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The remarkable micro-scorpion genus *Microbuthus* Kraepelin, 1898 in North Africa; description of a new species with comments on its biogeography and ecology (Scorpiones: Buthidae)

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Abstract

A new species, *Microbuthus saharicus* sp. n., is described from the inland deserts of Mauritania; it represents the first exception to the general coastal distribution observed in the species of this genus. With this new description, the total number of known species in Africa is increased to five. The disrupted peri-Saharan pattern of distribution presented by the group is however confirmed. Some comments are also added on the biogeography and ecology of the species.

Keywords: Scorpion, *Microbuthus*, Buthidae, new species, Mauritania.

Introduction

As previously summarized in earlier publications (Vachon, 1952; Lourenço, 2002, 2011; Lourenço & Duhem, 2007) the genus *Microbuthus* was originally described by Kraepelin (1898), with the type species being *Microbuthus pusillus* Kraepelin, 1898 which was collected from the region of Tadjura Bay (= Tadscharabay) in the Gulf of Aden (= Yemen). Subsequently, a second species *Butheolus litoralis* Pavesi, 1885 from Assab, on the Red Sea coast of Eritrea was transferred to the genus *Microbuthus* by Birula (1905). The genus *Microbuthus* was represented exclusively by these two species until the description of *Microbuthus fagei* by Vachon (1949) based on specimens collected at Nouakchott in the coastal region of the Atlantic Ocean in the South of Mauritania. More recently, Lourenço (2002) studied a larger sample of specimens from both Mauritania and Morocco and proposed the description of a subspecies for *Microbuthus fagei* for the region of Tan-Tan in South Morocco as *Microbuthus fagei maroccanus* Lourenço, 2002. Subsequently, *Microbuthus maroccanus* was raised to the rank of species (Lourenço & Duhem, 2007).

The unexpected discovery of a quite particular specimen of *Microbuthus* in Egypt led to the description of a new species, *Microbuthus flavorufus* Lourenço & Duhem, 2007 (Fig. 1). This marked the first record of the genus *Microbuthus* for the country. In the subsequent years, there were no new contributions to the African *Microbuthus*. However, studies conducted in the Middle East, resulted in the description of new species, namely *Microbuthus gardneri* Lowe, 2010, *Microbuthus kristensenorum* Lowe, 2010 and *Microbuthus satyrus* Lowe, Kovařík, Stockmann & Stahlavsky, 2018 from Oman and Yemen (Lowe, 2010; Lowe *et al.*, 2018). Some difficulties for the study of the species of the genus arise from the fact that most species are rare, and some original types have been mislaid. This was the case for the type of *Butheolus litoralis* (= *Microbuthus litoralis*) which could not be found in any Italian Museum, what led to the proposition of a neotype for this species (Lourenço, 2011). In this same occasion the synonym of *Microbuthus pusillus* Kraepelin, 1898 with *Microbuthus litoralis* (Pavesi, 1885) was confirmed (Lourenço, 2011). While the type material of *Microbuthus fagei*, consisting of two specimens, remains misplaced in the collections of the Muséum in Paris, the characterisation of topotypes of this species allows for its accurate definition.

Among the wide array of known genera of Buthidae scorpions, *Microbuthus* remains enigmatic. The reasons for this are associated not only with the several unique morphological features of the different species, but are also due to the scarcity of available material for study. At present, a new species is described from the inland deserts of Mauritania, escaping therefore to the previous observed pattern of distribution along coastal zones. This discovery marks the fifth species documented in Africa. The disrupted peri-Saharan pattern of distribution observed among the species of the genus appears to be reaffirmed once more.

Fig. 1. Female holotype of *Microbuthus flavorufus* alive in the natural habitat in Egypt.

Material and Methods

Illustrations and measurements were produced using a Wild M5 stereo-microscope with a drawing tube and an ocular micrometre. Measurements follow Stahnke (1970) and are given in mm. Trichobothrial notations follow Vachon (1974), morphological terminology mostly follows Vachon (1952) and Hjelle (1990), and chelicerae dentition follows Vachon (1963). The type material described in this paper will be deposited in the collections of the 'Museu Nacional', Rio de Janeiro, Brazil.

The recognized species of *Microbuthus* Kraepelin, 1898 (African species in bold)

M. litoralis (Pavesi, 1885)
M. fagei Vachon, 1949
M. maroccanus Lourenço, 2002
M. flavorufus Lourenço & Duhem, 2007
M. gardneri Lowe, 2010
M. kristensenorum Lowe, 2010
M. satyrus Lowe, Kovařík, Stockmann & Stahlavsky, 2018
M. saharicus sp. nov.

