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DIVERSITY AND ABUNDANCE OF INSECTS IN TWO DIFFERENT DISTRICTS OF PUNJAB, PAKISTAN

K. Abid[1], N. Rana[1], W. Majeed[1]*, N.J. Alotaibi[2], H.A. Khan[1], S. Manzoor[3], S. Maalik[4], R. Kiran[1] and M.Z.E. Arif[1]

[1]Department of Zoology, Wildlife and Fisheries, University of Agriculture, Faisalabad, Pakistan
[2]Department of Biology, Faculty of Science, Taif University, P.O. Box 11099, Taif 21944, Saudi Arabia
[3]Department of Zoology, University of Sialkot, Sialkot, Pakistan
[4]Department of Zoology, Government College Women University, Sialkot, Pakistan
*Corresponding author: waqar.majeed@uaf.edu.pk

ABSTRACT

The diversity of insects is considered a key element in the ecosystem. Climatic conditions affect the distributional patterns of insects such as change in weather influence population dynamics and insect abundance. The present study was designed to ascertain the faunal diversity and abundance in two districts of Punjab, Pakistan. Insects were collected monthly for one year using light traps. Data were collected measuring the environmental variables, viz. temperature, humidity, and wind speed. Samples were then brought to the laboratory and shifted to vials. After that, the specimens were identified using taxonomic keys and literature. The maximum population recorded from the Hafizabad was 75.66% (N=14509), and the lowest population from the Faisalabad was 24.34% (N=4667). Insects belonging to 11 orders, 68 families, 123 genera, and 140 species were recorded from Hafizabad, while ten orders, 77 families, 145 genera, and 177 species were recorded from Faisalabad. *Tanytarsus* sp. was the most abundant taxon from both localities. The Shannon diversity (H′) index was recorded as 3.60 and 2.747 from Faisalabad and Hafizabad, respectively. Evenness was recorded highest from Faisalabad (0.6955), and dominance was maximum from Hafizabad (0.4440). The diversity of species was determined to be significantly different from both areas, while abundance from Faisalabad was less due to environmental variable influence. Since insect biomass reduction is critical in the contemporary world and, in-depth studies on insect diversity patterns are helpful for insect conservation plans.

Keywords: Diversity indices; Environment; Effects; Insects; Habitats.

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INTRODUCTION

Biodiversity is the variability of living creatures, including entire fauna and flora, which exist at morphological, genetic, anatomical, and structural levels (Majeed *et al.*, 2019; Ramzan *et al.*, 2021). It has great significance regarding ecosystem sustainability and plays a vital role in regulating environment at local and regional levels (Johnson *et al.*, 2013; Stork, 2018; Basset *et al.*, 2020). Research on biodiversity is highly applicable as it provides knowledge of ecosystem processes, especially in areas of high agricultural productivity. Insects are considered important environmental indicators and comprise the bulk of macrofauna (Carvalho *et al.*, 2020; Krahner *et al.*, 2021). They modify the environment directly and indirectly and make resources available for other species and improving ecosystem by providing pollination, decomposition, soil engineering, and removal of harmful and deleterious pests by predators (Culliney, 2013; Abid and Rana, 2019).

Insects are one of the most important creatures because of their diversity, distributional patterns, and ecological roles ecosystems (Finlay-Doney and Walter, 2012). Worldwide, 60 % of invertebrates are nocturnal and considered vital elements of the ecosystem, where their diversity decline will trigger ecological imbalances (Futahashi *et al.*, 2015). Nocturnal insects respond to environmental fluctuations, as do all species. Temperature significantly affects insect biodiversity, as do fluctuations in humidity; nocturnal insects are influenced by all these changes (Saunders, 2012; Filazzola *et al.*, 2021; Jägerbrand and Bouroussis, 2021; Outhwaite *et al.*, 2022). Species diversity, abundance, and distribution fluctuate around aquatic habitats, where structural characteristics affect their distributional patterns. These insects have a variety of adaptations that allow them to survive in wet areas (Macadam *et al.*, 2021; Skendžić *et al.*, 2021). They are good indicators of environmental fluctuations and are robust and rapid adaptive with high fecundity rates and short life cycles (Schowalter, 2016; Parikh *et al.*, 2021).

