# Feeding Behavior and Host Plant Preferences of *Episyrphus balteatus* (DeGeer) and *Ischiodon scutellaris* (Fabricius) in Southern Punjab, Pakistan

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## Abstract

During the present study, 300 adults along with 30 larvae of *Episyrphus balteatus* and 212 adults along with 25 larvae of *Ischiodon scutellaris* were collected from 15 and 13 host plants, respectively from Bahawalpur, Southern Punjab, Pakistan. The adults of these two species were found mostly on all vegetables and crops together hovering for nectar and oviposition site. For studying the occurrence pattern and foraging behavior of hoverflies fields were studied systematically and adults were collected using hand nets along with photographs in the field. The data was analyzed using modern tools of data analysis SPSS23. These species were found to be frequent visitors of flowering plants and aphid-infested plants, which was later confirmed in our data that they have a strong relation to aphid colonies for oviposition to provide a healthy diet and enough nectar to develop their eggs. Owing to this, both flies possess a variety of host plants and hence were dominant and abundant in most of the vegetative fields. Moreover, it has also been brought into being that March is most preferred for both species in which the highest number of specimens were collected and observed in the field due to the availability of flowering crops and vegetables in the studied site. Exploring host-plant relation and their foraging ecology in deep molecular ecology is highly recommended, because feeding behavior and host plants preferences are highly corelated, plant traits effect on the feeding behavior of insect pests and their predator. In addition nutritional quality of plants, plant associated factors and sometimes availability of prey or other predator influence the feeding behavior of many insects. By learning the dynamics of these natural enemies and host plants, our study shows the possibility of improving biological control strategies. This insect-host plant relationship is a promising solution to sustainable pest management, highlighting the significance of ecosystem-based approaches in agriculture.

**Keywords**: Hoverflies, *Episyrphus balteatus*, *Ischiodon scutellaris*, foraging, ecology

## Introduction

Hoverflies are a huge, assorted, and attractive assembly of the order Diptera with striped abdomen and are moreover named Syrphid flies, bloom flies, or ramble flies. The most remarkable feature of these flies is their ability to hover, darting from one plant to another in search of nectar and pollen while momentarily floating before alighting. These non-stinging flies pose no threat to humans or other animals, even though they display various forms of mimicry resembling dangerous bees and wasps, which aids in distracting their predators (1, 2). Although the aphidophagous hoverflies are pterygote insects that possess strong wings to fly everywhere to find food and live their occurrence is linked with the food preferences of their young generation. Hence, they are found in areas where they get enough food for the proper development of their eggs (3, 4) because they require organic molecules for the proper development of their eggs.

Besides this, they prefer places that possess enough aphid colonies as their larvae can survive only on these plants which possess their food as plenty of aphids (5) because the larvae of both species are aphidophagous (6). Therefore, they are bound to oviposit in the places where the vegetation possesses strong nectar as well as the aphid colonies. The larvae of these two species of aphidophagous hoverflies have been considered as generalist species of syrphid flies (7), therefore it reduces enough struggle as they can feed over more than one species of aphid. The larvae of aphidophagous hoverflies started feeding over aphid nymphs after 8 to 10 days and the feeding rate increased as the instars were changing (8). Due to their dual eco-friendly services, they have remained the focus of study, As the concept of integrated pest management came into being, preservation of local populations of natural enemies of pest organisms became a significant practice, which requires correct identification of beneficial organisms (9). In addition, their molecular analysis has been carried out in order to manipulate them for agriculture and environmental services (10, 11). Hoverflies are remarkably vital creatures for the environment, as a grown-up they serve as pollinators of numerous agrarian and green crops, vegetables, blooms, and wild plants whereas their hatchlings serve as natural enemies or pests of numerous arthropods (particularly aphids, thrips, caterpillars, and scales) (12).

As Syrphid hoverflies are extremely useful insects and very small is known approximately their food preferences in relation to their host plants and particular stages of growing plants, this study has been designed to investigate hoverflies' foraging ecology and host plants preferences. Aphidophagous hoverflies have long been assessed from different perspectives for their eco-friendly services as biocontrol agents and pollinators. Likewise in the current investigation host plant preference of *E. balteatus* and *I. scutellaris* were assessed from Bahawalpur, Southern Punjab, Pakistan from January to May 2017. For observation of host preferences, adults of *E. balteatus* and *I. scutellaris* were studied and observed in the natural and semi-natural environments along with their occurrence pattern and foraging behavior.

