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The first true deserticolous species of *Buthus* Leach, 1815 from Algeria (Scorpiones: Buthidae); Ecological and biogeographic considerations

La première espèce de Buthus *Leach, 1815 véritablement déserticole pour l'Algérie (Scorpiones : Buthidae) : considérations écologiques et biogéographiques*

Salah Eddine Sadine [a,b], Samia Bissati [c], Wilson R. Lourenço [d,*]

[a] *Laboratoire de recherche sur la phœniciculture, faculté des sciences de la nature et de la vie, université Kasdi-Merbah, 30000 Ouargla, Algeria*
[b] *Département des sciences agronomiques, faculté des sciences de la nature et de la vie et sciences de la terre, université de Ghardaïa, BP 455, 47000 Ghardaïa, Algeria*
[c] *Laboratoire « bio-ressources sahariennes : préservation et valorisation », faculté des sciences de la nature et de la vie, université Kasdi-Merbah, 30000 Ouargla, Algeria*
[d] *Muséum national d'histoire naturelle, département « systématique et évolution », UMR 7205, CP 053, 57, rue Cuvier, 75005 Paris, France*

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ABSTRACT

Since the early 2000s, the genus *Buthus* Leach, 1815 (family Buthidae) has been the subject of an important number of studies. These concerned particularly the species belonging to the '*Buthus occitanus*' complex. A number of populations previously considered as subspecies or varieties of *B. occitanus* Leach were raised to the rank of species, but also many new species have been described. Most of the species considered in these studies come from North Africa, in particular from Morocco, Mauritania, Chad, Sudan and Egypt, but only two new species were recorded from Algeria. At present, one more new species of *Buthus* is described from the Algerian Saharan Desert, raising the number of confirmed *Buthus* in Algeria to five. Since most *Buthus* species from North Africa, and in particular those from Algeria, inhabit more mesic environments than the Saharan Central compartment, the new species appears as the first true deserticolous species found in this country.

RÉSUMÉ

Depuis le début des années 2000, le genre *Buthus* Leach, 1815 a fait l'objet d'un nombre d'études très important. Celles-ci ont concerné en particulier les espèces associées au complexe « *Buthus occitanus* ». Un bon nombre de populations, préalablement considérées comme des sous-espèces ou variétés de *B. occitanus* Leach, ont été promues au rang d'espèce, mais surtout plusieurs nouvelles espèces ont été décrites. La majorité de celles considérées dans ces études avaient comme origine l'Afrique du Nord, notamment le

* Corresponding author.
E-mail addresses: sse.scorpion@yahoo.fr (S.E. Sadine), samia.bouafia@yahoo.fr (S. Bissati), arachne@mnhn.fr (W.R. Lourenço).

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Maroc, la Mauritanie, le Tchad, le Soudan et l'Égypte, mais seulement deux espèces nouvelles concernaient l'Algérie. À présent, une nouvelle espèce de *Buthus* est décrite du désert du Sahara algérien, élevant à cinq le nombre d'espèces de *Buthus* confirmées pour ce pays. Dans la mesure où la plupart des espèces de *Buthus* d'Afrique du Nord, et en particulier celles d'Algérie, habitent des milieux plus cléments que ceux rencontrés dans le compartiment central du Sahara, la nouvelle espèce apparaît comme le premier élément du genre véritablement déserticole trouvé dans ce pays.

1. Introduction

As already outlined in previous papers [1,2], following the preliminary revisions of the genus *Buthus* Leach, 1815 proposed by Lourenço [3,4], a significant number of new species have been described during the last 15 years, in particular associated with the '*Buthus occitanus*' complex.

Most of the new species have been discovered and described from North African countries [3–5] and in several cases these were from sub-Saharan regions [1,2,4,6,7]. A smaller number of new species has also been described from European countries [8–11], and in all instances, species were found in mesic environments compared to those of true deserticolous species.

Most of the new species from North Africa, were recorded and described from countries such as Morocco, Mauritania, Tunisia, Chad, Sudan and Egypt [2,4,5,7,12–14], but only two new species were recently recorded and described from Algeria [1,3].