Environmental conditions have significantly impacted insect species' growth, development, and reproduction (Sharkey *et al.*, 2017). Biotic and abiotic factors play essential roles in the existence of species. With any changes in these factors, insect species will face behavioral, anatomical, and physiological changes that affect their diversity in all ecosystems, including terrestrial, forest, and mixed environments (Régnière *et al.*, 2012). Previous research has shown that increasing agricultural field management intensity is one of the primary reasons for the loss in local species richness (Stein-Bachinger *et al.*, 2021). Light plays a significant role in spatiotemporal distribution, including their attraction toward light or disorientation from artificial illumination (Gaston *et al.*, 2013; Gaston and Holt, 2018). For many years, ecologists have been aware of the global decline in biodiversity that many terrestrial and aquatic species have suffered (Sánchez-Bayo and Wyckhuys, 2019). There is a scientific agreement that insects and other arthropods declining is a major problem that humanity must address (Pina and Hochkirch, 2017; Basset and Lamarre, 2019; Harvey *et al.*, 2020).

A wide variety of insects, with their intricate interactions, provide us with food and help to remove waste. Human existence would be impossible without these services. Even a low estimate of the economic value of a small subset of the ecosystem services provided by these insects would prioritize their conservation (Govorushko and Nowicki, 2019; Harvey *et al.*, 2020). These organisms are essential in ecosystem, comprising the food chain and ecological services. Thus, understanding their value they are considered extremely important. It is assumed that the diversity pattern and flow of species richness vary depending on the environmental variables. Keeping in view the importance of insect's richness and diversity in the ecosystem functioning, this study's main objective was to ascertain the diversity and abundance of the nocturnal insect fauna and the influence of environmental variables in two different areas of Punjab, Pakistan.

MATERIALS AND METHODS

Study areas: The present study was planned to find the diversity patterns and abundance of nocturnal insects from two Punjab districts, i.e., Hafizabad and Faisalabad in Pakistan. To achieve the objectives of the present study, a preliminary survey was made to select the sites. The work was done from the January to December 2018. The characteristics of habitats are represented in Table 1. A map is also presented for the location of sites (Fig. 1).

Experimental layout: White light bulbs (500 W) attached to poles and white screens were used to collect nocturnal insects. A 5-hectare vegetation area around the water bodies was selected for the sampling (once a month), and three sub-sites were marked in each area from January to December 2018. The Transect method was used to attach lights to poles and tubs kept in the transect area. The same trap type was used at three sub-sites (3-Twenty gallons of plastic washing tubs (1 ft height, 2ft diameter, 1 ft filled depth) were placed under the light containing a 30:70 formalin: water solution. Tubs were adjusted at equal distances in a 5-hectare area. Lights were operated from sunset to morning and the insects were collected the following day. A strainer was used to remove insects from the tubs. The ground insects were collected using forceps and handpicking. The three collecting sites from each location were considered a sample and repeated for one year (12 months). The sampling date, time, and number of samples along with average temperature and humidity (environmental factors data taken from the meteorology cells of both districts), were mentioned on the sample jar. After transporting samples to the Biodiversity Laboratory, Department of Zoology, Wildlife, and Fisheries, University of Agriculture, Faisalabad, specimens were separated based on their morphology and placed in different vials containing a 10% formalin along with a few drops of glycerin solution (Triplehorn *et al.*, 2005).

Identification of Specimens: All specimens were identified using a magnifying glass, the naked eye, simple and stereomicroscopes, taxonomic materials (Triplehorn *et al.*, 2005), the fauna of British India and online websites (Bugnet.com, AntWiki, Antweb, etc.).

Statistical analyses: Identified specimens were tabulated to taxonomic levels, including order, family, genus, and species. Shannon diversity index (Diversity (H'), evenness, richness, and dominance) was used to determination of various aspects of diversity (Magurran, 1988). ANOVA was used to compare the significance of the month-wise flow of species and analyze levels of variation within the species. A rarefaction curve was drawn to check the species richness from both Faisalabad and Hafizabad. Correlation was used to study the impact of climatic factors on insect diversity under different ecological conditions. All data were analyzed at the significance of $\alpha = 0.05$. Microsoft Excel, Past3, Graphpad Prism and Minitab software were used for the analysis.

