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First data on scorpion diversity and ecological distribution in the National Park of Belezma, Northeast Algeria

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Abstract

This study refers to the observations and collections of scorpions at National Park of Belezma (NPB), in Batna, Northeast Algeria. During the summer of 2006, the investigations conducted in the forests of Atlas cedar (*Cedrus atlantica* M.), of Aleppo pine (*Pinus halepensis* L.) and Holm oak (*Quercus ilex* L.) resulted in collecting a total of 103 scorpion specimens representing three species, belonging to two different families. The family Buthidae is represented by *Androctonus bicolor* (relative abundance "RA" = 1.9%) and *Buthus occitanus* (RA = 82.5%). The family Scorpionidae is represented only by *Scorpio maurus* (RA = 15.5%). According to the canonical correspondence analysis (CCA), two groups with more or less homogeneous distribution are distinguished: *A. bicolor* and *S. maurus* frequent foothills dominated by the herbaceous layer between 900 to 1100 meters of altitude, while *B. occitanus* was found in high mountain habitats at more than 1300 meters of altitude where the covering of woody vegetation is high. The main habitats colonized by these species are discussed according to their orographic characteristics, general appearance of the substrate and the structure of vegetation cover.

Keywords: scorpion, *Androctonus bicolor*, *Buthus occitanus*, *Scorpio maurus*, biodiversity, species range, montane landscape, Belezma, Algeria.

Introduction

The terms biodiversity or biological diversity were introduced by naturalists who were concerned about the rapid destruction of natural environments (Lévêque &

Mounolou, 2008). Becoming aware of their impact on natural environments and threats of exhaustion of biological resources, researchers proceeded to the study and the conservation of these natural heritages. Among the poorly investigated items of animal diversity, the scorpions, which are one of the oldest terrestrial groups on the planet, have a wide distribution, and are excellent biological models to be explored (Polis, 1990).

Currently more than 1500 species of scorpions, distributed in 18 families, are described worldwide (Prendini & Wheeler, 2005). Although comprising a relatively small group of terrestrial arthropods, scorpions are subjects of considerable interest to both the scientist and the layperson. Ecologically, scorpions are important components of arid and semiarid ecosystems, but they are not limited to these areas. They may be found over different biomes in other habitats including forests, grasslands, and high mountains, and caves (Sissom & Hendrixson, 2006). In general, scorpion species distributions depend on a range of climatic and environmental variables such as temperatures, rainfall, elevation, slope, aspect, soil properties, vegetation type and land cover (Polis, 1990; Prendini, 2005).

Scorpions are carnivorous and cannibalistic arthropods, occupying an important position in the food chain because they are considered highly efficient predators of different taxa, namely: Coleoptera, Blattaria, Orthoptera, Araneida, other Scorpionida, and even small mammals and reptiles (Gouge & Olson, 2001; Sadine, 2005).

North Africa was the subject of several studies on scorpions, which showed a relatively high scorpion diversity (Vachon, 1952; Lourenço, 2003). This group poses a real public health problem by the high incidence of scorpion envenomation (Goyffon & Billiald, 2007). New species and even genera are still being discovered in Ethiopia, Niger, Morocco, Egypt and Algeria (Lourenço, 1998, 1999a, 1999b, 2005; Lourenço & Leguin, 2011; Touloun & Boumezzough, 2011).

Algeria by its vast geographic scope, its various climates and diverse ecosystems houses a diverse scorpion fauna. More than 28 species, belonging to 13 genera and three families (Buthidae, Euscorpiidae and Scorpionidae) are described for the country (Vachon, 1952; El-Hennawy, 1992; Dupré, 2011). The northern Sahara in the east of Algeria is particularly rich with this fauna; it houses more than 30% of national richness (Sadine, 2012), where the Souf region itself represents almost 28% (Sadine *et al.*, 2011) and the Ouargla region more than 21% (Sadine & Idder, 2009).

