BIHAREAN BIOLOGIST 19 (1): 14 – 24
Article No.: e251201

http://biozoojournals.ro/bihbiol/index.html

# Diversity of insect fauna in croplands of District Chakwal, Punjab, Pakistan

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Received: 22 May 2024 / Accepted: 06 December 2024 / Available online: June 2025 / Printed: June 2025

**Abstract.** Insects are incredibly diverse and abundant creatures, comprising about three-quarters of all life forms on Earth. Insects play diverse roles in ecosystems, from pollination and providing biological pest control to spreading diseases and damaging crops. Understanding the diversity of insect fauna is essential for every agricultural country. The agricultural sector holds great importance in Pakistan's economy. In this study, we evaluated the diversity of insects among millet, maize, groundnut, and wheat croplands in District Chakwal, a key agricultural region in Pakistan. Using sweep nets, dip nets, and pitfall traps, we collected a total of 1589 insect specimens, belonging to 11 distinct orders. Maize croplands exhibited the highest diversity index, followed by millet, groundnut, and wheat. Similarly, the evenness index was highest for maize, followed by millet, groundnut, and wheat. Many insect species are declining worldwide due to various threats, including the use of pesticides and monoculture agriculture practices. In Pakistan, farmers extensively use agrochemicals due to a lack of comprehensive knowledge on their use. Monitoring programs are essential to evaluate changes in insect populations over time in Chakwal. Future research should prioritize the ecological roles of insects and their impact on crop health in Chakwal. Integrated Pest Management practices provide sustainable solutions for pest control while conserving the environment. Collaborative research and farmer education will play essential roles in promoting sustainable agriculture and protecting insect biodiversity.

**Keywords**: Chakwal, croplands, Coleoptera, Hymenoptera, Orthoptera, *Poekilocerus pictus*.

## Introduction

Insects represent a highly diverse and thriving group of life forms, accounting for approximately three-quarters of all organisms on our planet. Their unparalleled achievements in terms of species diversity and ecological adaptability are truly remarkable (Grimaldi & Engel 2005). Insects play a vital role in maintaining the balance of ecosystems (Yang & Gratton 2014). They inhabit virtually every terrestrial ecosystem, from the deepest caves to the highest mountain peaks, and from the polar regions to the tropics (Foottit & Adler 2009). The metamorphosis process allows them to exploit various ecological niches during their lifecycles, making them remarkably adaptable (Rolff et al. 2019). Their diverse dietary preferences also characterized them. Some are herbivores, nurturing themselves on plants and influencing the ecology of vegetation (Abbott & Dwyer 2007), while others are carnivores, hunting prey with ruthless precision, and still others are scavengers, tirelessly recycling decaying organic matter (Wäckers et al. 2005). Besides their ecological significance, insects have played profound roles in human culture and economics throughout history. Over 2,000 species of insects have been recognized as edible worldwide (Jiang et al. 2023). Unfortunately, some insects, such as mosquitoes, also bear the unfortunate role of disease vectors, transmitting illnesses that affect humans and animals (Patterson 2016).

Insects serve as crucial pollinators of flowering plants, underpinning the reproduction of countless food crops and contributing to the maintenance of global biodiversity (Rader et al. 2016). Although certain insects make valuable contributions, it's crucial to recognize that numerous insects can pose substantial challenges by emerging as significant pests in the agricultural sector (Mueller et al. 2005, Akhtar & Isman 2018). Determining the precise extent of losses attributed to insects is a complex task, primarily because their impact varies significantly, influenced by factors such as environmental conditions, the specific plant species being cultivated, socioeconomic variables, and available technological resources (Dhaliwal et al. 2015). On a global scale, it is emphasized that insects are responsible for reducing crop production by approximately 18–20%, resulting in losses exceeding $470 billion (Oerke & Dehne 2004).

Pakistan has a rich agricultural sector, with 62% of the rural population relying on agriculture for their livelihood. Major crops cultivated in Pakistan include cotton, maize, rice, sugarcane, and wheat (Azam & Shafique 2017). Croplands occupy a 368440 km² area of Pakistan (Majeed et al. 2022). Chakwal District in Pakistan is renowned for its varied agricultural production (Balouch et al. 2016). Chakwal's ecosystem supports a rich variety of wild species (Safi et al. 2020).