RESULTS

Population dynamics of the nocturnal insect fauna were documented in the wetlands of the Hafizabad and Faisalabad districts. A total of 19,176 specimens were collected from both territories, with the maximum population recorded from Hafizabad at 75.66% (N = 14509) and the least population recorded from Faisalabad at 24.34% (N = 4667). Taxonomic classification and composition of results were analyzed from Hafizabad and

Faisalabad. The most abundant species were recorded as *Tanytarsus* spp. from Hafizabad and Faisalabad, having a relative abundance of 14.69 % (N = 2132) and 19.26 % (N = 899), respectively. From Hafizabad, 12 orders, 68 families, 124 genera, and 141 species were collected. In comparison, Faisalabad had ten orders, 77 families, 147 genera, and 178 species (Fig. 2). The relative abundance of collected groups was calculated to indicate their dispersal and distribution between the different districts. In the present study, data were also documented up to the order level, and it was found that Hemiptera and Coleoptera were present in maximum abundance in Hafizabad, while in Faisalabad, Diptera and Hemiptera were highest (Fig. 3).

Maximum diversity (H′) was recorded (4.151) from Faisalabad as compared to Hafizabad (2.784). Evenness was recorded highest (0.356) in Faisalabad. Dominance and Simpson were maximum from Hafizabad (0.094) and Faisalabad (0.952). However, Richness (R) was recorded as maximum from Faisalabad (20.95) as compared to Hafizabad (14.61) (Table 2). From Hafizabad, diversity within species and between months was estimated as significant ($F_{225} = 1.664$, $p < 0.001$ and $F_{11} = 2.925$, $p < 0.001$), respectively. In contrast, in the case of Faisalabad, diversity was recorded as significant within species and between months ($F_{225} = 7.384$, $p < 0.001$ and $F_{11} = 7.307$, $p < 0.001$), respectively (Table 3).

The plot of the rarefaction curve indicated that insect taxa were more diverse in Faisalabad than in Hafizabad (Fig. 4). In the Faisalabad region, taxa were recorded as maximum in September, April, August, March, and July. In comparison, the minimum was found in January, December, November, and February (Fig. 5A). In the Hafizabad region, insect species were recorded in September, August, and July. In contrast, the minimum was found in February, December, and June (Fig. 5B).

The influence of environmental variables was most significant with decreasing and increasing temperature and humidity. Temperature demonstrated a significantly positive correlation to abundance, while a negative correlation was shown with humidity. Faisalabad temperature also demonstrated a significantly positive correlation to abundance, while a negative correlation was shown by humidity. A severe fluctuation was examined in the correlation of species diversity and wind speed (Fig. 6a-b).

Table 1: Characteristics of two study areas of Punjab, Pakistan

Information	Hafizabad	Faisalabad
Coordinates	32.0712° N, 73.6895° E	31.4504° N, 73.1350° E
Elevation	210.9 m	185.92 m
Average annual Temperature ºC	24.87ºC	26.2 °C
Average annual humidity %	68.3	64.5
Vegetation	Grassy plots, Shrubs, herbs, Plantation	Grassy fields, Shrubs, Plantation
Distance of sampling sites from water bodies	300 m	300 m
Distance between both areas	122 KMs	

