

Ecology / Écologie

A reappraisal of the geographical distribution of the genus *Pseudouroplectes* Lourenço (Scorpiones: Buthidae) in Madagascar

Wilson R. Lourenço^{a,*}, Steven M. Goodman^{b,c}

^a Département de systématique et évolution, USM 0602, section « Arthropodes » (Arachnologie), Muséum national d'histoire naturelle, CP 053, 61, rue Buffon, 75005 Paris, France

^b Field Museum of Natural History, 1400 South Lake Shore Drive, Chicago, IL 60605, USA

^c WWF, BP 738, Antananarivo (101), Madagascar

Received 18 July 2005; accepted after revision 6 October 2005

Available online 27 December 2005

Presented by Paul Ozenda

Abstract

We review aspects of the distributional patterns of Malagasy scorpions belonging to the endemic genus *Pseudouroplectes* (family Buthidae), restricted to dry forests formations in the south and southwest. One species is described here as new to science. We propose that the observed distributional pattern of members of this genus is not only a consequence of recent ecological features of the landscape, but also of historical biogeographical factors associated with the antiquity of this scorpion lineage. **To cite this article:** *W.R. Lourenço, S.M. Goodman, C. R. Biologies 329 (2006).*

© 2005 Académie des sciences. Published by Elsevier SAS. All rights reserved.

Résumé

Réexamen de la distribution géographique du genre *Pseudouroplectes* Lourenço (Scorpiones : Buthidae) à Madagascar. Des considérations sont proposées sur le modèle de distribution géographique présenté par le genre *Pseudouroplectes* à Madagascar (famille Buthidae). Ce genre semble être réparti exclusivement sur des formations de forêt sèche dans la région sud, sud-ouest de l'île. La description d'une espèce nouvelle vient conforter le modèle observé. Il est suggéré que ce type de répartition n'est pas seulement la conséquence des facteurs écologiques récents, mais aussi celle de facteurs biogéographiques historiques associés à l'ancienneté de ce groupe de scorpions. **Pour citer cet article :** *W.R. Lourenço, S.M. Goodman, C. R. Biologies 329 (2006).*

© 2005 Académie des sciences. Published by Elsevier SAS. All rights reserved.

Keywords: Scorpion; *Pseudouroplectes*; Madagascar; Distribution pattern

Mots-clés : Scorpion ; *Pseudouroplectes* ; Madagascar ; Modèle de distribution

Version française abrégée

1. Version abrégée

Comme on l'a déjà discuté dans des publications précédentes [1–3], les scorpions humicoles sont globalement rares. À Madagascar, les scorpions du sol les

* Corresponding author.

E-mail addresses: arachne@mnhn.fr (W.R. Lourenço), sgoodman@fieldmuseum.org (S.M. Goodman).

mieux étudiés sont représentés par les membres de la famille endémique des Microcharmidae [4–6]. *Microcharmus* Lourenço, 1995 a été le premier genre décrit pour cette famille [4], suivi de la description de deux autres genres : *Neoprotobuthus* Lourenço, 2000 [7] et *Ankaranocharmus* Lourenço, 2004 [2]. *Pseudouroplectes* Lourenço, 1995 [4], un genre de scorpion Buthidae du sol, a été décrit à partir de deux femelles collectées dans des formations de végétation arides du Sud-Ouest de Madagascar, à Andramanoetse Be, plateau Mahafaly, province de Toliara. Quelques années après, un autre spécimen de *Pseudouroplectes*, *P. pidgeoni* Lourenço et Goodman, 1999, a été collecté dans les forêts sèches du parc national d'Andohahela (parcelle 2), province de Toliara [8]. Le spécimen a été collecté dans un échantillon de sol d'une formation arbustive épineuse du parc, très voisine de la zone de transition entre les formations forestières sèche et humide. Jusqu'à la présente étude, à notre connaissance, aucun autre spécimen appartenant au genre *Pseudouroplectes* n'a été collecté. Entre temps, seule une étude ultra-structurale comparative avec le genre *Microcharmus* a été développée, confirmant ainsi la place du genre *Pseudouroplectes* au sein de la famille des Buthidae [2].

