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DIVERSITY OF CARABIDAE (COLEOPTERA) IN OUARGLA PALM GROVES (ALGERIAN SAHARA)

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Abstract. In this study, we made a list of all the Carabidae species recorded in Ouargla palm groves in the Algerian Sahara from August 2021 to September 2022 using pitfall traps, and we have investigated their diversity, abundance, and the environmental factors influencing their spatiotemporal distribution. The inventory allowed the identification of 28 species of Carabidae, with a total number of 288 specimens and the dominance of *Lophyra flexuosa* (202 individuals). The identified species belong to eleven subfamilies, of which Harpalinae was the most diverse with 10 species, whereas Cicindelinae was the most abundant (231 individuals). The values of Shannon-Weaver index (H') varied between 1.72 and 1.87 in the different sampling sites. The spatial distribution of Carabidae species seems to be influenced by several ecological parameters, mainly the soil covering and the palm grove maintenance. However, the temporal distribution of these insects seems to be influenced by climatic factors, namely precipitation and temperature.

INTRODUCTION

Carabidae is considered one of the most diversified and abundant families of Coleoptera, with approximately 38600 valid names occurring worldwide and an estimate of approximately 100 additional new species every year (Lorenz 2005). They can be present in different agrosystems and colonise all terrestrial environments, but they constitute one of the groups of invertebrates that are most susceptible to environmental disturbances (Cole et al. 2002; Gobbi and Fontaneto 2008), like the overuse of pesticides (Epstein et al. 2001; Goulet 2003; Van Toor 2006) and soil imbalance (Pfiffner and Luka 2003).

The ground beetles can be used as biological indicators to evaluate environmental changes in some areas due to the specificity of their habitats (e.g. Eyre and Luff 1990; Biaggini et al. 2007; Fadda et al. 2008; Kotze et al. 2011). Furthermore, most of them are considered efficient predators, thanks to their omnipresence and their predatory action against some pests like aphids, wireworms, and slugs (e.g. Goulet 2003; Saska 2007; Nietupskil et al. 2015).

Due to their popularity, many studies have been done on ground beetles in different regions around the world. In North Africa, in-depth studies on this family are rare, except those that treated the faunal composition of Carabidae in Algeria, Tunisia, and Morocco, namely: Seriziat (1885), Peyerimhoff (1931, 1948), Kocher and Reymond (1954), Antoine (1955, 1962), Pierre (1958), Chavanon (1994), and Chavanon et al. (1995). In Algeria, the data on carabid fauna are still scarce, except for some works like the studies done in the forests of Chréa and Djurdjura (Belhadid et al. 2014), in the agricultural landscapes of Constantine (Saouache et al. 2014), in Sabkha Djendli in Batna (Chenchouni et al. 2015), and in the Ramsar wetland Chott Tinsilt (Amri et al. 2019). In western Algeria, the ground beetles of the Sabkha of Oran and of the salt marshes of Tafna and Dayet El Ferd were studied, respectively, by Boukli-Hacene and Hassaine (2009), Boukli-Hacene et al. (2011), and Matallah et al. (2016). In semi-arid regions, we find the works of Bouragba (1992), Brague-Bouragba et al. (2006), Brague-Bouragba (2007), and Bouragba et al. (2018, 2020). Also, we can mention the work of Brahimi et al. (2021), in which the list of Carabidae inventoried in the central Saharan Atlas (Djelfa, Algeria) has been established. In the Algerian Sahara, no study has been done on Carabidae.

It is in this context that the current study aimed to focus specifically on the inventory of ground beetles that live in Saharan palm groves in Algeria and to provide fundamental information on the diversity and community structure of these beetles.

MATERIALS AND METHODS

Study areas

This study was performed in three palm groves located in the northern Algerian Sahara (Ouargla). The climate of the study area is typically arid (Saharan bioclimatic stage) with a mild winter. The meteorological data for the period 2005–2018 shows that the average annual temperature varies between 35.9°C (July) and 12.1°C (January), and the cumulative annual precipitation does not exceed 78.9 mm. The soil's mineral fraction is formed almost entirely of ground when the organic fraction is very low (less than 1%) and does not allow good aggregation (Daoud and Halitim 1994).

We chose three date palm (*Phoenix dactylifera* L.) groves for our study. They are situated at an area of about 10 km and differ widely in their maintenance, the nature of their plants, and the organization of their plantations. Each grove covers an area of about 70 to 100 km^2. In the palm grove of Djellabi, date palm cultivation contributes with 69.5% of the palm grove's total coverage. There are also many other plants like *Convolvulus arvensis*, *Suaeda ruticosa*, *Juncus rigidus*, *Medicago sativa*, *Cutandia dichotoma*, *Phragmites comminus,* and *Sonchus maritimus* (Figure 2A). According to the scale used by Duranton et al. (1982), this palm grove is classified as a dense vegetation area. However, the palm grove of Kasdi Merbah Ouargla University (K.M.O.U.) is 40% covered with date palms, while the rest of its surface is covered with other species like *Medicago sativa*, *Cutandia dichotoma*, *Phragmites communis,* and *Sonchus maritimus* (Figure 2B). According to the scale provided by Duranton et al. (1982), this palm grove is classified as an open vegetation area. The palm grove of Gouamid contains 196 date palms, which is 74% of the total coverage, along with many other plants like *Cutandia dichotoma*, *Phragmites communis*, *Cynodon dactylon,* and *Juncus maritimus* (Figure 1C). According to the scale given by Duranton et al. (1982), this palm grove is classified as a dense vegetation area. The location and other characteristics of each palm grove are respectively represented in Figures 1 and 2 and Table 1.

Data collection

The sampling of ground beetles was carried out with pitfall traps, which is the most adapted trapping method for this beetle family (Lövei and Sunderland 1996). The traps were constructed from round plastic containers

Table 1. Characteristics of the palm groves in the region of Ouargla, Algeria.

Palm grove	Latitude (North)	Longitude (East)	Elevation (m a.s.l.)	Maintenance	Plantation	Irrigation system
Djellabi	31°58'19"	5°23'07"	137	Maintained	Organised plantation	Drop-by-drop
K.M.O.U.	31°56'12"	5°17'42"	133	Half-maintained	Half-organised plantation	Submersion
Gouamid	31°56'33"	5°17'43"	136	Non-maintained	Irregular plantation	Submersion

