Biodiversity of Hoverflies (Diptera: Syrphidae) of district Khairpur Mirs, Sindh, Pakistan

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Abstract

Biodiversity of hoverflies was studied from January to December 2016 in six different habitat types present in district Khairpur Mirs. As a result, 688 specimens were collected belonging to 13 species and 8 genera. Simpson and Shannon-Weinners Diversity Indices were used to document species richness and evenness in the habitats like cereal crops, vegetables, fruit farms, oil seed plants, fodder and ornamental plants. In addition to these, Pearson correlation was employed to observe the strength of relationship among hoverflies, host plants and environmental factors. All these species are a new record from this district.

Keywords: Biodiversity; Hoverflies; Khairpur; Species richness and evenness

Introduction

Hoverflies or flowerflies are very beautiful and useful insects because they perform many functions in an ecosystem. They have medium to large-sized body usually bright coloured and stripped abdomen [1]. They are worldwide distributed and have around 6000 species and are divided in three sub-families i.e. Syrphinae, Eristalinae and Microdontinae [2]. These flies hover around the flowers before landing and are active during day time [3]. Flowerflies are among the most frequent insect visitors to flowers; and pollinate a wide range of plant species [4]. Adult hoverflies use nectar to get energy and pollen for proteins, lipids, and vitamins [5]. Some species of this group show excellent mimic of bees or wasps, often with their black and yellow stripes along the abdomen [6]. The larvae of Hoverflies act as natural enemies of multiple insects and exhibit different habits of feeding like aphidophagous, saprophagous, phytophagous and fungivorous [7]. Ecologically, the species of Syrphidae help in pollination, clean the environment as decomposers and assist in bio-control of crop pests. A lot of research study has been carried out in the world on hoverflies. In Pakistan, very little work has been done on these flies particularly by [8-13].

The main purpose of the current study is to document biodiversity of hoverflies present in district Khairpur Mirs as it had been an untouched area of Sindh. To know about distribution, abundance and species richness and evenness of these very important flies from six habitat types (cereal crops, fodder plants, vegetables, oil seeds, ornamental plants and fruit farms) present in different localities of the mentioned district. In the studied sites, interaction of hoverflies with biotic and abiotic factors of ecosystem was observed carefully along with their diversity. Whereas, hoverfly population dynamics due to effect of seasonal variation was also documented by using effective research tools. The present study is of great significance in the sense that all these 13 species are first time reported from this important agricultural region of Sindh, Pakistan.

Materials and Methods

Study site

The research was conducted in six plant habitats present in various locations of district Khairpur Mirs like Ahmedpur, Gambat, Choondko and Pir-Jo-Goth from January to December 2016. This region of province Sindh occupies an important geographical position where a large variety of crops are grown and it is surrounded by rich agro-ecosystems. It has harsh climatic conditions in the form of extreme Summer and Winter seasons. From May to August, there remains very warm summer season in which temperature reaches up to 50°C. The GPS (Global Positioning System) was used to measure different Geographical parameters of sampling stations (Table 1).
Sampling
The samples were collected time to time every month from four different localities of district Khairpur Mirs. The specimens of Syrphidae were trapped with the help of insect net from cereal crops, vegetables, fruit gardens, oil seed plants, fodder and ornamental plants. During winter, collection was carried out from 10:00 am to 4:00 pm and in summer, collection timing was from 7a.m to 12p.m and 5:00 pm to 6:30p.m. After collection with insect hand net, the specimens were put into the jars. Then jars containing hoverflies were kept into the refrigerator for 2-4 hours in order to kill them. These dead flies were put into desiccator containing water mixed with a little quantity of Ethanol for few hours to soften their body parts which can be stretched properly. After stretching of body parts like wings and legs, the specimens were pinned and preserved properly in special wooden insect boxes and labelled as per standard procedure. Some Naphthalene balls were placed at the center and the corners of the boxes in order to repel ants, bacteria and fungi. The information regarding environmental factors, location, host plants and date was provided with each specimen. The specimens were identified under dissecting binocular microscope through related literature and authentic keys like of other researchers [14-18]. Male and female hoverflies were identified and differentiated mainly by the size and shape of their eyes.

