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Diversity of arthropods subservient to olive groves in arid region (Northeastern Algeria)

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Abstract. *Olea europaea* L. 1753, is one of the oldest and most distinctive trees in the Mediterranean region. Its nutritional, social, cultural, and economic value is very important for populations in arid regions, where it is widely distributed. A sign of a sustainable environment in many agricultural regions is the existence of a wide variety and abundance of arthropod groups. The main objective of the study is to evaluate the diversity of arthropods subservientin in olive agro-systems in the arid region by using several sampling techniques, namely classic sight hunting, visual inspection, Barber pots, and yellow traps. The inventory is carried out over a period of 5 months, from February to June 2023, in three stations in M'Sila (northeastern Algeria). Three classes of arthropods were found: Insecta, Arachnida, and Malacostraca. Captures were numerically dominated by Insecta, representing 96.88% of total captures. Arachnida and Malacostraca classes represented about 2.74 and 0.38%, respectively. During this research, a total of 1861 arthropod individuals were collected and identified into 83 species, 79 genera, 53 families, and 15 orders. The most abundant orders were: Diptera (42.56%), Hymenoptera (28.11%), and Coleoptera (7.32%). However, we found a significant difference in species composition according to habitat ($P < 0.01$). The species were determined, and the ecological indices were calculated (Shannon Value, Evenness values and Simpson reciprocal index). The dominant functional feeding groups were phytophages (41.91 %), predators (32.94%), and polyphages (22.14%).

The arthropods included several olive pests such as *Euphyllura olivina* (Costa) (Hemiptera: Liviidae), *Bactrocera oleae* (Rossi) (Diptera: Tephritidae), *Prays oleae* (Bernard) (Lepidoptera: Praydidae), *Liothrips oleae* Costa (Thysanoptera: Phlaeothripidae), and *Oxycenus maxwelli* (Keifer) (Arachnida: Eriophyidae).

Keywords: diversity, arthropods, pests, olive grove, species richness, arid land.

Introduction

The olive tree (*Olea europaea* L. 1753) is among the most ancient and distinctive trees, holding significant historical and regional importance, particularly in the Mediterranean area. It is widely dispersed, and its nutritional, social, cultural, and economic value to the communities in this region is immense, as noted by Claridge and Walton in 1992. Olives, which are small trees belonging to the Oleaceae family, are indigenous to tropical and warm temperate zones worldwide.

Olives are grown in a variety of agroecological zones, mostly in plain and hilly areas (Gkisakis *et al.,* 2014). These agroecological zones differ in terms of elevation, biotic factors, pedoclimatic conditions, and landscape structure. In Algeria, the olive tree is a major element of the agricultural economy. The areas cultivated for olive growing in Algeria reach 450,000 hectares, with an olive number reaching 6.2 million trees and a production of 7 million quintals of olives and nearly 70,000 tons of olive oil (DSASI, 2018; Amrouni Sais *et al.*, 2021). M'Sila province occupies the most important rank in Algeria, with an established area of 11500 hectares (DSA, 2023). The irrigated areas have become widespread in the interior department due to rain deficiency and climate change. Olive production faces threats from various arthropods and pathogens that affect olive trees. Despite the hardiness and adaptability of the olive tree, enabling it to thrive and produce even in difficult ecological conditions, most olive plantations in Algeria are marked by either aging trees or a lack of proper cultural care (Chafaa, 2013).

Large populations of arthropods are present in the agroecosystem, and these populations are impacted by agronomic techniques, temperature, humidity, rainfall, and the surrounding crop (Divya Sri *et al.,* 2023). A few are harmful, such as agriculture pests and disease vectors whereas, others are beneficial, such as decomposers, seed dispersers, pollinators, and natural enemies of pests (Deghiche-Diab *et al.,* 2021). Numerous pest species cause significant harm to the olive tree and its yield by growing on its fruit, foliage, flowers, and timber (Chafaa *et al.,* 2019a). It is noteworthy to mention that climate is the main driver that controls the distribution range of arthropods as well as the seasonal variation in their community composition (Chenchouni *et al.,* 2015; Chafaa *et al.,* 2019a). Few studies have investigated the biodiversity of arthropods subservient to olive groves under arid and semiarid conditions carried out in Algeria (Chafaa *et al.,* 2019a, Deghiche-Diab *et al.,* 2021).

The main objective of this study is to assess the diversity of arthropods subservient to the agro-systems of olive plantations grown in three arid zones in M'Sila province (north-eastern Algeria).