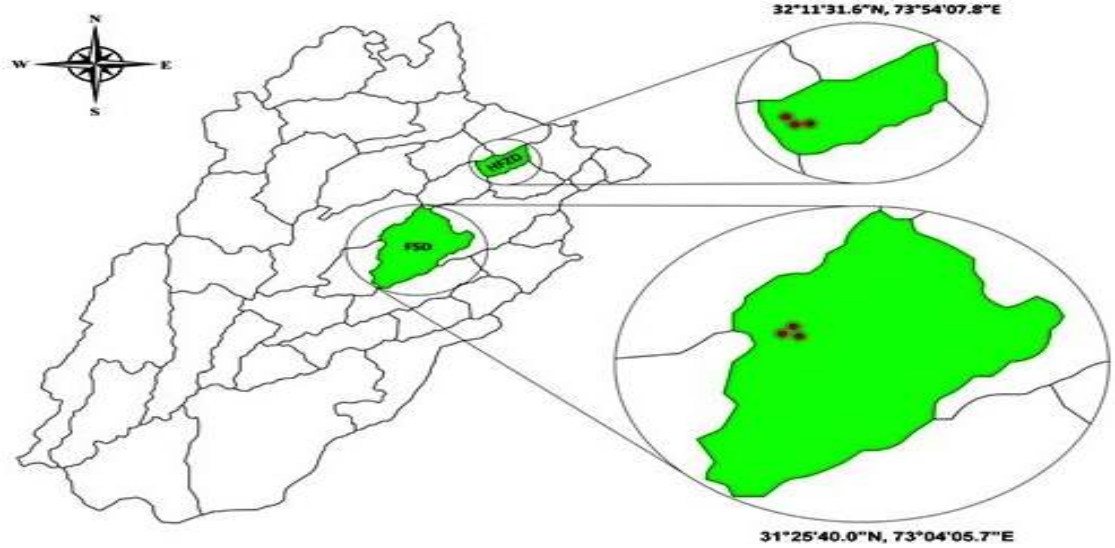

Figure 1: Map of the study areas. The whole map represents Punjab.

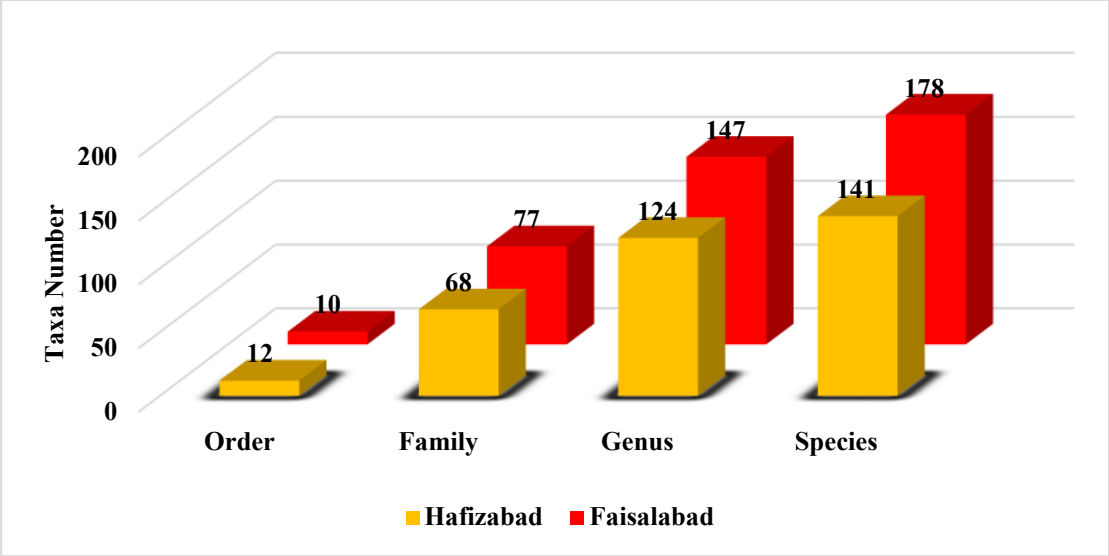

Figure 2: Taxa recorded from Hafizabad and Faisalabad

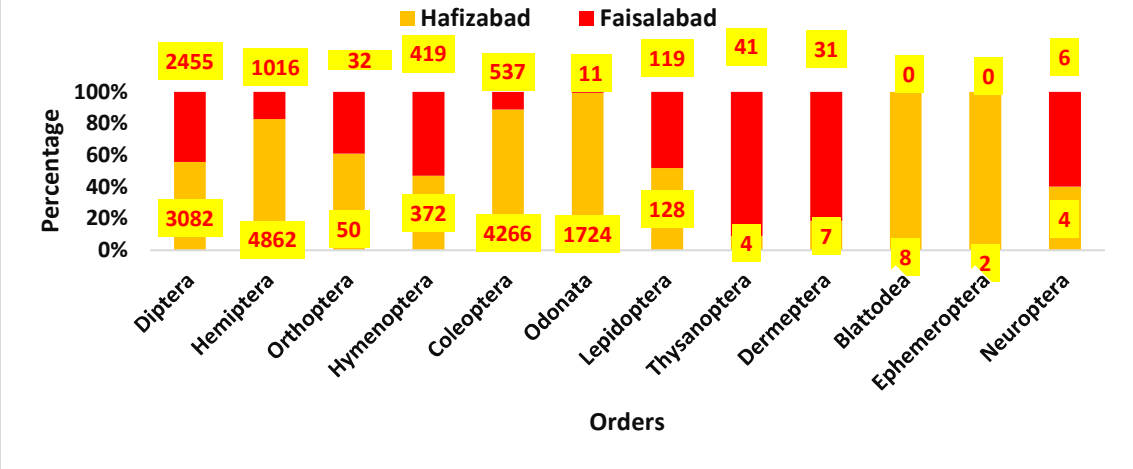

Figure 3: Abundance of insect orders from Hafizabad and Faisalabad

Table 2: Overall diversity indices recorded from Hafizabad and Faisalabad.

