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Assessing the Diversity and Relative Abundance of the Order Odonata, Hymenoptera, and Hemiptera in Rice, Maize, and Wheat Fields

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ABSTRACT

The objective of the current study was to assess the diversity of Odonata, Hymenoptera, and Hemiptera in the fields of rice, maize, and wheat under relevant factors. The area of these crops in the District Faisalabad was where specimens related to these orders were gathered. Faisalabad employees choose several ways of collecting, like hand picking, using a hand net, and forceps. From October 2013 to April 2014, the entire sampling was random. With the aid of taxonomic information, collected insects were identified based on their morphological traits and faunal diversity belonging to selected orders as the trustworthiness of these crops for these orders was documented. The highest variety (H′) was found in maize fields (7.3204), followed by rice (2.2707), and wheat fields (2.1758). In contrast, the highest diversity (H max) was almost equally distributed among the three crops. However, the highest levels of evenness (J) were found in the maize crop as compared to others. Wheat crop fields (0.1757), rice fields (0.0779), and maize fields (0.0779) showed the highest levels of dominance (D) (-2.0049). All crops had equal documented levels of wealth (R). The overall results between these crops were statistically significant (P = 0.05053; F = 3.0522) and t-Test analysis was also significant, but the P-value ratio was different.

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INTRODUCTION

About 90% of the grains produced for human use originate from cereal crops, such as wheat, rice, and maize. Cereals are a significant source of surplus food for both humans and animals. (Govt. of Pakistan, 2013; FAO, 2014). The "King of Cereals," wheat (*Triticum aestivum* L.), is ranked first among cereal crops and accounts for around 66% of the total yearly production of food crops. (Anonymous, 2013). In terms of cereal output and consumption, maize (*Zea mays* L.) comes in second place to wheat, according to international estimates. (FAO, 2013). Another of the most significant cereal crops in the world is rice (*Oryza sativa*), the primary source of essential food for most people (Emani *et al.,* 2008).

At both the macroscopic and microscopic scales, arthropods make up a major and significant part of the biosphere on Earth. The war on insects, which has been waged in the name of wasteful and profit-driven agriculture, has had disastrous effects on the survival of these species globally. In particular, pollinators' extinction is likely to result in a cascading ecosystem collapse (Sánchez-Bayo and Wyckhuys *et al.,* 2019). They live everywhere and are very important to the stability and operation of both terrestrial and aquatic ecosystems. Due to their ecological significance, biological diversity, and impact on agriculture, insects are significant. Pests, predators, parasitoids, pollinators, and non-economically important species make up the insect fauna connected to agroecosystems. (Adetundan *et al*., 2005; Premalatha *et al*., 2011).

Because most of the rise in global food production depends on expanding land conversion and deforestation rather than agricultural intensification, the progress made in providing food security is accompanied by a sizable loss of biodiversity. A crucial sustainability argument has centered on addressing the rising demand for agricultural land and the possibility of sharing vs spare land to accomplish biodiversity conservation and sustainable usage of these areas (Latini *et al*., 2020; Carney*et al.,* 2020). Arthropod diversity can be increased through specific management and conservation (Yekwayo *et al*., 2018; Geldenhuys *et al*., 2020).

Variations in phenology, diet breadth (some species polylactic, others oligolectic), and voltinism are all present in the Order Hymenoptera. Despite being the second-largest genus of bees, it is still unknown what causes such incredible diversity (Bossert *et al*., 2022). Hemipterans are a common and varied prey that is an essential link in many food webs since they are a food supply for many predators. Many of these predators also contribute to the high diversity of the groups by engaging in mutualism with other taxa. Due to their reliance on water quality, only a few members of this order serve as biological indicators (Lloyd *et al*., 2003). In several aquatic systems worldwide, Odonata-order insects have been used as environmental quality indicators. Odonata (dragonflies and damselflies), an order of aquatic insects, has distinguished itself due to its high habitat specialization and well-resolved taxonomy (junior *et al*., 2020).

