ENTOMOFAUNISTIC DIVERSITY ASSOCIATED WITH AGROECOSYSTEMS IN THE TEBESSA REGION (NORTH EASTERN ALGERIA)

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Abstract. The present study aimed to establish an inventory of the entomofauna associated with two distinct agroecosystems: cereal fields (*Triticum durum* L.) and olive orchards (*Olea europaea* L.) in the Tebessa region of northeastern Algeria. Systematic sampling was conducted from early December 2022 to the end of August 2023, using yellow traps and Barber traps. A total of 404 individuals, representing 8 insect orders and 31 families, were recorded in cereal fields, while 391 individuals belonging to 8 orders and 24 families were identified in olive orchards. Coleoptera and Hymenoptera were the most dominant orders across both systems. Biodiversity was higher in cereal fields, with a Shannon diversity index of 3.05 bits and an evenness of 0.68, compared to 2.85 bits and 0.75, respectively, in olive orchards. In both agroecosystems, the dominant trophic groups were phytophagous and predatory insects.The insect families captured by both sampling methods were analyzed using factorial correspondence analysis (FCA) to explore seasonal distribution patterns. The Chi-square (χ^2) test showed a significant and positive seasonal variation in the abundance of insect families within the olive orchards, and a correlated trend across the two ecosystems. The Venn diagram revealed a high number of shared families (18), indicating a strong similarity between the two agroecosystems, likely reflecting shared environmental and ecological conditions.
Keywords: *Entomofauna, Diversity, Cereal fields, Olive orchards, Tebessa*

Introduction

Insects represent a cosmopolitan group, occurring across a wide diversity of habitats from desert regions with extreme thermal amplitudes to the coldest polar areas. Each ecosystem, through its inherent nature and specific characteristics, provides suitable conditions for the emergence and persistence of life forms adapted to its environment (Stork, 2018; Zarges, 2021). The structural complexity of these habitats plays a pivotal role in determining insect diversity and abundance. Many entomological groups possess the ability to colonize various biotopes according to local conditions. This ecological plasticity contributes to the formation of a mosaic of habitats, where the availability of resources particularly water and vegetation, which in turn supports the richness and complexity of the entomofauna (Ruchin, 2024; Ulyshen, 2025). Insects are highly sensitive to local ecosystem variations, their diversity being closely linked to the spatial and structural characteristics of their habitats. Moreover, their abundance is widely recognized as a valuable indicator of ecosystem integrity and the proper functioning of terrestrial ecological processes (Lehmann et al., 2020; Halsch et al., 2021). The olive tree (*Olea europaea* L.) is among the oldest domesticated fruit trees (Besnard et al., 2018; Julca et al., 2020). Its cultivation spans various agroecological zones, primarily mainly in plains and hilly areas, which differ in altitude, pedoclimatic conditions, biotic factors, and landscape structure (Ortega et al., 2020; Solomou and Sfougaris,2021). Although olives are grown worldwide, approximately 98% of the cultivated area is concentrated in the Mediterranean basin, where the olive tree

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holds a central role both economically and socially (Bueno and Jones, 2002). It also carries significant nutritional, cultural, and heritage value. The Mediterranean region alone accounts for nearly 95% of global olive production and 85% of its consumption (Hernández-Mogollónet al., 2021; Dancausa Millán et al., 2023). In Algeria, total area devoted to olive cultivation has reached nearly 0.5 million hectares. Furthermore, about 79% of the olivesare directed for oil production, while 21% is addressed for table olive production (Khezzaniet al., 2019).

Cereals are major annual crops of global importance. They constitute the primary food source for both human consumption and animal feed, and occupy a strategic position in the structure of global agricultural production (Jukanti et al., 2016; Górska-Warsewicz et al., 2023). In Algeria, cereals are a key component of both agriculture and food security. Cereal production, mainly dominated by durum wheat and barley, covers the largest share of cultivated agricultural land and engages the majority of farmers (Berroukche and Terras, 2023; Rahal et al., 2025).Despite its strategic importance, national cereal production remains insufficient to meet domestic demand, due to limiting climatic conditions, low land productivity, and continued reliance on imports to bridge the supply gap (Bencharif et al., 2007; Lazereg et al., 2024). Therefore, the sustainable development of cereal cultivation represents a major challenge for Algeria, both economically and in terms of food security (Baghdad, 2022; Benbekhti et al., 2024).