Recent field work performed by the senior author in the Region of Ghardaïa, North of the Central Algerian Saharan region lead to the collection of several *Buthus* specimens. Precise analysis of these specimens showed that they were different from *Buthus tunetanus* (Herbst, 1800) and *Buthus paris* (C.L. Koch, 1839), which are two species currently distributed in the North of Algeria. Consequently, a new species of *Buthus* is described here. Moreover, the new species appears as the first true deserticolous species found in Algeria (see ecological section).

2. Methods

Illustrations and measurements were made with the aid of a Wild M5 stereo-microscope with a drawing tube (camera lucida) and an ocular micrometer. Measurements follow Stahnke [15] and are given in mm. Trichobothrial notations follow Vachon [16] and morphological terminology mostly follows Vachon [17] and Hjelle [18].

3. Ecology of the Ghardaïa region

The region of Ghardaïa is located in the North of the Central Algerian Saharan region (Fig. 1) and covers a total area of ca. 86,560 km^2. The average altitude of the main reliefs is of 520 meters. Geomorphological features are constituted by the Wadis and the Regs [19]. The region is characterized by a dry Saharan climate with extreme thermal amplitudes between the day and the night, reaching 15–16 degrees [20]. The coldest month is January with a minimal temperature of 6.2 °C, whereas the hottest month is July with a maximum temperature of 41.8 °C.

Rainfall is extremely low in the region of Ghardaïa with an average value of 80.2 mm per year. Air humidity is rather weak with a maximum value of 55.5% in December and a minimum of 21.6% in July [21]. Analysis of dry periods over several years attest that 11 months are dry, ranging from February to December; only a short and slightly more humid period can be experienced in January.

The new species described here was collected in a zone of desert rocks and grasses–Regs and Wadis (Figs. 2–3). This species seems to present some fossorial activities, since it digs small and shallow, from 3 to 15 cm deep, shelters (Fig. 4). *Buthus saharicus* sp. n. does not show the characteristics of a psammophilic element. Even if this area of the Sahara desert, in Central Algeria, is quite arid, it does not really have the characteristics of sand dunes deserts (Ergs).

4. Biogeographical considerations

As outlined in previous North African scorpion studies [7] the present pattern of distribution of the flora and fauna currently encountered in the Sahara may well be very old and most certainly reflects not only the consequences of palaeogeographic factors, but is also largely the result of various palaeoclimatic vicissitudes [22]. These palaeoclimatic events had an important impact during the Quaternary when extended areas at higher latitudes in Europe (and elsewhere) were covered with ice. During these, Africa experienced periods of intense rain and, additionally, an increase in the amount of ice on the mountains (particularly in Oriental Africa). The last documented wet period in the Sahara ended as early as 3000 years BP.

The present composition of the Saharan scorpion fauna is actually a heritage of ancient faunas present in North Africa since the beginning of or, at most, middle Cenozoic times [17]. North Africa has experienced numerous paleoclimatological vicissitudes in the last few million years, the latest occurring in the past thousands of years in the recent quaternary periods. The Sahara has undergone a series of wet periods, the most recent occurring 10,000–5000 years BP, and it was not until about 3000 years BP that the Sahara assumed its present arid state [23–25]. Even though recent studies suggest that the Sahara desert may be much older than was previously thought [26], it seems reasonable to postulate that extremely arid areas have always existed as patchy desert enclaves, even when the general climate of North Africa enjoyed more