Taxonomic treatment

Family **Buthidae** C.L. Koch, 1837
Genus ***Microbuthus*** Kraepelin, 1898
Microbuthus saharicus sp. n. (Figs. 2-10)

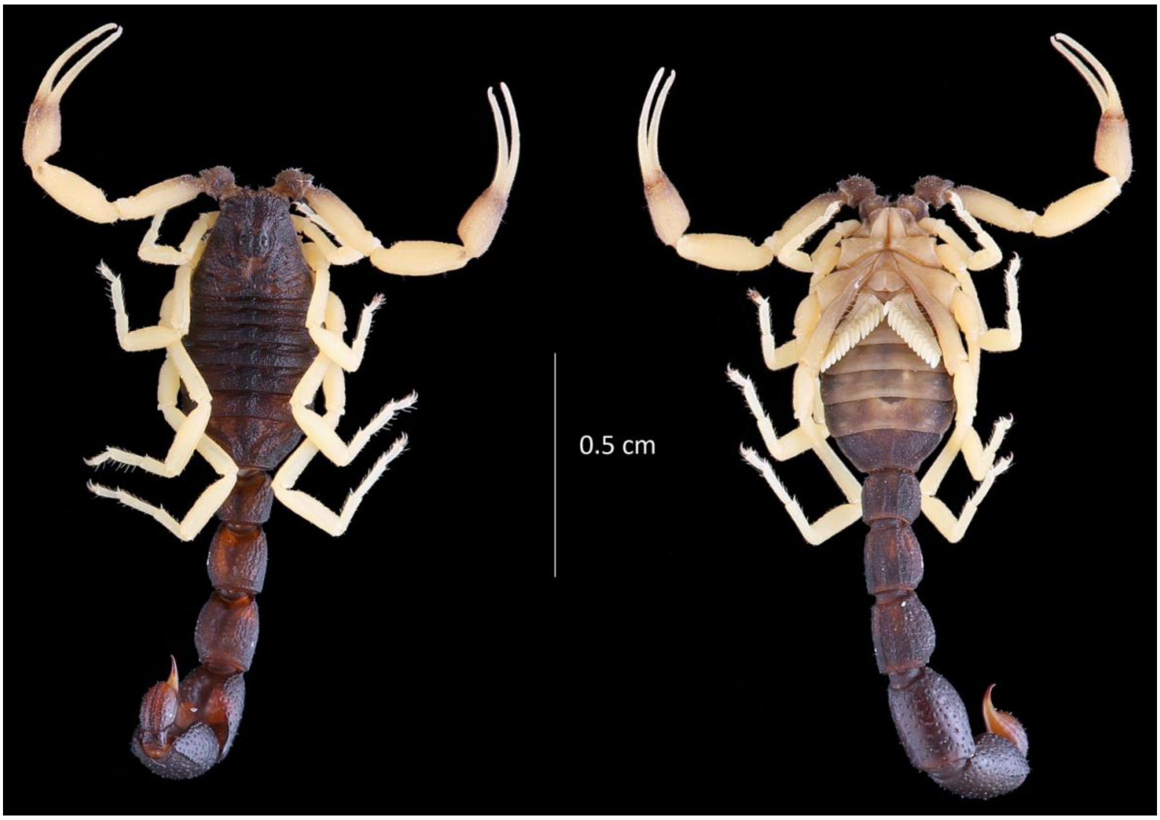
Type material: Male holotype, Mauritania, Bivouac de Tinterkat (near to Wadane), 20°56'39.45" N, 11°33'36.69" W; 4/XI/2001 (P. Lluch). The holotype will be deposited in the Museu Nacional, Rio de Janeiro, RJ, Brazil, as a contribution to the reposition of the collections destroyed by fire in 2018.

Etymology: Specific name refers to the Sahara Desert where the new species was found.

Diagnosis. A rather small species of scorpion; the total length reaches only 17.80 mm. Colouration dark as in some other species of the genus; the body is globally dark while the appendages are almost entirely yellow. Pectinal tooth count 12-13. Metasomal segment I wider than long; segments II to V longer than wide. Tibial spurs on leg III reduced; well developed on leg IV. Trichobothrial pattern: minorante neobothriotaxy; chela (hand + fixed finger) with the absence of trichobothria **est**, **Esb**, $\mathbf{Eb_3}$; patella with trichobothria $\mathbf{d_1}$ absent and $\mathbf{d_3}$ in a proximal position; seven external trichobothria, but with trichobothrium **em** strongly reduced; femur with the absence of trichobothria $\mathbf{d_2}$, and a reduced $\mathbf{d_5}$. Tibial spurs moderate on leg III and well developed on leg IV.