Materials and methods

Study area

M'Sila is located in northeastern Algeria. Overall, it is part of the region of the East Highlands and extends over an area of 18 718 km^2. It is composed of 47 municipalities grouped into 15 daïras. The area is characterised by a Mediterranean arid bioclimatic stage with a mild winter (Q_2 = 17.02 – 19.84, m = 3.37 to 4.10°C, M = 38.87 to 40.06°C, P = 182.94 to 201.86 mm) based in weather data from nearby meteorological stations (Zedam *et al.,* 2022). The rainy season spans from October to May, while the dry season typically persists until August. The region's Mediterranean climate is influenced by the Sahara (Mimeche and Oliva-Paterna, 2018). Hydrologically, this environment is linked to a rainfall regime marked by pronounced irregularities leading to the absence of permanent flows from most watercourses (Mimeche, 2014). Agriculture, still the primary occupation in the M'sila region, focuses on the production of vegetables, cereals (barley and corn) and olive orchard, adapting to the available water supplies. The arable land area covers an area of 50,000 ha, with 50% of it under irrigation (Abdesselam *et al.,* 2013). The majority of the groundwater in the M'Sila region is situated below 125 m.

Sample collection

The research was conducted from February to June 2023, in three pilot orchards located at different sites in M'Sila: Ouled Mansour (S1), Ouled Sidi Amor (S2) and District Ksob (S3) (Tab. 1). This period was chosen as it corresponds to the peak activity of many arthropods, and abundances exhibits the most significant differences across farming systems (Cotes *et al.,* 2011).

To prevent the edge effect, all samplings were carried out more than 30 meters from the olive grove's edge (Carpio *et al.,* 2019). It is important to combine different sample techniques since prior research has demonstrated that some sampling strategies might lead to a significant bias towards specific species. In this study, we used three sampling methods-pan traps, bait traps, and sweep nets – following the methodology outlined by Castro *et al.* in 2017.

The traps were placed above the ground and between olive trees to enhance visibility to arthropods; they were set at each study site for two weeks using different technics. We employed a combination of qualitative sampling (classical hunting) (Colas, 1974), and a quantitative sampling using different methods including trapping (colored traps, Barber pots, fly gobbles), and mowing (Benkhelil, 1991), as well as striking (Fauvel *et al.,* 1981).

The sampled species were taken to the laboratory and preserved in tubes filled with 70% alcohol. Each tube was labeled with essential information, including the date of collection, the type of traps used, and the specific site. In the laboratory, the collected insects were sorted, counted, and finally identified using specialized identification keys.

Table 1. Characteristics of studied Stations.

Site	Ouled Mansour (S1)	Ouled Sidi Amor (S2)	District KSob (S3)
Latitude	35°48’59’’N	35°56’51’’N	35°49’07’’N
Longitude	4°27’07’’E	4°22’58’’E	4°33’55’’E
Altitude (m)	504	828	556
Vegetation	Olive tree, pistachio tree, eggplant and chili pepper	Olive tree	Olive tree, Grenadine
Number and variety of olive tree	160 chemlal, 140 sigoise and 150 different variety	95 chemlal	105 chemlal and 50 Azeradj
Irrigation	by channel	by drip	by drip
Implantation date	2002	2009	2010
Treatments	do not benefit from phytosanitary treatments		

Statistical analysis

Diversity parameters of arthropods, diversity in each region of olive orchards were evaluated by calculating: (i) the relative frequency (RF) of each arthropod order (RF= percentage of the number of individuals of a species on the total number N in each station); (ii) species richness (S), which represents the total number of species identified; (iii) the N/S ratio; (iv) Shannon diversity index (H): $H = -\Sigma((ni/ N)\times \log2(ni N))$, with ni represents the abundance of species i and N is the total number of individuals of a given sample; (v) evenness (E) with $E = H/H max$, where $H max= \log2 S$ (Magurran 2004); (vi) Simpson reciprocal index, $SRI = (1/D)$, with $D=\Sigma(ni(ni-1)/N(N-1))$; and (vii) the SRI/S ratio, which varies between 0 and 1. Some diversity parameters (N, S, RF) were expressed at the level of taxonomic orders to facilitate comparisons with previous studies (Chenchouni, 2017; Chafaa *et al.,* 2019a).

We used Kruskal-Wallis to assess impacts of habitat (grouping factors) on biodiversity and species abundances. All of these analyzes were developed using PAST 4.16. 2024.