Diversity Indices	HFZD	FSD
Diversity (H)	2.784	4.151
Evenness (J)	0.114	0.356
Dominance (D)	0.094	0.048
Simpson (1-D)	0.906	0.952
Richness (R)	14.61	20.95

Table 3: Analysis of variance among species diversity and months.

Source of Variation	Hafizabad				Faisalabad			
	df	MS	F	P-value	df	MS	F	P-value
Species Diversity	225	351.89	7.384	0.000	225	6987.52	1.664	0.000
Months	11	348.22	7.307	0.000	11	12279.2	2.925	0.000
Error	2475	47.65			2475	4197.00		
Total	2711				2711			

$p < 0.05$* ; 0.01** ; 0.001***

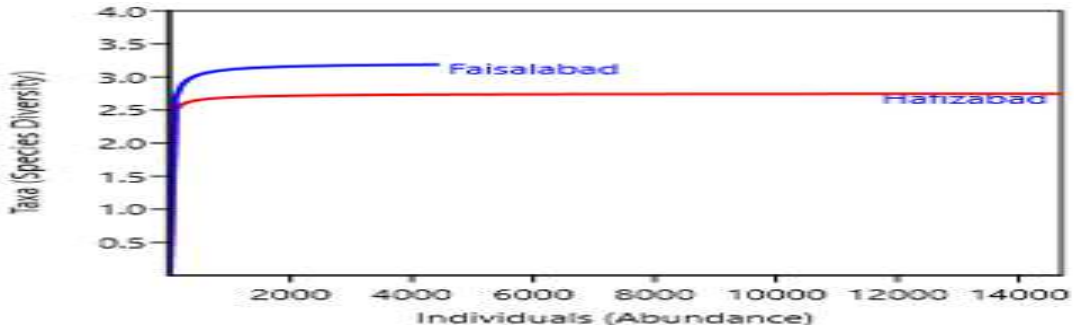

Figure 4: The rarefaction curve showing the abundance in Hafizabad and Faisalabad regions.

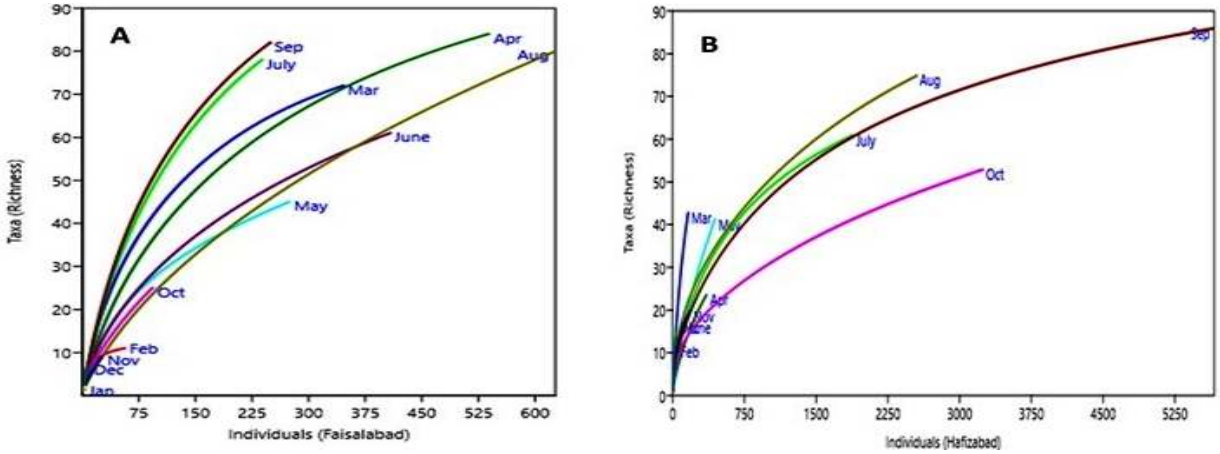

Figure 5: The rarefaction curve showing the month-wise species diversity A) Faisalabad B) Hafizabad

