Revista Ibérica de Aracnología, nº **32** (30/06/2018): 73–80.
Grupo Ibérico de Aracnología (S.E.A.). ISSN: 1576 - 9518.

TWO MORE NEW SPECIES OF *GROSPHUS* SIMON, 1880, ASSOCIATED TO THE '*GROSPHUS SIMONI* GROUP' (SCORPIONES: BUTHIDAE) FROM THE REGIONS OF THE TSINGY DE BEMARAHA AND MONTAGNE D'AMBRE (MADAGASCAR)

Wilson R. Lourenço[1], Lucienne Wilmé[2] & Patrick O. Waeber[3]

[1] Muséum national d'Histoire naturelle, Sorbonne Universités, Institut de Systématique, Evolution, Biodiversité (ISYEB), UMR7205-CNRS, MNHN, UPMC, EPHE, CP 53, 57 rue Cuvier, 75005 Paris, France: e-mail: wilson.lourenco@mnhn.fr
[2] Missouri Botanical Garden, Madagascar Research & Conservation Program, BP 3391, Antananarivo 101, Madagascar: lucienne.wilme@mobot-mg.org
[3] ETH Zurich, Department of ITES, Forest Management and Development (ForDev) Group, Universitätstrasse 16, 8092 Zurich, Switzerland: email: patrick.waeber@usys.ethz.ch

Abstract: The recent reanalysis of the type material of *Grosphus simoni* Lourenço, Goodman & Ramilijaona, 2004, along with new material of this species from north-eastern Madagascar, has led to a new diagnosis of *G. simoni* and the description of two associated new species. A more recent analysis of two isolated specimens collected in the Tsingy de Bemaraha and on Montagne d'Ambre, allow the characterisation of yet two new species, once again associated to the '*Grosphus simoni*' species group. These are herein described. What is known about the biogeography of this species group seems to suggest that its species have adapted to humid, dry and subarid environments; the populations encountered in the north, west and south may belong to relict populations which have survived extreme events in humid refugia during the dry episodes of the paleoclimate oscillations. The new species described here also suggest that the intense volcanic activity occurring at the end of the Cenozoic when central Madagascar was uplifted had an influence on the current distribution of the species belonging to the '*Grosphus simoni*' group.
Key words: Scorpiones, Buthidae, *Grosphus simoni* group*,* new species, Cenozoic volcanism, Quaternary refugia, Madagascar.

Otras dos especies nuevas de *Grosphus* Simon, 1880, asociadas al "grupo *Grosphus simoni*" (Scorpiones: Buthidae), de las regiones del Tsingy de Bemaraha y la Montagne d'Ambre (Madagascar)
Resumen: Un reciente reanálisis del material tipo de *Grosphus simoni* Lourenço, Goodman & Ramilijaona, 2004, junto con material nuevo de esta especie procedente del noreste de Madagascar, ha llevado a una nueva diagnosis de *G. simoni* y a la descripción de dos especies nuevas asociadas. Un análisis más reciente de dos especímenes aislados recogidos en el Tsingy de Bemaraha y en la Montagne d'Ambre permite la caracterización de otras dos especies nuevas, también asociadas al grupo de especies '*Grosphus simoni*'. Éstas se describen aquí. Los datos disponibles sobre la biogeografía de este grupo de especies parece sugerir que sus especies están adaptadas a medios húmedos, secos y subáridos; las poblaciones encontradas en el norte, oeste y sur puede que pertenezcan a núcleos relictas que han sobrevivido a acontecimientos extremos en refugios húmedos durante los episodios secos de las oscilaciones paleoclimáticas. Las especies nuevas aquí descritas también sugieren que la intensa actividad volcánica ocurrida al final del Cenozoico, cuando se elevó el centro de Madagascar, tuvo su influencia en la distribución actual de las especies pertenecientes al grupo '*Grosphus simoni*'.
Palabras clave: Scorpiones, Buthidae, grupo *Grosphus simoni*, especies nuevas, vulcanismo cenozoico, refugios cuaternarios, Madagascar.

Taxonomy / Taxonomía: *Grosphus bemaraha* **sp. n.,** *Grosphus ambre* **sp. n.**

Introduction

As already outlined in previous publications (Lourenço, 2014; Lourenço & Wilmé, 2015a,b, 2016; Lourenço *et al*., 2016a), and in particular in our recent paper about the *Grosphus* species associated to the '*Grosphus simoni*' group of species (Lourenço *et al*., 2017), attention was called to the considerable number of new species which have been added to the genus *Grosphus* Simon in recent years (Fig. 1-Map). One of the most reasonable explanations for this is the presence of numerous 'sibling' or vicariant species within this genus. Several of the recently described species showed some strong associations with other members of this genus that in some cases have been previously described. It is well accepted now that the taxonomy of *Grosphus*, one of the most relevant buthid genera endemic to Madagascar, is notably complicated, in particular concerning aspects of species' delimitations. For a more detailed discussion about the characters used in the taxonomy of *Grosphus*, see Lourenço (2014), Lourenço & Wilmé (2015a,b), Lourenço *et al*. (2016a, 2017).

The most recent example, which attested the complexity of the *Grosphus* populations was the description of *Grosphus simoni*, based on two male specimens collected in two totally distinct localities (Lourenço *et al*., 2004, 2017). The first site is located in a typical humid forest while the second is located in dry open formations. At the time of the description of the species, the status of the western specimen was unclear but a final decision could not be made due to lack of sufficient material. The study of a more abundant material related to *Grosphus simoni* led to the clarification of the status of the original material and the description of two new species associated to *G. simoni* (Lourenço *et al*., 2017). A recent analysis of two isolated specimens collected in the Tsingy of Bemaraha and on the Montagne d'Ambre, respectively, led to the characterisation of two further new species also associated to the '*Grosphus simoni*' group of species. These are described at present. Some biogeographical comments on the type localities of the new species are provided, as well as on the distribution of the species belonging to the '*Grosphus simoni* group'.

