5	2	-	-	50	22	
<i>Syrphus sp.</i>	3	2	-	-	-	-	2	2	-	-	2	-	-	-	-	-	3	2	3	1	2	-	-	-	2	2	-	-	2	1	-	-	3	2	-	-	22	12	
Sub total	31	15	14	6	11	1	17	13	13	5	10	3	11	5	12	5	9	11	21	7	4	7	16	7	5	6	17	8	18	12	2	1	15	13	4	-	230	125	
Total	82	38	42	23	27	8	57	28	53	25	43	20	36	12	30	18	48	28	60	28	29	14	50	22	45	28	49	28	44	26	47	24	36	25	37	14	820	417	
Grand total																																						1237	
Total species	16	16	12	10	11	5	14	14	12	12	11	10	11	7	11	10	11	13	15	13	10	9	12	11	10	10	14	13	15	14	12	10	13	13	11	6	19		

US= unsprayed, S=sprayed, 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 sprayed and unsprayed fruit orchards of Kashmir during 2014.

Sub-family, species	Distribution of Syrphid flies in sprayed and unsprayed fruit orchards of Kashmir (in number)																												Total											
	Srinagar														Baramullah																									
	Shalimar						Harwan						Gulabagh						Wagoora						Mamoosa						Warpora									
	Apple		Pear		Peach		Apple		Pear		Peach		Apple		Pear		Peach		Apple		Pear		Peach		Apple		Pear				Peach		Apple		Pear		Peach			
US	S	US	S	US	S	US	S	US	S	US	S	US	S	US	S	US	S	US	S	US	S	US	S	US	S	US	S	US	S	US	S	US	S	US	S					
Sub-Family: Eristalinae																																								
<i>Eristalinus aeneus</i> (Scopoli)	6	3	4	2	4	1	9	4	8	3	2	-	11	5	7	3	4	2	9	5	-	-	-	-	4	2	6	3	4	2	2	1	3	2	5	2	88	40		
<i>Eristalinus sp.</i>	5	2	2	-	5	3	6	4	7	3	-	-	10	5	-	-	4	2	5	3	4	2	3	-	7	3	3	-	2	-	5	2	4	2	3	1	75	32		
<i>Eristalis arbustorum</i> (L.)	8	4	3	2	-	-	5	3	2	-	4	2	4	1	2	-	4	2	15	7	6	3	6	2	5	3	2	-	-	-	4	2	2	1	-	-	72	32		
<i>Eoseristalis cerealis</i> (Fab.)	7	3	4	2	3	-	-	-	15	8	4	2	5	2	3	-	3	1	6	3	4	2	2	-	-	-	7	3	2	-	3	1	-	-	6	2	74	29		
<i>Eristalis tenax</i> (Linnaeus)	14	7	5	3	3	-	2	-	2	-	14	9	3	1	5	2	4	2	4	2	3	1	2	-	12	6	4	2	3	2	2	1	4	3	2	-	88	41		
<i>Eristalis interruptus</i> (Poda)	7	4	2	-	6	3	3	2	3	1	2	-	10	5	2	-	5	3	3	1	2	1	-	-	3	1	-	-	6	3	2	1	7	3	4	2	67	30		
<i>Eristalis linaeta</i> (Harris)	-	-	3	-	3	1	-	-	4	2	2	-	-	-	2	-	2	-	3	1	2	1	2	1	3	2	-	-	3	-	2	-	3	1	-	-	34	9		
