The genus *Grosphus* Simon, 1880 in South-Western Madagascar, with the description of a new species (Scorpiones, Buthidae)

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ABSTRACT
The South-Western portion of Madagascar appears to have one of the highest levels of scorpion diversity on the island. In this paper is presented an analysis of the known species of *Grosphus* Simon, 1880 from this region. Information on ecological aspects of the species is also given. A new species is also described from the region of Cap Sainte Marie, an area where micro-endemic patterns can be observed. The new species is characterized by a medium size with a total length of 50.3 mm. General coloration yellow to pale yellow without dark zones on body and appendages. Carapace yellow with an anterior reddish-orange zone, approximately forming an inverted triangle. Anterior margin of carapace strongly granular. Male pectines with 36-36 teeth. Fixed and movable fingers of pedipalps with 12-13 oblique rows of granules.

KEY WORDS
Scorpiones,
Buthidae,
Grosphus,
ecology,
endemism,
Madagascar,
new species.

RÉSUMÉ
Le genre Grosphus *Simon, 1880 dans le sud est de Madagascar, avec la description d'une nouvelle espèce (Scorpiones, Buthidae).*
La région sud-ouest de Madagascar présente l'une des plus importantes diversité de scorpions sur l'ensemble de l'île. Dans le présent article une analyse des différentes espèces de *Grosphus* Simon, 1880 distribuées dans cette région est proposée. L'écologie des espèces est également documentée Une nouvelle espèce est décrite pour la région du Cap Sainte Marie, où un important micro-endémisme est observé. La nouvelle espèce est caractérisée par une taille moyenne avec une longueur totale de 50,3 mm. La coloration générale va de jaune à jaune-pâle sans aucune zone foncée sur le corps ou les appendices. La carapace est jaunâtre avec une zone orange-rougeâtre antérieure en forme d'un triangle inversé. La partie antérieure de la carapace est fortement granulée. Les peignes du mâle ont 36-36 dents. Les doigts fixe et mobile des pédipalpes présentent 12-13 séries obliques de granulations.

MOTS CLÉS
Scorpiones,
Buthidae,
Grosphus,
écologie,
endémisme,
Madagascar,
espèce nouvelle.

INTRODUCTION

As discussed in previous publications (Lourenço 2000; Lourenço *et al.* 2007a, b), the South-Western portion of Madagascar contains a rich scorpion fauna compared to other portions of the island (see also Blanc & Paulian 1996). Recent detailed inventory work in the South-West has revealed several new species (Lourenço & Goodman 2006a, b; Lourenço *et al.* 2007a, b) and in particular species belonging to the genus *Grosphus* Simon, 1880 (Lourenço 2004; Lourenço *et al.* 2004, 2007a, b). These new insights into the regional scorpion fauna provides further support that South-Western Madagascar exhibits a rich and complex scorpion fauna.

The taxonomy of the genus *Grosphus* (Family Buthidae C. L. Koch, 1837), almost completely endemic to Madagascar, is primarily based on two characters – external coloration patterns and the morphology of the basal middle lamellae of the pectines in females. This last character has been considered by scorpion taxonomists to show species-specific features, with little intraspecific variation (Fage 1929). However, recent detailed investigations have shown that in some cases, closely related species have similar basal middle lamellae morphology (Lourenço 2003; Lourenço & Goodman 2003, 2006c; Lourenço *et al.* 2004, 2007a, b).

In the present paper, a synopsis of the known species of *Grosphus* distributed in South-Western Madagascar is presented. A new species is also described from the region of Cap Sainte Marie, a zone with a high degree of endemism within the island. Considerable collections have been made over the past few years during biological inventories, and the vast majority of scorpions were obtained with the use of pit-fall trapping devices, put in place principally for the capture of small mammals and reptiles (Raxworthy & Nussbaum 1994). Further, ecological information about the collection sites and possible patterns of distribution of the species are also discussed.

MATERIAL AND METHODS

Illustrations and measurements were produce using a Wild M5 stereo-microscope 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 mostly follows Vachon (1952) and Hjelle (1990).

ABBREVIATIONS

FMNH	Field Museum Natural History, Chicago;
MMNG	Muséum d'Histoire naturelle, Genève;
MNHN	Muséum national d'Histoire naturelle, Paris;
ZMH	Zoologischen Museum Hamburg.

TAXONOMY

Family BUTHIDAE C. L. Koch, 1837

Genus *Grosphus* Simon, 1880

TYPE SPECIES. — *Scorpio* (*Androctonus*) *madagascariensis* Gervais, 1843 by original designation.

DIAGNOSIS. — Scorpions of medium to large size ranging from 35 to 120 mm in total length. The general coloration can present almost all the colour patterns observed among scorpions in general, ranging from pale yellowish to yellow, reddish-yellow to reddish brown, dark brown and blackish, and with dark spots which may be distributed in many different configurations. Body and appendages can vary from weakly to strongly granulated. Dentate margins of pedipalp-chela fingers composed of 11 to 14 oblique rows of granules, but without supernumerary granules. Pectines with 18 to 40 teeth; basal middle lamellae not dilated in males but strongly dilated in females. Subaculear tubercle is absent in adults, but can be present in juveniles.

GEOGRAPHICAL DISTRIBUTION. — Only known from Madagascar and Mayotte.

Grosphus magalieae n. sp.
(Figs 1-4)

TYPE MATERIAL. — Male holotype: Madagascar, ex-Province de Toliara, Région Androy, near Lavanono village (25°25'17.28"S, 44°56'24.35"E), 2.VI.2010 (coll. M. Castelin, Atimo Vatae Expedition), MNHN.RS-8943.

ETYMOLOGY. — The specific name honors Magalie Castelin, MNHN, who collected the new species.

