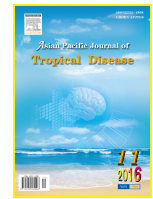


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Species composition and geographical distribution of Saharan scorpion fauna, Morocco

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ABSTRACT

Objective: To describe the species composition of scorpions and to study its geographical distribution in Laayoune-Sakia El Hamra and Dakhla-Oued Ed Dahab regions in July 2014.**Methods:** To locate scorpions, the ground was examined through searching the places under the stones, rocks and in burrows. The nocturnal missions were also conducted using portable ultraviolet lamps. The scorpions were subsequently identified in the laboratory.**Results:** The results of the investigations in these regions showed the presence of five scorpion species, two of which *Androctonus gonneti* and *Buthus bonito* were endemic in Morocco.**Conclusions:** This work is allowed to complete the inventory of the studied scorpion fauna and provides some considerations on the distribution patterns in the study area.

1. Introduction

The Vachon monography[1] is the only synthetic work remained so far on the systematics and distribution of scorpions in North Africa. Through this work, the majority of Moroccan scorpion fauna is known and processed. However, despite its importance, this work has rarely addressed the Saharan and pre-Saharan regions of Morocco where scorpion fauna remained unknown. Since the beginning of the last decade, many scientific works have contributed significantly to the knowledge of the ecology and biogeography of Saharan and pre-Saharan scorpions[2-9]. Some of these works led to the discovery of six new species for science, such as *Butheoloides occidentalis* near Tan Tan[3], *Buthus bonito* (*B. bonito*) along the Atlantic coast between Tan Tan and Tarfaya[5], *Microbuthus maroccanus* (*M. maroccanus*) at 20 km from North Tan Tan[2], *Sahabobuthus elegans* (*S. elegans*) in the extreme south of Morocco near Tichla[8], *Orthochirus maroccanus* at 45 km from Assa towards

Aouinet Torkoz[9] and *Butheoloides littoralis* in north of Sidi Ifni in the southern coast and Sidi Moussa, west of Tiznit[6].

As part of an overall program of ecological and biogeographical study of Moroccan scorpion fauna with the aim to contribute in the development of the knowledge about scorpion distribution in under-explored Saharan regions, an exploration and a collection mission in Saharan region have been conducted in July 2014. The current work presents the results of this study.

2. Materials and methods

2.1. Study areas

The study was conducted in two southern administrative regions of Morocco, Laayoune-Sakia El Hamra and Dakhla-Oued Ed Dahab, which occupy an area of around 282 883 km²[10,11]. Seven sites were surveyed (Figure 1) (Table 1).

The study area was a vast territory with homogeneous landscape. This was a large desert area with vast plateau and rocky slabs, usually limestones or sandstones. This area had no large variation relief, except dry wadis (riverbeds). Sand dunes were located in certain places and cliffs near the Atlantic coast.

The study area was affected both by the low amount of rainfall received and the intensity of the dry Saharan. This was a more temperate and humid coastal desert near the coast, but the climate was very dry eastward inside land.

As a vast stretch of the desert, the study area was dotted with a

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thin herbaceous vegetation or underwood. Sparse tufts of succulent species adapted to drought pronounced dominated by various species of Chenopodiaceae. Steppes of *Euphorbia officinarum* subsp. *echinus* (Euphorbiaceae) or *Acacia raddiana* (Fabaceae) were present locally.

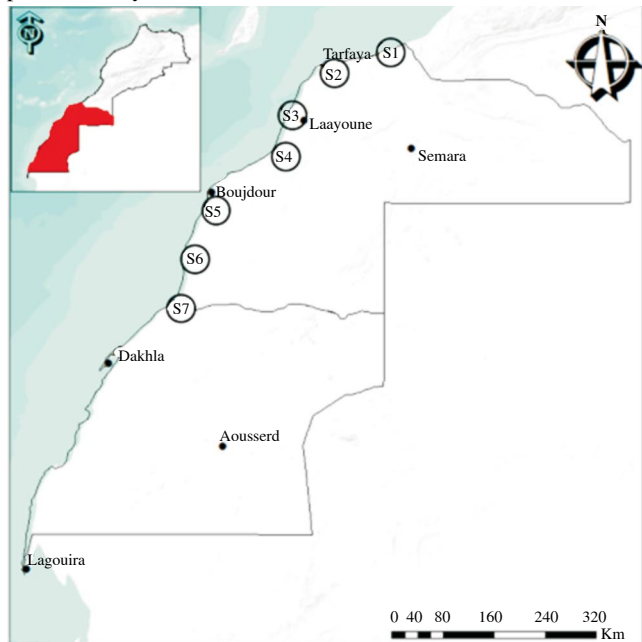


Figure 1. The study area with seven localities surveyed.

