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(RESEARCH ARTICLE)

Diversity of arthropods regarding habitat specialty in agro-ecosystem of Faisalabad, Pakistan

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Abstract

Biodiversity is a measurement of the variety of organisms within species present in an ecosystem and can refer to ecosystem variation, genetic variation and species variation within a biome. They consist of diversity, evenness, dominance and richness of inhabiting taxa in that area. This study was carried out to check the diversity of different arthropods among crops and fields of District Faisalabad, Punjab, Pakistan. Total 1088 specimens were collected belonging to 8 orders, 24 families, 35 genera and 38 species from agro- ecosystem. So, keeping in view the importance of these aspects, calculations were made as per Shannon Diversity Index and SPDIVERS.BAS software. Diversity (H) was recorded as (1.2720), while Diversity $_{Max.}$ (H'_{max}) was recorded (3.0366). Evenness was (0.0896) while dominance was (1.0896). The value for richness was recorded as (11.6423). To highlight their major distribution and contribution, relative abundance was recorded maximum for genus *Drosophila* 60.85% (N = 662), followed by *Musca* 7.17% (N = 78), *Chamaepsila* 6.34% (N = 69), *Hippodamia* 5.15% (N = 56), *Sepsis* 4.14% (N = 45), *Culex* 2.67% (N = 29), *Episyrphus* 1.56% (N = 17), *Coccinella* 1.38% (N = 15), *Aedes, xestia* 1.19% (N = 13), *Camnula, Omocestus* 0.92% (N = 10), Cheilomenes 0.83% (N = 9), *Aleiodes, Anchastus* 0.64% (N = 7) and *zizula* 0.55% (N = 6). However, least relative abundance (N≤ 5) was recorded for *Ochlerotatus, Nemopoda, Eupeodes, Sphaerophoria, Chrysotoxum, Culicoides, Chrysoperla, Acrida, Scudderia, Gigantiops, Ancistrocercus, Byturus, Leptinotarsa, Dyscinetus, Haploa, Oncopeltus, Cimex, Araniella* and *Argiope*.

Keywords: Diversity; Arthropods; Abundance; Agro-ecosystem; *Musca*; *Chamaepsila*

1. Introduction

An ecological sphere having plantation, animal and other type of organisms is inhabited is called biosphere. It defines as zone where the organisms can live and finds all ecological resources such as protection, shelter, food and mates for reproduction [1]. Habitat specialization defines the degree of isolation of population and the ability of species to disperse, so it is considered as very important determinants of species vulnerability for fragmentation and habitat loss. Moreover, the species dispersal success in a particular habitat depends on distance between fragments that is conditioned landscape from total amount of habitat [2]. Biodiversity is a measure of the variety of organisms within species and between species present in an ecosystem. This can refer to ecosystem variation, genetic variation and species variation within a biome, area and planet [3]. Biodiversity also provides many useful ecosystem services and goods including maintenance of habitats for beneficial insects and pollinators, nutrient recycling and reducing soil water runoff [4].

Phylum Arthropoda is the largest and most important group of Kingdom Animalia. Worldwide, the phylum Arthropoda contains an estimated 2 million to 50 million specie [5]. Some of the more well-known arthropods include insects,

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crustaceans and spiders, as well as the mollusks [6]. Arthropods account for the largest percentage of animal biomass and biodiversity in the agro-ecosystem [7]. Arthropods play a vital role in ecosystem services as pollinators, predators, decomposers and nutrient recycler and their quick responses to ecological changes make them potentially good bio-indicators [8]. Predators are remarkably beneficial and affect the guilds diversity of other invertebrate in agro-ecosystems because they help to suppress and regulate phytophagous pest populations [9, 10, 11]. For example, members of insect orders like coleoptera and neuroptera have been used as bio control agents [12]. They help the humans directly and indirectly as providing food and as pollinators. These factors showed that they are most importantly used in agricultural and ecological research studies and compare intercropping agro-forestry in terms of biological diversity and sustainability.

