

SCORPIONS COLLECTED IN THE MAKAY MOUNTAIN RANGE, MADAGASCAR (SCORPIONES: HORMURIDAE, BUTHIDAE) AND WITH DESCRIPTION OF A NEW SPECIES

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Abstract: New considerations regarding *Grosphus limbatus* (Pocock, 1889), described from an undefined locality in Madagascar, are proposed. One new species, *Grosphus makay* sp. n., closely allied to *G. limbatus*, is described from the Makay sandstone mountain range, Atsimo-Andrefana Region (ex Province of Toliara) in south-western Madagascar. The description of the new species brings further evidence of the existence of micro-endemic and vicariant populations within the Malagasy scorpion fauna.

Key words: Scorpiones, Hormuridae, Buthidae, *Grosphus*, new species, micro-endemism, geomorphology, Madagascar.

Escorpiones recolectados en la cordillera de Makay, Madagascar (Scorpiones: Hormuridae, Buthidae) y descripción de una especie nueva

Resumen: Se analiza el caso de *Grosphus limbatus* (Pocock, 1889), descrito de una localidad imprecisa de Madagascar. Se describe una especie nueva, *Grosphus makay* sp. n., muy próxima a *G. limbatus*, de la cordillera de Makay, constituida por areniscas y situada en la región de Atsimo-Andrefana (antes provincia de Toliara), en el suroeste de Madagascar. La descripción de la especie nueva aporta más pruebas de la existencia de poblaciones microendémicas y vicariantes dentro de la fauna de escorpiones malgache.

Palabras clave: Scorpiones, Hormuridae, Buthidae, *Grosphus*, especie nueva, microendemismo, geomorfología, Madagascar.

Taxonomy / Taxonomía: *Grosphus makay* sp. n.

Introduction

The first *Grosphus* species described from Madagascar was *Scorpio* (*Androctonus*) *madagascariensis* Gervais (1843) = *G. madagascariensis* (Gervais, 1843) (cf., Lourenço, 1996, 2014a; Lourenço & Goodman, 2006; Lourenço *et al.*, 2004, 2007). Some years after this first publication, Pocock (1889) published a detailed description of another scorpion: *Buthus limbatus* (= *Grosphus limbatus*), collected from a totally unclear locality (see the following section). Kraepelin (1900) largely contributed to the study of the genus *Grosphus* and described several new species. In his monograph on the scorpions of Madagascar, Fage (1929) characterized the totality of the known species to that date. In recent years, several new species of *Grosphus* were described attesting to a much greater diversity of the group than what was originally expected (e. g. Lourenço, 1999, 2003, 2013, 2014a; Lourenço & Goodman, 2003; Lourenço *et al.*, 2009; Waeber *et al.*, 2015).

The taxonomy of *Grosphus* is based mainly on two characteristics: the pattern of coloration and the morphology of the pectines, in particular that of the basal middle lamellae of females. The latter has been considered by previous scorpion taxonomists to show species specific aspects with little intraspecific variation (cf Fage, 1929; Lourenço, 1996). However, more detailed investigations have showed that in some cases closely related species have rather similar basal middle lamellae morphology (Lourenço, 2003, 2014a; Lourenço & Goodman, 2003). On the basis of this character, populations closely associated to species, such as *G. madagascariensis*, *G. hirtus*, *G. limbatus*, and *G. bistriatus*, probably remain yet undescribed.

The present study of some scorpions collected in the Makay sandstone Mountains leads to the characterisation of yet another new species of *Grosphus*, closely allied to *G. limbatus*. The discovery of this population brings new evidence about the existence of micro-endemic populations within the Malagasy scorpion fauna, as it was recently characterized for other groups of Malagasy scorpions (Lourenço, 2014b; Lourenço & Wilmé, 2015).

Taxonomic history of *Grosphus limbatus* (= *Buthus limbatus* Pocock, 1889)

Buthus limbatus (now in the genus *Grosphus*) was described based on four specimens, obtained in Madagascar by the Reverend Richard Baron. He also collected the specimens used in the description of *Tityobuthus baroni* (see Lourenço *et al.*, 2008). No details of the original collection locality were given by Pocock (1889), and one important question remained unanswered: from what region of Madagascar was the type material of *B. limbatus* collected?