Le Dr. Brian Fisher et ses collègues de l'Académie des sciences de Californie ont mené, au cours des dernières années, des inventaires systématiques sur les invertébrés de diverses régions de Madagascar, y compris celles des formations végétales arides. Pour cela, ils ont employé des pièges, ainsi que diverses méthodes d'extraction du sol. De tels inventaires ont conduit à la collecte de plusieurs exemplaires de *Pseudouroplectes*, tous dans des zones à végétation sèche, confirmant ainsi un modèle de répartition limité à ce type de formation. De plus, plusieurs spécimens, collectés dans le Sud-Ouest de l'île, appartiennent à une nouvelle espèce décrite à présent.

Le modèle de distribution présenté par le genre Pseudouroplectes

La répartition du genre *Pseudouroplectes*, initialement fondée sur les deux premières espèces décrites, se limitait aux forêts sèches de l'Extrême-Sud de l'île. À présent, ce modèle de distribution est conforté par des nouvelles collectes de ces deux espèces. La description d'une nouvelle espèce de *Pseudouroplectes* élargit la répartition connue du genre vers le nord, dans les terres basses du Sud-Ouest de Madagascar. *P. betschi* et *P. pidgeoni* présentent, de toute évidence, une zone de parapatricie, voire même de sympatricie, dans le Sud de l'île. La distribution du genre *Pseudouroplectes* exclusi-

vement dans des formations végétales sèches ou arides composées d'arbustes épineux pourrait être imputée à des échantillonnages insuffisants dans d'autres parties de l'île. Cette hypothèse semble pouvoir être écartée a priori car, si les *Pseudouroplectes* sont des scorpions rares, des échantillonnages systématiques avec utilisation de techniques similaires ont été employés dans différentes régions de l'île, avec des résultats positifs uniquement pour le Sud et le Sud-Ouest. La découverte des *Pseudouroplectes* dans le Sud et Sud-Ouest de Madagascar exclusivement semble, au contraire, plaider en faveur de facteurs biogéographiques historiques bien plus anciens, qui sont confortés par les affinités des *Pseudouroplectes* avec des éléments africains relictuels, mais aussi par la très grande ancienneté de cette lignée de scorpions.

1. Introduction

As already discussed in previous papers [1–3], soil scorpions are universally rare. In Madagascar, the best-studied soil scorpions are represented by members of the endemic family Microcharmidae [4–6]. *Microcharmus* Lourenço was the first genus to be described in this family [4], followed by the description of two other genera: *Neoprotobuthus* Lourenço [7] and *Ankaranocharmus* Lourenço [2]. *Pseudouroplectes* Lourenço [4], a buthid genus of soil scorpions, was described based on two females collected in dry southwestern vegetation formations at Andramanoetse Be, Plateau Mahafaly, Toliara Province. A few years later, another *Pseudouroplectes* specimen, *P. pidgeoni*, was collected in the extreme southeastern dry forests of the 'Parc national d'Andohahela' (parcel 2), Toliara Province [8]. This animal was collected in a soil litter sample in a spiny bush parcel of the reserve, within a few kilometres of the ecotone between dry and wet forest formations. Until the specimens reviewed in the current paper were collected, no additional material to our knowledge was obtained of the genus *Pseudouroplectes*. In the interim period, a comparative ultra-structural study was carried out with the genus *Microcharmus* and confirms the position of the genus *Pseudouroplectes* as an element of the family Buthidae [2].

Dr. Brian Fisher and colleagues at The California Academy of Sciences have been conducting systematic invertebrate inventories at various sites across Madagascar, including the dry vegetational formations, over the past few years and employ pit fall traps and different methods of soil litter extraction. These inventories lead to the collection of several specimens of *Pseudouroplectes*, all from dry vegetation sites, further supporting

the pattern that this genus is restricted to that formation. Moreover, several specimens of *Pseudouroplectes* from these new collections obtained in the southwestern portion of the island belong to a new species, described here.

2. The pattern of distribution presented by the genus *Pseudouroplectes*

The distributional pattern of this genus, based on the two previously known species of *Pseudouroplectes*, is restricted to the extreme southern dry forest formations (Fig. 1). This geographic range is further supported by the more recent collections (see below). The description of a new species herein extends the known distribution of the genus slightly further to the north in the lowland regions of southwestern Madagascar. *P. betschi* and *P. pidgeoni* apparently present a parapatric or even a small sympatric zone of distribution in the extreme southern portion of the island. The distribution of the genus *Pseudouroplectes* exclusively in spiny bush and transitional spiny bush-dry deciduous vegetational for-

mations could possibly be attributed to the lack of appropriate collecting methods in other parts of the island. This hypothesis can be eliminated a priori, since similar sampling methods have been used in all the different regions of the island. The exclusive presence of the genus *Pseudouroplectes* in the southern and southwestern portions of the island, in rather unique and highly endemic plant formations, can, however, be attributed to historical biogeographical factors. This idea is supported by the phylogenetic affinities of *Pseudouroplectes* with African relict elements [5] and particularly associated with the antiquity of this scorpion lineage.

