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The diversity of arthropods community in dunes and a palm grove (*Phoenix dactylifera*) in the Touggourt region (Septentrionale Sahara)

M. Hadjoudj[1]*, K. Souttou[2] and S. Doumandji[3]

[1]Scientific and Technical Research Centre for Arid Areas (CRSTRA), R N°3 Ain Sahara Nezla – BP 360 Touggourt, RP 30200, Ouargla, Algeria; [2]Department of Agronomy, Faculty of Natural and Life Science, University of Djelfa, Djelfa, Algeria; [3]Department of Zoology, National Agronomic superior school, El Harrach, Algiers, Algeria

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Abstract. An inventory of arthropods was carried out at locations in the desert area of Touggourt, southeast Algeria. Samples were collected from two diverse habitats, a palm grove (agricultural habitat) and dunes (natural habitat). Using the Barber pitfall trap, 1100 specimens, divided into four classes, 15 orders, 44 families and 99 species were obtained. In the palm grove, 660 arthropods were trapped, belonging to four classes and 12 orders. Of these four classes, Insecta dominated followed by Crustacea, Arachnida and Entognata. Insecta accounted for 59.49% of the total capture and was dominated by two orders: Hymenoptera (41.81%) and Amphipoda (34.55%). In the Hymenoptera, *Cataglyphis* sp. was the most abundant (38.2%), followed by *Pheidole pallidula* (2.3%). In the dunes, 440 individuals were trapped. Insecta was the most abundant (90.69%), and Crustacea and Arachnida were scarce. Of the dominance by insects, Hymenoptera was most abundant (68.15%), and within that order, *Cataglyphis bombycina* (35.5%) was the most abundant followed by *Monomorium subopacum* (8.9%). In the palm grove, 42 species were recorded, compared to 57 in the dunes. The Shannon–Weaver index and equitability varied in both stations. In the palm grove, the diversity was 2.6, and the equitability was 0.5. By contrast in the dunes, the diversity was equal to 4 and the Equitability equal to 0.7. The differences in vegetation between the two sites reflect the differences in species diversity.

Key words: Arthropods, Barber pitfall trap, palm grove, sand dunes, Touggourt, Southeast Algeria

Introduction

The Sahara of Africa represents the largest desert of our planet and is between 7,000,000 and 9,000,000 km^2 in area (Tucker *et al.*, 1991). According to Chehma (2011), the Sahara is not only the largest of the deserts but also the most expressive and typical by its extreme aridity. In Algeria, the Sahara occupies more than 80% of the total area of the country, and the northern Sahara of this country has an area of 1 million km^2 subjected to an extreme Mediterranean climate (Chehma, 2011). The desert shares a number of features (climate, weather and a low density of vegetation) (Tucker *et al.*, 1991). The number of species that a desert can harbour per unit area is relatively small. In the desert, a surprising variety of invertebrate animals, fish, reptiles, amphibians, birds and mammals exists (Sid Amar, 2011). Among these groups are arthropods, which include a diverse group of taxa, such as arachnids, crustaceans, hexapods and centipedes (Haupt, 1993; Mosharrof, 2010). The arthropods are essential for our existence, directly or indirectly, as they provide us with food, clothing, medicines

*E-mail: mhadjoudj@gmail.com

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and protection from harmful organisms (Mosharrof, 2010). Also, they constitute a good biological indicator and they form an essential element of the food availability for many animal species (Souttou *et al.*, 2011). Arthropods have been recognized as effective indicators of ecosystem function and recommended for use in conservation planning (Rosenberg *et al.*, 1986; Finnamore, 1996) and many researchers have assessed habitat quality and measured habitat differences using arthropods (Kitching *et al.*, 2000; Gibb and Hochuli, 2002). Arthropods can be used to show the developed changes in an ecosystem, because they are sensitive to ecosystem change (Ali-Shtayeh *et al.*, 2010).

Many studies have been carried on arthropods, for example, Haupt (1993) described the centipedes, arachnids and insects of the Mediterranean region. Norfolk *et al.* (2012) studied the effects of runoff agroforestry in Egypt, by comparing the biodiversity of ground arthropods within the gardens to that of the surrounding natural habitat. They found that the harvested rainwater has created agricultural home gardens that ameliorate the abundance of ground arthropods. Chapelin-Viscardi and Maillet-Mezeray (2013) published a research paper on entomological diversity in the agricultural plain of Santerre (France) using another technique (Malaise trap). Their work provides new information on the biogeography of some species. Evans *et al.* (2016) in Central Illinois (USA) determined the relation between invertebrate richness and diversity in agricultural field interiors and edges, and the complexity of the surrounding landscape. Their paper shows that the taxonomic richness and diversity in field edges is positively related to large-scale landscape complexity, but the relationship is negative for field interiors. Arthropods have also been studied in Algeria. Brague-Bouragba *et al.* (2006) carried out a faunistic and ecological study of some families of Coleoptera in various sub-desert plant formations (Djelfa), and note the major plant damage in monoculture farming caused by pests, for which treatments are expensive. Brague-Bouragba (2007) studied the systematics and ecology of some groups of arthropods associated with various plant formations in semi-arid zones. They concluded that if reforestation did not change the biological diversity, it would induce dramatic modifications in the organization and functioning of the arthropod communities. In the Saharan zone, Kourim *et al.* (2010) compared the entomological diversity in different agricultural stations in the Ahaggar National Park (Tamanrasset, Sahara). Kherbouche *et al.* (2016) reported on the evaluation and characterization of the arthropod diversity of a Ghout palm grove in Oued Souf. These authors note that insects, especially the Formicidae, collect in this type of oasis, while the Aphididae, Scoliidae and Muscidae assemble in the herbaceous stratum.

The current study aims to describe the composition and structure of the arthropod community in two contrasting environments (a palm grove and dunes) in the Touggourt region, northern Sahara, Algeria, and to create an inventory of arthropods, to enrich the knowledge on these environments.

Materials and methods

Study area

This study was conducted in the Touggourt region, southeast Algeria. This region resembles the high part of Oued Righ area. The region is bordered in the south and the east by the large Eastern Erg (a field of sand dunes), in the north by the palm plantations of Megarine and in the west by dunes (33° 02′ to 33° 12′ N, 5° 59′ to 6° 14′ E) (Fig. 1). The area is located at an altitude of 75 m (Dubost, 2002).

The daily temperature varies from a mean minimum of 11.7 °C in January to a mean maximum of 35.1 °C in July. The average annual rainfall is 155.7 mm. The climate is characterized by a long dry season from February to December. The rainy season is in January. The highest wind speed varies one month to another, and ranges between 10.3 m/s (37 km/h) in June and 19.5 m/s (70.2 km/h) in March.