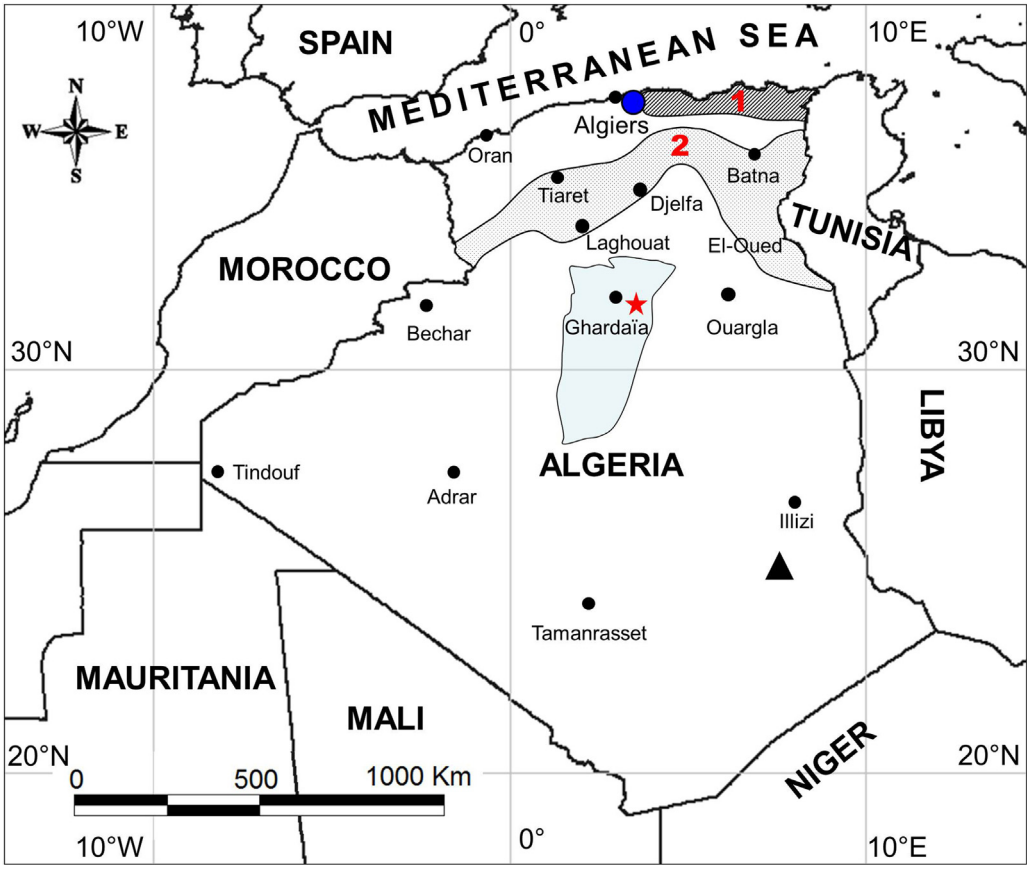

Fig. 1. Map of Algeria, showing the Ghardaïa region and the distribution of the known *Buthus* species. *Buthus paris* (dashed area 1). *Buthus tunetanus* (dashed area 2). *Buthus tassili* (black triangle). *Buthus pusillus* (blue circle). *Buthus saharicus* sp. n. (red star).

mesic conditions. In these desert regions, a specialized scorpion fauna would have evolved. In contrast, other lineages less well adapted to drought, and previously present only in more mesic environments, probably experienced important regressions in their distribution. In other cases, populations have been reduced to restricted and patchy zones sometimes with remarkable disjunctions in their distribution patterns. Given the paucity of distribution data for some *Buthus* populations with modern distributions limited to more mesic environments (Fig. 5), it is difficult to decipher a precise model. However, there is evidence that some of these lineages have been present in North Africa for at least 10 to 15 My [8,27].

The patterns observed today in the distribution of North African scorpions can be summarized as following: (i) a core Saharan region defined by Vachon [17] as the 'central compartment' in which only the groups best adapted to xeric conditions have a large distribution; and (ii) a peri-Saharan

Fig. 2. Reg formation, habitat of *Buthus saharicus* sp. n.

Fig. 3. Wadi formation on sand bed, also habitat of *Buthus saharicus* sp. n.

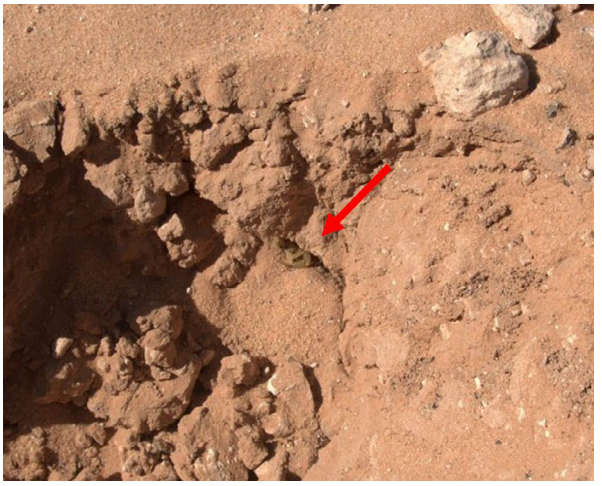

Fig. 4. Shelter dug by *Buthus saharicus* sp. n. in the Reg formation. The scorpion is indicated by the red arrow.

zone of distribution almost forming a ring around the most arid core region of the Sahara. In this zone many groups better adapted to more mesic conditions are encountered, including several *Buthus* populations [1].