Table 1. The GPS showing different geographical parameters of the surveyed localities and habitat types present in district Khairpur Mirs

<table>
<thead>
<tr>
<th>S No.</th>
<th>Name of locality</th>
<th>Altitude</th>
<th>Latitude</th>
<th>Longitude</th>
<th>Habitat Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Ahmedpur</td>
<td>61m</td>
<td>27.55 N</td>
<td>68.55 E</td>
<td>Cereals, fodder crops, oil seeds, ornamental plants and vegetables</td>
</tr>
<tr>
<td>2.</td>
<td>Gambat</td>
<td>52m</td>
<td>27.35 N</td>
<td>68.52 E</td>
<td>Cereals, fodder crops, oil seeds and vegetables</td>
</tr>
<tr>
<td>3.</td>
<td>Choondko</td>
<td>49m</td>
<td>27.52 N</td>
<td>69.04 E</td>
<td>Fruit gardens, cereals, fodder crops, oil seeds and vegetables</td>
</tr>
<tr>
<td>4.</td>
<td>Pir-Jo-Goth</td>
<td>53m</td>
<td>27.59 N</td>
<td>68.61 E</td>
<td>Fruit gardens, cereals, fodder crops, oil seeds, ornamental plants and vegetables</td>
</tr>
</tbody>
</table>

Data analysis

Species richness and evenness
Biodiversity of species increases with the complexity of habitat. It takes in account both the species richness and evenness. Species evenness measures abundance of various species which make the richness of an ecosystem. Therefore, species evenness is a vital part of diversity indices [19, 20].

Simpson diversity index (D)
It is supposed that the two individuals selected randomly from a sample will be of the same species. This diversity index is more frequently used to observe species richness and evenness. Hoverfly biodiversity of six different habitats present in four localities was measured by using Simpson’s Diversity Index(SDI) through following equation:

\[
D = 1 - \left( \frac{\sum n(n-1)}{N(N-1)} \right)
\]

D = Simpson Index of Diversity  
\( \Sigma \) = sum of total  
\( n \) = the number of individuals of each species  
\( N \) = the total number of individuals of all the species  
The value of D is measured from 0 to 1

Shannon-Weiner diversity index
According to Shannon-Weiner Index of Diversity the individuals sampled randomly are from a separate large population and all the species are represented equally in that sample. It is broadly used to compare biodiversity among different habitats [21]. It has following formula:

\[
H' = -\sum Pi \ln Pi
\]

Where, \( H' \) = Diversity Index  
Pi = is the proportion of each species in the sample
\( \ln Pi \) = natural logarithm of this proportion Shannon Weiner Diversity Index ranges from 1.5 to 3.5.
To observe the strength and direction of relationship between environmental factors (temperature and humidity) and host plants with hoverflies, Pearson correlation was used and data were analyzed through SPSS 22.0 Software. The value of \( r \) (Pearson correlation) ranges from +1 to −1.

Results and Discussion
As a result of the present research work, 688 hoverfly specimens belonging to 13 species and 8 genera of two sub-families (Eristalinae and Syrphinae) were collected from six habitats based on 29 plant species in four localities of district Khairpur Mirs throughout the year 2016. These species include: *Episyrphus balteatus* (Degeer, 1776), *Ischiodon scutellaris* (Fabricius,1805) *Sphaerophoria scripta* (Linnaeus, 1758), *Sphaerophoria Indiana* (Bigot, 1884), *Eupeodes corollae* (Fabricius, 1794), *Eupeodes luniger* (Meigen, 1822), *Paragus bicolar* (Fabricius,1794),
Eristalinus aeneus (Scopoli, 1763), Eristalinus megacephalus (Rossi 1794), Mesembrius bengalensis (Wiedmann, 1819), Mesembrius quadrivittatus (Wiedmann, 1819), Syritta pipiens (Linnaeus, 1758) and Syritta orientalis (Macquart, 1842). The abundance of sub-family Syrphinae (389) was greater than that of sub-family Eristalinae (299). Among the reported species, the maximum population was of Episyrphus balteatus (145) which was observed to visit 20 plant species followed by Eristalinus aeneus (123) having 18 host plants. While the minimum population was of Syritta orientalis (26) which visited 6 plant species. Paragus bicolor had the least number of host plants (5) as shown in (Table 2). The most frequently visited plant species were: Triticum aestivum, Brassica campestris, Mangifera indica, Spinacia oleracea, Coriandrum sativum and Calendula officinalis.