Approximately one quarter of all insect species are phytophagous and play a crucial role in agro-ecosystems as consumers of plants and as food for predators [13]. The members of Hymenoptera, Diptera, Thysanoptera, Lepidoptera, Phasmida, Orthoptera, Hemiptera, Demaptera, Coleoptera, Hornoptera and Lepidoptera are naturally herbivores [14, 15]. Although, they are generally considered as pests and biocontrol agents of weeds within an agro-ecosystem [16]. On the other side, they are considered as vector and pest that transmit a huge number of diseases and are responsible for global crop losses of almost 20-50% of potential production, respectively. These diseases have hazardous effects on human population [17].

Community of biotic components linked with abiotic components of their surrounding or environment (abiotic factors like water, mineral soil and air) act as a system called an ecosystem. However, their nature differs as per their characteristics (desert, aquatic, terrestrial, forests, wetlands and agro-ecosystems etc.). The function of ecosystem is the mixture of ecosystem goods, services and properties [18]. In agro-ecology, the fundamental unit of study is an agro-ecosystem that is subjectively defined as functionally and spatially coherent unit of activity of agriculture system which is also includes the biotic and abiotic components and their interactions [19].

Agro-ecosystem is composed of socio economic dimensions, in which human introduced a well plan selective composition of biota such as livestock and crops maintained by the farmers, by replacing smaller and larger amount of the natural biodiversity of location [20]. Agriculture is the backbone of the economy of Pakistan. They are key motor of the universal economy covering about 28% of all land with 38% in the temperate, 38% in the tropical and 23% in the subtropical regions. In Pakistan, the total Geographical area is 79.6 million hectares, from this agriculture land covers 27% of total surface area [21]. Agriculture dependent population is 75-80% from which the gross domestic product included 30%. In an agro-ecosystem, the amount of disturbance varies significantly in the conditions of intensity, frequency and types of interruption. The main disturbances are application of pesticides and herbicides, and tillage operations to manage insect pests and crop harvest. Particularly, Vegetable production systems are greatly disturbed because of short crop cycles sometimes with multiple crops per year, regular tillage and usually higher fertilizer and pesticide use [22]. So, keeping in view the ecological interaction of arthropods with agro-ecosystem; the present study was proposed to find: The diversity and relative abundance of arthropods among agro-ecosystem.

2. Material and methods

2.1. Study area

Present study was conducted in the agricultural fields of different crops in district Faisalabad, Punjab, Pakistan in 2016 and study was consisting of rolling flat plains, between longitude 73°74 E, latitude 30° 31.5° N, with an elevation of 184 meters (604 ft) above sea level including area 58.56 km^2. Vegetation was consisting of different herbs/ shrubs, grasses and different crops: *Triticum aestivum*, *Brassica compestris*, *Trifolium alexandrium* and *Saccharum officinarum.*

Figure 1 Vegetaion of A) *Trifolium alexandrium* B) *Triticum aestivum* and *Brassica compestris* crops C) *Saccharum officinarum* crop

2.2. Collection of data

To collect the arthropods fauna from sampling sites, sample were made weekly (12 weeks) for two hours from 6:00 am to 8:00 am by following methods: Direct hand picking, by using Sweep Net and by using Forceps. Total 1088 specimens were collected, and specimens were stored in jars containing 70:30% alcohol and glycerin solution and thereafter collected specimens were shifted to Biodiversity Laboratory, Department of Zoology, Wildlife and Fisheries, University of Agriculture, Faisalabad for further systematic studies. Here, the specimens were separated and preserved in separate glass vials, containing 70:30% alcohol and glycerin solution for further identification. The glass vials were labeled as sampling number, canal name and with time of day of sampling. The collected specimens were identified and sorted with the aid of naked eye, magnifying glass and microscope. The identifications were conducted based on morphological characters. All the specimens were identified up to species level according to the taxonomic/ reference material [23].

2.3. Statistical analysis

Thereafter, all the observed specimens were arranged in table form according to their morphological and taxonomic characters e.g. order, family, genus and species. To determine the various aspects of diversity, Shannon Diversity Index was used [24]

$$Diversity\ (H'): H' = -\sum pi\ ln\ pi$$

Where p_i is the proportion of individuals found in the ith species. The value of p_i is estimated as $n_i/\ N$.