MATERIALS AND METHODS

To achieve the study's goals, sampling locations were chosen from the rice, maize, and wheat fields in five distinct locations throughout the District Faisalabad: Jaranwala, Sadar, Samundri, Chak Jhumra, and Tandlianwala. Our sampling locations (fields of rice, maize and wheat) was almost at 7-8 km away from these main cities. For a total of six months, from October 2013 to March 2014, sampling was done on a fortnightly basis. Sampling mostly done during early morning (round about 6am-9am) and late noon (round about 3pm-6pm). Hand-picking (for Hemiptera and Hymenoptera) and aerial netting (for Hymenoptera) techniques were used to collect the fauna either passing through or living permanently on the rice, wheat, and maize fields that were visible to the naked eye. Collected specimens were carefully moved to the Department of Zoology and Fisheries' Ecological Laboratory at the University of Agriculture, Faisalabad to prevent any harm. The specimens were kept separate in 03:07% formalin and alcohol solutions with a few drops of glycerin in labeled vials. This solution is characterized as an inexpensive and effective preservative for preserving insects. Using taxonomy information, collected specimens were identified based on their morphological traits. According to literature from Fauna of British India, Bingham (1897), and Barraud (1905), and online material, the identification was completed up to the species level. Data were statistically examined to identify the relative abundance of crops, species richness, dominance, and evenness with the Shannon-Weiner Diversity Index (1948). To estimate the distinctness of crops in terms of population dynamics/relative abundance of dwelling specimens, a t-test analysis was done. We can examine the data and explain how different treatments and factors interact using ANOVA (variance analysis). Three crops were studied using an ANOVA to emphasize the random effects and responses of Odonata, Hemiptera, and Hymenoptera orders.

RESULTS

Three crops yielded 993 specimens of Odonata, Hymenoptera, and Hemiptera. They consisted, in that order, of 43.91% (N = 436) wheat fields, 29.02% (N = 290) rice fields, and 26.89% (N = 267) maize fields.

Oebalus pungnax (Hemiptera: Pentatomidae), *Leptocorisa oratorius* (Hemiptera: Alydidae), *Lygaeidae nymph* (Hemiptera: Lygaeidae), 5.52% (N = 16), and *Nilaparvata lugens* (Hemiptera: Delphacidae), 4.83% (N=12). The hemipteran species *Euchistus servus* (Pentatomidae), *Triatoma infestans* (Reduviidae), *Leptocorisa acuta* (Alydidae), *Nabis kinbergii* (Mirridae), and *Macrocentrus grandi* (Hymenoptera: Braconidae) had the lowest relative abundance. Nevertheless, none of the following insects was found in rice fields: *Chinavia hilaris* (Hemiptera: Pentatomidae), *Nezara viridula* (Hemiptera: Pentatomidae), *Componotus spp*. (Hymenoptera: Formicidae), *Apis florae* (Hymenoptera: Vespidae), *Proctoturpes caudatus* (Hymenoptera). *Lygaeus saxatilies* (Hemiptera: Lygaeidae) had the highest relative abundance in maize fields, with 5.99% (N = 16); it was followed by *Solenopsis invicta* (Hymenoptera: Formicidae), 5.24% (N = 14), and *Lygaeidae nymp*h (Hemiptera: Lygaeidae), *Dolichder plagiatus*

(Hymenoptera: Formicidae) 4.14% (N = 12). *Zelus longipes*, *Triatoma infestans* (Hemiptera: Reduviidae), *Oncopeltus fasciatus*, *Leptocorisa acuta* (Hemiptera: Alydidae), and *Dolichoderus mariae* (Hymenoptera: Andrenidae) were the species with the lowest relative abundances, each with 0.75% (N = 02). *Tritoma sanguissuga* (Hemiptera: Reduviidae), *Nezara viridula* (Hemiptera: Pentatomidae), *Sympertrum spp.* (Odonata: Libellulidae) and *Triepeolus alachuensis* (Hymenoptera) were not observed in any fields.