Table 1

Coordinates of the surveyed sites in the study area.

Stations	Altitude (m)	Location	Scorpion species inventory in the present study
S1 (Akhfennir)	40	28°6'14.940" N 12°2'17.448" W	<i>B. bonito</i>
S2 (Tarfaya)	5	27°55'54.516" N 12°52'59.087" W	<i>B. bonito</i>
S3 (Laayoune)	15	27°11'29.148" N 13°19'50.808" W	<i>Androctonus amoreuxi</i> (<i>A. amoreuxi</i>), <i>B. bonito</i>
S4 (59 km south of Laayoune)	81	26°40'58.000" N 13°32'51.997" W	<i>B. bonito</i>
S5 (30 km south of Boujdour)	94	26°0'13.882" N 14°29'27.758" W	<i>Microbuthus fagei</i> (<i>M. fagei</i>), <i>B. bonito</i>
S6 (106 km south of Boujdour)	96	25°14'13.500" N 14°49'11.599" W	<i>Androctonus gonneti</i> (<i>A. gonneti</i>), <i>B. bonito</i> ,
S7 (30 km north of Dakhla)	94	24°38'2.760" N 14°57'6.804" W	<i>Buthacus occidentalis</i> (<i>B. occidentalis</i>), <i>B. bonito</i> ,

2.2. Collection and identification of specimens

To locate scorpions, the ground was examined by lifting stones and tree barks. The burrows considered to be occupied by scorpions were destroyed with a shovel to try to dislodge the scorpions. The nocturnal missions in the field were carried out with ultraviolet lamps. The collected specimens were then identified using taxonomic descriptions according to previous works[1,2,4,12-15].

3. Results

3.1. Scorpion fauna composition

Currently, there were 55 species and subspecies of scorpions in Morocco of which 41 were endemic. They belonged to two families,

Buthidae and Scorpionidae. This ecological survey involved in five species of scorpions belonging to four genera in Buthidae family: *A. amoreuxi*, *A. gonneti*, *B. occidentalis*, *B. bonito* and *M. fagei* (Figure 2).

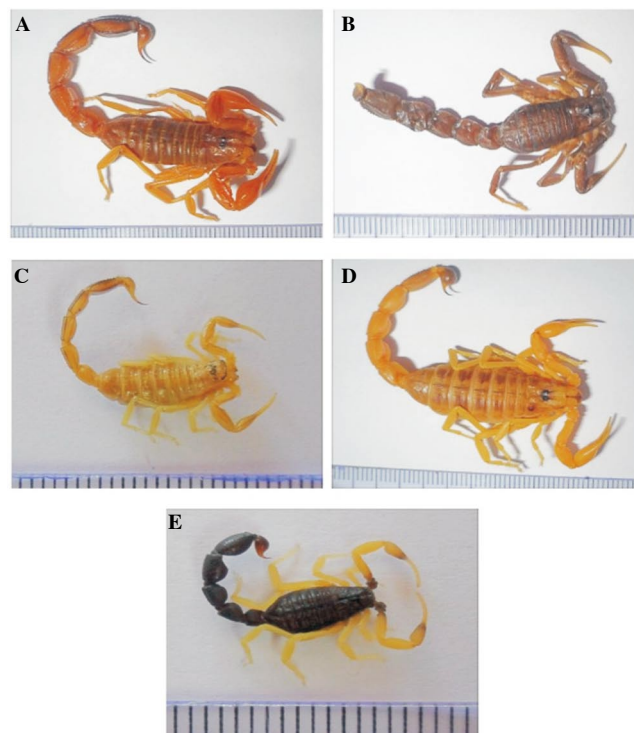


Figure 2. Scorpion species found in the study area. A: *A. amoreuxi*; B: *A. gonneti*; C: *B. occidentalis*; D: *B. bonito*; E: *M. fagei*.

3.2. Ecological and biogeographical characteristics of inventory scorpion fauna

3.2.1. *A. amoreuxi*

A. amoreuxi was a large yellow straw color scorpion that could reach 8 cm in size (Figure 2). It had a very wide distribution ranging from North Africa to Sudan, Senegal and Tchad. In the present study, this species was collected in Dchira, southeast of Laayoune (S3) (Figure 3).