Results

Abundances and relative frequency of arthropods

A taxonomic composition analysis of the species identified in the study area revealed the presence of 83 species from 1861 individuals in 3 classes, 15 orders, 53 families, and 79 genera. In the M'Sila region, three classes of arthropods were found: Insecta, Arachnida, and Malacostraca.

Insecta accounted for 96.88% of all captures, while Arachnida and Malacostraca classes represented approximately 2.74 and 0.38%, respectively. At the Ouled Mansour station, 65 species belonged to 14 orders; Ouled Sidi Amor station had 57 species belonged to 14 orders, and in the Ksob district station, insects included 54 species in 13 orders (Tab. 2). The Kruskal-Wallis test revealed a significant variation in arthropods abundances between the three stations (χ^2= 10.28, $P < 0.01$).

Out of a total of 1,861 individuals collected during the sampling period in three olive grove, the most abundant species were from Diptera order; *Bactrocera oleae* (7.52%) and *Musca domestica* (6.99%). In Ouled Mansour station, the most abundant species was *Bactrocera oleae* (Diptera) (10.27%); *Musca domestica* (9.53%), *Apis mellifera* (8.39%), *Chlorops* sp, and *Halictuss cabiosae* (5.83%) in OuledSidi Amor station. In the district Ksob, the most abundant species were from Diptera order *Bactrocera oleae* (10.55%) and *Musca domestica* (8.97%), Blattodea order; *Blatta orientalis* (8.44%), and Hymenoptera order; *Aphaenogaster rupestris* (5.28%).

Arthropods families with high capture frequency included Thephritidae (18.49%), Formicidae (11.04%), and Syrphidae (7.06%) in Ouled Mansour station; in Ouled Sidi Amor Apidae (14.94%), Formicidae (13.51%), Syrphidae (9.67%), Muscidae (9.53%) and Calliphoridae (7.82%); in the district Ksob olive grove Thephritidae (13.46%), Formicidae (11.35%), Blattidae (10.82%), Syrphidae (5.54) and Myrmicinae (5.28%). The abundance of other orders was <5% in all three stations of olive groves (Tab. 3). The Kruskal-Wallis test showed a significant relationship between the abundances of arthropods families in the three stations (χ^2= 6.20, P < 0.01).

Arthropods orders with high capture frequencies were Diptera (42.88%), Hymenoptera (21.05%), Coleoptera (6.68%), and Hemiptera (5.91%) in Ouled Mansour station; in the second station Ouled Sidi Amor, Diptera (45.95%), Hymenoptera (37.98%), Coleoptera (5.83%), and Homoptera (5.12%). In the district Ksob olive grove; Diptera (35.62%), Hymenoptera (37.98%), and Blattodea (10.82). The abundance of other orders was <5% in all three olive groves (Tab. 4). Overall, there was no difference in the frequency of abundance, as indicated by the non-significant variation in abundances between stations (Kruskal-Wallis test, *P*> 0.05).

Table 2. Systematic list of the relative frequency (RF) of arthropods and functional feeding group recorded in olive groves at three stations in M'Sila, Algeria.

Class	Order	Family	Species	RF (%)				FFG
				S1	S2	S3	Overall	
Insecta	Orthoptera	Acrididae	*Locusta migratoria*	0.13	0.14	3.69	0.86	Phy
			Anacridium aegyptium	2.44	0.00	0.79	1.18	Phy
		Gryllidae	*Gryllus campestris*	0.00	0.28	1.32	0.38	Phy
	Homoptera	Aphididae	*Myzus* sp.	0.26	0.00	0.26	0.16	Phy
			Aphis gossypii	0.51	0.00	0.26	0.27	Phy
			Aphis fabae	0.64	0.00	0.00	0.27	Phy
		Psyllidae	*Euphyllura olivina*	1.54	4.41	2.64	2.85	Phy
		Pentatomidae	*Palomena* sp	0.13	0.71	0.00	0.32	Phy
	Coleoptera	Coccinellidae	*Coccinella algerica*	0.64	0.14	2.37	0.81	Pre
			Hippodamia variegata	0.26	0.43	0.00	0.27	Pre
		Chrysomelidae	*Longitarsus* sp	0.00	0.43	0.00	0.16	Phy
		Anobiidae	*Lasioderma* sp	0.13	0.00	0.00	0.05	Phy
		Curculionidae	*Phloeotribus scarabeoides*	0.00	0.71	0.26	0.32	Phy
		Melyridae	*Psilothrix* sp	0.39	0.00	0.00	0.16	Phy