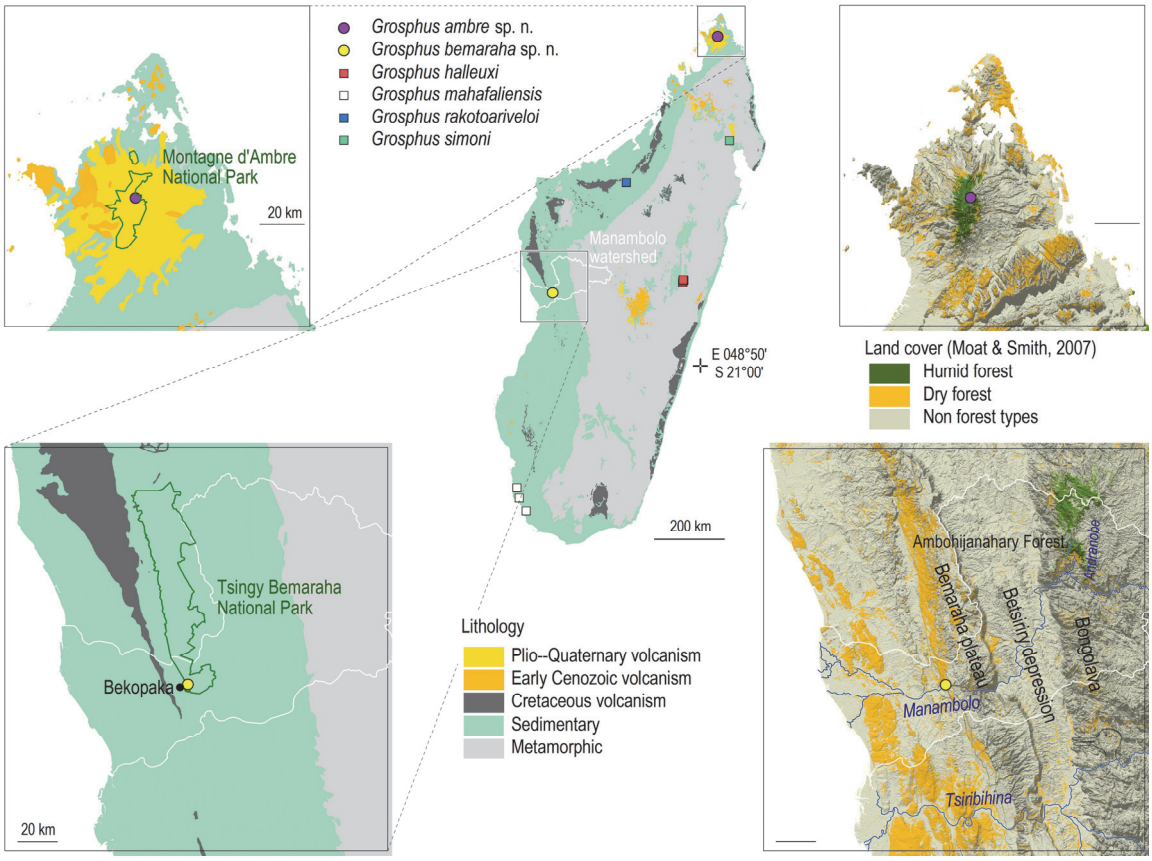


Fig. 1. Distribution of the sister species in the '*Grosphus simoni*' group.

Methods

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

Species considered in the present study

Grosphus simoni Lourenço, Goodman & Ramilijaona, 2004
Grosphus rakotoariveloi Lourenço, Wilmé, Soarimalala & Waeber, 2017
Grosphus halleuxi Lourenço, Wilmé, Soarimalala & Waeber, 2017
Grosphus mahafaliensis Lourenço, Goodman & Ramilijaona, 2004 (Fig. 2-5)

***Grosphus bemaraha* sp. n.**
Fig. 6-15.

Madagascar, ex-Province of Mahajanga, Region of Melaky, NE Bekopaka, Tsingy Bemaraha, (dry-forest), 160 m, X/1972 (J.-M. Betsch – RCP-225): 1 male holotype deposited in the Muséum national d'Histoire naturelle, Paris (MNHN-RS-9115).

ETYMOLOGY: The specific name refers to the Bemaraha Tsingy, region where the new species was found.

DIAGNOSIS: Scorpions of medium size in relation to the average size of the species in the genus, with a total length of 65.3 mm for the male. General coloration reddish-yellow to dark brown. Metasomal granulations moderately marked; dorsal carinae moderately to strongly marked, with a few spinoid granules. Pectines with 29-30 teeth. Cutting edges of chela fingers with 13-14 rows of granules. Chela with a weakly marked scalloping of the proximal dentate margin of fixed finger. Internal carinae of femur and patella of pedipalps with spinoid granules.

RELATIONSHIPS.
By a number of features, such as spinoid granules on the dorsal carinae of metasomal segments II-IV and on internal carinae of pedipalp femur and patella, the new species can be associated to the '*Grosphus simoni* group'. It can also be associated to *Grosphus mahafaliensis* by the high number of teeth on the pectines. The distance between the collection localities of these two species is succeeding 560 km in a direct line (Fig. 1), suggesting that new species in the '*Grosphus simoni* group' may be discovered in western Madagascar or that some species in the group may have been locally extirpated in the past. Among the species defined in the '*Grosphus simoni* group' by Lourenço *et al*. (2017) the new species appears closer to *Grosphus rakotoariveloi* Lourenço *et al*., 2017 which inhabits a dry-forest habitat, at a distance of at least 375 km in a direct line to the northwest of the new species described (Fig. 1).