Table 2. Showing percentage and plant species visited by the hoverflies

<table>
<thead>
<tr>
<th></th>
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<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1.Episyrphus balteatus</td>
<td>21 %</td>
<td>20</td>
<td>1.Eristalinus aeneus</td>
<td>17.8 %</td>
<td>18</td>
</tr>
<tr>
<td>2.Ischiodon scutellaris</td>
<td>7.4 %</td>
<td>15</td>
<td>2.Eristalinus megacephalus</td>
<td>6.5 %</td>
<td>15</td>
</tr>
<tr>
<td>3.Sphaeroporia scripta</td>
<td>7.5 %</td>
<td>11</td>
<td>3.Mesembrius bengalensis</td>
<td>5.8 %</td>
<td>7</td>
</tr>
<tr>
<td>4.Sphaeroporia indiana</td>
<td>5 %</td>
<td>9</td>
<td>4.Mesembrius quadrivittatus</td>
<td>4.8 %</td>
<td>7</td>
</tr>
<tr>
<td>5.Eupeodes corollae</td>
<td>5.7%</td>
<td>14</td>
<td>5.Syritta pipiens</td>
<td>4.6 %</td>
<td>8</td>
</tr>
<tr>
<td>6.Eupeodes luniger</td>
<td>5.7%</td>
<td>12</td>
<td>6.Syritta orientalis</td>
<td>3.8%</td>
<td>6</td>
</tr>
<tr>
<td>7.Paragus bicolor</td>
<td>4 %</td>
<td>5</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Among the six habitats from where these hoverflies were collected, cereal crops had the highest Simpson Diversity Index (0.92) and more species richness (13) and the lowest diversity index was of fodder crops (0.88) along with low richness (8). The species evenness was very high in fodder crops (1.08) and the lowest evenness was of cereal crops (1.00). Whereas, the highest Shannon-Weiner Index of diversity was of cereal crops (2.53) and the lowest was of fodder crops (2.05) as given in (Table 3). While, among the four localities, the maximum number of flower flies was collected from Ahmedpur (234) which also had the highest species richness and the minimum abundance was from Gambat (119) having very low species richness. There was great effect of seasonal variation on the population of hoverflies. During spring season there was much more availability of host plants and season was also favourable for egg laying and feeding of larvae as well as adults. Out of the total collection, 39 percent population was captured in spring which was the highest rate and the lowest 14 percent was caught in winter season (Fig. 1). It was observed that seasonal variation had great impact on hoverfly catch as mentioned earlier. The maximum population of these flies was captured during spring and the minimum in winter season. Whereas, the largest number of hoverfly individuals was recorded in the month of March (128) and the lowest abundance was observed in January (20) (Fig. 2). The members of sub-family Syrphinae were more abundant in Spring season than the individuals of sub-family Eristalinae which were in high number during Summer season (Fig. 3). The Pearson correlation revealed that abundance of hoverflies had a strong positive relationship (r=0.80, p=0.002) with the number of host plants. Whereas, hoverfly abundance was in weak positive correlation (r=0.20, p=0.5) with average temperature. Humidity and hoverfly abundance were found in negative correlation (r=-0.38, p=0.22) which indicates if there is high humidity then hoverfly population would be low (Fig. 4, 5 & 6).
Table 3. Showing different habitats, hoverfly abundance and Diversity Indices