Class	Order	Family	Species	RF (%)				FFG
				S1	S2	S3	Overall	
		Cryptophagidae	*Cryptophagus* sp	0.26	0.00	0.26	0.16	Phy
		Geotrupidae	*Geotrupes*sp	0.00	0.28	0.00	0.11	Cop
		Scarabaeidae	*Phyllognathus excavatus*	1.67	0.28	1.06	1.02	Sap
		Tenebrionidae	*Omophlus* sp	0.00	0.43	0.26	0.21	Pre
			Tenebrio molitor	0.26	0.00	0.00	0.11	Pol
		Melolonthidae	*Amphimallonsolsticialis*	0.00	0.00	2.11	0.43	Phy
		Carabidae	*Amara* sp	0.13	0.00	1.58	0.38	Pre
			Calathus fuxipes	1.41	0.28	0.00	0.70	Pre
			Chlaenius spoliatus	0.00	0.28	0.00	0.11	Pre
			Badister sp	0.00	0.00	0.79	0.16	Pre
			Harpalussp	0.13	0.00	0.53	0.16	Pre
			Carabusfami ninumidus	0.00	1.56	0.00	0.59	Pre
		Staphylinidae	*Tachyporus hypnorum*	0.00	0.57	0.00	0.21	Pre
		Cleridae	*Trichodes alvearius*	1.41	0.43	2.11	1.18	Pre
	Diptera	Syrphidae	*Eupeodes corollae*	3.34	4.84	3.17	3.87	Pre
			Toxomerus marginatus	3.72	4.84	2.37	3.87	Pre
		Muscidae	*Musca domestica*	3.72	9.53	8.97	6.99	Pol
		Drosophilidae	*Drosophila melanogaster*	1.54	2.99	0.53	1.88	Sap
		Calliphoridae	*Calliphora erythrocephala*	1.54	4.84	2.37	2.96	Pol
			Calliphora vicina	2.18	1.14	1.32	1.61	Pol
			Chloroprocta sp	0.77	1.85	0.00	1.02	Pol
		Chloropidae	*Chlorops* sp	3.98	6.54	2.90	4.73	Phy
			Thaumatomyiaglabra	0.26	2.70	0.00	1.13	Pre
		Sarcophagidae	*Sarcophaga* sp	0.51	0.00	0.00	0.21	Pre
		Tephritidae	*Bactrocera oleae*	10.27	2.84	10.55	7.52	Phy
			Tephritis postica	1.80	0.28	0.00	0.86	Phy
			Tephritis praecox	1.41	0.00	0.79	0.75	Phy
			Ceratitis capitata	4.62	2.13	2.11	3.17	Pol
			Trupanea guimari	0.39	0.00	0.00	0.16	Phy
		Tachinidae	*Phryxe vulgaris*	2.82	1.42	0.53	1.83	Pol
	Hymenoptera	Formicidae	*Camponotus* sp	3.34	2.99	0.00	2.53	Pre
			Monomorium salomonis	1.54	2.28	2.11	1.93	Pre
			Cataglyphis bicolor	1.93	2.56	2.64	2.31	Pre
			Tetramorium lanuginosum	0.00	0.00	3.96	0.81	Pre
			Tapinoma melanocephalum	2.18	3.84	0.53	2.47	Pre
			Tapinoma nigerrimum	2.05	1.85	2.11	1.99	Pre