### Materials and Methods

### Field study

For the collection of data different vegetables, crops, and plants in three districts (Bahawalpur, Bahawalnagar, and Rahim Yar Khan) of southern Punjab, Pakistan were surveyed from January to May 2017. Moreover, the X-Y Coordinates (Table 1) and Geo-referencing of collections sites are recorded on the map by using Google Earth Pro and ArcGIS 10.7.1 (Fig. 1).

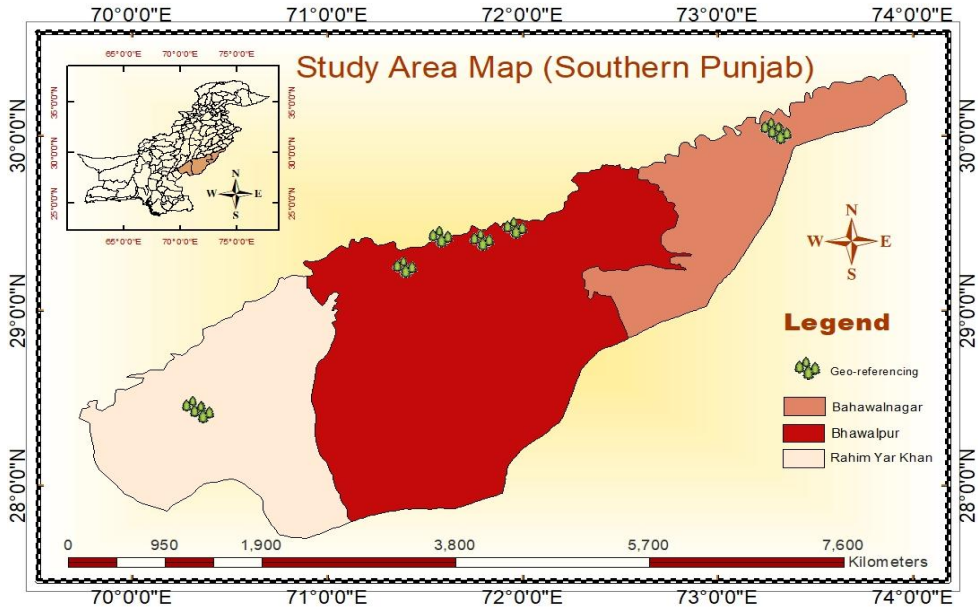


**Fig 1.** Geographical map of collection site of Syrphid flies in Southern Punjab.

**Table 1.** X-Y Coordinates of various localities of Punjab.

| District | Locality | Coordinates (X-Y) |
|---|---|---|
| Rahim Yar Khan | Amin Garh | 28.450462, 70.316534 |
| Rahim Yar Khan | Aman Garh | 28.416974, 70.359463 |
| Bahawalpur | Basti Allah Rakha Sahoo | 29.248907, 71.397246 |
| Bahawalpur | Khanu Wali | 29.421829, 71.580821 |
| Bahawalpur | Chak 7 BC | 29.404751, 71.791333 |
| Bahawalpur | Guddan | 29.473590, 71.959396 |
| Bahawalnagar | Kabootri | 30.042754, 73.280059 |
| Bahawalnagar | Kabootri | 30.014042, 73.315336 |

**Collection and studied method**

The adult species of aphidophagous hoverflies were collected using a hand net (80% collection) and malaise trap (20% collection) from January-May 2021 as recommended by (Jamali et al., 2018) and identified based on taxonomic keys following (13, 14). The collected material from the Malaise trap was retrieved every 15 days, either at 11:00 am or 4:00 pm. Specimens were simultaneously collected using insect nets and hand-picking methods, and their occurrence and hovering periods were recorded in the field. Total 330 specimens (300 adult + 30 larvae) of *E. balteatus* and 237 specimens (212 adult + 25 larvae) of *I. scutellaris* were trapped from 15 and 13 host plants respectively. The occurrence pattern of larvae of both species was also studied and recorded in the field in perspective of

ecological factors like temperature, humidity, and wind speed (Table 2).

