EEET ECOLOGICAL ENGINEERING & ENVIRONMENTAL TECHNOLOGY

Ecological Engineering & Environmental Technology, 2026, 27(10), 134–145
https://doi.org/10.12912/27197050/231188
ISSN 2719–7050, License CC-BY 4.0

Received: 2026.06.16
Accepted: 2026.08.17
Published: 2026.09.15

Entomofaunal diversity and functional guilds in agroecosystems under a semi-arid climate

Nabila Boubekka[1,2*], Naila Maizi[3], Aatika Boubekka[4], Lounes Saharaoui[5], Ikram Hamani[1], Imad Kherroubi[1], Fariza Boussad[6], Khadidja Mahdi[1,2]

[1] Department of Agricultural Sciences, Faculty of Natural and Life Sciences and Earth Sciences, Akli Mohand Oulhadj University, Bouira 10000, Algeria
[2] Laboratory of Biotechnology and Protection of Agricultural and Natural Ecosystems (LBPEAN), Université de Bouira, Bouira 10000, Algeria
[3] Laboratory for the Management and Valorization of Natural Resources and Quality Assurance, Akli Mohand Oulhadj University, Bouira 10000, Algeria
[4] Mouloud Mammeri University, P.O. Box 17 RP, 15000 Tizi Ouzou, Algeria
[5] National Higher School of Agronomy, EL-Harrach, Algeria
[6] Crop Protection Laboratory, National Institute of Agronomic Research of Algeria, 2 rue les Frères Ouadek, BP N 200 Hassen Badi, 16200 EL-Harrach, Algeria
* Corresponding author's e-mail: n.boubekka@univ-bouira.dz

ABSTRACT

Entomological biodiversity plays a crucial role in maintaining the ecological balance of agroecosystems by providing essential ecosystem services such as pollination, pest regulation, and the decomposition of organic matter. In this context, the present study assessed the diversity and structure of entomofauna in agroecosystems under semi-arid climatic conditions. The study was conducted from February to May 2025 in apple (*Malus domestica*) and peach (*Prunus persica*) orchards located in Aïn Oussara (Djelfa, Algeria). Insect sampling was carried out using yellow sticky traps (20 × 25 cm), with one trap installed per hectare in the canopy of randomly selected trees. A total of 4.614 individuals were collected, belonging to 7 orders, 51 families, and 95 species. In terms of abundance, the order Thysanoptera was the most represented in both orchards. Within this order, the predatory species *Aeolothrips fasciatus* was dominant, accounting for 19.70% and 21.44% of the total captures in the apple and peach orchards, respectively, and exhibiting a constancy of 100% in both orchards. Regarding species richness, the order Hymenoptera was the most diverse. Ecological index analyses revealed high species richness, a relatively even distribution of individuals, and a well-structured entomological community in both orchards. The analysis of functional guilds showed that phytophagous insects were the most abundant and species-rich group, followed by predators in terms of abundance and parasitoids in terms of species diversity. These findings provide valuable insights into entomological biodiversity and trophic guild composition, both of which are essential for maintaining ecological balance and promoting natural pest regulation. Moreover, the identification of 25 parasitoid species and 9 predatory species highlights their potential use in biological control programs.

Keywords: entomofauna, diversity, agroecosystem, trophic guilds, semi-arid climate.

INTRODUCTION

Insects are essential for the functioning, stability, and productivity of global ecosystems and serve as valuable indicators of ecological health in monitoring programs, nsects are vital to ecosystem processes such as pollination, nutrient cycling, and pest control. Despite their crucial role, insect biodiversity is declining sharply due to multiple stress factors. Some studies estimate that up to 40% of species could disappear in the coming decades (Gavloski et al., 2024, Cawood et al., 2026, Justino et al., 2026).

This phenomenon is particularly pronounced in areas heavily influenced by human activity, especially agroecosystems. Intensive agricultural practices, such as the expansion of cultivated areas, higher fertilizer and pesticide use, increased cropping frequency, and the pursuit of higher yields, play a major role in reducing insect diversity and abundance. This decline is not limited to cultivated fields but also extends to surrounding natural habitats, leading to widespread changes in insect communities (Mazed et al., 2022, Plénet et al., 2023, Zhao et al., 2024).

Moreover, insect abundance and their biological activities, including reproduction and foraging behavior, are closely influenced by climatic conditions. This relationship is especially pronounced in arid and semi-arid regions, which account for roughly 40% of the Earth's land surface. In these challenging environments, climatic variations play a crucial role in shaping insect population dynamics, directly affecting their abundance, distribution, and functional roles within ecosystems (Vasconcellos et al., 2010, Nautiyal et al., 2015).

Identifying landscapes that can reconcile biodiversity conservation with agricultural production remains a major challenge for current research, especially since conservation efforts have long focused on habitats outside agricultural areas, such as semi-natural environments. Recent studies, however, have increasingly examined the potential of crop heterogeneity, which includes both compositional heterogeneity (crop diversity) and configurational heterogeneity (field edge density) (Lenné and Wood, 2024, Tassoni et al., 2024).

In this context, the present study was conducted in the municipality of Aïn Oussara, located in the northern Algerian Sahara and characterized by a semi-arid climate. Its primary aim was to assess the diversity of insect fauna in two agroecosystems: an apple orchard (*Malus domestica* Borkh., 1803) and a peach orchard (*Prunus persica* L. Batsch, 1801), where herbicides were not applied to the surrounding weeds. These herbaceous plants serve as reservoirs for insect fauna, playing a crucial role in the functioning of ecosystems in semi-arid regions due to the close involvement of insects in ecosystem trophic networks (Mazed et al., 2022). The secondary objective of this study was therefore to identify the different trophic guilds present in these two agroecosystems.

MATERIALS AND METHODS

Study sites

The study was conducted between 4 February and 4 May 2025 in the municipality of Aïn Oussara, located in the wilaya of Djelfa, at 35°30'15"N latitude and 2°52'07"E longitude, covering an area of 13.76 km² (Dib et al., 2022). The municipality is situated approximately 100 km north of the city of Djelfa and about 300 km south of Algiers. The region is characterized by a semi-arid climate, with cold and harsh winters and hot, dry summers. It exhibits a high thermal amplitude, and the average annual precipitation is around 350 mm, unevenly distributed from north to south, with higher values recorded in the agricultural zones of the municipality. The average duration of snowfall ranges from 4 to 13 days per year. Winds are notable for their intensity and frequency, predominantly blowing from the northeast, with oceanic and northern origins. The region is also affected by the sirocco, a desert-origin wind whose duration varies between 20 and 30 days (El Mouchir, 2022).

The study site is an agroecosystem covering 74.5 hectares, comprising 59,232 trees distributed as follows: apricot trees occupying 18.09 ha (11,800 trees), peach trees covering 24.99 ha (16,505 trees), apple trees over 9.91 ha (13,081 trees), plum trees over 15 ha (9,846 trees), and vineyards covering 6.02 ha (80,000 vines). The crops were equipped with a drip irrigation system (Figure 1), with no weed control treatments applied. Pesticides were used cautiously and only in cases of severe pest infestation.

