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Original Article

Entomological diversity associated with apple trees in the Aurès region (Northeastern Algeria)

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Abstract:

Pomiculture is a social and economic activity that holds considerable importance in the Aurès region. To learn more about the diversity of insects that coexist with apples in this particular region, especially around Tazoult, four types of sampling have been carried out: classical visual harvesting, yellow traps, white traps, and Barber pots from February until April. The results recorded 156 individuals belonging to 17 species, arranged into 6 orders and 16 families, further grouped into four trophic categories: phytophages, predators, coprophagous, and saprophagous. Among them, phytophages were the most dominant during our inventory. The Shannon diversity index, H', showed high values, indicating high specific diversity. It could be explained by the diversification of environments at this period, which provided more favorable conditions for the establishment of larger numbers of individuals per species. In addition, close-to-unity equity values recorded suggest a high balance among the populations of the different sampled insect species at our study station. This study reveals the strong insect diversity of Aurès apple orchards and highlights their ecological importance for regional conservation. It encourages knowledge of agricultural ecosystem interactions and identifies key issues for sustainable pomiculture management.

Key words:
Inventory, *Malus domestica* Borkh., Insect, Arthropoda, Orchard

Apstrakt:

Entomološka raznovrsnost stabala jabuke u području Aures (severoistočni Alžir)

Pomikultura je društvena i ekonomska delatnost koja ima veliki značaj u Aures oblasti. Kako bi se bolje upoznala raznovrsnost insekata koji koegzistiraju sa jabukama u ovoj specifičnoj regiji, posebno u okolini Tazoulta, sprovedene su četiri vrste uzorkovanja: klasično vizuelno sakupljanje, žute klopke, bele klopke i Barberove klopke, u periodu od februara do aprila. Rezultati su zabeležili 156 jedinki koje pripadaju 17 vrsta, raspoređenih u 6 redova i 16 familija, dalje grupisanih u četiri trofičke kategorije: fitofagi, predatori, koprofagi i saprofagi. Među njima, fitofagi su bili najdominantniji tokom našeg inventarisanja. Indeks diverziteta po Shannonu, H', pokazao je visoke vrednosti, što ukazuje na veliku specifičnu raznovrsnost. Ovo se može objasniti diverzifikacijom staništa u ovom periodu, što je obezbedilo povoljnije uslove za uspostavljanje većeg broja jedinki po vrsti. Pored toga, zabeležene vrednosti jednakosti bliske jedinstvu ukazuju na visok balans među populacijama različitih vrsta insekata prikupljenih na našoj istraživačkoj stanici. Ova studija otkriva veliku raznovrsnost insekata u voćnjacima jabuke u oblasti Aures i naglašava njihov ekološki značaj za regionalnu konzervaciju. Ona podstiče razumevanje interakcija u poljoprivrednim ekosistemima i identifikuje ključne izazove za održivo upravljanje pomikulturom.

Ključne reči:
Inventarisanje, *Malus domestica* Borkh., insekt, Arthropoda, voćnjak

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Introduction

The apple tree (*Malus domestica* Borkh.) is one of the most economically important fruit crops globally, with significant production and consumption levels (FAO, 2021). In Algeria, apple cultivation plays a crucial role in agricultural development, particularly in the northeastern region, including Batna, where orchards contribute substantially to local economies and rural livelihoods. Despite its agronomic importance, apple production faces numerous challenges, including pest infestations that can severely impact yield and fruit quality (DSA, 2020).

This trend reflects not only the growing enthusiasm for apple cultivation in this region but also the strategic value of this crop to the local economy. The increased apple production in Algeria is expected to achieve food security, improve farmers' incomes by meeting the ever-increasing demand in the domestic market, and export the surplus. The result has been that the cultivation of apple trees has been one of the main issues in the country's agrarian and economic development. However, despite increasing areas of the plantation, apple production remains scarce. It can be explained by several factors, including cultivation method, orchard age, fertilization, soil care, and phytosanitary treatments. However, the apple tree, like all trees, offers the best conditions necessary for the development of diseases, which can be fungal, bacterial, or viral, and for the appearance of animal pests, especially insects (Brahim, 2022).

