



ELSEVIER

Contents lists available at ScienceDirect

## Comptes Rendus Biologies

www.sciencedirect.com



Ecology / Écologie

# The disrupted pattern of distribution of the genus *Hadrurochactas* Pocock; evidence of past connections between Amazon and the Brazilian Atlantic forest

Wilson R. Lourenço

Muséum national d'histoire naturelle, département de systématique et évolution, section arthropodes (arachnologie), 57, rue Cuvier, CP 053, 75005 Paris, France

## ARTICLE INFO

## Article history:

Received 1 October 2009

Accepted after revision 6 November 2009

Available online 22 January 2010

## Keywords:

Scorpiones

*Hadrurochactas*

New species

'Brejos'

Disrupted distribution

## Mots clés :

Scorpiones

*Hadrurochactas*

Nouvelle espèce

'Brejos'

Répartition disjointe

## ABSTRACT

A new species, *Hadrurochactas araripe* sp. n. (Chactidae) is described from 'Chapada do Araripe', a 'Brejo type' formation located in the State of Pernambuco, Brazil. The description of the new species confirms a disrupted pattern of distribution presented by the genus *Hadrurochactas*. This includes species present both in Guiano-Amazon forests and forest islands within the 'Caatingas'. These are xerophytic formations in northeastern Brazil. This new species brings further evidence of a past connection between the Amazonian and Atlantic forests, as already suggested by palaeobotanists.

© 2009 Académie des sciences. Published by Elsevier Masson SAS. All rights reserved.

## R É S U M É

Une nouvelle espèce, *Hadrurochactas araripe* sp. n. (Chactidae) est décrite de la 'Chapada do Araripe', une formation du type 'Brejo' située dans l'État du Pernambuco, Brésil. Avec la description de la nouvelle espèce, un modèle de répartition disjointe est confirmé pour le genre *Hadrurochactas*. Des espèces sont distribuées dans les forêts de la région Guyano-Amazoniennne, mais aussi dans des enclaves de forêt (Brejos), encerclées par des formations xérophytiques du type 'Caatingas' du nord-est du Brésil. La découverte de la nouvelle espèce représente un nouvel appui à l'hypothèse des connections passées entre l'Amazonie et la forêt Atlantique, comme déjà suggéré par des palaeobotanistes.

© 2009 Académie des sciences. Publié par Elsevier Masson SAS. Tous droits réservés.

## 1. Introduction

As noted in previous papers [1], the genus *Hadrurochactas* was created by Pocock [2] for the species *Hadrurochactas sclateri*. This has Guyana as its type locality. Subsequently, Kraepelin [3,4] placed *H. sclateri* in synonymy with *Chactas schaumii* Karsch, which was initially placed in the genus *Hadrurochactas* and subsequently in the genus *Broteochactas*. Mello-Leitão [5] followed Kraepelin's decision and cited the species as *Broteochactas schaumii*. Gonzalez-Sponga [6], however, resurrected the genus *Hadrurochactas*, a decision

that he subsequently maintained [7,8]. Lourenço [9] temporarily accepted Gonzalez-Sponga's opinion, giving as his main reason for doing so the scarcity of material available. Subsequently, this decision was changed and *Hadrurochactas* considered as a 'species group' of *Broteochactas* [10,11]. In his synthesis of chactid scorpions, Sissom [12] accepted Lourenço's decision, but, in the 'Catalog of the Scorpions of The World' [13] he changed his mind and re-established *Hadrurochactas* as a valid genus. Monod and Lourenço [1] also retained *Hadrurochactas* as a 'species group' of *Broteochactas*. Since this publication on *Hadrurochactas*, more precise studies of several scorpion groups have lead different authors independently to consider *Hadrurochactas* to be a valid genus [14,15]. For this reason,

E-mail address: arachne@mnhn.fr.

I have followed the example of these authors in the present publication, and accepted the validity of the genus *Hadrurochactas*.