Fage (1929) subsequently identified *G. limbatus* from several different localities. More recently, a detailed study of several species of *Grosphus* similar to *G. limbatus* demonstrated examples of animals misidentified by Fage (1929), and confirmed this specie's distributional area as being confined to the Central Highlands (Lourenço, 2003), the portion of the island generally defined as above 800 m.

Rev. Richard Baron arrived in Madagascar in 1872 and was associated with the London Missionary Society and

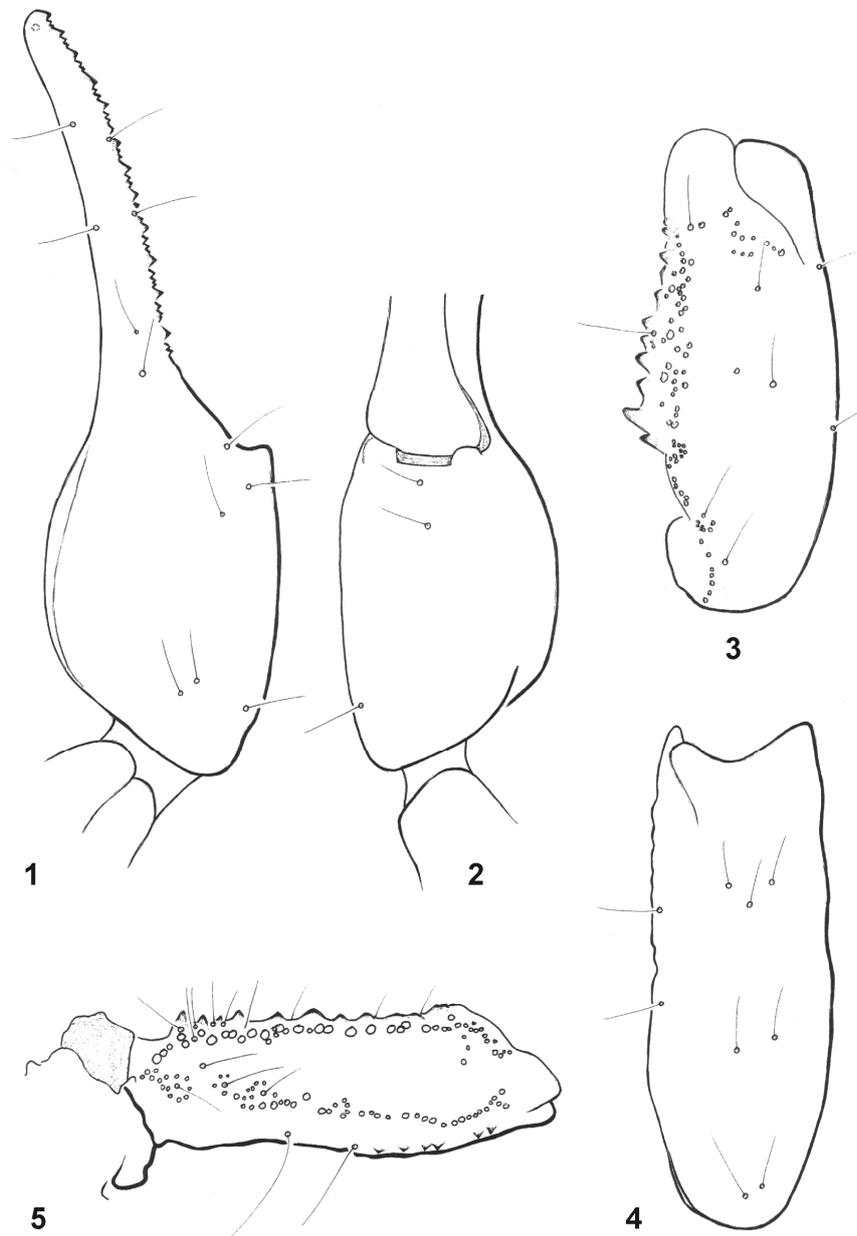


Fig. 1-5. *Grosphus makay* sp. n., female holotype. Trichobothrial pattern. **1-2.** Chela, dorso-external and ventral aspects. **3-4.** Patella, dorsal and external aspects. **5.** Femur, dorsal aspect.