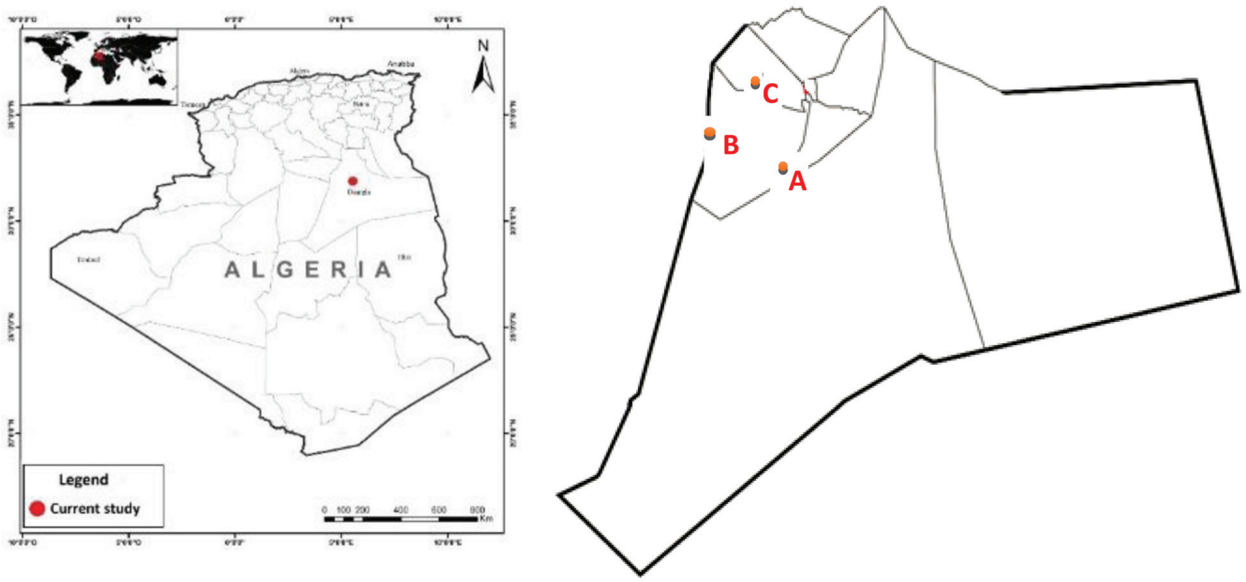

Figure 1. Map showing the location of the palm groves chosen in the region of Ouargla, Algeria (A: Djellabi, B: K.M.O.U., C: Gouamid).

Figure 2. The palm groves chosen for study in the region of Ouargla, Algeria (A: Djellabi, B: K.M.O.U., C: Gouamid).

with a 10 cm height and a 7 cm diameter. Traps were filled to 2/3 with water and 5% diluted formol. The technique consists of pressing the traps into the soil with their upper edges coinciding with the level of soil.

The sampling was conducted four times a month for 12 months (from August 2021 to September 2022). A total of 10 traps were placed in each palm grove. The distance between the traps amounted to 10 m according to the method of transects. The identification was performed using the keys of Bedel (1895–1914), Perrier (1927), and DuChatenet (2005).

Data Analysis

Ecological indices

The data obtained on the abundance and diversity of species in the study areas were analysed with PAST software (Paleontological Statistics) version 2.17 and certain ecological indices such as:

Total richness (*S*), which is the total number of species captured in the traps (Blondel 1975).

Relative abundance of the species: $AR\% – n_i \times 100 \div N$, where n_i means the number of individuals of the *i*-th species, and *N* means the total number of individuals (Zaime and Gautier 1989).

Shannon index (H' bits): $H' = \Sigma q_i \log_2 q_i$, where q_i is the relative frequency of the species *i* (Magurran 2004).

Index of equitability (*E*), which corresponds to the ratio of the observed diversity H' to the maximum diversity $H'max$: $H'max = \log_2 S$.

It is calculated based on the following formula: $E – H' \div H'max$ (Ramade 1984).

Factorial correspondence analysis (FCA)

According to Dervin (1992), factorial correspondence analysis (FCA) is a descriptive method for analysing correspondences between two qualitative variables. In our work, FCA was used to highlight the distribution of Carabidae species captured by pitfall traps at three selected stations in the Ouargla region, taking into account their presence or absence at these stations. The program used to carry out that analysis was IBM SPSS Statistics version 30.0.

Hierarchical clustering dendrogram

The main aim of the automatic classification methods is to divide the elements of a set into groups, or, in other words, to establish a partition of this set. In our study, the hierarchical clustering dendrogram has been used to illustrate the abundance-based similarity of ground beetle species among months in the region of Ouargla. The program used to carry out that analysis was IBM SPSS Statistics version 30.0.

Kruskall-Wallis test

The Kruskal-Wallis test is a nonparametric method for testing whether samples originated from the same distribution (Yinglin 2020). In our study, the Kruskall-Wallis test was used to highlight the existence of any significant difference between the numbers of individuals of Carabidae inventoried in the three phoenicultural gardens in Ouargla region.

RESULTS

The different species of ground beetles collected with pitfall traps in the palm groves of the studied area are represented in Table 2, along with their authors and years of description.

The systematic list of carabids collected in the areas of study included 28 species belonging to eleven subfamilies (Table 2). Among the subfamilies, Harpalinae was the most diversified with 10 species. Scaritinae and Carabinae came in second with three species each, followed by Cicindelinae, Brachininae, Antiinae, and Pterostichinae with two species each. The rest of the subfamilies (Apotominae, Platyninae, Trechinae, and Siagoninae) were composed by only one species each. Also, the list presented above revealed the presence of 22 genera of ground beetles. *Scarites* and *Harpalus*

Table 2. Subfamilies, species, number of individuals, relative abundances, *H'*, *H'max*. and *E* of ground beetles collected with pitfall traps in the palm groves of the region of Ouargla.

Species	Species code	Djellabi		K.M.O.U.		Goumid		Annual distribution for all the palm groves											
		Ni	AR%	Ni	AR%	Ni	AR%	1	2	3	4	5	6	7	8	9	10	11	12
Cicindelinae																			
Lophyra flexuosa (Fabricius, 1758)	sp. 1	51	64.6	63	70.8	88	74	1	5	10	8	25	60	47	20	15	7	2	2
Cicindela campestris (Linnaeus, 1758)	sp. 2	15	19	6	6.7	8	6.7	0	1	2	1	3	5	6	6	2	1	1	1
Carabinae																			
Carabus faminii Dejean, 1826	sp. 3	0	0	1	1.1	0	0	0	0	0	0	0	0	0	0	1	0	0	0
Calosoma algiricum Géhin, 1885	sp. 4	1	1.3	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
Calosoma maderae (Fabricius, 1775)	sp. 5	1	1.3	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
Scaritinae																			
Scarites buparius (Förster, 1771)	sp. 6	3	3.8	4	4.5	4	3	1	0	2	2	1	1	1	1	2	0	0	0
Scarites impressus Fabricius, 1801	sp. 7	0	0	1	1,1	0	0	0	0	0	0	0	0	0	0	0	1	0	0
Scarites cyclops Crotch, 1871	sp. 8	0	0	1	1.1	0	0	0	0	0	0	0	1	0	0	0	0	0	0
Apotominae																			
Apotomus rufithorax Pecchioli, 1837	sp. 9	0	0	1	1.1	0	0	0	0	0	0	0	0	0	1	0	0	0	0
Brachininae																			
Brachinus explodens Duftschmid, 1812	sp. 10	0	0	0	0	1	0.8	0	0	0	0	1	0	0	0	0	0	0	0
Pheropsophus africanus (Dejean, 1825)	sp. 11	0	0	0	0	1	0.8	0	0	0	0	0	1	0	0	0	0	0	0
Harpalinae																			
Drypta distincta (P. Rossi, 1792)	sp. 12	0	0	1	1.1	0	0	0	0	0	0	0	0	1	0	0	0	0	0
Harpalus lethierryi Reiche, 1860	sp. 13	0	0	1	1.1	1	0.8	0	0	0	1	0	0	0	1	0	0	0	0
Harpalus affinis (Schrank, 1781)	sp. 14	0	0	1	1.1	0	0	0	0	0	1	0	0	0	0	0	0	0	0
Harpalus tenebrosus Dejean, 1829	sp. 15	0	0	0	0	2	1.7	0	1	0	0	0	0	1	0	0	0	0	0
Microlestes luctuosus (Holdhaus in Apfelbeck, 1904)	sp. 16	0	0	0	0	1	0.8	0	0	0	1	0	0	0	0	0	0	0	0
Acinopus megacephalus (P. Rossi, 1794)	sp. 17	1	1.3	1	1.1	2	1.7	0	0	0	0	2	0	0	1	1	0	0	0
Acupalpus elegans (Dejean, 1829)	sp. 18	3	3.8	4	4.5	2	1.7	0	0	1	0	2	3	2	0	1	0	0	0
Syntomus fuscomaculatus (Motschulsky, 1844)	sp. 19	1	1.3	0		0	0	0	0	0	1	0	0	0	0	0	0	0	0
Cymindis lineola L. Dufour, 1820	sp. 20	0	0	2	2.2	0	0	0	0	0	0	0	0	0	2	0	0	0	0
Graphipterus serrator (Forskål, 1775)	sp. 21	0	0	0	0	1	0.8	0	0	0	0	0	1	0	0	0	0	0	0
Platyninae																			
Calathus mollis (Marsham, 1802)	sp. 22	0	0	0	0	3	2.5	0	0	0	0	1	0	1	0	1	0	0	0
Trechinae																			
Bembidion tetracolum Say, 1823	sp. 23	1	1.3	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
Siagoninae																			
Siagona europaea Dejean, 1826	sp. 24	1	1.3	0	0	1	0.8	0	0	0	0	0	0	1	1	0	0	0	0
Antiinae																			
Anthia sexmaculata (Fabricius, 1787)	sp. 25	0	0	0	0	1	0.8	0	0	0	0	0	0	0	0	0	0	1	0
Anthia duodecimguttata Bonelli, 1813	sp. 26	0	0	1	1.1	0	0	0	0	0	0	0	0	0	0	0	0	1	0
Pterostichinae																			
Pterostichus nigrita (Paykull, 1790)	sp. 27	2	2.5	0	0	3	2.5	0	1	0	0	0	1	3	0	0	0	0	0
Poecilus nitidus (Dejean, 1828)	sp. 28	0	0	1	1.1	0	0	0	0	1	0	0	0	0	0	0	0	0	0
Number of individuals (N)		79		89		119		2	8	16	15	36	70	64	32	23	9	5	3
Number of species (S)		11		15		15		2	4	5	7	9	8	11	8	7	3	4	2
Shannon_H		1.79		1.87		1.72													