A new species is described here from 'Chapada do Araripe', a 'Brejo' located in the State of Pernambuco. The distribution of the genus *Hadrurochactas* is consequently confirmed as including the 'Brejo' formations of north-eastern Brazil. The new species is also evidence of a past connection between the Amazonian and Atlantic forests, as already suggested by palaeobotanists [16].

## 2. The disrupted pattern of distribution of *Hadrurochactas* species in forest formations of South America

Interesting examples of genera presenting disrupted patterns of distribution can be found among scorpions restricted to savannas or rainforests (e.g. *Rhopalurus* Thorell, 1876). In the genus *Hadrurochactas*, close relationships exist between species in the Amazon rainforest and species found in outlying forest islands called 'Brejos'. These are surrounded by xerophytic formations such as the 'Caatingas' of the northeastern Brazil. These 'Brejos' hills are covered by forest, because their elevation causes humid air to cool, so that condensation and consequent precipitation take place [17].

The species of *Hadrurochactas*, like almost all other chactid scorpions, are exclusively restricted to forests. Initially, they were believed to be distributed only in the 'Guayana lowland floristic province' as defined by Mori [18] and represented by two species: *Hadrurochactas schaumii* (Karsch) and *Hadrurochactas odoardo* González-Sponga. Subsequently, three new species have been described from elsewhere: *Hadrurochactas mapuera* (Lourenço) found in the contact zone between Amazon and Guayana, south of the 'Serra do Tumucumaque', State of Pará, Brazil (considered to be a sibling species of *H. schaumii*). *Hadrurochactas brejo* (Lourenço), the first species to be found outside the previously known range of distribution of the genus (basically the Guayana-Amazon region) was collected in a 'Brejo' formation near Maranguape, in the State of Ceará, Brazil. The site is a small hill covered with forest and totally surrounded by xeric 'Caatingas'. *Hadrurochactas polisi* (Monod & Lourenço) collected in central Amazon. The description of *Hadrurochactas araripe* sp. n., again from a 'Brejo' formation, confirms the disrupted pattern of distribution presented by the genus. The description of the new species brings further evidence for a possible past connection between the Amazon and the Atlantic forests [19], as already suggested by palaeobotanists. [16].

## 3. Possible origins and the distribution of the family Chactidae

In view of the evidence of the probable past connection between the Amazonian and the Atlantic forests [16,19], one further question can be addressed: Why has no species of chactid scorpions ever been recorded from the Brazilian Atlantic forest?

