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Diversity and relative abundance of braconids (Hymenoptera) among selected crops of District Faisalabad, Pakistan

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Authors' Contribution | **Malik, S., S. Mushtaq, A. Hafeez , M. Batool & N. Bano** collected the data ana analysed the result.

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ABSTRACT

The present study was conducted to determine the diversity and abundance of Braconid parasitoid fauna of District Faisalabad. Four crops fodder, *Brassica*, vegetables and wheat, were selected for sampling where the sweep net method was applied. A total of 2553 specimens belonging to 5 genera and 10 species were recorded. *Cotesia vestalis* (27.99%) was the dominant species, followed by *C. flavipes* (25.53%), *Heterospilus spp*. (16.58%), *C. congregate* (7.07%), *C. plutellae* (6.71%), *Bracon hebetor* (5.84%), *H. eurostae* (5.57%), *Alysia incongrua* (3%), *Biosteres arisanus* (2.61%) and *Bracon uromelas* (1.11%). Significant differences were found among four crops by applying the Shannon Diversity Index and T-test. Canonical Correspondence Analysis was also applied to check the association of Braconid larval parasitoids with different crops. A strong association was found with fodder while the weak association was observed for wheat. Such types of studies are needed to investigate the biological diversity and richness of various insect fauna among different parts of the world.

Keywords: Diversity, relative abundance, braconidae, parasitoid, shannon index, per-sweep number.

INTRODUCTION: The biodiversity of natural enemies such as parasitoids plays a very important role in the control and reduction of pest populations in an agro-forest ecosystem (Khalil *et al.*, 2019). A sustainable ecosystem is driven by various interacting ecological services that biodiversity performs (Jankielsohn, 2018). Braconids (commonly known as wasps) is an important group of parasitoids in agroforest ecosystems that which regulate and control various pest populations especially herbivore insect's pests. They perform a role as a measure of ecosystem health because these species indicate the presence of host plant population and related insect pests. So in this way braconids can be used in various biological insect pest control programs (Avila *et al.*, 2013). Within the order Hymenoptera, these are as the second most diverse family with more than 15000 species described, though their species richness now expected above 100,000 (Gadelha *et al.*, 2012). Braconids are globally distributed and can be establish in nearly all kinds of habitats (Shaw and Huddleston, 1991). These insects normally have a size between 2-15mm and have traces of black, red, orange, yellow or different colors on their bodies. As a distinct character they have a long ovipositor and sixteen or more segmented antennae (Hanson and Gauld, 2006). They mostly attack larvae of the species Lepidoptera, Diptera, and Coleoptera which are their common hosts (Hanson and Gauld, 2006). Although Braconids have great ecological and economic importance, very little work is done to study their richness, distribution or ecology (Cardoso *et al.*, 2011). Different regions of the world such as North and South America, Europe, Japan, Iran and India carried out various research on their biology, diversity or distribution (Rezwani *et al.*, 2007) but in Pakistan a lot of research is required in order to study them. Inayatullah and Naeem (2004) reported 18 subfamilies of Braconidae from different zones of the NWFP. Among these 8 subfamilies have been reported from Okara district and 6 subfamilies were first time recorded from NWFP Inayatullah and Naeem (2004). In 2008, the study conducted by Irshad (2008), described 66 Braconidae species from Pakistan. In 2012, Bodlah *et al.* (2012) studiedthe genera Binodoxys Mackauer and Praon Haliday (Aphidiinae: Braconidae) from arid zones of the Punjab Province. In 2013, a similar study carried out by Tahira *et al.* (2013) reported 4 genera by the subfamily Euphorinae (Braconidae: Hymenoptera) for the first time from Khyber Pakhtunkhwa Province, of Pakistan (Tahira *et al.*, 2013). In (2015), the study conducted by Khalil *et al.* (2019) reported 23 species of Microgastrinae under 9 genera (*Cotesia C., Apanteles F., Microplitis F., Glyptapanteles A., Dolichogenidea V., Snellenius WMicrogaster L., Paroplitis W and Diolcogaster A.*) from Khyber Pakhtunkhwa Province. The study of Ullah *et al.* (2015) recorded 8 genera of Aphidiinae parasitoids containing, *Praon, Binodoxys, Ephedrus, Diaeretiella, Aphidius, Trioxys, Toxares and Monoctonus* from the District Dera Ismail Khan. However, a little efforts have been carried out to discover the braconid parasitoids fauna of Province Punjab.