<i>Eristalis sp.</i>	-	-	2	-	3	1	2	-	-	-	2	1	-	-	3	1	-	-	2	1	2	-	4	2	3	1	-	-	2	1	2	-	3	-	3	2	33	10		
<i>Palpada sp.</i>	3	-	4	2	2	-	4	2	2	1	4	2	2	-	-	-	2	1	-	-	2	1	2	-	1	-	3	2	2	-	3	2	2	-	2	1	40	14		
<i>Helophilus trivittatus</i> Weid	4	2	3	1	4	2	2	-	-	2	-	1	-	-	-	5	3	4	2	-	-	3	-	2	-	6	3	3	2	2	-	2	-	5	2	48	17			
<i>Copestylum sp.</i>	5	1	2	-	3	-	2	1	2	-	3	2	5	2	2	-	3	-	-	-	4	2	4	2	2	1	9	4	2	-	4	-	6	3	3	1	61	19		
Sub total	59	26	34	12	36	11	35	16	45	18	39	18	51	21	26	6	36	16	51	25	29	13	28	7	42	19	40	17	30	10	31	10	36	15	33	12	680	273		
Sub-Family:Syrphinae																																								
<i>Episyrphus balteatus</i> (De Geer)	8	3	6	2	3	2	2	-	-	-	-	-	6	3	3	2	7	4	1	-	-	-	5	2	3	2	-	-	8	2	2	1	2	-	5	2	61	25		
<i>Eupeodus corolla</i> (Fabricius)	6	3	2	-	2	1	-	-	4	2	-	-	4	2	-	-	6	3	2	1	2	-	-	-	3	2	-	-	-	-	2	-	-	-	3	2	36	17		
<i>Scaeva pyrastris</i> (Linnaeus)	6	2	-	-	-	-	4	2	-	-	2	-	2	-	-	-	-	-	-	7	3	4	2	4	2	-	-	3	2	2	-	6	3	3	2	43	18			
<i>Sphaerophoria bengalensis</i> Mac	5	3	4	2	-	-	2	-	-	-	-	-	-	7	3	5	2	3	2	4	2	-	-	2	-	2	-	5	2	2	1	-	-	4	2	45	19			
<i>Sphaerophoria indiana</i> Bigot	3	1	2	-	-	-	2	-	3	1	-	-	4	2	2	-	3	1	-	-	4	2	-	-	5	3	-	-	3	2	-	-	2	-	2	-	35	12		
<i>Sphaerophoria scripta</i> (L.)	4	2	6	3	4	2	2	-	9	4	4	3	4	2	-	-	3	2	5	2	-	-	2	-	6	3	4	2	2	-	3	1	9	4	6	2	73	32		
<i>Syrphus sp.</i>	4	3	-	-	-	-	2	-	3	-	2	-	-	-	4	2	2	-	-	-	2	-	-	-	-	-	-	-	-	-	3	2	2	1	3	-	27	8		
Sub total	36	17	20	7	9	5	14	2	19	7	8	3	20	9	16	7	26	12	11	5	19	7	11	4	23	12	6	2	21	8	14	5	19	8	26	8	320	131		
Total	95	43	54	19	45	16	49	18	64	25	47	21	71	30	42	13	62	28	62	30	48	20	39	11	65	31	46	19	51	18	45	15	55	23	59	20	1000	404		
Grand total																																							1404	
Total species	16	15	16	9	12	10	15	7	13	9	13	7	14	11	12	6	16	13	13	12	14	10	12	6	16	13	10	6	15	9	17	11	15	10	16	13	18			

US= unsprayed, S=sprayed, 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 sprayed and unsprayed fruit orchards of Kashmir during 2013