The characters in the following table I define the major differences among males of these three species.

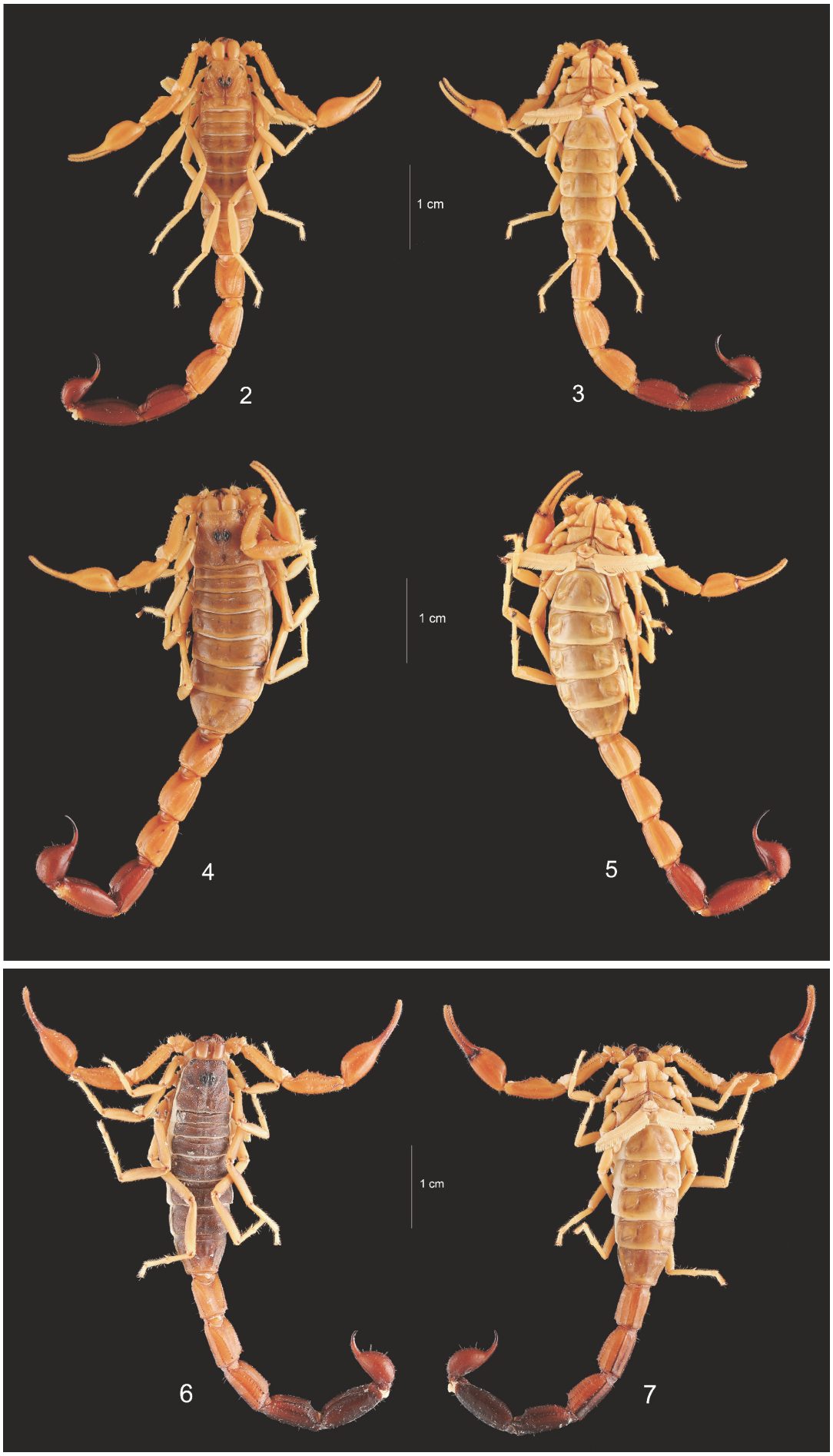


Fig. 2-5. *Grosphus mahafaliensis* male and female from Itampolo. Habitus, dorsal and ventral aspects.
Fig. 6-7. *Grosphus bemaraha* sp. n. Male holotype. Habitus, dorsal and ventral aspects.

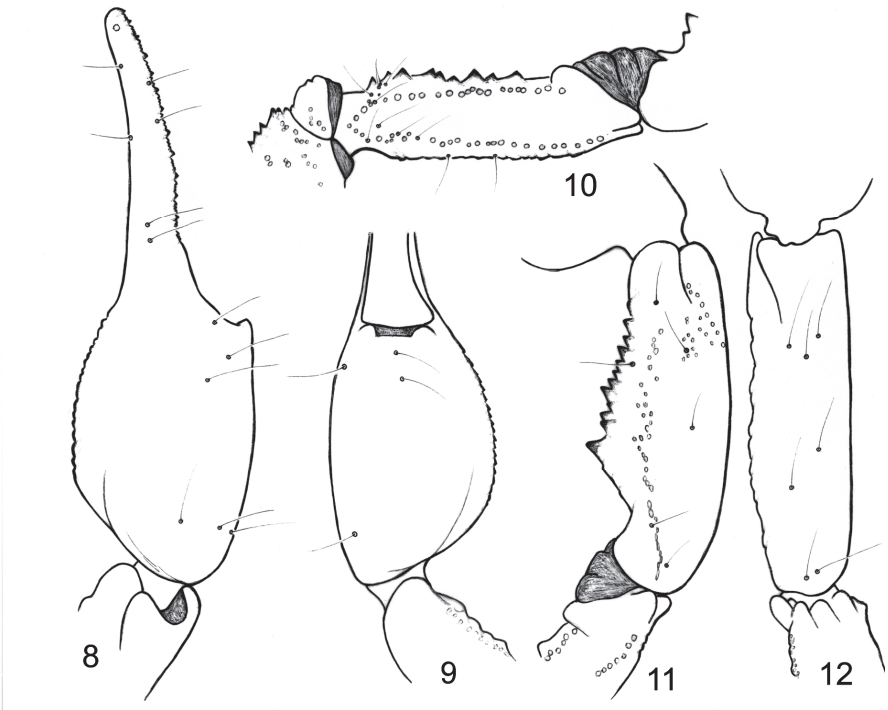


Fig. 8-12. *Grosphus bemaraha* sp. n. Male holotype. Trichobothrial pattern. **8-9**. Chela dorso-external and ventral aspects. **10**. Femur, dorsal aspect. **11**-**12**. Patella, dorsal and external aspects

Table I. Differences among males of three species *Grosphus*.