Pseudouroplectes betschi: Andramanoetse Be, 'Plateau Karimbola' [= Plateau Mahafaly]; 'Réserve spéciale de Cap-Sainte-Marie' (25°35'40''S–45°8'49''E).

Pseudouroplectes pidgeoni: Parc national (formerly a 'Réserve naturelle intégrale') d'Andohahela (parcel 2), 'Forêt de Manantalinjo' (24°49'1''S–46°36'36''E); 'Parc National de Tsimanampetsotsa', 'Forêt de Bemanateza' (23°59'32''S–43°52'50''E); Mitoho Cave (24°2'50''S–43°46'11''E); 6.7 km 130° southeast of Efoetse (24°06'02''S–43°45'36''E); 'Réserve spéciale

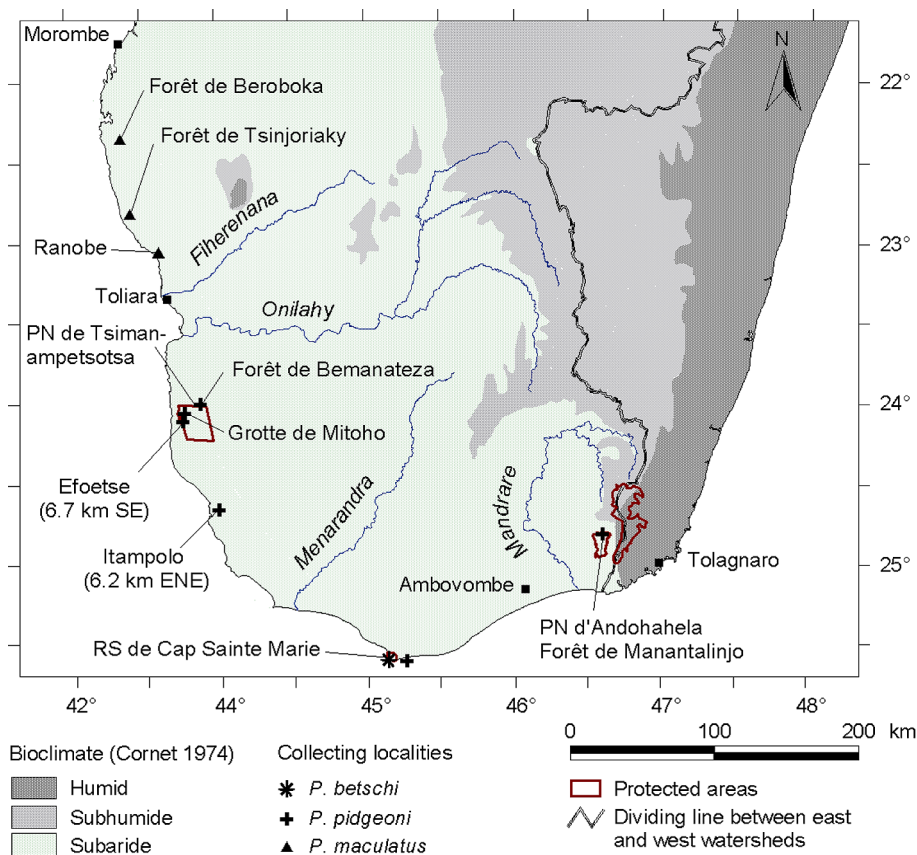


Fig. 1. Map of the southern portion of Madagascar showing the known distribution of *Pseudouroplectes* species overlaid on certain bioclimatic parameters.

de Cap-Sainte-Marie' (25°35'40''S–45°8'49''E); Plateau Mahafaly, 6.2 km ENE of Itampolo (24°39'13''S–43°59'48''E).