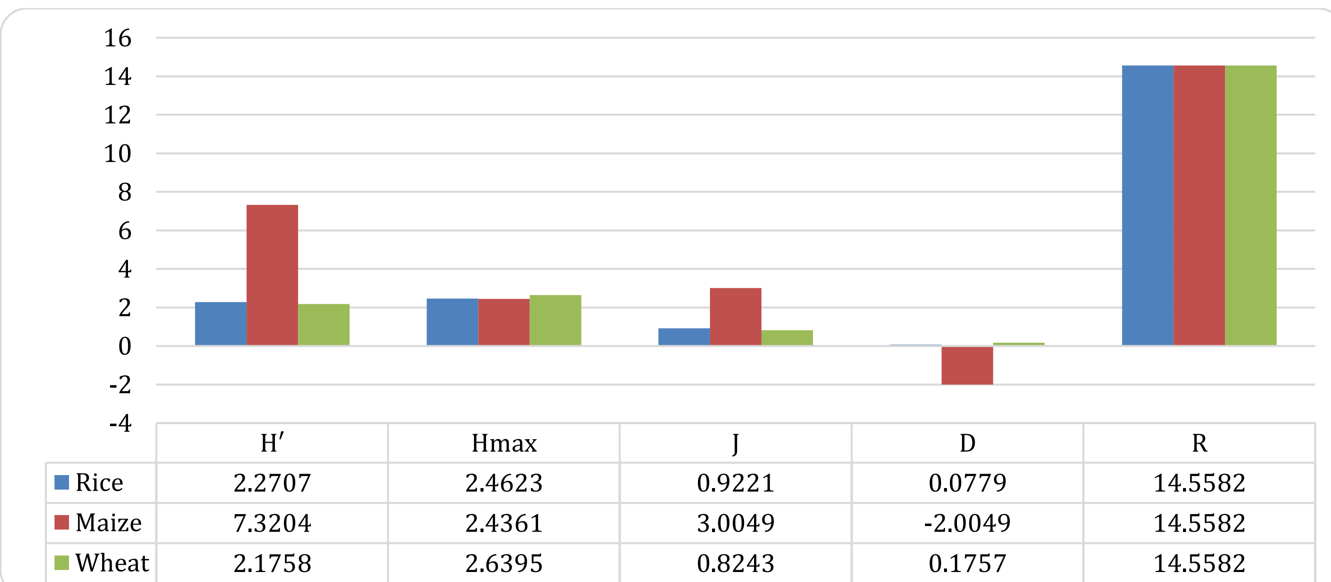
In wheat fields, *Polistes olivaceous* and *Vespa orientalis* (Hymenoptera: Vespidae) accounted for 14.91% (N = 65) and 8.72% (N = 38), respectively, of the relative abundance. The highest relative abundance was found in *Andrena walkella* (Hymenoptera: Andrenidae), which was reported at 4.59% (N = 20). *Phenacoccus hirsutus* (Hemiptera: Pyrrchocoridae) and *Componotus spp.* (Hymenoptera: Formicidae) were next with 4.13% (N = 18) and 3.67% (N = 16), respectively. *Cassidarubiginosa* (Hemiptera: Chrysomelidae), *Sogatella furcifera* (Hemiptera: Delphacidae), *Triepeolus alachuensis* (Hymenoptera: Apidae) 3.67% (N = 16).Whereas *Chinavia hilaris*, *Euchistus servus* (Hemiptera: Pentatomidae), *Zelus longipes* (Hemiptera: Reduviidae), *Leptocorisa oratorius* (Hemiptera: Alydidae), and *Dysderscus koenigii* (Pyrrchocoridae) were the species with the lowest relative abundance0.46 percent, *Oebalus pungnax* (Hemiptera: Pentatomidae), *Triatoma infestans*, *Triatoma sanguissuga* (Hemiptera: Reduviidae), *Nabis kinbergii* (Hemiptera: Mirridae), *Macrocentrus gifuensis* (Hymenoptera: Braconodae), *Astata boops* (Hymenoptera: Carbronidae), *Plactrotena mandibularis* (Hymenoptera: Formicidae) and *Proctoturpes caudatus* (Hymenoptera: Proctotrupidae) (Table 1).