Class	Order	Family	Species	RF (%)				FFG
				S1	S2	S3	Overall	
		Myrmicinae	*Aphaenogaster rupestris*	0.00	0.00	5.28	1.07	Pre
		Halictidae	*Halictus scabiosae*	2.70	5.83	0.53	3.44	Phy
		Scoliidae	*Scolia* sp	0.39	0.71	0.00	0.43	Pre
		Megachilidae	*Anthidium laterale*	1.54	1.71	0.79	1.45	Phy
			Hoplitis anthocopoides	0.51	0.00	2.37	0.70	Phy
		Vespidae	*Polistes gallicus*	0.64	0.00	0.26	0.32	Pre
		Apidae	*Nomada cinnabarina*	0.00	3.84	0.26	1.50	Phy
			Andrena bicolor	0.39	1.14	1.32	0.86	Phy
			Eucera oraniensis	0.00	0.43	1.06	0.38	Phy
			Bombus terrestris	0.26	1.14	0.00	0.54	Phy
			Apis mellifera	2.70	8.39	0.53	4.41	Phy
		Braconidae	*Psyttalia concolor*	0.90	1.28	0.26	0.91	Pre
	Thysanoptera	Aeolothripidae	*Aeolothrips* sp	0.64	0.00	0.00	0.27	Pre
		Phlaeothripidae	*Liothrips oleae*	0.26	0.57	0.00	0.32	Phy
	Blattodea	Ectobiidae	*Dziriblatta stenoptera*	0.00	0.14	0.00	0.05	Phy
		Blattidae	*Periplaneta americana*	1.93	0.28	2.37	1.40	Pol
			Blatta orientalis	1.54	0.00	8.44	2.36	Phy
	Dermaptera	Forficulidae	*Forficula auricularia*	1.41	0.28	1.06	0.91	Pol
		Anisolabididae	*Anisolabis maritima*	0.00	0.71	0.00	0.27	Pol
	Neuroptera	Coniopterygidae	*Conwentzia psociformis*	1.80	0.00	1.32	1.02	Pre
		Chrysopidae	*Chrysoperla carnea*	2.82	0.28	1.06	1.50	Pre
	Lepidoptera	Noctuiidae	*Agrotis segetum*	0.39	0.00	0.26	0.21	Phy
		Praydidae	*Prays oleae*	1.16	0.57	0.00	0.70	Phy
	Hemiptera	Lyctocoridae	*Lyctocoris* sp	0.77	0.00	0.00	0.32	Pre
		Pentatomidae	*Nezara viridula*	2.82	0.43	2.64	1.88	Pol
		Lygaeidae	*Spilostethus pandurus*	2.31	0.28	0.26	1.13	Phy
	Mantodea	Mantidae	*Mantis religiosa*	0.00	0.57	0.53	0.32	Pre
Arachnida	Aranea	Agelenidae	*Lycosoides coarctata*	0.00	0.00	0.26	0.05	Pre
		Lycosidae	*Trochosa* sp	0.26	0.00	0.00	0.11	Pre
		Dysderidae	*Dysdera crocata*	1.16	0.43	0.26	0.70	Pre
	Trombidiformes	Eriophyidae	*Aculops lycopersici*	2.44	0.00	0.00	1.02	Phy
			Oxycenus maxwelli	1.16	0.14	1.58	0.86	Phy
Malacostraca	Isopoda	Agnaridae	*Hemilepistus* sp	0.90	0.00	0.00	0.38	Phy

FFG, functional feeding group; Phy, phytophagous species; Pre, predatory species; Cop, coprophagous species; Sap, saprophagous specie; Pol, polyphagous species.

Table 3. Summarisation of species richness (S) and relative frequency (RF) for arthropods family recorded in olive groves, M'Sila (Algeria).