DIAGNOSIS. — A scorpion of medium size (total length of 50.3 mm) in relation to other species within the genus. General coloration yellow to pale yellow without dark zones on body and appendages. Anterior margin

Fig. 1. — *Grosphus magalieae* n. sp., male holotype: **A**, **B**, habitus, dorsal (**A**), ventral (**B**). Scale bar: 1 cm.

of carapace strongly granular. Pectines with 36-36 teeth; basal middle lamellae of each pecten not dilated in males. Metasomal segments I and II with 10 carinae; III and IV with 8 carinae. Femur and patella of pedipalps with strongly spinoid carinae. Fixed and movable fingers of pedipalps with 12-13 oblique rows of granules respectively. Trichobothriotaxy, orthobothriotaxy, type A – α (alpha).

Relationships. — The general morphology and pigmentation pattern of the new species shows it to be close to the *Grosphus limbatus* (Pocock, 1889)/*G. bistriatus* Kraepelin, 1900 group. This group of species is largely distributed in the South-Western region of Madagascar. The closest related species however, is *Grosphus rossii* Lourenço, 2013 (Lourenço 2013) (Fig. 4D, E), recently described from central region of the island (see Discussion). Both species can be readily distinguished by the following characters: i) pectines with 36-36 teeth in *G. magalieae* n. sp. vs 28-28 in *G. rossii*; ii) cutting edges of pedipalp fingers with 12-13 rows of granules in *G. magalieae* n. sp. vs 12-12 in *G. rossii*; and iii) an overall paler coloration in *G. magalieae* n. sp.

Description based on male holotype

Morphometric values following the description

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

Morphology. Carapace weakly granular except on the anterior triangular zone which is strongly granular; anterior margin with a weak median concavity. All carinae weak; furrows moderately developed. Median ocular tubercle anterior to the centre of the carapace; median eyes separated by 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 36-36; basal middle lamellae of each pecten not dilated. Sternites smooth, with elongated stigmata; VII with vestigial carinae. Metasoma: segments I and II with 10 carinae, moderately crenulate. Segments III and IV with 8 carinae, moderately crenulate. Segment V with 5 carinae. Dorsal carinae on segments II to IV without posterior spinoid granules. Intercarinal spaces moderately to weakly granular. Telson with a moderate to weak granulation over latero-ventral and ventral surfaces; its dorsal surface smooth; aculeus weakly curved and slightly 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 with strong spinoid carinae; patella with dorsointernal and dorsoexternal carinae and with several spinoid granules on the internal face; chela without carinae and with the internal face moderately granular. Fixed and movable fingers with 12-13 oblique rows of granules respectively. Trichobothriotaxy; orthobothriotaxy A-α (alpha) (Vachon 1974, 1975). Legs: tarsus with numerous short thin setae ventrally. Tibial spurs present on legs III and IV, thin and long; pedal spurs present on legs I to IV, moderate to strong.

Female. Unknown.

Morphometric values (*in mm*) *of the male holotype*
Total length (including telson), 50.3. Carapace: length, 4.8; anterior width, 3.7; posterior width, 5.2. Mesosoma length, 13.6. Metasomal segments. I: length, 4.1; width, 3.3; II: length, 4.5; width, 3.2; III: length, 4.8; width, 3.1; IV: length, 5.5; width, 3.0; V: length, 6.2; width, 3.0; depth, 2.5. Telson length, 6.1. Vesicle: width, 2.5; depth, 2.2. Pedipalp: femur length, 4.7, width, 1.4; patella length, 5.2, width, 1.9; chela length, 8.5, width, 2.4, depth, 2.5; movable finger length, 5.0.

ECOLOGY
As already described for *Grosphus feti* Lourenço, 1996, which was also collected in the Cap Sainte Marie (Lourenço *et al.* 2007b), the natural habitat of *Grosphus magalieae* n. sp. is marked by a high level of endemism. The region of Tanjon' I Vohimena (Cap Sainte Marie) in the ex-Province de Toliara, Region Androy, is characterized by the stunted coastal forest formation of the Réserve Spéciale de Cap Sainte Marie. The new species is only known from the type locality, which has a very particular habitat and vegetational community (Nicoll & Langrand 1989). The holotype of *Grosphus magalieae* n. sp. was collected together with a female specimen of *Opisthacanthus lucienneae* Lourenço & Goodman, 2006 (Liochelidae), species also endemic to South-Western Madagascar.

OTHER *GROSPHUS* SPECIES IN THE SOUTH-WESTERN REGION

Grosphus hirtus Kraepelin, 1900

Grosphus hirtus Kraepelin, 1900: 15.

TYPE MATERIAL. — Female holotype: Madagascar, Central region, Makaraingo, 1898 (Dr Escoffe), MNHN.RS-1545.

DIAGNOSIS. — Scorpion of medium size with a total length of 40 to 50 mm. General coloration yellowish to reddish-yellow with variegated brownish spots over the body and appendages. Carapace weakly to moderately granular; anterior margin almost straight. Pectines: pectinal teeth count in average 19-19 in males and 15-15 in females; basal middle lamellae of each pecten not dilated in males, strongly dilated in females with a more or less square shape. Metasomal segment I wider than long. Dorsal carinae on segments II to IV with one strong posterior spinoid granule. Fixed and movable fingers with 11-12 oblique rows of granules.

DISTRIBUTION AND ECOLOGY. — It was first suggested that this species was broadly distributed in the island (Lourenço 1996). However, more precise inspection of specimens previously allocated to *G. hirtus* indicates that several previous records attributed to this taxon were misidentifications of morphologically similar species, which were subsequently described as new species (Lourenço 2005). After a reexamination of available material, there is no evidence for the occurrence of *G. hirtus* in South-Western Madagascar (Lourenço *et al.* 2007a, b).