were the most diversified genera, with three species for each. *Calosoma* and *Anthia* came in second with two species each. The other 18 genera were all represented by a single species.

The inventory done in the three palm groves allowed for the collection of 288 carabid specimens. The subfamily Cicindelinae, with two genera, *Cicindella* and *Lophyra*, was the most represented with 231 individuals (80.2%). It was followed by Harpalinae (8.3%) with its two genera: *Acupalpus* (9 individuals or 3.1%) and *Harpalus* (5 individuals or 1.7%). Then we find Scaritinae (4.5%) with its single genus *Scarites*, Pterostichinae (2.1%) with its genus *Pterostichus*, Platyninae, and Carabinae (1%). However, the centesimal frequency of the species belonging to the other subfamilies did not exceed 0.7% (Table 2).

Concerning species dominance, *Lophyra flexuosa* was the super dominant species with 202 individuals (70.1%), *Cicindela campestris* was the subdominant one with 29 individuals (10.1%), then came *Scarites buparius* (11 individuals, 4.5%), and *Acupalpus elegans* (9 individuals, 3.1%). The mentioned species alone represented 86.2% of the total number of carabids. However, *Pterostichus nigrita* and *Acinopus megacephalus* were represented with 5 and 4 individuals, respectively, whereas the other species contained only one to three individuals each. Five of the 28 species were found in all the sites, namely: *Lophyra flexuosa*, *Cicindela campestris*, *Scarites buparius*, *Acinopus megacephalus,* and *Acupalpus elegans* (Table 2).

According to the results presented in Table 2, the values of the Shannon-Weaver index (H') are between 1.72 and 1.87 bits, showing that the non-maintained (Gouamid's) and half-maintained (K.M.O.U.) palm groves are more diversified in Carabidae species (15 species each) than the maintained palm grove of Djellabi (11 species). The values of the equitability index (E) revealed that the communities present in the sites of sampling are too imbalanced (Table 2).

Furthermore, the existence of any significant difference between the numbers of individuals of Carabidae inventoried in the three phoenicultural gardens was checked using the Kruskall-wallis test. The later was chosen after applying the Kolmogorov-Smirnov normality test and finding that the normality is not significant.

In this case, the statistics of the Kruskall-Wallis test give a value equal to 1.292 with a probability greater than 0.05. We therefore retain the null hypothesis according to which there is no significant difference between the values of the numbers of Carabidae individuals inventoried in the maintained, half-maintained and non-maintained phoenicultural gardens. In other words, the difference between the means of these three groups is not significant.

In addition, the FCA highlighted the distribution of carabid species captured in a plane defined by axes 1 and 2, taking into account their presence/absence at the three study stations (Figure 3). The contribution of arthropods to the construction of the axes was equal to 58.08% for axis 1 and 41.92% for axis 2. The contributions of the various areas to the formation of axes 1 and 2 were as follows:

Axis 1: The K.M.O.U. palm grove contributed strongly to the construction of axis 1 with 63.3%, followed by Gouamid with 23.21% and Djellabi with 13.45%.

Axis 2: The Djellabi palm grove contributed intensively to the formation of axis 2 with 59.72%, followed by Gouamid with 40.20% and K.M.O.U. with only 0.08% (Figure 3).

Concerning the contribution of the various species to the formation of axis 1 and 2, we cite, for axis 1: *Carabus faminii* (sp. 3), *Scarites cyclops* (sp. 8), and *Poecilus nitidus* (sp. 28). Each of these species accounted for 7.07% of the total. In second place came the species that contributed with a 4.62% share. These are *Pterostichus nigrita* (sp. 27) and *Siagona europaea* (sp. 24). The remaining species contributed between 2.05% and 2.59%, with the exception of some species whose percentages did not exceed 0.55%. The species contributing strongly to the formation of axis 2 were: *Calosoma algiricum* (sp. 4), *Calosoma maderae* (sp. 5), and *Bembidion tetracolum* (sp. 23). Each of these species accounted for 12.59% of the total. *Brachinus explodens* (sp. 10), *Pheropsophus africanus* (sp. 11), *Acupalpus elegans* (sp. 18), and *Anthia sexmaculata* (sp. 25) ranked second with 6.22%. *Harpalus affinis* (sp. 14) accounted for 3.39%, while the remaining species contributed with 0.01 to 0.56% (Figure 3). The codes for the various Carabidae species are given in Table 2.

The graphical representation of axes 1 and 2 shows that the K.M.O.U. palm grove is in the second quadrant, that of Gouamid is in the third quadrant, and that of Djellabi is in the fourth quadrant.

For the Carabidae species inventoried in the three palm groves, we noted the presence of six groupings (Figure 3). The group A comprises carabids caught only in the K.M.O.U. palm grove, like *Scarites impressus* (sp. 7), *Anthia duodecimguttata* (sp. 26), and *Cymindis lineola* (sp. 20). Figure 3 also shows that *Harpalus lethierryi* (sp. 13) is the only common species between the K.M.O.U. and Gouamid's palm groves. The species forming point cloud B are typical of Gouamid's palm grove (like *Graphipterus serrator* (sp. 21) and *Calathus encaustus* (sp. 22). Group C represents Carabidae species common to all three palm groves, like *Lophyra flexuosa* (sp. 1) and *Cicindela campestris* (sp. 2), while carabids common to the Gouamid's and Djellabi's palm groves were represented by group D. These species are *Siagona* *europaea* sp. 24) and *Pterostichus nigrita* (sp. 27). Carabids caught only in the Djellabi's palm grove form group E – *Calosoma algiricum* (sp. 4), *Calosoma maderae* (sp. 5), *Syntomus fuscomaculatus* (sp. 19), and *Bembidion tetracolum* (sp. 23) (Figure 3).

On the other hand, trying to highlight the existence of any significant difference between the numbers of individuals of carabids captured in the twelve months of the year, we used the Kruskall-Wallis test, after applying the Kolmogorov-Smirnov normality test and finding that the normality is not significant.