Species	Abundance of Syrphid flies in sprayed and unsprayed fruit orchards of Kashmir (%)																Total	
	Srinagar								Baramullah									
	Apple		Pear		Peach		Total		Apple		Pear		Peach		Total			
	US	S	US	S	US	S	US	S	US	S	US	S	US	S	US	S	US	S
Sub-Family: Eristalinae																		
<i>Eristalinus aeneus</i> (Scopoli)	3.95	1.97	6.28	2.62	8.62	2.87	5.97	2.42	4.74	2.14	2.62	1.57	9.84	5.18	5.67	2.92	5.82	2.67
<i>Eristalinus sp.</i>	2.37	1.58	2.62	1.57	0.00	0.00	1.77	1.13	2.14	1.72	1.57	1.57	4.66	0.52	2.75	1.30	2.26	1.21
<i>Eristalis arbustorum</i> (L.)	3.16	1.58	1.05	1.05	3.45	0.57	2.58	1.13	5.58	3.00	2.09	0.52	5.70	2.59	4.54	2.11	3.56	1.62
<i>Eoserista liscerealis</i> (Fabricius)	4.35	1.97	7.85	3.65	8.04	4.02	6.45	3.38	10.30	4.29	6.81	2.62	4.66	2.59	7.46	3.24	6.95	3.15
<i>Eristalis tenax</i>	10.70	3.16	5.76	4.19	10.34	4.59	9.03	3.87	10.30	4.72	6.81	3.66	3.12	2.59	6.97	3.73	8.00	3.72
<i>Eristalis interruptus</i> (Poda)	9.88	2.37	7.85	4.19	4.02	2.29	7.58	2.90	8.15	4.72	4.19	2.62	6.22	2.59	4.70	3.40	6.95	3.15
<i>Eristalis linaeta</i> (Harris)	2.77	0.79	1.57	1.05	2.30	1.72	2.26	1.13	0.00	0.00	4.19	3.14	2.59	1.55	2.11	1.46	2.18	1.29
<i>Eristalis</i> sp.	1.96	1.18	1.05	0.52	2.87	1.15	1.93	0.97	2.58	2.15	2.09	1.05	3.11	2.07	2.59	1.78	2.26	1.46
<i>Helophilus trivittatus</i> Weid	1.58	0.97	3.14	2.10	2.30	0.57	2.26	1.13	2.58	2.15	1.05	1.04	1.55	1.04	1.78	1.46	2.02	1.29
<i>Helophilus sp.</i>	2.77	1.58	3.66	2.10	6.90	4.02	4.19	2.42	2.58	2.15	7.33	3.66	3.11	1.04	4.21	2.27	4.20	2.34
<i>Syrittasp.</i>	1.18	0.00	1.57	1.05	0.58	0.57	1.13	0.48	1.29	0.43	0.52	0.52	2.07	0.00	1.30	0.32	1.21	0.40
<i>Copestylus sp.</i>	1.18	0.79	2.62	2.10	1.15	1.72	1.61	1.29	3.43	0.86	3.66	1.57	1.55	0.52	2.92	0.97	2.26	1.13
Sub total	45.86	17.76	45.02	26.17	50.58	23.56	46.77	22.26	53.65	28.33	42.93	23.56	48.19	22.28	48.62	24.96	47.70	23.61
Sub-Family: Syrphinae																		
<i>Episyrphus balteatus</i> (De Geer)	7.11	2.56	5.24	1.57	0.0	2.87	4.51	2.74	1.72	0.86	1.04	6.81	2.07	2.59	1.62	3.24	3.07	2.99
<i>Eupeodus corolla</i> (Fabricius)	1.97	2.37	2.10	0.00	2.87	1.15	2.26	1.29	0.86	0.00	3.14	1.57	1.55	1.04	1.78	0.81	2.02	1.05
<i>Scaeva pyrastris</i> (Linnaeus)	3.16	1.58	0.00	0.00	3.45	1.14	2.26	0.97	1.29	0.86	2.09	0.52	1.55	0.52	1.62	0.65	1.94	0.81
<i>Sphaerophoria bengalensis</i> Mac.	2.37	1.18	2.10	1.05	5.17	1.14	3.06	1.13	1.72	0.86	1.57	1.04	3.11	1.04	2.11	0.97	2.59	1.05
<i>Sphaerophoria indiana</i> Bigot	3.16	1.18	5.24	2.69	0.57	0.57	3.06	1.45	1.72	1.29	4.19	1.57	5.15	1.55	3.24	1.46	3.15	1.46
<i>Sphaerophoria scripta</i> (L.)	3.56	1.58	5.76	3.14	2.29	0.57	3.87	1.77	2.57	0.86	4.19	2.09	6.22	2.07	4.21	1.78	4.04	1.78
<i>Syrphus sp.</i>	1.97	1.58	0.00	0.00	2.87	1.14	1.61	0.97	2.14	1.29	2.62	1.04	1.04	0.52	1.94	0.97	1.78	0.89
Sub total	23.32	13.05	20.44	8.38	17.24	8.62	20.65	10.32	12.02	6.01	18.85	14.66	19.68	9.84	16.53	9.89	18.59	11.10
Total	69.18	30.81	65.46	34.55	67.82	32.18	67.42	32.58	65.67	34.34	61.78	38.22	67.87	32.13	65.15	34.85	66.29	34.71
Total individuals	175	78	125	66	118	56	418	202	153	80	118	73	131	62	402	215	820	417
	253		191		174		620		233		191		193		617		1237	

