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ONE MORE VICARIANT NEW SPECIES OF *GROSPHUS* SIMON, 1880 (SCORPIONES: BUTHIDAE) FROM MADAGASCAR

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Abstract: A new species, associated with *Grosphus annulatus* Fage, 1929, is described from the Ankarana Massif in the north of Madagascar. Some comments on biogeographical aspects linking the new species with its possible vicariant are also included.
Key words: Scorpiones, Buthidae, *Grosphus*, new species, vicariance, Madagascar.

Una especie nueva vicariante de *Grosphus* Simon, 1880 (Scorpiones: Buthidae) de Madagascar
Resumen: Se describe una nueva especie, asociada con *Grosphus annulatus* Fage, 1929, del Macizo de Ankarana en el norte de Madagascar. Se realizan algunos comentarios sobre los aspectos biogeográficos que vinculan la nueva especie con su posible especie vicariante.
Palabras clave: Scorpiones, Buthidae, *Grosphus*, especie nueva, vicarianza, Madagascar.

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

Introduction

As already outlined in recent papers (Lourenço & Wilmé, 2015a, b, 2016), a considerable number of new species have been added to the genus *Grosphus* Simon, in recent years. Among these cases, some of the recently described species showed some clear associations with other members of this genus, some described more than 100 years ago. Moreover, in a number of cases these new species proved to be vicariant elements to species already known, but with quite distinct ranges of distribution. Based on several studies from the last 20 years, it was clearly demonstrated that the taxonomy of the genus *Grosphus* is notably complicated, particularly aspects of species' delimitations. Since the taxonomic history and the geographic patterns of distribution of this genus have already been the subject of detailed discussion in previous papers (Lourenço & Wilmé, 2015a, b, 2016), these will not be treated here again.

In the present note we confirm the status of new species for one specimen of *Grosphus* from the Ankarana Massif, already cited in another study about the genus *Neogrosphus* (Lourenço, Wilmé & Waeber, 2015). The new species is described here.

Material and methods

Material related with the new species is now deposited in Muséum national d'Histoire naturelle, Paris. Illustrations and measurements were produced using a Wild M5 stereomicroscope with a drawing tube and an ocular micrometer. Measurements follow Stahnke (1970) and are given in mm. Trichobothrial notations follow Vachon (1974) and morphological terminology is after Vachon (1952) and Hjelle (1990).

Taxonomic treatment

Family **BUTHIDAE** C. L. Koch, 1837

Genus ***Grosphus*** Simon, 1880

***Grosphus annulatus* Fage, 1929**

Grosphus annulatus was originally described by Fage (1929) only as a variety, as *G. limbatus annulata*. More detailed studies indicated that it was necessary to elevate this form to the rank of species (Lourenço, 1996). *Grosphus annulatus* is a species of small to moderate size, with males and females 36 and 46 mm in total length, respectively. It can be easily distinguished from *G. limbatus* (Pocock, 1889) by a characteristic pigmentation pattern − the carapace and tergites are extensively yellowish, but the metasomal segments IV and V are markedly blackish. *Grosphus limbatus* and *G. annulatus* show notable shape differences in the basal middle lamellae of the female pectines.

Based on pigmentation patterns, *G. annulatus* is probably closely related to *G. olgae* Lourenço, 2004 described from South-western Madagascar. These species can, however, be distinguished from one another based on the shape of basal middle lamellae of the female pectines, and distinct shape differences in the telson. In *G. annulatus*, the vesicle is strongly globular and longer than the aculeus, while in *G. olgae*, the vesicle is weakly globular and shorter than the aculeus. Given all of the fieldwork conducted in South-western Madagascar, it is rather remarkable that *G. annulatus* is only known from the original type locality of 'Province Tuléar [=Toliara], Sarodrano' (Fage, 1929). The coastal sand dune habitat surrounding the Sarodrano area has not been the subject of a recent inventory using pit-fall traps and perhaps this taxon has very specific ecological requirements. Fresh material will be needed for molecular studies to resolve the relationships of this species.

Fig. 1-2. *Grosphus ganzhorni* **sp. n.** Female holotype. Habitus, dorsal and ventral aspects.