Insect sampling methods

Sampling was conducted in two fruit crops, apple (*Malus domestica*) and peach (*Prunus persica*), using yellow sticky traps measuring 20 × 25 cm. One trap per hectare was installed, suspended from two branches of randomly selected trees within the canopy. After one week, the traps were collected, and each was labeled with the date, location, and crop to identify the captured insects later. Traps were replaced weekly, with placement designed to cover the entire plot.

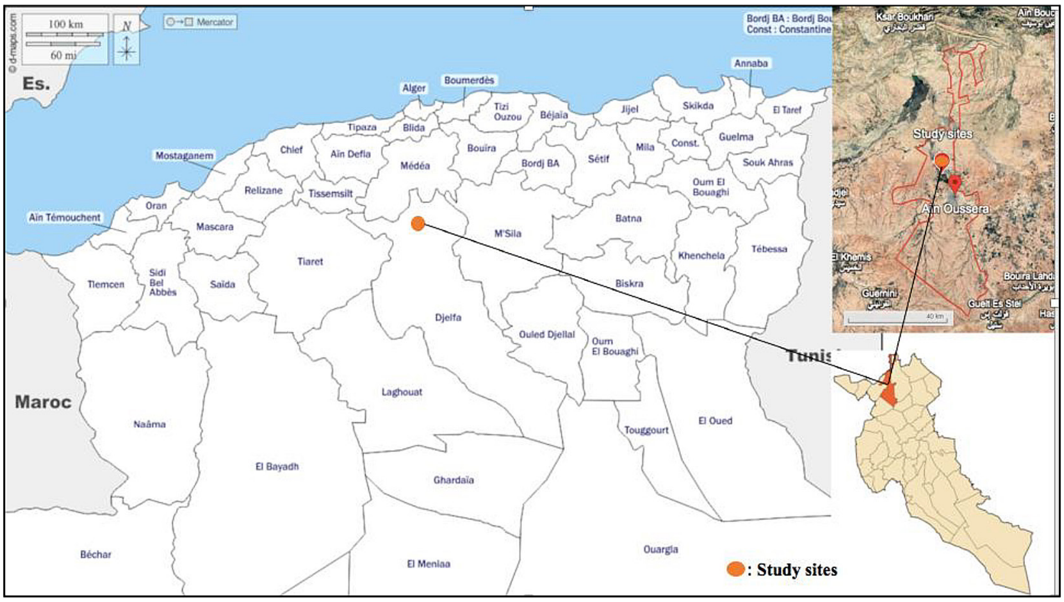

Figure 1. Geographic location of the study site situated in the commune of Aïn Oussara (Djelfa Province), northern Algerian Sahara

Identification of insects and functional guilds

Species with distinct morphological traits that allowed easy recognition were identified directly on the sticky traps. For taxa requiring more detailed examination, individuals were carefully removed from the adhesive surface using a fine brush and immersed in hexane to facilitate extraction. The recovered specimens were then mounted for accurate identification. Taxonomic identification was conducted in the laboratory of the National Higher School of Agronomy and carried out to the most precise taxonomic level possible using specialized dichotomous keys: Perrier (1927, 1932); Perrier and Séguy (1937); Perrier and Berland (1949); Leclant (1978, 1999, 2000).

Entomofauna analysis

The results of the present study were analyzed using ecological indices of composition and structure: abundance, species richness (S), the Shannon–Weaver diversity index (H′) and Pielou's evenness index. Data processing and analysis were performed using R (version 4.4.1). The main packages used included dplyr (version 1.1.4) and ggplot2 (version 3.5.1), as well as vegan for calculating the Shannon diversity and Pielou evenness indices, and tidyr for restructuring data into long format when required for graphical representation.

RESULTS AND DISCUSSION

Relative abundance, constancy and species diversity

A total of 4.614 individuals belonging to 7 orders, 51 families, and 95 insect species were recorded across the two studied crops. The entomofauna associated with apple (*Malus domestica* Borkh., 1803) was characterized by higher richness and abundance, with 2.748 individuals distributed among 84 species and 48 families. In comparison, peach (*Prunus persica* L. Batsch, 1801) harbored 1.866 individuals corresponding to 66 species and 40 families (Table 1). Such differences in entomofaunal composition between fruit tree species are generally attributed to variations in plant architecture, phenology, and the availability of trophic resources. Moreover, the presence of wildflowers and the species richness of ground vegetation constitute major factors structuring entomological biodiversity within orchards (Sáenz-Romo et al., 2019, Vergara et al., 2022, Judt et al., 2023, Granata et al., 2025).

Regarding species distribution between the two crops, eleven species were recorded exclusively in the peach orchard, including the peach thrips *Thrips meridionalis*. In contrast, twenty-eight species were found only in the apple orchard, such as the green apple aphid *Aphis pomi*. Furthermore, fifty-six species were common to both crops, including pollinators such as *Apis* *mellifera* (Table 1). This distribution can be explained by plant-insect interactions. Herbivorous insects exhibit varying degrees of specialization, ranging from strictly monophagous to polyphagous species, which determines their association with a particular crop. In contrast, most pollinator species are generalists and relatively non-selective in their foraging behavior (Aydın et al., 2020, Nishimura et al., 2024, Shah et al., 2025).

The species *Aeolothrips fasciatus* from the family Aeolothripidae is the most abundant and ubiquitous species in both orchards. The same results were observed by Daghefali et al. (2025) in a study on the wheat entomofauna under semi-arid conditions in Algeria.This species is observed on the flowers of plants belonging to various botanical families, is present throughout the year, and is particularly abundant in spring. It is a Holarctic and mesophilic species, known as a predator of other thrips species, and plays an important role in the biological control of pest thrips (Alavi et al., 2015, Koutti et al., 2017, Elimem et al., 2022).

Among the species recorded in both studied agroecosystems, *Hippodamia variegata* (Goeze) was distinguished by a high constancy reaching 77.8% (Table 1). This lady beetle plays a major ecological role as a predator in biological control programs targeting arthropod pests, particularly aphids in fruit tree orchards (Dou et al., 2026, Zhang et al., 2026).

Biodiversity indices

The results presented in Table 2 show that both crops exhibit high species diversity, with Shannon–Weaver index values of 3.48 for the apple orchard and 3.23 for the peach orchard. The apple orchard thus stands out with slightly higher diversity, reflecting either greater species richness or a more balanced distribution of abundances among species.

The evenness values (E = 0.79 for apple and E = 0.77 for peach) indicate a relatively homogeneous distribution of individuals and a well-structured entomofauna in both agroecosystems, with a slight ecological advantage observed in the apple orchard (Dajoz, 2019) (Table 2).