In this context, the present study seeks to evaluate both the species and functional diversity of entomofauna within agroecosystems, with the objective of gaining deeper insight into the relationships between agricultural practices, insect community structure, and the ecological functioning of these systems.

Material and methods

Description of the region and study area

The study area was carried out in the Tebessa region, located in the northeastern part of Algeria included between 35 °29′N and 35° 40′N latitudes and 07° 35′E and 08 °23′E longitudes with altitude ranging between 700 and 1000 m above sea level, covering an area of 13,878 km² (*Figure 1*). This region is part of the semi-arid bioclimatic zone, characterized by cold, low-rainfall winters and dry, hot summers (minimum temperature =1,7°C, maximum temperature=35°C and Emberger's index Q2 = 38,12).It is naturally associated with the country's wide steppe landscape (Sbiki, 2017).

The study was carried out in the Cheria region, located approximately 86 km southwest of Tebessa Province, at an altitude of 1,090 meters. Two distinct agroecosystems were selected as study area:

- A cereal fields cultivated with durum wheat (*Triticum durum*), covering 3 hectares.
- An olive orchard (*Olea europaea*), covering 2 hectares.

Sampling methods and data collection

Insect fauna sampling

Insects were sampled monthly from December 2022 to August 2023. The trapping techniques used were the Barber traps and yellow traps to capture the invertebrates. We used cylindrical metal containers with a diameter of approximately 6 to 8 cm and a depth of 8 to 10 cm. The rim of the trap was placed 1-7 mm below the substrate surface level, and these traps were installed within a square plot of 400 m² (20 m × 20 m). These uncovered

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traps were arranged in a 3-3 configuration along three rows, spaced 5 m apart. The Barber traps are used to capture the invertebrates moving on the ground.

Figure 1.*Geographical position of Tebessa and Cheria region, Algeria (Grabsi, 2025)*

The yellow traps technique is a more selective sampling method compared to the previous one. Yellow traps are often used to collect flying insects. We used square-shaped plastic food packaging traps, bright yellow in color, measuring 14 cm per side and 12 cm in depth. In each plot, we placed four colored traps, spaced 5 m apart, and aligned in pairs along two parallel lines. Each trap was filled 3/4 full with water containing a wetting agent, and the captured insects were retrieved monthly after one week of trapping, starting from the first day of installation (Benkhelil, 1992). The captured specimens were identified by genus and species. Nomenclature and taxonomy were based on references Perrier (1927, 1932, 1972), Chopard (1943), Zahraduik (1988), and Auber (1999).

Data analysis

The relative frequency (%) corresponds to the percentage of individuals of a species (ni) compared to the total number of individuals counted (N) in a sample(Magurran, 2004):

$$RF = (ni / N) \times 100 \quad \text{(Eq.1)}$$

The Shannon diversity index (H') is calculated as(Magurran, 2004):

$$H' = -\sum Pi \log2 Pi \quad \text{(Eq.2)}$$

where Pi represents the proportion of individuals (ni) of species *i* relative to the total number of counted individuals (N) (Magurran, 2004):

$$Pi = ni / N \quad \text{(Eq.3)}$$

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The Evenness index (E) is calculated as the ratio between the diversity (H') and the maximum diversity (H'max), with:

$$H'max = \log 2 \qquad \text{(Eq.4)}$$

where S is the total number of species (Magurran, 2004).

Graphs were created using the software GRAPH PAD PRISM 7.

The relationship between the differences in the family members and the study sites used by the Chi-square test($\chi 2$) and the factorial correspondence analysis (FCA). All statistical analyzes were conducted using SPSS V 10 for Windows with a significance threshold set at $p<0.05$.

A Venn diagram was constructed to represent the number of families shared among the different systems (http://www.interactivenn.net/index.html).