	G. rakotoariveloi	*G. mahafaliensis*	*G. bemaraha* sp. n.
Color	yellow/	yellow/	
Pattern	reddish-yellow	reddish-yellow	reddish-brown
Spines on metasomal segment	strong	absent	moderate
Rows of granules	13-14	11-12	13-14
Teeth on Pectines	18-19	35-40	29-30
Position of trichobothria est	basal to **db**	basal to **db**	distal to **db**

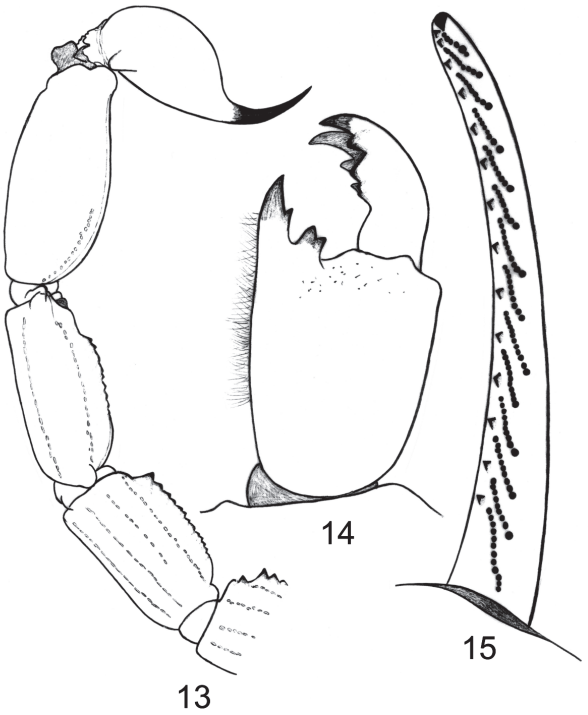


Fig. 13-15. *Grosphus bemaraha* sp. n. Male holotype. **13**. Metasomal segments III-V and telson, lateral aspect. **14**. Chelicera, dorsal aspect. **15**. Cutting edge of movable finger showing rows of granules.

DESCRIPTION BASED ON MALE HOLOTYPE.

Measurements. Total length 65.3. Carapace: length 6.5; anterior width 4.6; posterior width 6.8. Mesosoma length 18.7. Metasomal segments: I, length 5.1, width 3.6; II, length 5.6, width 3.6; III, length 6.2, width 3.8; IV, length 7.2, width 3.7; V, length 8.2, width 3.6, depth 3.2. Telson length 7.8; vesicle width 3.0, depth 2.8. Pedipalp: femur length 6.4, width 1.7; patella length 7.5, width 2.6; chela length 12.2, width 3.4, depth 3.2; movable finger length 7.0.

Coloration. Basically reddish-yellow to dark brown. Prosoma: carapace reddish-brown to brown; eyes surrounded by black pigment. Mesosoma: reddish-brown to brown with dark strips on the posterior margins of tergites. Metasomal segments I to III reddish-yellow to reddish with some dark pigmentation on the ventral carinae; segments IV and V reddish-brown to dark brown. Telson dark red without spots; aculeus with reddish base and dark reddish tip. Venter: coxapophysis and sternum yellow, genital operculum and pectines pale yellow; sternites yellow to slightly reddish-yellow; VII darker. Chelicerae yellowish with brownish variegated pigmentation over the entire surface; fingers and teeth reddish. Pedipalps: reddish-yellow with darker carinae. Legs yellow with some fuscosities.

Morphology. Carapace strongly granular; anterior margin with a weak median concavity. All carinae moderate; furrows moderately to strongly developed. Median ocular tubercle anterior to the centre of the carapace; median eyes separated by approximately one ocular diameter. Three pairs of lateral