OBJECTIVES: The present study has been carried out to estimate the diversity and abundance of different species of Braconidae among the agriculture fauna of Faisalabad district, of Punjab.

MATERIAL AND METHODS: Study area: Faisalabad, located in central Punjab, with latitude 31° 26', longitude 71° 06' and 184.4 m from mean sea level. During summer the average temperature was recorded as 39°C as maximum while 27°C as minimum temperature. In winter the mean maximum and minimum temperature remains 17°C and 6°C respectively. The mean annual rainfall recorded in 2019 is about 300mm (Ullah *et al.*, 2015).

Sampling design and data collection: Sweep net method was used for collection of wasp species. These wasps were collected from different sites located 15-35 km distant from the University of Agriculture, Faisalabad (figure 1).

Figure 1: Map of yield area.

Brassica, wheat, vegetables and fodder were selected for each sample collection. An area of 2.5 hectares were randomly selected from two fields of each crop during whole sampling duration. 40 sweeps were fixed for each field, by moving (making pattern of 8 in the fields) the net through field 10 times horizontally, 15 times vertically and 15 diagonally.

Preservation and identification: The specimens collected from the field were preserved in 70% alcohol and also labeled with date of collection, sample number, micro or macro-habitats, and location from which it was collected. Specimens when brought in laboratory were washed with tap water and preserved in 70% alcohol again. A few drops of glycerin were also added to keep specimens smooth and flexible. Collected specimens were identified up to species level by using different electronic keys available on different websites. They were also confirmed by using available, related taxonomic information in "Fauna of British India by Borror and DeLong (1971). To calculate per sweep numbers, number of specimen/specimens were divided by total number of sweeps per sampling.

Statistical analysis: The Shannon diversity index was used to calculate species richness and evenness, while diversity t- test was applied to interpret the significance of results. Species distribution was analyzed by canonical correspondence analysis (CCA). Kernel Density Estimation (KDE) approach was used to analyze the diversity dynamics of braconids species during studies (Kuter *et al.*, 2011).

RESULTS AND DISCUSSION: Crop wise distribution: A total of 2553 specimens belonging to 5 genera and 10 species of Braconidae were collected from all of the four crops. Figure 2 showed the

relative abundance of 10 species recorded during the whole study. Braconids were abundantly found in fodder.

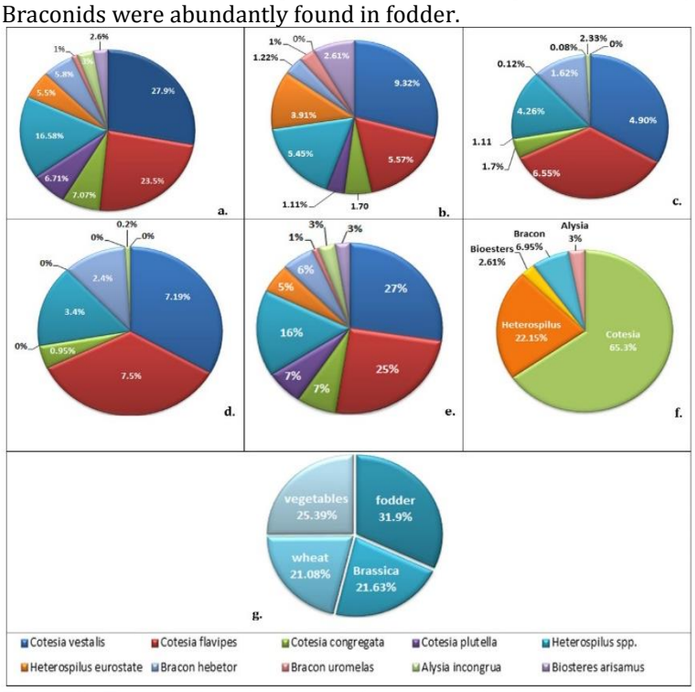

Figure 2: The relative abundance (percentage) of all of the species in (a) Fodder (b) vegetables (c) Brassica (d) wheat (e) all of the four crops (f) Relative abundance of five genus among all crops (g) overall abundance of Braconids in four crops.