Many studies have been conducted on the vertebrate fauna of Chakwal. Rais et al. (2012, 2015) investigated amphibians and reptiles, while Balouch et al. (2016, 2022) focused on squamate reptiles in Chakwal. Birds at Kallar Kahar Lake were studied by Rais et al. (2011). In the case of mammals, the Indian pangolin (*Manis crassicaudata*) has been the subject of research (Mahmood et al. 2012, 2016). However, there are no records of significant studies on the insect fauna of Chakwal, with only one study on *Deilephila elpenor* to date (Hanif et al. 2016). Our main objective was to explore the diversity of insects in the agricultural lands of Chakwal. We hypothesized that the insect fauna has different diversity among the four different croplands.

## Materials and methods

### Study area

The fieldwork was conducted in District Chakwal, Punjab, Pakistan (Figure 1). Chakwal covers an area of 6524 km². Its southern and southeastern regions are characterized by mountainous and rocky terrain adorned with scrub forests, interspersed with flat plains. In contrast, northern and northeastern areas consist of plains with some rocky zones. Chakwal experiences a summer temperature range of 15°C to 40°C, while winter temperatures typically range from 4°C to 25 °C. The average annual rainfall in Chakwal is 620 mm (Balouch et al. 2016). The vegetation of Chakwal falls under the category of a dry subtropical broadleaved scrub type. The prominent plant species are *Capparis decidua*, *Cymbopogon jwarancusa*, *Dodonaea viscosa*, *Gymnosporia royleana*, *Heteropogon contortus*, *Olea ferruginea*, *Prosopis juliflora* and *Senegalia modesta*. Only 8% of the cultivated land in the district is irrigated through methods such as canals, wells, and tube wells, while most of the land relies on rainfall for moisture. Wheat is the most widely cultivated crop in Chakwal, although groundnut, maize, chickpea, millet, and guar are also grown in many areas (Aslam et al. 2000, Qureshi et al. 2009, Balouch et al. 2016, 2022). Kallar Kahar Lake, situated 25 km north of Chakwal city, holds significant importance in terms of biodiversity. Chumbi Surla Wildlife Sanctuary stands as a crucially protected region, covering more than 550 km² (Rais et al. 2012).

### Insects collection

A total of 48 surveys were conducted in four different croplands, namely millet (Figure 2A), maize (Figure 2B), groundnut (Figure 2C), and wheat (Figure 2D), within randomly selected sampling locations from September 2019 to August 2020, to collect various species. Insects were collected using sweep nets, dip nets, and pitfall traps. Each technique was used on specific insect species and environmental conditions. Sweep nets were used to collect flying insects, such as butterflies, bees, and wasps. Dip nets were used for collecting aquatic insects and insects near water bodies, such as dragonflies. Pitfall traps were used to capture ground-dwelling insects, particularly those active at night, such as ground beetles and ants. After collection, the insects were killed by using a killing jar containing potassium cyanide. Large insects were pinned, while small insects were preserved in 70% alcohol. The collected insects were transported to the Department of Zoology at the University of Sargodha for identification. Keys developed by Triplehorn & Johnson (2005) and Resh & Carde (2009) were used to identify insect species. Additionally, species taxonomy was confirmed from BugGuide.