Table 1. Odonata, Hemiptera, and Hymenoptera relative abundance and population dynamics in rice, maize, and wheat fields.

Order	Family	Species	Rice Relative abundance (Population dynamics)	Maize Relative abundance (Population dynamics)	Wheat Relative abundance (Population dynamics)
Odonata	Libellulidae	*Crocothemis spp*.	3.45 (10)	1.50 (4)	3.67 (16)
	Aeshnidae	*Sympetrum spp.*	1.38 (4)	0.00 (0)	2.29 (10)
		Anax Parthenope	3.45 (10)	0.75 (2)	1.38 (6)
	Lestidae	*Lestes spp.*	4.83 (14)	1.50 (4)	1.83 (8)
		Ischnura spp.	0.69 (2)	2.25 (6)	3.21 (14)
	Coenagrionidae	*Pseudagrion spp.*	2.07 (6)	1.50 (4)	2.75 (12)
Hemiptera	Rhopalidae	*Boisea Trivittata*	2.07 (6)	1.87 (5)	0.69 (3)
	Pentatomidae	*Chinavia hilaris*	0.00 (0)	1.50 (4)	0.46 (2)
		Scotinophora coarctata	2.07 (6)	1.50 (4)	0.92 (4)
		Euchistus servus	0.69 (2)	3.75 (10)	0.46 (2)
		Oebalus Pungnax	4.83 (14)	1.50 (4)	0.00 (0)
		Nezara viridula	0.00 (0)	0.00 (0)	3.21 (14)
		Thyanta custator	1.38 (4)	1.50 (4)	2.29 (10)
	Reduviidae	*Zelus longipes*	1.38 (4)	0.75 (2)	0.46 (2)
		Triatoma infestans	0.69 (2)	0.75 (2)	0.00 (0)
		Tritoma sanguissuga	3.45 (10)	0.00 (0)	0.00 (0)
	Alydidae	*Oncopeltus fasciatus*	1.38 (4)	0.75 (2)	0.92 (4)
	Mirridae	*Leptocorisa oratorius*	5.52 (16)	1.50 (4)	0.46 (2)
		Leptocorisa acuta	0.69 (2)	0.75 (2)	0.92 (4)
		Nabis kinbergii	0.69 (2)	3.75 (10)	0.00 (0)
	Pentatomorpha	*Xyonysius californicus*	3.45 (10)	1.50 (4)	0.92 (4)
	Pyrrchocoridae	*Dysderscus koenigii*	2.07 (6)	3.75 (10)	0.46 (2)
		Phenacoccus hirsutus	3.45 (10)	3.75 (10)	4.13 (18)
	Lygaeidae	*Lygaeidae nymph*	5.52 (16)	4.49 (12)	1.83 (8)
		Lygaeus saxatilies	3.45 (10)	5.99 (16)	2.29 (10)
	Chrysomelidae	*Cassida rubiginosa*	6.21 (18)	3.75 (10)	3.67 (16)
	Delphacidae	*Nilaparvata lugens*	4.83 (14)	2.25 (6)	3.21 (14)
		Sogatella furcifera	2.76 (8)	1.50 (4)	3.67 (16)