<table>
<thead>
<tr>
<th>Habitat type</th>
<th>Host plants</th>
<th>Abundance of Hoverflies</th>
<th>Species Richness (r)</th>
<th>Species Evenness (E)</th>
<th>Simpson Diversity Index (D)</th>
<th>Shannon Weiner Diversity Index (H)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fodder crops</td>
<td>Alfalfa (<em>Medicago sativa</em>), Sorghum (<em>Sorghum bicolor</em>), Berseem (<em>Trifolium alexandrinum</em>) and various types of grasses.</td>
<td>59</td>
<td>8</td>
<td>1.08</td>
<td>0.88</td>
<td>2.05</td>
</tr>
<tr>
<td>Fruit Farms</td>
<td>Mango (<em>Mangifera indica</em>), watermelon (<em>Citrullus lanatus</em>), Musk melon/Gidro (<em>Cucumis melo</em>)/Phalsa/Grewia asiatica/Papaya (<em>Carica papaya</em>).</td>
<td>90</td>
<td>11</td>
<td>1.07</td>
<td>0.91</td>
<td>2.39</td>
</tr>
<tr>
<td>Ornamental plants</td>
<td>Marigold (<em>Calendula officinalis</em>), Rose (<em>Rosa indica</em>), Yellow bell (<em>Allamanda</em>), Static plant (<em>Limonium</em>), Daisy (<em>Bellisperennis</em>), Amarillo (<em>Tagetes erecta</em>).</td>
<td>85</td>
<td>9</td>
<td>1.06</td>
<td>0.89</td>
<td>2.18</td>
</tr>
<tr>
<td>Cereal crops</td>
<td>Wheat (<em>Triticum aestivum</em>), Rice (<em>Oryza sativa</em>), Barley (<em>Hordeum vulgare</em>), Sorghum (<em>Sorghum bicolor</em>), Millet (<em>Pennisetum glaucum</em>).</td>
<td>223</td>
<td>13</td>
<td>1.00</td>
<td>0.92</td>
<td>2.53</td>
</tr>
<tr>
<td>Oil seed crops</td>
<td>Mustard (<em>Brassica campestris</em>), Sunflower (<em>Helianthus annuus</em>), Janbho (<em>Taramira/a ngula</em>).</td>
<td>134</td>
<td>12</td>
<td>1.02</td>
<td>0.91</td>
<td>2.47</td>
</tr>
<tr>
<td>Vegetables</td>
<td>Toori (<em>Luffa acutangula</em>), Onion (<em>Allium cepa</em>), Tomato (<em>Cuminum cyminum</em>), Lady finger (<em>Abelmoschus esculentus</em>), Cabbage (<em>Brassica oleracea</em>), Spinach / Palak (<em>Spinacia oleracea</em>), Brinjal (<em>Solanum melongena</em>), Dhana (<em>Coriandrum ovatum</em>).</td>
<td>97</td>
<td>10</td>
<td>1.01</td>
<td>0.90</td>
<td>2.23</td>
</tr>
</tbody>
</table>

Figure 1. Seasonal variation showing abundance of Syrphinae and Eristalinae during Jan-Dec 2016.
Figure 2. Month wise hoverfly collection from Khairpur Mirs

Figure 3. Showing number of different hoverfly species

Figure 4. Strong positive correlation between number of host plants and abundance of hoverflies
Figure 5. Showing weak positive relationship between average temperature and abundance of hoverflies

Figure 6. Showing negative relationship between relative humidity and abundance of hoverflies

Discussion

Hoverflies are widely and abundantly distributed in District Khairpur Mirs and their biodiversity is also rich as indicated by the results. Biodiversity of hoverflies was higher in cereal crops than all the other habitats. The lowest biodiversity of hoverflies was found in fodder crops. Majority of the hoverfly species in this study were aphidophagous. Pearson correlation indicated that there was a strong positive relationship between population of hoverflies and number of host plants which reveals that if there were more host plants then there would be more population of these syrphid flies. In this regard, many earlier researchers have also shown a positive relationship between availability of flowers and pollinators [22-24]. The larvae of sub-family Syrphinae are aphidophagous which play a very important role in biological control of various aphid pests of our crops which seems the main reason behind the highest hoverfly catch from cereal crops like wheat and rice. While, the larvae of Eristalinae are saprophagous. Owing to seasonal variation, syrphid flies thrive throughout the year with fluctuation in their population. The presence of a hoverfly in variable number in a particular habitat greatly depends on the availability of host plants which provide food and shelter for adults as well as larval forms. Species richness and evenness of sub-family Syrphinae was higher than that of sub-family Eristalinae. The members of subfamily Syrphinae were found much sensitive to climatic factors particularly with temperature and their abundance was very low during Summer (i.e. May, June and July in which maximum recorded temperature was 50°C in May) and Winter season i.e December to February (temperature ranged from 9°C to 16°C). Whereas, the species of sub-family Eristalinae were observed to bear such a temperature range of upto 50°C, that's why, they remain more active in this season. In Spring and Autumn, Syrphinae remains very active as also reported by Ansari et al. [11].

Conclusion

It can be concluded from the above discussion that this untouched area of Sindh has rich biodiversity of hoverflies. Their diversity was higher in cereal crops than all
the other habitats. These flies thrive throughout the year but their population varies with the change of season. Study revealed that majority of the hoverfly species were aphidophagous which means they are useful for the bio-control of the crop pests like aphids. Hence, such eco-friendly flies need attention for natural pest control and enhancement of per acre yield in Sindh as well as in Pakistan.

Authors’ contributions
Conceived and designed the experiments: N Memon & MA Shah. Performed the experiments: SM Kanher. Analyzed the data: SM Kanher. Contributed materials/analysis/tools: SM Kanher. Wrote the paper: SM Kanher.

References