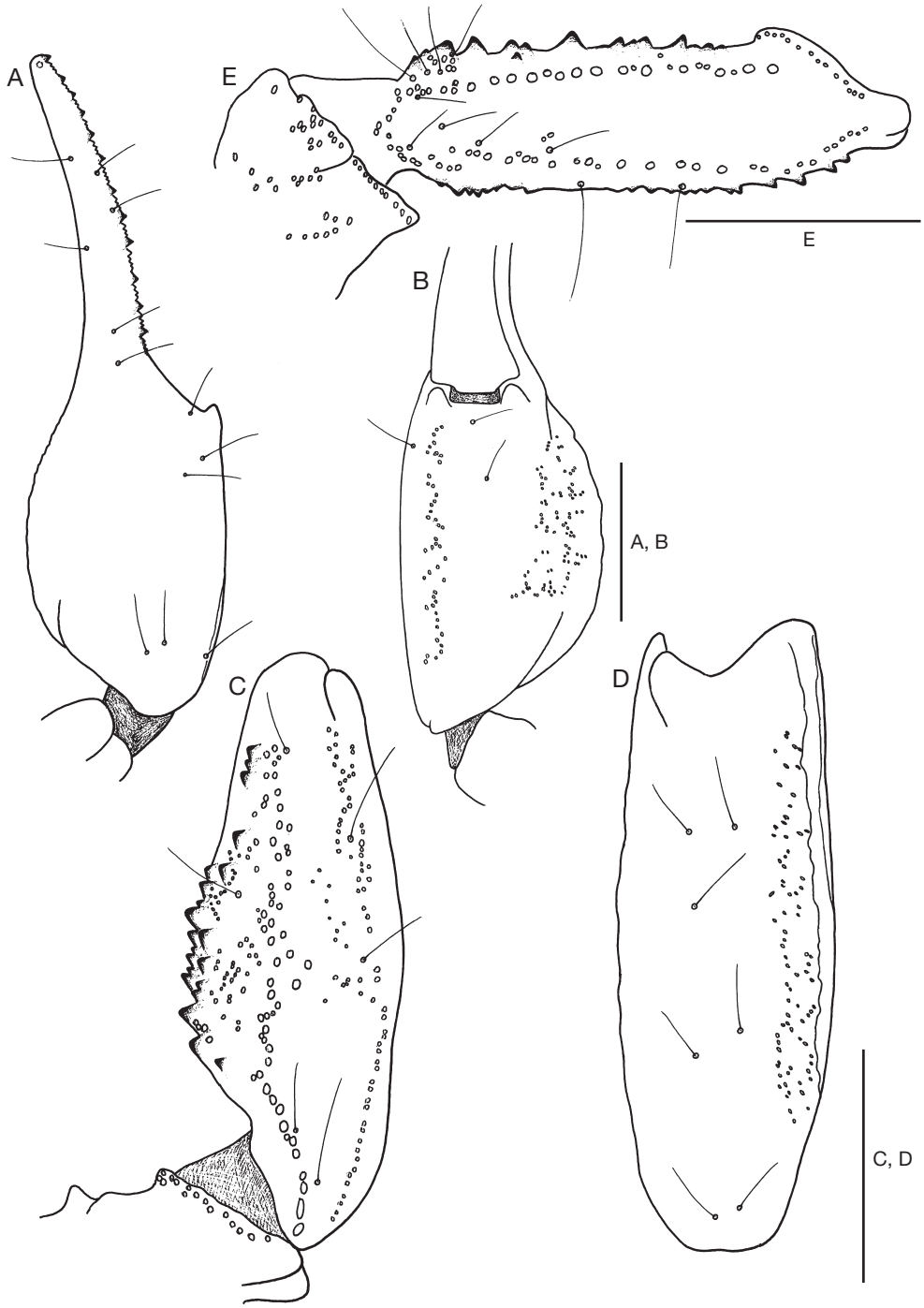

Fig. 2. — *Grosphus magalieae* n. sp., trichobothrial pattern: **A**, **B**, chela, dorso-external (**A**) and ventral aspects (**B**); **C**, **D**, patella, dorsal (**C**) and external aspects (**D**); **E**, femur, dorsal aspect. Scale bars: 2 mm.

Grosphus grandidieri Kraepelin, 1900

Grosphus grandidieri Kraepelin, 1900: 13.

Type material. — Female lectotype and male juvenile paralectotype: Madagascar, Ankotofotsy, Vallée du St Augustin 23.V.1898 (G. Grandidier), MNHN.RS-1324, MNHN.RS-8720.

Diagnosis. — Scorpions of large size, when compared with most species of the genus, and adults ranging from 85 to 90 mm in total length. The species is only smaller than *G. ankarana* Lourenço & Goodman, 2003. General coloration almost entirely blackish over the body and appendages, with paler areas on the ventral surface. Disposition of granulations on the dentate margins of the pedipalp chela fixed and movable fingers, arranged in 13-14 rows of granules. Pectinal teeth count 29 to 40; 34 to 40 in males and 29 to 34 in females; basal middle lamellae of each pecten not dilated in males; very elongated and curved in females; just after the base, to the apex, covering 8 to 9 most proximal teeth.

Distribution and ecology. — *Grosphus grandidieri* was originally collected by G. Grandidier at an unspecified locality. This species is distributed across portions of South-Western Madagascar (Lourenço 1996; Lourenço *et al.* 2009). On the basis of recent collections made with pit-fall traps, *G. grandidieri* does not appear to be particularly common in South-Western Madagascar, compared to some other members of this genus.

Grosphus annulatus Fage, 1929

Grosphus limbatus var. *annulata* Fage, 1929: 655.

Type material. — Syntypes, 5 males and 8 females: Madagascar, South region, S-SE of Toliara, Sarodrano, 11.VIII.1901 (G. Grandidier), MNHN.RS-1314.

Diagnosis. — Scorpion of small size with a total length of 35 to 45 mm. General coloration yellowish; metasomal segments IV and V almost blackish. Carapace and tergites weakly granular. Pectines: pectinal teeth count in average 32-34 in males and 24-29 in females; basal middle lamellae of each pecten not dilated in males; dilated and elongated in females; just after the base, to the apex, covering 4 to 5 most proximal teeth. Dorsal carinae on segments II to IV without any posterior spinoid granule. Fixed and movable fingers with 11-11 oblique rows of granules.