Sampling sites

Two stations were selected for this study, the first was an agricultural site (palm grove) and the second represents a natural environment (dunes) (Fig. 1). The palm grove station (33 05′ N, 6 04′ E) is a semi-open area of 103 ha with 12,000 palm trees. In this location, two strata were recorded. First, the 'nakhla' *Phoenix dactylifera* L. trees form the arborescent stratum. Second, several species of wild plants, e.g. 'gasba' *Phragmites communis* Trin., 'lebena' *Convolvulus arvensis* L., 'djerir' *Conium maculatum* L. and 'rezam' *Chrysanthemum myconis* L. form the herbaceous stratum. These plants produce an appropriate microclimate for various species of animals.

The dunes site (33 05′N, 6 04′ E) corresponded to an open area with herbaceous vegetation of low density. The species present were 'el aggaia' *Zygophyllum album* L., 'zita' *Limoniastrum guyonianum* Durieu ex Boiss. and 'damran' *Traganum nudatum* Delile. The scarcity of plants made an arid climate in this area.

Sampling techniques

Arthopods were sampled over a 12-month period (February 2009–January 2010). The capture

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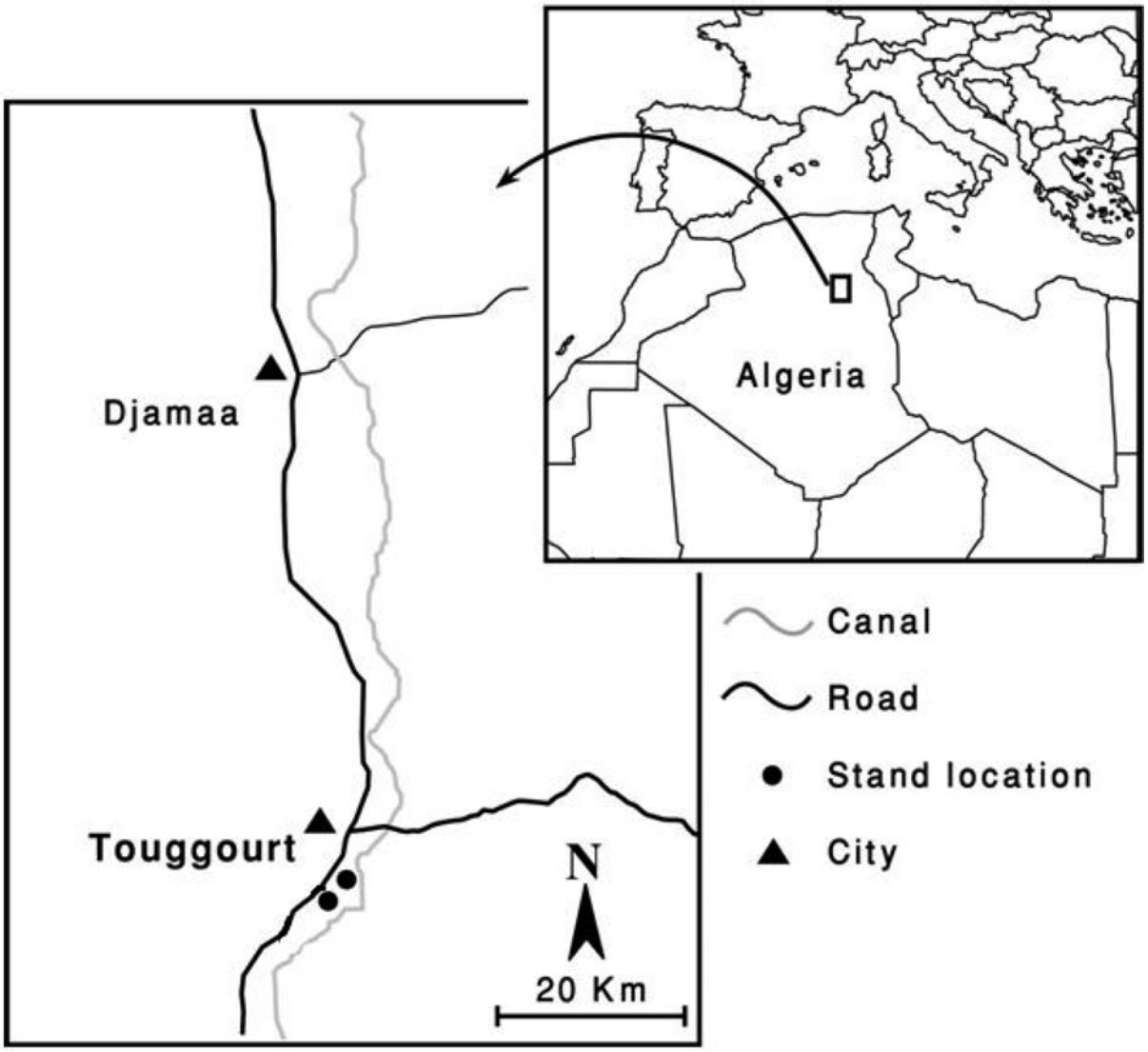

Fig. 1. Map of the Touggourt area (southeast Algeria) and the location of sampling sites.

of arthropods species was performed with Barber pitfall traps (Benkhelil, 1992; Kherbouche *et al.*, 2015; Selmane *et al.*, 2016). The pitfall traps were cylindrical containers, buried vertically with an opening flush with the ground. The size of each trap was 1 L. Each of the Barber pitfall traps was filled to 1/3 of its height with water containing 2 g powdered soap detergent, to prevent trapped invertebrates from escaping. Eight Barber pitfall traps were installed in a line and separated 5 m apart. A flat stone raised above the opening by two small pebbles protected each trap. This flat stone slowed down the evaporation of the water in the trap. After 24 hr, the content of each trap was collected. Captured arthropods were identified using dichotomous keys (Perrier, 1923; 1926; 1927; 1932, 1937; Chopard, 1943; Balachowsky, 1962). The collections of the Agricultural Department and the Forest Zoology Department (ENSA, Algiers) were also used as a reference.

Data analysis

Results were expressed as the total richness (S), representing the number of families or species captured on each station over the course of a sampling session (Blondel, 1975; Caro, 2001; Horn *et al.*, 2012), and average richness (Sm), the average number of species present in N surveys (Ramade, 1984). Additionally, results were expressed as a relative abundance (RA %), which is the percent proportion of the individual number of each species (ni) to the total number of captured individuals of

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all species from a station (N) (Hamdine *et al.*, 2006; Hadjoudj *et al.*, 2015).

To explain the diversity in the arthropods community, we also used the Shannon–Wiener Index ($H' = -\Sigma$ Pi * log (Pi), where Pi = ni/N). (H′) increases with (S), but in practice do not exceed 5.0 in biological communities (Krebs, 1998). The evenness index (E) indicated how the species were distributed in the community, and was derived from H′ (E=H′/lnS) (Weesie and Belemsobgo, 1997; Faurie *et al.* 2006; Hadjoudj *et al.*, 2015). The values varied from 0 (one dominant species) to 1 (all species equally represented in the community).