Family	S1		S2		S3		Overall	
	S	RF (%)	S	RF (%)	S	RF (%)	S	RF (%)
Acrididae	2	2.57	1	0.14	2	4.49	2	2.04
Gryllidae	0	0.00	1	0.28	1	1.32	1	0.38
Aphididae	3	1.41	0	0.00	2	0.53	3	0.70
Psyllidae	1	1.54	1	4.41	1	2.64	1	2.85
Pentatomidae	1	0.13	1	0.71	0	0.00	1	0.32
Coccinellidae	2	0.90	2	0.57	1	2.37	2	1.07
Chrysomelidae	0	0.00	1	0.43	0	0.00	1	0.16
Anobiidae	1	0.13	0	0.00	0	0.00	1	0.05
Curculionidae	0	0.00	1	0.71	1	0.26	1	0.32
Melyridae	1	0.39	0	0.00	0	0.00	1	0.16
Cryptophagidae	1	0.26	0	0.00	1	0.26	1	0.16
Geotrupidae	0	0.00	1	0.28	0	0.00	1	0.11
Scarabaeidae	1	1.67	1	0.28	1	1.06	1	1.02
Tenebrionidae	1	0.26	1	0.43	1	0.26	2	0.32
Melolonthidae	0	0.00	0	0.00	1	2.11	1	0.43
Carabidae	3	1.67	3	2.13	3	2.90	6	2.10
Staphylinidae	0	0.00	1	0.57	0	0.00	1	0.21
Cleridae	1	1.41	1	0.43	1	2.11	1	1.18
Syrphidae	2	7.06	2	9.67	2	5.54	2	7.74
Muscidae	1	3.72	1	9.53	1	8.97	1	6.99
Drosophilidae	1	1.54	1	2.99	1	0.53	1	1.88
Calliphoridae	3	4.49	3	7.82	2	3.69	3	5.59
Chloropidae	2	4.24	2	9.25	1	2.90	2	5.86
Sarcophagidae	1	0.51	0	0.00	0	0.00	1	0.21
Tephritidae	5	18.49	3	5.26	3	13.46	5	12.47
Tachinidae	1	2.82	1	1.42	1	0.53	1	1.83
Formicidae	5	11.04	5	13.51	5	11.35	6	12.04
Myrmicinae	0	0.00	0	0.00	1	5.28	1	1.07
Halictidae	1	2.70	1	5.83	1	0.53	1	3.44
Scoliidae	1	0.39	1	0.71	0	0.00	1	0.43
Megachilidae	2	2.05	1	1.71	1	3.17	2	2.15
Vespidae	1	0.64	0	0.00	1	0.26	1	0.32
Apidae	3	3.34	5	14.94	4	3.17	5	7.68
Braconidae	1	0.90	1	1.28	1	0.26	1	0.91
Aeolothripidae	1	0.64	0	0.00	0	0.00	1	0.27
Phlaeothripidae	1	0.26	1	0.57	0	0.00	1	0.32
Ectobiidae	0	0.00	1	0.14	0	0.00	1	0.05
Blattidae	2	3.47	1	0.28	2	10.82	2	3.76
Forficulidae	1	1.41	1	0.28	1	1.06	1	0.91
Anisolabididae	0	0.00	1	0.71	0	0.00	1	0.27
Coniopterygidae	1	1.80	0	0.00	1	1.32	1	1.02
Chrysopidae	1	2.82	1	0.28	1	1.06	1	1.50
Noctuiidae	1	0.39	0	0.00	1	0.26	1	0.21

Family	S1		S2		S3		Overall	
	S	RF (%)	S	RF (%)	S	RF (%)	S	RF (%)
Praydidae	1	1.16	1	0.57	0	0.00	1	0.70
Lyctocoridae	1	0.77	0	0.00	0	0.00	1	0.32
Pentatomidae	1	2.82	1	0.43	1	2.64	1	1.88
Lygaeidae	1	2.31	1	0.28	1	0.26	1	1.13
Mantidae	0	0.00	1	0.57	1	0.53	1	0.32
Agelenidae	0	0.00	0	0.00	1	0.26	1	0.05
Lycosidae	1	0.26	0	0.00	0	0.00	1	0.11
Dysderidae	1	1.16	1	0.43	1	0.26	1	0.70
Eriophyidae	2	3.59	1	0.14	1	1.58	2	1.88
Agnaridae	1	0.90	0	0.00	0	0.00	1	0.38
Total	65	100	55	100	53	100	83	100

Table 4. Summarisation of species richness (S), relative frequency (RF) and variation of diversity indices for arthropods orders recorded in olive groves, M'Sila (Algeria).

Order	S1		S2		S3		Overall	
	S	RF (%)	S	RF (%)	S	RF (%)	S	RF (%)
Orthoptera	2	2.57	2	0.43	3	5.80	3	2.42
Homoptera	5	3.08	2	5.12	2	3.17	5	3.87
Coleoptera	11	6.68	12	5.83	10	11.35	20	7.31
Diptera	16	42.88	14	45.95	11	35.62	16	42.56
Hymenoptera	14	21.05	14	37.98	15	24.01	18	28.05
Thysanoptera	2	0.90	1	0.57	0	0	2	0.59
Blattodea	2	3.47	2	0.43	2	10.82	3	3.82
Dermaptera	1	1.41	2	1.00	1	1.06	2	1.18
Neuroptera	2	4.62	1	0.28	2	2.37	2	2.53
Lepidoptera	2	1.54	1	0.57	1	0.26	2	0.91
Hemiptera	3	5.91	2	0.71	2	2.90	3	3.33
Mantodea	0	0	1	0.57	1	0.53	1	0.32
Aranea	2	1.41	1	0.43	2	0.53	3	0.86
Trombidiformes	2	3.59	1	0.14	1	1.58	2	1.88
Isopoda	1	0.90	0	0	0	0	1	0.38
S	65		57		54		83	
N	779		703		379		1861	
Ratio N/S	11.98		12.33		7.02		22.42	
Shannon_H	3.195		2.83		3.069		3.213	
Evenness e^H/S	0.581		0.446		0.5815		0.4687	
Simpson 1-D	0.9336		0.917		0.9348		0.9396	
Ratio SRI /S	0.0144		0.0161		0.0173		0.0113	