As suggested by Vachon [17], several groups less well adapted to xeric environments have their populations limited to refugia. These can be represented by some oases and in particular by the Saharan massifs. In contrast, the presence of species belonging to groups associated with 'ancient lineages' in mesic environments, as it seems to be the case for the species belonging to the genus *Buthus*, may suggest a secondary re-adaptation. This could explain the presence of endemic species of *Buthus* in several Saharan massifs and Mountain ranges [3,7].

5. Taxonomic treatment

Family Buthidae C. L. Koch, 1837
Genus ***Buthus*** Leach, 1815
Buthus saharicus sp. n. (Figs. 6–8)

Fig. 5. Mediterranean forest in the region of Batna, example of a Mesic environment, typical habitat of *Buthus tunetanus*.

Fig. 6. *Buthus saharicus* sp. n. Female holotype alive in natural Reg environment.

Algeria, region of Ghardaïa (32°18'N, 003° 50'E), in Wadi bed, buried in shelter, 436 m, 14/II/2015 (S.E. Sadine), female holotype; 4/VI/2015 (S.E. Sadine), 1 male paratype; 14/II/2015 (S.E. Sadine & A. Houtia) 1 female juvenile paratype. Holotype and female juvenile paratype deposited in the "Muséum national d'histoire naturelle", Paris; male paratype deposited in the University of Ghardaïa, Algeria.

Etymology: The specific name refers to the Sahara desert where the type material has been collected.

Diagnosis: Scorpion of moderate size, reaching a total length of 67 and 52 mm in female and male respectively. General coloration yellow to pale yellow without spots; only some carinae are slightly reddish in adults; juveniles with some dark spots over carinae and on metasomal segment V. Carinae moderately to strongly marked;

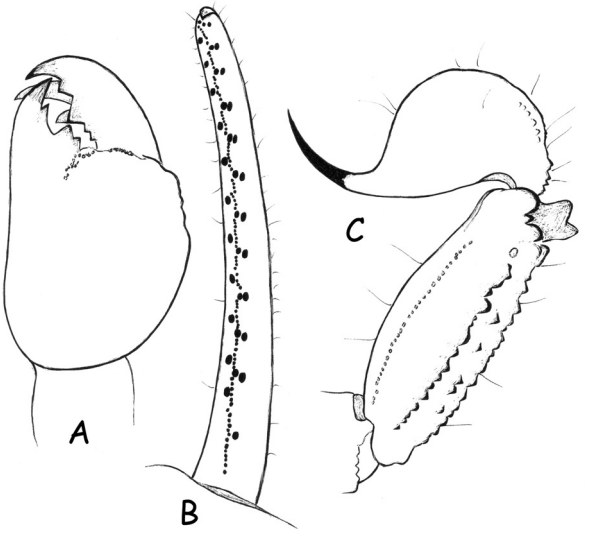

Fig. 7. *Buthus saharicus* sp. n. Female holotype. A. Chelicera, dorsal aspect. B. Cutting edge of movable finger with rows of granules. C. Metasomal segment V and telson, lateral aspect.

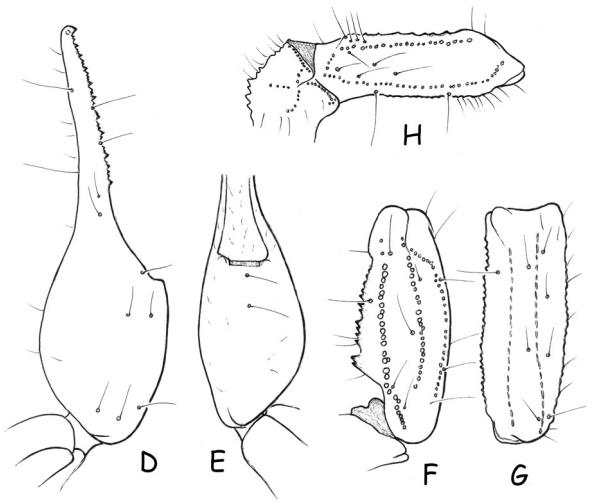

Fig. 8. *Buthus saharicus* sp. n. Female holotype. Trichobothrial pattern. D–E. Chela, dorso-external and ventral aspects. F–G. Patella, dorsal and external aspects. H. Femur, dorsal aspect.