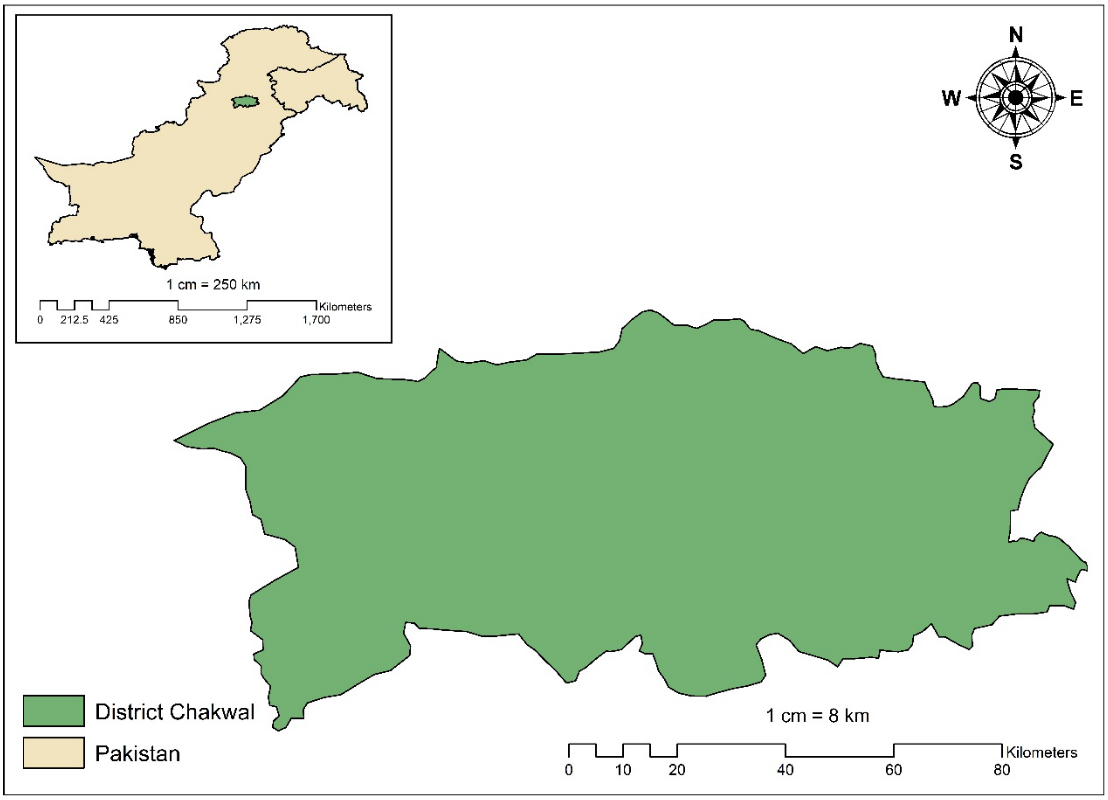


Figure 1. Map of District Chakwal, Punjab, Pakistan.

Data analysis

The Shannon-Wiener Diversity Index and Shannon-Wiener Evenness Index were calculated to compare the diversity and evenness of insects among different croplands, following Joshi et al. (2008). Heat maps presented the number of insects collected from millet, maize, groundnut, and wheat croplands, showing the count of the insect species collected. At the same time, scatter plots were created to illustrate the diversity and evenness index among these croplands using the "ggplot2" (Wickham 2011) and "dplyr" (Yarberry 2021) packages in R 4.2.2 (R Core Team 2022).


Figure 2. Croplands; A. Millet; B. Maize; C. Groundnut; D. Wheat. © Ahmed Junaid.

**Results**

A total of 1589 insects belonging to 34 species were collected, with the highest numbers found in millet, followed by maize, groundnut, and wheat croplands in Chakwal (Figure 3). The collected insects represented a broad array of orders, including Blattodea, Coleoptera, Diptera, Hemiptera, Hymenoptera, Isoptera, Lepidoptera, Mantodea, Odonata, Orthoptera, and Phasmatodea. The highest insect diversity index was observed in maize (2.6533), followed by millet (2.6225), groundnut (2.3976), and was the lowest in wheat croplands (1.6472) (Figure 4). Maize exhibited the highest evenness index (0.4550), followed by millet (0.4497) and groundnut (0.4111), while wheat croplands had the lowest index (0.2825) (Figure 5).