Variation of insect diversity parameters

The variation in insect diversity parameters was evident across the olive groves, particularly between Ouled Mansour and district Ksob stations. The insects spices richness recorded in Ouled Mansour station was notably higher (65 species), compared to Ouled Sidi Amor, and district Ksob station, which recorded 57 and 54 species respectively (Tab. 4). The average number of individuals per species (ratio N/S) was higher in Ouled Sidi Amor station (12.33) compared to the other stations (11.98 in Ouled Mansour. and 7.02 in district Ksob). However, the values of Shannon diversity index and evenness were very close between Ouled Mansour and district Ksob olive groves (H′ = 3.19; E = 0.5 and H′ = 3.07; E = 0.58 respectively). Both stations showed greater diversity compared to Ouled Sidi Amor (H′ = 2.83. E = 0. 44). In addition, the values of Simpson reciprocal index (SRI) and SRI/S very close across all olive groves in M'Sila region.

Functional diversity

In all three olive groves stations, phytophagous, predators and polyphagous arthropods were the most frequently captured (Tab. 5). In terms of the number of species. phytophagous arthropods were the most abundant, totaling 36 species across the entire M'Sila region, followed by predators arthropods with 33 species. Polyphagous arthropods, on the other hand, exhibited a species richness of 11 species across all olive groves. Other functional groups displayed lower numbers and richness (Tab. 5).

Table 5. Species richness (S) and relative frequency (RF in %) for the functional feeding groups of arthropods captured in olive groves located in M'Sila (Algeria).

Trophic status	S1		S2		S3		Overall	
	S	**RF (%)**	**S**	**RF (%)**	**S**	**RF (%)**	**S**	**RF (%)**
Coprophages	0	0	1	0.28	0	0	1	0.11
Phytophages	30	42.49	21	40.54	23	43.27	36	41.91
Polyphages	10	22.08	10	22.62	8	21.37	11	22.14
Predators	24	32.22	21	33.29	21	33.77	33	32.94
Saprophages	2	3.21	2	3.27	2	1.58	2	2.90
Total	66	100	55	100	54	100	83	100

Discussion

Arthropods play a crucial role in the food web as herbivores, predators, parasitoids, and detritivores, thus making significant contribution to biodiversity. This study was designed to gather information about arthropod biodiversity in olive groves. Throughout all the olive groves, a diverse range of specimens from various taxa was discovered, with insects particularly dominating the captures in terms of numbers. During the present study a total of 1861arthropods belonging to 83 species were recorded from three olive groves: Ouled Mansour station, Ouled Sidi Amor, and district Ksob. Comparing these results with those of other inventories conducted in Algeria and various countries, we find that they have relatively significant importance. Chafaa *et al.* (2019a) used the same trapping technique in Batna region and reported the presence of 1325 individuals distributed among 15 species. In a study by Deghiche-Diab *et al.* (2021), 725 individuals belonging to 69 taxa of arthropods were caught in olive grove in Biskra, (Algeria). Jiménez-García *et al.* (2019) reported 2275 individuals distributed among 25 families, with species trapped belonging to the classes of Arachnida and Insecta in vineyard agroecosystems in La Rioja (Spain). The presence of some spontaneous plants adapted to the climate conditions of the region attracts more phytophagous and pollinating insects mainly during the spring (Chafaa *et al.,* 2019a; Deghiche-Diab *et al.,* 2021).

The Tephritidae family, consisting of fruit flies, was the most abundant family of the Diptera order, that was collected mainly from yellow sticky traps (Ullah *et al.,* 2023). These flies are widely recognized across the world as major pests of economically valuable fruits in gardens and orchards (Courtney *et al.,* 2017; Ullah *et al.,* 2023). Within the Diptera order, *O. europea* flowers attracted various number of different Syrphidae species (Canale and Loni, 2010). According to Santos *et al.* (2007) and *Cotes et al.* (2011), the most prevalent taxon in olive orchard soil is Formicidae. It is commonly known that Formicidae play a significant role in agricultural ecosystems. They actively contribute to soil improvement, pollination, natural control, and nutrient management (Gonçalves and Pereira, 2012).