Results

We collected 440 specimens from three classes of arthropods (Arachnida, Crustacea and Insecta) in the dune environment (Table 1). The Insecta class represented the largest part of the collected specimens with a highest relative abundance (392 specimens, RA% = 90.69%) followed by Crustacea (RA% = 6.36%) and Arachnida (RA% = 4.74%) (Table 1, Fig. 2). The capture of arthropods (660 specimens) in the palm grove was richer than the dunes of which four classes were inventoried (Arachnida, Crustacea, Entognata and Insecta) (Table 1, Fig. 2). Most species captured in this study were in the class Insecta with 392 specimens (RA% = 59.49%), followed by Crustacea (RA% = 36.82%), Arachnida (RA% = 3.16%) and Entognata.

A total of 15 orders were inventoried. In the dunes, 12 orders were found where Hymenoptera dominated with 68.15% followed by Coleoptera (14.18%), Isopoda (6.36%) and Diptera (4.06%) (Table 1, Fig. 3). The relative abundances of the other orders varied between 0.46% and 3.64%. Three orders were not found in the dunes (Amphipoda, Entomobryomorpha and Orthoptera). In the palm groves, 12 orders were identified (Table 1, Fig. 3), with Hymenoptera the most abundant with a value of relative abundance of 41.81% followed by Amphipoda (34.55%), Coleoptera (14.2%) and Araneae (3.16%). The other orders had a relative abundance ranging between 0.15% and 2.27%. Three orders were absent from the palm grove (Scorpiones, Solifugae and Lepidoptera).

In total, 44 families were recorded for the dunes and palm grove sites. First, in the dunes landscape, 33 families were captured in which the Formicidae was the most abundant with 243 specimens (55.23%) followed by Tenebrionidae (34 specimens; RA% = 8.11%) and Onicidae (28 specimens; RA% = 6.36%) (Table 1). However, 20 families were sampled in the palm grove environment, of which the Formicidae represented the most substantial part of the sampling with 276 specimens (41.81%), followed by an undetermined family of Amphipoda with 228 specimens (34.55%), and Carabidae (93 specimens; 14.2%).

Regarding species, the value of total richness noted in the dunes was 57 species and an average richness of 9.67 species. In this natural landscape, the high relative abundance value was recorded for *Cataglyphis bombycina* (35.45%) followed by *Monomorium subopacum* (8.86%), *Monomorium* sp. (8.64%) and undetermined Oniscidae sp. The other species were weakly represented ($0.23\% \leq RA \leq 3.41\%$).

In the agricultural landscape (palm grove), the total richness recorded was 42 species with an average richness equal to 3.5 species. *Cataglyphis* sp. was the most abundant species recorded in the palm grove with 38.18%, followed by an undetermined Amphipoda sp. (34.55%), and *Cicindella flexuosa* (10.72%). *Pheidole pallidula* (2.27%) and *Scarites* sp. (2.27%). The other values of abundance ranged between 0.15% and 1.36%.

The diversity values H′ and H′max varied between the two sample sites in this study. The Shannon–Weaver index H′ was 3.97 and H′max was 5.83 for the dunes site. For the palm grove site, H′ was 2.59 and H′max was 5.39. For the Evenness index, the values were dissimilar. For the dunes, the evenness was 0.68, meaning a tendency towards a balance between the arthropod species captured by our technique. In contrast, in the palm grove, the noted Evenness was 0.48, implying an imbalance between the arthropod species of this landscape.

Discussion

In this work, four classes of Arthropoda (Arachnida, Crustacea, Entognata and Insecta) were collected using Barber pitfall traps in the Touggourt region. The Insecta was the most abundant class in dunes (90.69%) and the palm grove (59.49%), followed by Crustacea and Arachnida. The Entognata class was found only in the palm grove landscape. The pitfall trap is considered an efficient technique to capture arthropods that are active at the ground surface. Using the same method at Ifri agricultural site in the Djanet region (Great South of Algeria), Beddiaf *et al.* (2014) found three classes (Arachnida, Crustacea and Insecta). These workers mention the high abundance of Insecta class with 98.5%. Another work carried by Kherbouche *et al.* (2015) at Ouargla (Northern Sahara of Algeria) records the existence of four classes (Arachnida, Crustacea, Entognata and Insecta) at three lucerne (*Medicago sativa* L.) fields where insects were the most sampled at three sites ($64.4\% \leq RA \leq 71.1\%$). These workers found Entognata in the three fields of lucerne. According to Bachelier (1978), the presence of Collembola in the Saharan environments is due to water runoff, which contributes to the spread of many species

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Table 1. Number and relative abundance of arthropods sampled in sand dunes and palm groves in the Touggourt, southeast Algeria