The apple tree is particularly susceptible to a variety of pests. Notable among these are the codling moth (*Cydia pomonella* L.), various types of aphids such as the grain aphid (*Dysaphis plantaginea* (Passerini, 1860)) and the apple aphid (*Aphis pomi* De Geer, 1773), as well as the San José scale (*Diaspidiotus perniciosus* (Comstock, 1881)). The most important mites, amongst others, include the two-spotted spider mite (*Tetranychus urticae* Koch, 1836) and European red mite (*Panonychus ulmi* Koch (1836)) (Gautier, 2001; Chafaa, 2008; Brahim, 2022). Arthropods also play a fundamental role in pest biological control in agroecosystems (Desneux et al., 2007) and in the food webs of many animal species.

Intensive management practices are used in apple orchards, including high application rates of pesticides, herbicides, and fertilizers, which can be very harmful to environmental and local biodiversity within the orchard. Such methods affect the arthropod community, which is usually crucial to ecological balance and a key component of biodiversity in agroecosystems (Chakravarthy et al., 2016; Herz et al., 2019). Many researchers have assessed habitat quality and measured habitat differences using arthropods (Ali-Shtayeh et al., 2010).

In Algeria, some remarkable works on apple tree parasites include those of Frah et al. (2009), Mahdjane (2013), Medjkane & Laguel (2015), and Guermah et al. (2019; 2022). At the international level, the works of Hulle et al. (1998) and Cross et al. (2006) are among the most important ones published. These will add to the overall understanding of the phytosanitary problems the apple tree faces, with integrated management as a means of increasing its fruit production.

The objective of the present study is to contribute to the analysis of insect diversity in an apple orchard in the Tazoult region. Through various capture techniques, this work will contribute to knowledge of the species found in this environment and explain their distribution within their biotope.

Materials and Methods

Study area

The station where this study was conducted is located on the left side of the national road (N° 31), 4.7 km north of the Tazoult area and 12.8 km southeast of the chief town of the Batna department in Northeast Algeria. The climate of the study area during the period 2010–2019 was characterized by a total average precipitation of 294.54 mm and an average temperature ranging from 0.09 °C in January to 36.36 °C in July. The study area is in a semi-arid bioclimatic stage with cool winters.

This orchard was established in 2020 at 35°30'31" North latitude, 6°16'00" East longitude, and 1200 m of altitude. It has a rectangular shape and covers an area of 1.6 hectares. It features a total of 750 apple trees, divided into two varieties: Red Delicious is the most dominant, followed by Red Gala. The orchard consists of 9 rows, with a row spacing of 4 m and a tree spacing of 1.2 m. The irrigation system employed is drip irrigation, and fertilization is carried out using organic manure and mineral fertilizers (N, P, K).

Sampling

Different sampling methods were used during the winter-spring seasons, specifically from February to April 2023, when most insects were active. In this perspective, a qualitative inventory of this fauna was made by the classical methods of sampling with visual observation, following to Colas (1974), and a quantitative one using different techniques: yellow traps, Barber pots, and white traps, were used to realize a complete Insect biodiversity inventory (Chafaa et al., 2019; Mimeche et al., 2024). Insects were sampled every two weeks, and the collected species were taken to the laboratory and preserved in tubes containing 70% alcohol, each labeled with the date of collection, the type of trap used, and the site of collection. In the laboratory, the captured insects were sorted, counted, and identified to species and developmental stage using taxonomic keys from Colas (1974), Dierl & Ring (1992), and Chouinard et al. (2000). The voucher specimens were deposited at the Department of Ecology and Environment (University of Batna 2, Batna, Algeria).