remained on the island for the subsequent 35 years (Dorr, 1987). He made considerable plant collections. He lived for a portion of this period near Fianarantsoa and Ambohidratrimo (near Antananarivo) in the Central Highlands; the majority of his plant collections bear the ambiguous locality 'Imerina, Betsileoland and Tanala' (Baker, 1908). He did visit other portions of the island, from where he collected at least plants (Dorr, 1987). *Grosphus limbatus* remains rare (Fig. 11-12) when compared to other species of the genus. Nevertheless, all the specimens which clearly match the rather precise description done by Pocock (1889) have exclusively been collected in the Central Highlands of the island. The material originally collected by Rev. Baron, used for the description of *G. limbatus*, was most certainly found in the Central Highlands, probably in the vicinity of Antananarivo or Fianarantsoa.

Material and methods

Illustrations and measurements were produced using a Wild M5 stereo-microscope with a drawing tube (camera lucida) and an ocular micrometer. Measurements follow Stahnke (1970) and are given in mm. Trichobothrial notations follow Vachon (1974) and morphological terminology mostly follows Hjelle (1990).

Specimens used in this taxonomic work come from the California Academy of Sciences, San Francisco (CAS), and are in part now deposited also in the Muséum national d'Histoire naturelle, Paris (MNHN).

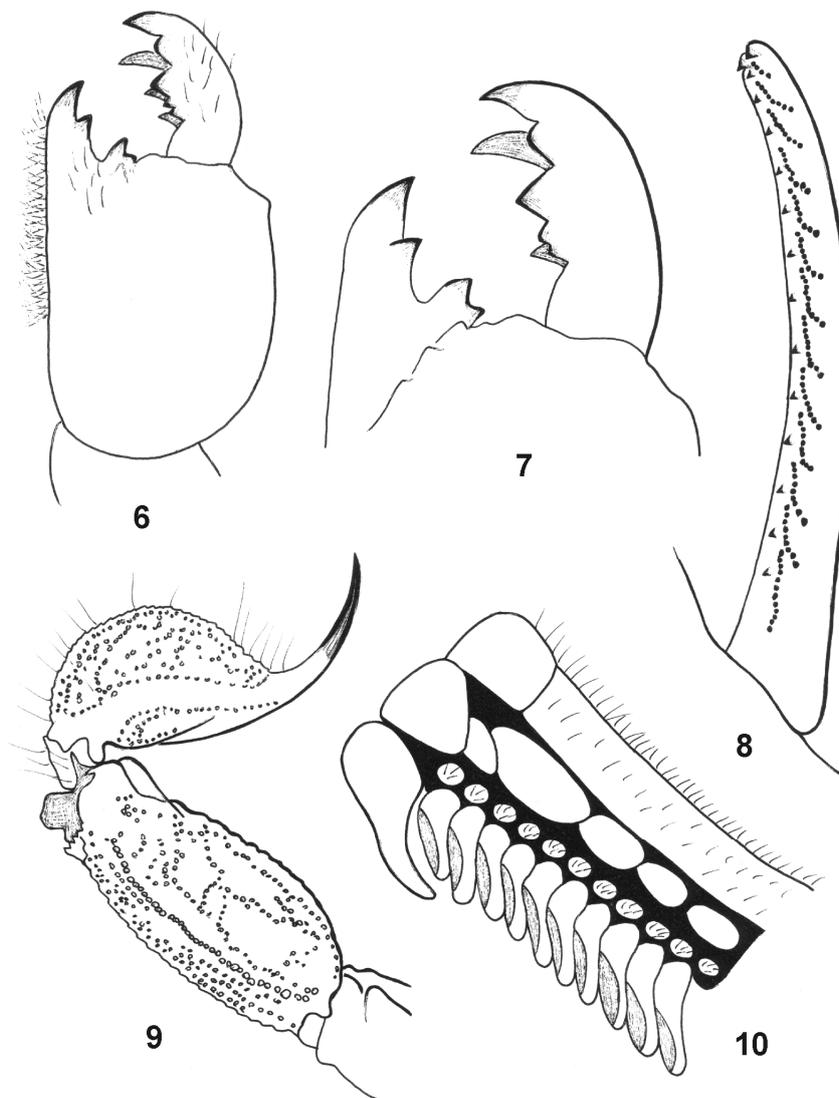


Fig. 6-10. *Grosphus makay* sp. n., female holotype. 6-7. Chelicera, dorsal aspect. 8. Cutting edge of chelal movable finger, showing rows of granules. 9. Metasomal segment V and telson, lateral aspect. 10. Proximal region of pecten, showing the shape of middle basal lamella.

Taxonomic treatment

Family Hormuridae Laurie, 1896

Genus *Opisthacanthus* Peters, 1861

Opisthacanthus sp.

Madagascar, Region Atsimo-Andrefana, ex Province of Toliara, Makay Mts. (21.34109°S– - 45.18054° E), 28/XI/2010 (B. L. Fisher *et al.*), 500 m, Barren Rock with sparse vegetation, burned grass, scorpion under stone. One second instar juvenile, possibly *Opisthacanthus madagascariensis* Kraepelin, 1894. BLF25342 (CAS).

Family Buthidae C. L. Koch, 1837

Genus *Tityobuthus* Pocock, 1893

Tityobuthus petrae Lourenço, 1996

MATERIAL. Madagascar, Region Atsimo-Andrefana, ex Province of Toliara, Makay Mts.

Misc, Ground Forager(s), 25/XI/2010, Base Makay 03 500, Gallery forest on sandy soil (B. L. Fisher *et al.*), 1 female. BLF25278 (CAS). Sifted litter, 10 MaxiWinks, mixed sam-

ples, 12/03/2010, Dry forest on sandy soil (B. L. Fisher *et al.*), 8 juveniles. BLF25548 (CAS). Sifted litter, 10 MaxiWinks, mixed samples, 27/XI/2010, Base Makay 08 525, Gallery forest on sandy soil (B. L. Fisher *et al.*), 1 male, 1 juvenile. BLF25359 (MNHN).

Genus *Grosphus* Simon, 1880

Grosphus makay sp. n.

Fig. 1-10, 13-14.

MATERIAL. Madagascar, Region Atsimo-Andrefana, ex Province of Toliara, Makay Mts., General Collection, dry-Forest on sandy soil, 12/III/2010 (B.L. Fisher *et al.*). BLF 25549. Female holotype (CAS), 1 female paratype (CAS), 1 female paratype (MNHN).

ETYMOLOGY: The specific name is a noun in apposition to the generic name and refers to the region where the new species was found, the Makay Mountains.

DIAGNOSIS (based on females): Scorpions of medium size with a total length of 56-57 mm. General coloration yellow to reddish-yellow heavily spotted with blackish-brown spots. Carinae and granulation moderately marked. Pectines with 25 to 28 teeth; fulcra conspicuous; basal middle lamellae of each pecten elongated and weakly curved, covering until the second tooth, widening on proximal half. Metasomal segments with 10-10-8-8-5 carinae; dorsal carinae without any conspicuous spinoid granules. Fixed and movable chelal fingers with 12/13 oblique rows of granules. Tibial spurs strongly marked on legs III and IV.