In this case, the statistics of the Kruskall-Wallis test give a value equal to 18,828 with a probability greater than 0.05. We therefore retain the null hypothesis according to which there is no significant difference between the values of the numbers of Carabidae individuals inventoried in the twelve months.

The hierarchical clustering analysis based on the Euclidean paired group (UPGMA) of ground beetles collected in the separate months of the research highlighted two discriminated groups (Figure 4): group 2 consisted of June and July (the hottest months), and group 1 included all remaining months (Figure 4). The dendrogram demonstrated that the first grouping merges the months of January and December into one category because they both were characterised with low carabids abundances (1 and 3 specimens, respectively), and then October alone forms another category that merges with the first one, and then November also forms a third category that merges with the two previous categories. The months forming this grouping (October, November, December, and January) are the coldest in the region of Ouargla. The Carabidae abundances seem to be very low at that time of the year. The second grouping merges the months of February and April into one category. The latter is added to the category formed by the month of March. The Carabidae abundances start to be more important during that period of the year (February, March, and April), and some new species start to appear (*Scarites buparius*, *Acupalpus elegans,* and *Pterostichus nigrita*). The months of August, September, and April form separate categories. Together, these months form group 1, while group 2 comprises just two variables. These are the months of June and July (the hottest), during which we noted an important increase in Carabidae abundance.

DISCUSSION

This study is the first of its kind in the Algerian Sahara. It allowed us to identify the carabids present in three palm groves of Ouargla and followed the spatiotemporal variation of their diversity patterns. The sampling during a whole year resulted in the identification of 28 species distributed over 22 genera and 11 subfamilies. Our findings differ from those of Borges and Meriguet (2005), who identified 60 species in the marsh of Frocourt (northern France) between June and July 2005. In addition, Ghannem and Boumaiza (2017) cited 65 species belonging to 45 genera, 24 tribes, and nine subfamilies

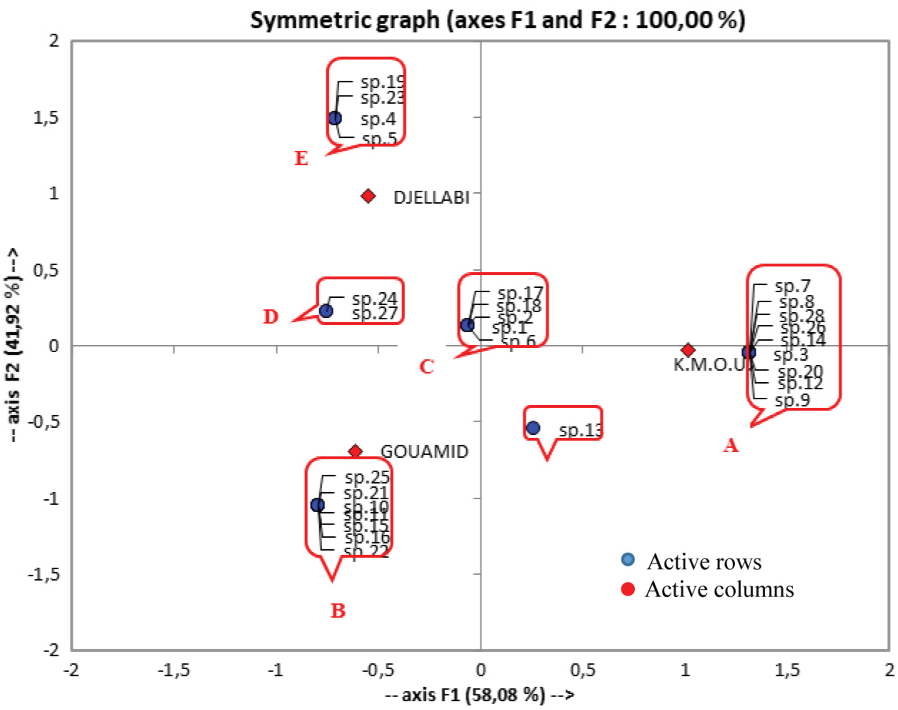

Figure 3. Analysis of results obtained on the Carabidae species captured in three selected palm groves in Ouargla using factorial correspondence analysis.

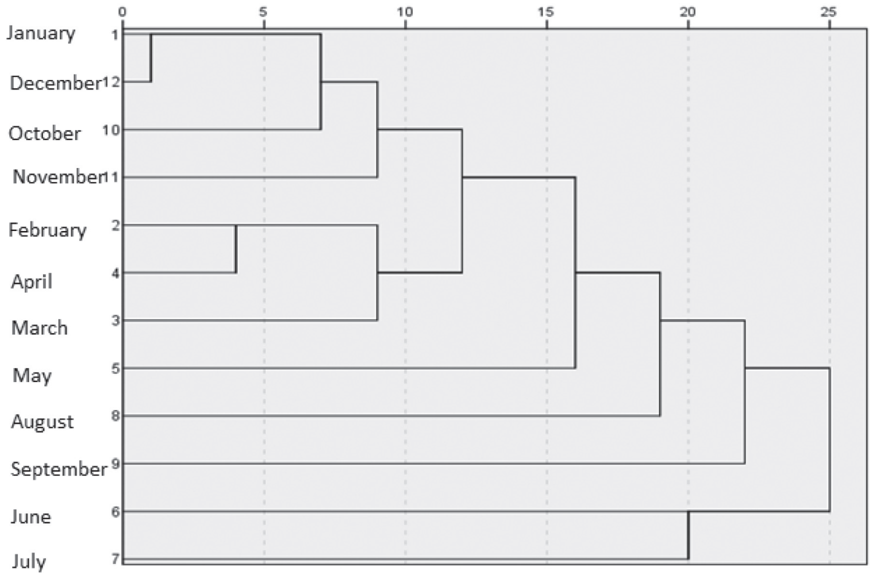

Figure 4. Hierarchical clustering dendrogram illustrating abundance-based similarity of ground beetle species among months in Ouargla palm groves.

in northern Tunisia, and 157 species have been identified at the mouth of the Moulouya River in the north-eastern part of Morocco by Chavanon and Mahboub (1998). The last authors' findings seem to be more elevated than ours, because they have all carried out their inventories in humid climates when our work has been done in an arid climate. In Algeria, Boukli-Hacene and Hassaine (2009) reported 20 taxa of Carabidae from the salt marsh Sebkha of Oran (northwest of Algeria) during a preliminary study conducted between January and June 2004. Some intriguing patterns have emerged as a result of a recent work by Belhadid et al. (2013) in the Chréa National Park at Blida (the centre of Algeria), where a total of 29 species from seven families of Caraboidea were collected, and the family Pterostichidae was the richest, with nine species. However, Bakroune et al. (2023), inventorying the Coleopterofauna associated with durum wheat in Ziban region (Northern Sahara of Algeria), have found just six Carabidae species: *Cicindela campestris*, *Calosoma sycophanta*, *Pterostechus* sp., *Brachinus* sp., *Carabus inquisitor,* and *Broscus cephalotes*. Seghier and Djazouli (2018) found a beetle community composed of 413 individuals from 32 species caught in the region of Bechar (southern Algeria). The family of Carabidae was represented with 119 individuals (7 species: *Scarites gigas*, *Scarites occidentalis*, *Anthia sexmaculata*, *Calosoma* sp., *Harpalus* sp., *Carabus* sp., and *Lophyra flexuosa*). We can note that the diversity values we have registered were more important than the ones registered by Bakroune et al. (2023) and Seghier and Djazouli (2018) despite the fact that they have also worked in arid regions like we did. The main difference between our study and theirs is that we have chosen to do ours in the palm groves when they have chosen different habitats like the durum wheat terrains and some other Saharan localities. The coverage offered by the palm grove seems to be preferred by the carabids. Many abiotic and biotic factors like temperature, humidity, light, predator distribution, food supply, and life cycle strategies can lead to difference in species richness (Lövei and Sunderland 1996), but abiotic factors like disturbance could be more efficient to explain the distribution of carabids than biotic ones (Dufrêne 1992). Indeed, there is an inverse relationship between species richness and habitat modification or disturbance (Gray 1989).