The millet fields had the greatest insect abundance, with a total of 755 insects recorded. *Poekilocerus pictus* had the highest number of individuals, collected from millet (Figure 6). In the maize croplands, the second-highest number of insects, 347, were documented. *Apis mellifera* was the highest individual count among the specimens collected from maize (Figure 7). Groundnut croplands had the third-highest number, i.e., 307. *Heterotermes indicola* was the most abundant species collected from groundnut (Figure 8). Wheat croplands had the lowest number of insects, with a total of 180. *Harmonia axyridis* had the highest individual count among the collection of wheat (Figure 9). *Poekilocerus pictus* exhibited the highest frequency among insects collected from a single type of cropland, i.e., from millet, indicating its prevalence as a common species. Conversely, the single collection of *Erthesina fullo* strongly implies its comparatively sparse presence within the croplands of Chakwal (Figure 10).

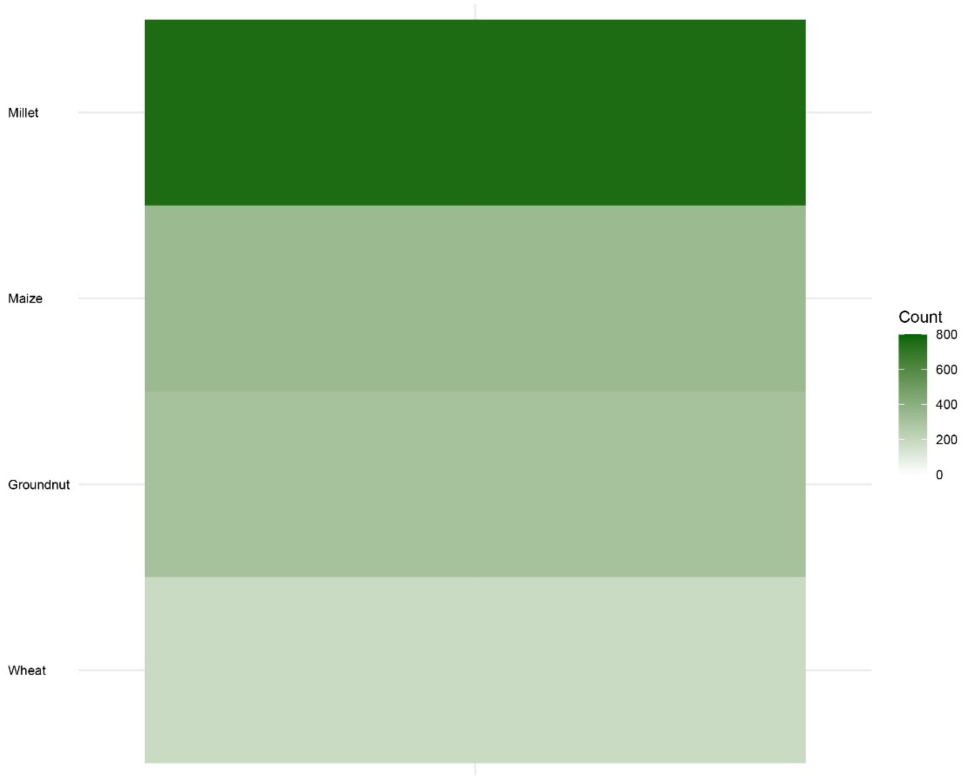


Figure 3. A heat map visualizing the insect collection data from millet, maize, groundnut and wheat croplands.