Results

Entomological inventory

The entomafauna identified in the two agroecosystems can be classified into 8 orders and 37 families (*Table 1*). Coleoptera were the best represented with 34.67%, followed by Hymenoptera (34.53%) and then Diptera (14.84%). The other orders are noted with low relative abundances: Dermaptera (1.76%), Heteroptera (2.64%), Homoptera (4.4%), Orthoptera (4.65%) and Lepidoptera (2.51%) (*Table 1*).

Table 1. *Taxonomic classification of insect families and their relative frequency (%) in the agroecosystems, Cheria (Tebessa)*

Order	Family	RF(%)
Dermaptera	Labiduridae	1.51
	Forficulidae	0.25
Heteroptera	Pyrrhocoridae	2.51
	Pentatomidae	0.13
Homoptera	Cicadellidae	4.40
Orthoptera	Acrididae	3.14
	Gryllidae	1.51
Hymenoptera	Apidae	10.54
	Halictidae	3.77
	Andrenidae	1.63
	Vespidae	4.15
	Megachilidae	1.38
	Formicidae	13.06
Lepidoptera	Nymphalidae	1.13
	Pieridae	1.38
Coleoptera	Curculionidae	1.88
	Coccinellidae	4.90
	Buprestidae	0.25
	Chrysomelidae	0.38

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	Cetonidae	0.38
	Tenebrionidae	3.52
	Trogidae	1.13
	Carabidae	10.41
	Cerambycidae	0.63
	Dyticidae	0.75
	Scarabaeidae	3.39
	Hydrophilidae	1.01
	Histeridae	0.38
	Silphidae	1.01
	Elateridae	0.88
	Meloidae	0.63
	Staphylinidae	0.75
	Dermestidae	2.39
Diptera	Tabanidae	3.02
	Calliphoridae	3.02
	Mucidae	7.79
	Bombyliidae	1.01

Spatio-temporal composition

The cereal fields revealed the highest insect abundance, with 404 individuals distributed across 31 families, whereas the olive orchards registered 391 individuals from 24 families. In cereal fields, the dominant insect orders were Coleoptera (44.81%), Hymenoptera (29.69%) and Diptera (17.57%). In the olive orchards, Hymenoptera were the most abundant with 39.53%, followed by Coleoptera (24.24%) and Diptera (12%). The abundance of other orders was < 5%.

According to climatic seasons, in the cereal fields, abundance ranged from 16.34% in winter to 49.01% in summer. Coleoptera emerged as the dominant order throughout the year, with proportions of 51.42% in spring, 45.48% in winter, and 39.9% in summer. They were followed by Hymenoptera, representing 32.83% in summer, 27.14% in spring, and 25.74% in winter. Diptera maintained relatively stable frequencies, accounting for 18.18% in summer, 17.16% in spring, and 16.66% in winter (*Figs.2,3*).

In olive orchards, relative abundance varied with the seasons, ranging from 15.82% in winter to 46.94% in summer. Hymenoptera always dominated the insect community, with proportions of 42.96% in summer, 38.7% in winter and 35.64% in spring. Coleoptera were more important in winter (33.88%), decreased slightly in spring (27.39%) and decreased again in summer (18.47%). Diptera were represented with relative abundances of 15.21% in summer, 9.59% in spring and 8.06% in winter (*Figs. 2,3*).

Generalized linear models revealed that the abundance of insect families captured in the olive orchards was significantly different and positively correlated ($\chi 2$ = 66.222, p = 0.027) between seasons, the same remark for the cereal fields ($\chi 2$ = 87.908, p = 0.011).