Pseudouroplectes maculatus sp.n.: 'Forêt de Beroboka' (22°19'59''S–43°21'59''E), (22°13'59''S–43°21'59''E); Ranobe (23°02'22''S–43°36'37''E – spiny forest-thicket); Ranobe (23°02.351'S–43°36.692'E – riparian forest); 'Forêt de Tsinjoriaky' (22°48'8''S–43°25'14''E).

The western portion of Madagascar receives less annual precipitation and has a more pronounced dry season than the eastern and central highland areas of the island. Along the west coast there is a pronounced north-south cline in decreasing annual rainfall from 1503 mm at Mahajanga, 780 mm at Morondava, 496 mm at Morombe, and 390 mm at Toliara [9]. Following this cline, the shift in rainfall gives rise to changes in vegetational types that range from deciduous forest in the northwest to a notably drier deciduous forest along the west-central lowland area, and then a sub-arid spiny bush towards the southwest. The transition zone between the dry deciduous forest and spiny bush transition falls between Belo-sur-Mer and Toliara, and more precisely in the region of the 'Forêt des Mikea', defined as the lowland area between the zone north of Toliara to Morombe, exactly the region where specimens of *P. maculatus* were collected. Other scorpion species known from the 'Forêt des Mikea' include *Grosphus olgae* and *Neogrosphus griveaudi* (Family Buthidae) [10]. As currently understood all records of *P. maculatus* sp.n. are north of the Onilahy River and those of *P. betshi* and *P. pidgeoni* south of the Onilahy River. The Forêt des Mikea is known to be a zone of considerable microendemism across a broad range of animal taxa [11–13].

3. Taxonomic treatment

Family Buthidae C.L. Koch, 1837

Genus *Pseudouroplectes* Lourenço, 1995

Pseudouroplectes maculatus sp.n. (Figs. 2–10)

CAS = California Academy of Sciences, San Francisco.

MGF = Madagascar Frontier Project

MNHN = 'Muséum national d'histoire naturelle', Paris.

Type material. Male holotype. Madagascar, Toliara Province, 'Forêt de Beroboka', 6.9 km 131° SE Ankidranoka (22°19'59''S–43°21'59''E), 80 m alt., 12–16 March 2002 (Fisher and Griswold et al.), general collecting, tropical dry forest (CAS). Paratypes. Toliara Province, 'Forêt de Beroboka', 5.9 km 131° SE Ankidranoka (22°13'59''S–43°21'59''E), 80 m alt.,

12–16 March 2002 (Fisher and Griswold et al.), pit-fall trap, in tropical dry forest 1 male (CAS), 1 female (MNHN). Toliara Province, Ranobe (23°02'22''S–43°36'37''E), 30 m alt., spiny forest-thicket, EH11 sifted litter (leaf mold, rotten wood), 5–28 January 2003 (Frontier Project, MGF 054), 1 male (CAS). Ranobe (23°02'351'S–43°36'692'E), riparian Forest, 20 m alt., general collecting 22–29 April 2003 (Frontier Project, 2003-MGF 067), 1 male (MNHN). Forêt de Tsinjoriaky (22°48'8''S–43°25'14''E), 6.2 km 84°E Tsifota, 70 m alt., 6–10 March 2002 (Fisher and Griswold et al.), general collecting, spiny forest-thicket, 2 male juveniles (CAS–MNHN).

Etymology. The specific name makes reference to the dark pigmentation of the new species.