**Table 2.** Ecological factors recorded in the field.

| Month | AT ($^0$C) (Mean) | H (%) (Mean) | WP (m/h) (Mean) |
|---|---|---|---|
| January | 14 | 50 | 10 |
| February | 23 | 48 | 7 |
| March | 29 | 43 | 6 |
| April | 33 | 52 | 9 |
| May | 37 | 54 | 9 |

*Note: WS: Wind Speed, AT: Average Temperature, H: Humidity.*

### Data Analysis

Data was analyzed using SPSS 23 software. The Pearson correlation of abundance with the host plant and aphid colonies of each aphidophagous fly hoverfly was calculated. Data of both biocontrol agents and aphid colonies was also calculated using SPSS, this test was used for measurement of linear relationship between two variables.

### Analysis of foraging rate and speed

The foraging rate was measured concerning the eating number of aphids by larvae minute under controlled conditions in insect insect-rearing chamber at the Department of Zoology, University of Sindh, Jamshoro, Pakistan.

## Results

During the present study, some 330 specimens of *E. balteatus* and 237 specimens of *I. scutellaris* were collected for investigation about feeding behavior and hostplant preferences.

### Host plants range to *E. balteatus* and *I. scutellaris*

The host plant range of these two species diverged significantly in the studied site during this period of study, where the number of host plants of *E. balteatus* was high as compared to the *I. scutellaris* (Tables 3 and 4). Both were found in abundance on *Brassica* while *I. scutellaris* was not found on some of the crops in the study site. Their abundance on the host plant was again affiliated with the flowering season of that crop e.g., the number of these hoverflies was found high on *Brassica* in March while their number was low in January and May where there was no such flowering season in the early and late period of *Brassica* crop. In the same way, the number of larvae of both species fluctuates slightly due to the high oviposition rate of *E. balteatus* as compared to *I. scutellaris.* Besides this the other factor is type of aphid because these predator are very specialist and specific in nature they feed on specific species. Although they are generalist in nature but still they possess some unique species which they prefer more.

**Table 3.** Showing host plant range of *Episyrphus balteatus*

| Specimen of *E. balteatus* | Aphid colonies/acre | Syrphid larvae/colony | Host Plant Species |
|---|---|---|---|
| 43 | 22 | 10 | *Brassica campestris* |
| 30 | 17 | 05 | *Brassica rapa* |
| 15 | 06 | 03 | *Momordica charantia* |
| 13 | 07 | 02 | *Luffa acutangular* |
| 16 | 07 | 03 | *Abelmoschus esculentus* |
| 10 | 06 | 03 | *Brassica oleracea* |
| 23 | 08 | 03 | *Gossypium* |

| | | | |
|---|---|---|---|
| 20 | 07 | 02 | *Oryza sativa* |
| 13 | 05 | 02 | *Allium cepa* |
| 14 | 07 | 03 | *Spinacia oleracea* |
| 14 | 05 | 03 | *Solanum lycopersicum* |
| 15 | 04 | 02 | *Capsicum frutescens* |
| 17 | 06 | 02 | *Coriandrum sativum* |
| 09 | 03 | 01 | *Rosa indica* |
| 05 | 00 | 00 | Shrubs |

**Table 4.** Showing host plant range of *Ischiodon scutellaris*

| *I. scutellaris* | Aphid colonies/acre | Availability of syrphid larvae/colony | Host Plant Species |
|---|---|---|---|
| 30 | 15 | 6 | *Brassica campestris* |
| 28 | 12 | 5 | *Brassica rapa* |
| 15 | 08 | 3 | *Momordica charantia* |
| 12 | 06 | 3 | *Rosa indica* |
| 10 | 05 | 2 | *Solanum lycopersicum* |
| 8 | 03 | 0 | *Capsicum frutescens* |
| 10 | 00 | 0 | Shrubs |
| 09 | 03 | 2 | *Coriandrum sativum* |
| 09 | 04 | 2 | *Gossypium* |
| 09 | 05 | 3 | *Oryza sativa* |

**Correlation of abundance between hoverflies, aphid colonies and host plants**

The correlation between the abundance of *E. balteatus* and *I. scutellaris* was calculated and analyzed which showed a strong positive correlation of abundance with aphid colonies and several number host plants. Furthermore, it has been analyzed that the connection with the host plant is affiliated with its flowering season. We took a random sample of plants from the experimental zone and visually examined them for aphid colony infestations. For each randomly chosen plant, we counted the number of aphids on a standard number of leaves, usually the top or most infested leaves (Tables 5 and 6).