Hymenoptera	Braconidae	*Macrocentrus grandii*	0.69 (2)	3.75 (10)	3.21 (14)
		Macrocentrus gifuensis	2.76 (8)	1.50 (4)	0.00 (0)
	Carbronidae	*Astata boops*	1.38 (4)	0.75 (4)	0.00 (0)
	Formicidae	*Solenopsis invicta*	1.38 (4)	5.24 (14)	1.38 (6)
		Plactrotena mandibularis	4.14 (12)	5.99 (16)	0.00 (0)
		Dolichderus plagiatus	4.14 (12)	4.49 (12)	3.21 (14)
		Camponotus spp	0.00 (0)	3.75 (10)	4.13 (18)
	Vespidae	*Polistes olivaceous*	2.76 (8)	3.00 (8)	14.91 (65)
		Apis florae	0.00 (0)	1.50 (4)	2.52 (11)
		Vespa orientalis	2.07 (6)	1.50 (4)	8.72 (38)
	Proctotrupidae	*Proctoturpes caudatus*	0.00 (0)	2.25 (6)	0.00 (0)
		Cephus pygmeus	2.76 (8)	2.25 (6)	1.38 (6)
	Apidae	*Triepeolus alachuensis*	0.00 (0)	0.00 (0)	3.67 (16)
	Andrenidae	*Apis dorsata*	0.00 (0)	3.75 (10)	3.44 (15)
		Andrena prima	0.00 (0)	2.25 (6)	1.38 (6)
		Andrena walkella	3.45 (10)	2.25 (6)	4.59 (20)
		Dolichoderus mariae	2.07 (6)	0.75 (2)	1.38 (6)
Total			290	267	436

The maximum diversity (H′) was found in maize fields (7.3204), followed by rice fields (2.2707) and wheat fields (2.1758). In contrast, the three crops' greatest levels of diversity (Hmax) were nearly similar. The highest levels of evenness (J) were found in maize crop fields (3.0049), followed by rice fields (0.9221) and wheat fields (0.8243). The highest levels of dominance (D) were found in wheat crop fields (0.1757), followed by rice fields (0.0779) and maize fields (0.0780). (0.0779). (-2.0049). All crops have comparable richness records (R).



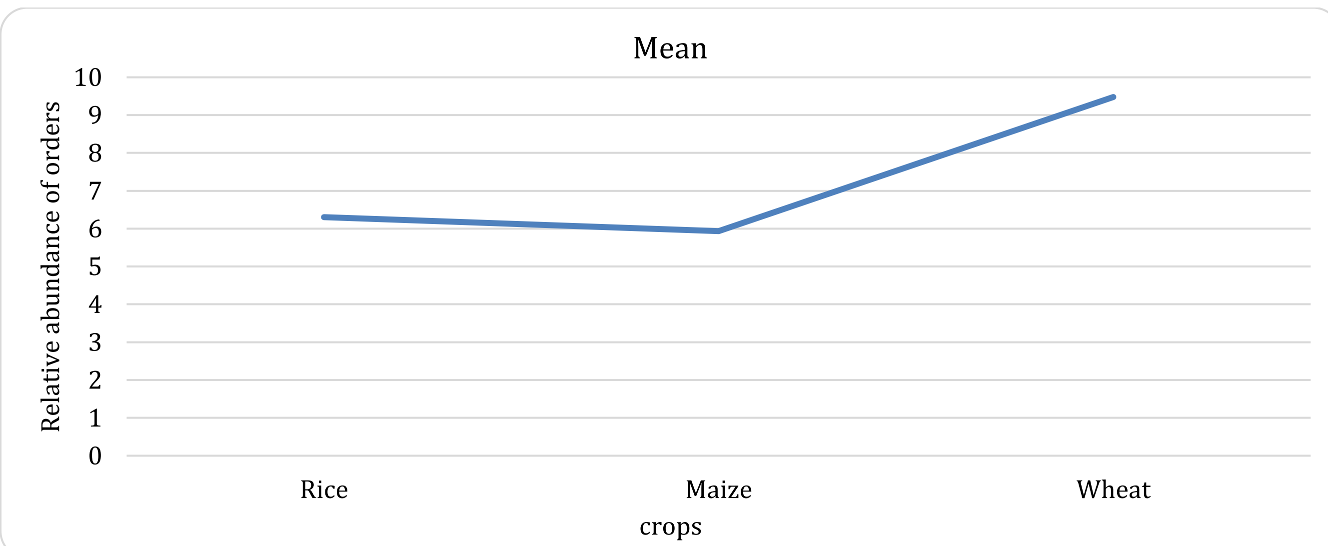
Graph 1. Diversity(H'), Diversity $_{\text{Maximum}}$ (Hmax), Evenness(J), Dominance(D), and Richness(R) of the order Odonata, Hemiptera, and Hymenoptera among rice, maize, and wheat fields.