Distribution and ecology. — *Grosphus annulatus* was originally described by Fage (1929) only as a variety, *G. limbatus var. annulata* Fage, 1929. More detailed studies indicated that it was necessary to elevate this form to the rank of species (Lourenço 1996). 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. Based on pigmentation patterns, *G. annulatus* is probably closely related to *G. olgae* Lourenço, 2004 described from South-Western Madagascar (see below). 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 (Figs 3A, B; 4A, B). 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 Toliara [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.

Grosphus feti Lourenço, 1996

Grosphus feti Lourenço, 1996: 14.

Type material. — Male holotype and male paratype: Madagascar, South region, Toliara, Tanjon I Vohimena (Cap Sainte Marie), X.1995 (S. M. Goodman), FMNH.

Diagnosis. — Scorpion of small size with a total length of 30 to 40 mm. General coloration yellowish; carapace, tergites, pedipalps and legs with blackish spots. Carapace and tergites weakly granular. Pectines: pectinal teeth count 30-30 in both male holotype and paratype; basal middle lamellae of each pecten not dilated in males. Dorsal carinae on segments II to IV without any posterior spinoid granule. Fixed and movable fingers with 11-12 oblique rows of granules.

Distribution and ecology. — *Grosphus feti* comes from the stunted coastal forest formation of the Réserve Spéciale de Cap Sainte Marie. The original diagnosis of this species was based on its unique pigmentation pattern, including a general yellowish coloration with an inverted blackish triangle on the front of the carapace (as for *G. limbatus*), and the presence of five longitudinal stripes over the tergites. These stripes are arranged as one thin line over the central carinae, two large latero-internal lines, and two rather thin latero-external lines. Metasomal segment V and telson are granulated and blackish (Fig. 4C). These

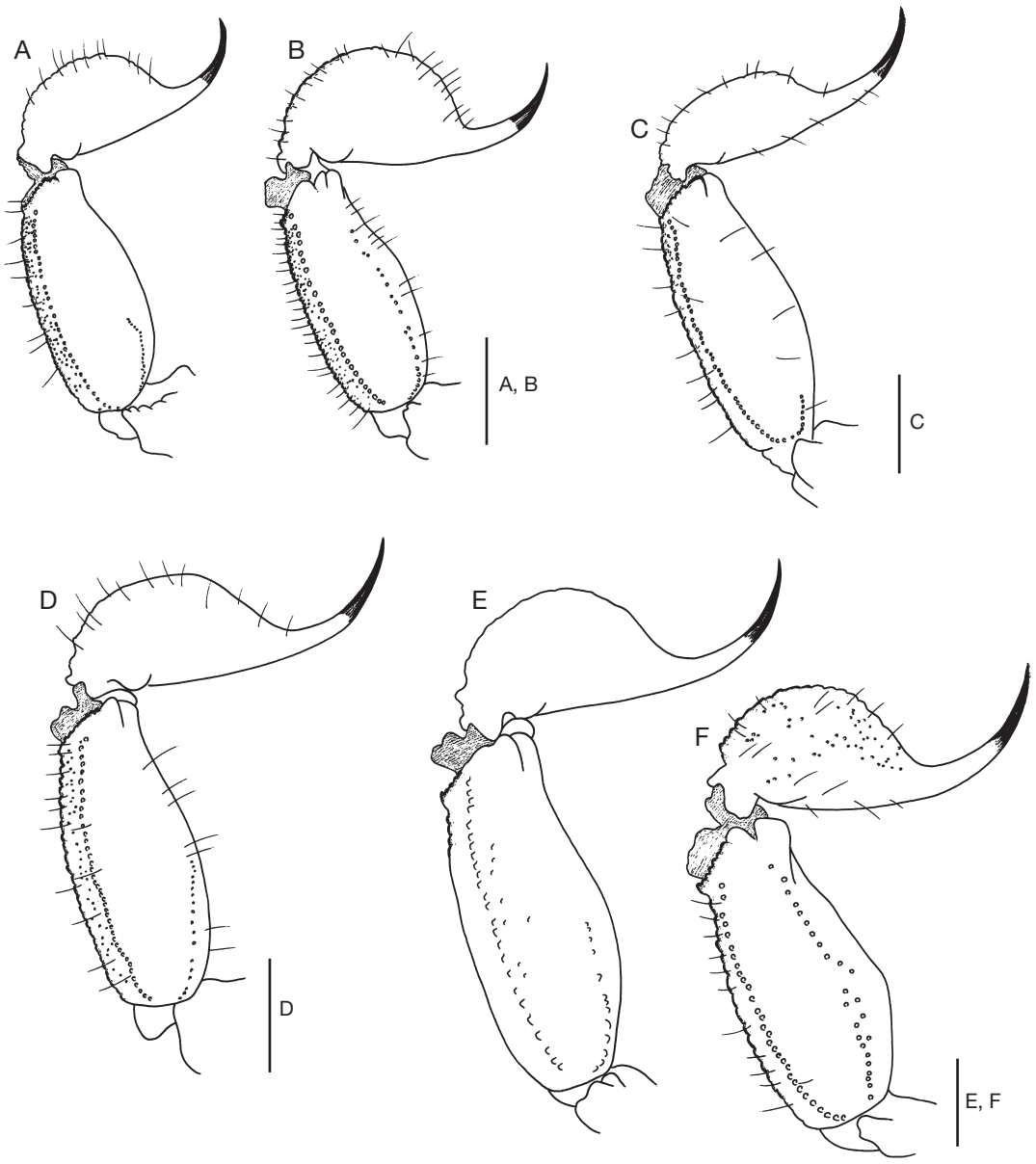

Fig. 3. — *Grophus* ssp., Metasomal segment V and telson, lateral aspect: **A**, **B**, *Grosphus annulatus* Fage, 1929: **A**, male paralectotype; **B**, female lectotype; **C**, **D**, *Grosphus intertidalis* Lourenço, 1999, male (**C**) and female (**D**); **E**, **F**, *Grosphus mahafaliensis* Lourenço, Goodman & Ramilijaona, 2004, male (**E**) and female (**F**). Scale bars: 2 mm.

coloration patterns are more similar to *G. limbatus* than to *G. annulatus* or *G. olgae*. However, *G. feti* is only known by two male specimens and as long as the female remains unknown, further precise comparisons between these species remains impossible. *Gropshus feti* is only known from the type locality, which has a very particular habitat and vegetational community (Nicoll & Langrand 1989).