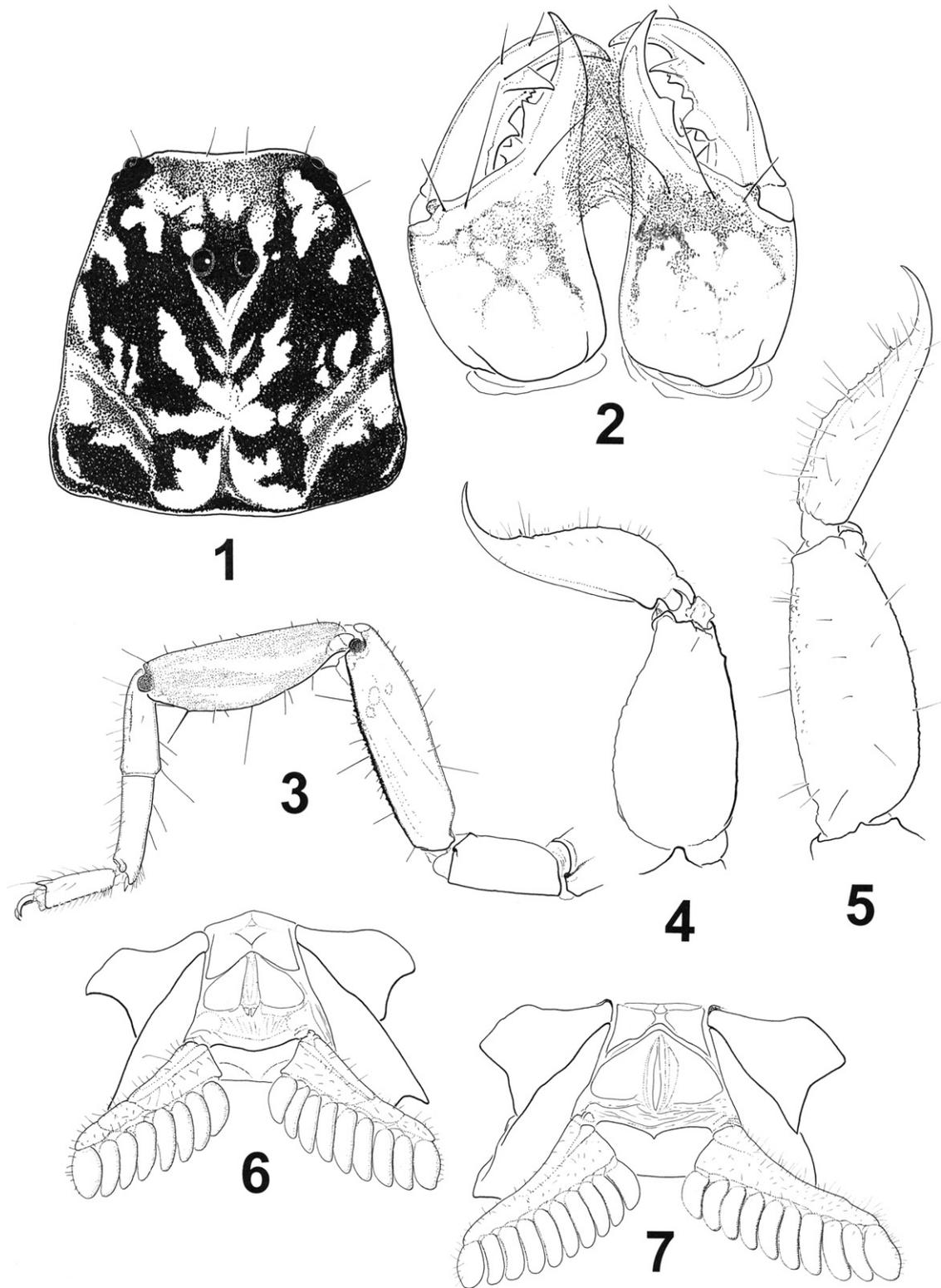
It seems evident that there is a gap in this particular forest formation in species of the family Chactidae. In fact,

there are very few examples of typically Amazonian scorpions in the Brazilian Atlantic forest [20]. Only groups having a large geographical distribution (such as some basal elements of the family Buthidae), have been recorded from both forest formations. It also appears likely that some widely distributed groups, such as the genera *Ananteris* Thorell and *Tityus* C. L. Koch, have a Gondwanian origin. This seems not to be the case with chactids. The proto-elements that are at the base of the extant chactid (*sensu strictu*), undoubtedly have their origin in Laurasia, as do elements of the family Iuridae [21,22]. The proto-elements of the family Chactidae definitely originated from the North. Subsequently, a remarkable radiation took place in the tropical forests of the South American continent. Some fossil evidence justifies assuming a possible Gondwanian origin for the Chactidae [23]. However, fossil evidence is very often weak and can lead to 'free interpretations'. These naturally are open to possible misinterpretations. For example, Lourenço [24] assigned *Palaeoescorpius gallicus* from the Lower Cretaceous amber of France, to the Chactoidae. This conclusion was based on a single incomplete pedipalp, which is a rather weak evidence. Nevertheless, Menon [23], confirmed the previous opinion of Soleglad and Fet [14], according to which, this species is not a member of the Chactoidae. In the same line of thought, the decision to assign *Araripescorpius ligabuei* Campos from the Lower Cretaceous of Brazil to the family Chactidae, even if based on some trichobothrial evidence, remains a 'free interpretation'. More than 100 my separate the fossil species from the Lower Cretaceous of Brazil (Santana formation) from the extant species of Chactidae, including *Hadrurochactas araripe* sp. n. In this same line of thought, it appeared more logical to Carvalho and Lourenço [25] to assign *Protoischnurus axelrodorum*, also from the Lower Cretaceous of Brazil, to a new family Protoischnuridae, within the Scorpionioidea, as a possible proto-element (*sedis mutabilis*) of both families Scorpionidae and Ischnuridae (now Liochelidae). This position was, however, rejected by Menon [23], on the basis that age does not count: "Mere difference in age is not be a valid criterion on which to create a new family". Here, we are faced once again, with a conflict between reductionism and divisionism.