These elevated values may be explained by several factors, including the absence of weed removal in both agroecosystems, which promotes habitat heterogeneity, as well as the influx of insects from surrounding habitats. In addition, the sampling period coincided with spring, a season known to favor insect activity and diversity. Indeed, seasonal effects strongly influence the taxonomic composition and abundance of arthropod communities, spring and autumn presented the highest values of diversity parameters. (Chenchouni et al., 2015, Schnerch et al., 2025). In this context, Chatterjee et al. (2025) reported that significantly higher insect abundance is generally observed during the flowering period. Taken together, these factors highlight the importance of an integrated agroecological approach for biodiversity conservation and the enhancement of natural biological regulation. The positive relationship observed between crop diversification and biodiversity in orchards reflects a well-functioning ecological system. Indeed, the association of fruit trees with grasses or flowering plants, combined with reduced pesticide use, promotes increased faunal biodiversity within orchards (Littlewood et al., 2006, Markó et al., 2017, Zhu et al., 2025).

Diversity and abundance of entomofauna according to orders

The inventory of entomofauna conducted in two semi-arid agroecosystems, an apple orchard and a peach orchard, led to the identification of seven orders belonging to the class Insecta. In terms of abundance, Hymenoptera, Thysanoptera and Diptera were the dominant orders in the apple orchard, accounting for 30.64%, 27.37% and 25.07%, respectively. A similar trend was observed in the peach orchard, where these same orders were also predominant. However, Thysanoptera ranked first in the peach orchard (33.23%), followed by Diptera (29.10%) and Hemiptera (23.69%). In contrast, Psocodea represented the least abundant order in both orchards, with 0.44% in the apple orchard and 0.38% in the peach orchard (Figure 2). In contrast, Chafaa et al. (2019) and Brahim et al. (2025) reported that Coleoptera and Hymenoptera were the dominant orders in inventories of entomofauna associated with apricot (*Prunus armeniaca* L.) and apple trees (*Malus domestica* Borkh.), respectively, in Northeastern Algeria.

The dominance of Hymenoptera and Thysanoptera in both orchards may be related to the abundance of food resources and the presence of favorable microhabitats (flowers, young leaves, trichomes, etc.). Previous studies have shown that thrips are often abundant in orchards due to the prolonged availability of young plant tissues and favorable microclimatic conditions (Morse and Hoddle, 2006).

Table 1. Relative abundance (F%), constancy (C %) and functional guilds (FG) of the species recorded in the two agroecosystems apple orchard and peach orchard; Det: Detritivores; Hyp: Hyperparasitoids; Omn: Omnivores; Par: Parasitoids; Phy: Phytophagous; Pol: Polyphagous; Pre: Predators; Sap: Saprophagous

Species	FG	Apple		Peach		Species		Apple		Peach	
		F%	C%	F%	C%			F%	C%	F%	C%
Cecidomyiidae sp	Pol	0.47	22.2	0.11	22.2	*Aeolothrips fasciatus*	Pre	19.7	100	21.44	100
Bradysia sp	Sap	1.27	77.8	0	0	*Melanthrips pallidior*	Phy	0.33	66.7	0	0
Calliopum sp	Pol	1.09	22.2	0	0	*Thrips tabaci*	Phy	1.24	88.9	2.89	100
Culex sp	Pol	0.04	11.1	0.21	22.2	*Thrips meridionalis*	Phy	0	0	0.75	11.1
Delia coarctata	Phy	0.36	55.6	2.95	55.6	*Frankliniela occidentalis*	Phy	6.11	88.9	8.15	88.9
Musca domestica	Pol	0.87	100	2.3	100	*Agrothereutes lanceolatus*	Par	0.22	11.1	0	0
Hydrellia griseola	Pol	3.97	77.8	4.66	66.7	*Diadegma* sp	Par	1.42	66.7	0.91	66.7
Lucilia sericata	Pol	0.04	11.1	0.21	33.3	*Ichneumon sp*	Par	0.07	11.1	0	0
Phytomyza sp	Phy	1.2	33.3	0	0	*Phygadeuontini sp*	Par	0.07	11.1	0.16	11.1
Liriomyza bryoniae	Phy	1.06	88.9	3.27	100	*Eurycryptus unicolor*	Par	0.07	22.2	0	0
Chromatomyia horticola	Phy	0.36	22.2	0	0	*Gravenhorstiini sp*	Par	0.04	11.1	0	0
Agromyzidae sp	Phy	5.09	77.8	5.09	88.9	*Barylypa delictor*	Par	0.07	11.1	0	0
Ophiomyia sp	Phy	1.06	33.3	0	0	*Encyrtidae sp*	Par	0.04	11.1	0.16	11.1
Otites formosa	Pol	0.18	22.2	0.16	22.2	*Syrphophagus aphidivorus*	Hyp	1.46	77.8	1.66	66.7
Thaumatomyia sp	Pre	5.82	44.4	8.74	33.3	*Chrysis bicolor*	Par	0.51	11.1	0	0
Phoridae sp	Pol	0.66	55.6	0.91	55.6	*Chrysis augustula*	Par	0	0	0.05	11.1
Platystoma sp	Sap	0.07	11.1	0	0	*Chrysididae sp*	Par	0	0	0.16	11.1
Sarcophaga carnaria	Sap	0.76	22.2	0.16	11.1	*Omalus auratus*	Par	0.18	11.1	0	0
Eupeodes corollae	Pre	0	0	0.16	22.2	*Alloxysta victrix*	Hyp	1.38	55.6	0.48	44.4
Drosophila sp	Pol	0.69	11.1	0.16	11.1	*Andrena flavipes*	Pol	1.24	55.6	0.75	55.6
Anoplotrupes sp	Sap	0.07	11.1	0	0	*Andrena sp*	Pol	1.35	33.3	1.39	33.3
Cantharidae sp	Pre	0.07	11.1	0	0	*Bombus sp*	Pol	0.07	11.1	0.11	11.1
Anthonomus pomorum	Phy	0.04	11.1	0	0	*Apis mellifera*	Pol	0.62	33.3	0.16	33.3
Curculio sp	Phy	0.04	11.1	0.05	11.1	*Asaphes sp*	Hyp	3.24	88.9	3.75	100
Harpalus sp	Omn	0.18	11.1	0	0	*Dipara sp*	Par	0.73	33.3	0.16	11.1
Hippodamia variegata	Pre	0.58	77.8	0.8	77.8	*Pachyneuron aphidis*	Hyp	3.46	55.6	2.3	44.4
Coccinella septempunctata	Pre	0.29	33.3	0.27	33.3	*Coruna clavata*	Hyp	4.88	77.8	4.29	77.8
Scymnus subvillosus	Pre	0	0	0.11	22.2	*Bethylus sp*	Par	0.4	11.1	0	0
Stethorus punctillum	Pre	0	0	0.05	11.1	*Binodoxys angelicae*	Par	0.36	11.1	0	0
Staphylinus sp	Omn	0	0	0.11	22.2	*Chorebus sp*	Par	0.33	33.3	0.38	33.3
Tenebrio sp	Omn	0.04	11.1	0	0	*Diaeretiella rapae*	Par	0.47	66.7	0.59	66.7
Tenebrio molitor	Omn	0.07	11.1	0.05	11.1	*Cotesia glomerata*	Par	0.36	22.2	0.05	11.1
Anthocoris confusus	Pre	0.66	66.7	0.7	66.7	*Ephedrus plagiator*	Par	1.64	55.6	0.48	33.3
Cicadella sp	Phy	1.49	88.9	1.61	88.9	*Aphidius ervi*	Par	0.44	11.1	0	0
Dicranocephalus agilis	Phy	0.04	11.1	0	0	*Aphidius matricariae*	Par	0.58	11.1	0.91	55.6
Hyalopterus pruni	Phy	0.91	77.8	2.3	77.8	*Agathis sp*	Par	0.55	11.1	0	0
Myzus persicae	Phy	0.76	55.6	1.61	55.6	*Dendrocerus aphidum*	Hyp	1.09	77.8	1.55	66.7
Rhopalosiphum padi	Phy	0	0	0.16	22.2	*Mymaridae sp*	Par	0.98	44.4	0.43	44.4
Brachycaudus prunicola	Phy	0.15	66.7	0.64	55.6	*Eulophidae sp*	Par	0.87	44.4	1.55	44.4
Macrosiphoniella sanborni	Phy	0.07	11.1	0	0	*Tetrastichus sp*	Par	0	0	0.96	22.2