Grosphus intertidalis Lourenço, 1999

Grosphus intertidalis Lourenço, 1999: 135.

TYPE MATERIAL. — Female holotype: Madagascar, South region, Toliara, 3.5 km N of Toliara (Coastal zone, on the beach sands), IV.1998 (N. Lutzmann), ZMH.

DIAGNOSIS. — Scorpion of medium size with a total length of 55 to 60 mm. General coloration pale yellow, without any spots. Carapace and tergites moderately to weakly granular. Pectines: pectinal teeth count 28-30 in females and 32-34 in males; basal middle lamellae of each pecten elongated and curved, widening only partially after the first internal tooth – this character is diagnostic of the species. Dorsal carinae on segments II to IV without any posterior spinoid granule. The telson vesicle is not globular in shape, but rather pear-like, particularly in males (Fig. 3C, D). Fixed and movable fingers with 10-10 oblique rows of granules.

DISTRIBUTION AND ECOLOGY. — *Grosphus intertidalis* was described based on a single specimen collected in the coastal zone 3.5 km to the north of Tulear (Toliara). More recently, Lourenço (2004) described a male specimen collected in the Province of Toliara, Parc National de Tsimanampetsotsa, 21.5 km NE d'Efoetse (24°0.5'S, 43°53.9'E). The specimen was found at 100 m of altitude under a stone, in a slightly disturbed zone of spiny bush. This species remains poorly known and was not represented in most recent samples coming from field inventories.

Grosphus olgae Lourenço, 2004

Grosphus olgae Lourenço, 2004: 27.

TYPE MATERIAL. — Male holotype, 14 males and 3 female paratypes: Madagascar, South region, Toliara, Forêt de Mikea, 7.5 km NE Tsifotsa, 22°48.0'S, 43°26.'E, 21-25.II.2003 (S. M. Goodman & V. Soarimalala); 1 ♂ holotype, 4 ♂♂ and 3 ♀♀ paratypes; 9.5 km W. Ankililoaka, 22°46.7'S, 43°31.4'E, 14-19.II.2003 (S. M. Goodman & V. Soarimalala), 9 ♂♂ paratypes; Parc National de Tsimanampetsotsa, 6.5 km NE Efoetse, 24°3.0'S, 43°45.0'E, 28.II-5.III.2002 (S. M. Goodman), 1 ♂. Holotype and 13 paratypes, FMNH; 3 paratypes, MNHN-RS-8675; 1 paratype, MHNG.

DIAGNOSIS. — Scorpion of small to medium size with a total length of 35 to 40 mm. General coloration pale yellow, with dark spots on metasomal segment V and telson. Telson elongated with aculeus longer than vesicle. Carapace and tergites moderately to weakly granular. Pectines: pectinal teeth count 26-27 in females and 29-33 in males; basal middle lamellae of each pecten elongated and curved, widening only partially after the first internal tooth, covering 3 to 4 most proximal teeth. Dorsal carinae on segments II to IV without any posterior spinoid granule. The telson vesicle is not globular but rather elongated, with a pear-like shape, particularly in males (Fig. 3C, D). Fixed and movable fingers with 13-14 oblique rows of granules.

DISTRIBUTION AND ECOLOGY. — In contrast to the descriptions of the vast majority of *Grosphus* sp., based on single specimens, *G. olgae* was named from a series of almost 20 specimens, allowing a good assessment of character variability. On the basis of the basal middle lamellae shape of the female pectines, *G. olgae* shows notable similarity to *G. limbatus*. However, it differs from *G. limbatus* by the general colour pattern (absence of spots on carapace and tergites). This species appears to be very common both in the Forêt de Mikea, its type locality, but also on and at the base of the Plateau Mahafaly, where new collections document its sympatric occurrence with *Grosphus mahafaliensis* Lourenço, Goodman & Ramilijaona, 2004 (see next section). Based on the study of an extensive material, *Grosphus olgae* occurs in a variety of habitats that include both limestone and sandy soil substrates, although it was notably more common on the former substrate. Animals registered under a single field collection number were all collected during the same dawn pitfall trap check and were presumed to have been active the previous night. These new data indicate that *G. olgae* occurs in sympatry with *G. mahafaliensis*, at most sites this latter species outnumbers the former. Further, there are several cases of *Neogrosphus griveaudi* (Vachon, 1969) being captured in the same pitfalls as *G. olgae*. Thus, these three species show broad geographical overlap in portions of South-Western Madagascar.

Grosphus mahafaliensis Lourenço, Goodman & Ramilijaona, 2004

Grosphus mahafaliensis Lourenço, Goodman & Ramilijaona, 2004: 226.

TYPE MATERIAL. — Male holotype: Madagascar, South region, Toliara, Parc National de Tsimanampetsotsa, N of Efoetse, in coastal *Euphorbia* scrub (N. Lutzmann & J. Kohler), X.2001 (under rock), MNHN. RS-8671.