We discovered also that the non-maintained palm grove has a higher diversity than the half-maintained and maintained ones. The conditions of non-maintained palm groves (with many weeds and a surplus of irrigation water) have attracted a big number of species after creating many microhabitats. Magura et al. (2001) and Standberg et al. (2005) also have reported that habitats with dense vegetation cover are characterised by a higher species richness. In addition, Lalonde (2011) found that a high vegetation density can provide a higher relative soil humidity level that remains for a longer period of time, which promotes a greater abundance of carabids (Kromp 1989; Cardwell et al. 1994). However, the maintained palm groves are characterised by some conditions that can disturb the populations of carabids, namely: the absence of weeds, the surplus of water and plant debris, the continuity of cultivation operations, the use of pesticides and fertilizers, etc. According to many authors, toxic pesticides have a negative effect on Carabidae, reducing their abundance and diversity (e.g. Kromp 1999; Lee et al. 2001; Dajoz 2002; Melnychuk et al. 2003; Menalled et al. 2007; Fountain et al. 2009).

However, the Shannon index, the evenness values, the factorial correspondence analysis, and the results of

Kruskall-Wallis test revealed that there is no significant difference between the abundances of carabids captured in the three phoenicultural gardens of Ouargla. This observation can be attributed to the fact that the majority of the ground beetles caught in the palm groves were accidental there. They came looking for better living conditions. Indeed, Dajoz (2002) argues that animals always look for an area where the ideal conditions for living can gather.

Although only two species from two different genera, *Lophyra flexuosa* and *Cicindela campestris,* made up Cicindelinae, it was the most abundant subfamily. Jaskula and Rewicz (2015) have also noted the presence of only two species of Cicindelinae in the desert regions of Tunisia. According to them, Cicindelinae occurring in these areas inhabit predominantly river banks and oases, because they prefer to live in sandy humid terrains and can colonise a large number of microhabitats the oases offer. The same authors have also noted that the desert regions are characterised by a much lower diversity than the region that is adjacent to the Mediterranean Sea coastline. However, the subfamily Harpalinae was the most diverse with 10 species. Also, Lorenz (2005) has reported that the subfamily Harpalinae is the most diverse among the carabids with approximately 19,000 species.

On the other hand, if we compare our list of species with those mentioned by other authors in Algeria during the last 6 years (2018–2024), we find that only five species have been found in the arid regions of the country. These species are *Lophyra flexuosa* in some Saharan localities of Bechar, some durum wheat terrains in Ouled Djellal and some palm groves in Tougourt (Seghier and Djazouli 2018; Deghiche-Diab et al. 2022; Hadjoudj et al. 2018), *Scarites occidentalis* in some Saharan localities in Bechar (Seghier and Djazouli 2018), *Brachinus explodens* in some durum wheat terrains in Ouled Djellal (Deghiche-Diab et al. 2022), and *Calosoma algiricum* with *Pheropsophus africanus* in some terrains of water melon crops in Ouargla (Kacha et al. 2021), which is in accordance with the data we obtained.

Our list also includes the species mentioned from arid regions in other parts of Algeria, as well. These include *Graphipterus serrator* from Tougourt palm groves and the Central Saharan Atlas of Djelfa (Brahimi et al. 2021; Hadjoudj et al. 2018; Bouragba et al. 2020), *Pterostichus nigrita* from some terrains of water melon crops in Ouargla and the national park of El Kala (Kacha et al. 2021; Iboud et al. 2023), and *Anthia sexmaculata* in some Tougourt palm groves, two Saharan biotopes of Bechar and the Central Saharan Atlas of Djelfa (Hadjoudj et al. 2018; Seghier and Djazouli 2018; Brahimi et al. 2021).

Other species are not mentioned in the arid regions. These include *Calosoma maderae* found in two types of arboreal terrains in Belezma, two native xerotic shrub species in Tebessa and a ramsar wetland in Chott Tinsilt (Ouchtati et al. 2021; Amri et al. 2019; Habbari et al. 2023), *Harpalus tenebrosus* in some Durum wheat terrains in Oum Bouaghi (Amokrane et al. 2020), *Harpalus luctuosus*, *Calathus encaustus* and *Cymindis lineola* in the Central Saharan Atlas of Djelfa (Brahimi et al. 2021), *Bembidion tetracolum* in some saline wetlands of Setif (Mouhoubi et al. 2018), *Poecilus nitidus* in a Ramsar wetland of Chott Tinsilt and two native xerotic shrub species in Tebessa (Ouchtati et al. 2021; Amri et al. 2019), *Harpalus lethieryi* in a Ramsar wetland of Chott Tinsilt, two native xerotic shrub species in Tebessa, some olive groves in Batna, some Ramsar wetlands in El Kala and Tlemcen (Amri et al. 2019; Matallah et al. 2016; Ouchtati et al. 2021; Chafaa et al. 2019; Iboud et al. 2023), *Acinopus megacephalus* in Belezma national park, some olive groves in Batna and some Ramsar wetlands in Tlemcen (Matallah et al. 2016; Chafaa et al. 2019; Habbari et al. 2023) and *Siagona europaea* in two native xerotic shrub species in Tebessa some Ramsar wetlands in El Kala and Tlemcen (Matallah et al. 2016; Ouchtati et al. 2021; Iboud et al. 2023).

Other species are so far found only in the humid regions of Algeria: *Scarites buparius, Acupalpus elegans* and *Drypta distinctata* in El Kala national park (Iboud et al. 2023), *Apotomus rufithorax* in a Ramsar wetland of Tlemcen (Matallah et al. 2016), and *Harpalus affinis* in some animal crops in various localities of Tizi Ouzou (Marniche et al. 2019).

On the other hand, there are species that have been mentioned in all bioclimatic zones of Algeria, namely: *Carabus faminii* in some step habitats of Ouled Djellal, El Kala national park and Tikedjda forest (Deghiche-Diab et al. 2022; Abbassen et al. 2022; Iboud et al. 2023) and *Cicindela campestris* in some durum wheat terrains of Ziban, some step habitats of Ouled Djellal, Tebessa, some olive groves of Batna, and El Kala national park (Deghiche-Diab et al. 2022; Bakroune et al. 2023; Ouchtati et al. 2021; Chafaa et al. 2019; Iboud et al. 2023).

We have noted that the total number of specimens did not exceed 288 specimens with a small number of individuals representing each species. The same observations have been done by other authors working in some arid regions of Algeria, like Kacha et al. (2021) who mentioned only 24 individuals during three years of sampling in a watermelon crops station at Ouargla and by Chafaa et al. (2019) who has inventoried only 23 individuals in an arid region of Batna. Also, Seghier and Djazouli (2018) have caught 119 ground beetles between January and December 2014 in the region of Bechar. In the semiarid regions of Algeria, the number of individuals is relatively higher, such as in the works of Amokrane et al. (2020) and Hebbari et al. (2023), who have caught, respectively, 543 individuals in Oum Bouaghi and 1172 individuals in Batna during a year of study. Brahimi et al. (2021) also have registered 4934 specimens during ten years of carabids sampling (between 2000 and 2011) in the region of Djelfa. The lack or insufficiency of food in Saharan palm groves, which result in fierce competition between the species, and the emergence of such distribution models could account for this outcome, since it is known that the spatiotemporal distribution of carabids and the structure of communities can be regulated by many factors like competition, predation and parasitism (e.g. Baguette 1992; Boukli-Hacene et al. 2012; Belhadid et al. 2013).