During the present study, the total number of observation between all crops were equal (46), the degree of freedom was also equal (90), and Hypothesis Mean Difference was also the same (0). However, the mean was different among all treatments, e.g., rice vs maize (6.304348 vs 5.934783), rice vs wheat (6.304348 vs 9.478261), and maize vs wheat (5.934783 vs 9.478261). Likely, Variance was also different, e.g., rice vs maize (26.12754 vs

16.99565), rice vs wheat (26.12754 vs 128.4329), and maize vs wheat (16.99565 vs 128.4329). Consequently, Pooled Variance was also in-line, e.g., rice vs maize (21.56159), rice vs wheat (77.28019), and maize vs wheat (72.71425). The results of the t-test were significant, but the ratio of P-value was different, e.g., P-value one-tale was (0.351794/ rice vs maize), rice vs wheat (0.043394) and maize vs wheat (0.024651) – two-tale was (0.703589/ rice vs maize), rice vs wheat (0.086787) and maize vs wheat (0.049302) (Table 2).

Table 2. t-Test Analysis.

Types	Rice	Maize	Wheat
Mean	6.304348	5.934783	9.478261
Variance	26.12754	16.99565	128.4329
Observations	46	46	46
Pooled Variance	21.56159		
Hypothesized Mean Difference	0		
D.f	90		
t Stat	0.381693		
P(T<=t) one-tail	0.351794		
t Critical one-tail	1.661961		
P(T<=t) two-tail	0.703589		
t Critical two-tail	1.986674		



Graph 2. comparison of relative abundance of orders in rice, maize and wheat.

DISCUSSION

Regardless of the classification system, biodiversity can be thought of as the complete variety of life at all organizational levels. Many investigations have been motivated to better understand this diversity. Seasonal extremes change the diversity and number of arthropods in any region, making climatic fluctuations a major problem for our ecology. Habitat structure, climate, and biogeographical dynamics like habitat area are the common factors affecting species diversity in terrestrial and aquatic ecosystems (Colwell, 2009: Dossey, 2010).

Watanasit (2003) and Noon-anant *et al*. (2005) said several approaches are acceptable for any in-depth inquiry in a particular situation. Numerous additional researchers concur with the same findings (Watanasit, 2003; Watanasit *et al*., 2005a; Noon-anant *et al*., 2005). Our results support the claims made by Agosti *et al*. (2000), Eguchi (2001), Sitthicharoenchai and Chantarasawat (2006), and Habibullah *et al*. (2021) that temperature and rainfall have an impact on the ecosystem's population stability.

Burd and Porter *et al*. (2005) studied the biotypic diversity of these orders (Schizaphis graminum Rondani) (Hemiptera: Aphididae) from farmed wheat (*Triticum* *aestivum* L.) and sorghum, and they found comparable results (Sorghum bicolour L., Moench). Bosco *et al*. (2023); Watanasit *et al*. (2000); Lane *et al*., (2006); Horgan (2005); Kritsaneeapiboon and Saiboon (2001); Watanasit *et al*., 2003; Watanasit *et al*., 2000; Watanasit *et al*., 2003; (2005b) According to Watanasit (2003), Watanasit *et al*. (2003), Noonanant *et al*. (2005), and Burd and Porter (2005), in addition to the adverse effects of pesticide use and environmental successions, habitat destruction/disturbance is a critical factor in the eradication of relative richness and diversity of the concerned fauna.

Ballal *et al*. (2022), Chandish *et al*. (2022), Engmeier *et al*. (2022), and Alonso *et al*. (2000) studied the environmental changes have a substantial impact on the population of arthropods, The kind and structure of their habitats, as well as variations in microclimate, were factors that many species showed sensitivity to, and they responded to with different frequency. These adjustments should be sensitive to a species or group of species' diversity, distribution, and relative abundance since they may alter temperature, precipitation, and relative humidity.