Class	Order	Family	Species	Dunes		Palm groves	
				ni.	RA%	ni.	RA%
Arachnida	Scorpiones	Buthidae	*Orthochirus innesi*	1	0.23	–	–
			Buthacus arenicola	1	0.23	–	–
	Araneae		Aranea sp. 1 und.	–	–	1	0.15
			Aranea sp. 2 und.	–	–	1	0.15
			Aranea sp. 3 und.	–	–	2	0.3
			Aranea sp. 4 und.	15	3.41	1	0.15
		Dysderidae	Dysderidae sp. und.	–	–	4	0.61
		Pisauridae	*Pisaura* sp.	–	–	1	0.15
		Miturgidae	*Zora* sp.	–	–	1	0.15
		Lycosidae	*Trochosa* sp. 1	–	–	3	0.45
			Trochosa sp. 2	–	–	3	0.45
			Alopecosa sp.	–	–	1	0.15
			Alopecosa albofasciata	–	–	1	0.15
		Linyphiidae	*Lepthyphantes* sp.	1	0.23	1	0.15
			Lepthyphante stenuis	–	–	1	0.15
	Solifugae	Galeodidae	*Galeodes* sp.	2	0.64	–	–
Crustacea	Isopoda		Isopoda sp. und.	–	–	1	0.15
		Oniscidae	Oniscidae sp. und.	28	6.36	5	0.76
		Porcellionidae	*Porcellio* sp.	–	–	9	1.36
	Amphipoda		Amphipoda sp. und.	–	–	228	34.55
Entognata	Entomobryomorpha	Entomobryidae	Entomobryidae sp. und.	–	–	7	1.06
Insecta	Zygentoma		Zygentoma sp.	1	0.23	–	–
		Lepismatidae	Lepismatidae sp. und.	1	0.23	1	0.15
	Mantodea	Mantidae	*Mantisreligiosa*	–	–	1	0.15
			Iris oratoria	1	0.23	–	–
	Orthoptera	Gryllotalpidae	*Gryllotalpa africana*	–	–	1	0.15
		Gryllidae	*Gryllulus* sp.	–	–	2	0.3
			Gryllulus chudeaui	–	–	1	0.15
			Gryllulus algirius	–	–	2	0.3
		Pyrgomorphidae	*Pyrgomorpha cognata*	–	–	1	0.15
		Acrididae	*Aiolopus thalassinus*	–	–	2	0.3
			Ochrilidia sp.	–	–	1	0.15
			Ochrilidia gracilis	–	–	1	0.15
			Ochrilidia harterti	–	–	2	0.3
			Duroniella lucasi	–	–	1	0.15
	Homoptera	Jassidae	Jassidae sp.	3	0.68	1	0.15
	Hemiptera	Capsidae	Capsidae sp. und.	1	0.23	–	–
		Lygaeidae	*Oxycarenus* sp.	1	0.23	–	–
			Lygaeidae sp. und.	–		1	0.15
			Nysius sp.	1	0.23	–	–
		Aphididae	*Macrosiphum* sp.	1	0.23	–	–
		Rhyparochromidae	*Plociomerus fractiollis*	–	–	1	0.15
	Coleoptera	Carabidae	*Cicindella flexuosa*	–	–	72	10.72
			Cicindella maura	–	–	6	0.91
			Scarites sp.	–	–	13	2.27
			Harpalus sp.	–	–	1	0.15
			Lebiinae sp. und.	–	–	1	0.15
			Anthaxia sexmaculata	1	0.23	–	–
			Graphopterus serrator	9	2.09	–	–
		Scarabaeidae	*Rhizotrogus* sp.	1	0.23	–	–
			Tropinotas qualida	1	0.23	–	–
		Staphylinidae	Staphylinidae sp. 1 und.	2	0.64	–	–
			Staphylinidae sp. 2 und.	3	0.68	–	–

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Table 1. Continued

Class	Order	Family	Species	Dunes		Palm groves	
				ni.	RA%	ni.	RA%
		Tenebrionidae	Tenebrionide sp.	4	0.91	–	–
			Pimelia sp.	3	0.68	–	–
			Pimelia grandis	1	0.23	–	–
			Pimelia interstitialis	2	0.64	–	–
			Erodius zophoideus	1	0.23	–	–
			Pachychila sp.	8	1.82	–	–
			Blaps superstiticum	2	0.64	–	–
			Mesostena sp.	5	1.14	–	–
			Opatroides sp.	1	0.23	–	–
			Zophosis zuberi	7	1.59	–	–
		Silvanidae	*Oryzaephilus surinamensis*	1	0.23	–	–
		Leiodidae	*Agathidium* sp.	2	0.64	–	–
		Anobiidae	*Ptinus* sp.	1	0.23	–	–
		Curculionidae	*Plagiographus* sp.	2	0.64	–	–
		Cerambycidae	*Prionus pectinicornis*	1	0.23	–	–
	Hymenoptera	Aphelinidae	Aphelinidae sp. und.	1	0.23	–	–
		Braconidae	Braconidae sp. und.	2	0.64	–	–
		Bethylidae	Bethylidae sp. und.	1	0.23	–	–
		Scoliidae	Scoliidae sp. und.	14	3.18	–	–
		Vespoïdae	Vespoïdae sp. und.	12	2.73	–	–
		Mutillidae	Mutillidae sp. und.	14	3.18	–	–
			Stenomutilla sp.	11	2.5	–	–
		Pompilidae	Pompilidae sp. und.	1	0.23	–	–
		Formicidae	Formicidae sp. und.	1	0.23	–	–
			Camponotus sp.	7	1.59	1	0.15
			Cataglyphis sp.	1	0.23	252	38.18
			Cataglyphis bombycina	156	35.45	–	–
			Cataglyphis bicolor	–	–	1	0.15
			Messor capitatus	1	0.23	–	–
			Monomorium sp.	38	8.64	–	–
			Monomorium subopacum	39	8.86	1	0.15
			Tapinoma nigerrimum	–	–	6	0.91
			Pheidole pallidula	–	–	15	2.27
	Lepidoptera		Lepidoptera sp. und.	1	0.23	–	–
		Pyralidae	Pyralidae sp. und.	2	0.64	–	–
		Tineidae	Tineidae sp. und.	5	1.14	–	–
	Diptera	Asilidae	Asilidae sp. und.	1	0.23	–	–
		Drosophilidae	Drosophilidae sp. und.	9	2.05	–	–
		Calliphoridae	Calliphoridae sp. und.	2	0.64	–	–
		Cecidomyiidae	Cyclorrhapha sp.	5	1.14	4	0.61
			Total	440	100	660	100

ni: Individual number; RA%: Relative abundance.

that float on the water surface. Near Touggourt in the Oued Souf area, Bousbia (2010) reported the sampling of Arachnida and Insecta classes, as well as the dominance of Insecta with the highest value of relative abundance (95.9%). The current study confirms the results of Bousbia (2010), Beddiaf *et al.* (2014) and Kherbouche *et al.* (2015). In another study on the abundance and diversity of arthropods in the Arabian Desert, Tigar and Osborne (1997) sampled four Arthropoda classes of which Insecta was dominant (97.34%) followed by Arachnida (2.63%). In the olive grove ecosystem (Portugal), Santos *et al.* (2007) examined the abundance and diversity of soil Arthropoda. These workers found 12,937 arthropod specimens belonging to five classes (Arachnida, Entognata, Insecta, Chilopoda and Diplopoda) of which Insecta was the most abundant (70%). The results of our research concur with those of Tigar and Osborne (1997) and with those of Santos *et al.* (2007). Mosharrof (2010) conducted arthropod sampling of three habitats at Rajshahi University Campus in Bangladesh using the pitfall traps and mentions

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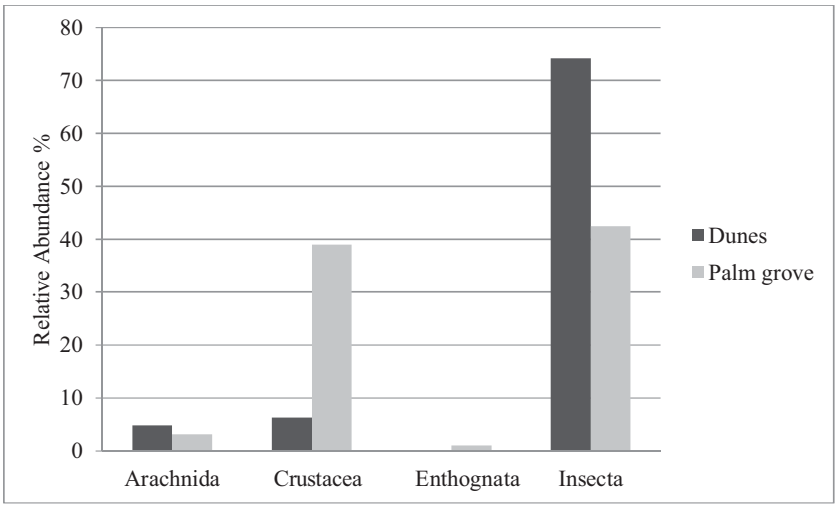

Fig. 2. Relative abundance (RA%) of arthropod classes for two different environments (dunes and palm grove) in Touggourt, southeast Algeria.

