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RELATIVE ABUNDANCE OF INSECT SPECIES IN WHEAT (*TRITICUM AESTIVUM*) AND MAIZE (*ZEA MAYS* L.) CROPS

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ABSTARCT

This investigation aimed to assess and compare the abundance and biodiversity of beneficial insects in two arable crops, namely wheat and maize, within Okara district. Beneficial and pest insects were collected using pitfall trapping method. The predominant order in maize crops was Coleoptera (family Carabidae), with orders Diptera and Hymenoptera. Wheat crops exhibited several orders, including Coleoptera, Diptera, Hymenoptera, Plecoptera, Orthoptera, and Lepidoptera. In maize crops, the percentage of Carabidae was 34.7%, with Lycosidae comprising 11%, Muscidae accounting for 15%, and other families collectively constituting less than 15% of the total crop. Conversely, in wheat, the percentage of Carabidae was 0.3%, with Lycosidae, Muscidae, Formicidae, and other families each contributing less than 11%. The combined percentage of Coleoptera (family Carabidae) was 31.3% in both crops, with orders having lower percentages. In combined maize and wheat crops, Lycosidae, Muscidae, Formicidae, Deinopidae, and Thomisidae families constituted 19.12%, 18.38%, 9.5%, 3.7%, and 3.23%, respectively. The dominant order across crops remained Coleoptera (Carabidae). Distances between fields were measured in kilometers, revealing a distance of 0.41 km between two wheat crops (W1-W2) and 0.68 km from the first maize crop (M1) to the second maize crop (M2-M3), with a further distance of 0.87 km from the second to the third maize crop (M3). Temporal and spatial differences in insect populations were discussed, highlighting significant variations in insect abundance between maize and wheat crops ($F(1, 2895) = 1.3465$, $p = 0.24599$). The study emphasizes that arable crops express a dominant presence of the Coleoptera order (Carabidae).

KEYWORDS: Wheat (*Triticum aestivum*), Maize (*Zea mays* L.), Coleoptera, Carabidae, Aranae, Lycosidae, Diversity indices, Relative abundance.

INTRODUCTION

Invertebrates, particularly insects, serve as natural control agents, playing a crucial role in agriculture by contributing to ecosystem health and acting as integral components of the food chain. They significantly contribute to biodiversity.[1] Many ground beetles, known as generalist predators, actively seek prey on the soil surface of agricultural fields and adjacent habitats.[2-5] These ground beetles play a key role in controlling pest populations in various agroecosystems.[6-12] However, the effectiveness of ground beetles in pest control varies across different cropping systems and cultural practices, with examples of their abundance and diversity being influenced by such factors.[13-17]

Within agricultural landscapes, two prominent groups, namely Carabidae (Coleoptera) and Araneae (Arachnidae), emerge as crucial protectors of crops.[18,19] Staphylinid beetles, Carabidae beetles, and spiders are particularly noteworthy as predatory invertebrates with significant importance as biological control agents in arable crops.[20-23] Winter crops like wheat, pea, and barley show greater compatibility with Carabidae beetles compared to sugar, beet, onion, or carrot. However, the behavior of beetles can have indirect effects on ground beetle diversity, making it challenging to estimate the impact of natural enemies.[24-27]

The spatial dynamics of beneficial insects are affected by factors such as population distribution, uncultivated lands, and their dispersion in segmented patches, leading to reduced scattering in the examined land.[18,28-34] Invertebrates exhibit variability within the same fields between years, yet investigations into their spatial distribution are lacking.[18] Polyphagous and generalist predators, such as aphidophagous species, are more abundant in arable crops.[35] During the early stages of pest infestation, predators, particularly those targeting aphids, are highly effective. These predators are characterized by a large presence during attack stages, with minimal movement reported in response to pest aggregation.[36-38] While not all species respond uniformly, carabidae (Coleoptera) find aphids to be a primary food source when homogeneously scattered.[39] Predators that exhibit heterogeneous distribution in crops are generally generalist predators, and it is not well understood whether this pattern exists. The multitude of arthropod predators entering crops may significantly impact crop maintenance and administration, especially in uncultivated lands.[1,28,30,40,49]