From fodder a total of 31.90% (808 specimens) of all crop samples belonging to 9 species except *A. incongrua* were collected. Similar kind of studies have done by Gadelha *et al.* (2012) who collected 377 speciemens of braconids wasps belonging to 17 subfamilies. In present studies *C. vestalis* was abundantly present in fodder shared 29.21% specimens in the whole braconid sample while B. uromelas was least abundantly present and shares 3.22 %. A total of 21.63% (548) specimens belonging to six species were collected from Brassica. The most commonly founded species in Brassica was *C. flavipes* shares 34.67 % while *H. eurostae, C. plutellae and B. uromelas* were not found in this crop. From vegetables 25.39% (643 specimens) belonging to 9 species were collected. Throughout sampling *B. arisanus* was not collected from vegetables. The most abundant species found in vegetables was *C. flavipes* shares 25.82 %, whereas *Bracon uromelas* with 0.31% was the least abundantly present. From wheat 21.08% (534) of Braconids from eight species were collected. Overall *C. flavipes* with 25.53% and *C. vestalis* with 27.99% were present abundantly with in all of four crops. Genus Cotesia shared 65.30% among all of the Braconids and thus it is the most dominating genus with maximum number present in fodder 17.69% and then in vegetables 16.98%. Another dominant genus found was Heterospilus which contribute 22.15% of the total data. It was abundantly found in fodder (9.36%) and in wheat (5.01%). The least abundant genus with shares only 2.61% among total Braconid population was Biosteres and was collected from fodder. Well maintained agricultural system contains good diversity of Braconids due to availability of nectar and host species for breeding (Yadav and Sarma, 2022). As results have exhibited that Cotesia was most abundant genus, similar kind of results have been recorded by Murthy *et al.* (2011) and represented by four braconids species viz. *C. flavipes, C. vestalis, C. plutellae* and *C. congregata*. Density plots provide a visual representation about the fundamental distribution of the data. For this purpose Kernel Density Estimation (KDE) has been plotted for the braconids collected from four selected fields. Figure 3 indicates that maximum density of the Braconidae family was ranging from 20 to 100. Highest density was recorded from fodder while minimum density was recorded from wheat crop.

Shannon diversity indices: The data was analyzed statistically by applying the Shannon diversity index (Magurran, 1988) to calculate species richness and evenness among four crops. Table 1 showed diversity indices. The diversity index was found to be significantly higher ($p < 0.05$) for fodder among other crops. Evenness was also higher in fodder than in wheat, Brassica and vegetables respectively. Results were also confirmed by using t-test ($p < 0.05$) and highly significant results were found between fodder and other crops. Khalil *et al.* (2019) also reported significant differences in diversity and abundance of the braconid population in citrus crops of Sargodha.

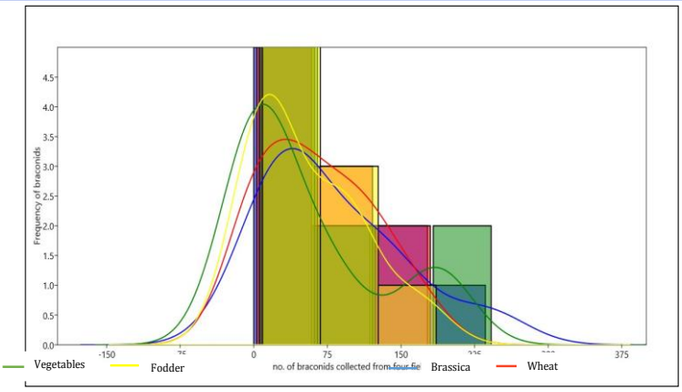

Figure 3: Graph showing kernel density estimation of braconids collected from four selected crops.

Canonical correspondence analysis: To check the distribution of braconid larval parasitoids Canonical Correspondence Analysis (CCA) was applied using MVSP software (version 3.13f). The distribution of braconids was variable with respect to four crops. Crop type is an important factor in the distribution of braconid larval parasitoids, particularly for *C. flavipes* and *C. vestalis*. The two species exhibited associations with wheat, brassica and vegetables. A positive correlation was observed in *H. spp*. for wheat, brassica and vegetables. *B. hebetor* also exhibits a positive correlation with fodder. A variation of 30.41% exhibit along two of the axes for different species. Among these *H. eurostae*, *B. uromelas, C. plutellae, B. arisanus, C. congregata, and A. incongrua* showed the positive correlation with axis 1 whereas *C. vestalis* and *C. flavipes* showed negative correlation with both of the axis (figure 4).