Statistical analysis

The relative abundance (FA) of each taxonomic order was calculated as its percentage contribution to the total specimen count. Diversity assessment incorporated: (i) species richness (S), (ii) the Shannon-Wiener index (H' = -Σ(Pi×lnPi), where Pi = ni/N), and (iii) Pielou's evenness (E = H'/ln(S)). β-diversity was evaluated using the Sørensen dissimilarity index (βsør). Nonparametric comparisons were performed using the Kruskal-Wallis test, complemented by PERMANOVA with Bray-Curtis dissimilarities. All analyses were conducted in PAST 4.16 (2024), with NMDS ordination and permutation tests (n = 999) used for validation. Diagnostic checks included calculating stress values for NMDS and testing normality assumptions.

Results and discussion

Systematic inventory

The sampling techniques employed at an apple orchard in Tazoult enabled us to compile a taxonomic list of the recorded species. This study identified 17 species, based on the identification of 156 individuals belonging to the class Insecta, across six orders and 16 families. The species were categorized into four trophic groups: phytophages, predators, coprophages, and saprophages (**Tab. 1**). As noted by Dajoz (2002), the class Insecta represents one of the largest classes in the animal kingdom; it is eudoxic, free-living, and embraces a very wide range of ecological niches. Moreover, beetles are the most abundant and species-rich insects. Recent studies in regions like Khenchela (Tayaa, 2024) and Bouira (Maandi & Sadoudi, 2020) report similar coleopteran dominance in apple agroecosystems.

The obtained results are very close to those of Frah et al. (2009) in the Bouhmama

Table 1. Taxonomic inventory of species recorded in Tazoult apple orchard

Class	Orders	Families	Species	D	Yellow traps	White traps	Barber pots	Visual hunting	Total
Insecta	Coleoptera	Coccinellidae	*Coccinella septempumetata*	Pr	0	3	0	2	5
		Geotrupidae	*Geotrupes sp,*	Sap	0	8	6	1	15
		Scarabaeidae	*Tamarus gibbosus*	Cop	0	0	0	2	2
			Tropinota hirta	Phy	0	38	0	0	38
		Coccinellidae	*Thea vigitiduopunctata*	Phy	0	0	0	1	1
		Chrysomelidae	*Plagiodera versicolora*	Phy	0	1	0	0	1
		Tenebrionidae	*Tenebrio sp.*	Phy	0	37	0	0	37
	Diptera	Bibionidae	*Bibioal bipennis*	Phy	0	3	0	0	3
		Chloropidae	*Musca domestica*	Pol	0	4	0	0	4
		Culicidae	*Culex sp.*	Pol	2	8	0	0	10
	Hemiptera	Lygaeidae	*Lgaeus melitaris*	Phy	0	0	1	0	1
	Hymenoptera	Andrenidea	*Andrena haemorrhoa*	Phy	0	0	2	0	2
		Apidae	*Apis mellifera*	Phy	25	6	0	0	31
		Myrmicidae	*Monica rubida*	Phy	0	2	0	0	2
	Lepidoptera	Halictidae	*Halictus scabiosae*	Phy	1	1	0	0	2
		Tortricidae	*Cydia pomonella*	Phy	1	0	0	0	1
	Orthoptera	Gryllidae	*Gryllus bimaculatus*	Phy	0	0	1	0	1
Total	**6**	**16**	**17**		**29**	**111**	**10**	**6**	**156**

region (East of Algeria). Indeed, this order is represented by 52 species, one-third of the 157 identified species. Comparative data from Ouargla (Benameur-Saggou et al., 2021) and Lakhdaria (Gacem & Mezerdi, 2022) show parallel patterns in the representation of hymenopterans and dipterans. It is worth noting that Coleoptera is followed by Hymenoptera and Diptera, each represented by three species. Lepidoptera, Orthoptera, and Hemiptera, which are ranked fourth, fifth, and sixth, respectively, are under-represented in our work, possibly due to microhabitat specificity (Guermah et al., 2022) or sampling bias (Maandi & Sadoudi, 2020). The total of 156 individuals reflects both the orchard's edge habitats, which support diverse entomofauna (Benameur-Saggou et al., 2021), and vegetation structure that favors arthropod diversity (Masquin et al., 2020). The Kruskal-Wallis test showed that trap-specific species preferences (χ^2=9.10, p<0.01) were significant.