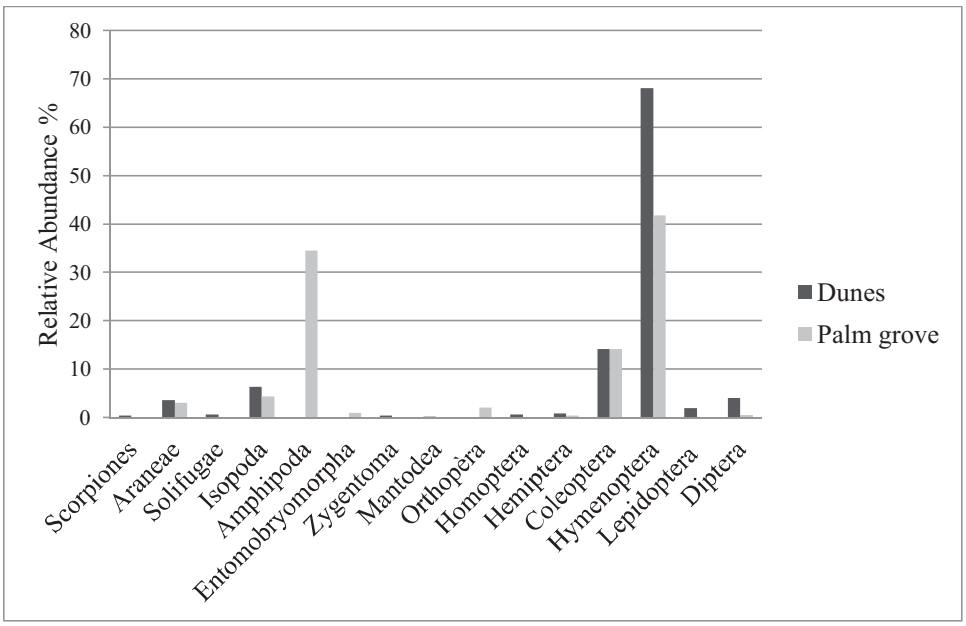

Fig. 3. Relative abundance (RA%) of arthropod orders for two different environments (palm grove and dunes) in Touggourt, southeast Algeria.

that the maximum number of the entire collected specimens was insects (85%) and the rest were arachnids (5%).

In the current study, the use of the pitfall trapping method allowed the sampling of 15 orders of Insecta at the two stations of Touggourt. In the dune landscape, Hymenoptera was the most dominant order with 68.15% followed by Coleoptera (14.18%), Isopoda (6.36%) and Diptera (4.06%). Also, in the palm grove site, the Hymenoptera was the most abundant (41.81%) followed by Amphipoda (34.55%), Coleoptera (14.2 %) and Araneae (3.41%). The current study is consistent with the results of Souttou *et al.* (2015) on the ecology of arthropods in the reforested zone containing the evergreen Aleppo pine in a sub-Saharan area at Djelfa (Algeria), which identified 15 orders, with Hymenoptera being the most abundant (92.13%) followed by Coleoptera (2.93%) and Diptera (2.51%). Our results are also consistent with a study at a palm grove in a 'ghout', a traditional hydro agricultural system at Oued Souf, using the Barber pitfall traps in which Hymenoptera was dominant with 52.4% (Kherbouche *et al.*, 2016). Also, these workers note that Coleoptera was

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second (19.4%) and Diptera third in abundance. The dominance of Hymenoptera in our study corresponds with the result of Ali-Shtayeh *et al.* (2010) in a natural grassland environment in Palestine. These workers showed that Hymenoptera was the most sampled order with 89.2%. Indeed, Pizarro-Araya *et al.* (2012) studied the arthropods assemblages in the Quebrada del Morel private protected area (Atacama, Chile), sampling eight orders of which Coleoptera (33.8%) was the most frequent followed by Solifugae (22.8%), Orthoptera (21.9%) and Hymenoptera (12.6%). However, the other orders were inadequately represented. Nevertheless, the results of the present observation do not concur with those of Pizarro-Araya *et al.* (2012). In the semi-dry grassland (Vienna, Austria), Zaller *et al.* (2015) established a comparison between three techniques (pitfall trapping, quadrat sampling and video monitoring). The pitfall traps allowed the capture of six orders of which Hymenoptera (54.54%) was dominant followed by Araneae (20%) and Coleoptera (18.18%). Indeed, it is known that Hymenoptera and Isoptera are distributed around the world, especially in the tropics, subtropics and particularly in semi-arid regions (Dushimirimana, 2017). *Aranea* was captured to a much lower extent in our study but was more abundant in the palm grove than in the dune. This result is consistent with that of Philpott *et al.* (2014) who showed that spiders are more abundant in disturbed habitats, such as the palm grove examined here that experience more mowing and soil manipulation during the summer season. Orthoptera was also inadequately present in the palm grove but absent in the dune. The presence of Orthoptera in the palm grove was associated with plant communities. Pizzaro-Araya *et al.* (2012) showed that the Gryllidae family (Orthoptera) existed under the different types of vegetation in sampling points.

