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EFFECT OF DAWN AND DUSK ON THE DIVERSITY AND ABUNDANCE OF ARTHROPODS IN A MIXED AGROECOSYSTEM

Sawera Maqsood, Naureen Rana, Waqar Majeed and Shahla Nargis

Department of Zoology Wildlife and Fisheries, University of Agriculture, Faisalabad 38000.
***Corresponding author's e-mail: waqarchaudhry20@gmail.com**

Arthropods are the major part of the fauna on earth, they participate significantly in sustaining agricultural ecological systems. Their participation makes them functional bioindicators for determining agro-ecosystem stability. Yet, their abundance and diversity in some terrestrial ecosystems are still undisclosed. This study was done to determine the diversity of arthropod fauna in a mixed agroecosystem of District Faisalabad, Pakistan. Additionally, it was compared and analyzed the diversity, abundance, and richness of species in the Morning and Evening periods. A total of 172 species belonging from 10 orders,70 families, and 2741 specimens were collected from the agroecosystem. The diversity parameters used to analyze the diversity of arthropods were Shannon index, Evenness Margalef index, Simpson index, and Sorenson similarity index. We observed that most abundantly found orders were Orthoptera, Diptera, and Hemiptera. Morning fauna exhibited the highest diversity than evening. The arthropod's abundance differed significantly in the morning and evening. From the overall study, it was observed that fauna has a great association with the agro-ecological zones. Further research work of a broad level is needed to explore the more prevalence of fauna in this area, which will be helpful in the management strategies of IPM and crop rotations.
Keywords: Diversity; Morning and Evening; Periods; Fauna; Agriculture landscape.

INTRODUCTION

Agro-ecosystem is composed of socio-economic dimensions, in which a well-planned biota composition is maintained for crops and livestock, resultantly replacing the habitats of biodiversity specifically arthropods (Swift et al., 1996; Rana et al., 2019). Diversity of invertebrates is the pillar of all levels of ecosystems e.g. species, population, and individual (Cardinale et al., 2006). Arthropods play a significant role in ecosystem sustainability as it is the base of all ecological services (Rathore and Jasrai, 2013). They are the major part of the species and most successful phylum on earth representing 1,302,809 species, or about 78.5% of the total living species (Addenda, 2013). They overcome the whole of the universe, except for the oceanic benthic zone (Grimaldi and Engel, 2005).

Order Hemiptera are in majority of habitats, generally terrestrial (Szwedo, 2018). Coleoptera is the biggest order ranging from 350,000-400,000 species, which comprises 30% of all the animals and 40% of class Insecta. They are found in all-natural environments where vegetation is found (Foottit et al., 2009). Lepidoptera is the wide-ranging order of class Insecta in natural ecosystems from the majority of the worldly associated species (Zhang, 2011).

Arthropods emulate eminent role in sustaining agriculture ecological systems e.g. crop pollination (AAFC, 2001), which roughly pollinates 75% of crop species worldwide (Klein et al., 2013). Their participation makes them functional bioindicators for determining agro-ecosystem stability and are very functional biological indicators to measure the consequences of different agricultural landscapes (Majeed et al., 2019; Naseem et al., 2020). The use of biological control helps to eliminate pesticide practices (Purslow, 2004).

Over 50% of the human population occupies agriculture as a profession. Therefore, the arthropod's role in agro-ecosystem is significant to humans. Several arthropods cause severe harm to crop and reduce crop yield. Natural enemies regulate their population by eating their hosts/prey. Agricultural crops fulfill the needs for food, fibers, and other products. It has also started to increase knowledge and understanding the biodiversity and to find a source of action to minimize the unfavorable impacts of practices. Agro-industries considers for about 2/3 of total industrial output, the agricultural sector accounted for 22% of gross domestic product (GDP) and employed 45% percent of the labor force (Idrees et al., 2020; Alam and Naqvi, 2003). In Asia, the average production of vegetables contributes approximately 218 million tones, the maximum of which is produced in Pakistan, China, and India (Ali, 2015). Additionally, to provide economic benefits in the system of agriculture, the arthropod fauna satisfies a diversity of environmental factors inside the natural ecosystems (Isaacs et al., 2009).