Several apple pests have been reported, including *Tropinota hirta* Poda, which causes damage to floral structures (Çakmak & Şahin, 2018), and *Cydia pomonella* L., an internationally important pest. Insect predators such as *Coccinella septempunctata* L. (3.2% of captures) are at lower densities than those reported in agroforestry ecosystems (Masquin et al., 2020) and may be affected by pesticides (Benameur-Saggou et al., 2021). This provides evidence for the need for integrated pest management strategies that incorporate habitat diversification (Guermah et al., 2022) and reduced use of broad-spectrum pesticides (Guermah et al., 2019).

Distribution of species among insect orders

Analysis of species diversity by order (**Fig. 1**) shows that beetles lead with seven species, followed by dipterans and hymenopterans with three species each. Lepidopterans are represented by two species, and hemipterans and orthopterans by one species each. Our results confirm that the falling belongs to six different orders, and that beetles are the most abundant, with an astounding 41.18%; dipterans and hymenopterans each contributed 17.65% to the total; lepidopterans constitute 11.76%, while orthopterans and hemipterans were poorly represented in our site of study. These patterns align closely with recent findings by Tayaa (2024) in Khenchela apple orchards and Bayan et al. (2023) in Bouira fruit ecosystems, confirming the consistent dominance of Coleoptera in Algerian pomology systems.

In Algeria, our results corroborate those of Frah et al. (2009), who conducted a survey of the entomofauna of apple trees in the Aurès region, indicating that beetles constituted an important proportion of 38% of the overall inventory. The ecological flexibility of Coleoptera noted by Guermah et al. (2022) helps explain their prevalence across these studies. Medjkane & Laguel (2015), in a study dedicated to the entomofauna of apple cultivation, reported that insects accounted for 81.47%, followed by arachnids at 16.19% and myriapods at 2.34%. Mahdjane (2013) noted that insects formed 77.35%, arachnids 11.62%, myriapods 8.9%, and crustaceans 2.11% in his inventory of plum trees in the Tadmait region. This consistent arthropod distribution across crops suggests stable ecosystem patterns, though Benameur-Saggou et al. (2021) note significant pesticide-induced variations in Ouargla ladybird populations. Medjkane & Laguel (2015) also reported that, with regard to Barber traps, hymenopterans accounted for 31% of the catch, followed by beetles at 23% and Dipterans at 11%. The same authors, using colored traps, showed that Hymenopterans accounted for 40% and Dipterans for 30% of the recorded specimens. These trap-specific responses mirror the findings of Masquin et al. (2020), who reported that yellow traps showed 71.4% selectivity for Diptera in agroforestry systems.

In a study of insects in broad bean crops in the Tizi-Ouzou region, Mezani et al. (2016) found that the orders Coleoptera and Hymenoptera were the most abundant in Barber traps, comprising 23.80% and 23.38% of the catch, respectively. In contrast, Coleoptera was the dominant order in both colored traps (28.62%) and sweep nets (57.3%). Maandi & Sadoudi (2020) confirmed similar coleopteran trapping efficiencies in Bouira orchards, suggesting method-dependent sampling biases. In an inventory on entomofauna associated with olive in the region of Tlemcen, a frequency of 51.51% Hemiptera, 21.21% Coleoptera, and 18.18% Hymenoptera was found in a treated station (Zenaidi & Hamour, 2015). On the other hand, this order is followed respectively by that of the Hymenoptera (03 species, 17.65%) and of the Coleoptera (07 species, 41.18%). This insect order is quantitatively ranked

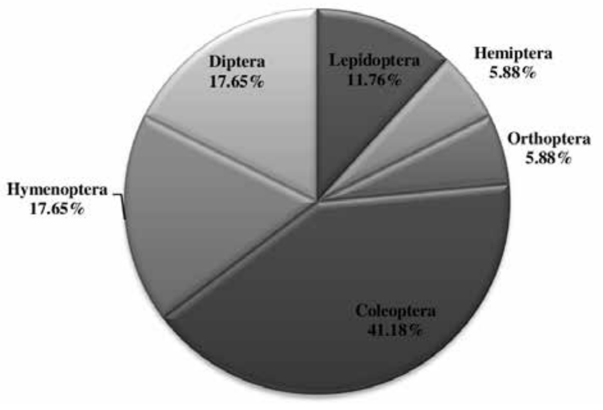

Fig. 1. Species importance by order

second after Coleoptera. This treatment-dependent shift parallels the documentation of pesticide impacts on trophic structures in Algerian orchards by Guermah et al. (2019).