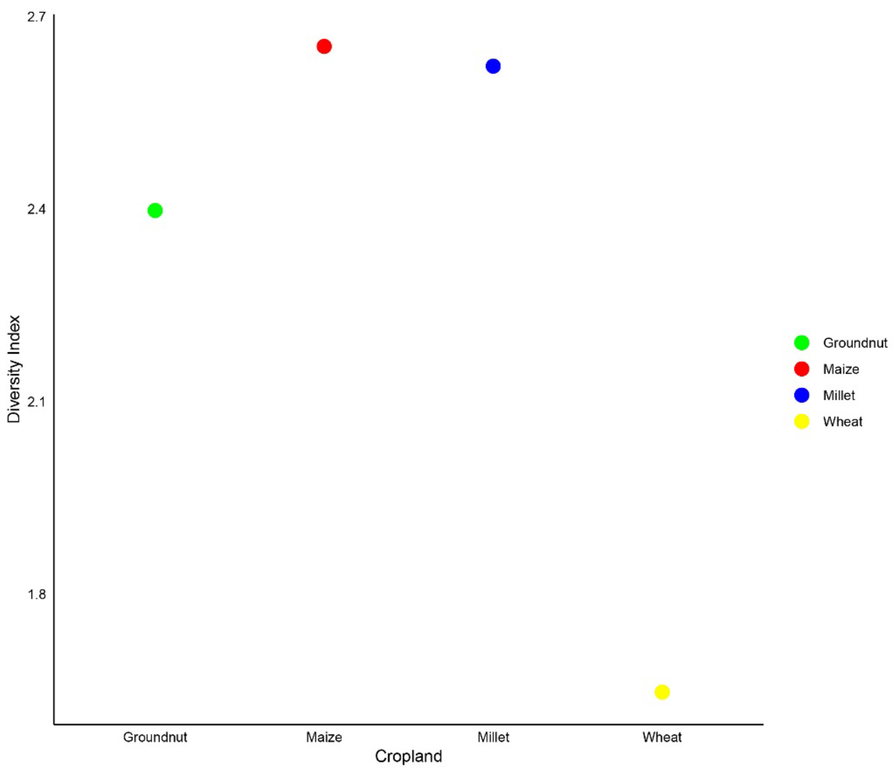


Figure 4. A scatter plot illustrating the diversity index of insect species in croplands of millet, maize, groundnut and wheat.

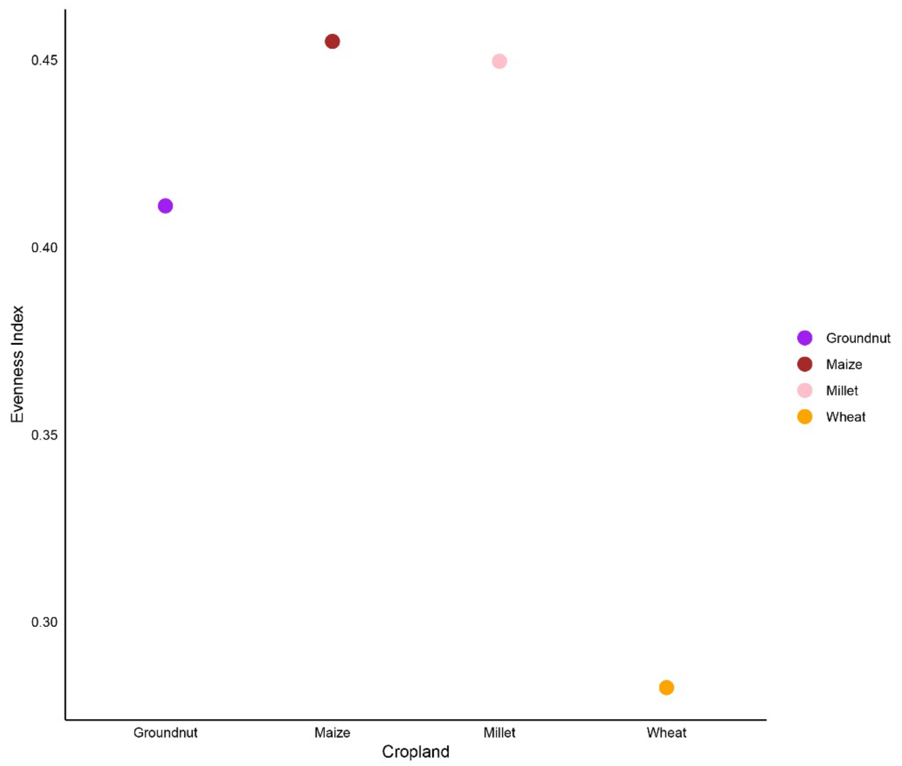


Figure 5. A scatter plot illustrating the evenness index of insect species across millet, maize, groundnut and wheat croplands.