Coming to carabids' temporal distribution, it is concluded that abiotic factors have a more remarkable effect on the community structure than biotic factors (Soberón 2010). A low number of specimens captured in all the palm groves (only 288 specimens) does not allow us to find significant differences between the values of the numbers of Carabidae individuals inventoried in the twelve months. However, the temporal variation of carabids diversity seems to be controlled by climatic conditions (mainly temperature and precipitation). Indeed, the highest values of Carabidae species richness were those registered in June and July (high average temperature and low average precipitation), while the lowest values were those found in January and December (lower average temperature and higher average precipitation). According to Sanders et al. (2007), all organisms' species richness can be determined by the temperature, as it affects their metabolic reactions. The influence of precipitation on carabids' structure is also remarkable because it provides them with a higher soil moisture and a greater plant diversity (Yan et al. 2015). The same result is given by Amri et al. (2019), who found that spatiotemporal patterns of ground beetle diversity in a Ramsar wetland of Algeria are markedly affected by climatic factors.

CONCLUSION

The results revealed that the non-maintained palm grove was more diverse in Carabidae than the half-maintained and the maintained ones. Also, the temporal distribution of the species is affected by climatic conditions, while their spatial distribution is affected by many factors like the microclimate and ecosystem disturbance. We can suggest that studies of Carabidae could play an important role in ecosystems' studies to characterise habitats and determine the environmental integrity. Furthermore, palm groves, thanks to their dense vegetation cover and the microclimate they offer, seem to be favourite sites for insect communities, including carabids. However, the ecological challenge is very important there and the biodiversity can be more significant and well preserved if these areas are protected or at least sustainable in relation to their exploitation. On the other hand, we have to make more efforts to better study the diversity and spatiotemporal distribution of ground beetles in similar ecosystems. That will allow us to identify and locate endemic, rare, or endangered species for conservation.

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Conflict of interests

The co-authors report no conflicts of interest.

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Data availability

The data used to support the findings of this study are included within the article.

REFERENCES

Abbassen, A., Derridj, A., Krouchin, F., Háva, J., & Chakali, G. 2022. Ground beetles diversity in Tikjda forest, Algeria. *Euroasian entomological journal* 21(2), 61–71. https://doi.org/10.15298/euroasentj.21.2.01

Amokrane, A., Khammar, H., Hadjab, R., & Saheb, M. 2020. Evaluation of The Diversity of Durum Wheat Coleoptera (Triticum Durum Desf.) in the Region of Sigus Oum El Bouaghi (Eastern Algeria). *Journal of Bioresource Management* 7(4). DOI: https://doi.org/10.35691/JBM.0202.0149 ISSN: 2309-3854

Amri, C., Neffar, S., Ouchtati, N., & Chenchouni, H. 2019. Spatiotemporal patterns of ground beetle diversity (Coleoptera: Carabidae) in a Ramsar wetland (Chott Tinsilt) of Algeria. *Turkish Journal of Zoology* 43(5). https://doi.org/10.3906/zoo-1904-19

Antoine, M. 1955. Moroccan beetles. 1st part. Society memory. *Sci. Natu and Phys. Marocco Zool*. 1, 1–177.

Antoine, M. 1962. Moroccan beetles. 5th part. Society memory. *Sci. Natu and Phys. Marocco Zool*. 9, 539–693.

Baguette, M. 1992. Selection of Carabidae habitat in forest environments. Phd thesis. Dep. biol. ecol. biogeogr. Univ. Cath. Louvain-laNeuve, 104 pp.

Bakroune, N., Boultif, M., Rouahna, H., & Sellami, M. 2023. Coleoptera species associated with durum wheat in Ziban region (Northern Sahara of Algeria): Diversity, abundance and sharing of trophic resources. *Journal Algérien des Régions Arides* 15(1), 130–138.

Belhadid, Z., Chakali, G., Ghalem, M., Haddar, L., & Boughrara, H. 2013. Distribution of caraboidae in different forest stands of the Chréa National Park, Algeria. *Lebanese Science Journal* 14(2), 53–61.

Belhadid, Z., Aberkane, F., & Chakali, G. 2014. Variability of groud beetels (Coleoptera-Carabidae) assemblages in Atlas cyder of Algeria. *International Journal of Zoology and Research (IJZR)* 4(3), 71–78.

Biaggini, M., Consorti R., Dapporto, L., Dellacasa, M., Paggetti, E., & Corti, C. 2007. The taxonomic level order as a possible tool or rapid assessment of Arthropod diversity in agricultural landscapes. *Agricultures, Ecosystems and Environment* 122, 183–191. http://dx.doi.org/10.1016/j.agee.2006.12.032

Blondel, J. 1975. The analysis of bird populations, elements of an ecological diagnosis. I – The Progressive Frequency Sampling (E.F.P.) method. *Ecology Review (Earth and Life)* 29(4), 533–589.

Borges, A., & Mériguet, B. 2005. *Sensitive natural area: Frocourt marshes. Entomological inventory: Coleoptera*. OPIE-1. Paris, 32 pp.

Boukli-Hacene, S., & Hassaine, K. 2009. Bioecology of Coleoptera populations in salty and humid environments in western Algeria. *Orthopteric and Entomocenotic Materials* 14, 103–109.

Boukli-Hecene, S., Hassaine, K., & Ponel, P. 2011. The populations of beetles in the salt marsh at the mouth of the Tafna (Algeria). *Ecology Review (Earth and Life)* 66, 1–15.

Boukli-Hacene, S., Hassaine, K., & Ponel, P. 2012. The populations of the Coleoptera of the salt marsh at the mouth of the Tafna (Algeria). *Revue d'Écologie (La Terre et la Vie)* 67, 101–115.

Bouragba, N. 1992. Systematic and ecological study of Coleoptera Carabidae in two pine forests Aleppo, in the Djelfa region. Magisterium thesis, US. T.H.B, Algiers, 160 pp.

Bouragba, N., Amraoui, S., Brague, A., & Beladjal, L. 2018. Dung beetle communities structure in three different ungrazed ecosystems in the steppe zone of Djelfa (Algeria). *Vie et milieu – Life and environment* 68(23), 99–108.

Bouragba, N., Bouragba, M., Djouklafi, A., Amraoui, S., Brague, A., & Beladjal, L. 2020. Spider (Araneae) and beetle (Coleoptera) communities structure in the North African streamside zone (Zahrez Gharbi, Djelfa, Algeria) after reforestation. *African Entomology* 28 (1), 25–34.

Brague-Bouragba, N., Serrano, J., & Lieutier, F. 2006. Contribution à l'étude faunistique et écologique de quelques familles de Coleoptera dans différentes formations végétales subdésertiques (Cas de Djelfa, Algérie). *Bulletin De L'institut Royal Des Sciences Naturelles De Belgique, Entomologie* 76, 93–101.

Brague-Bouragba, N., Brague, A., Dellouli, S., & Lieurtier, F., 2007. Comparison of beetle and spider populations in reforested areas and steppe areas in a pre-Saharan region of Algeria. *C.R. Biologies* 330, 923–939. https://doi.org/10.1016/j.crvi.2007.09.004

Brahimi, O., Amraoui, S., Bouragba, N., Brague, A., Djouklafi, A. 2021. Contribution to the stationary inventory of Carabidae (Coleoptera) in the Central Saharan Atlas (Djelfa, Algeria). *Annual Research for Algeria* 11(02), 75–87.