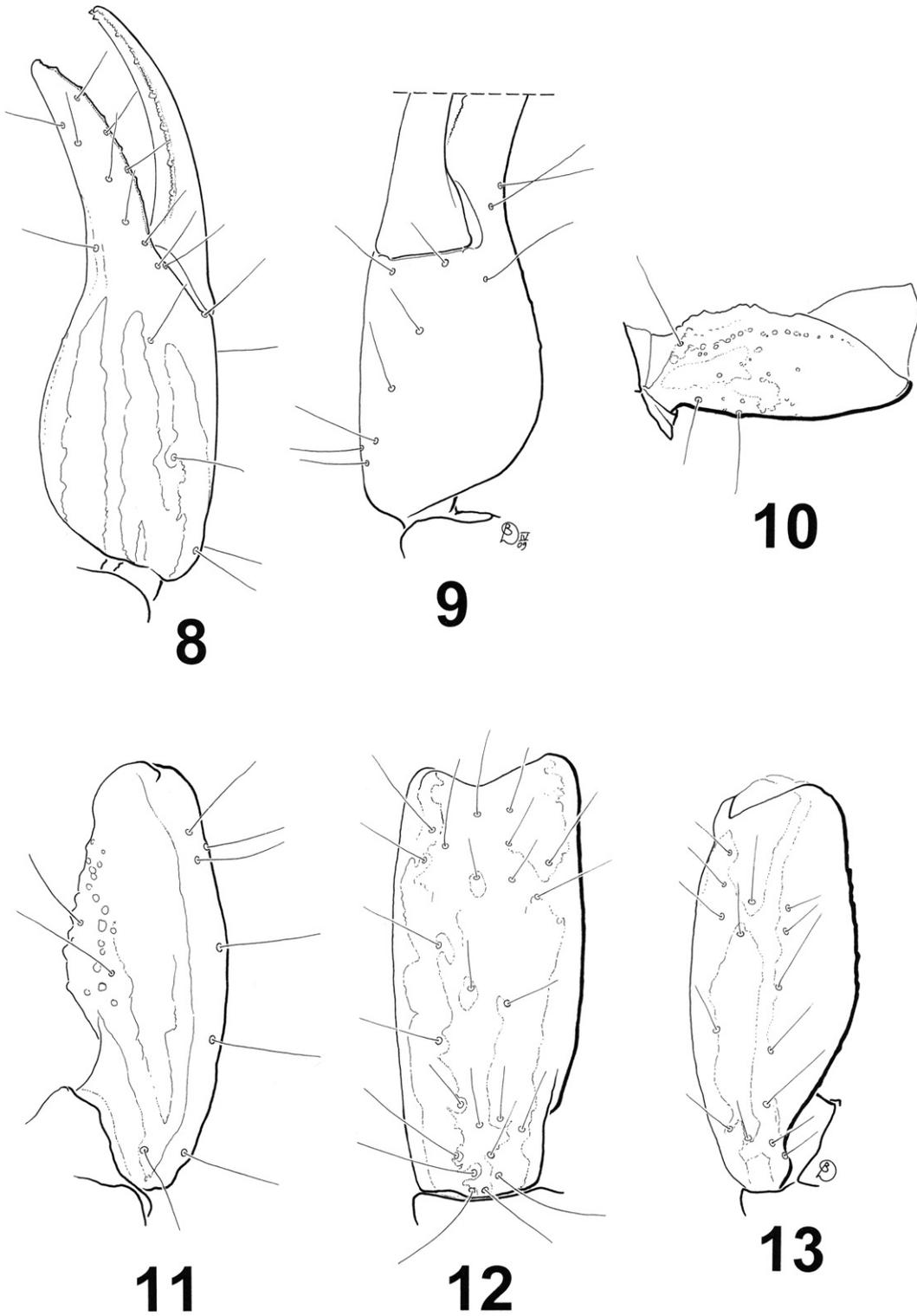
A further consideration that should support the case for a non-Gondwanian model for chactids is the remarkable gaps they represent in the faunas of Africa, Australia and especially in Madagascar. Since its rupture from Africa almost 100 my BP, and subsequently from Australia and India [26], Madagascar remained isolated and preserved some of the original lineages that had been present in Gondwana. Only two scorpion lineages, Buthoidea and Scorpionioidea can be observed in Madagascar [27]. These contain typical Gondwanian elements such as the genera *Tityobuthus* Pocock and *Opisthacanthus* Peters [26,27]. This suggests that chactoids were never represented in the fauna of Gondwana.