However, huge gaps exist in the knowledge of this fauna in the north of the country, particularly in forest and mountain regions. From this point of view, this work aims to enrich the existing knowledge on scorpion diversity in the protected area of the National Park of Belezma (NPB) on the one hand, and to describe the environmental conditions of habitats in which each species lives, on the other hand.

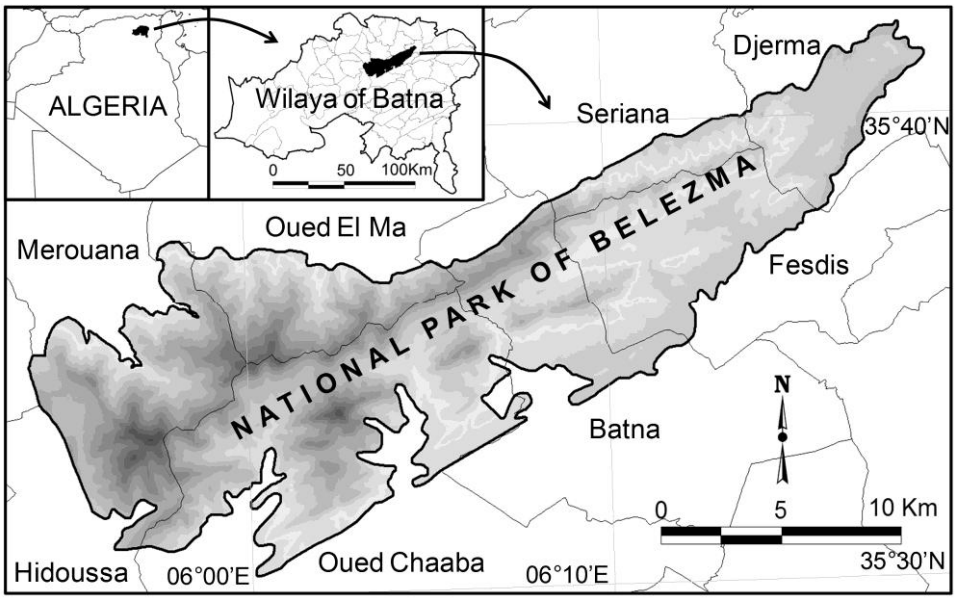
Material and Methods

Study area

The National Park of Belezma (26,250 ha) is located at the western end of the Aures Mountains in the eastern part of northern Algeria, northwest of Batna City (~ 300.000 inhabitants). Its geographic coordinates are 35°32'40"N to 35°37'46"N and 5°55'10"E to 6°10'45"E (Map 1). The massif of Belezma is a protected high mountain area characterized by a very rugged relief, with slopes often exceeding 75º and peaks up to 2136 m (Djebel Tichaou) and 2078 m (Djebel Reffaa).

Minimum temperatures are recorded in January (0-8°C) and maximum temperatures, in July (30-35°C). The annual average of rain precipitation is about 350 mm. The general bioclimate is semi-arid with a cold winter. However, the altitudinal gradient brings up subhumid and humid bioclimates while climbing the altitude

(Chenchouni *et al.*, 2010). This bioclimatic diversity corresponds to an impressive biodiversity in flora (510 species) and fauna (over 400 species) as well as in ecosystem structure (Chenchouni *et al.*, 2008). Tree species characteristic of the NPB are *Quercus ilex* (Fagaceae), *Cedrus atlantica* (Pinaceae), *Pinus halepensis* (Pinaceae), *Juniperus oxycedrus* (Cupressaceae), *Juniperus phoenicea* (Cupressaceae) and *Fraxinus xanthoxyloides* (Oleaceae).



Map 1. Location map of the National Park of Belezma (Batna, Northeast Algeria).

Sampling and data collection

During the period stretching between July and August of the year 2006, investigations were conducted at the NPB in forests of Atlas cedar (*Cedrus atlantica* M.), of Aleppo pine (*Pinus halepensis* L.) and of Holm oak (*Quercus ilex* L.).