Table 2. Diversity indices recorded for the two crops, apple and peach

Ecological indices	Apple	Peach
Abundance	2748	1866
Species richness (S)	84	66
Shannon–Weaver diversity index (H′)	3.48	3.23
Equitability(E)	0.79	0.77

Regarding species diversity, Hymenoptera was the most diversified order in both agroecosystems, representing 42.86% of the species sampled in the apple orchard and 39.39% in the peach orchard. It was followed by Diptera, with 22.62% of the recorded species in the apple orchard and 21.21% in the peach orchard. Neuroptera and Psocodea exhibited the lowest levels of diversity, accounting for 1.52% in the peach orchard and 1.19% in the apple orchard, respectively (Figure 3). These results corroborate the findings of Forbes et al. (2018), who suggested that Hymenoptera may comprise 2.5 to 3.2 times more species than Coleoptera, traditionally regarded as the most species-rich insect order, mainly due to the extraordinary diversity of parasitoid wasps.

Functional guilds in apple *Malus domestica* and peach *Prunus persica*

This study revealed the presence of eight trophic guilds in the two orchards investigated. Among these, phytophagous insects represented the most abundant group, followed by predators (Figure 4). These results are consistent with those reported by Chafaa et al. (2019) in a study on the entomofauna of *Prunus armeniaca* L., where six trophic categories were recorded. In that study, phytophagous insects were also the most abundant group with 2.654 individuals, while predators ranked second with 842 individuals. Similar observations were reported by Brahim et al. (2025), who identified four main trophic categories: phytophages, predators, coprophages, and saprophages, with phytophages being the most dominant group.

Regarding species diversity, phytophagous insects also appeared to be the most diverse group in the two orchards (Figure 5). Comparable results were reported by Santistevan Méndez et al. (2024) in a study conducted on the entomofauna associated with two fruit crops in a semi-arid climate, where phytophagous species accounted for 61% of the recorded species in passion fruit cultivation and 57% in lemon cultivation.

This study identified the presence of ten phytophagous species belonging to the Aphididae family: *Hyalopterus pruni*, *Myzus persicae*, *Rhopalosiphum padi*, *Brachycaudus prunicola*, *Macrosiphoniella sanborni*, *Lipaphis erysimi*, *Aphis gossypii*, *Aphis pomi*, *Uroleucon aeneum*, and *Brachycaudus helichrys*. Ladybirds (Coleoptera: Coccinellidae) are widely recognized as beneficial predatory insects whose feeding activity helps regulate herbivorous pest populations in both natural ecosystems and agricultural landscapes (Rondoni et al. 2021). Four predatory species belonging to the Coccinellidae family were sampled: *Hippodamia variegata*, *Coccinella septempunctata*, *Scymnus subvillosus*, and *Stethorus punctillum*. Among them, *Hippodamia*

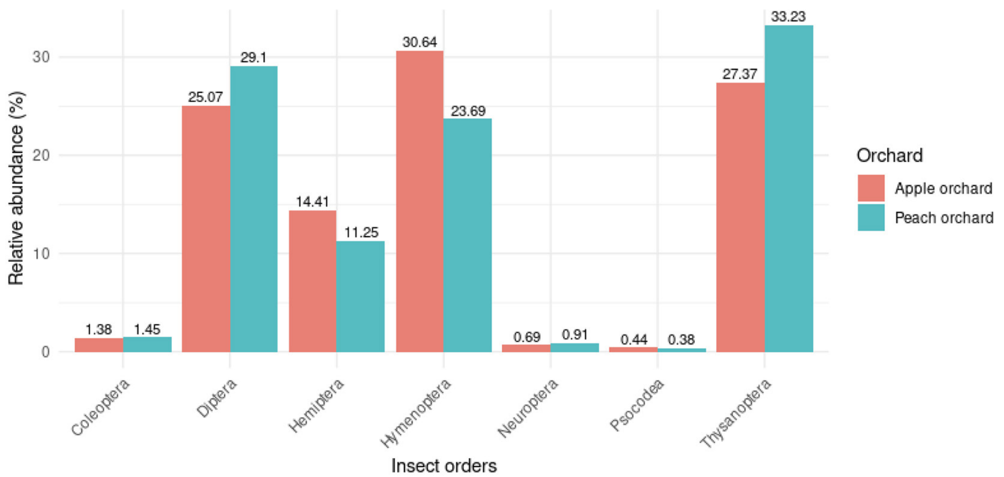

Figure 2. Relative abundance (%) of insect orders sampled in the two agroecosystems: apple and peach orchards

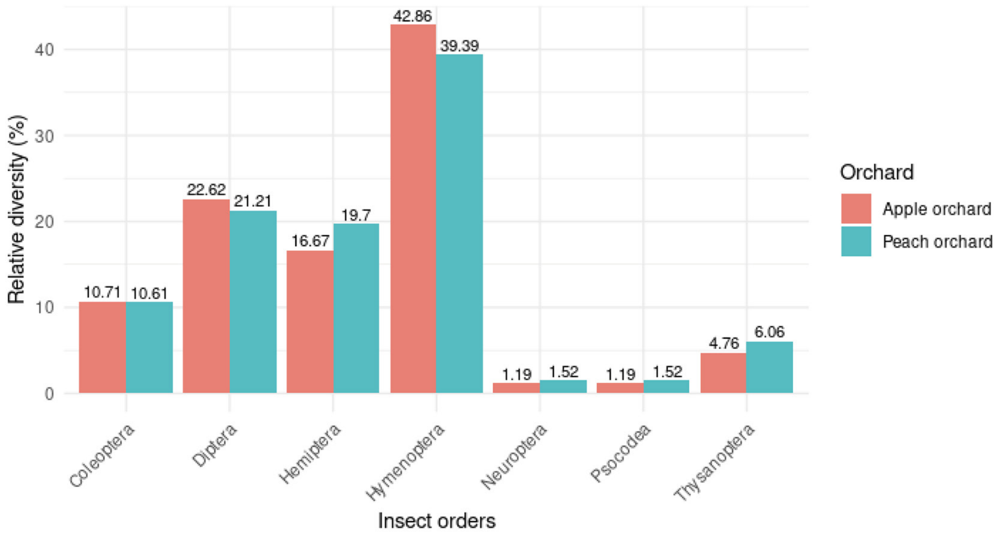

Figure 3. Relative diversity(%) of insect orders sampled in the two agroecosystems: apple and peach orchards