2.3.1. Maximum Diversity

$$H_{max} = -\sum_{i=1}^{S} \frac{1}{S} \ln \frac{1}{S} = \ln S$$

2.3.2. Evenness "Hill's Modified Ratio (E)" [25]

$$E = \frac{\left(\frac{1}{\bar{\lambda}}\right)}{e^{H-1}} = \frac{N^{2-1}}{N^{1-1}}$$

Where, E is the index of evenness, λ is the Simpson's index of diversity and N1 and N2 are the number of abundant and very abundant species respectively in the sample. The richness, diversity and evenness indices were computed by using the Program SPDIVERS.BAS.

2.3.3. Richness

$$S = n + \left(n - \frac{1}{n}\right)^{k}$$

Where, S = species richness, n = total number of species present in sample population, k = number of "unique" species (of which only one organism was found in sample population).

2.3.4. Dominance

D = 1-E

Where, "E" is evenness.

3. Results and discussion

After completing the whole research trials as per methodology, total 1088 specimens were collected belonging to 8 orders, 24 families, 35 genera and 38 species (Table 1). Arthropods were observed in agro-ecosystem *Brassica Juncea* and *Brassica napus* from (Multan, Dera ghazi khan and Bahawalpur) Punjab on weekly basis. During the study no arthropods other than insects were observed. As the most abundant among all insects observed *Lipaphis erysimi, Brevicoryne brassicae* (L.), *Myzus persicae* on *B. juncea* and *B. napus*. Other insects that were recorded includes the whitefly, *Bemisia tabaci* (Hemiptera), *Athalia lugens* (Hymenoptera), *Spodoptera litura* L. and *Helicoverpa armigera* (Lepidoptera), Neuroptera and Coleoptera were observed [26]. Abundance and composition of arthropod were studied in the aboveground and guild structure in upland rice agro-ecosystem at Matalam, North Cotabato, Philippines. By using direct counting techniques and sweep netting sampling. A total of 29 arthropod species were documented that was belonging to 21 families in nine orders [27].

Table 1 Overall taxa composition among agro-ecosystem

Category	Frequency
Order	8
Families	24
Genera	35
Species	38

Table 2 Overall relative abundance of recorded species among agro-ecosystem

Order	Family	Species	Relative abundance (%)
Diptera	Muscidae	*Musca domestica*	7.17(78)
	Drosophilidae	*Drosophila melanogaster*	4.14(45)
		Drosophila funebris	27.57(300)
		Drosophila hydei	28.68(312)
		Drosophila suzukii	0.46(5)
	Culicidae	*Culex pipiens*	2.67(29)
		Aedes abserratus	1.19(13)
		ochlerotatus triseriatus	0.09(1)
	Sepsidae	*Sepsis fulgens*	4.14(45)
		Nemopoda nitidula	0.28(3)
	Syrphidae	*Episyrphus balteatus*	1.56(17)
		Eupeodes corolla	0.09(1)
		Sphaerophoria scripta	0.09(1)
		Chrysotoxum festivum	0.46(5)
	Psilidae	*Chamaepsila rosae*	6.34(69)
	Ceratopogonidae	*Culicoides impunctatus*	0.09(1)
Neuroptera	Chrysopidae	*Chrysoperla carnea*	0.09(1)
Orthoptera	Acrididae	*Acrida conica*	0.28(3)
		Camnula pellucida	0.92(10)
		Omocestus viridulus	0.92(10)
	Tettigoniidae	*Scudderia mexicana*	0.09(1)
Hymenoptera	Formicidae	*Gigantiops destructor*	0.18(2)
	Braconidae	*Aleiodes indiscretus*	0.64(7)
	vespidae	*Ancistrocercus antilope*	0.18(2)
Coleoptera	Coccinellidae	*Coccinella septempunctata*	1.38(15)
		Hippodamia tredecimpunctata	5.15(56)
		Cheilomenes sexmaculata	0.83(9)
	Byturidae	*Byturus unicolor*	0.09(1)
	Chrysomelidae	*Leptinotarsa decemlineata*	0.46(5)
	Scarabaeidae	*Dyscinetus morator*	0.37(4)
	Elateridae	*Anchastus binus*	0.64(7)
Lepidoptera	Lycaenidae	*Zizula hylax*	0.55(6)
	Noctuidae	*Xestia baja*	1.19(13)
	Arctiidae	*Haploa reversa*	0.09(1)
Hemiptera	Lygaeidae	*Oncopeltus fasciatus*	0.28(3)
	Cimicidae	*Cimex lectularius*	0.18(2)
Araneae	Araneidae	*Araniella cucurbitina*	0.37(4)
		Argiope aurantia	0.09(1)
Total			1088