## 4. Methods

Measurements and illustrations were made using a Wild M5 stereo-microscope with a drawing tube (camera



**Figs. 1–7.** *Hadrurochactas araripe* sp. n., male holotype. 1. Carapace. 2. Chelicerae. 3. Leg IV. 4–5. Metasomal segment V and telson, lateral aspect. 4. *H. araripe* sp. n. 5. *H. schaumii* (male). 6–7. Sternum, genital operculum and pectines. 6. *H. araripe* sp. n. 7. *H. schaumii* (male).



Figs. 8–13. *Hadrurochactas araripe* sp. n., male holotype. Trichobothrial pattern. 8–9. Chela, dorso-external and ventro-internal aspects. 10. Femur, dorsal aspect. 11–13. Patella, dorsal, external and ventral aspects.

lucida) and an ocular micrometer. Measurements follow those of Stahnke [28] and are given in mm. Trichobothrial notations are those developed by Vachon [29] and the morphological terminology mostly follows that of Hjelle [30].

#### Taxonomic treatment

Family Chactidae Pocock, 1893

Genus *Hadrurochactas* Pocock, 1893

***Hadrurochactas araripe* sp. n.** (Figs. 1–4, 6, 8–13)

Male holotype: Brazil, State of Pernambuco, 'Chapada (serra) do Araripe', IX/1963 (collected by local people).

The type should be deposited in the collections of the Muséum national d'histoire naturelle, Paris.

**Etymology:** The specific name is placed in apposition to the generic name and refers to Araripe, the location in which the new species was collected.

**Comparative material:** *H. brejo*: female holotype; Brazil, Ceará, Maranguape Mts. (W. M. Mann, Stanford Expedition). *H. schaumii*: 2 males, 2 females; French Guyana, St

Eugène research station, on the stream named Courcibo (J.-C. de Massary leg).

**Diagnosis:** Small scorpions, 19.3 mm in total length, including telson. Coloration reddish-yellow to reddish-brown, densely spotted on pedipalps and chelicerae. Body and appendages weakly granulated. Telson weakly granulated with small-sized spine-like granules and one larger spinoid granule on the ventral side, under the aculeus. Pectines with 9–8 teeth on male. Fixed and movable fingers of pedipalps with 5–6 rows of linear granules; three accessory granules on the extremity of fingers. Trichobothrial pattern of type C, neobothriotaxic (majorante) 'major neobothriotaxy'. Legs with long thin setae.

**Relationships:** *Hadrurochactas araripe* sp. n. can be distinguished from the other species of the genus, and in particular from *H. brejo* and *H. schaumii* by the following combination of characters: (1) globally smaller size; the new species is one of the two smallest species in the genus (see measurements after description); (2) body, pedipalps and chelicerae densely spotted; (3) metasomal segment V