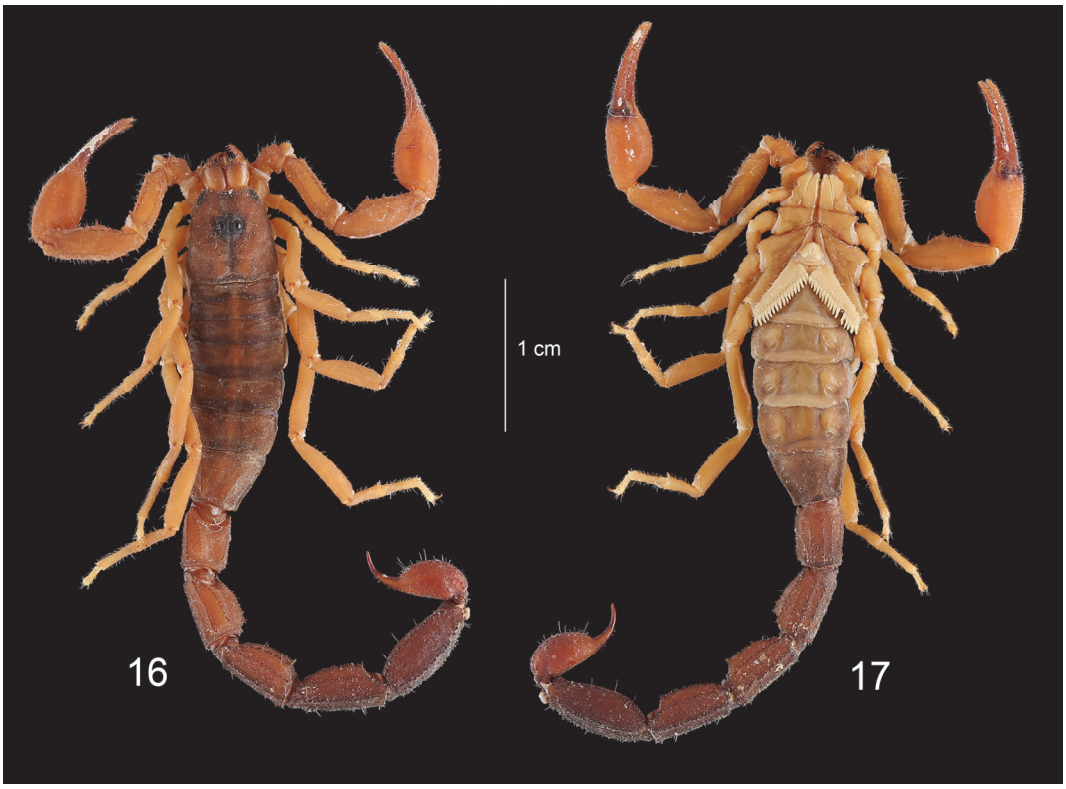


Fig. 16-17. *Grosphus ambre* sp. n. Male holotype. Habitus, dorsal and ventral aspects.

eyes. Sternum sub-triangular in shape. Mesosoma: tergites with a moderately marked granulation. Median carina moderately developed in all tergites. Tergite VII pentacarinate. Venter: genital operculum consisting of two semi-oval plates. Pectines: pectinal tooth count 29-30 in male holotype; basal middle lamellae of each pecten not dilated in male. Sternites smooth, with elongated stigmata; VII with four vestigial carinae but no granulations. Metasomal segments I to III with 10 carinae, crenulate; segment IV with 8 carinae, crenulate. Segment V with 5 carinae; intermediate carinae incomplete on segments II-III. Dorsal carinae on segments II to IV with a few strong posterior spinoid granules. Intercarinal spaces weakly granular to smooth. Telson 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 pentacarinate; internal carina with spinoid granules; patella with a moderate dorsal carina and a strong dorsointernal carina with the presence of several strong spinoid granules; chela smooth, without carinae, only the internal face with several granules. Fixed and movable fingers with 13-14 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.

FEMALE unknown.

***Grosphus ambre* sp. n.**
Fig. 16-25.

Madagascar, ex-Province of Antsiranana, Region of DIANA, National Park of Montagne d'Ambre, IX/2001 (W. R. Lourenço), humid forest, under litter, 920 m: 1 male holotype deposited in the Muséum national d'Histoire naturelle, Paris (MNHN-RS-9116).

ETYMOLOGY: The specific name refers to the Montagne d'Ambre, region where the new species was found.

DIAGNOSIS: Scorpions of medium size in relation to the average size of the species in the genus, with a total length of 56.1 mm for the male. General coloration reddish-yellow to reddish. Metasomal granulations and dorsal carinae strongly marked; presence of one very sharp posterior spinoid granule on segments II-IV. Pectines with 17-17 teeth. Cutting edges of chela fingers with 12-14 rows of granules. Chela with a moderate to weakly marked scalloping of the proximal dentate margin of fixed finger and a marked chetotaxy. Internal carinae of patella of pedipalps with spinoid granules.

RELATIONSHIPS.
By a number of features, such as spinoid granules on the dorsal carinae of metasomal segments II-IV and on internal carinae of pedipalp patella, the new species can be associated to the '*Grosphus simoni* group'. Among the species defined in the '*Grosphus simoni* group' by Lourenço *et al*. (2017) the new species appears closer to *Grosphus rakotoariveloi* Lourenço *et al*., 2017 which inhabits a dry-forest habitat.

The characters in the following table II define the major differences among males of these two species.

DESCRIPTION BASED ON MALE HOLOTYPE.
Measurements: Total length 56.1. Carapace: length 6.3; anterior width 4.2; posterior width 6.3. Mesosoma length 15.1. Metasomal segments: I, length 4.2, width 3.2; II, length 4.8, width 3.1; III, length 5.2, width 3.1; IV, length 6.2, width 3.0; V, length 7.2, width 2.9, depth 3.0. Telson length 7.1; vesicle width 2.7, depth 2.6. Pedipalp: femur length 5.8, width 1.6; patella length 6.7, width 2.4; chela length 11.4, width 2.9, depth 2.8; movable finger length 6.4.