CONCLUSION

The distribution of arthropod variety was examined the fields of wheat, rice and maize,, and it was found that wheat fields had the highest abundance of all these three orders and the highest number of species compared to rice and maize fields. The degree of habitat complexity had a favorable impact on the species richness of the order Hemiptera and Hymenoptera .Throughout the course of the trial, the number of species and specimens was also recorded. As a result, this study demonstrates that the impact of the seasons, climate, and habitat structure. Findings could be useful in creating a plan for biological control that is natural. It is recommended that the fields, employing various conventional and non-intensive ways, would be the best fortification for the species evaluated in this study. Only by coordinating planning and conservation efforts across sites can this be accomplished.

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REFERENCES

Adetundan, S.A., T.I Ofuya and J.A Fuwape. 2005. Environmental effects of insects herbivores and logging on tree species diversity in Akure Forest Reserve (Apomu). Nigeria Tropical Agriculture, 9(1&2):12-18.

Alonso, L.A., D. Agosti, J.D. Majer, L.E. Alonso and T.R. Schultz. 2000. Biodiversity studies, monitoring, and ants: An overview. In Ants. Standard methods for measuring and monitoring biodiversity. Smithsonian Institute Press, Washington. p. 1-8.

Anita, K., V. Sivakumar, V. Santhi and J. F. Borgia. 2013. Hymenopteran diversity in a delicious forest from South India. Int. J. Biod. Cons., 5: 660-670.

Anonymous. 2013. Monthly Bulletin of Statistics Federal Bureau Statistics. Statistical Division, Govt. of Pakistan Agric. Section, pp. 1.

Ballal, C.R. 2022. Success stories in biological control: Lessons learnt. Vantage: Journal of Thematic Analysis, p. 7-20.

Bosco, L., V. Moser, M.M. Jones, O. Opedal, O. Ovaskainen, G. Sonja, R. Van Klink, S.A. Cushman, R. Arlettaz and A. Jacot. 2023. Habitat area and local habitat conditions outweigh fragmentation effects on insect communities in vineyards. Ecological Solutions and Evidence, 4(1): 1-12

Bossert, S., T.J. Wood, S. Patiny, D. Michez, E.A.B. Almeida, R.L. Minckley, *et al*. (2022). The rapid diversification of andrenid bees and their brood parasites (Nomada) in the Neogene. Systematic Entomology, 47: 283-302.

Burd, D.J and D.R. Porter. J. Econ. 2005. Biotypic Diversity in Greenbug (Hemiptera: Aphididae): Characterizing New Virulence and Host Associations. Entomol, 99: 959-965.

Carney, J.A. 2020. Subsistence in the Plantationocene: dooryard gardens, agrobiodiversity, and the subaltern economies of slavery. The Journal of Peasant Studies, 1–25.

Colwell, R.K. 2009. Biodiversity: Concepts, patterns, and measurement. In: The Princeton guide to ecology (eds. S.A. Levin, S.R. Carpenter, H. Charles, J. Godfray, A.P. Kinzig, M. Loreau, J.B. Losos, B. Walker and D.S. Wilcove). Princeton University Press. pp. 257-263.

Dossey, A. 2010. Insects and their chemical weaponry: new potential for drug discovery. Nat. Prod. Rep., 27: 1737-1757

Eguchi, K. 2001. A Revision of the Bornean Species of the Ant Genus Pheidole (Insecta: Hymenoptera: Formicidae: Myrmicinea). Tropics, 2 (Monograph Series): 1-154 pp.

Emani, C., Y. Jiang, B. Miro, T.C. Hall and A. Kohli. 2008. Transgenic cereals and forage grasses. In: Compendium of Transgenic Crop Plants (eds) Kole, C. and Hall, T.C. 1: 230-234.