AFFINITIES: Several morphological characters indicate that *G. makay* sp. n. is closely related to *Grosphus limbatus* (Pocock, 1889), a species distributed only on the Central Mountain range of Madagascar. The new species can, however, be distinguished from *G. bistratus* by a distinct pattern of pigmentation, and in particular by: (i) an incomplete inverted black triangle on the anterior zone of the carapace; (ii) longitudinal blackish strip over tergites enlarged, strongly marked and divided medially; (iii) metasomal segment V and telson dark brown to blackish (iii) anterior edge of chelicerae with a blackish variegated zone; (iv) legs marbled with diffused blackish spots; (v) pectines longer but narrower than those of *G. limbatus*; (vi) basal middle lamellae, shorter than that of *G. limbatus*.

DESCRIPTION based on female holotype and female paratypes. Measurements following the description.

Coloration. Yellow to reddish-yellow. Prosoma: carapace yellow with the presence of one inverted black triangle on the anterior zone of the carapace, from the lateral eyes to the median eyes; no spotted zone over the posterior furrow; eyes surrounded by black pigment. Mesosoma: yellow with one dark strip, divided medially and ranging from the posterior edge of carapace to the anterior edge of tergite VII; spots slightly confluent on tergites I-VI. Metasomal segments I-IV reddish-yellow; V dark-brown to blackish; all segments with ventral and latero-ventral carinae spotted with blackish. Telson blackish-brown; aculeus with reddish-yellow base and dark-brown tip. Venter: coxapophysis, sternum, genital operculum, pectines and sternites yellow; VII with carinae marked with blackish. Chelicerae reddish-yellow with dark variegated pigmentation on the anterior edge, just behind fingers; fingers yellow; teeth reddish-brown. Pedipalps: reddish-yellow; femur and patella marbled with brownish spots; cutting edges of chela fingers with blackish rows of granules. Legs yellowish marbled with diffused blackish spots.

Morphology. Carapace covered with a thin but intense granulation; anterior margin almost straight, with a very weak median concavity. All carinae weak; furrows moderately to strongly developed. Median ocular tubercle anterior to the centre of carapace; median eyes separated by one and half ocular diameter. Three pairs of lateral eyes. Sternum sub-triangular in shape. Mesosoma: tergites with moderately marked granulation. Median carina moderately developed in tergites II-VI, absent from I. Tergite VII pentacarinat. Venter: genital operculum consisting of two semi-oval plates. Pectines: pectinal tooth count 28-27 (holotype), 25-26 and 27-26 (paratypes); fulcra conspicuous; basal middle lamellae of each pecten elongated and weakly curved, covering until the second tooth, widening on proximal half.

Sternites smooth, with moderately elongated spiracles; VII with four weak to moderate carinae. Metasomal segments I and II with 10 carinae, moderately crenulate; segment III-IV with 8 carinae, moderately crenulate. Segment V with 5 carinae. Dorsal carinae on segments II to IV without any conspicuous spinoid granules. Intercarinal spaces moderately granular. Telson moderately to strongly granular over latero-ventral and ventral surfaces; its dorsal surface smooth; aculeus moderately curved and shorter than the vesicle; subaculear tooth absent. Cheliceral dentition characteristic of the family Buthidae (Vachon, 1963); two distinct basal teeth present on the movable finger; ventral aspect of both fingers and of manus with dense, long setae. Pedipalps: femur pentacarinat; patella with dorsointernal and ventral-internal carinae and with some strong spinoid granules on the internal face; chela smooth, without carinae. Fixed and movable fingers with 12/13 oblique rows of granules. Trichobothriotaxy; orthobothriotaxy A- α (Vachon, 1974, 1975). Legs: tarsus with numerous short thin setae ventrally. Tibial spurs present on legs III and IV; pedal spurs present on legs I to IV; all spurs strong.

Morphometric values (in mm) of female holotype. Total length (including telson) 56.4. Carapace: length 6.0; anterior width 4.6; posterior width 7.4. Mesosoma length 16.6. Metasomal segment I: length 4.2, width 4.0; II: length 4.8, width 3.8; III: length 5.1, width 3.7; IV: length 5.5, width 3.6; V: length 6.6, width 3.6, depth 3.3. Telson length 7.6. Vesicle: width 3.4, depth 3.2. Pedipalp: femur length 5.2, width 1.6; patella length 6.0, width 2.5; chela length 9.5, width 2.7, depth 2.5; movable finger length 5.7.