***Grosphus ganzhorni* sp. n.** (Fig. 1-5, 7-11).
Grosphus sp. Lourenço, Wilmé & Waeber, 2015: 771.

Type material. Female holotype. Madagascar, ex-Province d'Antsiranana, Région de DIANA, Ankarana Massif, near Andrafiabe cave, IX/2001 (local people to W. R. Lourenço). Holotype deposited in the Muséum national d'Histoire naturelle, RS.

Etymology: The specific name honours Professor Joerg U. Ganzhorn (University of Hamburg, Germany) for his breadth and creativity in ecological and zoological research and commitment and endurance to the conservation of the endemic biodiversity of Madagascar.

Diagnosis: A scorpion of medium size (total length of 41.4 mm) in relation to other species within the genus. General coloration yellow to reddish-yellow without darker zones on body and appendages. Anterior margin of carapace almost smooth. Pectines with 28-25 teeth; basal middle lamellae of each pecten strongly dilated in female and covering the first three proximal teeth. Metasomal segments I and II with 10 carinae; intermediate carinae incomplete on segment II; III and IV with 8 carinae. Femur and patella of pedipalps with moderately spinoid carinae. Fixed and movable fingers of pedipalps with 13-13 oblique rows of granules respectively. Trichobothriotaxy, orthobothriotaxy, type A-α (alpha).