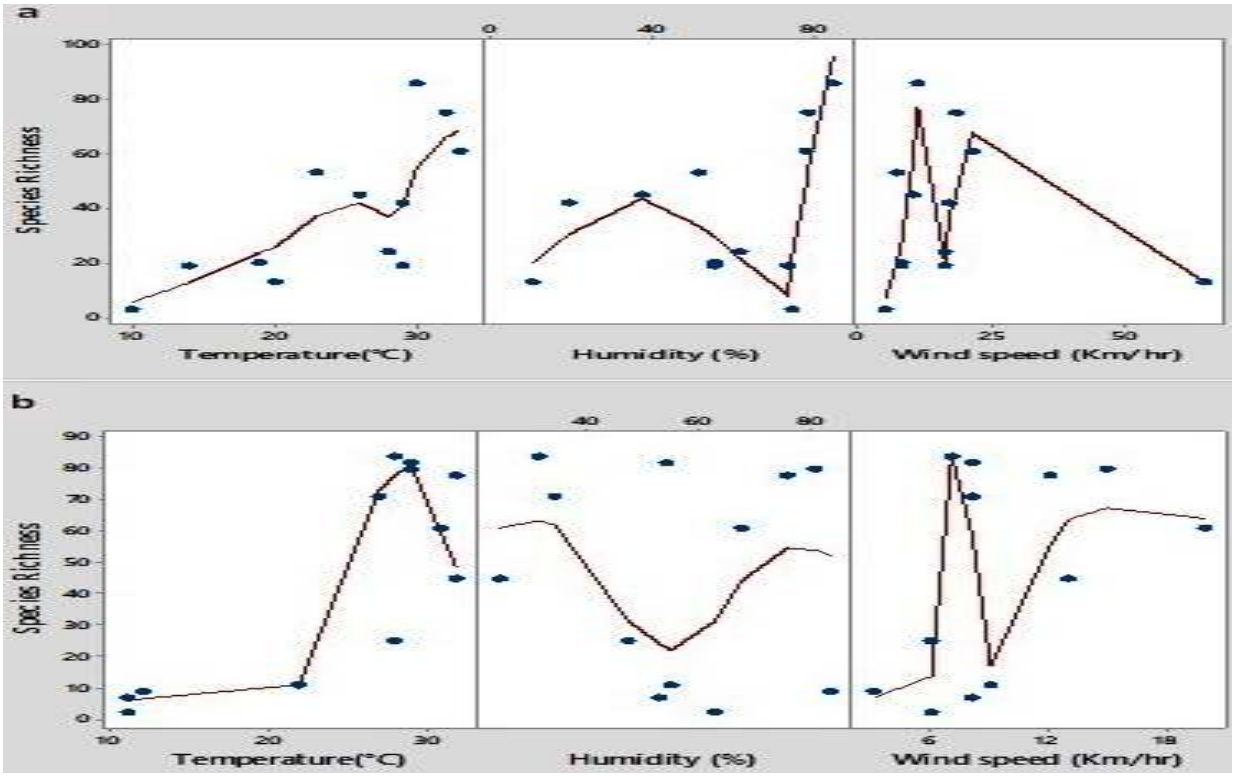

Figure 6: Relationship of species with Temperature, Humidity and Wind speed of both territories A) Hafizabad B) Faisalabad.

DISCUSSION

In the present study, Hafizabad showed maximum insect abundance compared to Faisalabad, reasoning variability in environmental changes that affect fauna's abundance (Neuvonen and Virtanen, 2015; Facon *et al.*, 2021). Kyerematen and Gordon, (2012) studied the population dynamics of the insect fauna of different territories for one year covering all seasons. They identified seven orders belonging to twenty-six families and 57 species. The same trends of findings in which the diversity of insects was affected by the environmental variables were recorded by (Majeed *et al.*, 2020) and (Maneechan and Prommi, 2015). Species diversity and abundance may also fluctuate between habitat types or years attributed (Ives *et al.*, 2005; Kriegel *et al.*, 2021). Many species of animals, including insects, modify their behavior in the presence of predatory animals, e.g., avoiding open areas or remaining longer under the leaves (Thomson *et al.*, 2006; Kawahara *et al.*, 2021). Hemiptera order was recorded more in both territories, showing that the pest population is higher in the cropping system, which can be destructive in the future.