3.2.2. *A. gonneti*

This species was *Androctonus crassicauda gonneti* before its elevation to the species rank after the revision of the genus in 2005. It was dark and described in Morocco from Akka region[1], which varied from black-brown to black but with the ends of the ambulatory legs clearer (Figure 2).

It differed mainly from *Androctonus mauritanicus* by the absence of setae on the pedipalp patella and by the absence of chitin granules on the dorsum of the first ring of the tail *Androctonus liouvillei*.

In this mission, a specimen of 5.7 cm size in the station S6 on sandy substrates was discovered (Figure 3).

3.2.3. *B. occidentalis*

In the present study, a female specimen of *B. occidentalis* with a size of 2.61 cm (Figure 2) in the S7 station in syntopy with *B. bonito* (Figure 3) was found .

During the previous mission, we collected this species in the Sebkhla Imlily, about 150 km south of the present station and Oued Jenna, northwest of Aousserd[7](Figure 3).

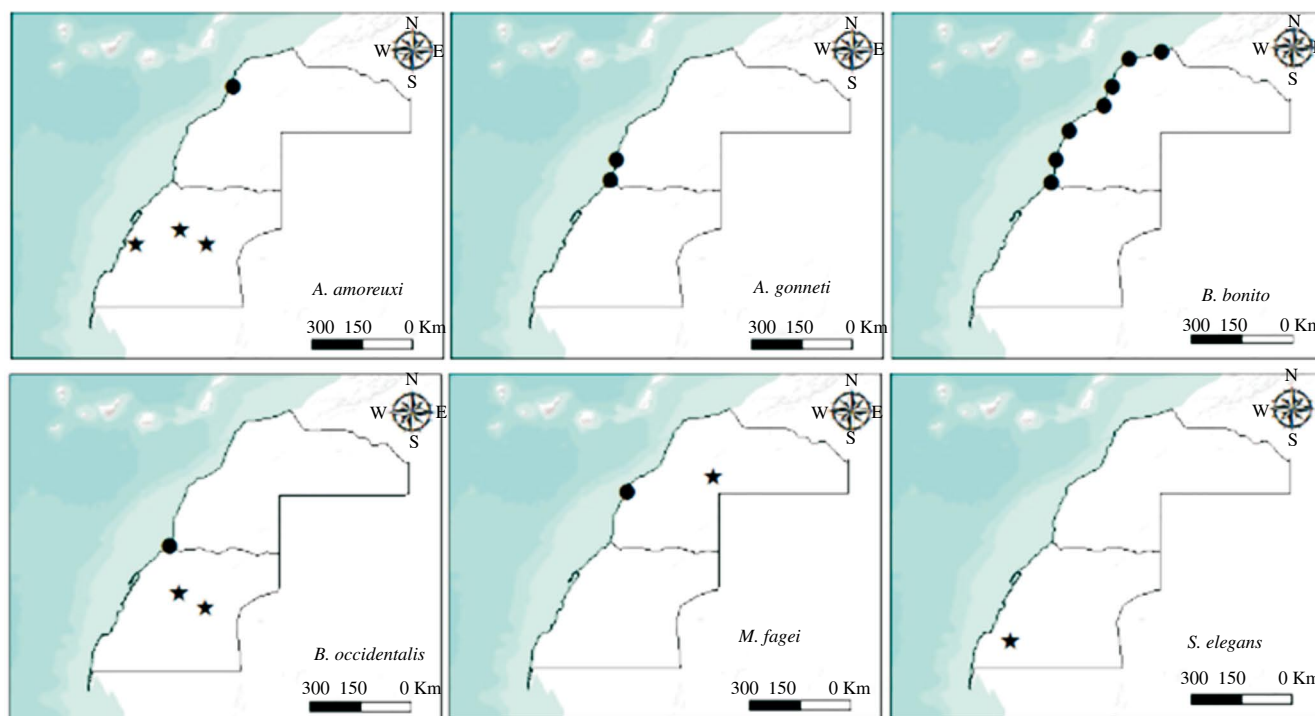


Figure 3. Distributions of the scorpion fauna in the study area.

● : Stations of this study; ★ : Stations of the previous works.

3.2.4. *B. bonito*

This species was described from the Khnifiss lagoon in the northeast of Tarfaya[4]. It had yellow straw color with the fifth ring tail and the telson darkened (Figure 2).

B. bonito having already been discovered in 32 km south of Tan Tan beach on the Atlantic coast by one of us in 2008 has been the most ubiquitous species in Morocco until now. Indeed, during this mission, it was captured in all surveyed stations (Figure 3). This species lived in the crumbly white sand or was compacted under the limestone rocks and sometimes dug burrows with a few centimeters deep.