A systematic sampling of scorpions, based on observations and direct captures *in situ* was applied. In each habitat, areas suspected of housing scorpions (under rocks, pieces of wood, ...) were systematically explored. At each sampling point, habitat descriptors were recorded: elevation above sea level "a.s.l." (m), Aspect, ground physiognomy, vegetation layers and cover (%). During the identification of specimens collected, we referred to morphological criteria, among others: the total length, the carina arrangement on the body (cephalothorax, abdomen and sting), the shape of the sting and the pedipalps and the number of teeth of the pectine. Species identification was based on identification keys established by Vachon (1952), Kovařík (2009) and Lourenço (2009).

Data Analysis

To detect gradients in species composition and in species-environment relations, canonical correspondence analysis (CCA) was performed. Specifically, we used the CCA to allow us to relate the abundance of species to environmental variables and thus to highlight relationships between environmental variables and the distribution of scorpion species. With its ability to combine ordination and gradient analysis functions, the CCA is convenient to visualize dimensional ecological data in a readily interpretable manner without prior transformation (Ter Braak, 1986; Palmer, 1993). During CCA computation, elevation and vegetation cover were taken as quantitative explanatory variables, while

Aspect, ground physiognomy and vegetation layers were considered as qualitative explanatory inputs. The permutation test was used to test the significance of CCA with 1000 permutations at a significance level of 5%.

Results

The systematic inventory, following to the identification of a set of 103 specimens, consists of three species, belonging to two families: the Buthidae represented by *Androctonus bicolor* Ehrenberg, 1828 and *Buthus occitanus* Amoreux, 1789, and Scorpionidae represented by *Scorpio maurus* Linnaeus, 1758 (Table 1).

Table 1. Relative abundance of scorpion species recorded in NPB, with characteristics of surveyed habitats.

Family	Buthidae	Buthidae			Scorpionidae
Species	*Androctonus bicolor* Ehrenberg, 1828	*Buthus occitanus* Amoreux, 1789			*Scorpio maurus* Linnaeus, 1758
Relative Abundance (%)	1.9	10.6	4.9	67.0	15.5
Elevation (m)	900–1100	800–1100	1100–1300	1300–2000	900–1100
Aspect	south	south, south-east, south-west			south
Ground physiognomy	Gravelly and stony grounds				
Vegetation layer	Herbaceous	Herbaceous	Upper tree	Upper tree	Herbaceous
Vegetation cover (%)	50	>50	<60	80	>50

At the NPB, *A. bicolor* (Fig. 1A) appears only with two individuals (RA = 1.9%). It frequents the foothills of Belezma between 900 to 1100 meters of altitude where the herbaceous layer is dominant (covering > 50%) on a predominantly stony soil. *B. occitanus* (Fig. 1B) is most abundant in the NPB with a relative frequency of 82.5%. It is found more abundantly (RA = 67.0%) in high mountain habitats at over 1300 meters of altitude where the tree layer, mainly composed of *Cedrus atlantica*, has a large covering (> 80%). *S. maurus* (Fig. 1C) with RA = 15.5%, is encountered only in southern orientation foothills at altitudes ranging from 900 to 1100 meters. Sites where the species is found are mainly characterized by *Quercus ilex*, *Pinus halepensis* and *Juniperus oxycedrus*, where the herbaceous layer occupies a covering > 50% on stony soil surface (Table 1).