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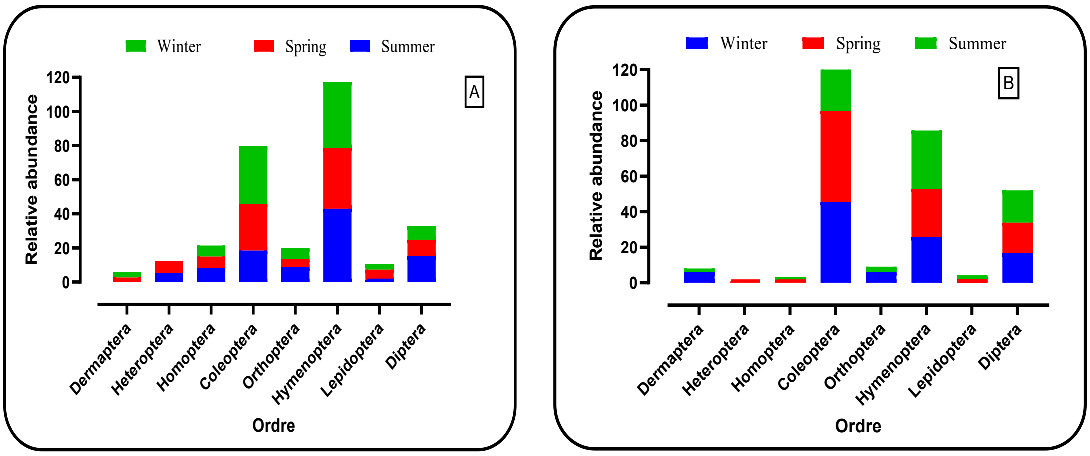

Figure 2. *Distribution of orders according to seasons in Olive orchards (A) and Cereal fields (B)*