**Table 5.** Showing the correlation of abundance between hoverflies (*Episyrphus balteatus*), aphid colonies and host plants.

| Correlations | | Aphid colonies | Aphid nymph | *E. balteatus* |
|---|---|---|---|---|
| Aphid colonies | Pearson Correlation | 1 | 0.941** | 0.954** |
| | Sig. (2-tailed) | - | 0.000 | 0.000 |
| | N | 15 | 15 | 15 |
| Aphid Nymph | Pearson Correlation | 0.941** | 1 | 0.913** |
| | Sig. (2-tailed) | 0.000 | - | 0.000 |
| | N | 15 | 15 | 15 |
| *E. balteatus* | Pearson Correlation | 0.954** | 0.913** | 1 |
| | Sig. (2-tailed) | 0.000 | 0.000 | - |
| | N | 15 | 15 | 15 |

**. Correlation is significant at the 0.01 level (2-tailed).

**Table 6.** Showing the correlation of abundance between hoverflies (*Ischiodon scutellaris*) aphid colonies and host plants.

| Correlations | | Aphid colonies | Aphid nymph | *I. scutellaris* |
|---|---|---|---|---|
| Aphid colonies | Pearson Correlation | 1 | 0.946** | 0.929** |
| | Sig. (2-tailed) | - | 0.000 | 0.000 |
| | N | 10 | 10 | 10 |
| Aphid Nymph | Pearson Correlation | 0.946** | 1 | 0.861** |
| | Sig. (2-tailed) | 0.000 | - | 0.001 |
| | N | 10 | 10 | 10 |
| *I. scutellaris* | Pearson Correlation | 0.929** | 0.861** | 1 |
| | Sig. (2-tailed) | 0.000 | 0.001 | - |
| | N | 10 | 10 | 10 |

**. Correlation is significant at the 0.01 level (2-tailed).

**Foraging ecology of larvae of *E. balteatus* and *I. scutellaris***

Each larva was provided with the aphids in a petri dish. The speed and number of eating larvae increased with increasing instars of larvae which were found maximum in the 7th instars about 120 to 140 aphids' nymph (Green peach aphid) were consumed in a single day by larvae of *E. balteatus* and 125 to 130 aphids (Green peach aphids) were consumed by larvae of *I. scutellaris* (Figure 2).