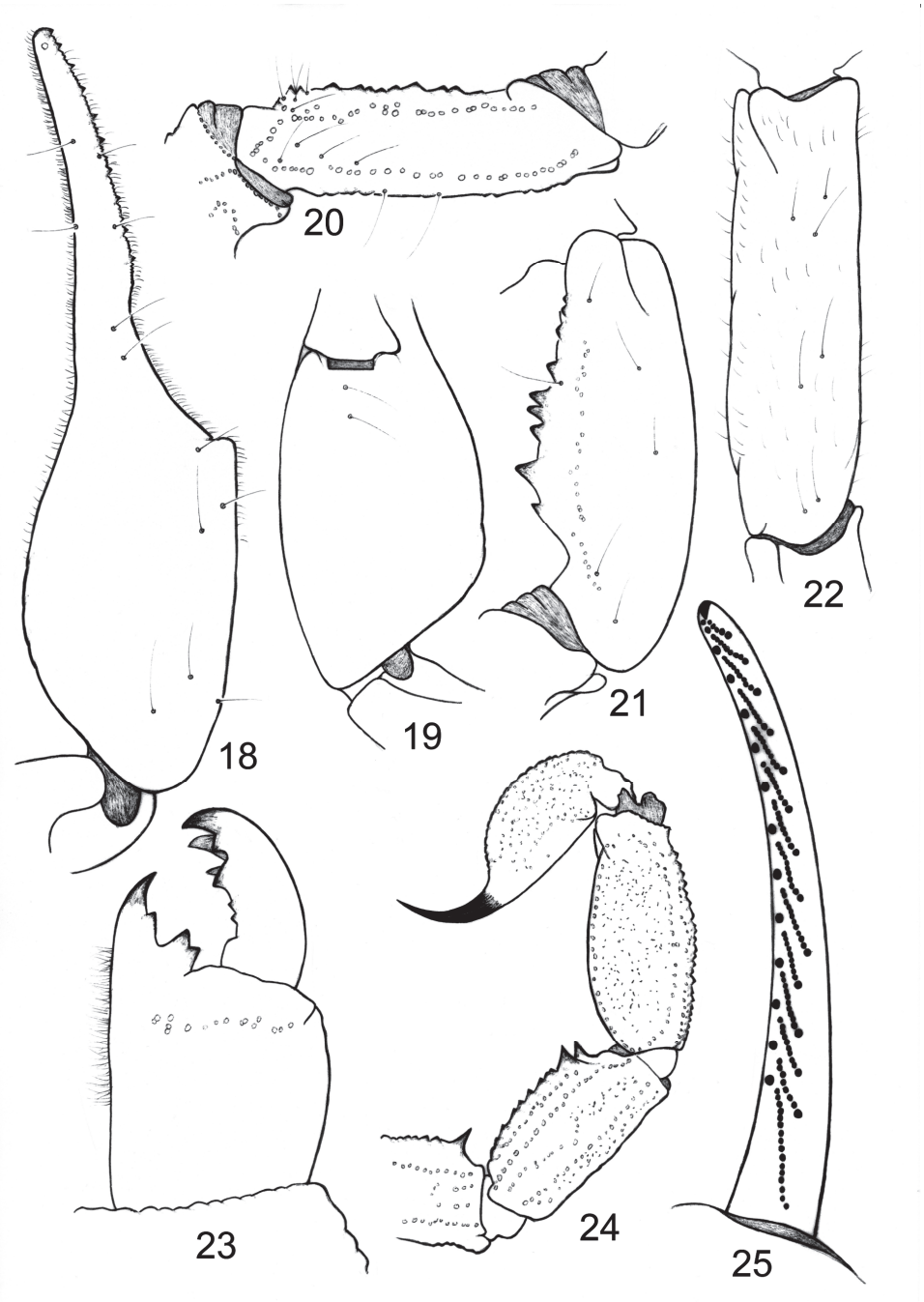


Fig. 18-25. *Grosphus ambre* sp. n. Male holotype. **18-22**. Trichobothrial pattern. **18-19**. Chela, dorso-external and ventral aspects. **20**. Femur, dorsal aspect. **21-22**. Patella, dorsal and external aspects. **23**. Chelicera, dorsal aspect. **24**. Metasomal segments III-V and telson, lateral aspect. **25**. Cutting edge of movable finger showing rows of granules.

Table II. Differences among males of two species *Grosphus*.

	G. rakotoariveloi	*G. ambre* sp. n.
Color	yellow/	reddish-yellow
Pattern	reddish-yellow	to reddish
Spines on metasomal segment	several strong-not sharped	one strong sharped
Rows of granules	13-14	12-14
Teeth on Pectines	18-19	17-17
Position of trichobothria e**st**	basal to **db**	same level of **db**
Chetotaxy on chela	weak/moderate	strong

Coloration. Basically reddish-yellow to reddish. Prosoma: carapace reddish-yellow with the posterior margin dark; eyes surrounded by black pigment. Mesosoma: reddish-yellow with dark strips on the posterior margins of tergites. Metasoma: all segments reddish-yellow with some dark pigmentation on the ventral carinae. Telson reddish without spots; aculeus with reddish-yellow base and reddish tip. Venter: coxapophysis and sternum dark yellow, genital operculum and pectines pale yellow; sternites yellow; VII darker. Chelicerae yellowish with brownish variegated pigmentation over the entire surface but better marked anteriorly; fingers and teeth reddish-yellow. Pedipalps: reddish-yellow. Legs yellow to pale yellow without spots.

Morphology. Carapace moderately granular; anterior margin

with a moderate to strong median concavity. All carinae moderate to weak; furrows moderately developed. Median ocular tubercle anterior to the centre of the carapace; median eyes large in size and separated by one ocular diameter. Three pairs of lateral eyes. Sternum sub-triangular in shape. Mesosoma: tergites with a thin but intense granulation. Median carina moderately to weakly developed in all tergites. Tergite VII pentacarinate. Venter: genital operculum consisting of two semi-oval plates. Pectines: pectinal tooth count 17-17 in male holotype; basal middle lamellae of each pecten not dilated in male. Sternites smooth, with elongated stigmata; V with a whitish smooth zone; VII with four vestigial carinae but no granulations. Metasomal segments I-II with 10 carinae, crenulate; segments III-IV with 8 carinae, crenulate. Segment V with 5 carinae; intermediate carinae incomplete on segment II. Dorsal carinae on segments II to IV with one strong and sharp posterior spinoid granule. Intercarinal spaces strongly granular. Telson moderately to strongly granular over latero-ventral and ventral surfaces; 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 pentacarinate; internal carina with spinoid granules; patella with a moderate dorsal carina and a strong dorsointernal carina with the presence of several strong spinoid granules; chela smooth, without carinae, including in the internal; presence of a dense chetotaxy. Fixed and movable fingers with 12-14 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.