Farmers usually depend on the honeybee to contribute roughly $200 billion to food production (Gallai et al., 2009). However, due to loss in the domain of diversity and abundance (i.e. flowering plants), exposure to parasites, and pesticides (e.g., Varroa mites in honeybees), a reduction in the population has occurred (Goulson et al., 2015). Due to adaptability in all types of environments grasshoppers are well known to potentially damage the crops, they are also considered as the major pests of many crops they also provide an ecological status of the pest species regarding different crops and seasons (Emosairue, 2007).

Many researchers have been illustrated in their studies that arthropods have a strong influence on the surrounding environment (Balasubramanian et al., 2005; Balakrishnan et al., 2014; Ojija and Laizer, 2016). Furthermore, due to their lesser size, high reproductive rates, and short life spans, the arthropods species can alter by time scale, population adjustment to new conditions, and minimizing time lags between environmental changes (Belamkar and Jadesh, 2012; Nazir et al., 2014). Arthropods respond immensely to environmental changes, as well as those resulting from anthropogenic activity to agriculture (Ojija and Kavishe, 2016).

Arthropod abundance and diversity are valuable indicators of the impact of agricultural practices on biodiversity as their populations and communities are associated with certain vegetation types, habitat structure and the environmental conditions of the area (Longcore, 2003). That tends to shift their diversity and population abundance in the dawn and dusk in microhabitat (Reddy and Sreedevi, 2016). In such a way, behavioral thermoregulation enables the arthropods to move at the dawn and dusk due to their food sources and maintain the body energy in the environment. However, relatively little is known about long-term patterns in their abundance, especially from at different times in a day such as dawn and dusk (Meserve et al., 2016). So, keeping in view all the ecological significance of fauna and agriculture landscape the present study was designed to find the diversity of arthropods in a mixed agro-ecosystem and also to check the influence of dawn and dusk periods on the abundance and diversity formulation of fauna.

MATERIALS AND METHODS

***Area of study*:** The current study was conducted to check out the diversity of arthropods in mixed agro-ecosystem at district Faisalabad in the area of 251/R. B Bandala District Faisalabad (Punjab), Pakistan. The vegetation area of present study sites was containing a mixed Agro-field zone e.g. (Sugarcane, Wheat, Alfalfa, Garlic, Wild grasses, Turnips, Sesame, Mustard, Beans, and pumpkin).

***Experimental layout*:** Arthropods fauna was collected from a mixed Agro-field zone (detail mentioned above) on monthly basis from Dawn (8:00 am 10:00 am) and Dusk (3:00 pm 5:00 pm) for one year from the single station/area with repetition of twelve samples. Sweep net, handpicking and forceps methods were used for the collection of fauna. Then, as per their morphology, they were sorted and preserved in the glass vials containing the alcohol and glycerin (70:30%) and Identification was done up-to-the species level with help of taxonomic, internet keys and scientific literature (Holloway et al., 1992; Triplehorn and Johnson, 2005).

***Statistical analysis*:** Biodiversity was assessed using diversity-based indices. Species distribution of arthropods at dawn and dusk was computed by the use of the Shannon-Weiner index (Shannon, 1948). Sorensen similarity index was also used to verify the resemblance in species present at both timings and Margalef index was used to measure the richness of species. Relative abundance was also found by using the standard formulas. T-test was used to assess the data between richness and abundance of orders in the morning and evening and all the data was tested at the level of significance (α = 0.05). All the data were analyzed by using the Graph pad prism, Microsoft office, and Minitab.