Environmental factors, both biotic and abiotic, can lead to crop loss, resulting in yields lower than their potential.[50] Issues such as the temporal and spatial distribution of pests, plant and pest reactions to unusual weather conditions and soil characteristics, excessive harvesting, and the interplay between pests and pathogens contribute to uncertainties in estimating production losses caused by pests.[51] In Punjab, Pakistan, wheat crops exhibit rich aphid diversity, though they rarely surpass economic threshold levels.[52] Notable pests in the region include Sitobion avenae (Fabricius), Schizaphis graminum (Rondani), Rhopalosiphum rufiabdominalis (Sasaki), and Rhopalosiphum maidis (Fitch). Stem borer (Sesamia inferens Walker) and Oriental armyworm (Mythimna separata Walker) occasionally cause severe damage. Despite the presence of natural predators, particularly spiders, in wheat crops in the Punjab region of Pakistan, their abundance may not be sufficient to act as effective biological control agents.

The present study was conducted in the 28/G.D village near Bakshu in Okara, focusing on comparing insect biodiversity at the family level and assessing insect abundance in crops at the family level.

MATERIALS AND METHODS

Study site and crops

The research in arable crops was conducted in the Okara district of Pakistan, specifically in the village of 28/G.D. The study focused on two prominent summer crops, wheat, and maize, with a research duration spanning two months. Two fields, designated as the Wheat field and Maize field, were selected for detailed investigation.

Sampling methods

The collection of insects was carried out using the straightforward and efficient pitfall trap method. This involved taking a glass bottle, digging it into the soil within the crop patch or undisturbed areas where traps were set, and securing it in the soil while leveling the surrounding soil to guide moving insects directly into the glass pitfall trap, as described by.[53] To prevent predatory birds from consuming the trapped insects, the pitfall trap was covered with a wooden plate. This method proved highly effective for insect collection from the crops.[54] When the time for collection arrived, the bottle containing the trapped insects was carefully picked up, placed in a basket, and replaced with a new pitfall trap at the same location. Subsequently, the collected insects were transported to the laboratory, where they were separated from the glass pitfall trap using a needle. The isolated insects were then transferred to a new plastic bottle. To ensure proper preservation, the collected insects were immersed in a solution comprising 1% formaldehyde and 90% water. This particular solution was chosen for its suitability in preserving insects. Such a preservation method is commonly referred to as a wet collection.

Pitfall trapping method

Sampling efforts were directed towards wheat and maize crops among the summer crops. For the wheat crop, two fields, each spanning 1 hectare, were selected, with a total of 26 traps per field. The arrangement involved creating four rows in the field, placing one trap at the center of every two rows (Fig. c). Consequently, a total of 52 traps were utilized for insect collection in the wheat crop.[53] Each hectare of wheat comprised four rows, with each row equipped with six traps, and one trap situated at the center of every two rows. The sampling pattern for the maize crop mirrored that of wheat, with three selected fields. The first maize field covered 2 hectares and was sampled with 68 traps due to its extensive area. The arrangement involved creating four rows, each with eight traps, and one trap positioned at the center of every two rows. The second maize field, covering 1 hectare, was sampled with 36 traps, arranged in eight rows with one trap at the center of every two rows. The third maize field, also covering 1 hectare, utilized 34 traps arranged in four rows, with one trap at the center of every two rows (Fig. 1). This led to a total of 138 pitfall traps being employed across these three crop fields.[53]

Throughout the insect collection process in both crops, various farming activities were observed, including field watering, fertilization for growth, and chemical spraying to prevent insect attacks. In the wheat crop, the trapping period extended from February 28, 2018, to May 5, 2018. During this timeframe, a diverse array of beneficial and prey insects, including those with destructive tendencies towards the crops, was identified. Similarly, in the maize crop, the trapping period spanned from February 25, 2018, to April 22, 2018, revealing a substantial diversity of beneficial and prey insects.[55]