Biogeographic considerations

Grosphus makay type and only known locality is found in the upper portion of the subwatershed of the Makay river, a lower tributary of the Mangoky river, above a sandy duricrust (Fig. 15). As such, *Grosphus makay* sp. n. does not occur in the Central Menabe center of endemism, sensu Wilmé *et al.* (2012).

The Makay mountains of sandstone and red clay, are found in the lower subsequent depression, i.e., with rivers following the strike of the strata, bordering the eastern portion of the Central Menabe (Fig. 15). The Central Menabe is slightly inclined towards the west and is drained by several peneconsequent rivers, i.e., almost following the original slope of the land before erosion, with headwaters in the Makay massif. The Makay is dissected by a dense network of narrow and deep canyons where permanent, temporary, or groundwater flow. The mountains show steep slopes, steeper on the eastern side, and are the remnants of a Mesozoic larger massif which has been heavily eroded (Werding, 1971). The Makay culminates at Andranomita *Zohy Loharano* at an altitude of 1034 m, near the junction of three watersheds, namely the Morondava watershed of the Central Menabe, and the large watersheds of the Tsiribihina to the north, and the Mangoky to the south (Fig. 15). When compared to the peneconsequent rivers of the Central Menabe, the subsequent tributaries of the Tsiribihina and Mangoky rivers, to the east of the Makay, have a lower base level. This lower base, together with the steeper slopes on the east side of the Makay, give these tributaries a higher potential of erosion. Over time, they have decapitated the