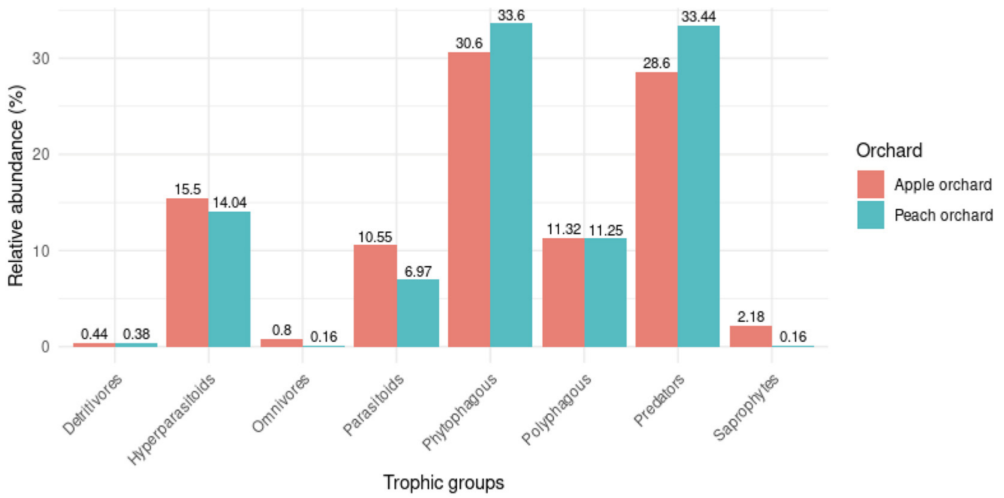

Figure 4. Relative abundance (%) of trophic guilds in the two agroecosystems: apple and peach orchards diversity (%) of trophic guilds in the two agroecosystems: apple and peach orchards

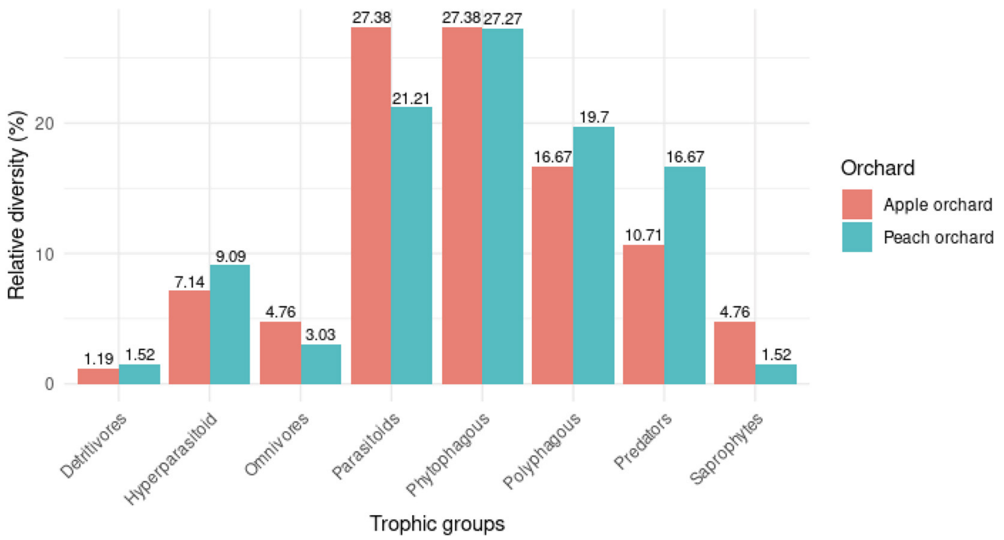

Figure 5. Relative diversity (%) of trophic guilds in the two agroecosystems: apple and peach orchards

variegata, *Coccinella septempunctata*, and *Scymnus subvillosus* are top aphidophagous predators, representing a significant portion of predatory lady beetles in agroecosystems. The abundance of these predators is closely linked to the density and quality of their phytophagous prey. The adaptive value (fitness) of Scymnus subvillosus is particularly high when fed a mixed diet composed of two aphid species (Khan and Yoldaş, 2018, Bouvet et al., 2019, Li et al., 2021, Rondoni et al., 2021).

Finally, *Stethorus punctillum* is an effective acariphage, widely used in biological control against pest spider mites in agricultural crops (Roy et al., 2005, Shimoda et al., 2015).

Among the most abundant and diverse functional groups recorded in this study were parasitoids, hyperparasitoids, and polyphagous insects. The family Braconidae was well represented, with eight parasitoid species identified: *Binodoxys angelicae*, *Chorebus* sp., *Diaeretiella rapae*, *Cotesia glomerata*, *Ephedrus plagiator*, *Aphidius ervi*, *Aphidius matricariae*, and *Agathis* sp.

The primary generalist aphid parasitoid *Ephedrus plagiator* was the most dominant species in both organic and conventional farming systems (Macfadyen et al., 2009). In addition, *Aphidius ervi* Haliday is known as a quasi-gregarious parasitoid attacking several economically important aphid pests (He and Wang, 2008). Another generalist species belonging to the genus *Aphidius*, *Aphidius matricariae*, has also been reported to contribute significantly to the natural regulation of aphid populations (Alford et al., 2017).

Laboratory studies have demonstrated that *Diaeretiella rapae* exhibits high parasitism efficiency on aphid hosts such as *Myzus persicae* and *Lipaphis erysimi*, with a marked preference for *M. persicae*. This host species resulted in a high parasitism rate (58.60%) and increased fecundity (76 eggs per female), highlighting its potential suitability for the mass rearing of *D. rapae* in augmentative biological control programmes (Soni et al., 2022).

Furthermore, *Cotesia glomerata* L. is a gregarious endoparasitoid associated with *Pieris* species (Lepidoptera: Pieridae), including *Pieris brassicae*, where it plays an important role in suppressing populations of phytophagous lepidopteran pests (Hasan and Ansari 2012).

The second most diverse family of parasitoids after Braconidae is the Ichneumonidae, which includes seven species: *Agrothereutes lanceolatus*, *Diadegma* sp., *Ichneumon* sp., *Phygadeuontini* sp., *Eurycryptus unicolor*, *Gravenhorstiini* sp., and *Barylypa delictor*.