Englmeier, J., O. Mitesser, M.E. Benbow, T. Hothorn, C. von Hoermann, C. Benjamin, U. Fricke, C. Ganuza, M. Haensel, S. Redlich, R. Riebl, S. Rojas Botero, T. Rummler, I. Steffan-Dewenter, E. Stengel, C. Tobisch, J. Uhler, L. Uphus, J. Zhang and J. Muller. 2022. Diverse Effects of Climate, Land Use, and Insects on Dung and Carrion Decompositio''. *Ecosystems (2022)*

Geldenhuys, M., R, Gaigher, J.S., Pryke and M.J. Samways. 2021. Diverse herbaceous cover crops promote vineyard arthropod diversity across different management regimes. Agriculture, Ecosystems and Environment, 307: 107-222.

Habibullah, M.S., B.H. Din, S.H. Tan and H. Zahid. 2021. Impact of climate change on biodiversity loss: global evidence. Environmental Science and Pollution Research,29(1):1073-1086

Horgan, F.G. 2005. Effects of deforestation on diversity, bio-mass and function of dung beetles on the eastern slopes of the Peruvian Andes. Forest Ecology and Management, 216: 117-133.

Kritsaneepaiboon, S and S. Saiboon. 2000. Ant species (Hy- menoptera: Formicidae) in longkong (Meliaceae: Aglaia dookkoo Griff.) plantation. Songklanakarin. J. Sci Techn, 22: 393-396

Latini, A.O., D.P. Silva, F.M.L. Souza, M.C. Ferreira, M.S. de Moura and N.F. Suarez. 2020. Reconciling coffee productivity and natural vegetation conservation in an agroecosystem landscape in Brazil. J. Nat. Conserv, 57: 125-902

Noon-anant, N., R. Kohout, S. Watanasit, S, Yamane and D. Wiwatwitaya. 2009. Additional Records of Polyrhachis (Myrmatepa) varicoloured Viehmeyer (Formicidae: Formicinae) from Southern Thailand, with Notes on Its Nesting Habits. The Natural History Journal of Chulalongkorn University, 9: 171-188.

Noon-anant, N., S. Watanasit and D. Wiwatwitaya. 2005. Species diversity and abundance of ants in lowland tropical rain forest of Bala Forest, Narathiwat Province, southern peninsular Thailand. National History Bulletin of the Siam Society, 53: 203-213.

Oliveira-Junior, J.M.B., T.S. Rocha, S.F. Vinagre, J.C. Miranda-Filho, C.C. Mendoza-Penagos, K. Dias-Silva, L. Juen and L.B. Calvao, L.B. 2022. A Bibliometric Analysis of the Global Research in Odonata: Trends and Gaps. Diversity, 14: 1074.

Prematatha, M., T Abbasi, S.A. Abbasi. 2011. Energy efficient food production to reduce global warming ecodegradation: The use of edible insects. Renewable Sustainable Energy Review, 15 (9): 4357-4360.

Sanchez-Bayo, F. and K.A.G. Wyckhuys. 2019. Worldwide decline of the entomofauna: a review of its drivers. Biological Conservation, 232: 8-27.

Sitthicharoenchai, D and N. Chantarasawat. 2006. Ant Species Diversity in the Establishing Area for Advanced Technology Institute at Lai-Nan Sub-district, Wiang Sa District, Nan Province, Thailand. The Natural History Journal of Chulalongkorn University, 6: 67-74.

Watanasit, S., C. Phonphuntin and S. Permkam. 2000. Diversity of ants (Hymenoptera: Formicidae) from Ton Nga Chang Wildlife Sanctuary, Songkhla, Thailand. Science Asia, 26: 187-194.

Watanasit, S., N. Noon-anant and N. Binnima. 2005. A preliminary survey of ants at a reserved area of Prince of Songkla University, Songkhla Province, Southern Thailand. Songklanakarin J. Sci. Tech, 27: 39-46.

Watanasit, S., S. Sonthichai and N. Noon-anant. 2003. Preliminary survey of ants at Tarutao National Park, Southern Thailand. Songklanakarin J. Sci. Tech, 25: 115-122

Yekwayo I., J.S. Pryke, R. Gaither and M.J. Samways. 2018. Only multi-taxon studies show the full range of arthropod responses to fire. Plos One, 13 (4).