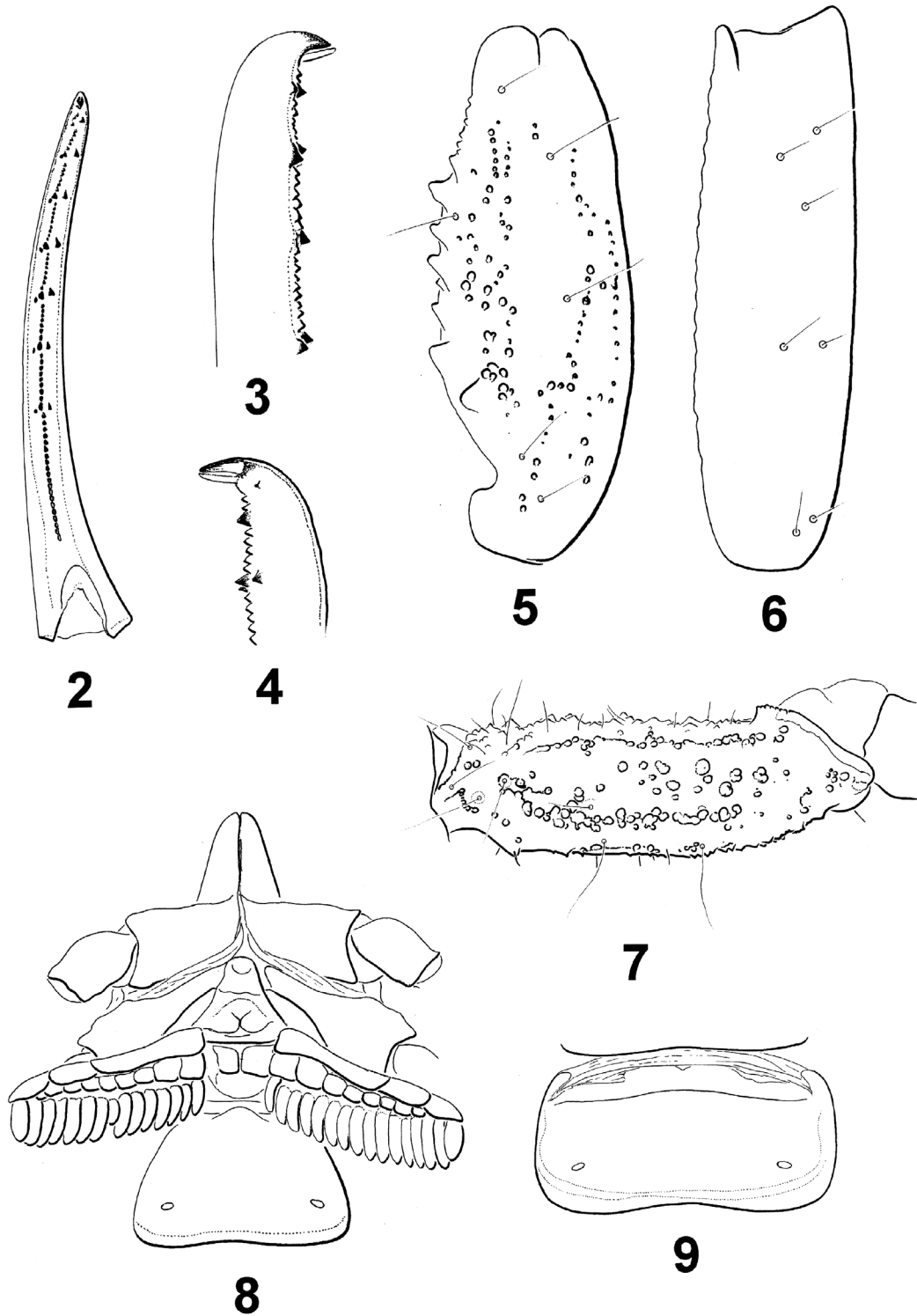
Diagnosis. Small scorpions, when compared with the average size of most species of micro-buthid genera, and measuring up to 15.87 mm in total length (see morphometric values). General coloration dark reddish-yellow with blackish spots over the body and appendages. Granulations strongly marked on body and appendages.

Relationships. The new species can be readily distinguished from all the other species of the genus *Pseudouroplectes* Lourenço, by (i) body, pedipalps and legs intensely marked with blackish spots, (ii) strongly marked carinae on tergites and metasomal segments, and (iii) presence of a conspicuous spinoid posterior granule on dorsal and subdorsal carinae of metasomal segments I–III.

Description based on male holotype.

Coloration. Basically dark reddish-yellow with blackish spots over the body and appendages. Carapace, pedipalps, and legs with variegated blackish spots; tergites with four longitudinal blackish stripes; dorsal and subdorsal carinae of metasomal segments I–III densely spotted. Venter and chelicera yellowish without spots.