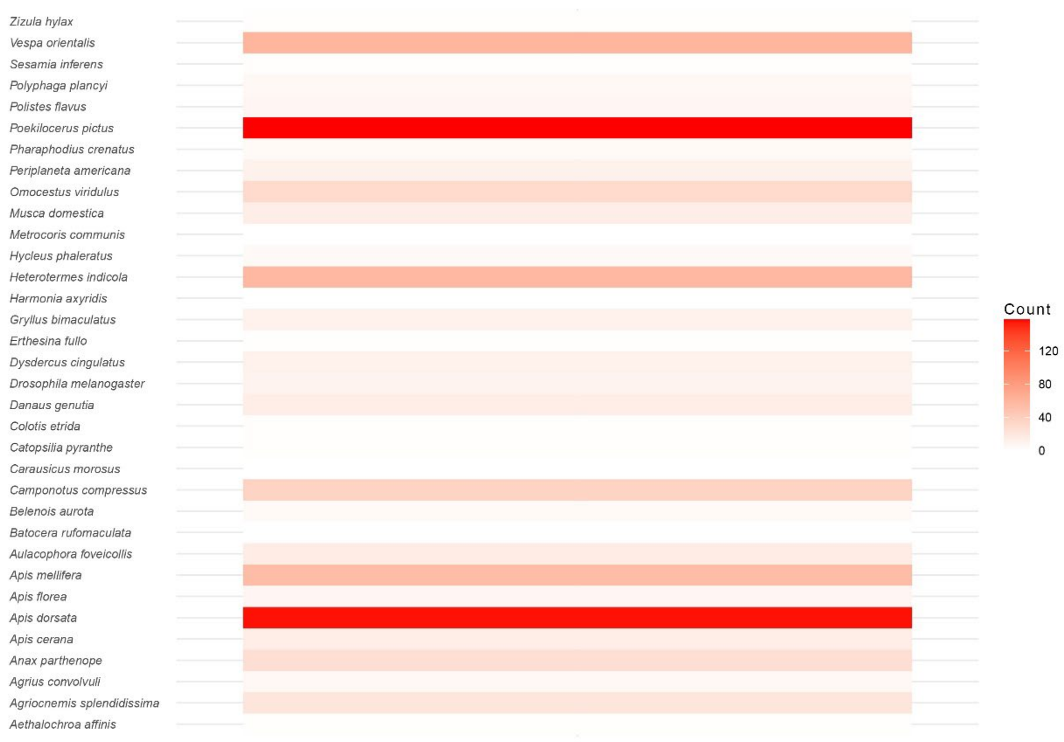


Figure 6. Heatmap illustrating the number of each insect species collected from millet.


Figure 7. Heatmap illustrating the number of each insect species collected from maize.


Figure 8. Heatmap illustrating the number of each insect species collected from groundnut.