Regarding families, our study recorded 44 families in total in the Touggourt region, with 33 families captured in the dunes. The most substantial abundance was noted for the Formicidae (55.23%) followed by Tenebrionidae (8.11%) and Onicidae (6.36%). However, 20 families were sampled in the palm grove environment in which the Formicidae represent the most significant part of the sampling with 41.81%. The undetermined family of Amphipoda occupies the second position (34.55 %), and the Carabidae occupies the third place (4.2%). Abensperg-Traun and Steven (1995) associated the rapid locomotory behaviour of many diurnal species (such as some Formicidae) to the proneness to capture by pitfall traps. Using five methods of sampling insect populations (Barber pitfall traps, Yallow plates, beating sheet, sweep net and sampling of branches and sheets) in two palm grove landscapes (El Kantara, Biskra), Achoura and Belhamra (2010) found 31 families of Arthropoda of which the Acrididae (15.93%) was the most frequently found followed by the Pieridae (13.88%) and then by the Carabidae (7.45%). The results of our investigation are comparable with those of Achoura and Belhamra (2010). In the sub-Saharan environment at Djelfa (Algeria), Souttou *et al.* (2015) using pitfall trap sampling inventoried 45 families of Arthropoda, of which Formicidae dominated with 86.10% followed by an undetermined dipteran family. In Arizona, USA, Wynne and Voyles (2014) sampled approximately 29 Arthropoda families. Moreover, these workers mentioned the existence of seven families of Araneae and six families of Coleoptera. Our observations are similar to the results of Souttou *et al.* (2015) and those of Wynne and Voyles (2014). According to Pizarro-Araya *et al.* (2012), in the Atacama desert (Chile), a richness of 30 families was found of which the Mummuciidae was the most sampled with 22.5% followed by the Tenebrionidae (19.4%) and the Gryllidae (18.8%). A comparison between our results and those of Pizarro-Araya *et al.* (2012) shows a similarity in the quantitative aspect but a difference in the qualitative aspect, because of the nature of the soil and vegetation, which are dissimilar.

An analysis of the total richness and the average richness shows that for dunes the total richness recorded was 57 species and the average richness was 9.67 species. Furthermore, at the palm grove station, the total richness equals 42 species, and the average richness accounts for 3.5 species. The results of our study are fewer when compared to those of Chouihet and Doumandji-Metiche (2015) who conducted a study in three palm groves of Ghardaïa, where they found 85 species in Beni Izguen, 74 species in El Atteuf and 51 species in Dayah palm. Compared to Touggourt, in the two agricultural landscapes at Djanet (Tassili N'ajjer), Beddiaf *et al.* (2014) mention high values of total richness. These workers show that in Ifri site the total richness is 70 species and at In Abarbar it is 59 species. Tigar and Osborne (1997) carried out an investigation on the arthropods in Abu Dhabi for 2 years and found a total richness of 33 species, which is fewer than in our study because they set the traps 2 hr before dusk to 2 hr after dawn.

In the natural landscape (dunes), the high relative abundance value is unregistered for *Cataglyphis bombycina* (35.45%) followed by *Monomorium subopacum* (8.86%), *Monomorium* sp. (8.64%) and an undetermined Onicidae sp. Our results agree with those of Rubinstein *et al.* (2012) in the Nizzanim Nature Reserve (southwestern, Israel), as they mentioned that *Cataglyphis nigra* (15.17%) was the most frequent followed by *Messor arenarius* (11.11%) and *Pimelia angulata* (8.29%). The presence of sandy soil in this region could explain this similarity. Our

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results are similar also to those of Bousbia (2010) at the fixed dunes of Sidi Mestour (Oued Souf), at which *Cataglyphis bombycina* (17.4%) dominates followed by *Messor* sp. (7.4%). In the present study, we rarely captured the scorpions *Orthochirus innesi* (0.2%) and *Buthacus arenicola* (0.2%). According to Sadine and Idder (2009), *Orthochirus innesi* is found exclusively in palm groves and *Buthacus arenicola* in sandy soil.

Moreover, in the agricultural landscape (palm grove), *Cataglyphis* sp. is the most frequent species with 38.18% followed by an undetermined Amphipoda sp. (34.55%), and then by *Cicindella flexuosa* (10.72%). This observation is consistent with that of Sekour-Kherbouche *et al.* (2010) in a palm grove of Hassi Khalifa near El Oued (Oued Souf). These workers cite *Messor arenarius* (14.1%) as the dominant species followed by *Cataglyphis bombycina* (10.9%). Similar information is noted in the palm grove of the Technical Institute of Saharan Agronomy in Ouargla where Chennouf *et al.* (2010) showed that *Pheidole* sp. is the most abundant species (17.4%) followed by *Monomorium* sp. (17%).

The diversity values H′ and H′max varied between the two sample sites in this study. The Shannon–Weaver index H′ was 3.97 and H′max was 5.83 for the dunes site. These results are close to those cited by Bousbia (2010) at Sidi Mestour near Oued Souf (H′ = 4.6). The present value of H′ is also similar to the result found by Souttou *et al.* (2015) in the reforested zone in a sub-Saharan area at Djelfa with H′ equal to 3.38. In the palm grove, the value of H′ is 2.59 and H′max value is 5.39. This H′ result is close to 2.9 obtained by Souttou *et al.* (2006) on the border of Oued Sidi Zarzour near a palm grove near Biskra. The diversity richness in our study, however, appears less than that reported by Yasri *et al.* (2009) and by Sekour-Kherbouche *et al.* (2010). Indeed, Yasri *et al.* (2009) report the value of H′ equal to 5.3 in Ghoufi palm grove. Similarly, in a palm grove environment (Oued Souf), Sekour-Kherbouche *et al.* (2010) report an H′ value of 4.7.

Conclusion

The similarities and differences of arthropod communities were determined using Barber pot traps for two diverse habitats: dunes (a natural environment) and palm grove (an agricultural environment), in the Touggourt region, southeast Algeria. The results of the present study are essential to determine the arthropods biodiversity in the two different environments. The dune habitat has a much higher total richness than the palm grove habitat. In both habitats, the Insecta class was dominant. The Entognata class was present only in the palm site, most likely due to the availability of irrigated water. Among the Insecta, Hymenoptera was the most abundant in the palm grove and dunes. In addition, in the dunes habitat, *Cataglyphis bombycina* was the dominant species followed by the undetermined Amphipoda sp. and *Cicindella flexuosa*.

In contrast, *Cataglyphis* sp. was the predominant species in the palm grove agricultural landscape followed by *Pheidole pallidula* and *Tapinoma nigerrimum*. The Orthoptera, Amphipoda and Entomobryomorpha species were specific to the palm grove site. We also noted that Scorpiones, Solifugae and Lepidoptera were present only in the dunes. The palm grove, which is anthropized and disturbed by cultural practices, has less diversity than dunes, which are undisturbed by humans. The evenness in the palm grove shows an imbalance between the arthropod species of this landscape but shows a tendency towards a balance between the arthropod species at the dune site.

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References

Abensperg-Traun M. and Steven D. (1995) The effects of pitfall trap diameter on ant species richness (Hymenoptera: Formicidae) and species composition of the catch in a semi-arid eucalypt woodland. *Austral Ecology* 20, 282–287.

Achoura A. and Belhamra M. (2010) Aperçu sur la faune arthropodologique des palmeraies d'El-Kantara. *Courrier du Savoir* 10, 93–101.

Ali-Shtayeh M. S., Ali W. M. D. and Jamous R. M. (2010) Ecological investigations on terrestrial arthropod biodiversity under different grassland ecosystems in El-Fara'a area (Palestine). *Biodiversity and Environmental Sciences Studies Series* 5, 19–34.