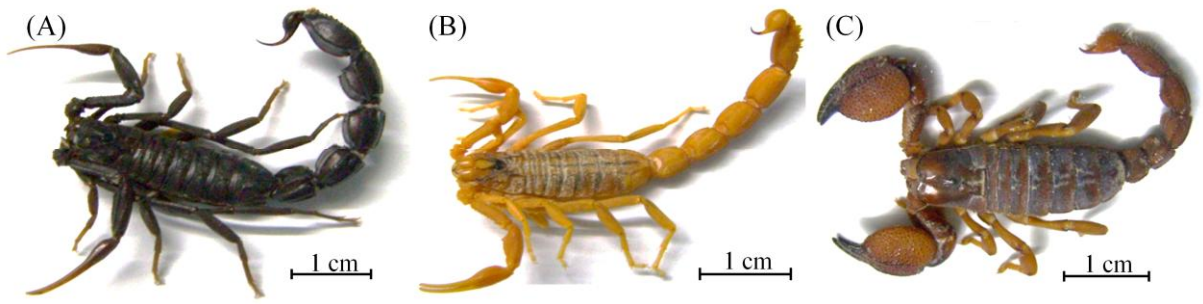


Fig. 1. Photographs of the censused scorpions of NPB: (A) *Androctonus bicolor*, (B) *Buthus occitanus*, and (C) *Scorpio maurus*, by Salah Eddine Sadine (2010).

CCA Eigenvalues of species and environment scores in canonical axis 1 and 2 were high and explaining 93.8 % and 6.2 % of the constrained inertia, respectively. A test for significance with a permutation test (1000 permutations) confirmed the significance of the first two axes ($p = 0.011$) (Table 2). As the computed *p*-value is lower than the significance level alpha = 0.05, we should accept the hypothesis that the sampled habitats/species abundances data are linearly related to the habitats/variables data.

Table 2. The results of canonical correspondence analysis (CCA) and permutation test for studied environmental traits.

Summary of CCA	**Axis 1**	**Axis 2**
Canonical Eigenvalue	0.54	0.04
Constrained inertia (%)	93.75	6.25
Cumulative %	93.75	100.00
Total inertia	77.37	5.15
Cumulative % (%)	77.37	82.52

Summary of the permutation test	
Permutations	1000
Pseudo *F*	1.574
p-value	0.011
alpha	0.050

From the intra-set regressions of the habitat factors with the two axes of CCA; elevation, vegetation cover and vegetation layer were the most significant parameters in axis 1. Upper-tree vegetation was positively correlated with elevation and vegetation cover, while herbaceous layer was negatively correlated with elevation and vegetation cover. Ground physiognomy, vegetation cover and elevation a.s.l. show comparatively high regression coefficient values with axis 2 (Table 3).

Table 3. Intraset regression coefficients of habitat variables with axes of CCA ordination.

Environmental variables	**Axis 1**	**Axis 2**
Elevation	0.479	-0.002
Vegetation cover	0.229	-1.665
Vegetation layer		
Herbaceous	-0.180	-0.656
Upper tree	0.180	0.656
Aspect		
South	-0.034	-0.285
South-east	-0.004	0.574
South-west	0.044	-0.093
Ground physiognomy		
Gravelly (2–15 cm)	0.035	-0.313
Stony (>15 cm)	-0.035	0.313

According to CCA analysis, *Scorpio maurus* was associated herbaceous vegetation in southern aspects. Vegetation layers and aspects indicated a strong trend of variation from left to right. Ground physiognomy varied from up to down where stony grounds separated, from other species on axis 2, the *Androctonus bicolor*, which was also associated with herbaceous vegetation in southern aspects. In addition, axis 1 showed

several factors influencing the distribution of *Buthus occitanus*, which was positioned on the opposite site of the axis 1 as compared to the other species. This species was positively associated with elevation, upper-tree vegetation, vegetation cover, SW and SE aspects. Both *A. bicolor* and *S. maurus* were negatively associated with elevation, upper-tree vegetation and vegetation cover (Fig. 2).