Distance measurement between crops

The distances between the fields were measured in kilometers. The distance between the two summer wheat crops (i.e., W1-W2) was recorded at 0.41 km. Similarly, for the three maize crops (i.e., M1-M2-M3), the distance from the first maize crop to the second maize crop was

0.68 km, and the distance from the second maize crop to the third maize crop was 0.87 km.[55]

Arrangement of pitfall traps
The arrangement of traps in the crops is depicted in Fig. 1. This method involved utilizing all traps available in the field.[53]

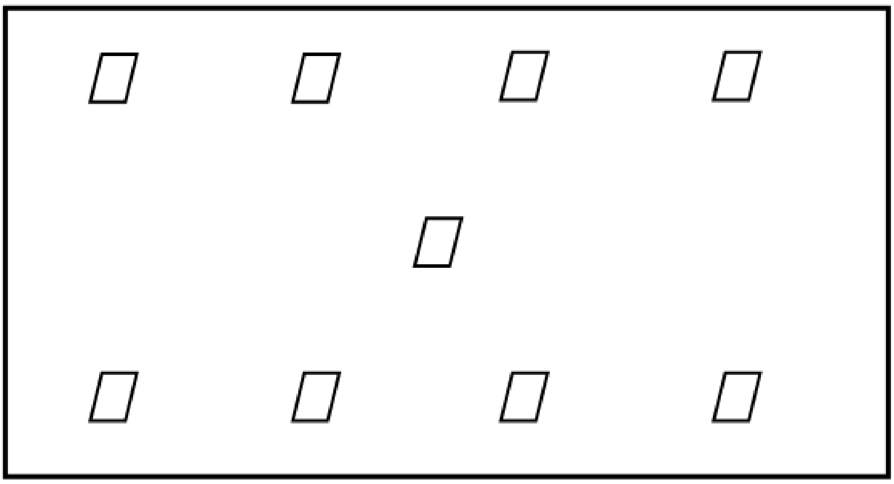

Fig. 1: Utilization of traps in field.

Statistical analysis
In addition to the previously mentioned methods, the analysis of insect abundance and diversity in arable crops utilized the ANOVA tool within Statistica software. This software was employed to assess the abundance of insects in the arable crops. Additionally, Past software, specifically its Diversity Indices functionality, was employed to determine the diversity indices of insects in arable crops. These software tools facilitated a comprehensive analysis of both the abundance and diversity aspects of the insect populations within the studied crops.[56]

RESULTS

In total, approximately 1819 individual insects were collected from the maize crop, with 1423 individuals found in the wheat crop. Among the captured insects, various families from different orders were identified, each exhibiting varying numbers of individuals. In the maize crop, 550 individuals of Carabidae and 398 individuals of Lycosidae were observed, with lower numbers for other orders. For the wheat crop, 466 individuals of Carabidae and 222 individuals of Lycosidae were identified. The distribution of individuals among different families and orders highlights the variability in insect populations across the two crops.

Percentage of abundant insect families
Table 1 illustrates the percentage distribution of different insect families in maize and wheat crops. The combined percentage of insect families, such as Carabidae, Lycosidae, Muscidae, Formicidae, Deinopidae, and Thomisidae, constitutes 31.34%, 19.12%, 18.38%, 9.5%, 3.7%, and 3.23%, respectively, in both maize and wheat crops. All other families identified during the study period collectively make up less than 3% of the total field.

In the maize crop, the percentage of Carabidae was 34.7%, Lycosidae comprised 11%, and Muscidae accounted for 15% of the total crop. Other families constituted less than 15% of the total field. Conversely, in the wheat crop, the percentage of Carabidae was 0.3%, Lycosidae comprised 0.2%, Muscidae represented 0.06%, and Formicidae accounted for 0.11% of the total crop. Other families made up less than 11% of the total field. This breakdown provides insights into the proportional representation of various insect families in the studied crops.