Morphology. Carapace with a strongly marked granulation; anterior margin almost straight. Carinae weak; furrows inconspicuous. Median ocular tubercle distinctly on the anterior third of the carapace; median eyes separated by a little more than one ocular diameter. Three pairs of lateral eyes. Sternum subpentagonal. Mesosoma: tergites strongly granular. Median carina moderate in all tergites. Tergite VII pentacarinat. Venter: genital operculum divided longitudinally, each plate having a more or less subtriangular shape. Pectines large: pectinal tooth count 16–16 (male paratypes with 15–16 and 16–16); basal middle lamellae of the pectines not dilated; fulcra absent. Sternites smooth with short semi-slit-like spiracles; VII with a few granulations and vestigial carinae. Metasoma: segments I to IV with



Figs. 2–9. *Pseudouroplectes maculatus* sp.n. 2–7. Male holotype. 2. Disposition of granulations on the dentate margins of the pedipalp chela movable finger. 3–4. Extremity of pedipalp chela movable finger, external and internal aspects. 5–7. Trichobothrial pattern. 5–6. Patella, dorsal and external aspects. 7. Femur, dorsal aspect. 8–9. Male paratype. 8. Ventral aspect, showing coxapophysis, sternum, genital operculum, pectines and sternite III. 9. Sternite V, showing oval-shape spiracles.

Table 1

Key to the known species of *Pseudouroplectes*

1. Pale scorpions, yellowish to reddish-yellow, with or without spots	2
(1) Dark scorpions with several blackish scorpions over the body and appendages	<i>P. maculatus</i> sp.n.
2. Coloration yellowish without any spots; female pectinal tooth count 18/19	<i>P. betschi</i>
(2) Coloration yellowish with four longitudinal reddish-brown strips over the tergites; female pectinal tooth count 14/15	<i>P. pigeoni</i>

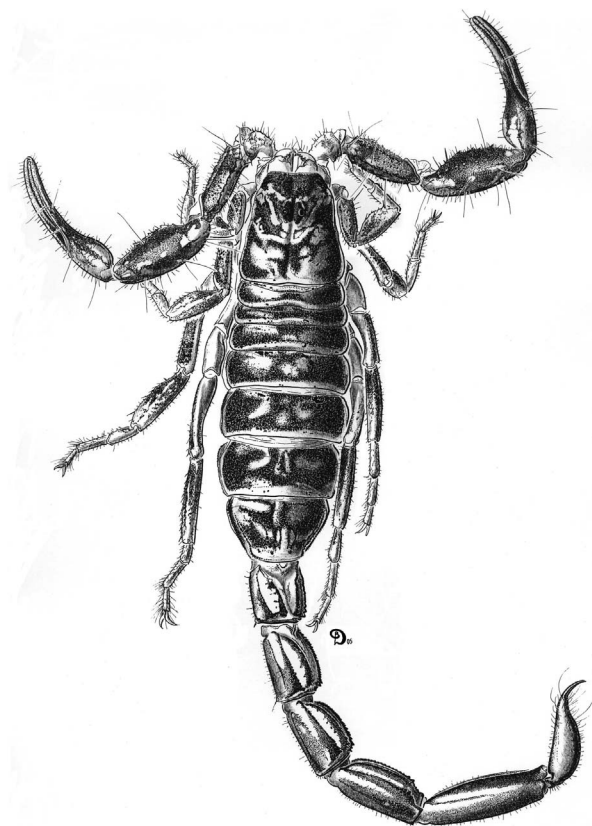


Fig. 10. *Pseudouroplectes maculatus* sp.n. Female paratype (Forêt de Beroboka). Habitus.

10 carinae, crenulate; ventral carinae vestigial on segments III–IV; intercarinal spaces weakly granular. Segment V rounded with five carinae. Telson with a very elongated ‘pear-like’ shape, smooth with strong setation; aculeus short, weakly curved; subaculear tooth absent. Cheliceral dentition characteristic of the family Buthidae [14]; fixed finger with two moderate basal teeth; movable finger with two very weak and fused basal teeth; ventral aspect of both finger and manus with dense, long setae. Pedipalps: femur pentacarinat; patella with seven carinae; internal face of patella with 4–5 spinoid granules; chela with vestigial carinae; all faces moderately granular. Fixed and movable fingers with 6–7 almost linear rows of granules; two accessory granules present at the base of each row; extremity of

fixed and movable fingers with one long and sharp denticle. Trichobothriotaxy; orthobothriotaxy A- α [15,16]. Legs: tarsus with very numerous fine median setae ventrally. Pedal spurs reduced; tibial spurs absent.

Morphometric values (in mm) of the holotype.