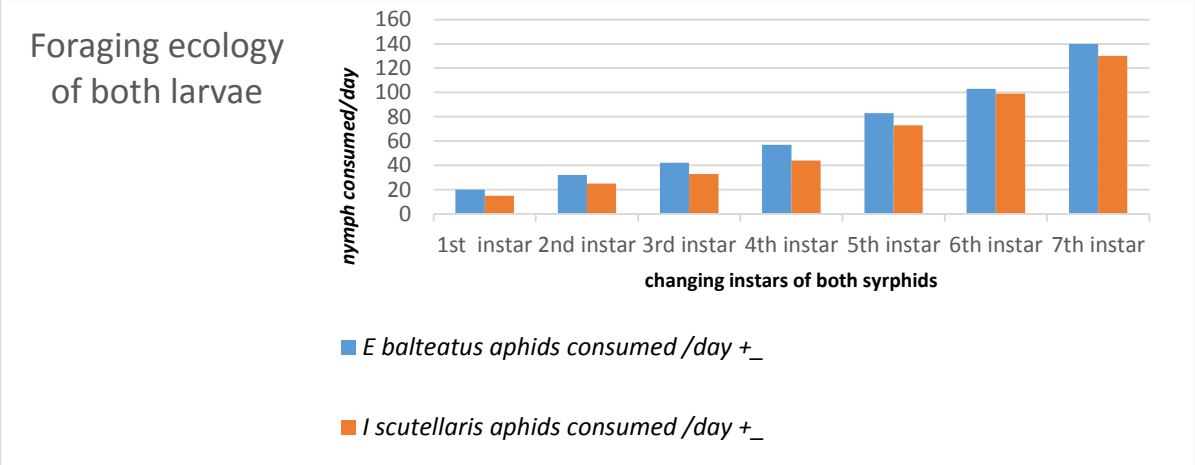


**Fig 2.** Foraging the ecology of *E. balteatus* and *I. scutellaris*

**Effect of size of aphid colonies**

The availability and size of aphid colonies were either fresh or old which heavily influenced the oviposition behavior of aphidophagous hoverflies.

**Table 7.** Effect of size of aphid colonies on eggs/larvae of Hoverflies.

| Size of aphid colonies | Larvae/ plant | Eggs/ plant |
|---|---|---|
| Large | 3 | 6 |
| Medium | 2 | 3 |
| Small | 2 | 1 |

The adults were mostly attracted towards the fresh aphid colonies near the center of the crop as they were influenced by ecological factors like wind near the edges of the crop. The eggs were mostly laid near colonies on the leaf of the crop instead of directly on aphid colonies, thereafter the young ones crawled in search of food and reached towards aphids (Table 7).

**Availability of adult of *E. balteatus* and *I. scutellaris* during sampling**

Samples collected during the study period showed that the adults of *E. balteatus* and *I. scutellaris* were found abundant in the month of March due to *Brassica*, which is the most important host plant of both species persisting in March with flowering stages. While they were found throughout the study period, their number slightly decreased in the month of May as the temperature was increasing and their host plants were losing their flowering seasons (Tables 8 and 9).

**Table 8.** Month-wise occurrence of *Episyrphus balteatus*

| Month | *E. balteatus* | Host Plant Species |
|---|---|---|
| January | 52 | *Capsicum frutescens, Oryza sativa, Spinaciaoleracea, Solanum lycopersicum, Rosa indica.* |
| February | 85 | *Brassicacampestris, Capsicum frutescens, Solanum lycopersicum, Brassica rapa, Momordicacharantia, Abelmoschusesculentus.* |
| March | 113 | *Capsicum frutescens, Abelmoschusesculentus, Brassica rapa, Brassica campestris, Capsicum frutescens, Solanum lycopersicum.* |
| April | 75 | *Solanum lycopersicum, Allium cepa, Brassica oleracea.* |
| May | 30 | *Coriandrum sativum, Gossypium, Shrubs.* |

**Table 9.** Month-wise occurrence of *Ischiodon scutellaris*

| Month | *I. scutellaris* | Host Plant Species |
|---|---|---|
| January | 20 | *Brassica campestris, Brassicarapa, Rosa indica, Solanum lycopersicum* |
| February | 35 | *Brassica campestris, Capsicum frutescens, Solanum lycopersicum, Brassicarapa* |
| March | 42 | *Brassica rapa, Brassica campestris, Capsicum frutescens, Solanum lycopersicum,Luffa acutangula, Oryza sativa* |
| April | 31 | *Solanum lycopersicum, Brassica rapa, Gossypium,Shrubs* |
| May | 15 | *Coriandrum sativum, Gossypium, Shrubs, Allium cepa* |

**Comparison of host plants' preferences of *Episyrphus balteatus* and *Ischiodon scutellaris***

The analyzed data showed that the most preferable host plants for *E.* balteatus were mustard and turnip. The number of visited specimens of *E. balteatus* on mustard and turnip plants was recorded at 43* and 30* respectively, which is the highest number. The least preferable host plants for *E. balteatus* were roses and bushes. The number of visited specimens of *E. balteatus* on rose and bushes plants was recorded at 9^ and 5^ respectively that is the least number. The most preferable host plants for *I. Scutellaris* were also mustard and turnip. The number of visited

specimens of *E. balteatus* on mustard and turnip plants was recorded at 30* and 20* respectively, which is the highest number. The least preferable host plants for *I. Scutellaris* were roses and bushes. The number of visited specimens of *I. Scutellaris* on coriander and chili plants were recorded at 9^ and 8^ respectively, which is the least number (Table 10).