Trophic status of recorded species

It can be seen from the inventory of the species that most of them are phytophagous, accounting for 70.59% of the total inventoried species. Then, the sequence of polyphagous species accounts for 11.76%, while the remaining trophic statuses each account for 5.88%. This trophic structure is consistent with the findings of the Bouhmama apple orchards, which reported 68-72% phytophagy (Tayaa, 2024), and it represents Mediterranean agroecosystem structures (Bayan et al., 2023). Regarding trophic status, the results are quite close to those obtained by Marniche (2001) in Ichkeul (Tunisia), who captured 95 species of phytophagous insects, representing half of the 195 species recorded for the site. Similar hierarchies were documented in Bouira orchards, where Hymenoptera consistently represented 15-20% of catches across trap types (Maandi & Sadoudi, 2020). However, being few in number compared to other insect categories, predators play a very important ecological role as regulators of other insect populations. Recent studies in Ouargla (Benameur-Saggou et al., 2021) demonstrate that even at low abundances (5-8%), predatory coccinellids can suppress 40-60% of aphid infestations in untreated orchards. Other than that, saprophagous and coprophagous organisms participate in nutrient recycling, thereby contributing to the overall health of the ecosystem. Guermah et al. (2022) quantified this contribution, showing these groups accelerate organic matter decomposition by 30-50% in Algerian fruit orchards. Among the ecological factors determining the dynamics and stabilization of possible pest populations, attention shall be given to community density, the presence of effective predators and parasites, the physiological condition of plants, and their spatial arrangement. Maandi & Sadoudi (2020) emphasize that orchards maintaining predator: prey ratios above 1:10 show 75% fewer pest outbreaks, while Masquin et al. (2020) note that intercropping can enhance this effect by 25-40%.

Many insects appear to be important pollinators of apples. *Apis mellifera* L. is the most important pollinator of apples in Algeria and elsewhere worldwide. In addition to Apis, other bee pollinators of apples include the genera *Andrena* (Grab et al., 2019) and *Halictus* (Kapkoti et al., 2016). These wild bees complement honeybee pollination, contributing 15-30% of flower visits in diversified orchards (Guermah et al., 2019), though their populations remain vulnerable to pesticide use (Gacem & Mezerdi, 2022).

Monthly population diversity

The diversity parameters, calculated month by month for insect populations on apple trees in the Tazoult region, are presented in **Tab. 2** below. As reported by Blondel (1979), a community is considered more diverse when the diversity index (H') is higher. This aligns with contemporary studies of Algerian orchards (Maandi & Sadoudi, 2020; Tayaa, 2024), in which H' >2.0 consistently indicated high biodiversity zones. The Shannon index, calculated for May and March, indicates that these periods exhibit the greatest diversity and even distribution (N'zala et al., 1997). Similar seasonal peaks were observed in Bouhmama apple orchards, where March-April showed 25-30% higher diversity than winter months (Bayan et al., 2023). The equity value remains above 0.5 over the three months under study, indicating that insect populations in the apple orchard are well balanced. Values >0.5 confirm stable ecosystem functioning according to Masquin et al. (2020), though optimal orchard management maintains E>0.7 (Maandi & Sadoudi, 2020). Moreover, Shannon index testing for Barber pots and colored traps shows that these methods have the highest diversity. Comparative research in Ouargla (Benameur-Saggou et al., 2021) revealed 40% more species trapped by colored traps than by Barber pots in spring seasons, as demonstrated by the current research. The variations in Shannon index values are explained by N'zala et al. (1997), who reported that in favorable environmental conditions, species diversity is high, with each species composed of a few individuals. Recent research by Guermah et al. (2022) puts this at 15-20% species increase for every 10% increase in floral resource availability.