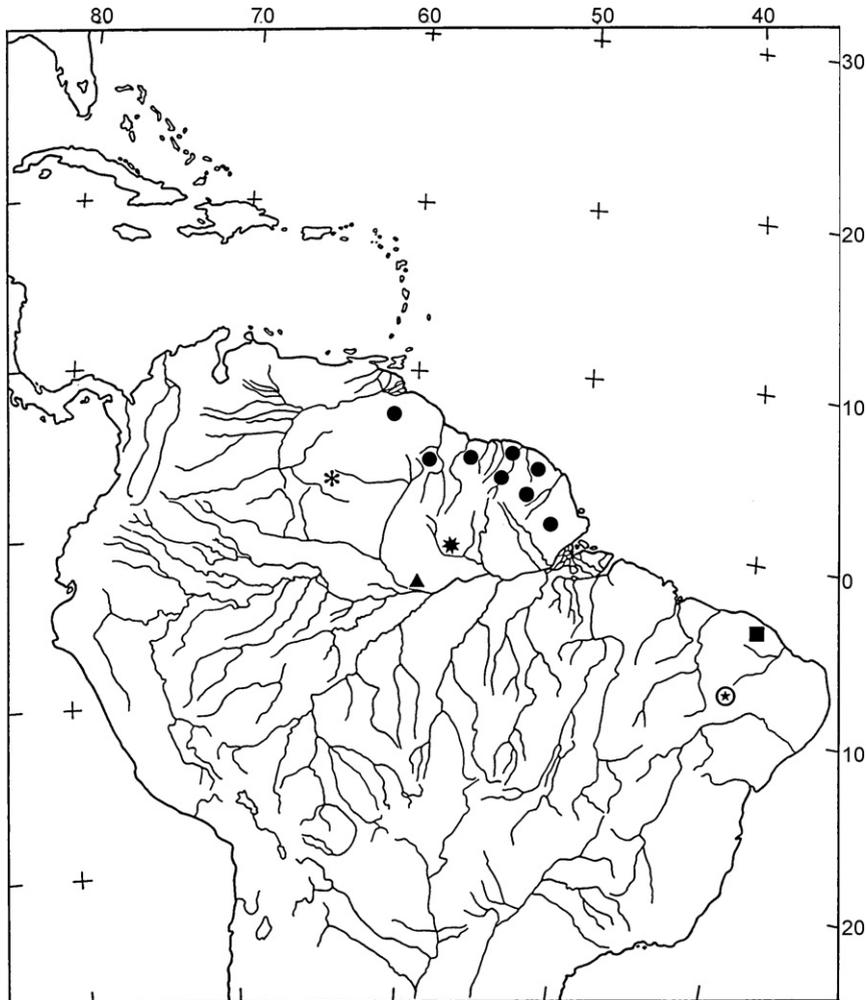


Fig. 14. Map of Northern South America showing the distribution of *Hadrurochactas* species. *H. schaumii* (black circle). *H. odoardi* (black flower). *H. mapuera* (black star). *H. brejo* (black square). *H. polisi* (black triangle). *H. araripe* sp. n. (circle with black star). For a precise delimitation of the morphoclimatic regions of tropical South America refer to Lourenço [32].

and telson weakly granulated to smooth; telson short and bulky; (4) ventral surface of metasomal segment V sparsely granular; (5) ventral side of telson with small-sized spine-like granules and one larger spinoid granule under the aculeus; (6) pectines with only 8–9 teeth.

Description based on male holotype

Coloration. General coloration reddish-yellow to reddish-brown, densely spotted on pedipalps and chelicerae. Prosoma reddish-brown with several dark spots. Mesosoma: Tergites reddish-brown with confluent dark spots; sternites III to V yellowish, sternites VI and VII reddish-yellow to dark reddish; coxapophysis and sternum reddish-yellow; genital operculum and pectines pale yellow. Metasoma: all segments reddish-brown; carinae dark, almost blackish; telson reddish to reddish-brown; aculeus dark, almost blackish. Chelicerae yellowish with variegated brownish spots; fingers yellowish with reddish teeth. Pedipalps reddish-brown with dark longitudinal stripes on femur, patella and chela. Legs yellowish with very diffused pale brown spots; basitarsus and tarsus pale yellow.