**Table 10.** Two most and least preferred host plants of *Episyrphus balteatus* and *Ischiodon scutellaris*

| Plant species | Common name | No: of aphid colonies | *E. balteatus* | *I. Scutellaris* |
|---|---|---|---|---|
| *Brassica repa* | Mustard | $22^{a}$ & $15^{b}$ | $43^{*}$ | $30^{*}$ |
| *Brassica rapa rapa* | Turnip | $17^{a}$ & $12^{b}$ | $30^{*}$ | $20^{*}$ |
| *Coriandrum sativum* | Coriander | $6^{a}$ & $3^{b}$ | 17 | $09^{\wedge}$ |
| Bushes and shrubs | Bushes and Shrubs | 0 & 0 | $5^{\wedge}$ | 10 |
| *Rosa indica* | Rose | $3^{a}$ & $6^{b}$ | $9^{\wedge}$ | 12 |
| *Capsicum frutescens* | Chilies | $3^{a}$ & $4^{b}$ | 15 | $8^{\wedge}$ |

Note: Most ($^{*}$), $^{a}$ (*E. balteatus)*, Least ($^{\wedge}$), $^{b}$ (*I. scutellaris).*

**Figure 3.** *Ischiodon scutellaris* hovering over *Brassica* (left)and larvae of *Ischiodon scutellaris* on aphid colonies on the stem of *Brassica* (right).

## Discussion

The current study of foraging ecology and hostplant preference of two aphidophagous hoverflies i.e., *E. balteatus* and *I. scutellaris* was conducted in Bahawalpur, Punjab, Pakistan. During the present study adults and larvae of both species were collected using a hands net and malaise trap for studying foraging ecology and hostplant preferences in the laboratory as well as in the laboratory at Department of Zoology, University of Sindh, Jamshoro, Pakistan. The data showed that *E. balteatus* was abundantly found on 15 different crops and vegetables in district Bahawalpur and its adjacent areas, a total of 300 adults and 30 larvae were collected. *E. balteatus* was recorded second most abundant species by (15) in Spain. While *I. scutellaris* was also richly found on 13 crops and vegetables in the studied area, a

total of 212 adults and 25 larvae were collected. The correlation of abundance of both species was heavily influenced by abiotic i.e. host plants and aphid colonies and biotic factors i.e., temperature, wind, and humidity, (16) has also studied the positive influence of floral resources on the abundance of syrphid flies. The month of March was found to be most preferred for both species in which the highest number of specimens were collected and observed in the field due to the availability of flowering crops and vegetables in the site studied. While the occurrence and abundance of larvae were correlated with the presence of aphid colonies in the crop which served as a basic need for the proper growth and development of larvae. The foraging ecology of larvae of *E. balteatus* and *I. scutellaris* was calculated in the laboratory under controlled conditions which showed that each larva consumed an average of 420 nymphs of green peach aphids in its total life span of 9 to 10 days. While Varshney & Bisht, (17) has calculated bout 411 aphid nymphs in the total life span of two aphidophagous hoverflies. This minor difference could be due to ecological conditions like temperature and humidity and the size of each aphid consumed.

## Conclusion

The hoverfly species *E. balteatus* and *I. scutellaris* were found to be frequent visitors of flowering plants and aphid-infested plants, which has been confirmed in our data that they have a strong relation to aphid colonies for oviposition to provide a healthy diet and enough nectar for development of their eggs. Owing to this, both flies possess a variety of host plants and hence were dominant and abundant in most of the vegetative fields. Moreover, it has been also brought into being that March is most preferred for both species in which the highest number of specimens were collected and observed in the field due to the availability of flowering crops and vegetables in the studied site. To explore host-plant relation and their foraging ecology in deep molecular ecology is highly recommended. Our results highlight the significance of certain host plants as a source of adult food and oviposition, thus enhancing the lifecycle and population stability of these hoverflies. From our results, we suggest the introduction of these syrphid species into biological control systems within integrated pest management (IPM) programs. Promoting habitat management practices that favor nectar and pollen-producing flora will maintain hoverfly populations and optimize the long-term efficiency of aphid control in agro-ecosystems.

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### Conflict of interest

The authors declare no conflict of interest.

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