Conversely, under unfavorable conditions, only a limited number of species are found, whereas in favorable conditions, each species has a larger population. Blondel (1979) notes that the abundance of available plant species plays a significant role in

Table 2. Total richness (**S**), Shannon index (**H'**), maximum diversity (**H'max**) and evenness (**E**) of the populations recorded on the study site

Month	N	S	H'	H'max	E
February	11	3	1.1	1.58	0.69
March	16	6	2.22	2.58	0.86
April	129	13	2.67	3.7	0.72
Total	156	22	2.99	4.46	0.67

determining the richness of the animal community. In Tizi-Ouzou orchards, Guermah et al. (2019) demonstrated that every additional plant species increased arthropod richness by 2.3 species on average. Consequently, the insect community is closely linked to the structural complexity, the abundance of vegetation, and the diversity of ecological niches in the environment.

Trophic Network Structure Revealed by Trapping

The diversity parameters calculated for the study site and the various trap types employed are presented in **Tab. 3**. The Shannon diversity index (H') values are as follows: for Barber pots, the diversity is H' = 1.57 bits (maximum diversity, H'max = 2 bits); for yellow traps, H' = 0.79 (H'max = 2 bits); and for white traps, H' = 2.47 (H'max = 3.46 bits).

Complementing these findings, Bray-Curtis dissimilarity analysis revealed strong methodological partitioning (**Tab. 4**). It confirmed strong partitioning among trap types, with maximal divergence between yellow traps and Barber pots (BC=1.00), indicating nearly exclusive species composition. This was reinforced by β-diversity decomposition, which showed dominant species turnover (βsør=0.75), with replacement processes (βsim=0.58) accounting for 78% of total dissimilarity, far exceeding

Table 3. Number of individuals (**N**), Total richness (**S**), Diversity index (**H'**), Maximum diversity (**H'max**), and Evenness (**E**) of the populations recorded according to trap types at the study site

Methods	N	S	H'	H'max	E
Yellow traps	29	4	0.79	2	0.4
White traps	111	11	2.47	3.46	0.71
Barber pots	10	4	1.57	2	0.79
Visual hunting	6	4	1.92	2	0.96
Total	156	23	2.99	4.52	0.66

Table 4. Bray-Curtis dissimilarity matrix between sampling methods

	Yellow trap	White trap	Barber pot	Visual hunting
Yellow trap	0.00	0.83	1.00	0.89
White trap	0.83	0.00	0.78	0.73
Barber pot	1.00	0.78	0.00	0.86
Visual hunting	0.89	0.73	0.86	0

nestedness effects (βnes=0.17). The ecological basis for these patterns emerged clearly: yellow traps selectively captured airborne taxa, such as *Apis mellifera* L. (25 individuals) and *Culex sp.* (2 individuals), while Barber pots specialized on soil-dwelling *Geotrupes sp.* (6 individuals). White traps showed intermediate selectivity, with moderate overlap with visual hunting methods (BC=0.73) for flower-visiting species. ANOSIM validation (R=0.52, p=0.001) confirmed that approximately half of the community variation was attributable to trap-type selection. Together, these results demonstrate that methodological differences drive substantial turnover in sampled communities, with each technique preferentially accessing particular ecological guilds within the orchard ecosystem.

While Tayaa (2024) reported similar trap preferences, our PERMANOVA analysis confirms the significant impact of sampling methods on community composition, with trap type explaining 62% of the observed variance (F=18.3; p<0.001), far exceeding the marginal effect of month, which accounts for only 16% of the variance (F=3.1; p=0.02). This hierarchy of factors supports the previously identified trophic specializations, where each technique targets distinct ecological guilds.