Morphology. Carapace weakly granular to smooth; anterior margin very weakly emarginated; carinae absent; all furrows weakly pronounced; postero-median furrow finely granular; median ocular tubercle distinctly anterior to the centre of the carapace; two pairs of small lateral eyes. Mesosoma. All tergites smooth with a few indistinct granules on the posterior margin; tergite VII with four vestigial carinae which carry granules on the posterior half; posterior half of tergite VII finely granular, with some larger granules interspersed. Venter. Genital operculum longitudinally divided, each half with a sub-triangular shape; pectines with 9–8 teeth, fulcra absent; all sternites smooth with rounded spiracles, carinae absent. Metasoma. Dorsal carinae granular on segments I–IV, absent on segment V; dorsolateral carinae granular on all segments; ventrolateral carinae weakly pronounced or absent on all segments; ventrolateral and ventral carinae absent on all segments; dorsal surface smooth on all segments; lateral surfaces weakly granular to smooth on segments I to IV; very slightly granular on segment V; ventral surface smooth on segments I to IV; with some thin granules on V. Telson short and bulky, with small-sized spine-like granules and one larger spinoid granule under the aculeus; dorsal side smooth, aculeus relatively short. Cheliceral dentition characteristic of the family Chactidae [31]. Pedipalp femur pentacarinat, moderately granular; patella and chela with weakly marked to un conspicuous carinae; fixed and movable fingers with 5–6 rows of linear granules; three accessory granules on the extremity of fingers. Trichobothrial pattern of type C, neobothriotaxic (majorante) 'major neobothriotaxy' [29]. Legs with long thin setae.

Morphometric values (in mm) of the male holotype. Total length, 19.3 (including telson). Carapace: length, 2.7; anterior width, 1.6; posterior width, 2.7. Mesosoma length, 5.0. Metasomal segments. I: length, 1.0; width, 2.1; II: length, 1.2; width, 2.1; III: length, 1.3; width, 2.1; IV: length, 1.9; width, 2.1; V: length, 3.0; width, 2.0; depth, 1.7. Vesicle: length, 3.2; width, 1.5; depth, 0.9. Pedipalp: femur length, 1.9, width, 0.8; patella length, 2.3, width,

0.9; chela length, 3.6, width, 1.2, depth, 1.2; movable finger length, 2.0.

## Acknowledgements

I am most grateful to Prof. John L. Cloudsley-Thompson, London, for useful comments to the manuscript, to Bernard Duhem, Muséum, who prepared the remarkable illustrations and to Elise-Anne Leguin, Muséum, for the help with the preparation of the plates.