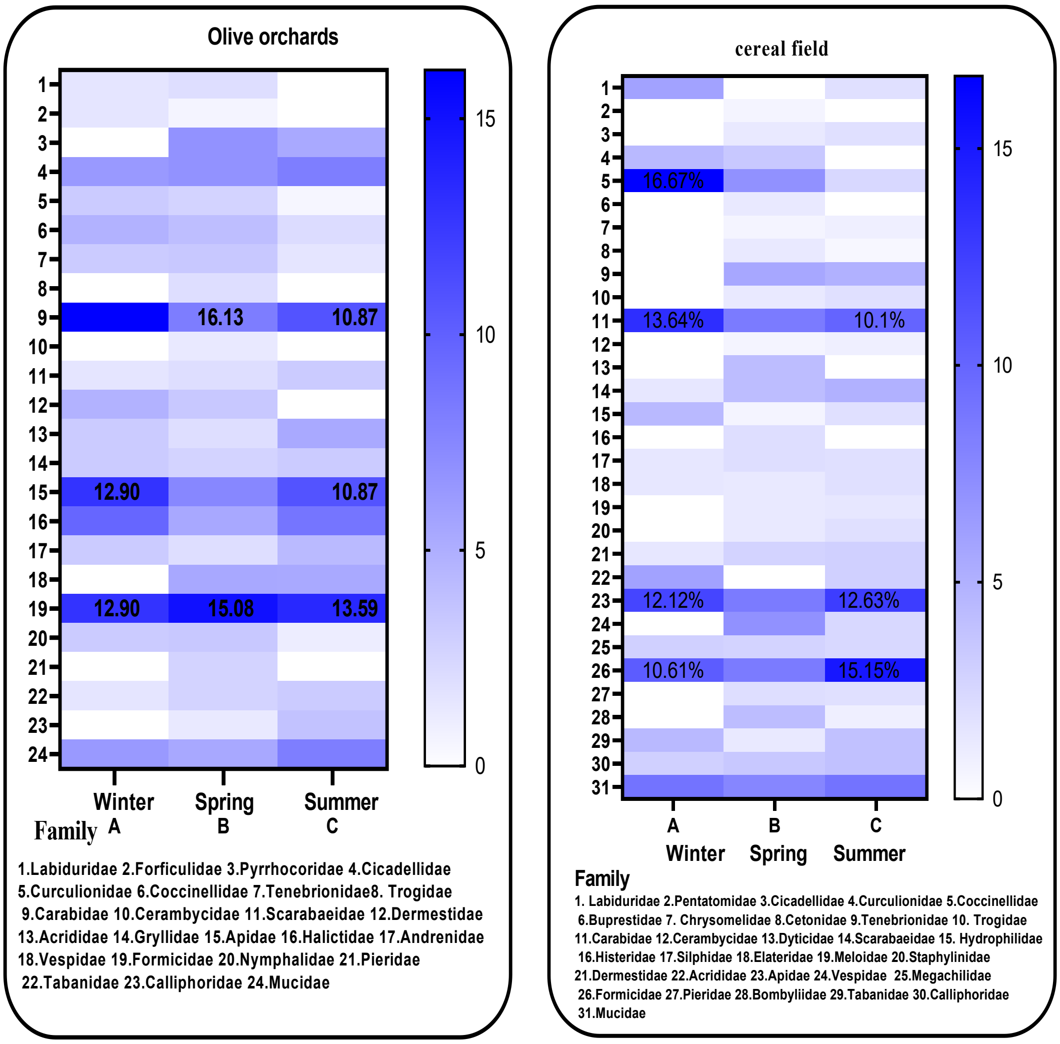

Figure 3. *Distribution of family of insects according to seasons in Olive orchards and Cereal fields*

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The species collected using the two sampling methods were analyzed using factorial correspondence analysis (FCA), to examine the distribution of insect family according to climatic seasons.Inolive orchards, winter appears in the upper left quadrant and is associated with family such as Coccinellidae, Curculionidae, Carabidae, and Dermestidae. Spring is positioned toward the center-right of the plot, in proximity to Vespidae, Pieridae, and Cerambycidae. Summer is located in the lower right quadrant, showing associations with Scarabaeidae, Tenebrionidae, Cicadellidae, and Calliphoridae (*Figure 4A*).

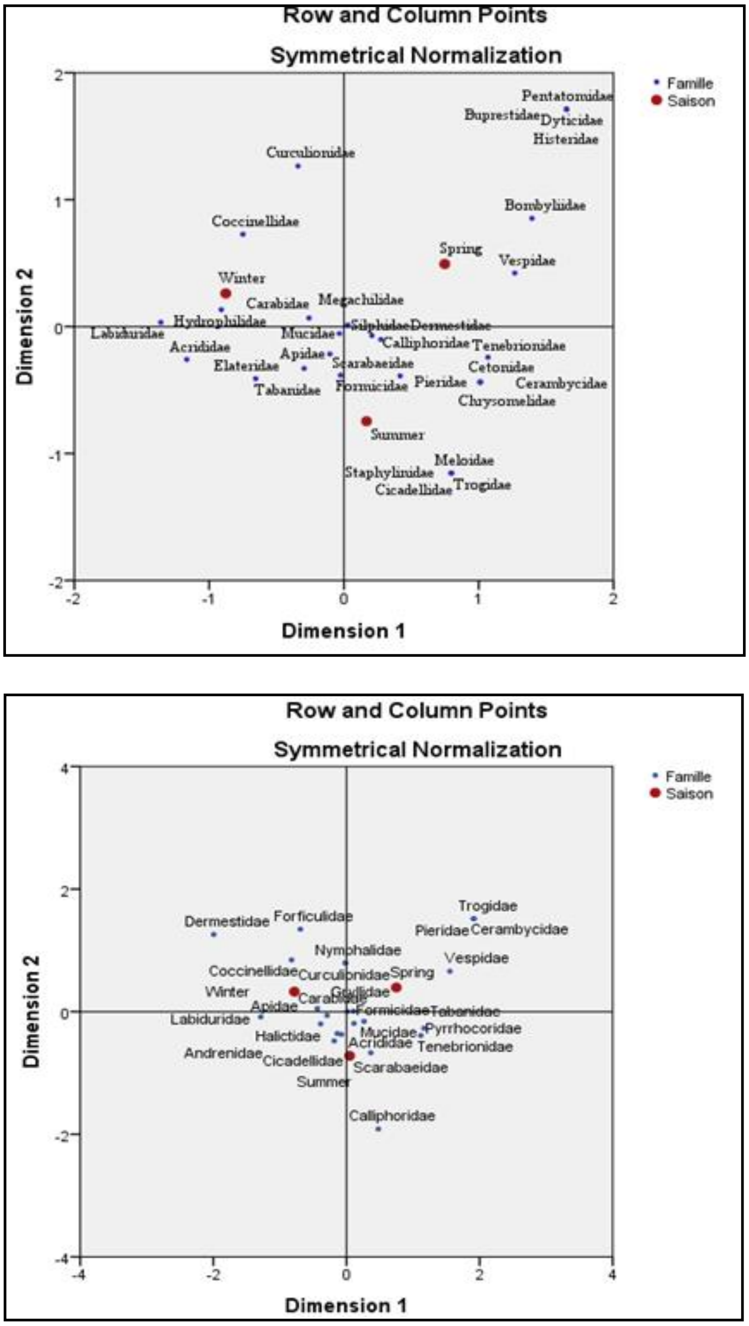

Figure 4. *Factorial correspondence analysis (FCA) biplot showing the relationship between insect family distribution and climatic seasons (A): Olive orchards) and (B): cereal fields*