Table 1: Number and percentage of families captured from maize.

Family	total no of insects	Grand total	perecentage
Carabidae	550	1745	31.52
Lycosidae	398	1745	22.81
Muscidae	434	1745	24.87
Formicidae	166	1745	9.51
Deinopidae	76	1745	4.36
Gryellidae	47	1745	2.69
Ctenidae	34	1745	1.95
Pisauridae	22	1745	1.26

Coccinellidae	9	1745	0.52
Scytodidae	8	1745	0.46
Zoropsidae	1	1745	0.06

Table 2: Number and percentage of families captured from wheat.

Family	Total no of insects	Grand total	Percentage
Carabidae	466	1423	32.75
Lycosidae	222	1423	15.60
Muscidae	162	1423	11.38
Formicidae	142	1423	9.98
Deinopidae	46	1423	3.23
Thomicidae	105	1423	7.38
Gryellidae	6	1423	0.42
Aglenidae	40	1423	2.81
Oxyopidae	39	1423	2.74
Tenebrionidae	38	1423	2.67
Salticidae	36	1423	2.53
Cucujidae	31	1423	2.18
Theraphosidae	21	1423	1.48
Orusidae	15	1423	1.05
Silphidae	11	1423	0.77
Coccinellidae	7	1423	0.49
Perlodidae	8	1423	0.56
Amaurobidae	5	1423	0.35
Corinnidae	4	1423	0.28
Rhysodidae	4	1423	0.28
Sicariidae	4	1423	0.28
Acrididae	3	1423	0.21
Hexapoda	3	1423	0.21
Philodromidae	3	1423	0.21
Therididae	2	1423	0.14
	1423		

Abundance of insects in arable crops

The abundance of insects was observed to vary across different crops during the research. Specifically, the abundance of insects was higher in the wheat crop. It's worth noting that, in addition to the overall abundance, the percentage distribution of insect abundance also exhibited variations between the crops.

Maize, Wheat

The comparison between the two crops, maize and wheat, revealed significant differences in the abundance of insects, as indicated by the statistical analysis (F (1, 2895) = 1.3465, p = 0.24599). The graphical representation in Fig. 2 illustrates that wheat exhibited a higher abundance of insects compared to maize. Specifically, the abundance was calculated as 0.1586 for wheat and 0.1560 for maize. Therefore, the results suggest that wheat crops had a higher abundance of insects than maize crops.

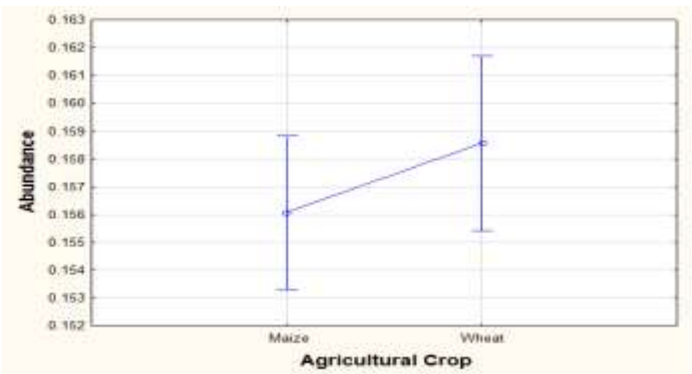

Fig. 2: Abundance of Maize and Wheat.

Day wise abundance of insects in arable crops

The day-wise abundance of insect diversity is depicted in Fig. 3, showcasing the variation in the number of insects captured each day. Notably, the graph highlights that the highest number of insects were captured per day in the wheat-1 crop.

Observing the day-wise abundance, it is evident that the peak occurred on February 28, 2018, and reached its lowest point on March 11, 2018, for wheat crops. On the other hand, for maize crops, the abundance was highest on February 25, 2018, and lowest on March 25, 2018. This graphical representation provides a visual overview of the fluctuating abundance of insects on different days in both wheat and maize crops.