Bachelier G. (1978) *La Faune des Sols, Son Écologie et Son Action*. ORSTOM, Paris.

Balachowsky A. S. (1962) *Entomologie Appliquée à l'agriculture. Tome I, Coléoptères*. Masson et Cie, Paris. 564 pp.

Beddiaf R., Kherbouche Y., Sekour M., Souttou K., Ababsa L., Djillali K., Doumandji S., Ebouz A., Guerguer L., Hamid Oudjana A. and Hadj Seyd A. (2014) Aperçu sur la faune arthropodologique de Djanet (Tassili n'Ajjer, Algérie). *Revue El Wahat pour les Recherches et les Etudes* 7, 85–94.

Benkhelil M. L. (1992) *Les Techniques de Récolte et de Piégeage Utilisées en Entomologie Terrestre*. Off. Publ. Univ. Alger. 60 pp.

Blondel J. (1975) L'analyse des peuplements d'oiseaux – éléments d'un diagnostic écologique, I. La méthode des échantillonnages fréquentiels progressifs (E.F.P). *Revue d'Ecologie - (Terre et Vie)* 29, 533–589.

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Bousbia R. (2010) Inventaire des arthropodes dans la région d'Oued Souf Cas—Robbah—El-Ogla et Sidi Mestour. Mémoire de Fin d'Etude Ingé. Agro., Faculté des Sciences de la Vie et de la Terre, Univ. Kasdi Merbah, Ouargla, 124 pp.

Brague-Bouragba N., Brague A., Dellouli S. and Lieutier F. (2007) Comparaison des peuplements de Coléoptères et d'Araignées en zone reboisée et en zone steppique dans une région présaharienne d'Algérie. *Comptes Rendus Biologies* 330, 923–939.

Brague-Bouragba N., Habita A. and Lieutier F. (2006) Les arthropodes associés à *Atriplex halimus* et *Atriplex canescens* dans la région de Djelfa, pp. 168–177. In *Actes du Congrès International d'Entomologie et de Nématologie*, 17–20 Abril 2006, Institut National Supérieur Agronomique, Alger, Algérie.

Caro T. M. (2001) Species richness and abundance of small mammals inside and outside an African national park. *Biological Conservation* 98, 251–257.

Chapelin-Viscardi J. D. and Maillet-Mezeray J. (2013) Diversité entomologique recensée grâce aux pièges d'interception en plaine agricole du Santerre (Somme, France) (Coleoptera, Heteroptera, Lepidoptera, Mecoptera, Neuroptera). *L'Entomologiste Picard* 23, 3–13.

Chehma A. (2011) Le Sahara en Algérie, situation et défis, pp. 14–21. In *Actes du Séminaire sur l'effet du Changement Climatique sur l'élevage et la gestion durable des parcours dans les zones arides et semi-arides du Maghreb*, du 21 au 24 Novembre 2011, Université Kasdi Merbah, Ouargla, Algérie.

Chennouf R., Doumandji-Mitiche B., Guezoul O. and Sekour M. (2010) Place des Insecta dans un périmètre phoenicicole à Hassi Ben Abdellah (Ouargla, Sahara septentrional), p. 167. In *Journées nationales de zoologie agricole et forestière*, du 19 au 21 Avril 2010, Institut National Supérieur Agronomique, El Harrach, Algérie.

Chopard L. (1943) Orthopteroïdes de l'Afrique du Nord. Ed. Larose, Paris, «Coll. Faune de L'Empire Français», I, 450 pp.

Chouihet N. and Doumandji-Metiche B. (2015) Biodiversité des invertébrés notamment des arthropodes des oasis de la Vallée du M'Zab (Ghardaïa, Algérie), p. 24. In *Actes du Seminaire Internationale sur la Biodiversité Faunistique en Zones Arides et Semi-Arides*, 29 et 30 Novembre 2015, Faculté des Science de la Vie et de la Terre, Université Kasdi Merbah, Ouargla, Algérie.

Dubost D. (2002) *Ecologie, Aménagement et Développement Agricole des Oasis Algériennes*. Ed. Centre de Recherche Scientifiqueet Technique sur les Régions Arides, CRSTRA, Biskra, 423 pp.

Dushimirimana S. (2017) Abondance et interactions écologiques de différents groupes taxonomiques d'invertébrés du sol de la région de Bugesera du Burundi. *Bulletin Scientifique sur l'Environnement et la Biodiversité* 2, 9–16.

Evans T. R., Mahoney M. J., Cashatt E. D., Noordijk J., De Snoo G. and Musters C. J. M. (2016) The impact of landscape complexity on invertebrate diversity in edges and fields in an agricultural area. *Insects* 7, 7. doi:10.3390/insects7010007.

Faurie C., Ferra C., Médori P., Dévaux J. and Hemptinne J. L. (2006) *Ecologie: Approche Scientifique et Pratique*. Lavoisier, Paris. 531 pp.

Finnamore A. T. (1996) *The Advantages of Using Arthropods in Ecosystem Management: A Brief from the Biological Survey of Canada (Terrestrial Arthropods)*. The Entomological Society of Canada, Ottawa.

Gibb H. and Hochuli D. F. (2002) Habitat fragmentation in an urban environment: Large and small fragments support different arthropod assemblages. *Biological Consevation* 106, 91–100.

Hadjoudj M., Souttou K. and Doumandji S. (2015) Diversity and richness of rodent communities in various landscapes of Touggourt Area (Southeast Algeria). *Acta Zoologica Bulgarica* 67, 415–420.

Hamdine W., Khammar F. and Gernigon T. (2006) Distribution des Gerbillidés dans les milieux arides d'El – Goléa et de Béni-Abbès (Algérie). *Bulletin de la Société d'histoire naturelle d'Afrique du Nord* 73, 45–55.

Haupt J. (1993) *Guide des Mille-pattes, Arachnides et Insectes de la région Méditerranéenne*. Delachaux et Niestlé, Paris. 356 pp.

Horn K.J., McMillan B.R. and St Clair S.B. (2012) Expansive fire in Mojave Desert shrubland reduces abundance and species diversity of small mammals. *Journal of Environments* 77, 54–58.

Kherbouche Y., Bousbia R., Beddiaf R., Souttou K., Chakali G. and Sekour M. (2016) Evaluation et caractérisation de la diversité arthropodologique d'une palmeraie de type Ghout (Souf, Sahara Septentrional). *Revue des BioRessources* 6, 70–79.

Kherbouche Y., Sekour M., Gasmi D., Chaabna A., Chakali G., Lasserre-Joulin F. and Doumandji S. (2015) Diversity and distribution of arthropod community in the lucerne fields in Northern Sahara of Algeria. *Pakistan Journal of Zoology* 47, 505–514.