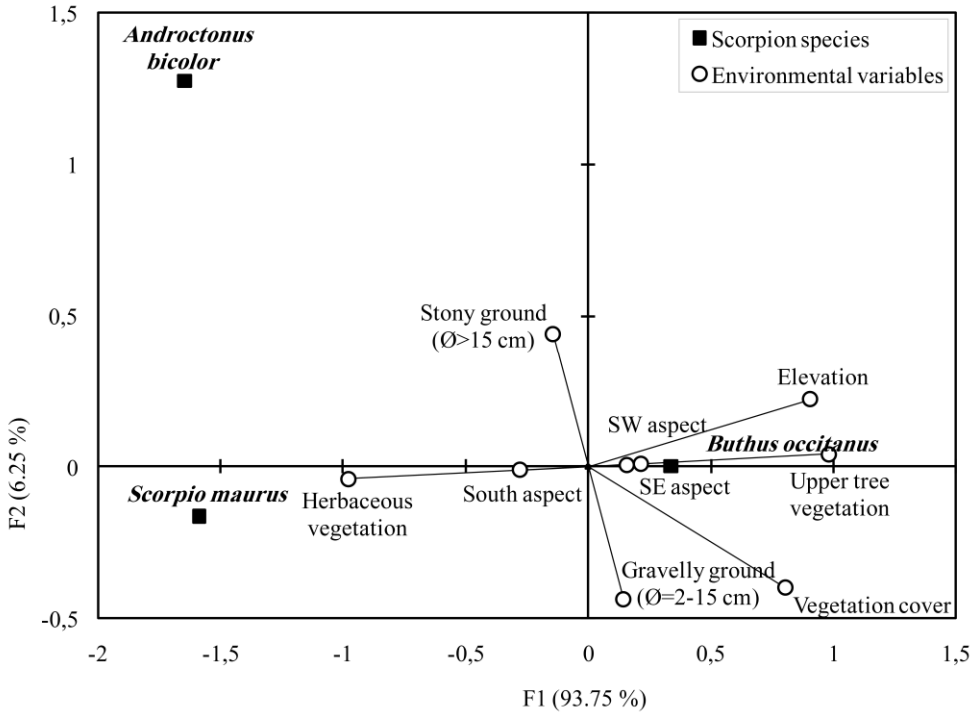


Fig. 2. Canonical Correspondence Analysis (CCA) diagram for habitat traits and scorpion species.

Discussion

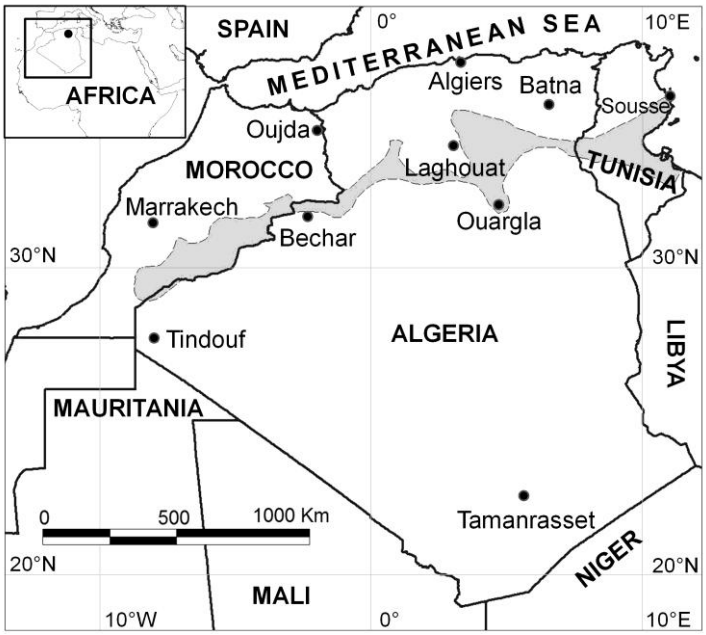
Although this study was carried out during the hot summer period permitting good sampling of the arthropodofauna, species diversity is low at the NPB. This could be due to more or less cold climatic conditions unfavourable to the existence of a significant diversity in species of scorpions which are more abundant in deserts and arid areas (Polis, 1990; Qi & Lourenço, 2007).