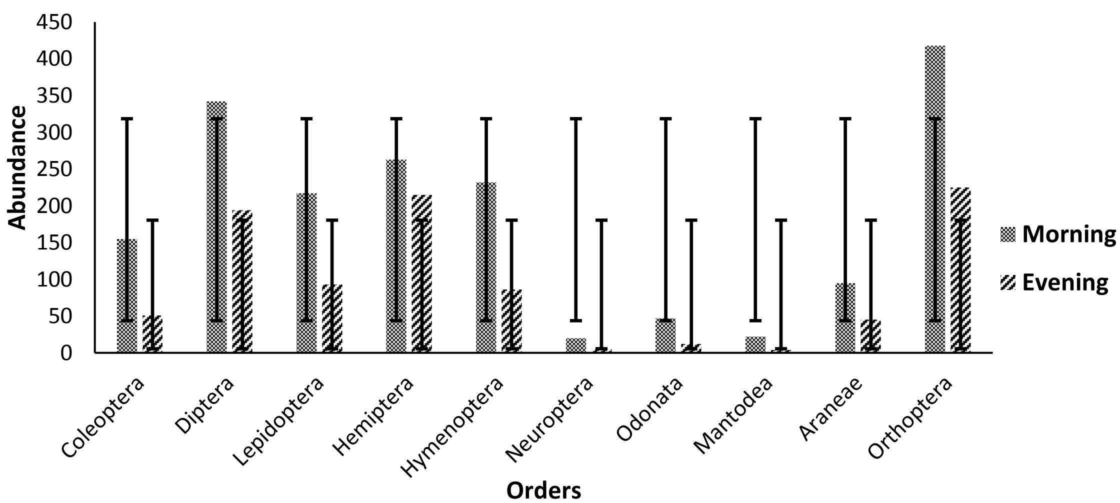

Figure 1. Abundance of arthropods among different orders collected from dawn (8:00 am-10:00 am) and dusk (3:00 pm - 5:00 pm) in a mixed agroecosystem of District Faisalabad, Pakistan

RESULTS

A total of 172 species belonging to 10 orders, 70 families and 2741 specimens were collected from the agroecosystem. In the morning, 1811 specimens were collected and from evening time total of 930 specimens were collected. From the evening period (*Tanytarsus sylvaticus*: Chironomidae) was found a maximum of 9.67 % (N = 90), while lower 4.80 % (N = 87) in morning period. The most abundantly found orders from morning and evening were Orthoptera (N = 418, 225) and Hemiptera (N = 263, 215). Moreover, the least abundant group of arthropods from the morning are Neuroptera (N = 20) and Odonata (N = 22). While from evening Neuroptera (N = 5) and Odonata (N = 4) (Figure 1). Morning time

Table 1. Comparison of arthropods diversity from dawn (8:00 am-10:00 am) and dusk (3:00 pm-5:00 pm) based on different diversity parameters

Insect Orders	Time scale	Species richness	Abundance	Relative abundance	Shannon index	Margalef index	Evenness index	Sorensen similarity index
Overall	Morning	122	1811		4.343	61.495	0.904	0.779
	Evening	123	930		2.535	63.996	0.523	
Coleoptera	Morning	16	155	8.55%	2.170	8.468	0.782	0.909
	Evening	17	51	5.48%	1.169	8.970	0.412	
Diptera	Morning	20	342	18.88%	2.538	10.475	0.847	0.700
	Evening	20	194	20.86%	1.514	10.475	0.505	
Lepidoptera	Morning	17	217	11.98%	2.347	8.970	0.828	0.933
	Evening	13	93	10.00%	1.235	6.961	0.481	
Hemiptera	Morning	16	263	14.52%	2.341	8.468	0.844	0.975
	Evening	26	215	23.11%	2.469	13.480	0.757	
Hymenoptera	Morning	18	232	12.81%	2.683	0.472	0.928	7.325
	Evening	23	86	9.24%	1.414	11.978	0.450	
Neuroptera	Morning	2	20	1.10%	0.688	1.250	0.992	4.573
	Evening	2	5	0.53%	0.471	1.250	0.679	
Odonata	Morning	2	22	2.59%	0.544	1.250	0.784	14.450
	Evening	2	4	1.29%	0.511	1.250	0.737	
Mantodea	Morning	2	47	1.21%	0.566	1.250	0.816	0.667
	Evening	1	12	0.43%	0.309	0.500	0.000	
Araneae	Morning	7	95	5.24%	1.369	3.928	0.703	1.000
	Evening	5	45	4.83%	0.948	2.900	0.589	
Orthoptera	Morning	29	418	23.08%	2.593	10.976	0.851	0.600
	Evening	19	225	24.19%	1.753	9.973	0.595	