From the overall data (Table 2), *Drosophila hydei* (Diptera: Drosophilidae) was recorded as an extraordinary contributing species with relative abundance of 28.68% (N = 312), followed by *Drosophila funebris* (Diptera: Drosophilidae) 27.57% (N = 300), *Musca domestica* (Diptera: Muscidae) 7.17% (N = 78), *Chamaepsila rosae* (Diptera: Psilidae) 6.34% (N = 69), *Hippodamia tredecimpunctata* (Coleoptera: Coccinellidae) 5.15% (N = 56), *Drosophila melanogaster* (Diptera: Drosophilidae), *Sepsis fulgens* (Diptera: Sepsidae) 4.14% (N = 45), *Culex pipiens* (Diptera: Culicidae) 2.67% (N = 29), *Episyrphus balteatus* (Diptera: Syrphidae) 1.56% (N = 17), *Coccinella septempunctata* (Coleoptera: Coccinellidae) 1.38% (N = 15), *Aedes abserratus* (Diptera: Culicidae), *Xestia baja* (Lepidoptera: Noctuidae) 1.19% (N = 13), *Camnula pellucida* (Orthoptera: Acrididae), *Omocestus viridulus* (Orthoptera: Acrididae) 0.92% (N = 10), *Cheilomenes sexmaculata* (Coleoptera: Coccinellidae) 0.83% (N = 9), *Aleiodes indiscretus* (Hymenoptera: Braconidae), *Anchastus binus* (Coleoptera: Elateridae) 0.64% (N = 7) and *Zizula hylax* (Lepidoptera: Lycaenidae) 0.55% (N = 6). However, least relative abundance (N≤ 5) was recorded for *Drosophila suzukii* (Diptera: Drosophilidae), *Ochlerotatus triseriatus* (Diptera: Culicidae), *Nemopoda nitidula* (Diptera: Sepsidae), *Eupeodes corollae* (Diptera: Syrphidae), *Sphaerophoria scripta* (Diptera: Syrphidae), *Chrysotoxum festivum* (Diptera: Syrphidae), *Culicoides impunctatus* (Diptera: Ceratopogonidae), *Chrysoperla carnea* (Neuroptera: Chrysopidae), *Acrida conica* (Orthoptera: Acrididae), *Scudderia mexicana* (Orthoptera: Tettigoniidae), *Gigantiops destructor* (Hymenoptera: Formicidae), *Ancistrocercus antelope* (Hymenoptera: Vespidae), *Byturus unicolor* (Coloeptera: Byturidae), *Leptinotarsa decemlineata* (Coleoptera: Chrysomelidae), *Dyscinetus morator* (Coleoptera: Scarabaeidae), *Haploa reversa* (Lepidoptera: Arctiidae), *Oncopeltus fasciatus* (Hemiptera: Lygaeidae), *Cimex lectularius* (Hemiptera: Cimicidae), *Araniella cucurbitina* (Araneae: Araneidae) and *Argiope aurantia* (Araneae: Araneidae).

The orders with respect to the number of individuals in the different sites were as follows: Diptera (42%), Coleoptera (18%), Orthoptera (11%), Hymenoptera and lepidoptera (8%), Hemiptera and Araneae (5%) and Neuroptera (3%). A maximum number of species was recorded that belonged to order Diptera and others respectively and these species were found in the both sites (Figure 2). Total number of specimens recorded belonging to different orders: Diptera (N=925), Coleoptera (N=97), Orthoptera (N=24), Hymenoptera (N=11) Lepidoptera (N=20), Hemiptera (N=5) and Araneae (N=5) and Neuroptera (N=1). Highest number is recorded for the dipterans (Figure 3). This trend has also been recorded previously, Insect diversity in the mangroves of Andaman and Nicobar Islands of India, reported the following results: Lepidoptera 50%; Coleoptera 20%; Hemiptera 15%; Diptera 5%; Hymenoptera 3%; Orthoptera, 5%; Thysanoptera, 2% [28].