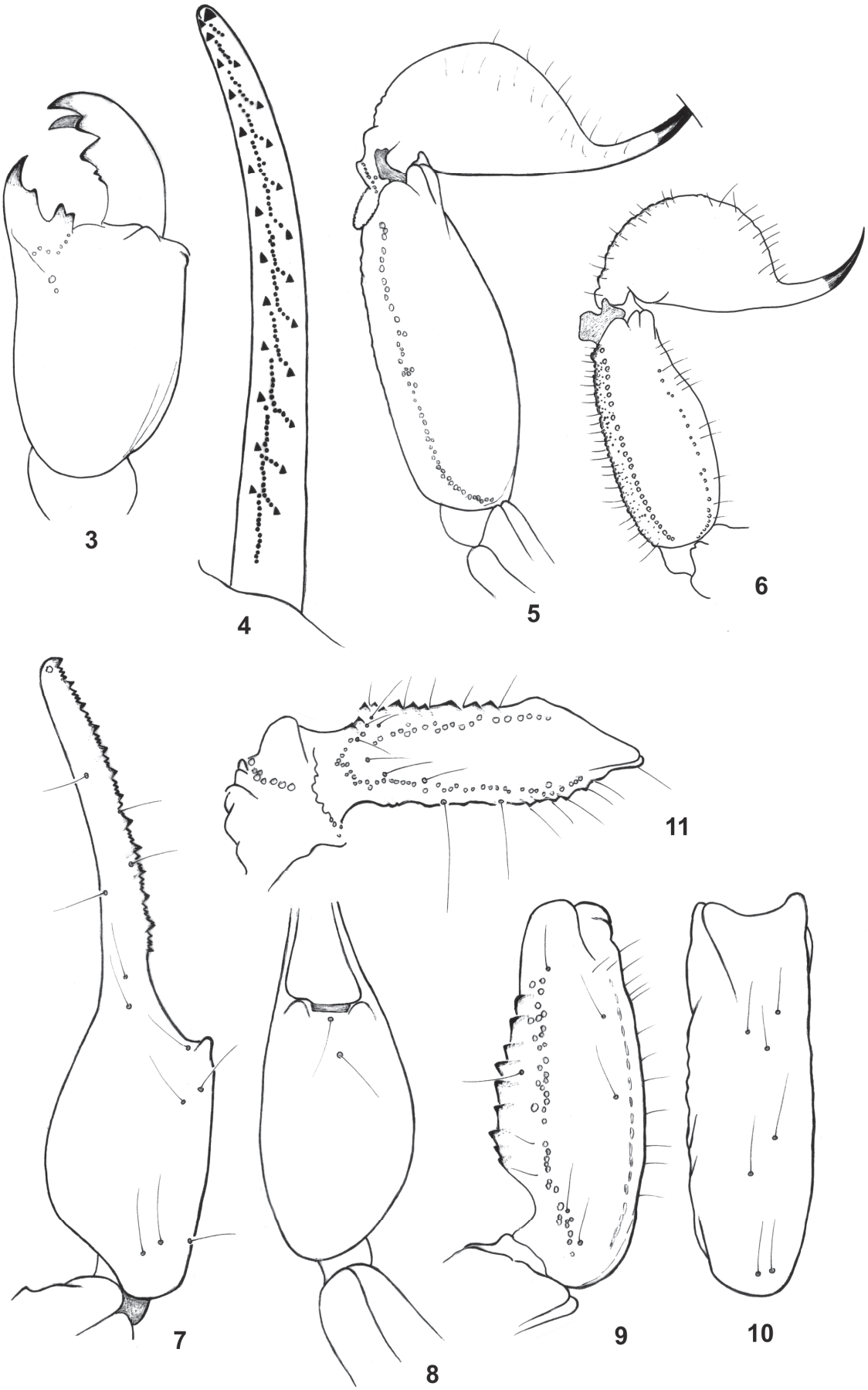

Fig. 3-5. *Grosphus ganzhorni* sp. n. Female holotype. **3**. Chelicera, dorsal aspect. **4**. Cutting edge of movable finger. **5**. Metasomal segment V and telson, lateral aspect. **6**. Idem, *Grosphus annulatus*, female lectotype. **Fig. 7-11.** *Grosphus ganzhorni* sp. n. Female holotype. Trichobothrial pattern. **7-8**. Chela, dorso-external and ventral aspects. **9-10**. Patella, dorsal and external aspects. **11**. Femur, dorsal aspect.

RELATIONSHIPS: The general morphology and pigmentation pattern of the new species shows it to be close to *Grosphus annulatus* Fage, 1929, species distributed in the South-western region of Madagascar (see biogeographic section). Both species are similar but can be distinguished by the following characters: (i) the new species show a paler coloration and have not the dark ring on metasomal segment V, (ii) cutting edges of pedipalp fingers with 13-13 rows of granules in the new species vs. 11-11 or 11-12 in *G. annulatus*, (iii) In *G. annulatus*, the vesicle is strongly globular and longer than the aculeus, while in the new species the vesicle has about the same length of the aculeus.

DESCRIPTION BASED ON FEMALE HOLOTYPE. Morphometric values following the description.

Coloration. Overall yellow to reddish-yellow without dark zones on the body and appendages. Prosoma: carapace yellow with an anterior slightly darker zone, approximately forming an inverted triangle; eyes surrounded by black pigment. Mesosoma yellow to reddish-yellow, slightly darker than carapace. Metasomal segments I to III yellowish; IV and V slightly reddish to reddish-yellow; V with some diffused reddish pigmentation. Telson pale red without spots; aculeus reddish. Venter: coxapophysis, sternum, genital operculum pectines and sternites yellow to pale yellow. Chelicerae yellow without any variegated pigmentation; fingers with reddish teeth. Pedipalps yellow with some carinae and rows of granules on chela fingers reddish. Legs pale yellow; carinae with slightly reddish zones.

Morphology. Carapace weakly granular; anterior triangular zone almost smooth; anterior margin with a median concavity. All carinae weak; furrows moderately to weakly developed. Median ocular tubercle anterior to the centre of the carapace; median eyes large and separated by a little more than one ocular diameter. Three pairs of lateral eyes. Sternum sub-triangular in shape. Mesosomal tergites with thin granulations, almost smooth. Median carina moderately to weakly marked in all tergites. Tergite VII pentacarinate. Venter: genital operculum consisting of two suboval plates. Pectines: pectinal teeth count 28-25; basal middle lamellae of each pecten strongly dilated and covering the first three proximal teeth. Sternites smooth, with elongated stigmata; VII without carinae. Metasomal segments I and II with 10 carinae, moderately crenulated; intermediate carinae incomplete on II. Segments III and IV with 8 carinae, moderately crenulate. Segment V with 5 carinae. Dorsal carinae on segments I to III with a minute posterior spinoid granule. Intercarinal spaces weakly granular to smooth. Telson smooth; aculeus weakly curved and with the same length as 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 pentacarinate with moderate spinoid carinae; patella with dorsal, dorsointernal and dorsoexternal carinae and with several spinoid granules on the internal face; chela without carinae and globally smooth. Fixed and movable fingers with 13-13 oblique rows of granules respectively. Trichobothriotaxy; orthobothriotaxy A-α (alpha) (Vachon, 1974, 1975). Legs: tarsus with numerous short thin setae ventrally, forming a brush. Tibial spurs present on legs III and IV, thin and long; pedal spurs present on legs I to IV, moderate to strong.