Androctonus bicolor Ehrenberg, 1828

Androctonus bicolor was synonymised with *Androctonus aeneas* by Lourenço (2005). The distribution of this species is North African, occurring from Tunisia to Morocco through the Hauts plateaux region in Algeria where it occupies the central horizontal band of Tebessa and Khenchela in East Algeria, to Naama in the west (Map 2) (Vachon, 1952; Sadine, 2012).

The rarity of this species in the NPB (RA = 1.9%) is explained by the occurrence of the species outside its limit of distribution in altitude and high latitude, which is defined by Vachon (1952), in Eastern Algerian, in the Zibans and in the southern limits of Saharan Atlas chain (Map 2). Furthermore, the CCA showed that the abundance of the species is negatively correlated with the dense forest vegetation (vegetation structure) on the one hand and with altitude that determines the climatic conditions of the site on the

other hand. However, the analysis revealed that *A. bicolor* has an affinity to herbaceous habitats more or less warm (south aspects) whose surface is dominated by large boulders. Indeed, Vachon (1952) captured individuals in geomorphological forms, with sparse rangeland-floristic compositions, similar to foothills of Belezma in Laghouat (Messaad and Taguine) and Biskra (Ouled Djellal). In the Lower Sahara, Sadine *et al.* (2011) stated that *A. bicolor* is found in specific biotopes like Reg or plain lands with a stony bottom.

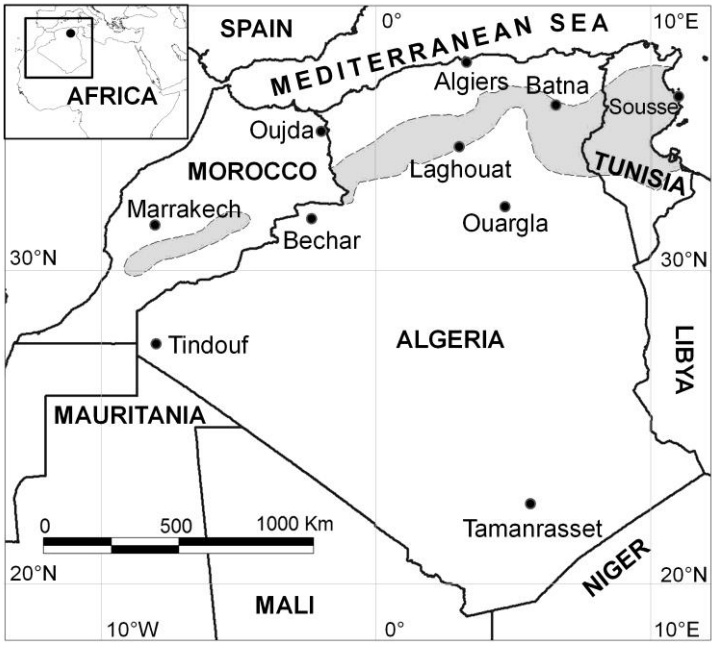


Map 2. Distribution of *Androctonus bicolor* in North Africa
(map according to Vachon, 1952).

Buthus occitanus Amoreux, 1789

B. occitanus and its subspecies have a wide distribution in North Africa. It was the subject of several studies in North Africa (Vachon, 1952; Fet & Lowe, 2000), Morocco (Touloun *et al.*, 1999), Algeria (Lourenço, 2002) and Tunisia (Kovařík, 2006). It frequents preferentially arid and semi-arid areas of southern slopes of the Atlas Mountains (Map 3). This eurytopic species occupies various types of environments; low altitude, under stones, in sand, in the forests as well as in altitude, in the mountains, even near snow line (Vachon, 1952). These findings are supported by the CCA. As an indication, the related species *B. tunetanus* (formerly subspecies *B. occitanus tunetanus*) is one of the scorpions that can populate the habitats of high mountains, namely; Oued Nail Mountains and High tablelands (near Djelfa) and the Mountains of Ksour and Abiodh (El-Hennawy, 1992).