Female unknown.

Biogeographical comments

The collection localities of all the species belonging to the *Grosphus simoni* group are distant of several hundred kilometres from each other (Fig. 1). The Tsingy de Bemaraha National Park, type locality of *Grosphus bemaraha* sp. n., lies on the western slope of Madagascar, in the lower portion of the Manambolo watershed (Fig. 1). The type locality is close to the Manambolo river, one of the few peneconsequent river of the region, running through the Bemaraha plateau in a deep gorge. The river Andranobe, a right tributary of the Manambolo river, has its headwaters in the Western humid forests of Ambohijanahary culminating at an altitude of 1124 m in the Bongolava. After its confluence with the Andranobe, the river Manambolo descends the escarpement of the Bongolava in the Betsiriry depression, then crosses the Bemaraha plateau through deep gorges (Fig. 1). The Manambolo watershed is included in the Melaky center of endemism (Wilmé *et al*., 2006, 2012), with its headwaters at medium altitude. The karst relief has been influenced by the paleoclimate oscillations together with its sea level oscillations (Veress *et al*., 2008). The Manambolo river borders the tsingy, the typical karst features of the Bemaraha, on the south, and controls the elevation of the karst watertable. It has been proposed that the large vertical extensions of the tsingy, i.e., the grikes or lapiaz, are the results of former caves whose roofs became thinner and thinner before collapsing and opening to the surface (Veress *et al*., 2008). The tsingy relief encountered on the Bemaraha plateau maintains mesic conditions and some places within the tsingy could have served as refugia during the driest periods of the paleoclimate oscillations and thus allowed the survival of the ancestral population of *G. bemaraha* sp. n. (cf. Mercier & Wilmé, 2013).

The type locality of *Grosphus amber* sp. n. lies on a stratovolcano, Montagne d'Ambre, whose successive products accumulated from late Miocene to Pleistocene over an area of ca. 2500 km² (Emerick & Duncan, 1982, 1983; Cucciniello *et al*., 2011). The second highest mean annual rainfall recorded over a period of 30 years is from the Montagne d'Ambre 'station des Roussettes' near the type locality, with a total of 3878 mm in a perhumid bioclimate (Cornet, 1974). Montagne d'Ambre is covered by a humid forest, and is surrounded by patches of dry and subarid forests in Northern Madagascar (Moat & Smith, 2007; Fig. 1). The specimens of *Grosphus amber* sp. n. has been collected in the leaf litter by the first author, and is the only *Grosphus* amongst the three sister species for which such ecological detail is available.

The three sister species, closely related *Grosphus amber* sp. n., *G. rakotoariveloi* Lourenço *et al*., 2017, and *G. bemaraha* sp. n. have a patchy distribution, respectively from the extreme north in a per-humid bioclimate on a Plio-Quaternary volcano to the dry forest of Ankarafantsika, at a distance > 500 km, to the sub-humid and dry forests encountered in a karstic relief in Bemaraha, at a distance > 375 km (Fig. 1). The 'combined' distribution of the three sister species is reminiscent of the patchy distribution of the Spirobolida endemic monotypic *Madabolus maximus* Wesener and Enghoff, 2008 encountered in Ankarafantsika and Bemaraha, but also in the tsingy of Namoroka and on the Mahafaly plateau (Wesener *et al*., 2008).

The distribution patterns of the bradytelic scorpions (cf. Lourenço *et al*., 2016b) cannot be accommodated with bioclimates (sensu Cornet 1974) because they represent a geologically very recent situation for the island; thus, they may not have driven the distribution pattern of the scorpions. However, the new species described here shed some light on the overall distribution of the group and shows a wide transect from the Plio-Quaternary volcano in the extreme North over the sedimentary basins along the West. The Plio-Quaternary events have certainly shaped the evolution of this group of scorpions. The two new species have the closest affinities with the western *Grosphus rakotoariveleoi* Lourenço *et al*., 2017 but occur in distant region in different environments (Fig. 1). The biogeography of this group seems to suggest that the species belonging to the '*Grosphus simoni*' group are adapted to humid, dry and subarid environments and the individuals encountered in the West and the South belong to relict populations, which may have survived in humid refugia encountered in the sedimentary basins during the dry episodes of the paleoclimate oscillations. At the end of the Cenozoic, when central Madagascar was uplifted (de Wit, 2003; Cucciniello *et al*., 2017; Rocco *et al*., 2017), active volcanism occurring until the Pleistocene may have influenced the current distribution of the species encountered in the humid forests of the North-east and the North.

Acknowledgements

We are most grateful to Elise-Anne Leguin (Muséum, Paris) for her assistance in the preparation of the photos and plates.

References

CORNET, A. 1974. Essai de Cartographie Bioclimatique à Madagascar. *Notice explicative* N° **55**. ORSTOM, Paris: 28pp.

CUCCINIELLO, C., L. MELLUSO, V. MORRA, M. STOREY, I. ROCCO, L. FRANCIOSI, C. GRIFA, C. M. PETRONE & M. VINCENT 2011. New 40Ar/39Ar ages and petrogenesis of a tholeiitic to strongly alkaline volcanic complex: the Massif d'Ambre, Northern Madagascar. *Geological Society of America Special Papers,* **478**: 257-282.

CUCCINIELLO, C., L. MELLUSO, A. P. LE ROEX, F. JOURDAN, V. MORRA, R. DE' GENNARO & C. GRIFA 2017. From olivine nephelinite, basanite and basalt to peralkaline trachyphonolite and comendite in the Ankaratra volcanic complex, Madagascar: $^{40}Ar/^{39}Ar$ ages, phase compositions and bulkrock geochemical and isotopic evolution. *Lithos,* **274-275**: 363-382.