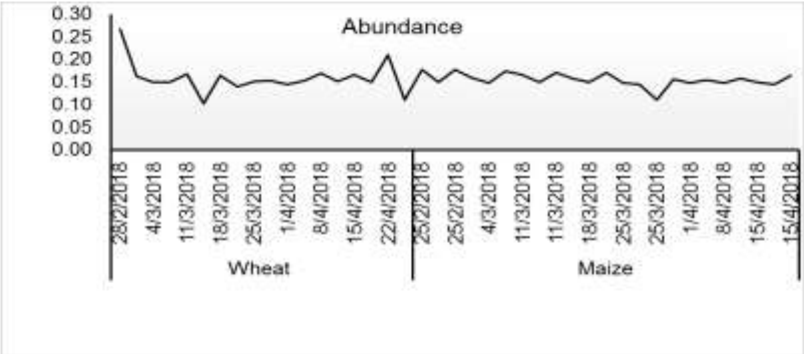

Fig. 3: Day wise abundance of insects in arable crops.

Beneficial v/s Pests insects of maize

The total count of 1819 insects from the maize crop revealed the presence of various beneficial and pest families. Among the beneficial families, Carabidae, Coccinellidae, and Tenebrionidae from the order Coleoptera were identified. Additionally, Scytodidae and Araneidae from the order Araneae were recognized as beneficial. On the contrary, some families were identified as pests, posing threats to both crops and humans. These include Lycosidae, Ctenidae, and Zoropsidae, which are harmful to humans, and Sicariidae and Thomisidae from the order Araneae. Furthermore, Muscidae and Formicidae from the orders Diptera and Hymenoptera, respectively, were also classified as pests. Table 3 provides a detailed breakdown of the beneficial and pest insect families found in maize.

Table 3: Beneficial v/s Pests insects of maize.

Families of maize	Beneficial	Pests	No. of insects
Carabidae	Yes		550
Coccinellidae	Yes		9
Deinopidae	Yes		76
Lycosidae		Yes	398
Zoropsidae		Yes	1
Ctenidae		Yes	34
Scytodidae	Yes		8
Araneidae	Yes		74
Muscidae		Yes	434
Formicidae	Yes	Yes	166
Gryellidae		Yes	47
			1819

Beneficial vs Pests insects of wheat

The total count of 1423 insects from the wheat crop revealed the presence of various beneficial and pest families. Among the beneficial families, Carabidae, Coccinellidae, and Tenebrionidae from the order Coleoptera were identified. Additionally, Oxyopidae, Salticidae, and Theraphosidae from the order Araneae, and Perlodidae from the order Plecoptera were recognized as beneficial to the crops. The family Formicidae from the order Hymenoptera was identified as beneficial but could also act as a pest to grains.

Conversely, some families were identified as pests, posing threats to both crops and humans. These include Lycosidae, which is harmful to humans, Sicariidae, and Thomisidae from the order Araneae. Furthermore, Muscidae and Formicidae from the orders Diptera and Hymenoptera, respectively, were also classified as pests. Table 4 provides a detailed breakdown of the beneficial and pest insect families found in wheat.

Table 4: Beneficial v/s Pests insects of wheat.

Families of wheat	Beneficial	Pests	No. of insects
Carabidae	Yes		466
Coccinellidae	Yes		7
Cucujidae		Yes	31
Tenebrionidae	Yes		38
Silphidae	Yes		11
Aglenidae		Yes	40
Corinnidae		Yes	4
Deinopidae	Yes		46
Lycosidae		Yes	222
Oxyopidae	Yes		39
Salticidae	Yes		36
Sicariidae		Yes	4
Therididae	Yes		2
Thomisidae		Yes	105
Theraphosidae	Yes		21
Muscidae		Yes	162
Formicidae	Yes	Yes	142
Orusidae	Yes		125
Gryellidae		Yes	6
Perlodidae	Yes	Yes	8
Acrididae		Yes	3
Hexapoda		Yes	3
			1423