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In cereal fields, winter is also situated in the upper left quadrant, associated with Coccinellidae, Curculionidae, Carabidae, Hydrophilidae, and Muscidae. Spring is positioned in the center-right region of the plot, near Bombyliidae, Vespidae, Pentatomidae, Buprestidae, Dytiscidae, and Histeridae. Finally, summer is located in the lower right quadrant, associated with Meloidae, Staphylinidae, Cicadellidae, and Trogidae (*Figure 4B*).

Diversity faunistic of agroecosystems

The Shannon index showed values of 3.05 bits in the cereal fields and 2.85 bits in the Olive orchards. Evenness was measured at 0.68 in the cereal fields and 0.75 in the Olive orchards (*Table2*).

Across different climatic seasons, the cereal fields recorded its highest Shannon index in spring (3.09 bits), followed by summer (2.9 bits) and winter (2.5 bits). Evenness values were approximately 0.76 in winter, 0.75 in spring, and 0.70 in summer (*Table2*).

Table 2. *Variation of insect diversity parameters in agroecosystems*

Site	Season	Winter	Spring	Summer	Overall
Cereal fields	Shannon's index (H')	2.5	3.09	2.9	3.05
	Evenness (E)	0.76	0.75	0.7	0.68
Olive orchards	Shannon's index (H')	2.6	2.95	2.67	2.85
	Evenness (E)	0.79	0.82	0.8	0.75

In the Olive orchards, Shannon index values were around 2.6 bits in winter, 2.95 bits in spring, and 2.67 bits in summer. Corresponding evenness values were about 0.79 in winter, 0.82 in spring, and 0.8 in summer (*Table 2*).

Structure and diversity of functional trophic groups

In the cereal fields, the most abundant groups are Phytophages and Predators, comprising 35.89% and 32.18% of the total, respectively, followed by Polyphages (19.06%), Coprophages (6.93%), and Saprophages (5.94%). Over the different climatic seasons, Phytophages are most abundant in winter (43.94%), followed by spring (37.86%) and summer (33.34%). Predators show their highest abundance in spring (33.57%) and have similar proportions in winter and summer (30.3%) (*Table3*). Polyphages are most numerous in winter (22.73%) and summer (21.21%), while spring sees a decrease to 14.29%. Coprophages are recorded at lower levels, with 8.08% in summer, 7.14% in spring, and 3.03% in winter. Saprophages are absent in winter, but appear with similar proportions in spring (7.14%) and summer (7.07%). The Shannon diversity index is highest for Phytophages (2.24 bits) and lowest for Saprophages(0.67 bits). The Evenness index is highest for Coprophages (0.97) and lowest for Phytophages (0.62).

In the Olive orchards, Phytophages and Predators are also the most abundant, at 49.23% and 29.34%, respectively, followed by Polyphages (13.52%), Coprophages (4.59%), and Saprophages (3.32%). Over the seasons, Phytophages dominate with 50% in winter, 49.7% in spring, and 48.48% in summer. Predators show their highest abundance in summer (33.33%), followed by winter (29.03%) and spring (25.45%). Polyphagesare most abundant in spring (15.15%), followed by summer (12.73%) and

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winter (11.29%). Coprophages are present at their lowest levels, with 4.85% in spring, 6.45% in winter, and 3.64% in summer. Saprophages are recorded at 3.23% in winter, 4.85% in spring (*Table3*).