3.2.5. *M. fagei*

In this study, we discovered three males of this species in the S6 station (Figure 3) which is the second station of its discovery in Morocco, about 250 Km from the Semara station in Morocco and more than 600 km from the typical station Nouadhibou in Mauritania.

The investigations studied in the area did not reveal the presence of *S. elegans* endemic of Morocco described from the southwest of Aousserd at 430 m of altitude[8].

4. Discussion

In Morocco, *A. amoreuxi* is identified in the Draa Valley, the Anti-Atlas and Tafilalet region[1]. Recently, it was captured near Oujda region, northeast of Morocco[16].

In addition to Dakhla-Oued Ed Dahab region, it was collected also in Oued El Jena, Dar Amane (northwest of Aousserd) and in Sebkhla Imlily at 120 km south of Dakhla[8]. The discovery of this scorpion studied in the region shows that it has a wide distribution in Morocco

and strong preference for sandy substrates.

A. gonneti is endemic in Morocco. It is known to the Anti-Atlas[1]. This new station, far more than 800 km from the typical station of the species, is so far the most southern point of its geographical distribution in Morocco.

In this important work on the north African scorpions, Vachon[1] reported the wide distribution of the genus *Buthacus* from the Atlantic to Afghanistan. Recently, a new species has been described in India. Vachon[1] and Lourenço[14] note that *Buthacus leptochelys* and *Buthacus arenicola* could represent two species complexes.

According to Vachon[1], the determination key of Kovařík[13] and Lourenço[14], the material review, has enabled us to confirm that it is *B. occidentalis*. Indeed, all granules series of the movable finger are equipped with external granules that characterize the *Buthacus leptochelys* complex. The presence of tibial spurs of the same size at the legs III and IV and eight series of granules in the fingers pincers show that it is *B. occidentalis*.

It may be noted in *B. bonito*[4] that many common characteristics with scorpions adapted to sandy life and desertic environment (even among *Buthacus* species) were pale color at least of appendages, slender habitus, length of the pincers and tail, flattening of the basitarsus, long pectines of basitarsal setae, long pectine with many teeth, many tarsus setae and the behavioral, response to the rapid capture.

Known primarily from the Atlantic coast and the Red Sea, *Microbuthus* genus, occupied the coast of Mauritania (Nouakchott and Port-Etienne) with the species *M. fagei* and it reached the eastern coast of Eritrea (Assab), Djibouti, the Red Sea coast and Yemen[1,15].

Our investigations in the Saharan regions have allowed us to discover *M. fagei* for the second record in Morocco in 60 km west of Semara city[17]. The latter station is so far the most continental of

this species and even of genera, since it is located at 170 km east of the Atlantic coast. This specimen also remains the only male found until now, because the two known specimens of this subspecies in Mauritania are of female sex.

Thereafter, Lourenço[2] described a new species of the genus, *M. maroccanus* from Western Tan Tan on the Atlantic coast before being discovered in the southwest of the typical station of the species to 72 km, 92 km and 80 km north of Tarfaya[17], which had expanded the species' range towards south.

The originality of the scorpion fauna is its position in transition zone between Palaearctic and Afrotropical biogeographic areas.

According to the present results associated with those of the previous study[7], the low diversity of habitats has not affected the scorpion specific richness. Indeed, the current inventory of this scorpion fauna is nine species with six Moroccan endemic species. Also, the distribution of water points in the interior in the depressions promotes the development of a vegetation cover, which may be a good refuge for this scorpion fauna by providing a favorable microclimate case of sebkha and wadis[7].

However, it is interesting to highlight that the inventory established through this study is not exhaustively and provisionally given the vast size of the study area, especially that some species are small size allowing it to easily escape from the investigations (cases of *Microbuthus* and *Buthacus* species). *Hottentota gentili* already discovered in the Semara region[17] is not included in the current inventory, probably because of the fact that its distribution is usually dependent on a fairly dense vegetation cover associated with a rocky substratum[5].

Thus, more investigations are needed to clarify the taxonomic status of some species and provide more data on their distribution, particularly the Moroccan endemic species *S. elegans*[8].

It is also important to intensify surveys in the transition area between the ranges of *B. bonito* and other species of *Buthus* genera such as *B. mariefranceae*, *B. rochati* and *B. atlantis* to determine the possible existence of hybrid forms between these species and optionally to determine the presence of a cline. The same problem also remains to be clarified between *M. maroccanus* and *M. fagei*.

Conflict of interest statement

We declare that we have no conflict of interest.

Acknowledgments

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