ventral carinae of metasomal segments II–III strongly lobated; two lateral lobes on metasomal segment V with one smaller lobe in between these two lobes; granulations moderately to weakly marked. Fixed and movable fingers with 11-11 rows of granules. Pectines with 27 to 29 teeth in females, 31 teeth in male. Trichobothrial pattern A-**β** (beta), orthobothriotaxic; trichobotrium $\mathbf{d_2}$ of femur extremely reduced, and **db** on fixed finger displaced to the internal face. Tibial spurs strongly developed.

Relationships: *B. saharicus* sp. n. certainly belongs to the '*B. occitanus*' complex of species. The new species is, however, quite singular by its very pale pattern of pigmentation. It can be distinguished from other species of *Buthus* and in particular from *B. tunetanus* and *B. paris*, species distributed in the North range of Algeria, by the following characters: (i) the new species has a paler color pattern, without any spots in adults, (ii) the new species has a reduced number of pectinal teeth compared to *B. tunetanus*, (iii) *B. paris* has 12-14 rows of granules on the chela fingers whereas the new species has 11-11, (iv) *B. saharicus* sp. n. shows a weak setation on pedipalps, metasomal segments and telson ('oligotriche', sensu Vachon [17]); this setation is better marked in the other two species, (v) ventral carinae on segments II–III have strongly lobate granules in the new species, (vi) in the new species, lateral lobes on metasomal segment V have one smaller lobe in between the two lobes, and (vii) in the new species metasomal segment I is longer than wide whereas in both *B. tunetanus* and *B. paris* it is wider than long [28].

Description based on female holotype and paratypes. Measurements after the description.

Coloration basically yellow to pale yellow without spots; only some carinae are slightly reddish in adults; juveniles with some dark spots over carinae and on metasomal segment V. Prosoma: carapace yellow with reddish carinae; eyes marked by dark pigment. Mesosoma yellow without spots; the median carina reddish. Metasomal segments yellow with some reddish spots over carinae; vesicle pale yellow; aculeus reddish-yellow at its base and dark red at its extremity. Venter yellow; pectines and genital operculum pale yellow. Chelicerae pale yellow with some vestigial variegated spots at the base of fingers; fingers yellow with reddish teeth. Pedipalps yellow with carinae and oblique rows of granules in fingers slightly red. Legs pale yellow.

Morphology. Carapace moderately to weakly granular; anterior margin with a weak concavity. Carinae moderately to strongly marked; anterior median strongly granular, central median and posterior median carinae moderately granular, with 'lyre' configuration. All furrows moderate. Median ocular tubercle slightly anterior to the center of carapace. Eyes separated by more than two ocular diameters. Four pairs of lateral eyes; the first three of moderate size in relation to median eyes; the fourth pair reduced in size. Sternum triangular, not narrowed; slightly wider than long. Mesosoma: tergites moderately granular. Three longitudinal carinae moderately to weakly crenulate in all tergites; lateral carinae strongly reduced in tergites I and II. Tergite VII pentacarinate. Venter: genital operculum divided longitudinally, which plate with a semi-oval to semi-triangular shape. Pectines: pectinal tooth count 29-28 in female holotype (paratypes with 27-27-female and 31-31-male); middle basal lamella of the pectines not dilated. Sternites without granules, smooth with elongated spiracles; four carinae on sternite VII; other sternites acarinated and with two vestigial furrows. Metasomal segments with a weak setation; segments I to III with ten crenulated carinae; ventral strongly marked on II–III, with conspicuous lobate granules; segment IV with eight carinae, crenulated; all segments with a smooth dorsal depression; segment V with five carinae; the latero-ventral carinae crenulate with 5–6 lobate denticles posteriorly; ventral median carina divided posteriorly over 1/2 of the segment length; anal arc composed of 6–7 ventral teeth, and two strong lateral lobes with a third smaller lobe in between the other two. Intercarinal spaces weakly granular. Telson with a few minute granulations ventrally, almost smooth; aculeus curved and shorter than the vesicle, without a subaculear tubercle. Cheliceral dentition as defined by Vachon [29] for the family Buthidae; external distal and internal distal teeth approximately the same length; basal teeth on movable finger small but not fused; ventral aspect of both fingers and manus covered with long dense setae. Pedipalps with a moderate setation; femur pentacarinate; patella with eight carinae, strongly marked; all faces weakly granular to smooth; chela smooth, with vestigial carinae. Fixed and movable fingers with 11-11 oblique rows of granules. Internal and external accessory granules present, moderately strong; three accessory granules on the distal end of the movable finger next to the terminal denticle. Legs: tarsus with two longitudinal rows of long setae ventrally; tibial spurs very strong on legs III and IV; pedal spurs strong on legs I to IV. Trichobothriotaxy: trichobothrial pattern of type A, orthobothriotaxic as defined by Vachon [16]. Dorsal trichobothria of femur arranged in **β** (beta) configuration [30]; trichobotrium $\mathbf{d_2}$ of femur extremely reduced, and **db** on fixed finger displaced to the internal face.