Sampled arthropods belonged to 12 insect orders, 2 Arachnida orders, and 1 Isopoda. Diptera, Hymenoptera, and Coleoptera are the three most dominant arthropod taxa in our study region. Happe *et al.* (2019) reported, the coleopteran and dipteran were more common in organic than in integrated pest management (IPM) orchards. Hymenoptera dominated below-ground arthropod groups, as revealed by a comprehensive analysis of terrestrial arthropod populations in dry areas of southeast Spain (Piñero *et al*., 2011). Hymenoptera are important in terms of abundance in the arid area as they find ideal ecological conditions to thrive (Chafaa *et al.,* 2019a).

The Shannon diversity index, Evenness and Simpson reciprocal index offer a comprehensive overview of the diversity across all populations. These indices take into account the number of individuals from various populations, including different stand and trophic groups, in addition to the number of species (Chafaa *et al*., 2019b).Importantly, these diversity indices provide more information than simply counting the numbers of species present (Drouai *et al*., 2018).

The dominance of phytophagous arthropods in the studied groves in M'Sila region can be attributed to the permanent presence of water in olive orchards and the high specific diversity of herbaceous plants in the olive grove understory, which provides abundant food resources (Chafaa *et al.,* 2019a). According to Haddad *et al.,* (2009), the low plant diversity can lead to a decrease in arthropod diversity and a shift in trophic structure. Phytophagous insects exhibit a high degree of selectivity for plant species that they prefer (Chafaa *et al.,* 2019b). The phytophagous species represented by pollinators from bees (*Apis mellifera*; *Bombus terrestris*; *Halictus scabiosae*) and ants (three species of *Tapinoma*), are related to the flowering period of olive trees and the presence of weeds in and around field (Deghiche-Diab *et al.,* 2021). Nectar from flowers likely serves as a significant food source for species within the *Tapinoma* genera (Seifert, 2016). We have recorded five phytophagous arthropods considered serious pests in olive cultivation. These includes four species belonging to the insect class: *Euphyllura olivina* (Homoptera), *Bactrocera oleae* (Diptera), *Liothrips oleae* (Thysanoptera), *Prays oleae* (Lepidoptera), as well as one species in the arachnida class: *Oxycenus maxwelli* (Arachnida). Several studies have mentioned the presence of certain olive tree pests in Algeria, *E. olivina* (Chafaa *et al.,* 2019a; Chabaane *et al.,* 2023), *B oleae* and *L. oleae* (Chafaa *et al.,* 2019a; Deghiche-Diab *et al.,* 2021), *P.oleae* (Nichane and Khelil, 2015; Ilias *et al.,* 2017), and olive bud mite *Oxycenus maxwelli* (Arachnida) (Smith Meyer, 1990). The abundance of phytophagous arthropods has a positive impact on the evolution of natural predators, as arthropods serve as a food source for predators (Susanti *et al.,* 2022).

In the study region, predators constitute the second most diverse group after phytophagous arthropods. Predators play a vital role in agroecosystems by controlling the populations of arthropod pests (Chafaa *et al.,* 2019a). In fact, the three stations do not undergo any phytosanitary treatment. The four most important predators identified are: *Psyttalia concolor*, *Chrysoper lacarnea*, *Coccinella algerica,* and *Hippodamia variegata*. This predatory parasite complex contribute to the regulation of olive tree. The polyphagous are the third group. Numerous polyphagous species reside in plants, and these species can act as alternate hosts or prey for many entomophagous species. Due to their polyphagous nature, entomophagous species interact with phytophagous species specifically linked to olive trees (González-Ruiz *et al.,* 2023).

Conclusions

In conclusion, our results reveal that the dominant arthropods in our olives groves belong to the following orders and families: Diptera (Tephritidae, Muscidae, Syrphidae, and Chloropidae), Hymenoptera (Formicidae and Apidae), Coleoptera (Carabidae, Cleridae, Coccinellidae, and Scarabaeidae). The dominant functional feeding groups were phytophagous and predators. We recorded five phytophagous arthropods, identified as serious pests in the olive grove of M'Sila (*Euphyllura olivina*, *Bactrocera oleae*, *Liothrips oleae*, *Prays oleae* and *Oxycenus maxwelli)*. Many natural enemies were supported by pest populations as a source of food. These results provide a fundamental tool for directing prevention and control efforts against the primary pests of olive trees.

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