DIAGNOSIS. — Scorpion of medium size with a total length of 55 to 60 mm. General coloration reddish-yellow with some dark zones on the body. Carapace and tergites moderately granular. Pectines: pectinal teeth count 27-31 in females and 34-38 in males; basal middle lamellae

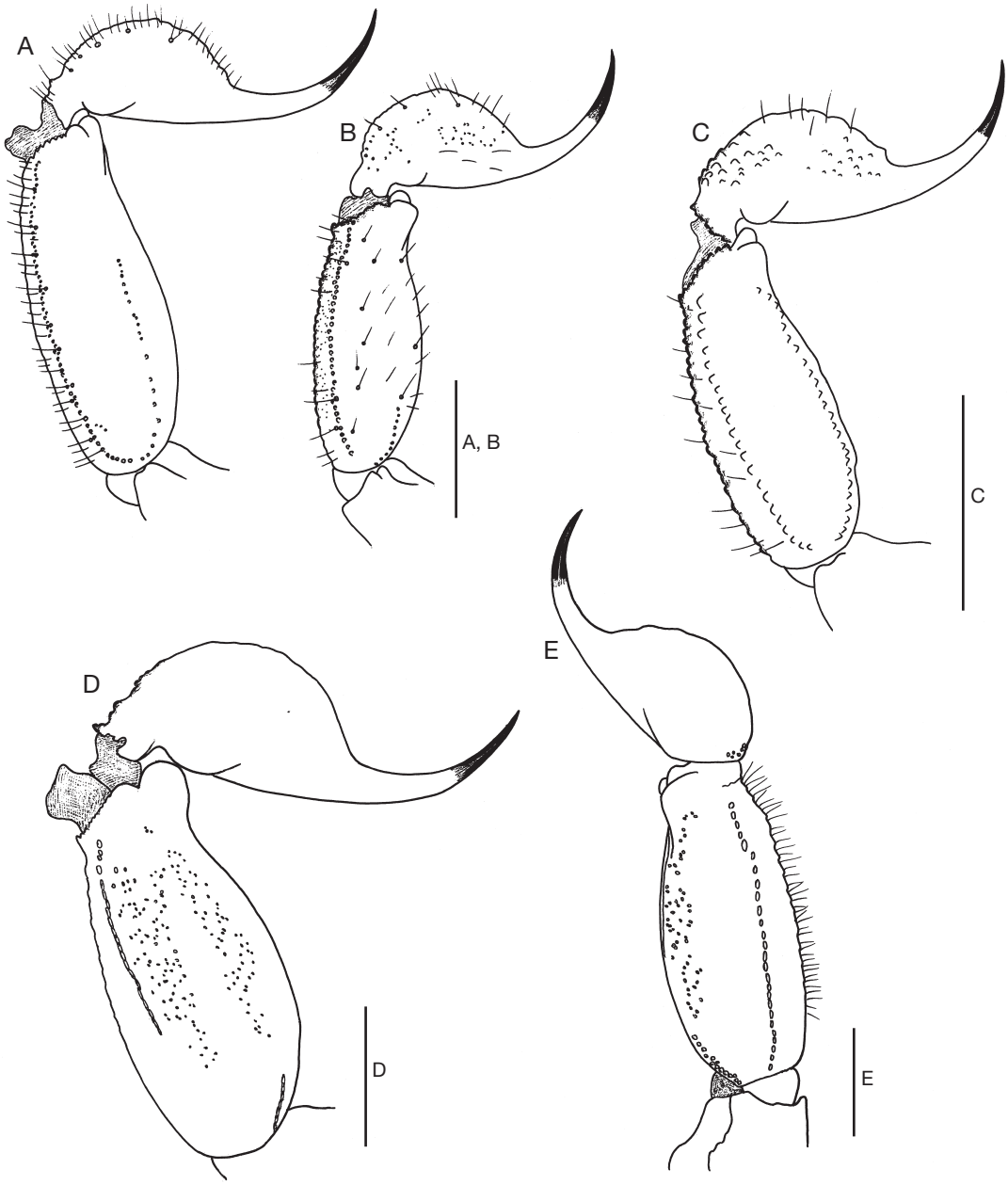

FIG. 4. — *Grophus* ssp., Metasomal segment V and telson, lateral aspect: **A**, **B**, *Grosphus olgae* Lourenço, 2004, male (**A**) and female (**B**) paratypes; **C**, *Grosphus feti* Lourenço, 1996, male holotype; **D**, *Grosphus rossii* Lourenço, 2013, male holotype; **E**, *Grosphus magalieae* n. sp., male holotype. Scale bars: 2 mm.

of each pecten elongated and curved, widening after the first internal tooth, covering 3 to 4 most proximal teeth. Dorsal carinae on segments II to IV without any posterior spinoid granule. The telson vesicle is globular in shape (Fig. 3E, F). Fixed and movable fingers with 11-13 oblique rows of granules.

DISTRIBUTION AND ECOLOGY. — *Grosphus mahafaliensis* was described based on a single male specimen collected in the Province de Toliara. Recent collections however, indicate that this species is very common in the region of the Plateau Mahafaly. Almost 150 new specimens have been obtained by the use of pit fall traps, including females which were previously unknown. The general shape of the basal middle lamellae of the female pectines is similar to *G. limbatus*, however the basal middle lamellae of *G. mahafaliensis* is broader, and covers the four most proximal teeth. Further, these two species show notable differences in colour patterns – *G. mahafaliensis* being reddish-yellow without any spots over the body or appendages. Moreover, pectinal tooth counts in *G. mahafaliensis* are notably greater. For more details on *G. mahafaliensis* see the original description by Lourenço *et al.* (2004).

Based on the study of an extensive amount of material, it can be inferred that *Grosphus mahafaliensis* has a broad distribution across the inventory sites on the limestone substrate of the Mahafaly Plateau. These new data indicate that this species occurs in sympatry with *G. olgae*, and based on pitfall trap captures, it is the more abundant of the two scorpions. There is one case of *G. mahafaliensis* occurring in sympatry with *Neogrosphus griveaudi* (Vachon, 1969). Thus, these three species show broad geographical overlap in portions of South-Western Madagascar. Based on pitfall captures male *G. mahafaliensis* greatly outnumber females.

Other species of scorpions known to occur specifically in the Tsimanampetsotsa area or elsewhere on the Mahafaly Plateau include: *Grosphus annulatus* from the region of Sarodrano close to sea-level; *G. olgae* from near Mitoho Cave within the Parc National de Tsimanampetsotsa; *Pseudouroplectes betschi* Lourenço, 1995 from the Mahafaly Plateau to the north of Itampolo (Lourenço 1995, 2004); and *Palaeocheloctonus pauliani* Lourenço, 1996 from Efoetse (Lourenço 1996).