Morphometric values of the female holotype of *B. saharicus* sp. n. Total length including the telson 67.3. Carapace: length 7.6, anterior width 5.7, posterior width 9.0. Metasomal segments: I length, 5.2, width 4.9; II length 5.8, width 4.6; III length 6.0, width 4.5; IV length 6.7, width 4.3; V length 8.5, width 4.1, depth 3.2. Telson length 7.2, vesicle: width 4.0, depth 3.5. Pedipalp: femur length 6.6, width 2.1; patella length 7.3, width 2.8; chela length 12.6, width 3.3, depth 3.5; movable finger length 8.0.

Disclosure of interest

The authors declare that they have no competing interest.

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References

[1] W.R. Lourenço, A new species of *Buthus* Leach, 1815 from Algeria (Scorpiones, Buthidae), Entomol. Mitt. Zool. Mus. Hamburg 16 (2013) 63–68.
[2] W.R. Lourenço, Deux nouvelles espèces de scorpions de la famille des Buthidae C.L. Koch, 1837 collectées dans le parc national de Zakouma au Tchad, Rev. Iberica Aracnol. 26 (2015) 19–24.
[3] W.R. Lourenço, Considérations sur les modèles de distribution et différentiation du genre *Buthus* Leach, 1815, avec la description d'une nouvelle espèce des montagnes du Tassili des Ajjer, Algérie (Scorpiones, Buthidae), Biogeographica 78 (2002) 109–127.
[4] W.R. Lourenço, Compléments à la faune de scorpions (Arachnida) de l'Afrique du Nord, avec des considérations sur le genre *Buthus* Leach, 1815, Rev. Suisse Zool. 110 (2003) 875–912.
[5] W.R. Lourenço, J.L. Cloudsley-Thompson, A new species of *Buthus* Leach, 1815 from Egypt (Scorpiones, Buthidae), Entomol. Mitt. Zool. Mus. Hamburg 16 (2012) 11–18.
[6] W.R. Lourenço, E.-A. Leguin, A new species of the genus *Buthus* (Scorpiones: Buthidae) from northern Cameroon, Euscorpius 152 (2012) 1–9.
[7] W.R. Lourenço, B. Duhem, J.L. Cloudsley-Thompson, Scorpions from Ennedi, Kapka and Tibesti, the mountains of Chad, with descriptions of nine new species (Scorpiones: Buthidae, Scorpionidae), Arthropoda Sel. 21 (2012) 307–338.
[8] W.R. Lourenço, M. Vachon, Considérations sur le genre *Buthus* Leach, 1815 en Espagne, et description de deux nouvelles espèces (Scorpiones, Buthidae), Rev, Iber. Aracnol. 9 (2004) 81–94.
[9] E.A. Yağmur, H. Koç, W.R. Lourenço, A new species of *Buthus* Leach, 1815 from Cyprus (Scorpiones, Buthidae), ZooKeys 115 (2011) 27–38.
[10] A. Rossi, Notes on the distribution of the species of the genus *Buthus* (Leach, 1815) (Scorpiones, Buthidae) in Europe, with a description of a new species from Spain, Bull. Br. Arachnol. Soc. 15 (2012) 273–279.
[11] W.R. Lourenço, A. Rossi, Confirmation of a new species of *Buthus* Leach, 1815 from Sicily (Scorpiones, Buthidae). Biogeographical implications, Rev. Iberica Aracnol. 22 (2013) 9–14.
[12] W.R. Lourenço, J.X. Qi, A new species of *Buthus* Leach, 1815 from Marocco (Scorpiones, Buthidae), Entomol. Mitt. Zool. Mus. Hamburg 14 (2006) 287–292.
[13] W.R. Lourenço, D. Sun, M.-S. Zhu, About the presence of the genus *Buthus* Leach, 1815 in Mauritania, with the description of a new species (Scorpiones, Buthidae), Bol, Soc. Entomol. Aragonesa 44 (2009) 53–58.