According to Ueno (2015), *Agrothereutes lanceolatus* is a common parasitoid that attacks several lepidopteran pests in forests and orchards. The genus *Diadegma* comprises a large group of parasitoid wasps, including species such as *Diadegma semiclausum* and *Diadegma insulare*, which are considered among the most effective parasitoids against the diamondback moth (*Plutella xylostella*) (Wagener et al., 2006; Sarfraz et al., 2009, Kadirvel et al., 2011).

In contrast, detritivores, omnivores, and saprophytes were weakly represented in the two studied agroecosystems. This low abundance was also observed by Chafaa et al. (2019) and Brahim et al. (2025), who reported only 11 and 15 saprophagous individuals, respectively, as well as a very limited number of coprophagous individuals. It should be noted that the nature and color of the traps used during sampling may influence the groups of insects collected. Yellow sticky traps, widely used in agroecosystems, particularly attract flying insects. The yellow color acts as a visual stimulus that attracts several groups of insects, especially thrips, aphids, and certain parasitoid hymenopterans (Park et al., 2001, Broughton and Harrison, 2012, Henderson, 2021, Gao et al., 2025).

Indeed, the functional composition of arthropod communities may vary depending on the ecological context and management practices. These variations appear to be particularly pronounced during certain periods of the growing season, especially in spring, and in specific habitats such as agroecosystems. Functional diversity and the distribution of ecological traits of arthropods are strongly influenced by seasonal factors and the specific characteristics of habitats (Burgess et al., 2024, Schnerch et al., 2025, Saunders et al., 2025).

CONCLUSIONS

This study highlights high species richness, a relatively homogeneous distribution of individuals, and an overall well-structured entomofauna in both agroecosystems, with a slight ecological advantage observed in the apple orchard. These observations suggest that the floristic diversity present within the orchards may help mitigate the impact of agricultural practices on agroecosystem biodiversity.

Regarding trophic guilds, phytophagous insects were the most abundant, followed by predators, hyperparasitoids, and parasitoids, while detritivores and saprophytes were weakly represented. This functional organization reflects the combined influence of ecological conditions and orchard management practices, which may promote both the establishment of pests and that of their natural enemies. Furthermore, the use of yellow sticky traps as a sampling method may have exerted a selective effect on the sampled entomofauna.

The notable presence of natural enemies in both cropping systems represents an important asset for the development of biological control strategies. In particular, *Aeolothrips fasciatus*, the most abundant and widely distributed species on both crops (19.69% of individuals in apple orchards and 21.44% in peach orchards), is recognized as a predator of other thrips and therefore plays a significant role in regulating populations of harmful thrips.

Acknowledgements

We would like to express our sincere thanks to Mr. Cherfaoui Farid for allowing us to carry out this sampling at Bourkiza Farm, located in the municipality of Aïn Oussara, Djelfa Province.

REFERENCES

1. Alavi J., Awal M.M., Fekrat L., Minaei K., Manzari S. (2015). The Holarctic genus *Aeolothrips* (Thysanoptera: Aeolothripidae) from Iran, with description of two new species. *Zootaxa*, *3972*(1), 93–100. https://doi.org/10.11646/zootaxa.3972.1.7
2. Alford L., Kishani Farahani H., Pierre J.-S., Burel F., van Baaren J. (2017). Why is there no impact of the host species on the cold tolerance of a generalist parasitoid? *Journal of Insect Physiology 103*, 71–77. https://doi.org/10.1016/j.jinsphys.2017.10.008
3. Aydın G., Šlachta M., Karaca I. (2020). Detection and monitoring of *Thrips meridionalis* with colored sticky traps. *Turkish Journal of Entomology 44*(3), 285–294. https://doi.org/10.16970/entoted.651503
4. Bouvet J. P. R., Urbaneja A., Monzó C. (2019). Life history traits of coccinellids on aphids. *Biological Control 132*, 49–56. https://doi.org/10.1016/j.biocontrol.2019.02.002
5. Brahim I., Chafaa S., Mimeche F., Kebieche M. (2025). Entomological diversity associated with apple trees in northeastern Algeria. *Biologica Nyssana 16*(2). https://doi.org/10.46793/BiolNyss.16.2.18B
6. Broughton S., Harrison J. (2012). Evaluation of monitoring methods for thrips and the effect of trap colour and semiochemicals on sticky trap capture of thrips (Thysanoptera) and beneficial insects (Syrphidae, Hemerobiidae) in deciduous fruit trees in Western Australia. *Crop Protection 42*, 156–163. https://doi.org/10.1016/j.cropro.2012.05.004
7. Burgess P., Betini G. S., Cholewka A., DeWaard J. R., DeWaard S., Griswold C., Hebert P. D. N., MacDougall A., McCann K. S., McGroarty J., Miller E., Perez K., Ratnasingham S., Reisiger C., Steinke D., Wright E., Zakharov E., Fryxell J. M. (2024). Spatial and seasonal determinants of arthropod communities composition across an agro-ecosystem landscape. *FACETS 9*, 1–15. https://doi.org/10.1139/facets-2023-0051
8. Cawood R. A., Seymour C. L., Pryke J. S. (2026). Passive recovery of insects after pine removalin a biodiversity rich shrubland is taxon dependent. *Biological Conservation 313*, 111583. https://doi.org/10.1016/j.biocon.2025.111583
9. Chafaa S., Belkhadria S., Mimeche F. (2019). Entomofauna investigations in apricot orchards (Prunus armeniaca) in northeastern Algeria. *Biodiversity Journal 10*(2), 95–100. https://doi.org/10.31396/Biodiv.Jour.2019.10.2.95.100
10. Chatterjee T., Chakrabarty S., Mitra B., Chaudhuri P. (2025). Unveiling the association of mangrove flowering phenology with insect dynamics. *Acta Oecologica 126*, 104052. https://doi.org/10.1016/j.actao.2024.104052
11. Chenchouni H., Menasria T., Neffar S., Chafaa S., Bradai L., Chaibi R., Mekahlia M. N., Bendjoudi D., Si Bachir A. (2015). Spatiotemporal diversity of insect assemblages in a semi-arid Sabkha ecosystem. *PeerJ 3*, e860. https://doi.org/10.7717/peerj.860
12. Daghefali N., Neddaf Hayet M., Khedam H., Chergui S., Djitli Y., Chikhi W., Saharaoui L., Berrai H., Daoudi Hacini S. (2025). Diversity and seasonal dynamics of key insect pests associated with durum wheat in two contrasting agroecosystems in northern algeria. *Acta Zoologica Bulgarica 77*(4). https://doi.org/10.71424/azb77.4.002932
13. Dajoz R. (2019). Précis d'écologie. Paris: Dunod. 640 p.
14. Dib S., Nouari S., Bengusmia D. (2022). Extraction of urban areas using spectral indices combination and Google Earth Engine in Algerian highlands (Case study: Cities of Djelfa, Messaad, Ain Oussera). *Anuário do Instituto de Geociências* 45:44537. https://doi.org/10.11137/1982-3908_2022_45_44537