Table 2. Comparison between dawn (8:00 am-10:00 am) and dusk (3:00 pm-5:00 pm) diversity based on the mean number of arthropod species

Insect Orders	Time scale	Species Abundance	Species richness	Mean ± SE	Standard deviation	t-value	p-value
Coleoptera	Morning	155	16	4.521±1.663	7.979	2.40	0.010*
	Evening	51	17				
Diptera	Morning	342	20	5.481±3.422	17.782	2.59	0.007**
	Evening	194	20				
Lepidoptera	Morning	217	17	5.636±2.306	10.891	2.20	0.010*
	Evening	93	13				
Hemiptera	Morning	263	16	1.548±2.005	11.166	0.55	0.290^{NS}
	Evening	215	26				
Hymenoptera	Morning	232	18	5.034±1.360	7.325	3.32	0.001**
	Evening	86	23				
Neuroptera	Morning	20	2	7.50±3.233	4.573	3.00	6.310^{NS}
	Evening	5	2				
Odonata	Morning	22	2	17.50±10.22	14.453	1.20	0.220^{NS}
	Evening	4	2				
Mantodea	Morning	47	2	9.00±4.490	6.350	1.50	0.180^{NS}
	Evening	12	1				
Araneae	Morning	95	7	10.00±3.755	11.874	1.51	0.080^{NS}
	Evening	45	5				
Orthoptera	Morning	418	29	7.423±3.131	15.969	2.25	0.010*
		225					

revealed the highest Shannon diversity index (H = 4.343) while the evening time revealed the least Shannon diversity index (2.535). The morning time showed the highest Margalef index (D = 63.99) and evening time showed the least Margalef index (D = 61.49). Concerning species numbers Orthoptera, Hymenoptera and Lepidoptera had a maximum number of species in the morning time, while in the evening Hemiptera, Hymenoptera, and Diptera had a greater number of species. In the morning Hymenoptera showed the highest Shannon-wiener index. While in the evening Orthoptera and Diptera showed the highest Shannon-wiener index. Based on the Sorensen similarity index, both times showed 77.9% similarity. Arthropods in the order Araneae revealed the highest similarity 100% followed by the Hemiptera 97.5%, Lepidoptera 93.3% and Coleoptera 90.9% (Table 1).

Moreover, a total of 10 orders were collected at morning and evening time, most of them were bearing a significant difference among the species means and also by *P* values of t-test; Diptera ($p < 0.05$), Hymenoptera ($p < 0.05$), Coleoptera ($p < 0.05$), Lepidoptera ($p < 0.05$) and Orthoptera ($p < 0.05$). It was also noted that abundance differed significantly differed in the morning and evening times (Table 2). The highly abundant orders of arthropods were Orthoptera 23.45% Diptera 19.55 %, Hemiptera 17.43%, while Mantodea 0.94% and Neuroptera 0.91% were recorded in less number, results suggest that maximum found orders are more associated with agroecosystems zones (Figure 2).

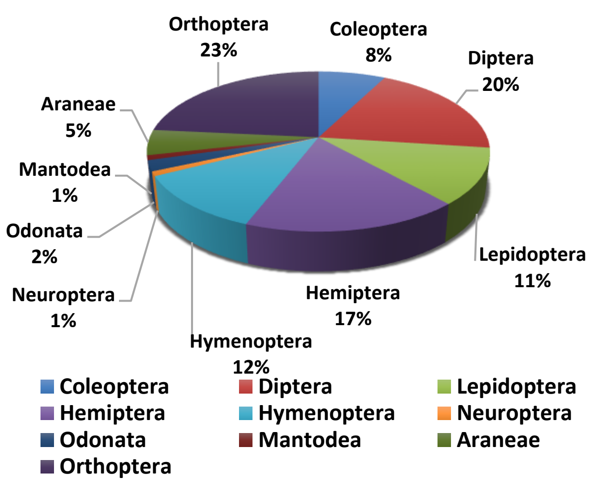

Figure 2. Abundance of arthropods in each order collected in a mixed agroecosystem of District Faisalabad, Pakistan