Relationships: By its general morphology the new species shows some affinities to both *Microbuthus maroccanus* from Morocco and *Microbuthus fagei* from Mauritania. However, the new species can be readily distinguished by its overall darker pigmentation on the tergites and sternites and a distinct number of trichobothria equally disposed in distinct positions.

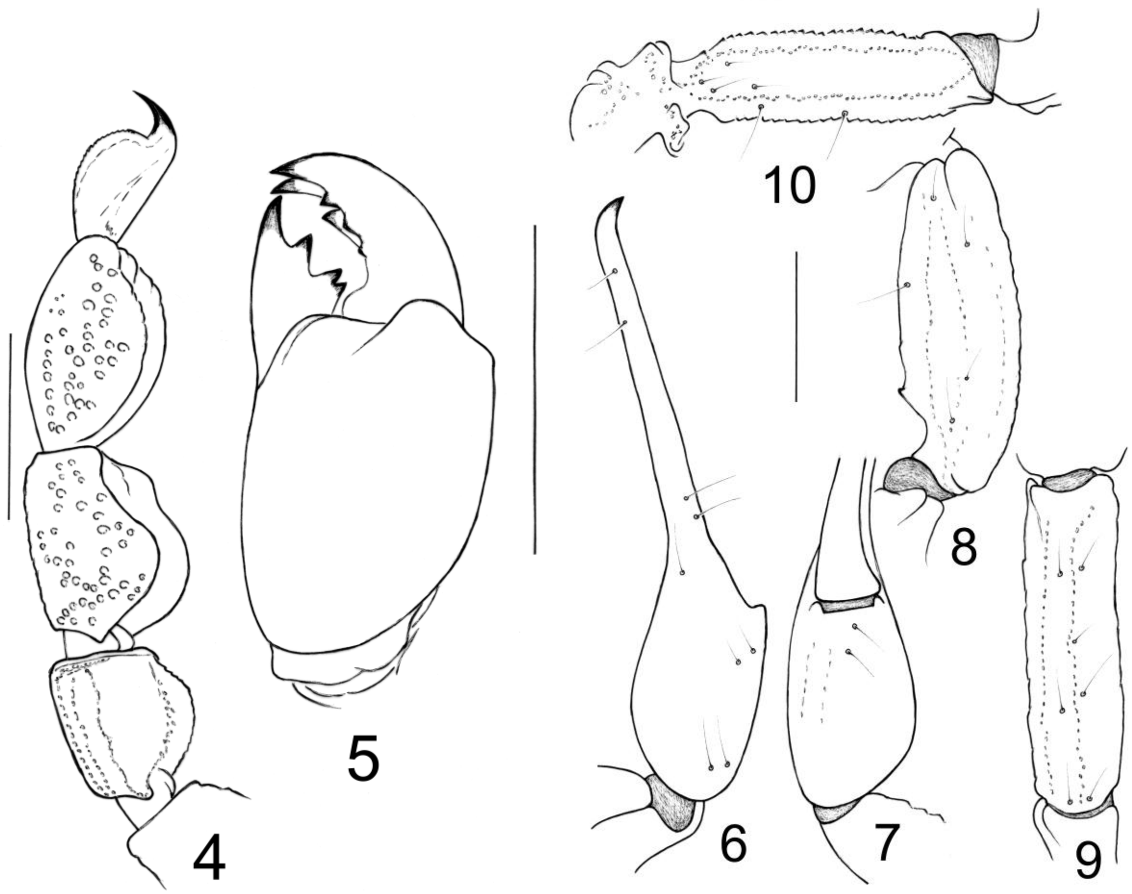
Description based on male holotype (measurements following the description).



Figs. 2-3. *Microbuthus saharicus* sp. n. Male holotype. Habitus, dorsal and ventral aspects.