15. Dou S., Liu B., Li Q., Sun M., Lu Y. (2026). Population dynamics of *Hippodamia variegata*. (Goeze) in Korla fragrant pear orchards of Xinjiang, *China Biological Control 215*, 106003. https://doi.org/10.1016/j.biocontrol.2026.106003
16. Elimem M., Kalboussi M., Lahfef C., Bousslema T., Limem-Sellami E., Slim, R. (2022). Thrips species biodiversity and dynamic populations in an organic Citrus orchard in northeastern Tunisia. *Journal of Entomology and Zoology Studies 9*(3), 1–7. https://doi.org/10.22271/23940522.2022.v9.i3a.906
17. El Mouchir (2022). Wilaya 17: Djelfa. Available online: https://elmouchir.caci.dz/wilaya/17 (accessed on 20 November 2025).
18. Forbes, A. A., Bagley, R. K., Beer, M. A., Hippee, A. C., Widmayer, H. A. (2018). Quantifying the unquantifiable: Why Hymenoptera, not Coleoptera, is the most speciose animal order. *BMC Ecology*, *18*, Article 21. https://doi.org/10.1186/s12898-018-0176-x
19. Gao, Y., Yin, F., Hong, C., Chen, X., Deng, H., Liu, Y., Li, Z., Yao, Q. (2025). Intelligent field monitoring system for cruciferous vegetable pests using yellow sticky board images and an improved Cascade R-CNN. Intelligent monitoring system for pests. *Journal of Integrative Agriculture 24*(1), 220–234. https://doi.org/10.1016/j.jia.2024.06.017
20. GavloskiA. J. A., DeWaard J., Steinke D., Fryxell J. M. (2024). Sampling requirements for standardized insect biodiversity monitoring vary with abundance. *FACETS 9*, 1–18. https://doi.org/10.1139/facets-2024-0007
21. Granata E., Mogilnaia E., Alessandrini C., Sethi K., Vitangeli V., Biella P., Fedrigotti C., Roseo F., Pedrini P., Brambilla M. (2025). Management factors strongly affect flower-visiting insects in intensive apple orchards. Agriculture, *Ecosystems & Environment 380*, 10938. https://doi.org/10.1016/j.agee.2024.109382
22. Hasan F., Ansari M. S. (2012). Superparasitism in *Cotesia glomerata* does not benefit the host plant by reduction of herbivory caused by *Pieris brassicae*. *Saudi Journal of Biological Sciences 19*(1), 65–71. https://doi.org/10.1016/j.sjbs.2010.11.002
23. Henderson P. A. (2021). *Southwood's ecological methods* (5th ed.). Oxford University Press. https://doi.org/10.1093/oso/9780198862277.001.0001
24. He X. Z., Wang Q. (2008). Reproductive strategies of *Aphidius ervi* Haliday (Hymenoptera: Aphidiidae). *Biological Control 45*(3), 281–287. https://doi.org/10.1016/j.biocontrol.2008.03.003
25. Judt C., Korányi D., Zaller J. G., Batáry P. (2023). Floral resources and ground covers promote natural enemies but not pest insects in apple orchards: A global meta-analysis. *Science of the Total Environment 903*, 166139. https://doi.org/10.1016/j.scitotenv.2023.166139
26. Justino G. L., Zanco B., Guzman L. M., Echeverri A., Noriega J. A., Fávaro L. F., Morimoto, J. 2026. Insects are underrepresented across red lists of threatened biodiversity in the Neotropics. *Biological Conservation 314*, 111649. https://doi.org/10.1016/j.biocon.2025.111649
27. Kadirvel P., Srinivasan R., Lin M.-Y., Al-Jouri E., Idraw M. W., de la Peña R. C. (2011). Occurrence of *Diadegma semiclausum* in Syria. *Journal of Asia-Pacific Entomology 14*(1), 52–57. https://doi.org/10.1016/j.aspen.2010.11.006
28. Khan M. H., Yoldaş Z. (2018). Intraguild predation between coccinellids, *Hippodamia variegata* (G.) and *Coccinella septempunctata* L. (Coleoptera: Coccinellidae): the role of prey abundance. *Biological Control 126*, 7–14. https://doi.org/10.1016/j.biocontrol.2018.07.011
29. Koutti A., Bounaceur F., Razi S. (2017). Diversité et distribution spatiale des thrips sur différentes variétés d'agrumes en Algérie. *Agrobiologia 7*(1), 263–273. https://asjp.cerist.dz/en/article/119414
30. Lenné J., Wood D. (2024). Crop diversity in agroecosystems for pest management and food production. *Plants 13*(8): 1164. https://doi.org/10.3390/plants13081164
31. Li H., Li B., Lövei G. L., Kring T. J., Obrycki J. J. (2021). *Interactions among native and non-native predatory Coccinellidae influence biological control and biodiversity*. *Annals of the Entomological Society of America, 114*(2), 119–136. https://doi.org/10.1093/aesa/saaa047
32. Littlewood N. A., Dennis P., Pakeman R. J., Woodin, S. J. (2006). Moorland restoration aids the reassembly of associated phytophagous insects. *Biological Conservation 132*(3): 395–404. https://doi.org/10.1016/j.biocon.2006.04.033
33. Macfadyen S., Gibson R., Raso L., Sint D., Traugott M., Memmott J. (2009). Parasitoid control of aphids in organic and conventional farming systems. *Agriculture, Ecosystems & Environment 133* (1–2): 14–18. https://doi.org/10.1016/j.agee.2009.04.012
34. Markó V., Elek Z., Kovács-Hostyánszki A., Kőrösi Á., Somay L., Földesi R., Varga Á., Iván Á., Báldi A. (2017). Landscapes, orchards, pesticides: Abundance of beetles (Coleoptera) in apple orchards along pesticide toxicity and landscape complexity gradients. *Agriculture, Ecosystems & Environment 247*, 246–254. https://doi.org/10.1016/j.agee.2017.06.038
35. Mazed M. K., Afroz M., Rahman M. M. (2022). Global decline of insects: A Review from Agricultural Perspective. *Agricultural Reviews 43*(3): 334–340. https://doi.org/10.18805/Ag.RF-223