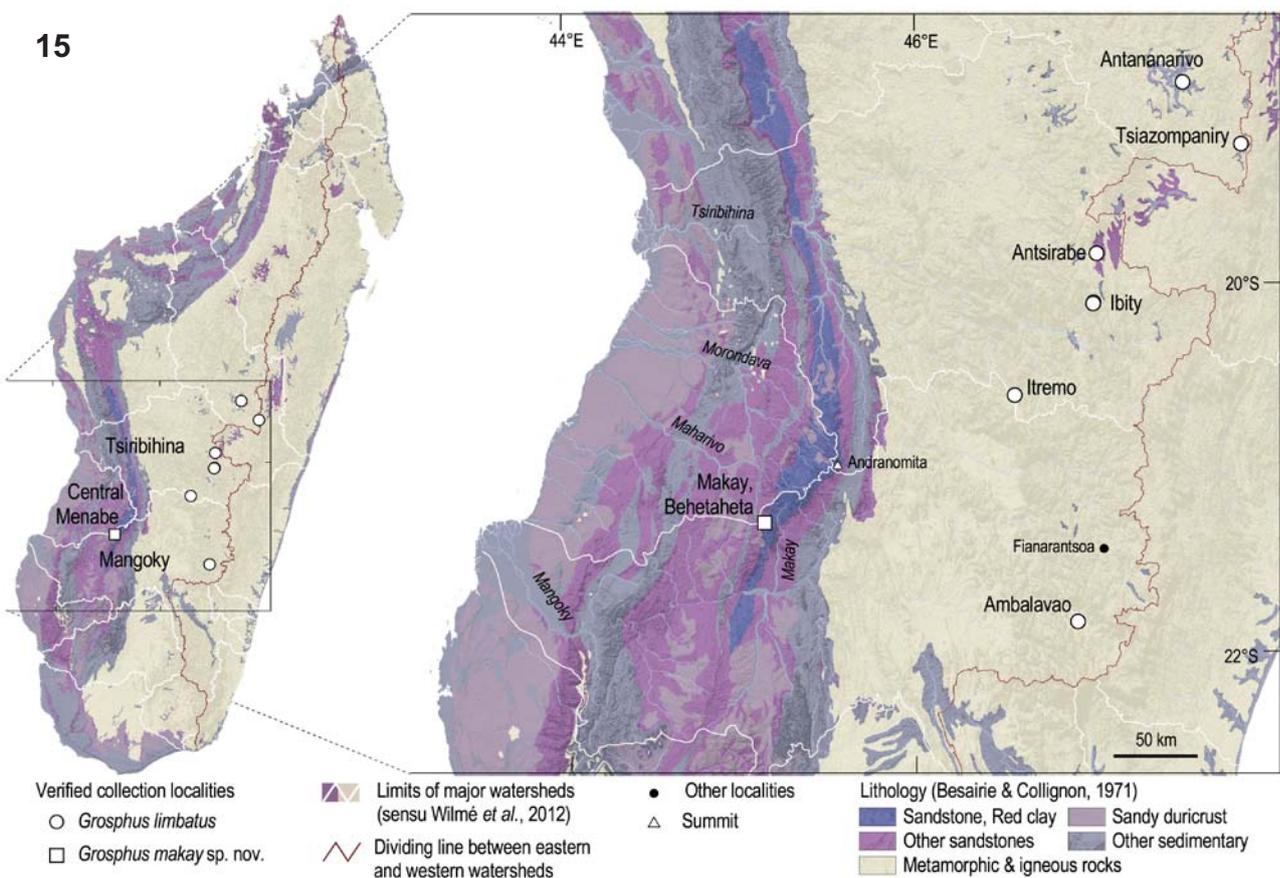