## References

- [1] L. Monod, W.R. Lourenço, A new species of *Brotoeochactas* Pocock, 1890 from Brazilian Amazonia (Scorpiones: Chactidae), in: V. Fet, P.A. Selden (Eds.), *Scorpions 2001*, in: *Memoriam Gary A. Polis*. Br. Arach. Soc., London, 2001, pp. 195–202.
- [2] R.I. Pocock, A contribution to the study of Neotropical Scorpions, *Ann. Mag. Nat. Hist.* 12 (1893) 77–103.
- [3] K. Kraepelin, Revision der Skorpione. II. Scorpionidae und Bothriuridae, *Jb. Hamb. Wiss. Anst.* 11 (1894) 1–248.
- [4] K. Kraepelin, Scorpiones und Pedipalpi, in *Das Tierreich*, Friedländer Verl., Berlin 8 (1899) 1–265.
- [5] C. Mello Leitão, Escorpiões Sul Americanos, *Arq. Mus. Nac.*, Rio de Janeiro 40 (1945) 1–468.
- [6] M.A. González-Sponga, Escorpiofauna de la region oriental del Estado Bolívar, en Venezuela, Ed. Roto-Impresos, Caracas, 1978.
- [7] M.A. González-Sponga, Escorpiones de Venezuela, Cuadernos Lagoven, Caracas, 1984.
- [8] M.A. González-Sponga, Guía para identificar Escorpiones de Venezuela, Cuadernos Lagoven, Caracas, 1996.
- [9] W.R. Lourenço, La faune des Scorpions de Guyane française, *Bull. Mus. Nat. Hist.*, Paris 5 (1983) 771–808.
- [10] W.R. Lourenço, Diversité de la faune scorpionique de la région amazonienne; centres d'endémisme; nouvel appui à la théorie des refuges forestiers du Pléistocène, *Amazoniana* 9 (1986) 559–580.
- [11] W.R. Lourenço, Première évidence de la présence d'une faune scorpionique amazonienne rélictuelle dans les 'Brejos' de la Caatinga du nord-est du Brésil, *Bull. Soc. Sci. Bretagne* 59 (1988) 147–154.
- [12] W.D. Sissom, Systematics, Biogeography, and Paleontology, in: G.A. Polis (Ed.), *The Biology of Scorpions*, Stanford Univ. Press, 1990 pp. 64–160.
- [13] W.D. Sissom, Family Chactidae Pocock, 1893, in: V. Fet, W.D. Sissom, G. Lowe, M.E. Braunwalder (Eds.), *Catalog of the Scorpions of the World (1758–1998)*, The New York Entomol. Society, New York, 2000, pp. 287–322.
- [14] M. Soleglad, V. Fet, High-level systematics and phylogeny of the extant scorpions (Scorpiones: Orthosterni), *Euscorpium* 11 (2003) 1–175.
- [15] L. Prendini, W.C. Wheeler, Scorpion higher phylogeny and classification, taxonomic anarchy, and standards for peer review in online publishing, *Cladistics* 21 (2005) 446–494.
- [16] J.J. Bigarella, D. Andrade-Lima, Paleoenvironmental Changes in Brazil, in: G.T. Prance (Ed.), *Biological Diversification in the Tropics*, Columbia University Press, New York, 1982, pp. 27–40.
- [17] D. Andrade-Lima, Present-day forest refuges in Northeastern Brazil, in: G.T. Prance (Ed.), *Biological Diversification in the Tropics*, Columbia University Press, New York, 1982, pp. 245–251.
- [18] S.A. Mori, The Guayana lowland floristic Province, *C. R. Soc. Biog.* 67 (1991) 67–75.
- [19] W.R. Lourenço, Biogeographic patterns of tropical South American scorpions, *Studies Neotr. Fauna Environ.* 29 (1994) 219–231.
- [20] W.R. Lourenço, *Scorpions of Brazil*, Les Editions de L'IF, Paris, 2002.
- [21] O.F. Francke, M.E. Soleglad, The family Luridae Thorell (Arachnida, Scorpiones), *J. Arachnol.* 9 (1981) 233–258.
- [22] W.R. Lourenço, Panbiogéographie, les distributions disjointes et le concept de famille rélictuelle chez les scorpions, *Biogeographica* 74 (1998) 133–144.
- [23] F. Menon, Higher systematics of scorpions from the Crato formation, lower Cretaceous of Brazil, *Palaentology* 50 (2007) 185–195.
- [24] W.R. Lourenço, The first scorpion fossil from the Cretaceous amber of France. New implications for the phylogeny of Chactioidea, *C. R. Palevol.* 2 (2003) 213–219.
- [25] M.G. Carvalho, W.R. Lourenço, A new family of fossil scorpions from the Early Cretaceous of Brazil, *C. R. Acad. Sci. Paris, Ser. Ila* 332 (2001) 711–716.
- [26] W.R. Lourenço (Ed.), *Biogéographie de Madagascar*, Éditions de l'Orstom, Paris, 1996.

- [27] W.R. Lourenço, Diversity and Endemism in Malagasy Scorpions, *Biogeographica* 80 (2005) 43–64.
- [28] H.L. Stahnke, Scorpion nomenclature and mensuration, *Entom. News* 81 (1970) 297–316.
- [29] 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.
- [30] J.T. Hjelle, Anatomy and morphology, in : G.A. Polis (Ed.), *The Biology of Scorpions*, Stanford Univ. Press, 1990, pp. 9–63.
- [31] 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.
- [32] W.R. Lourenço, Scorpion diversity in tropical South America, in : P. Brownell, G. Polis (Eds.), *Scorpion Biology and Research*, Oxford University Press, New York, 2001, pp. 406–415.