36. Morse J. G., Hoddle M. S. (2006). Invasion biology of thrips. *Annual Review of Entomology 51*, 67–89. https://doi.org/10.1146/annurev.ento.51.110104.151044
37. Nautiyal S., Bhaskar K., Khan Y. D. I. (2015). Biodiversity of semiarid landscape. *Cham: Springer*. https://doi.org/10.1007/978-3-319-15464-0
38. Nishimura I., Tachibana T., Uchida K., Lu X., Zhao X., Bai Y., Sasaki T. (2024). Complementarity effects among plant–pollinator interactions can enhance community seed production in semi-arid natural grasslands. *Journal of Arid Environments 224*, 105221. https://doi.org/10.1016/j.jaridenv.2024.105221
39. Park J.-J., Kim J.-K., Park H., Cho K. (2001). Development of time-efficient method for estimating aphids density using yellow sticky traps in cucumber greenhouses. *Journal of Asia-Pacific Entomology 4*(2), 143–148. https://doi.org/10.1016/S1226-8615(08)60115-6
40. Plénet D., Borg J., Hilaire C., Blanc P., Bussi C., Codini M., Drusch S., Gallia V., Greil, M.-L., Hostalnou E., Labeyrie B., Mercier V., Millan M., Montrognon Y., Monty D., Mouiren C., Ruesch J., Vercambre G. (2023). Agro-economic performance of peach orchards under low pesticide use and organic production in a cropping system experimental network in France. *European Journal of Agronomy 148*, 126866. https://doi.org/10.1016/j.eja.2023.126866
41. Rondoni G., Borges I., Collatz J., Conti E., Costamagna A., Dumont F. et al. (2021). Exotic ladybirds for biological control of herbivorous insects – a review. *Entomol. Exp. Appl. 169*, 6–27. https://doi.org/10.1111/eea.12963
42. Roy M., Brodeur J. Cloutier C. (2005). Seasonal activity of the spider mite predators *Stethorus punctillum* (Coleoptera: Coccinellidae) and *Neoseiulus fallacis* (Acarina: Phytoseiidae) in raspberry, two predators of *Tetranychus mcdanieli* (Acarina: Tetranychidae). *Biological Control 34*(1), 47–57. https://doi.org/10.1016/j.biocontrol.2005.03.012
43. Sáenz-Romo M. G., Veas-Bernal A., Martínez-García H., Campos-Herrera R., Ibáñez-Pascual S., Martínez-Villar E., Pérez-Moreno I., Santiago Marco-Mancebón V. (2019). Ground cover management in a Mediterranean vineyard: Impact on insect abundance and diversity. *Agriculture, Ecosystems & Environment*, *283*, 106571. https://doi.org/10.1016/j.agee.2019.106571.
44. Santistevan Méndez L., Santistevan Méndez M., Quevedo-Pinos N. (2024). Insect fauna associated with passion fruit (*Passiflora edulis*) and lemon (*Citrus aurantiifolia*) agroecosystems in a semi-arid climate in Ecuador. *Acta Agronómica 73*(2), 117–125. https://revistas.unal.edu.co/index.php/acta_agronomica/article/view/114653
45. Sarfraz M., Dosdall L. M., Keddie B. A. (2009). Fitness of the parasitoid Diadegma insulare is affected by its host's food plants. *Basic and Applied Ecology 10*(6), 563–572. https://doi.org/10.1016/j.baae.2009.01.006
46. Saunders M. E., Lees A. C., Grames E. M. (2025). Understanding and counteracting the denial of insect biodiversity loss. *Current Opinion in Insect Science 68*, 101338. https://doi.org/10.1016/j.cois.2025.101338
47. Schnerch B., Bucher R., Djoudi E. A., Hossain M., Niyibizi I. A. B., Birkhofer K. (2025). Growth stage, management and habitat influence arthropod communities in apple orchards. *Agriculture, Ecosystems & Environment 394*, 109901. https://doi.org/10.1016/j.agee.2025.109901
48. Shah M. A., Rehman S. A., Tramboo H. A., Rasool R., Raja W. H., Nabi S. U., Malik G., Mir J. I., Sharma O. C., Verma M. K. (2025). Outbreaks of green apple aphid *Aphis pomi* in apple orchards of Kashmir, India: Grower-Adopted management tactics and their implications for cultivation costs. *Crop Protection* 197, 107328. https://doi.org/10.1016/j.cropro.2025.107328
49. Shimoda T., Kobori Y., Yara K., Hinomoto N. (2015). A simple method of rearing insect natural enemies of spider mites. *Biological Control 80*, 70–76. https://doi.org/10.1016/j.biocontrol.2014.09.015
50. Soni S., Kumar S., Singh R., Badiyala A., Chandel R. S. (2022). Aphid parasitoid, *Diaeretiella rapae* (McIntosh) (Hymenoptera: Braconidae): opportunities for its use in integrated management of aphids infesting rapeseed-mustard in north-western Indian Himalayas. *Crop Protection 151*, 105819. https://doi.org/10.1016/j.cropro.2021.105819
51. Tassoni S., Becker D., Kasten M. K., Morinière J., Grass I. (2024). Insect conservation in agricultural landscapes needs both high crop heterogeneity and semi-natural habitats. *Global Ecology and Conservation 55*, e03218. https://doi.org/10.1016/j.gecco.2024.e03218
52. Ueno, T. (2015). Effects of host size and laboratory rearing on offspring development and sex ratio in the solitary parasitoid *Agrothereutes lanceolatus* (Hymenoptera: Ichneumonidae). *European Journal of Entomology, 112*(2), 281–287. https://doi.org/10.14411/eje.2015.048
53. Vasconcellos A., Andreazze R., Almeida A. M., Araujo H. F. P., Oliveira E. S., Oliveira U. 2010. Seasonality of insects in the semi-arid Caatinga of northeastern Brazil. *Revista Brasileira de Entomologia 54*(3), 471–476. https://doi.org/10.1590/S0085-56262010000300019
54. Vergara P. M., Fierro A., Carvajal M. A., Alaniz A. J., Quiroz M. (2022). Multiple environmental drivers for Patagonian forest-dwelling beetles :

Contrasting functional and taxonomic responses across strata and trophic guilds. *Science of the Total Environment 838*, 155906. https://doi.org/10.1016/j.scitotenv.2022.155906

55. Wagener B., Reineke A., Löhr B., Vidal S. (2006). Phylogenetic study of Diadegma species (Hymenoptera: Ichneumonidae) inferred from analysis of mitochondrial and nuclear DNA sequences. *Biological Control 37*(2), 131–140. https://doi.org/10.1016/j.biocontrol.2006.01.004
56. Zhang M., Yv H., Dai C., Lu Y. 2026. Contamination by systemic insecticide harms the dispersal ability of the lady beetle *Hippodamia variegata. Crop Protection 199*, 107426. https://doi.org/10.1016/j.cropro.2025.107426
57. Zhao J., Yu L., Newbold T., Shen X., Liu X., Hua F., Kanniah K., Ma K. (2024). Biodiversity responses to agricultural practices in cropland and natural habitats. *Science of the Total Environment 922*, 171296. https://doi.org/10.1016/j.scitotenv.2024.171296
58. Zhu Y., Gao Z., Wang X., Gong S., Lu Y., Yao D., Yang F. (2025). Quantifying the impacts of intercropping practices on above- and belowground biodiversity in China's orchards: *A meta-analysis. Ecological Engineering 216*, 107619. https://doi.org/10.1016/j.ecoleng.2025.107619