In the present study, maximum Diversity (H′) was recorded from Faisalabad, while the least diversity was recorded from Hafizabad as the habitat is more deteriorated in Faisalabad, which affects the abundance in this region. The species richness and diversity were also estimated by (Rimsha *et al*., 2020; Albrecht *et al*., 2021), and insects were found to be significantly diverse. Different diversity factors influence the variety and abundance of insects under other ecological conditions (Bar-Massada and Wood, 2014; Stein *et al.*, 2014; Dorji *et al.*, 2016). The abundance of insect species is also enhanced by a more cultivated area (where vegetation/crops are more) (Harris and Ratnieks, 2022). The study described that the temperature significantly correlated to the abundance, while a negative correlation was shown by humidity. The high temperature and humidity level majorly influenced the abundance. The richness of insects is influenced by environmental factors, such as temperature and humidity (González-Césped *et al.*, 2021; Goodwin *et al.*, 2021). Payakka and Prommi (2014) worked on the biological diversity of wet territory insects and collected 4257 specimens of 6 orders and 12 families. Nirmal *et al*. (2017) also worked on insect collection using various colored light traps and found significant results. Many studies have described the combined effects of natural landscape fragmentation, microclimatic conditions, relationship between these factors and insect populations in nonagricultural environments (Nguyen and Nansen, 2018; Ohler *et al.*, 2020). The various organisms' trophic are influenced by plant diversity (Han *et al.*, 2022). Plant diversity and flower visitors are connected owing to insect-specific preferences. The fluctuations in plant diversity and distribution, together with alterations in phenology, caused by increased temperatures may have harmful consequences for other trophic levels, particularly for flower-visiting insects and other pollinators (Hegland *et al.*, 2009; Hoiss *et al.*, 2015), thereby having an influence on community structure and putting ecosystem functioning in danger (Dunne *et al.*, 2003).

The current study showed that environmental conditions influenced insect diversity patterns as species richness abundance varied in both areas. Recent findings showed that terrestrial variables significantly impact the variety and compositions of rising insects within habitats (O'Malley *et al.*, 2020). The species richness of the order Diptera and Coleoptera was positively influenced by the degree of habitat complexity and these species are potential bioindicators of habitats (Balakrishnan *et al.*, 2014). In one of the studies, it was estimated that taxa populations of Diptera are at the highest of extinction (Santos *et al.*, 2017). The water bodies impact the diversity and occurrence of insects under different environmental conditions (Majeed *et al.*, 2019). The study led to the hypothesis that low light intensity (and perhaps other abiotic factors) may influence crepuscular insect flight responses from the population (Seybold *et al.*, 2012; Chen and Seybold, 2014). In the district of Faisalabad, the habitat condition is complex and polluted due to industrialization compared to Hafizabad. We have observed that these conditions may affect the abundance of fauna, which is alarming for species richness in the future. The present study found that more temperature affects species richness and vegetations prompt abundance. Extreme climatic conditions reduce the insect population while their population is highest at optimum temperature (Kanwal *et al.*, 2023). The impact of temperature on distributional patterns and diversity of macroinvertebrates seems to occur as it influences fauna (Gurney *et al.*, 2022). Environmental conditions and elevational gradients greatly affect insects' diversity and distributional patterns (Corcos *et al.*, 2018). To this end, we perceive a need for dispersed, standardized collaborative investigations across study systems and intensive re-analysis of existing data. In the future, this change in the diversity and abundance of insects should be prioritized and conservation measurements should be applied.

Conclusion: In conclusion, the pattern of the nocturnal insect fauna diversity in two different wetlands and it was concluded that maximum abundance was most incredible for Hafizabad. The species richness of the orders Diptera and Coleoptera was positively influenced by the degree of habitat complexity. From the results, we observed that water bodies significantly affect the diversity and distribution of the fauna. The diversity and abundance of the fauna were indications of environmental variables such as temperature and humidity, which can produce

significant changes. It was suggested that to balance faunal diversity, aquatic habitats must be maintained using different methods. It is an important concern that the insect population should be managed with appropriate conservation strategies. Further empirical investigations and syntheses focused on non-linear effects are needed to understand better the relationship's actual form and the applicability and validity of the heterogeneity area.

Conflicts of Interest: There is no conflict to declare among authors.

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