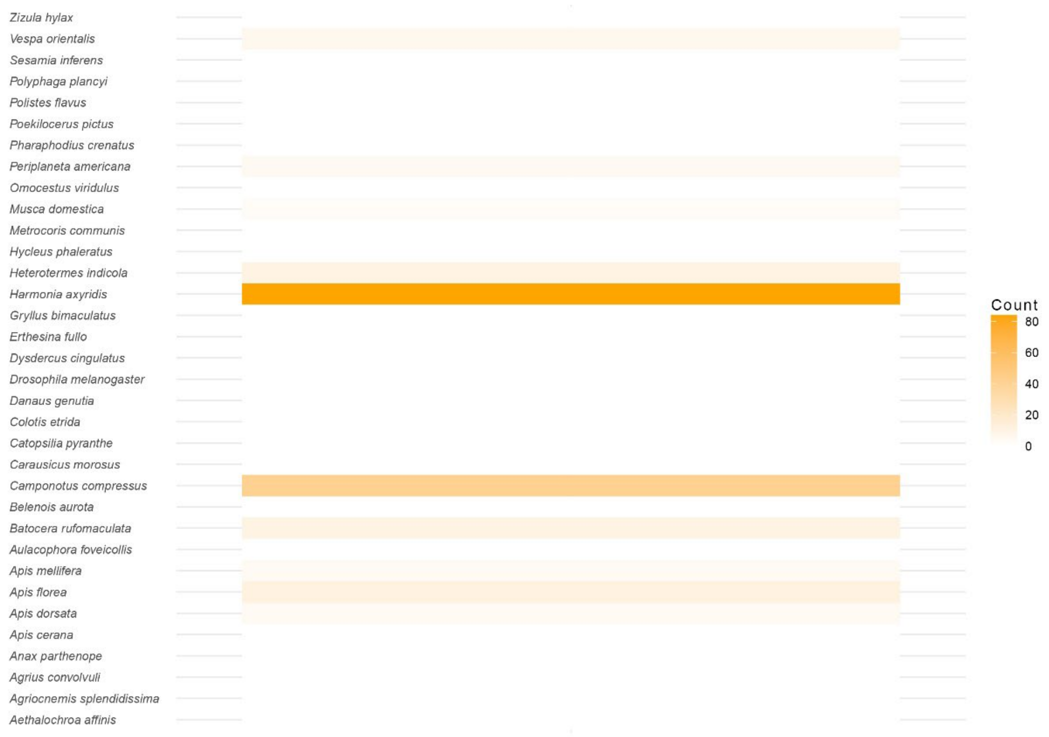


Figure 9. Heatmap illustrating the number of each insect species collected from wheat.


Figure 10. A. *Poekilocerus pictus*; B. *Erthesina fullo*. © Ahmed Junaid.

## Discussion

Insects provide a diverse array of ecosystem services that are essential to human life. In agricultural systems, pollination and biological control of crop pests are among the most valuable services (Redhead et al. 2020). Understanding insect fauna is crucial for enhancing crop productivity (Rusch et al. 2010) and facilitating the adoption of sustainable agricultural practices (Pauli et al. 2016). By promoting biodiversity and ecosystem resilience, farmers can cultivate healthier crops while minimizing environmental harm (Johns et al. 2013, Duru et al. 2015). Integrated Pest Management (IPM) techniques, which incorporate biological control methods alongside cultural and mechanical practices, become more viable with a comprehensive understanding of the insect fauna (Gurr & Kvedaras 2010, Nawaz et al. 2019).

The agricultural sector plays a crucial role in Pakistan's economy (Irshad & Stephen 2013). Globally essential cash crops, such as cotton, maize, and sugarcane, are cultivated on a large scale in Pakistan (Rehman et al. 2015). In Pakistan, insect control practices are implemented to enhance crop production, primarily using various types of agrochemicals (Khan & Damalas 2015). The use of agrochemicals also affects non-target insect species (Faly et al. 2023). Insect species are facing many threats such as habitat loss, pesticide use, emergence of parasites and diseases, climate change, introduction of non-native species, diminishing floral diversity, and growing prevalence of monoculture agriculture worldwide (Biesmeijer et al. 2006, Carvell et al. 2006, Brittain et al. 2010, Godfray et al. 2015). Insecticides are applied on a large scale to manage insect populations in agricultural fields in Pakistan. This application also impacts non-target beneficial insects (Khan 2020). Additionally, farmers in Pakistan extensively employ herbicides to eradicate weeds in croplands (Ali & Sharif 2011), which inadvertently pose threats to beneficial insect species (Asghar et al. 2013).

Biological control of insects offers benefits for biodiversity and ecosystem health. The practice of biological control is not new, as the first recorded instance dates back to 900 A.D. in China, where the Asian weaver ant (*Oecophylla smaragdina*) was used to control foliar-feeding insects (Shields et al. 2019). Effectively implementing this method relies heavily on understanding which insects can serve as effective biological control agents (Baker et al. 2020). Our findings provide an overview of insect diversity in croplands of Chakwal, addressing the previous knowledge gap. Additionally, this information will aid in managing pest insects in Chakwal's croplands.

We suggest that a long-term monitoring program be established to track changes in insect populations over time, considering their responses to environmental factors and agricultural practices in Pakistan, particularly in areas of agricultural importance like Chakwal. Research should focus on the ecological roles of insects and their influence on crop health. These investigations will help develop effective pest management strategies and conservation efforts. IPM practices offer sustainable solutions for controlling insect pests while protecting environmental health (Midingoyi et al. 2019). IPM methods should be promoted among farmers to control invertebrate pests. Collaborative research initiatives, farmer education, and policy support are crucial for promoting sustainable agriculture and protecting insect biodiversity in this region of Pakistan.

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