Table 3. *Functional feeding groups of arthropods captured in Cereal fields and Olive orchards located in study area*

Agroecosystems	Trophic status	Season			
		Winter	Spring	Summer	Overall
Cereal fields	Coprophages	3.03%	7.14%	8.08%	6.93%
	Phytophages	43.94%	37.86%	33.34%	35.89%
	Polyphages	22.73%	14.29%	21.21%	19.06%
	Predators	30.30%	33.57%	30.30%	32.18%
	Saprophages	0%	7.14%	7.07%	5.94%
Olive orchards	Coprophages	6.45%	4.85%	3.64%	4.59%
	Phytophages	50%	49.70%	48.48%	49.23%
	Polyphages	11.29%	15.15%	12.73%	13.52%
	Predators	29.03%	25.45%	33.33%	29.34%
	Saprophages	3.23%	4.85%	1.82%	3.32%

Venn diagram (spatial similarity)

The Venn diagram highlights that several insect families such as Labiduridae, Cicadellidae, Curculionidae, Coccinellidae, Tenebrionidae, Trogidae, Carabidae, Cerambycidae, Scarabaeidae, Dermestidae, Acrididae, Apidae, Mucidae, Vespidae, Formicidae, Pieridae, Tabanidae, and Calliphoridae are shared between the two study area. In contrast, some families show exclusivity to a specific site. Thus, the olive orchard hosts only the families Forficulidae, Pyrrhocoridae, Gryllidae, Halictidae, Andrenidae, and Nymphalidae, whereas the cereal fields is characterized by the exclusive presence of the families Pentatomidae, Buprestidae, Chrysomelidae, Cetonidae, Dytiscidae, Hydrophilidae, Histeridae, Silphidae, Elateridae, Meloidae, Staphylinidae, Megachilidae, and Bombyliidae (*Figure 5*).

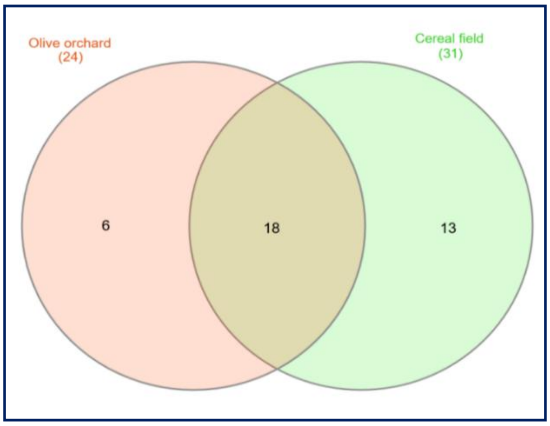

Figure 5. *Venn diagram representing the spatial distribution of insecta families collected in the Cheria region (Tebessa)*

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Discussion

The insect census we carried at both sites the olive groves and the cereal fields revealed significant species richness, distributed across 8 orders and 37 families. The cereal fields had the highest abundance of insects, with 404 individuals distributed across 31 families.

In terms of abundance, the orders Coleoptera, Hymenoptera, and Diptera clearly dominated over the other insect orders at both study area, while Dermaptera, Heteroptera, Hemiptera, Lepidoptera, Homoptera and Orthoptera are widely present, with the number of individuals captured varying among different sites. Our results are consistent with those reported in other Algerian regions, such as M'sila (Mimeche et al., 2024), Batna (Chafaa et al., 2019), and Biskra (Deghiche-Diab et al., 2021). All of these studies highlight the dominance of Coleoptera, Hymenoptera, and Diptera in the insect assemblages recorded in olive orchards.

Bakroune et al. (2020) in Biskra, and Kellil (2020) in the eastern high plateaus of Algeria, similarly observed a predominance of Coleoptera, Hymenoptera, and Diptera within insect communities associated with cereal agroecosystems.

Coleoptera is the most species-rich order in the animal kingdom, accounting for around a third of all known insect species worldwide (Zhang et al., 2011; Gullan and Cranston, 2014; Mohammedi et al., 2019). Coleoptera occupy a wide range of ecological niches and and play essential ecological functions: some function as decomposers (Scarabaeidae), others as predators (Carabidae), pollinators or phytophagous species, occasionally causing damage to crops. Their remarkable adaptability to diverse environments, coupled with the ease of their collection, sampling and preservation, makes them one of the most frequently studied insect groups in ecological research (Chenchouni et al., 2015; Egorov et al., 2024).