Grosphus polskyi Lourenço, Qi & Goodxman, 2007

Grosphus polskyi Lourenço, Qi & Goodman, 2007: 174.

TYPE MATERIAL. — Male holotype: Madagascar, South region, Toliara, Ifaty, 23°10'80"S, 43°37'00"E (dry spiny bush forest, dominated by baobabs – *Adansonia za* Baill., 1898, resting on red sand soil, 30 m (W. R. Lourenço), IX.2004, MNHN.RS-8950.

DIAGNOSIS. — Scorpion of small size with a total length of 33 mm. General coloration reddish-yellow with some diffused brownish variegated pigmentation on the carapace and tergites. Carapace weakly to moderately granular; anterior margin almost straight. Pectines: pectinal teeth count 19-18 in male; basal middle lamellae of each pecten not dilated in male. Metasomal segment I with a length equal to its width. Dorsal carinae on segments II to IV with one small posterior spinoid granule. Subaculear tooth moderately marked. Fixed and movable fingers with 12-13 oblique rows of granules.

DISTRIBUTION AND ECOLOGY. — Certain morphological characters indicate that *G. polskyi* is similar in certain aspects to *G. hirtus*, however, distinct from this last species by a much paler overall coloration with some diffused brownish pigmentation, a metasomal segment I with a length equal to its width, and a subaculear tooth moderately marked. This species remains known only from its type locality. The holotype was collected under death leaves at the base of one baobab tree (*Adansonia za* Baill.). The abundance of litter over the sand soil was rather poor and death leaves were most cumulated nearby the trunk of the tree together with some fallen fruit (Lourenço *et al.* 2007a).

Grosphus bicolor Lourenço, 2012

Grosphus bicolor Lourenço, 2012: 35.

TYPE MATERIAL. — Male holotype: Madagascar, South-Western region, inland zone, between Ranohira and Llakaka, (W. R. Lourenço), IX.2004, ZMH.

DIAGNOSIS. — Scorpions of small to moderate size with a total length of 30 mm in total length. Several characters suggest, however, that the type specimen is a juvenile. General coloration is brown to dark brown, almost blackish with two longitudinal yellow stripes over tergites; venter yellow to pale yellow; legs pale yellow. Pectinal teeth count 36-36 in male; basal middle lamellae of each pecten not dilated in male. Dorsal carinae on segments II to IV without any posterior spinoid granule. The telson vesicle is globular in shape. Fixed and movable fingers with 13-14 oblique rows

DISTRIBUTION AND ECOLOGY. — *Grosphus bicolor* was only recently described from the South-Western region of the island, but from a more inland zone, between Ranohira and Llakaka, from a dry forest formation (Lourenço 2012). Certain morphological characters suggest that *G. bicolor* has some similarities with *G. grandidieri*, however, distinct from this last species by the general pigmentation pattern. This species remains known only from its type locality. For more details, see the original description in Lourenço (2012).

KEY TO THE SPECIES OF THE GENUS *GROSPHUS* SIMON, 1880 DISTRIBUTED IN THE SOUTH-WEST OF MADAGASCAR

1. Pectines with a maximum of 20 teeth; coloration yellowish to reddish-yellow, with pale brownish variegated pigmentation present ..... *G. polskyi* Lourenço, Qi & Goodman, 2007
— Pectines with more than 23 teeth 2

2. Coloration pale yellow to yellow or reddish-yellow; brownish to blackish pigmentation present or not 3
— Coloration blackish throughout; pectines with 30 to 40 teeth; female basal middle lamellae covering up to 8 internal teeth ..... *G. grandidieri* Kraepelin, 1900

3. Coloration from pale yellow to reddish, without any brownish to blackish pigmentation 4
— Coloration yellowish with brownish to blackish pigmentation present 7

4. Coloration yellow to reddish; legs without white zones; carapace without an inverted reddish-orange triangle 5
— Coloration pale yellow; legs with white zones; carapace with an inverted reddish-orange triangle 6

5. Coloration yellow; pectines with 28 to 34 teeth; female basal middle lamellae covering the first internal tooth ..... *G. intertidalis* Lourenço, 1999
— Coloration reddish-yellow to reddish; pectines with 31 to 40 teeth; female basal middle lamellae covering the first four internal teeth ..... *G. mahafaliensis* Lourenço, Goodman & Ramilijaona, 2004

6. Male pectines with 28 teeth ..... *G. rossii* Lourenço, 2013
— Male pectines with 36 teeth ..... *G. magalieae* n. sp.

7. Carapace with an inverted blackish triangle; tergites with brownish to blackish longitudinal stripes 8
— Carapace without any blackish triangle; tergites without brownish or blackish stripes 9

8. Metasomal segment V and telson yellowish ..... *G. limbatus* (Pocock, 1889)
— Metasomal segment V and telson blackish ..... *G. feti* Lourenço, 1996

9. Vesicle strongly globular; aculeus shorter than vesicle ..... *G. annulatus* Fage, 1929
— Vesicle pear-like shaped; aculeus longer than the vesicle ..... *G. olgae* Lourenço, 2004

REMARK ABOUT THE KEY

G. limbatus (Pocok, 1889) and *G. rossii* Lourenço, 2013 are included for comparative purposes, although these species lives in the central region of the island.

DISCUSSION

It is well accepted by several authors that the arid formations of South-Western Madagascar, and in particular the specific region of the Cap Sainte Marie, shows important levels of diversity and endemism (Fig. 5; 6). This can be interpreted as a consequence of the isolation of this area in past periods and the very fast speciation process which took place locally (Paulian 1961).