Total length, 15.87. Carapace: length, 2.18; anterior width, 1.36; posterior width, 2.21. Metasomal segment I: length, 1.18; width, 1.22. Metasomal segment V: length, 2.72; width, 0.93; depth, 0.92. Vesicle: width, 0.77; depth, 0.78. Pedipalp: femur length, 1.63; width, 0.46; patella length, 1.99; width, 0.82; chela length, 2.85; width, 0.61; depth, 0.59; movable finger length, 1.97.

Key to the known species of *Pseudouroplectes* is given in Table 1.

Acknowledgements

We are very grateful to Mr. Bernard Duhem, Muséum, Paris for preparing the drawings and to Lucienne Wilmé, for the preparation of the map. Specimens were made available by Frontier-Madagascar (Society for Environmental Exploration) through Hannah Thomas and Annette Olsson. Field collections were funded in part by National Science Foundation (USA) awards to Brian L. Fisher and Charles E. Griswold (DEB-0072713) and to Brian L. Fisher and Phil S. Ward (DEB-0344731).

References

- [1] W.R. Lourenço, Humicolous buthoid scorpions; a new genus and species from French Guiana, C. R. Biologies 326 (2003) 1149–1155.
- [2] W.R. Lourenço, Humicolous microcharmids scorpions: a new genus and species from Madagascar, C. R. Biologies 327 (2004) 77–83.
- [3] W.R. Lourenço, Humicolous buthoid scorpions; a new species from Brazilian Amazon, C. R. Biologies 328 (2005) 949–954.
- [4] W.R. Lourenço, Description de trois nouveaux genres et de quatre nouvelles espèces de scorpions Buthidae de Madagascar, Bull. Mus. natl. Hist. nat., Paris, 4^e sér. 17 (1995) 79–90.
- [5] W.R. Lourenço, Scorpions, in : Faune de Madagascar, Paris, 87, 1996, pp. 1–102.
- [6] W.R. Lourenço, Un modèle de distribution géographique présenté par les scorpions du genre *Microcharmus* Lourenço, avec la description d’une nouvelle espèce, C. R. Acad. Sci. Paris, Ser. III 322 (1999) 843–846.

- [7] W.R. Lourenço, Un nouveau genre de Scorpion malgache, mailon possible entre les Microcharmidae et les Buthidae, C. R. Acad. Sci. Paris, Ser. III 323 (2000) 877–881.
- [8] W.R. Lourenço, S.M. Goodman, Taxonomic and ecological observations on the scorpions collected in the 'Réserve naturelle intégrale d'Andohahela', Madagascar, Fieldiana: Zoology, new series 94 (1999) 149–153.
- [9] P. Chaperon, J. Danloux, L. Ferry, Fleuves et rivières de Madagascar, Orstom Éditions, Paris, 1993, 874 p.
- [10] W.R. Lourenço, Scorpions du sud-ouest de Madagascar et en particulier de la forêt des Mikea, in: A.P. Raselimanana, S.M. Goodman (Eds.), Inventaire floristique et faunistique de la forêt de Mikea : Paysage écologique et diversité biologique d'une préoccupation majeure pour la conservation, Recherches pour le développement, Série Sciences biologiques 21 (2004) 25–35.
- [11] S.M. Goodman, V. Soarimalala, A new species of *Microgale* (Lipotyphla: Tenrecidae: Oryzorictinae) from the 'Forêt des Mikea' of southwestern Madagascar, Proc. Biol. Soc. Washington 117 (2004) 251–265.
- [12] S.M. Goodman, V. Soarimalala, A new species of *Macrotaromys* (Rodentia: Muridae: Nesomyinae) from the Forêt des Mikea of southwestern Madagascar, Proc. Biol. Soc. Washington (in press).
- [13] A.P. Raselimanana, S.M. Goodman (Eds.), Inventaire floristique et faunistique de la forêt de Mikea : Paysage écologique et diversité biologique d'une préoccupation majeure pour la conservation, Centre d'information et de documentation scientifique et technique, Antananarivo, Recherches pour le Développement, Série Sci. biol. 21 (2004) 1–105.
- [14] M. Vachon, De l'utilité, en systématique, d'une nomenclature des dents des chélicères chez les scorpions, Bull. Mus. natl Hist. nat., 2^e sér. 35 (1963) 161–166.
- [15] 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., Paris, 3^e sér., n^o 140, Zool. 104 (1974) 857–958.
- [16] 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. III 281 (1975) 1597–1599.