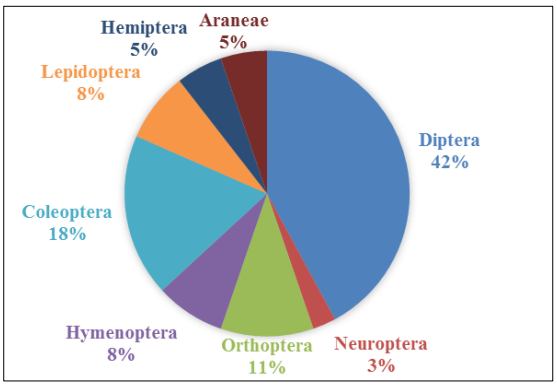

Figure 2 Diversity of species among orders in agro-ecosystem

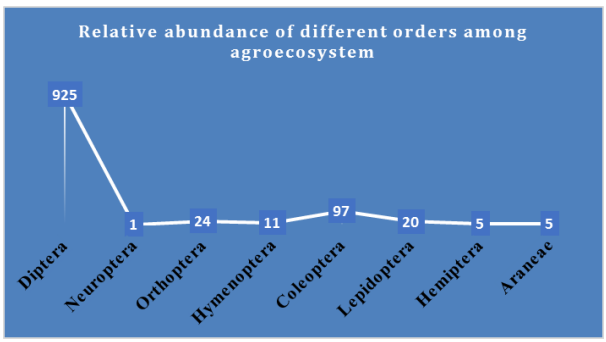

Figure 3 Relative abundance of recorded numbers up to order level among agro-ecosystem

Diversity indices are key components to draw the natural lines regarding taxa composition pertaining to any managed or unmanaged landscaping. They consist of diversity, evenness, dominance and richness of inhabiting taxa in that area. So, keeping in view the importance of these aspects, calculations were made as per Shannon Diversity Index [29]. In the discussion of future direction, it may be assumed that the region has diversity of described orders and these results may help in the proceeding of research for further work. Different other techniques and methodologies may be directed to evaluate better results. Diversity (H) was recorded as (1.2720), while Diversity $_{Max.}$ (H'_{max}) was recorded (3.0366). Evenness was (0.0896) while dominance was (1.0896). The value for richness was recorded as (11.6423) (Table 3). Seasonal abundance was calculated using the Shannon Wiener index, and a minimum value was found during summer. Species richness was calculated using the Margalef index, and we found that, among the three stations, Pichavaram has higher species richness and evenness (based on Pielou's index), as indicated by data from different seasons. In the present study, a marked variation in diversity indices was observed between the stations. In Station I, species diversity varied from 4.950 to 3.692. Species richness fluctuated between 4.478 and 7.955. As regards species evenness, it varied from 0.999 to 0.997. The taxonomic diversity and total phylogenetic diversity fluctuated from 90% to 30%. Species richness, population density, and species diversity of terrestrial insects in Uttaranchal were calculated by [30].

Table 3 Diversity indices recorded from Agro-ecosystem

Diversity indices	**Values**
Diversity (H′)	1.2720
Diversity $_{Max}$ (H'_{max})	3.0366
Evenness (J)	0.0896
Dominance (D)	1.0896
Richness (R)	11.6423

From the overall data presentation and discussion, it is confirmed that results of previous scientists and researchers in different areas over the world were analogous to our present findings, but sometime deviations were recorded due to variations in ecological conditions and skill power, handling expertise and documentation of data [26, 27].

4. Conclusion

From the overall data it is concluded that diversity among different orders of insects is present. As hypothesized, diversity may vary among different orders it is noted that species varied of different insect orders while pretending significance of results.

Compliance with ethical standards

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Disclosure of conflict of interest

The authors declare no conflict of interest.

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