Kitching R. L., Orr A. G., Thalib L., Mitchell H., Hopkins M. S. and Graham A. W. (2000) Moth assemblages as indicators of environmental quality in remnants of upland Australian rain forest. *Journal of Applied Ecology* 37, 284–297.

Kourim M. L., Doumandji-Mitiche B., Doumandji S. and Reggani A. (2010) Biodiversité entomologique dans le parc national de l'Ahaggar (Tamanrasset, Sahara). *Faunistic Entomology* 63, 149–155.

Krebs J. C. (1998) *Ecological Methodology*. 2nd ed. Harper & Row, New York, NY, USA. 620 p.

Mosharrof H. (2010) A preliminary survey of arthropod diversity through pitfall trap in the selective habitats at Rajshahi University Campus. *University Journal of Zoology, Rajshahi University* 29, 73–76.

Norfolk O., Abdel-Dayem M. and Gilbert F. (2012) Rainwater harvesting and arthropod biodiversity within an arid agro-ecosystem. *Agriculture, Ecosystems & Environment* 162, 8–14.

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Perrier R. (1923) *La Faune de la France. Fasc. 3: I. Myriapodes, II. Insectes Inférieurs*. Librairie Delagrave, Paris.

Perrier R. (1926) *La Faune de la France. Fasc. 4, Hémiptères, Anoploures, Mallophages, Lépidoptères*. Librairie Delagrave, Paris.

Perrier R. (1927) *La Faune de la France. Fasc. 5, Coléoptères (Part 1)*. Librairie Delagrave, Paris.

Perrier R. (in collaboration with Delphy J.) (1932) *La faune de la France. Coléoptères (Part 2)*. Librairie Delagrave, Tome VI, Paris.

Perrier R. (by Seguy E.) (1937) *La Faune de la France. Fasc. 8, Diptères*. Librairie Delagrave, Paris.

Philpott S. M., Cotton J., Bichier P., Friedrich R. L., Moorhead L. C., Uno S. and Valdez M. (2014) Local and landscape drivers of arthropod abundance, richness, and trophic composition in urban habitats. *Urban Ecosystems* 17, 513–532.

Pizarro-Araya J., Alfaro F. M., Agusto P., Castillo J. P., Ojanguren-Affilastro A. A. and Cepeda-Pizarro J. (2012) Arthropod assemblages of the Quebrada del Morel private protected area (Atacama Region, Chile). *Pan-Pacific Entomologist* 88, 8–21.

Ramade F. (1984) *Eléments d'écologie - Ecologie fondamentale*. Ed. McGraw-Hill, Paris. 397 pp.

Rosenberg D. M., Danks H. V. and Lehmkuhl D. M. (1986) Importance of insects in environmental impact assessment. *Environmental Management* 10, 773–783.

Rubinstein Y., Groner E., Yirhaq H., Svoray T. and Bar (Kutiel) P. (2012) An eco-spatial index for evaluating stabilization state of sand dunes. *Aeolian Research* 9, 75–87.

Sadine S. and Idder M. A. (2009) Aperçu sur la diversité scorpionique de la région d'Ouargla (Nord-Est Sahara algérien), p. 40. In *Actes du Séminaire International sur la Biodiversité Faunistique en Zones Arides et Semi-arides*, 22 au 24 novembre 2009, Faculté des Sciences de la Nature et de la Vie, Université Kasdi Merbah, Ouargla, Algérie.

Santos S. A. P., Cabanas J. E. and Pereira J. A. (2007) Abundance and diversity of soil arthropods in olive grove ecosystem (Portugal): Effect of pitfall trap type. *European Journal of Soil Biology* 43, 77–83.

Sekour-Kherbouche Y., Boucharia T., Sekour M., Souttou K., Doumandji S. and Chakali G. (2010) Composition et structure des arthropodes échantillonnés grâce à la technique des pots Barber à Souf (Sahara), p. 165. In *Journées Nationales de Zoologie Agricole et forêstière*, du 19 au 21 Avril 2010, Institut National Supérieur Agronomique, El Harrach, Algérie.

Selmane M., Ben Atouss I., Tliba S., Farej A. and Marnich F. (2016) Contribution to the study of insects in north east of Sahara of Algeria (El Oued region). *Journal of Entomology and Zoology Studies* 4, 203–206.

Sid Amar A. (2011) Biodiversité de l'arthropodofaune dans la région d'Adrar. Thèse Magister, Ecole National Supérieure Agronomique. El Harrach, 155 pp.

Souttou K., Choukri K., Sekour M., Guezoul O., Ababsa L. and Doumandji S. (2015) Ecologie des arthropodes en zone reboisée de Pin d'Alep dans une région présaharienne à Chbika (Djlefa, Algérie). *Faunistic Entomology* 68, 159–172.

Souttou K., Farhi Y., Baziz B., Sekour M., Guezoul O. and Doumandji S. (2006) Biodiversité des arthropodes dans la région de Filiach (Biskra, Algérie). *Ornithologia Algerica* 4, 15–18.

Souttou K., Sekour M., Ababsa L., Guezoul O., Bakouka F. and Doumandji S. (2011) Arthropodofaune recenses par la technique des pots barber dans un reboisement de Pin d'Alep a Sehary Guebly (Djelfa). *Revue des BioRessources* 1, 19–26.

Tigar B. J. and Osborne P. E. (1997) Patterns of arthropod abundance and diversity in an Arabian Desert. *Ecography* 20, 550–558.

Tucker C. J., Dregne H. E. and Newcomb W. W. (1991) Expansion and contraction of the Sahara Desert from 1980 to 1990. *Science* 253, 299–300.

Weesie D.M. and Belemsobgo U. (1997) Les rapaces diurnes du ranch de gibier de Nazinga (Burkina Faso): Liste commentée, analyse du peuplement et cadre biogéographique. *Alauda* 65, 263–278.

Wynne J. J. and Voyles K. D. (2014) Cave-dwelling arthropods and vertebrates of North Rim Grand Canyon, with notes on ecology and management. *Western North American Naturalist* 74, 1–17.

Yasri N., Bouisri R., Kherbouche O. and Arab A. (2009) Inventaire faunistique des arthropodes de la palmeraie de Ghoufi (Wilaya de Batna), p. 16. In *Séminaire International sur la Biodiversité Faunistique en Zones Arides et Semi-arides*, du 22 au 24 Novembre 2009, Faculté des Sciences de la Nature et de la Vie, Université Kasdi Merbah, Ouargla, Algérie.

Zaller J. G., Kerschbaumer G., Rizzoli R., Tiefenbacher A., Gruber E. and Schedl H. (2015) Monitoring arthropods in protected grasslands: Comparing pitfall trapping, quadrat sampling and video monitoring. *Web Ecology* 15, 15–23.

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