[14] W.R. Lourenço, O. Touloun, A. Boumezzough, Un nouveau *Buthus* Leach, 1815 (Scorpiones, Buthidae) pour le Nord du Maroc; possible lien entre les populations marocaines et européennes, Rev. Iberica Aracnol. 21 (2012) 21–25.
[15] H.L. Stahnke, Scorpion nomenclature and mensuration, Entomol. News 81 (1970) 297–316.
[16] M. Vachon, Étude des caractères utilisés pour classer les familles et les genres de Scorpions (Arachnides). 1. La trichobothriotaxie en arachnologie. Sigles trichobothriaux et types de trichobothriotaxie chez les Scorpions, Bull. Mus. natl. Hist. nat. 140 (1974) 857–958.
[17] M. Vachon, Études sur les scorpions, Publications de l'Institut Pasteur d'Algérie, Alger, 1952 [482 p].
[18] J.T. Hjelle, Anatomy and morphology, in: G.A. Polis (Ed.), The Biology of Scorpions, Stanford University Press, 1990, pp. 9–63.
[19] D. Benkenzou, S. Chegma, F. Merakchi, B. Zidane, Monographie de la wilaya de Ghardaïa, Direction de la Planification et de l'Aménagement du Territoire (D.P.A.T.), Statistiques au 31 décembre 2006, Ghardaïa, Algérie, 2007 [122 p].
[20] F. Sam, Réhabilitation thermique d'un local dans une zone aride: cas de Ghardaïa. Mémoire de Magister en Génie-mécanique, Université Mouloud-Mammeri de Tizi-Ouzou, Algeria, 2012 [111 p].
[21] A. Chehma, Le Sahara en Algérie, situation et défis. Séminaire « L'effet du changement climatique sur l'élevage et la gestion durable des parcours dans les zones arides et semi-arides du Maghreb », Université Kasdi Merbah, Ouargla, Algérie, 2011 [8 p].
[22] R. Furon, Les grandes lignes de la paléogéographie de la Berbérie et du Sahara; leur sens biogéographique, C. R. Somm. Seances Soc. Biogeogr. 241 (1951) 46–48.
[23] J.L. Cloudsley-Thompson, Recent expansion of the Sahara, Int. J. Environ. Stud. 2 (1971) 35–39.
[24] J.L. Cloudsley-Thompson, The expanding Sahara, Environ. Conserv. 1 (1974) 5–13.
[25] J.L. Cloudsley-Thompson (Ed.), Key Environments: Sahara Desert, Pergamon Press, Oxford, UK, 1984 [348 p].
[26] M. Schuster, P. Duringer, J.-F. Ghienne, P. Vignaud, H.T. Mackaye, A. Likius, M. Brunet, The age of the Sahara Desert, Science 311 (2006) 821.
[27] B. Gantenbein, C.R. Largiadèr, The phylogeographic importance of the Strait of Gibraltar as a gene flow barrier in terrestrial arthropods: a case study with the scorpion *Buthus occitanus* as model organism, Mol. Phylogenet. Evol. 28 (2003) 119–130.
[28] A. Rossi, G. Tropea, E. Yağmur, A new species of *Buthus* Leach, 1815 from Libya (Scorpiones: Buthidae), Euscorpius 167 (2013) 1–10.
[29] M. Vachon, De l'utilité, en systématique, d'une nomenclature des dents des chélicères chez les Scorpions, Bull. Mus. natl Hist. nat. 35 (1963) 161–166.
[30] M. Vachon, Sur l'utilisation de la trichobothriotaxie du bras des pédipalpes des Scorpions (Arachnides) dans le classement des genres de la famille des Buthidae Simon, C. R. Acad. Sci., Paris, Ser. D 281 (1975) 1597–1599.