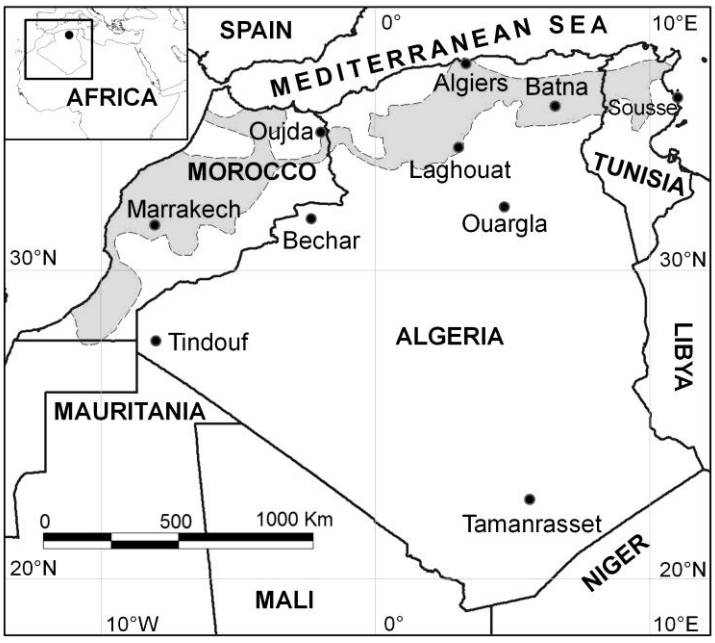
Although the NPB constitutes the upper latitudinal limit of the distribution of the species (Vachon, 1952), the abundance of this species may provide information about its plasticity and wide geographic distribution. Indeed, according to El-Hennawy (1992), the species has a wide distribution extending from northern Algeria (from Constantine in the east) to the south of the country in the Hoggar. The CCA confirms the wide ecological valence of the species whose abundance is strongly associated with altitude (climate staging), the vegetation covering and the tree layer.



Map 3. Range of *B. occitanus* in Maghreb (map according to Vachon, 1952).

Scorpio maurus Linnaeus, 1758

The genus *Scorpio* with its numerous subspecies was the subject of several taxonomic revisions (Lourenço, 2009; Kovařík, 2009). Currently, two species are recognized in Algeria, *S. maurus* and *S. tunetanus* (Simon, 1910; Fet, 2000; Acosta & Fet, 2005). Although *S. maurus* or its subspecies are known to be able to live at high altitude (Abdel-Nabi *et al.*, 2004; Sadine & Idder, 2009), particularly in North Africa (Vachon, 1952) (Map 4), it has a localized altitudinal distribution (900 to 1100 m a.s.l.).



Map 4. Population distribution of *S. maurus* (map according to Vachon, 1952).

Similarly, The CCA revealed a strong influence of the herbaceous layer (open habitats) despite that it frequents shrubby habitats, the "garrigue" composed of *Quercus ilex*, *Pinus halepensis* and *Juniperus oxycedrus*. Moreover, *S. maurus* is a fossorial species that prefers soils relatively moist (Vachon, 1952) or freshly worked (Sadine, 2009, 2012). Pallary (1929) mentioned the presence of the subspecies *S. maurus palmatus* in the high peaks of the Hoggar at 2450 m a.s.l.

Conclusion

This study is the first to highlight the composition of scorpion community in the National Park of Belezma. It described some environmental factors of sampled habitats in relation with scorpion distribution. Despite the relatively small area surveyed in the NPB, three scorpion species from different genera are identified, which constitutes a generic richness of 10.7% compared to the national level. Distribution patterns and habitats occupied by the surveyed species are heterogeneous, which deserves to be studied further by advanced approaches to identify the different ecological status of species recorded. Taking into account the high montane location of the NPB, which is also the southern limit of latitudinal distribution of several scorpions, it is recommended to carry out morphometric and molecular studies to investigate the existence of taxa or geographically differentiated populations.

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