US= unsprayed, S=sprayed, 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 sprayed and unsprayed fruit orchards of Kashmir during 2014

Species	Abundance of Syrphid flies in sprayed and unsprayed fruit orchards of Kashmir (%)																Total	
	Srinagar								Baramullah									
	Apple		Pear		Peach		Total		Apple		Pear		Peach		Total			
	US	S	US	S	US	S	US	S	US	S	US	S	US	S	US	S	US	S
Sub-Family: Eristalinae																		
<i>Eristalinus aeneus</i> (Scopoli)	8.50	3.92	8.76	3.69	4.48	1.35	7.37	3.08	6.05	3.23	4.07	2.26	4.41	1.96	4.84	2.48	6.27	2.85
<i>Eristalinus sp.</i>	6.86	3.59	4.15	1.38	4.04	2.24	5.23	2.55	6.85	3.23	4.98	1.81	3.92	0.49	5.25	1.84	5.34	2.28
<i>Eristalis arbustorum</i> (L.)	5.56	2.61	3.23	0.92	3.59	1.79	4.29	1.88	9.68	4.84	4.52	1.81	2.94	0.98	5.71	2.54	5.13	2.22
<i>Eoserista liscerealis</i> (Fabricius)	3.92	1.63	10.14	4.61	4.48	1.35	5.90	2.41	3.63	1.61	4.98	2.26	4.90	0.98	4.50	1.61	5.27	2.01
<i>Eristalis tenax</i>	6.21	2.61	5.53	2.30	9.42	4.93	7.10	4.02	7.26	3.63	4.98	2.71	3.43	0.98	5.22	2.44	6.27	2.92
<i>Eristalis interruptus</i> (Poda)	6.53	4.58	3.23	0.46	5.83	2.69	5.36	2.82	3.23	1.21	4.07	1.81	4.90	2.45	4.06	1.82	4.77	2.14
<i>Eristalis linaeta</i> (Harris)	0.00	0.0	4.15	0.92	3.14	0.45	2.14	0.40	3.23	1.21	2.26	0.90	2.45	0.45	2.64	0.85	2.42	0.64
<i>Eristalis sp.</i>	0.65	0.0	2.30	0.0	2.24	0.89	1.61	0.27	2.82	0.81	2.26	0.0	4.41	2.45	3.16	1.08	2.35	0.71
<i>Helophilus trivittatus</i> Weid	2.29	5.56	2.76	0.46	4.93	2.24	2.82	1.07	3.23	0.81	3.62	1.36	5.39	1.96	4.08	1.37	3.42	1.21
<i>Palpada sp.</i>	2.94	5.56	2.76	1.38	3.59	2.25	3.08	1.34	1.61	0.81	3.17	1.36	2.94	0.45	2.57	0.87	2.85	1.00
<i>Copestylus sp.</i>	3.92	1.31	2.76	0.0	4.04	0.89	3.62	1.88	2.42	0.40	8.59	4.07	4.41	1.47	5.14	1.98	4.34	1.35
Sub total	47.39	20.59	48.39	16.58	49.78	20.18	48.39	19.31	50.04	21.99	49.96	20.36	44.61	14.22	48.26	19.31	48.43	19.44
Sub-Family: Syrphinae																		
<i>Episyrphus balteatus</i> (De Geer)	5.23	1.96	4.15	1.84	4.48	2.69	4.69	2.14	2.42	1.61	3.17	0.90	8.82	2.94	4.80	1.81	4.34	1.78
<i>Eupeodus corolla</i> (Fabricius)	3.27	1.63	2.76	0.92	3.59	1.79	3.23	1.47	2.82	1.21	0.90	0.0	1.47	0.98	1.73	0.73	2.56	1.21
<i>Scaeva pyrastris</i> (Linnaeus)	3.92	1.31	0.0	0.0	0.89	0.0	1.88	0.53	2.42	1.61	3.62	1.36	4.90	2.94	3.64	1.97	3.06	1.28
<i>Sphaerophoria bengalensis</i> Mac.	2.29	0.98	5.07	2.30	2.24	0.89	3.08	1.34	2.82	1.21	5.88	2.71	4.41	1.96	4.37	1.96	3.21	1.35
<i>Sphaerophoria indiana</i> Bigot	2.94	0.98	3.23	0.46	3.14	2.25	3.08	1.21	2.02	1.21	2.71	0.90	2.45	0.98	2.39	1.03	2.49	0.85
<i>Sphaerophoria scripta</i> (L.)	3.27	1.31	6.91	3.23	4.93	3.14	4.83	2.41	5.65	2.47	5.88	2.71	4.90	0.94	4.52	1.81	5.20	2.22
<i>Syrphus sp.</i>	1.96	0.98	3.23	0.92	1.79	0.0	2.28	0.67	1.21	0.81	1.81	0.45	1.47	0.0	1.51	0.45	1.92	0.57
Sub total	22.87	9.15	25.35	9.68	19.28	10.76	22.52	9.78	19.35	8.87	20.45	9.34	8.43	12.74	22.63	9.80	22.79	9.34
Total	70.26	29.74	73.74	26.26	69.06	30.94	10.91	29.09	69.35	30.65	70.31	29.70	73.04	26.96	70.89	29.11	71.22	28.78
Total individuals	215	91	119	160	154	69	529	217	172	76	149	65	149	55	470	193	1000	404
	306		217		223		746		248		214		204		663		1404	