Hymenoptera comprise a wide range of species with diverse ecological functions, including pollinators such as bees, predators like wasps, and social insects such as ants. Their behavioral and ecological adaptability contributes to their widespread occurrence across various habitats (Basset et al., 2015; Meier et al., 2024). Diptera play a key role in ecosystem functioning due to their high functional diversity. They include decomposers (house flies, crane flies), pollinators (hoverflies, bee flies), as well as predators and parasites (targeting aphids, caterpillars), and are capable of exploiting a wide range of ecological niches (Mutamiswa et al., 2021). According to temporal variation, the highest abundances of invertebrates were recorded during the spring and summer seasons, particularly coleoptera, hymenoptera, and diptera. The Chi-square test ($\chi 2$) revealed a significant difference in insect distribution across the climatic seasons. This variation can be attributed to fluctuations in environmental conditions, which directly influence their activity and presence. Indeed, the presence or absence of invertebrates during certain periods can be explained by their specific phenology, which is closely linked to ecological factors such as climate and vegetation cover (Robinson et al., 2021; Fischer et al., 2022). Factorial correspondence analysis (FCA) at reveals a clear seasonal pattern in insect communities: In winter, some families show a strong association with this season. Their marked presence suggests a good adaptation to cold climatic conditions or to the availability of resources specific to this period (Reineke et al., 2016; Fernandez-Fernandez et al., 2019). In spring, other families are closely associated with this season, which is generally characterized by intense biological activity, abundant flowering and a wealth of resources, which all favors their development (Morneau et al.,2003; Aqueel et al.,2023).In summer, the high abundance of certain families is likely linked to climatic conditions that strongly support their life cycle(Kingsolver et al., 2011; Skendžić et al.,

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2021).The Shannon diversity index was higher in cereal fields than in olive orchards, indicating greater insect diversity in the cereal fields. In contrast, evenness values were 0.68 in the cereal fields and 0.75 in the olive orchards, suggesting a more even species distribution in the latter.The differences in species richness and composition between the two study areacan be explained by the presence of a dense herbaceous layer, which promotes the abundance of phytophagous and pollinating insects by providing greater access to food resources and microhabitats(Blaauw et al.,2014; Potts et al.,2016).The analysis of feeding group revealed a dominance of phytophagous species in both the olive orchards and cereal fields, which can be attributed to the continuous availability of water and the high diversity of herbaceous vegetation in the understory, providing abundant and sustained food resources (Ruiz et al., 2019; Korányi et al., 2023). Predatory insects represent the second most diverse trophic group after phytophagous species. As key components of agroecosystems, they play a crucial role in the biological control of pests. Their abundance is often linked to high plant diversity, which promotes a greater availability and variety of prey (Gurr et al., 2017; Álvarezzt al., 2023). Polyphagous species represent the third group. Many polyphagous insects inhabit plants and can serve as alternative hosts or prey for numerous entomophagous species (Özsisli, 2011; González-Ruiz et al., 2023).According to Chaafa et al. (2019), Mimeche et al. (2024) and Deghiche-Diab et al. (2021), phytophagous insects predominate in olive ecosystems. Kellil (2020) reported a high presence of phytophagous species in cereal fields. The similarity analysis was carried out using a Venn diagram, which reveals the high number of shared family (18) indicates a strong similarity between the two ecosystems, likely due to common ecological factors such as climate and geographical proximity. The cereal fields shows higher specific richness (31 family compared to 24 in the olive orchard), which may be attributed to greater microhabitat heterogeneity or increased availability of food resources. The family exclusive to each environment (6 in the olive orchard and 13 in the cereal fields) nonetheless highlight ecological specificity, potentially linked to differences in vegetation structure or agricultural practices.

Conclusion

In conclusion, this study highlights that agroecosystems serve as valuable indicators of arthropod biodiversity within a given region, providing habitats rich in entomological diversity. As a follow-up, we recommend extending the inventory to include other wheat varieties, with particular attention to key pests affecting cereals and olives, as well as assessing the role of natural enemies in regulating their populations.

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