Morphometric values (in mm). Total length (including telson), 41.4. Carapace: length, 4.8; anterior width, 3.8; posterior width, 6.0. Mesosoma length, 9.4. Metasomal segments. I: length, 3.4; width, 3.0; II: length, 3.8; width, 2.7; III: length, 4.0; width, 2.7; IV: length, 4.8; width, 2.6; V: length, 5.8; width, 2.5; depth, 2.3. Telson length, 5.4. Vesicle: width, 2.2; depth, 2.3. Pedipalp: femur length, 4.2, width, 1.3; patella length, 5.0, width, 2.0; chela length, 8.4, width, 2.0, depth, 2.0; movable finger length, 5.5.

MALE unknown.

Biogeographic considerations

Grosphus ganzhorni sp. n. is only known from its type locality in the Special Reserve of Ankarana, in the vicinity of Andrafiabe cave (Fig. 12). Northern Madagascar, or the so-called Diego sedimentary basin, is a complex of sedimentary, igneous and volcanic formations. The quaternary volcano Montagne d'Ambre is covered with rain forests and the limestone plateau of Ankarana and Analamerana harbors mainly dry forests, but sub-humid and humid forests occur in some valleys of the Ankarana. Beyond the cliff of Andrafiamena limiting the limestone plateau, the sandstone Andavakoera are also covered with dry forests (Fig. 12). The metamorphic formations to the south, in the region of Daraina present a mosaic of grasslands, dry forests and rainforests that are home to a distinct scorpion fauna (Lourenço, 2006). The extended cave system of more than 100 km of the Ankarana has revealed fossil bones of extinct lemurs but also living species whose distribution is currently limited to the rainforests of the east, as *Indri indri* or *Prolemur simus* (Godfrey et al., 1996). Bones attributed to *P. simus* have been found in a cave near Andrafiabe and bear an age of 4560 ± 70 yr BP (Simons *et al*., 1995). The fossil records of Ankarana point towards more humid conditions near the type locality of *Grosphus ganzhorni* sp. n. It is interesting to note that the new species is sympatric with the unrelated *G. ankarana*. Such cases of co-occurrences of two species at a site are not uncommon in the genus *Grosphus* which occurs mainly in the dry and spiny forests of western and southern Madagascar (see Lourenço & Wilmé, 2016: Figure 36).

During the Pliocene (5.3–2.6 Ma), climate became cooler and drier, with high frequency and low-amplitude paleoclimate oscillations. The Quaternary, with the Pleistocene and Holocene epochs, has been characterized by low frequency and high amplitude paleoclimate oscillations, with alternating warm and cold periods at higher latitudes, and wet and dry periods at lower latitudes. During the dry periods of the Quaternary, the equivalent sea level dropped to a minimum of -134 m during the recent Last Glacial Maximum at ca. 21 ka (Lambeck *et al*., 2014). Madagascar experienced a major tectonic phase during the Pliocene, and an increase in volcanic activity in several parts of Madagascar, which continued into the Quaternary in Montagne d'Ambre (Bardintzeff *et al*., 2010). Northern Madagascar has also entered the intense monsoon system during the Pliocene. This lead to increased rain in the Sambirano region due to its local topography (Wells, 2007). In Northern Madagascar, the environment has changed rapidly but several areas were certainly able to maintain some humidity and act as refugia during the driest periods, for example river valleys or caves (Mercier & Wilmé, 2013). Several geological and climatic processes occur-