US= unsprayed, S=sprayed, 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 sprayed and unsprayed fruit orchards of Kashmir (2013-2014)

Districts	Sites	Insecticide	S		N		Diversity (H)		Richness (Dmg)		Mean Diversity (H)	Mean Richness (Dmg)
			2013	2014	2013	2014	2013	2014	2013	2014		
Srinagar	Shalimar	unsprayed	19	18	151	194	2.705	2.770	3.587	3.227	2.737	3.407
		sprayed	19	18	69	78	2.712	2.693	4.251	3.902	2.702	4.076
	Harwan	unsprayed	19	18	153	160	2.795	2.676	3.578	3.349	2.735	3.463
		sprayed	19	18	73	64	2.771	2.379	4.195	4.087	2.575	4.141
	Gulabagh	unsprayed	19	18	114	175	2.690	2.721	3.800	3.291	2.705	3.545
		sprayed	19	18	58	71	2.778	2.577	4.433	3.988	2.677	4.210
Baramullah	Wagoora	unsprayed	19	18	139	149	2.818	2.692	3.647	3.397	2.755	3.522
		sprayed	19	18	64	61	2.718	2.513	4.328	4.135	2.615	4.231
	Mamoosa	unsprayed	19	18	138	162	2.711	2.715	3.653	3.341	2.713	3.497
		sprayed	19	18	82	68	2.676	2.702	4.084	4.028	2.689	4.056
	Warpora	unsprayed	19	18	120	159	2.681	2.717	3.759	3.353	2.699	3.556
		sprayed	19	18	63	58	2.678	2.795	4.344	4.186	2.736	4.265

S = Total number of species collected

N = Total number of individuals in all the species.

H = Shannon-Wiener biodiversity index

Dmg= Species Richness

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