Cardwell, C., Hassall, M., & White, P. 1994. Effects of headland management on carabid beetle communities in Breckland cereal fields. *Pedobiologia* 38, 50–62.

Chafaa, S., Mimeche, F., & Chenchouni, H. 2019. Diversity of insects associated with olive (Oleaceae) groves across a dryland climate gradient in Algeria. *Entomological Society of Canada* 00, 1–19. https://doi.org/10.4039/tce.2019.35

Chavanon, G. 1994. Study on the Moulouya base (Eastern Morocco) 3: The carbines of the banks of the river and its effluent the Oued Za. *The Entomologist* 50, 63–77.

Chavanon, G., & Mahboub, M. 1998. Studies on the Lower Moulouya (Eastern Morocco): 5. The carbines of the banks of the river and its tributary the Wadi Za: corrections and additions. *The Entomologist* 54, 119–127.

Chavanon, G., Rahhoul, I., & Chavanon, L. 1995. Study on the Moulouya base (Eastern Morocco) 4: The carbines on the banks of the Zeghzel River. *Bull. Mens. Soc. Lin. Lyon* 64, 188–192.

Chenchouni, H., Menasria, T., Neffar, S., Chafaa, S., Bradai, L., Chaibi, R., Mekahlia, M., Bendjoudi, D., & Si Bachir, A. 2015. Spatiotemporal diversity, structure and trophic guilds of insect assemblages in a semiarid Sabkha ecosystem. *Peer Journal* 860, 14–2. https://peerj.com/articles/860/#links

Cole, L.J., Mc Cracken, D.I., Dennis, P., Downie, I.SX., Griffin, A.L., Foster, G.N., Murphy, K.J., & Waterhouse, T. 2002. Relationships between agricultural management and ecological groups of ground beetles (Coleoptera: Carabidae) on Scottish farmland. *Agriculture, Ecosystems and environment* 93, 323–336.

Dajoz, R. 2002. *The beetles carabidate and tenebrionid. Ecology and biology*. Tec et Doc Ed., Paris, 522 pp.

Daoud, Y., & Halitim, A. 1994. Irrigation and salinization in the Algerian Sahara. *Secheresse* Drought 5(3), 151–160. https://www.iamm.ciheam.org/ress_doc/opac_css/index.php?lvl=notice_display&id=5061

Deghiche-Diab, N., Ababsa, M., & Diab Deghiche, T. 2022. Steppe Habitats' Entomofauna At Ouled Djellel-Algeria: Statistical Analysis. *Entomologia hellenica* 31(1), 1–18. https://doi.org/10.12681/eh.29042

Dervin, C. 1992. *How to interpret the results of a corre-*

spondence factor analysis? Ed. Inst. techn. cent. form. (I.T.C.F.). Paris, 72 pp.

Dufrêne, M. 1992. *Biogeography and ecology of the Carabides communities in Wallonia*. Vol. 1. Univ. Louvain la neuve: Cath. of Louvain, 196 pp.

Duranton, J.F., Launois, M., Launois-Luong, M.H., & Lecoq, M. 1982. *Manual of locust prospecting in the dry tropics*. Paris: Ed. Gerdat, 2, 696 pp.

Epstein, D.L., Zach, R.S., Brunner, J.F., Gut, L., & Brown, J.J. 2001. Ground beetles activity and apple orchards under reduced pesticide management regimes. *Biological control* 21, 97–104. https://doi.org/10.1006/bcon.2001.0929

Eyre, M.D., & Luff, M.L. 1990. A preliminary classification of European grassland habitats using carabid beetles. In *The Role of Ground Beetles in Ecological and Environmental studies,* edited by Nigel, E.S., 227–235. Andover, Hampshire: Intercept Ltd.

Fadda, S., Orgea, J., Ponel, P., Buisson, E., & Dutoit, T. 2008. Conservation of grassland patches failed to enhance colonization of ground-active beetles on formerly cultivated plots. *Environmental conservation* 3(2), 109–116. http://dx.doi.org/10.1017/S0376892908004712

Fountain, M.T., Thomas, R.S., Brown, V.K., Gange, A.C., Murray, P.J., & Symondson, W.O.C. 2009. Effects of nutrient and insecticide treatments on invertebrate numbers and predation on slugs in an upland grassland: A monoclonal antibody-based approach. *Agriculture, Ecosystems and Environment* 131, 145–153. https://doi.org/10.1016/j.agee.2009.01.005

Ghannem, S., & Boumaiza, M. 2017. New Data of Ground Beetles (Coleoptera: Carabidae) in Tunisia. *Journal of Entomological Research Society* 19(1), 15–37.

Gobbi, M., & Fontaneto, D. 2008. Biodeversity of ground beetles (Coleoptera: Carabidae) in different habitats of the Italian Po lawland. *Agriculture, Ecosystems and Environment* 127, 273–276.

Goulet, H. 2003. Biodiversity of ground beetles (Coleoptera: Carabidae) in Canadian agricultural soils. *Canadian journal of soil science* 83, 259–264.

Gray, J.S. 1989. Effects of environmental stress on species rich assemblages. *Biological journal of Linnean Society* 37, 19–32. https://doi.org/10.1111/j.1095-8312.1989.tb02003.x

Habbari, Y., Frah, N., Bouterfa, M., & Houichi, L. 2023. Collection of Ground Beetles (Coleoptera: Carabidae) in Two Types of Arboreal Terrain in the Natural Park of Belezma Batna (North-Eastern Algeria). *Journal of Bioresource Management* 10(1).

Hadjoudj, M., Souttou, K., & Doumandji, S. 2018. The diversity of arthropods community in dunes and a palm grove (*Phoenix dactylifera*) in the Touggourt region (Septentrionale Sahara). *International Journal of Tropical Insect Science* 38(4), 283–293. https://doi.org/10.1017/S1742758418000188

Heydemann, B. 1957. The biotope structure as spatial resistance and spatial fullness for the animal world. *German Zoological Society Hamburg* 20, 332–347.

Iboud, M.T., Boukli Hacene, S., & Ponel, P. 2023. Coleoptera Carabidae Beetles of El-Kala National Park (northeastern Algeria). *Biodiversity Journal* 14(2), 359–366. https://doi.org/10.31396/Biodiv.Jour.2023.14.2.359.366

Jaskula, R., & Rewicz, T. 2015. Tiger beetles (Coleoptera : Carabidae : Cicindelinae) of Tunisia: distribution, phenology, taxa list and new records. *African Entomology* 23(2). https://hdl.handle.net/10520/EJC176587

Kacha, D., Guezoul, O., Marniche, F., & Viñolas, A. 2021. Diversity of beetles associated with watermelon crops *Citrullus lanatus* (Thunb.) Mats. in the region of Ouargla (southern Algeria). *Arxius de Miscel·lània Zoològica* 19, 73–82. DOI: https://doi.org/10.32800/amz.2021.19.0073

Kocher, L., & Reymond, A. 1954. *The southern Moroccan hamadas.* Entomology, works of the Chérifien Scientific Institute, general series n°2. International edition, Tangier, 11, 191–260.

Kotze, D.J., Brandmayr, P., Casale, A., Dauffy-Richard, E., Dekoninck, W., Koivula, M.J., Lovei, G.L., Mossakowski, D., Noordijk, J., Paarmann, W., Pizzolotto, R., Saska, P., Schwerk, A., Serrano, J., Szyszko, J., Toboada, A., Turin, H., Venn, S., Vermeulen, R., & Zetto, T. 2011. Forty years of carabid beetles research in Europe-from taxonomy, biology, ecology and population studies to bioindication, habitat assessment and conservation. *Zookeys* 100, 55–148. https://doi.org/10.3897%2Fzookeys.100.1523

Kromp, B. 1989. Carabid beetle communities (Carabidae, Coleoptera) in biologically and conventionally farmed ecosystems. *Agriculture, Ecosystems and Environment* 27, 241–251.