Colouration (Figs. 2-3). Body dark brown with appendages yellow to pale yellow; only coxa and trochanter of pedipalps are dark. Prosoma: carapace dark brown; eyes intensely marked with a black pigmentation. Mesosomal tergites dark brown; tergite VII slightly paler with some yellowish zones. Metasomal segments I to V brown to dark brown with some yellowish zones; segments IV and V darker than I to III. Vesicle reddish-yellow; aculeus yellowish at the base and reddish at the tip. Venter, coxapophysis, sternum, genital operculum and pectines yellowish; pectines paler than the other structures; sternites yellowish with marked brownish zones; sternite VII darker than the others. Chelicerae yellow with some dark reticulated spots at the base of fingers; fingers yellowish with reddish teeth. Pedipalps pale yellow with coxa and trochanter dark brown, including proximal zone of femur; granulations on cutting edge of fingers slightly reddish. Legs pale yellow without any spots.

Morphology. Carapace strongly narrowed anteriorly, almost triangular; anterior margin with a vestigial median concavity; almost straight. Carinae weakly marked; granulations moderately to strongly marked by pearl-like granules. Furrows weak. Median ocular tubercle only slightly anterior to the centre of the carapace; median eyes separated by one and half ocular diameters. Three pairs of lateral eyes; the third pair reduced. Sternum triangular, longer than wide. Mesosomal tergites moderately to strongly granular. Median carina moderate and present in all tergites; the two lateral carinae vestigial. Tergite VII pentacarinate, moderately crenulate. Venter: genital operculum of moderate to large size divided longitudinally and wider than the sternum. Pectines: pectinal tooth count 12-13; basal middle lamellae of the pectines not dilated; fulcra moderate. Sternites III-VI with thin granulations; granules on VII stronger with four vestigial carinae; two lateral furrows present on sternites III-VI. Short slit-like spiracles. Metasoma: segments rounded with ten



Figs. 4-10. *Microbuthus saharicus* sp. n. Male holotype. 4. Metasomal segments III-V and telson, lateral aspect. 5. Chelicera, dorsal aspect. 6-10. Trichobothrial pattern. 6-7. Chela dorso-external and ventral aspects. 8-9. Patella, dorsal and external aspects. 10. Femur, dorsal aspect. (Scale bars: 4: 2 mm, 5: 0.5 mm, 6-10: 1 mm).

carinae moderately marked on segments I to III; carinae on segment III partially fused with the granulations; segments IV and V with only vestigial dorsal carinae and with numerous punctuations. Intercarinal spaces moderately granular. Telson slightly punctuated, with two small lateral furrows and one ventral carina with a serrula shape; aculeus very short and strongly curved; subaculear tooth absent. Cheliceral dentition characteristic of the family Buthidae (Fig. 5): the basal teeth in the movable finger are almost fused (Vachon, 1963). Pedipalps: femur pentacarinate; patella with seven weak carinae and the internal face without any spinoid granule; chela with vestigial carinae; all faces with thin but intense granulation. Fixed and movable fingers with one linear row of granules divided by some stronger accessory granules; extremity of the fingers with one strong accessory granule giving the shape of forceps to the fingers. Trichobothriotaxy (Figs. 6-10): minorante neobothriotaxy; A-β (beta) for the disposition of the dorsal trichobothria of the femur (Vachon, 1974, 1975); chela (hand + fixed finger) with the absence of trichobothria **est**, **Esb**, **Eb$_3$**; patella with trichobothria **d$_1$** absent and **d$_3$** in a proximal position; seven external trichobothria, but with trichobothrium **em** strongly reduced; femur with the absence of trichobothria **d$_2$**, and a reduced **d$_5$**. Legs: tarsus with a few median fine setae ventrally; pedal spurs moderate on legs III and IV; tibial spurs moderate on leg III and well developed on leg IV.

Morphometric values (in mm) of the new species. Total length, 17.80*. Carapace: length, 2.41; anterior width, 1.54; posterior width, 2.87. Mesosoma length, 3.94. Metasomal segments (Fig. 4). I: length, 1.34; width, 1.47; II: length, 1.62; width, 1.34; III: length, 1.74; width, 1.62; IV: length, 2.21; width, 1.74; V: length, 2.47; width, 1.87; depth, 1.54. Telson length 2.07; vesicle: width, 0.87; depth, 0.84. Pedipalp: femur length, 2.21, width, 0.67; patella length, 2.27, width, 0.87; chela length, 4.21, width, 0.87, depth, 0.81; movable finger length, 2.54 (* including telson).