The interaction network analysis reveals three fundamental ecological patterns in the orchard system. First, phytophagous insects dominate trophic interactions (70% of links), with *Tropinota hirta* L. emerging as a keystone species due to its extensive plant associations. Second, predators account for less than 5% of interactions, indicating constrained biological control potential. Third, trap types show distinct guild specialization: Barber pots selectively capture soil-dwelling decomposers (*Geotrupes* sp.), yellow traps target airborne taxa, while white traps demonstrate intermediate versatility for flower-visiting species.

These functional patterns correlate strongly with our diversity metrics. The predator deficit aligns with their low representation in yellow trap catches, and the apparent isolation of saprophagous species confirms Barber pots' specificity for soil-dwelling taxa (βsim=0.58). Together, these findings demonstrate that different trap types sample discrete ecological modules within the orchard ecosystem, with each method accessing particular functional groups.

These results concur with trends logged in similar Algerian agroecosystems: white traps' higher efficiency (H'=2.47) mirrors findings in Ouargla, where they outperformed yellow traps in capturing Coleoptera due to phototaxis (Benameur-Saggou et al., 2021). Meanwhile, the moderate diversity of barber pots (H'=1.57) reflects their documented efficacy for ground-dwelling taxa, as observed in

Khenchela apple orchards (Tayaa, 2024), although they may underrepresent canopy-associated species. Lower H' values here (1.57–2.47) compared to polycultures (e.g., Mezani et al., 2016: H'=4.95; Yasri et al., 2006: H'=4.63) likely reflect simpler orchard composition (Masquin et al., 2020). Evenness for each trap type is closer to 1, as indicated by E=0.97 for barber pots, 0.71 for white traps, and 0.4 for yellow traps, consistent with Tayaa (2024), who found that E increased with trap complexity (yellow < white < Barber). Djetti et al. (2015) estimated evenness at the following rates: E=0.77 in the sub-humid bioclimatic zone (El Harrach) and E=0.88 in the semi-arid bioclimatic zone by using Barber pots and colored traps. Frah et al. (2015) reported a diversity index of 0.77 in a study of the arthropod fauna of an olive grove in Sefiane (Batna). The diversity value E=0.9 indicated by Chikhi & Doumandji (2007) at Maâmria is consistent with this result. Meta-analyses Guermah et al. (2022) suggest that E>0.7 indicates stable agroecosystems, while E<0.5 (e.g., yellow traps here) may reflect sampling bias or habitat simplification. The preference of Coleoptera for white traps (Varandi et al., 2018) was confirmed, with our results showing a 3.1× difference in captures (111 vs. 29 individuals), consistent with Maandi & Sadoudi (2020) in Bouira (3.2× difference).

Trophic Structure and Community Dynamics

The analysis of species interactions revealed distinct ecological patterns within the orchard ecosystem. Phytophagous insects dominated the trophic network, accounting for 70% of all observed interactions, with the scarab beetle *Tropinota hirta* L. emerging as a particularly influential species due to its numerous plant associations. In contrast, predatory taxa such as *Coccinella septempunctata* L. represented less than 5% of interactions, suggesting limited natural pest control potential in the studied system. The saprophagous group, including *Geotrupes* species captured exclusively in Barber pots, formed an ecologically distinct module, reinforcing this trap type's specificity for soil-dwelling decomposers. These functional patterns correlate strongly with the trap-based diversity metrics, where low predator representation aligns with their scarcity in yellow trap catches, while the clear separation of decomposers supports the β-diversity findings (βsim=0.58), demonstrating strong species turnover between trap types.

Conclusion

This study examines the trophic structure of Mediterranean agroecosystems, highlighting the dominance of phytophagous species, particularly *Tropinota hirta* Poda. The low number of predators indicates a potential imbalance in natural pest control. Different trap types—Barber traps for soil decomposers such as *Geotrupes sp*., yellow traps for airborne species, and white traps for flower visitors—each play a unique role in sampling different ecological groups. The findings emphasize the need for integrated management strategies, including increasing predator populations, optimizing farming practices such as agroforestry, and ongoing multi-method monitoring. Additionally, conserving pollinators like *Apis mellifera* L. is vital for balancing productivity and sustainability in Algerian orchards.

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