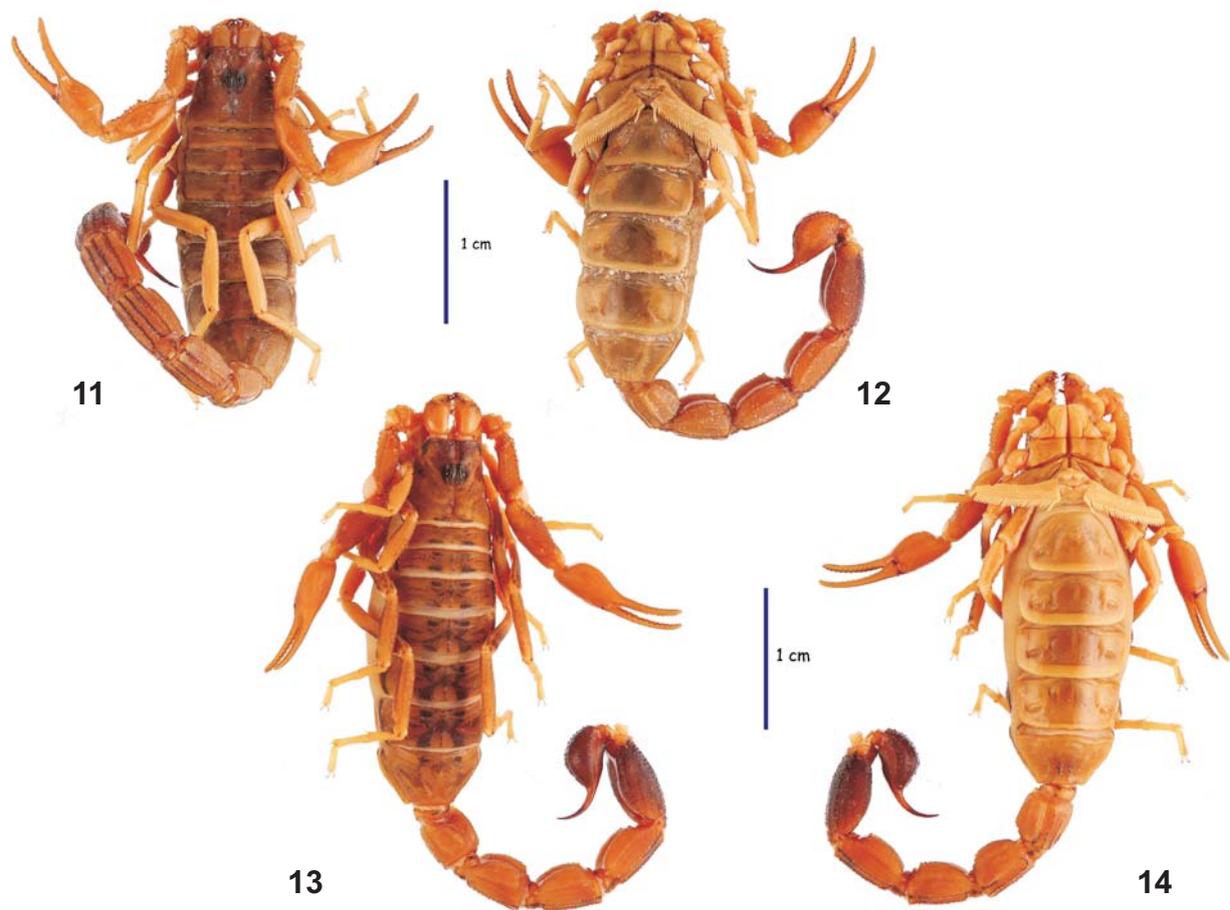