Kromp, B. 1999. Carabid beetles in sustainable agriculture: a review on pest control efficacy, cultivation impacts and enhancement. *Agriculture, Ecosystems and Environment* 74, 187–228. https://doi.org/10.1016/S0167-8809(99)00037-7

Lalonde, O. 2011. Evaluation of the relative abundance and species richness of ground beetles associated with different cropping systems and tillage. Doctoral thesis. Laval University. Quebec, 95 pp.

Lee, J.C., Menalled, F.D., & Landis, D.A. 2001. Refuge habitats modify impact of insecticide disturbance on carabid beetle communities. *Journal of Applied Ecology* 38, 472–483. https://doi.org/10.1046/j.1365-2664.2001.00602.x

Lorenz, W. 2005. *Systematic list of extant ground beetles of the world. (Coleoptera "Geadephaga": Trachypachidae and Carabidae incl. Paussinae, Cicindelinae, Rhysodinae)*. 2nd Edition. Tutzing: Published by the author, 530 pp.

Lövei, G.L., & Sunderland, K.D. 1996. Ecology and behaviour of ground beetles (Coleoptera, Carabidae). *Annual Review of Entomology* 41, 231–256. https://doi.org/10.1146/annurev.en.41.010196.001311

Magura, T., Tothmeresz, B., & Molnar, T. 2001. Forest edge and diversity: carabids along forest-grassland transects. *Biodiversity and Conservation* 10, 287–300. http://dx.doi.org/10.1023/A:1008967230493

Magurran, A.E. 2004. *Measuring Biological Diversity*. Blackwell Science, Blackwell Publishing, Oxford, 368 pp.

Marniche, F., Boughelit, N., Yahia, N., Milla, A., Ameur, M., Sarri, M., Toudart, L., Ferhati, G., Laloui F., & Medkour, M. 2019. Necrophagous beetles associated with different animal corpses in various Algerian localities. *Oltenia Journal for Studies in Natural Sciences* 35(2), 81–94. ref. http://olteniastudiisicomunicaristiintelenaturii.ro/cont/35_2/III.%20ANIMAL%20BIOLOGY%20III.a.%20INVERTEBRATES%20VARIOUS/11.%20Vol.%202%20Marniche%20NEV.-Claudia%20FINAL%20pt.%20publicat.pdf

Matallah, R., Abdellaoui-hassaine, K., Ponel, P., & Boukli-hacene, K. 2016. Diversity of ground beetles (Coleoptera Carabidae) in the Ramsar wetland: Dayet El Ferd, Tlemcen, Algeria. *Biodiversity Journal* 7, 301–310.

Melnychuk, N.A., Olfert, O., Youngs, B., & Gillott, C., 2003. Abundance and diversity of Carabidae (Coleoptera) in different farming systems. *Agriculture, Ecosystems and Environment* 95: 69–72. http://dx.doi.org/10.1016/S0167-8809(02)00119-6

Menalled, F.D., Smith, R.G., Dauer, J.T., & Fox, T.B. 2007. Impact of agricultural management on carabid Communities and weed seed predation. *Agriculture, Ecosystems and Environment* 118, 49–54.

Mouhoubi, D., Djenidi, R., & Bounechada, M. 2018. Contribution to the study of entomofauna of the saline wetland of chott of Beida in Algeria. *Journal of Entomology and Zoology Studies* 6(4), 317–323.

Nietupski, N., Kosewska, A., Markuszewski, B., & Sadej, W. 2015. Soil management system in hazelnut groves (*Corylus* sp.) versus the presence of ground beetles (Coleoptera: Carabidae). *Journal of plant protection research* 55(1), 26–34.

Ouchtati, N., Brandmayr, P., & Saouache, Y. 2021. A comparative analysis of the community of carabid beetles associated with two native xerophytic shrub species (*Atriplex halimus* L. and *Artemisia herba alba* L.) in the semi-arid zone of Algeria. *Entomological Society of Southern Africa* 28(1), 164–174. https://doi.org/10.4001/003.028.0164

Peyerimhoff, P. 1931. The Hoggar's scientific mission. *Mémoire de la société d'Histoire Naturelle de l'Afrique du Nord* 2, 173 pp.

Peyerimhoff, P. 1948. French mission to Fezzan (February–April 1944 and May–June 1947) Coleopteran insects. Saharan Research Institute of the University of Algiers. Scientific mission of the Fezzan. *Zoology* 5, 7–84.

Pfiffner, L., & Luka, H. 2003. Effects of low-imput farming systems on carabids and epigeal spiders-a paired from approach. *Basic and applied Ecology* 4, 117–127. https://doi.org/10.1078/1439-1791-00121

Pierre, F. 1958. *Ecology and entomological settlement of the living sands of the North-Western Sahara*. Paris, Editions du CNRS, 332 pp.

Ramade, F. 1984. *Elements of ecology. Fundamental ecology*. Paris: Ed. Mc Graw-Hill, 379 pp.

Sanders, N.J., Lessard, J.P., Fitzpatrick, M.C., & Dunn, R.R. 2007. Temperature, but not productivity or geometry, predicts elevational diversity gradients in ants across spatial grains. *Global Ecology and Biogeography* 16, 640–649. https://doi.org/10.1111/j.1466-8238.2007.00316.x

Saouache, Y., Doumandji, S., & Ouchtati, N. 2014. Ground beetles (Coleoptera: Carabidae) assemblages in two agricultural landscapes in North-Eastern Algeria. *Ecologia Mediterranea* 40, 5–16.

Saska, P. 2007. Diversity of Carabids (Coleoptera: Carabidae) within two Dutch cereal fields and their boundaries. *Baltic journal of Coleopterology* 7(1), 37–50.

Seghier, M., & Djazouli, Z.E. 2018. Ecological diversity of the beetle population in two Saharan biotopes in the Béchar region (Algeria). *Agrobiologia* 8(1), 832–844.

Seriziat, M. 1885. Study on Tebessa and its surroundings. Catalogue commented on Coleoptera. *Bulletin académique d'Hippone* 27, 175–247.

Soberón, J. 2010. Niche and area of distribution modeling: a population ecology perspective. *Ecography* 33, 159–167.

Standberg, B., Pedersen, M.B., & Elmegaard, N. 2005. Weed and arthropod populations in conventional and genetically modified herbicide tolerant fodder beet fields. *Agriculture, Ecosystems and Environment* 105, 243–253.

Tretzel, E. 1955. Technique and significance of trapping for ecological studies. *Zoological Gazette* 15, 276–287.

Van Toor, R.F. 2006. The effects of pesticides on Carabidae (Insecta: Coleoptera), predators of slugs (Mollusca: Gastropoda): literature review. *New Zealand Plant Protection* 59, 208–216.

Yan, H., Liang, C., Li, Z., Liu, Z., & Miao, B. 2015. Impact of precipitation patterns on biomass and species richness of annuals in a dry steppe. *PloS One* 10(4), 1–14. https://doi.org/10.1371/journal.pone.0125300

Yinglin, X. 2020. The Microbiome in Health and Disease. *Progress in Molecular Biology and Translational Science*. 1st Edition by Jun Sun, 171 pp.

Zaime, A., & Gautier, J.Y. 1989. Comparison of the diets of three sympatric species of Gerbillidae in the Saharan environment in Morocco. *Ecology Review (Earth and Life)* 44(3), 263–278.