Biogeography of the genus *Microbuthus*

The description of the new species, although collected in more inland deserts of Mauritania, suggests a potential disrupted peri-Saharan distribution pattern for African *Microbuthus* species (Fig. 11). This pattern was initially proposed by Vachon (1952) and subsequently re-affirmed by Lourenço (2002, 2011) and Lourenço & Duhem (2007). However, it was rejected by Lowe (2010) and Lowe *et al.* (2018) who stated as follows: *'The apparent widely disjunct distribution of Microbuthus in eastern and western coastal locations of North Africa was proposed to reflect a fragmentation or regression of ancient mesic faunas that were unable to adapt to xeric conditions that accompanied advent of the Sahara Desert'.* In addition, they also stated *'The fact that the few available museum specimens of Microbuthus were collected near coastal areas may reflect a bias in the sampling of small cryptic faunas for more densely populated and easily traveled coastal routes.'*

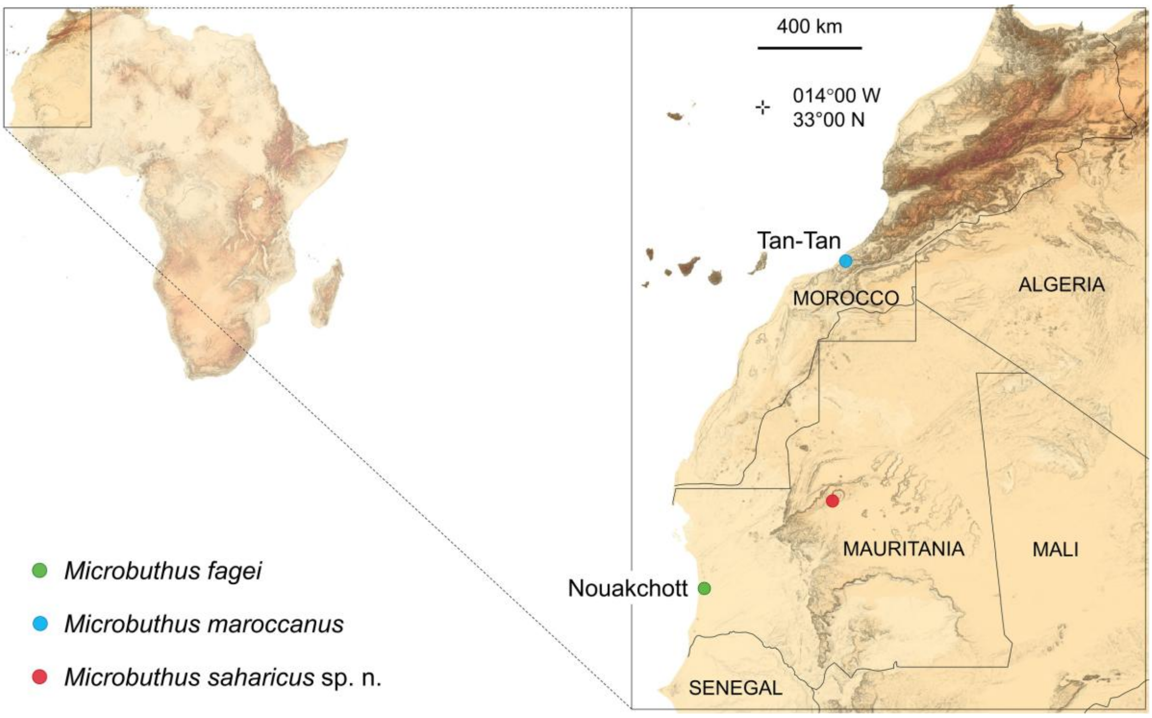


Fig. 11. Map of Occidental North Africa with the type localities of *Microbuthus* species known from this area.

These statements involve some degree of speculation. In fact, intense collecting predominantly occurred in what was formerly the 'Afrique Occidentale Française' field trips have been conducted not only over coastal areas, but very often in the inland regions (see Lourenço, 2019). Besides, *Microbuthus* is not the only genus presenting a particular pattern of distribution. Another example is the distribution pattern of the genus

Butheoloides Hirst, 1925. This genus is globally absent from the Central compartment of the Sahara Desert with all its species distributed in more mesic environments surrounding the Desert areas (see Lourenço, 2013). Consequently, the earlier hypothesis (Lourenço, 2002; Lourenço & Duhem, 2007) may still hold until new evidence emerges from the central portion of North Africa. I summarize here again some aspects of what was suggested before.

Furon (1951) suggested that the flora and fauna now present in the Sahara region may have ancient origins. Their present pattern is not solely the consequence of palaeogeographic factors, but is also significantly shaped by various palaeoclimatic events. These palaeoclimatic events had an important impact during the Quaternary period when Europe (and North America) underwent glaciation cycles. Meanwhile, Africa experienced periods of heightened rainfall and a notable increase in ice accumulation on its mountains, particularly in Eastern Africa. The most recent wet period in the Sahara occurred very recent, only some 5,000 years BP.