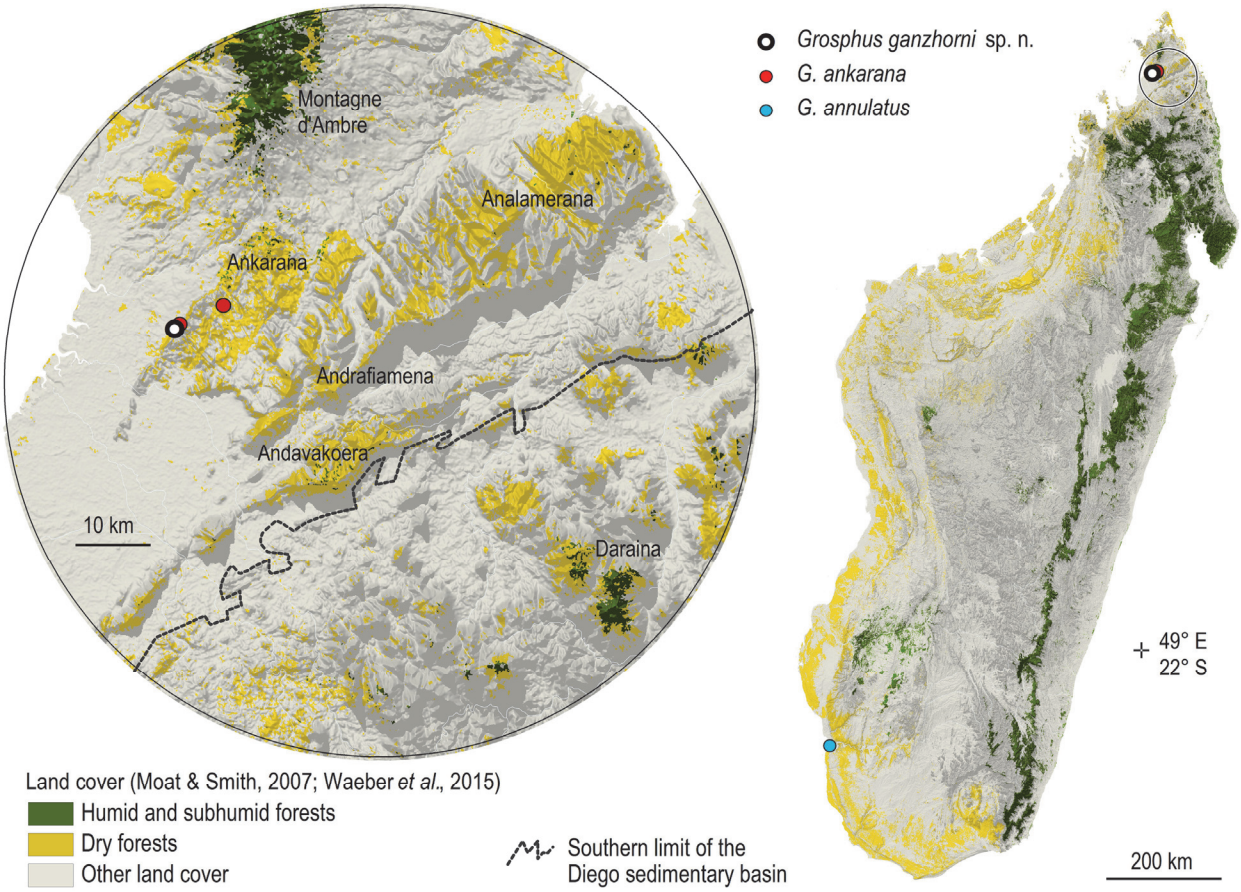

Fig. 12. Collection localities of *Grosphus ganzhorni* sp. n. and *G. annulatus*, according to land cover (right). Insets of northern Madagascar with the collection localities of *Grosphus ganzhorni* sp. n. and *G. ankarana*.

ring in the region together with the paleoclimate oscillations would have influenced the distribution of several taxa, at different spatial and temporal scales depending on their dispersal abilities, and tolerance to environmental change. The distribution of the new species follows patterns of the *Neogrosphus* rule (Lourenço *et al*., 2015, 2016): the lower the species' dispersal ability and the greater the niche breadth of the ancestor taxon, the higher the species richness in a changing environment producing geographical barriers, and vice-versa. When considering the scorpions' limited dispersal abilities in a 'rapidly' changing environment at the time scale of scorpion evolution, the species diversity of the genus *Grosphus* in Northern Madagascar points towards a great niche breadth of the ancestor taxon of the new species described here.

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