DISCUSSION

In the present study, diversity was recorded for the morning and in minimum number for the evening. Different orders were found such as Orthoptera, Diptera, Hemiptera, and Lepidoptera while some were found in the minimum number as discussed in the result section. The present study showed similarity with the previously studied results of Mubashar et al. (2017) which indicated the presence of 18 species and 3 families. Similarly, Rana et al. (2016) recorded the ecological diversity of three insect orders (Coleoptera, Siphonaptera, and Diptera) from which the highest abundance was recorded in order Diptera. Rana et al. (2019) and Naseem et al., (2020) estimated the diversity of arthropods regarding habitat specialty in agro-ecosystem. Mirfakhraie (2017) found the evenness and the richness in Coccinellids and aphids' species by diversity indices, these species were present in maximum in number and findings were similar to our results.

The difference in means of insect's diversity and abundance between both the communities may be effectively made by the unavailability/availability of resources and stability of the ecosystem (Adjaloo et al., 2012, Jaganmohan et al., 2013). Similarly, Amber et al. (2015) check out the abundance and richness of insect fauna. The high abundance of orthoptera probably was because of they are natural herbivores and well adapted in open areas, grasslands and croplands (Rehman, 2001; Qureshi and Bhattim, 2006; Sultana et al., 2013).

In Pakistan, many researchers worked on crop pests and reported orthoptera as pests (Usmani et al., 2012; Arya et al., 2015). In different studies conducted at Multan (Mehmood et al., 2011) and Mir Pur (Rafi and Usmani, 2013), 21 and 25 species of orthoptera were reported to feed on various species of crops. Different studies have shown that grasshopper species presented variations in different seasons (Akhtar et al., 2012). Order Hemiptera or true bugs live in the majority of habitats, generally terrestrial (Foottit et al., 2009). In recent study, Hemiptera was 3rd highest order and Hymenoptera was also recorded in good range as they are good pollinators of many habitats (Sharkey, 2007). Generally, Coleoptera is herbivores, scavengers, or predators (Lee et al., 2014). Coleopteran has special adaptive features in their mouthparts at larval and adult stage, which helps to feed on the diver's food and adaptability in different habitats (Rainio and Niemela, 2003; Lee et al., 2005; Lee et al., 2013).

The experiment clearly showed a significant difference in relative abundance in morning and evening times. Okrikata and Yusf (2016) conducted a field survey in Wukari, Taraba State to acquire the diversity and abundance of arthropod fauna in selected habitats and these results are similar to our findings. The number of foliage arthropods was higher at dawn time; it supports the claim that energy-related influences are of significance in influencing the temporal dynamics of the distribution of insect species (Ziesche, 2017). They tend to affect the conservation and management of species along the gradient, and while the underlying mechanisms that are believed to have interaction on the landscape scale (Lister and Garcia, 2018). This observation supports the idea that available energy may be more important for the chance of a species to persist in a habitat (Currie et al., 2004; Hurlbert and Jetz, 2010). The estimations of preceding researchers in wide-ranging areas were parallel to our recent findings, but due to diversity in environmental factors and artistry, expertise in handling and validation of data, sooner or later deviations were noted (Ayuke et al., 2009).

***Conclusion*: As long as, high diversity and abundance in the morning proposed a high range of successful species, arthropod fauna is less disturbed, ecologically stable, and few changes in ecological factors, while in the evening it was recorded less as compared to morning. Consequently, the results of this study revealed that both morning and evening timings had capability to sustenance the fauna diversity of arthropods. Fauna showed more association with the environment of morning time because their diversity and abundance was recorded maximum in number. As arthropods are of very great importance, more research work is needed to explore the fauna of the agro-ecosystem so that all the measurements should be taken in the conservation and management of biodiversity.

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