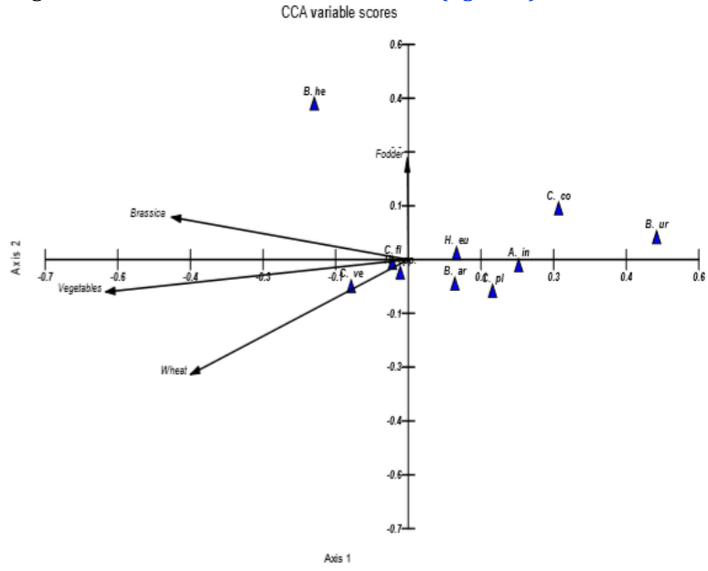

Figure 4: Canonical correspondance analysis (CCA), ordination biplot showing the association of braconids towards different crops (fodder, vegetables, brassica and wheat) in Faisalabad.

Abbreviations used in CCA: C. fl (*C. flavipes*), C. ve (*C. vestalis*), C. co (*C. congregata*), C. pl (*C. plutellae*), H. spp. (*H. spp*.), H. eu *(H. eurostae*), B. he (*B. hebetor*), B. eu (*B. euromelas*), A.in (*A. incongrua*) and B. ar (*B. arisanus*)

Per sweep number: Data was collected fortnightly from two fields of each crop. Therefore four fields of each crop were sampled in a month. The number of sweeps was fixed the 40 sweeps for each single field and thus 80 sweeps were used from two fields of each crop during each sampling for and a total of 160 sweeps were used in a month for each crop. A total of 1920 sweeps were annually used for each crop of fodder and vegetable. For each crop of Brassica a total of 1280 sweeps were used and for fodder 1120 sweeps were used. Table 2 represents the number of different species of braconids per sweep during the whole study. Highest per sweep number was recorded from wheat which is 0.48, for brassica 0.43, for fodder 0.42 and least were collected for vegetables that is 0.33. Per sweep number collected at its peak for *C. vestalis* (0.11) and *C. flavipes* (0.07). *C. vestalis* exhibits highest peak number from wheat (0.15) and least from vegetables (0.06) whereas *C. flavipes* shows a different trend as its maximum per sweep number was calculated from brassica (0.15) and least from fodder (0.07). Elpino-Campos *et al.* (2007) also investigated the biodiversity of Hymenoptera order and recorded 29 species of wasps.

Seasonal distribution: For Braconids the maximum population

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Type	N1	H'1	E1	N2	H'2	E2	t-test	Df	P-value
Fodder vs Vegetables	808	21.89	0.86	643	1.83	0.27	12.98	>120	<0.00***
Fodder vs Brassica	808	21.89	0.86	548	1.32	0.68	15.43	>120	<0.00***
Fodder vs Wheat	808	21.89	0.86	524	1.74	0.79	7.75	>120	<0.00***
Vegetables vs Brassica	643	1.83	0.27	548	1.32	0.68	12.98	>120	<0.01*
Vegetables vs Wheat	643	1.83	0.27	524	1.74	0.79	2.49	>120	>0.1ns
Brassica vs Wheat	548	1.32	0.68	524	1.74	0.79	7.79	>120	>0.1ns

Table 1: Shannon diversity indices of four crops. P value for test of factor are given (ns: p>0.05, * : p< 0.05, ***: p< 0.001).