The general patterns of distribution observed for a given zoological group are largely dependent on the historical factors which took place in more or less recent periods of time. The previous gen-

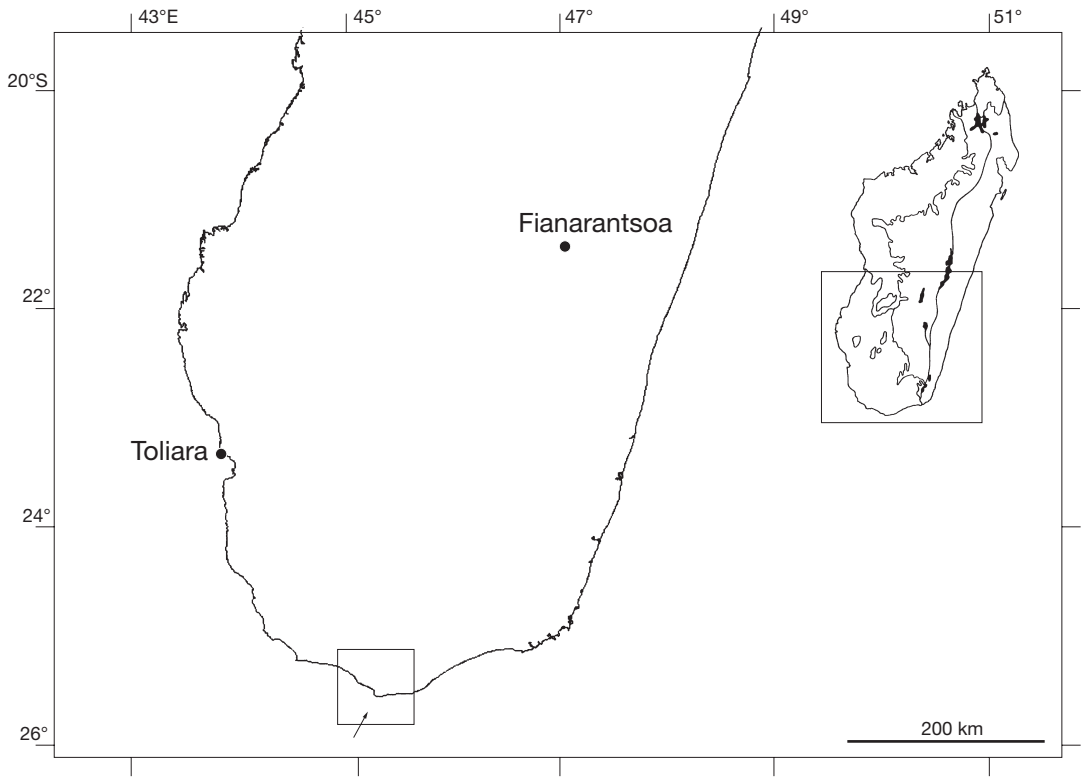

Fig. 5. — Map showing the southern portion of Madagascar and the Cap Saint Marie, the type locality of *Grosphus magalieae* n. sp.

eral idea was that environments have been stable for long periods of time. This old idea has been gradually replaced by a more accurate view, based on data from ecological, palaeoclimatological and palynological studies (Prance 1982a). These new results clearly attested that this supposed "stability" has been interrupted by periods of climatic change during several dry/wet/dry episodes of the late Cenozoic Period, especially during the Pleistocene and Holocene epochs. During the (earlier) Quaternary period, temperate regions were glaciated; while cooler, drier conditions prevailed in the tropical zones of today. These reduced the rainforest to savannas or dry-forests except in regions where localized conditions of temperature and humidity allowed the rain-forests to persist. This historical reduction of rainforests to patch refugia is supported by the existing biogeographical patterns of distribution and differentiation of several taxa, and by palynological and geomorphological evidence from many regions of the world. Several authors also postulate that the reduction of forest to small patches stimulated many changes in plant and animal populations in the refugia. These ranged from extinction to an increased rate of speciation (Van der Hammen 1974, 1982; Prance 1982a, b).

Scorpion biogeographical studies in tropical South America brought further evidence for the refuge theory (Lourenço 1986, 1987, 1991, 1994, 2001). These investigations led to the postulation of about 25 refugia, or areas of high endemism. The number, size and location of these sites correlate well with those described by other authors (Prance 1982b), and correspond to regions of high endemism.

FIG. 6. — The area of study in South-Western Madagascar (photo Ph. Bouchet).

In the case of Madagascar, these theories have received less attention than elsewhere, as stated by Burney (1996, 1997), "There has been an understandable tendency for biogeographers working in Madagascar to focus on historical factors operating on two quite different time scales. The island's isolation represents a profound influence on a scale of millions of years. Today, however, one sees everywhere in Madagascar the consequences of factors that have operated in a much more recent time frame. What of those events influencing the biogeography of Madagascar that function on intermediate temporal scales? Specifically, what roles have Quaternary climate change and other prehuman ecological variation played in Madagascar? Studies throughout the world have demonstrated the importance of glacial-interglacial climate cycles on scales of thousands, to hundreds of thousands of years."

Biogeographers have not discussed these factors much in the context of Madagascar because so little is known about their role there. "Paleoecological research has in recent years dispelled some mysteries regarding Madagascar's past, only to reveal others. Thinking about Madagascar as a dynamic biotic phenomenon that may always be changing on several temporal scales, can have profound impact on how we interpret the island's paleobiogeography…what significance any observed trends of change might have for understanding the biogeographic patterns we observe today" (Burney 1996).

The patterns of distribution observed for *Grosphus magalieae* n. sp. in the arid South-Western region and for its sibling species *Grosphus rossii* Lourenço, 2013 in the more mesic Central region of Madagascar,

can be tentatively explained as the result of a past continuous distribution over more arid formations which have changed subsequently to the recent Quaternary vicissitudes in a vicariant process (Bernardi 1986). Based on palynological evidence found in the Lake Tritrivakely near to Antsirabe in the more southern part of the central region, it appears that vegetation changed on this upland site during the last 11000 years. By the end of the Pleistocene this area was dominated by ericoid shrubs and grasses. Holocene warming and drying at the site shifted to grasses and some woody vegetation and herbs associated with dry environments. At circa 4000 years BP, trees and shrubs associated with forest edge, open woodlands, and riparian environment increased (Burney 1996).

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