DE WIT, M. J. 2003. Madagascar: Heads it's a continent, tail it's an island. *Annual Review of Earth and Planetary Sciences,* **31**: 213-248.

EMERICK, C. M. & R. A. DUNCAN 1982. Age progressive volcanism in the Comores Archipelago, western Indian Ocean and implications for Somali plate tectonics. *Earth and Planetary Science Letters,* **60**(3): 415-428.

EMERICK, C. M. & R. A. DUNCAN 1983. Errata to Age progressive volcanism in the Comores Archipelago, western Indian Ocean and implications for Somali plate tectonics. *Earth and Planetary Science Letters,* **62**: 439.

HJELLE, J. T. 1990. Anatomy and morphology. Pp. 9-63. *In*: Polis, G. A. (ed.). *The Biology of Scorpions*. Stanford Univ. Press, Stanford: 587 pp.

LOURENÇO, W. R. 2014. The genus *Grosphus* Simon, 1880 from South-western Madagascar, with the description of a new species (Scorpiones, Buthidae). *Zoosystema,* **36**(3): 631-645.

LOURENÇO, W. R. & L. WILMÉ 2015a. Scorpions collected in the Makay Mountain range, Madagascar (Scorpiones: Hormuridae, Buthidae) and description of a new species. *Revista Ibérica de Aracnologia,* **26**: 55-61(*).

LOURENÇO, W. R. & L. WILMÉ 2015b. Species of *Grosphus* Simon, 1880, associated to the group *madagascariensis*/*hirtus* (Scorpiones: Buthidae); description of a peculiar new species from the humid eastern forests of Madagascar. *Entomologische Mitteilungen aus dem Zoologischen Museum Hamburg,* **17**(194): 207-223.

LOURENÇO, W. R. & L. WILMÉ 2016. Three new species of *Grosphus* Simon 1880, (Scorpiones: Buthidae) from Madagascar; possible vicariant cases within the *Grosphus bistriatus* group of species. *Madagascar Conservation & Development,* **11**(2): 52-65.

LOURENÇO, W. R., L. WILMÉ & P. O. WAEBER 2016a. One more vicariant new species of *Grosphus* Simon, 1880, (Scorpiones: Buthidae) from Madagascar. *Revista Ibérica de Aracnologia,* **29**: 45-50(*).

LOURENÇO, W. R., P. O. WAEBER & L. WILMÉ 2016b. The geographical pattern of distribution of the genus *Tityobuthus* Pocock, 1890, a typical Ananterinae element endemic to Madagascar (Scorpiones: Buthidae). *Comptes Rendus Biologies,* **339** (9-10): 427-436.

LOURENÇO, W. R., L. WILMÉ, V. SOARIMALALA & P. O. WAEBER 2017. Species of *Grosphus* Simon, 1880 associated to *Grosphus simoni* Lourenço, Goodman & Ramilijaona, 2004 with description of two new species (Scorpiones: Buthidae). *Revista Ibérica de Aracnologia,* **30**: 61-69(*).

MERCIER, J.-L. & L. WILMÉ 2013. The Eco-Geo-Clim model: explaining Madagascar's endemism. *Madagascar Conservation & Development,* **8**(2): 63-68.

MOAT, J. & P. SMITH 2007. *Atlas of the vegetation of Madagascar*. Kew Publishing, Royal Botanic Gardens, Kew, U.K.

ROCCO, I., A. ZANETTI, L. MELLUSO & V. MORRA 2017. Ancient depleted and enriched mantle lithosphere domains in northern Madagascar: Geochemical and isotopic evidence from spinel-to-plagioclase-bearing ultramafic xenoliths. *Chemical Geology,* **466**: 70-85.

STAHNKE, H. L. 1970. Scorpion nomenclature and mensuration. *Entomological News,* **81**: 297-316.

VACHON, M. 1952. *Etudes sur les Scorpions*. Institut Pasteur d'Algérie: 482 pp. Alger.

VACHON, M. 1963. De l'utilité, en systématique, d'une nomenclature des dents des chélicères chez les Scorpions. *Bulletin du Muséum national d'Histoire naturelle*, Paris, 2e série, **35**(2): 161-166.

VACHON, M. 1974. Etude 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. *Bulletin du Muséum national d'Histoire naturelle*, Paris, 3e série, n° **140**, Zool., 104: 857-958.

VACHON, M. 1975. Sur l'utilisation de la trichobothriotaxie du bras des pédipalpes des Scorpions (Arachnides) dans le classement des genres de la famille des Buthidae Simon. *Comptes Rendus des Séances de l'Académie des Sciences,* **281**(D): 1597-1599.

VERESS, M., D. LÓCZY, Z. ZENTAI, G. TÓTH & R. SCHLÄFFER 2008. The origin of the Bemaraha tsingy (Madagascar). *International Journal of Speleology,* **37**(2): 131-142.

WESENER, T., H. ENGHOFF & J.-W. WÄGELE 2008. Pachybolini - a tribe of giant Afrotropical millipedes: arguments for monophyly and the description of a new genus from Madagascar (Diplopoda: Spirobolida: Pachybolidae). *Invertebrate Systematics,* **22**: 37-53.

WILMÉ, L., S. M. GOODMAN & J. U. GANZHORN 2006. Biogeographic evolution of Madagascar's microendemic biota. *Science,* **312**: 1063-1065.

WILMÉ, L., M. RAVOKATRA, R. DOLCH, D. SCHUURMAN, E. MATHIEU, H. SCHUETZ & P. O. WAEBER 2012. Toponyms for centers of endemism in Madagascar. *Madagascar Conservation & Development,* **7**(1): 30-40.

(*) Reference available in www.sea-entomologia.org