Qi & Lourenço (2007) emphasized that the current composition of the Saharan fauna likely represents the legacy of ancient faunas that have been present in North Africa since the early Cenozoic, or at least since mid-Cenozoic times (Vachon, 1952). North Africa has experienced numerous other palaeoclimatological vicissitudes in the last few million years, some of which occurred in more recent Quaternary times. The Sahara has undergone a long series of wet periods, the most recent occurring 10.000-5000 years BP. It was not until approximately 3000 years BP that the Sahara assumed its present arid state (Cloudsley-Thompson, 1971, 1974, 1984). Recent studies suggest that the Sahara Desert may be much older than was previously thought (Schuster *et al.*, 2006). It seems reasonable, therefore, to postulate that extremely arid areas may have existed as patchy desert enclaves for a very long time, even when the overall climate in North Africa enjoyed more mesic conditions. Within these desert regions, a specialized scorpion fauna would have evolved. In contrast, other lineages less well adapted to drought, and previously present only in mesic environments, have regressed markedly in their distribution. They have therefore experienced negative selection and are on the road to extinction. In other cases, populations have been reduced to very limited and patchy zones sometimes with remarkable disjunctions in their distribution patterns.

Among the patterns observed today in the distribution of North African scorpions (Qi & Lourenço, 2007) one of the most intriguing is the disjunction presented by the distribution of the genus *Microbuthus*, with two species known in Mauritania and Morocco in the West and two others respectively in Egypt, Eritrea and Djibouti in the East (and three more species in the Middle East). Vachon (1951a, 1952) had already drawn attention to this extremely localized pattern of distribution of the species of *Microbuthus* and defined it as a ‘disrupted and limited territory’. Vachon also attempted to explain the observed pattern and made reference to Braestrup (1947) who had suggested a mechanism for exchanges through the Sahara Desert. According to this mechanism, Southern elements (Ethiopian) were able to reach the Northern regions, and Northern elements (Palaearctic) were able to disperse to the Southern regions of the Sahara. However, this hypothesis primarily applies to dynamic elements with a strong dispersal capacity. Scorpion populations, in contrast, are often stable and less adaptable to new environments. The present distribution patterns of several scorpion groups, particularly the one presented by the genus *Microbuthus*, likely reflect a broader range of distribution in the past. The distinct palaeoclimatic vicissitudes experienced by the Sahara have constituted an important selective factor over its scorpion populations. The reaction of these to abiotic factors was certainly varied depending on their own ecological strategies (Polis, 1990; Lourenço, 1991). In some cases, the populations showed a significant regression in their distribution, and some populations may well have totally vanished. These regressions led to marked disruptions in geographic distributions and resulted in their present patchy distribution. This hypothesis offers a potential explanation for the disrupted distribution pattern of *Microbuthus* species.

Ecological and biological comments

According to Vachon (1951b), *Microbuthus* species could be classified as halophiles, since up to that date these were exclusively found in coastal zones, stretching from the Red Sea to the Atlantic Ocean. This ecological particularity was further confirmed for other species such as *M. maroccanus* (see Lourenço, 2002 for details). Lowe (2010) however, rejected this ecological trait and argues that for the species found in the Middle East this characteristic was unreliable. The new species described here, seems to confirm in part this assumption (Fig. 12). It was collected far from coastal zones and on an arid environment. Further discoveries should bring a more precise ecological pattern.

Fig. 12. Typical desert formation in Central Mauritania, near to the type locality of *Microbuthus saharicus* sp. n.

The fluorescence observed in *Microbuthus* species appears to be variable. In fact, for some living specimens of *M. litoralis* it proved to be rather weak. Fluorescence was previously considered as a global trait in scorpions, but more and more exceptions are presently found (see Lourenço, 2012).

The reproductive biology of most micro-scorpions remains relatively unexplored, but preliminary observations have revealed certain peculiarities. For instance, limited observations on *M. fagei* demonstrated that broods are composed of very small numbers, ranging from 3 to 4 (Lourenço, 2002, 2007). In contrast, pro-juveniles at birth are very large at birth. Female body length averages 8.4 mm, while pro-juveniles body length averages 4.2 mm. No precise data, however, are available on the embryonic and postembryonic development of the species. Nevertheless, using indirect methods and the morphometric values of juveniles collected in nature, it can be estimated that four moults are required to reach adulthood.

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***Microbuthus saharicus* Lourenço, 2023**
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