Fig. 11-12. *Grosphus limbatus*, female from Ibity. Habitus, dorsal and ventral aspects. **Fig. 13-14.** *Grosphus makay* sp. n., female paratype. Habitus, dorsal and ventral aspects. **Fig. 15.** Type locality of *Grosphus makay* sp. n. in western sedimentary formations, and collection localities of *Grosphus limbatus* on the central highlands.

Central Menabe river systems, therefore depleting the watersheds of the Morondava and Maharivo (Werding, 1971). As the Makay mountains have been eroded over time, the upper portion of the Central Menabe were captured by the two large river systems of the Tsiribihina and Mangoky.

Nowadays, the type locality of *Grosphus makay* sp. n. lies to the west of the Makay river, in an area which was drained by the Maharivo river system in the past. As such, the population of *G. makay* sp. n. may illustrate a typical micro endemic case of the Central Menabe, with a population which may have been isolated during Plio-Quaternary paleoclimate oscillations, for example in a refugium, sensu Mercier & Wilmé (2013) amongst the residual reliefs of the upper Central Menabe. The population of *G. makay* sp. n. may have specialized in its refugium, or more likely, a sub-population of *G. makay* sp. n. may have survived in isolation, in a residual relief in the Central Menabe, whereas the remaining population went extinct from former range. Nowadays, the narrow valleys of the Makay harbor humid and subhumid forests (Moat & Smith, 2007; Waeber *et al.*, 2015), contrasting with otherwise drier types of vegetation found in the area. The vegetation has changed over time, also during the paleoclimate oscillations, but it presumably remained almost stable in the so-called tropical refugia, i.e., in places where the hydrological balance remained positive, also during the driest events of the paleoclimate oscillations (Mercier & Wilmé, 2013).

Grosphus limbatus occurs at several locations on the metamorphic highlands (Fig. 15), in the upper portions of the watersheds of the Mangoky and Tsiribihina. These rivers with headwaters on the central highlands do benefit from orographic rainfall, and are therefore able to maintain riparian vegetation even during the driest events of the paleoclimate oscillations, at least in the middle portion of their courses. With increasing rainfall during wetter climatic periods, the various tributaries reconnected to the system also at higher elevation. Taxa encountered within such watersheds typically have wide ranges, as compared to micro-endemic taxa usually encountered in the centers of endemism defined within the Eco-Geo-Clim model (Mercier & Wilmé, 2013).

While several species are endemic to the forests of the lower portion of the Central Menabe, such as the lemur *Micromys berthae*, or the Giant jumping rat *Hypogeomys antimena*, *Grosphus makay* sp. n. is the first scorpion species endemic to the upper portion of the Central Menabe, while its sister species is typically located in the upper portion of the large watersheds of Tsiribihina and Mangoky (Fig. 15).

Acknowledgements

We are most grateful to Brian L. Fisher and Michelle Esposito (California Academy of Sciences) for arranging facilities to the study of the Makay material. To Elise-Anne Leguin (MNHN) for her assistance with the preparation of the photos and plates. Jean-Luc Mercier for advice on the geomorphology and biogeographical aspects, and Patrick Waeber for suggestions.

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