DISCUSSION

The present study aimed to assess the abundance of beneficial insects in arable crops, specifically focusing on maize and wheat. The findings indicated that the abundance of insects was higher in wheat crops. Additionally, the study observed the spreading and species arrangement of the lepidopterous corn borer in six sites in southern Nigeria during the second planting season of 1985 and 1986. Stem borers, including Sesamia cakmistis and Eldana saccharina, were identified as more abundant in these sites, with S. calamistis being the prominent species.[57]

They found the western maize rootworms Diabrotica virgifera virgifera LeConte (Coleoptera: Chrysomelidae) and the northern maize rootworms Diabrotica barberi.[58] (Coleoptera: Chrysomelidae) were main pests of maize (Zea mays L.).[59]

The study further noted the prevalence of western maize rootworms (Diabrotica virgifera virgifera) and northern maize rootworms (Diabrotica barberi) as the main pests of maize in certain regions. In maize crops, a large diversity of insects was found, encompassing different orders with various families. Twelve families of insects were identified in maize, while wheat crops exhibited even greater diversity, with twenty-five families identified. The abundance and biodiversity of insects were compared between the two crops, with maize showing a higher abundance.

In maize, families such as Carabidae, Coccinellidae, and Pisauridae from the order Coleoptera, and Lycosidae, Deinopidae, Scytodidae, Ctenidae, and Zoropsidae from the order Araneae were found. Additionally, Muscidae and Formicidae from the orders Diptera and Hymenoptera, and Gryllidae from the order Orthoptera were present, with Carabidae being the most abundant. The richness of Coccinellidae was linked to land arrangement, with higher prominence in fields with abundant forests and grasslands compared to cultivated fields.[60]

In wheat crops, families such as Carabidae, Coccinellidae, Silphidae, Tenebrionidae, and Cucujidae from the order Coleoptera, and various families from the order Araneae were identified. Muscidae and Amaurobidae from the orders Diptera, Formicidae, Orusidae from the order Hymenoptera, and Gryllidae, Hexapoda, and Acrididae from the order Orthoptera were also found. Carabidae was the most abundant family in wheat, followed by Lycosidae and Formicidae.

The study duration in Okara during 2018 focused on different orders, including Coleoptera, Araneae, Diptera, Hymenoptera, and Orthoptera in maize. In a five-year study in Catalonia, northeastern Spain, different orders such as Araneae, Heteroptera, Carabidae, Coccinellidae, and Staphylinidae were identified. The constitution and richness of hunter invertebrates of maize were examined, revealing Heteroptera, Carabidae, Coccinellidae, and Staphylinidae as the most plentiful groups.[61]

Environmental factors, both biotic and abiotic, were identified as potential causes of crop loss, leading to a decline in actual yield compared to attainable yield.[50] Quantitative and measurable losses were associated with factors such as pest infestations, while qualitative losses were linked to reduced nutritional substances, demand, storehouse qualities, and post-harvest crop infections.[51]

In the northern Great Plains of the United States, ground beetle diversity and species abundances were found to be influenced more by crop rotations than tillage practices.[62,63] Additionally, for ground beetles to effectively suppress pest populations, they must be able to inhabit field interiors.[16,64]

CONCLUSION

In conclusion, the study found that the abundance of insects, particularly in the Coleoptera order with the Carabidae family, is more prominent in arable crops. The comparison between maize and wheat crops revealed significant differences in insect abundance ($F(1, 2895) = 1.3465$, $p = 0.24599$). The prevalence of the Carabidae family, belonging to the Coleoptera order, is considered beneficial for farmers, as these beetles serve as natural control agents for pest insects in arable crops. The presence of such beneficial beetles contributes to the ecological balance in the agricultural ecosystem by acting as natural predators of pests. This can be advantageous for farmers as it helps in controlling pest populations without the need for excessive use of chemical pesticides. Additionally, the study identified certain orders with different families that act as pests in arable crops. Understanding the dynamics of both beneficial and pest insect populations is crucial for effective crop management and sustainable agriculture practices.

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