Species	Fodder	Brassica	Vegetables	Wheat	Total
Cotesia vestalis	0.12	0.14	0.06	0.15	0.11
Cotesia flavipes	0.07	0.15	0.09	0.09	0.07
Cotesia congregata	0.02	0.02	0.05	0.02	0.03
Cotesia plutellae	0.01	0.00	0.03	0.08	0.02
Heterospilus spp.	0.07	0.07	0.06	0.08	0.03
Heterospilus eurostae	0.05	0.00	0.00	0.03	0.01
Bracon hebetor	0.02	0.05	0.02	0.01	0.10
Bracon uromelas	0.01	0.00	0.00	0.00	0.02
Biosteres arisanus	0.03	0.00	0.00	0.00	0.01
Alysia incongrua	0.00	0.01	0.03	0.01	0.01
Total	0.42	0.43	0.33	0.48	0.41

Table 2: Per sweep number of *Braconidae* species calculated from District Faisalabad.

was found during spring season 62.18% and minimum was found during summer 1.67%. Winter and autumn show 26.61% and 9.55% respectively of the total population. During summer the most abundant species found was *C. flavipes* (0.55%) where *H. eurostae* was found to be least abundant (0.04%). *B. euromelas* and *B. arisanus* was not found during summer. During autumn the most founded species was *C. flavipes* 2.53% while *B. uromelas* was the minimum with 0.04%. A similar kind of results were reported by Khalil *et al.* (2019) while working on distribution of wasp in citrus crops. All of the 10 species were collected during winter. The most abundant species collected here was *C. vestalis* 6.51 % whereas the least was *B. uromelas* 0.36%. All of the species exhibit maximum abundance in spring; therefore it is the most preferred season. *C. vestalis* exhibit maximum population during spring 18.91% while the minimum was *B. uromelas* 0.71% (figure 5&6).

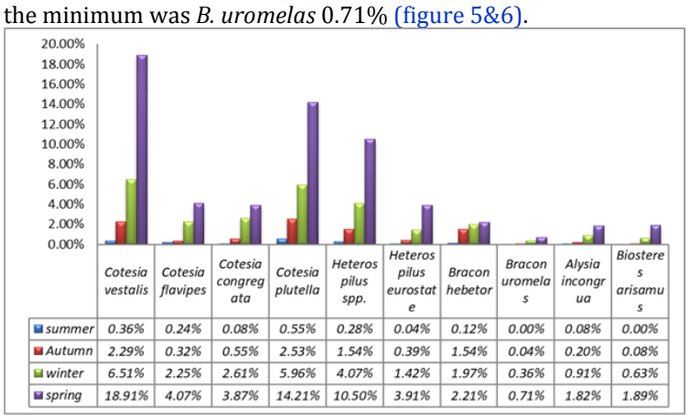

Figure 5: Distribution of Braconids in various seasons

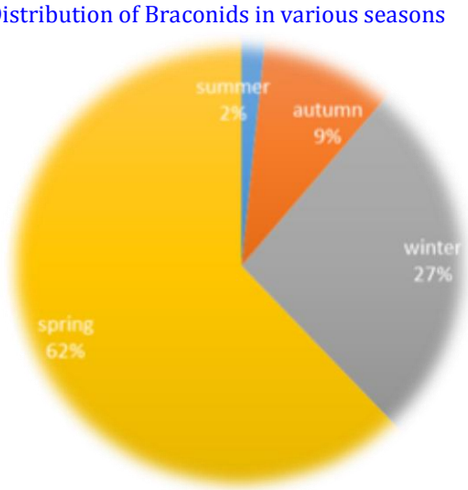

Figure 6: Overall abundance of all species among all of the four seasons

Braconids are effective parameter for determination of specific diversity of that region and to assess the effect of human activities on such communities (Elpino-Campos *et al.*, 2007). These wasps are important from ecological point of view because these species control the phytophagous insects and indirectly effect the survival and diversity of host plant species. Braconids are of also economical interest because of their use in pest control program (Elpino-Campos *et al.*, 2007).

CONCLUSIONS: The maximum relative abundance of Braconid fauna was recorded from fodder, followed by vegetables, Brassica and wheat. The most abundant genus recorded during the study was Cotesia followed by heterospilus, Bracon. Genus Alysia and Biosteres were less abundantly found during the study. The most abundant species found were *Cotesia vestalis* and *Cotesia flavipes*. Spring season is found to be favorable most for maximum growth and increase in Braconids population. Such type of studies can help us in knowing about the dominance, richness and abundance of Braconids fauna and their useful applications for the control of pest populations in fields and in integrated pest management programs.

CONFLICT OF INTEREST: The authors have no conflict of interest

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