Scorpions of the Réserve spéciale d'Ankarana, Madagascar, with particular reference to cave-dwelling animals and the description of two new species (Arachnida, Scorpiones)

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ABSTRACT
A synopsis is presented of the scorpion fauna documented in the Réserve spéciale d'Ankarana in northern Madagascar, an area of limestone karst. Two new species of liochelid scorpions, *Opisthacanthus milloti* n. sp. and *Opisthacanthus pauliani* n. sp., are described based on specimens collected in the reserve. One of these, *O. pauliani* n. sp. may represent the second troglobitic scorpion species found in Madagascar, and the first one belonging to the genus *Opisthacanthus* Peters, 1961 anywhere in the world.

KEY WORDS
Arachnida,
Scorpiones,
Liochelidae,
Opisthacanthus,
Madagascar,
Ankarana,
new species,
caves.

RÉSUMÉ
Les scorpions de la Réserve spéciale d'Ankarana, Madagascar, avec une note sur les animaux vivants dans les grottes et la description de deux espèces nouvelles.
Un synopsis est proposé pour la faune des scorpions de la Réserve spéciale d'Ankarana dans le Nord de Madagascar, une région composée de grottes karstiques. Deux nouvelles espèces de scorpion Liochelidae, *Opisthacanthus milloti* n. sp. et *Opisthacanthus pauliani* n. sp. sont décrites à partir de spécimens collectés dans la réserve. Une des ces deux espèces, *O. pauliani* n. sp., pourrait correspondre au deuxième élément cavernicole collecté à Madagascar et le premier appartenant au genre *Opisthacanthus* Peters, 1861 dans le monde.

MOTS CLÉS
Arachnida,
Scorpiones,
Liochelidae,
Opisthacanthus,
Madagascar,
Ankarana,
espèces nouvelles,
grottes.

INTRODUCTION

Madagascar is one of the most biologically diverse regions on Earth (see Vachon 1953; Paulian 1961; Lourenço 1996a; Goodman & Benstead 2003). Studies on the island's scorpions started in the first half of the 19th century, and advanced rapidly between 1890 and 1900, with numerous contributions, such as those by Gervais (1844), Pocock (1890, 1896), Kraepelin (1894, 1900), and Birula (1903). Other publications followed, in particular those of Fage (1929, 1946), and Vachon (1969). However, it was only by the middle of the 1990s, when the study of the island's scorpion fauna showed substantial progress, with the description of several new taxa (e.g., Lourenço 1995, 1996b). Since 1994, intensive field inventory programs have resulted in extensive new collections being made in diverse ecosystems of the island and using a variety of field collecting techniques (e.g., pit-fall traps, extraction by Winkler or detection with ultra-violet light). These new specimens have made possible to examine in a new light patterns of geographical distribution, taxonomy, diversity, and endemicity of Malagasy scorpions.

Between 1995 and 2006, the number of recognized scorpion taxa on Madagascar has risen by more than 400% (Lourenço 2003, 2005). Certain areas of the island exhibit particularly high levels of diversity and endemism. The Ankarana Massif, specifically the Réserve spéciale d'Ankarana, represents a possible epicenter of scorpion diversity and endemicity on the island (Lourenço 2003, 2005). This is presumably correlated with unique habitats occurring in the massif (Cardiff & Befourouack 2008) and a complex geological history of northern Madagascar, with numerous cases of vicariant events associated with climatic change, volcanism, etc. (Brenon 1972; Wilmé *et al.* 2006).

In this contribution, we provide a synopsis of the scorpion fauna known from the Ankarana Massif, including the description of two new species of *Opisthacanthus*, one of which may represent the second known species of cave-dwelling scorpion on the island.

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 millimeters. Trichobothrial notations follow Vachon (1974) and morphological terminology mostly follows Vachon (1952) and Hjelle (1990).

Type material is deposited in the Muséum national d'Histoire naturelle, Paris (MNHN).

ECOLOGY AND BIOGEOGRAPHY OF THE ANKARANA MASSIF

Numerous details on the Ankarana Massif can be found in Cardiff & Befourouack (2008), and only certain points will be mentioned here. The massif is an outcrop of middle Jurassic limestone, oriented NE-SW with about 25 km long and 8 km wide (Fig. 1). Quaternary earth movements (*c.* 1.5 million years ago) resulted in the splitting of the massif and elevating its western wall, which is now marked by vertical cliffs rising 100 to 150 m above the ground. A series of volcanic eruptions in recent geological time produced lava flows around the massif, including directly into some of the canyons (0.5 million years ago).

The Ankarana Massif is filled with a diversity of water cut canyons, crevices, and caves. This extensive karst landscape has 76 known caves, with over 114 km of passages (Radofilao 1977; Cardiff 2006). These different formations represent a wide variety of geomorphological types and presumably provide a considerable array of different habitats for invertebrates.

The Ankarana region receives slightly less than 2000 mm of annual rainfall (Hawkins *et al.* 1990). Even with this relatively high annual precipitation, the site has dry deciduous vegetation and this is due to a long dry season, lasting most years from May to November, and when the average daily temperature reaches about 26°C. The rainy season is generally from December to April, and accounts for 93% of the annual precipitation, and average daily temperature are 27.5°C.

The narrow and often deep canyons within the massif frequently have tall canopy semi-evergreen forests resting on slightly acidic soils of basaltic rock. These canyons provide a buffer against the dry and often windy conditions of this region. A permanent subterranean aquifer passing under the Ankarana Massif resurges at certain points in canyons or is close to the soil surface level. The forested habitat within the deep canyons forms ecological islands isolated from the surrounding areas by dry deciduous forests or anthropogenic savannas. The local plant and animal communities hold several microendemic species, some with affinities to eastern humid forest taxa and others to the western deciduous forest taxa. Subfossil remains recovered in certain Ankarana caves clearly demonstrate that the area supported more mesic conditions during the Quaternary (Godfrey *et al*. 1999) and the remaining canyon forests hold some relict taxa from this period.

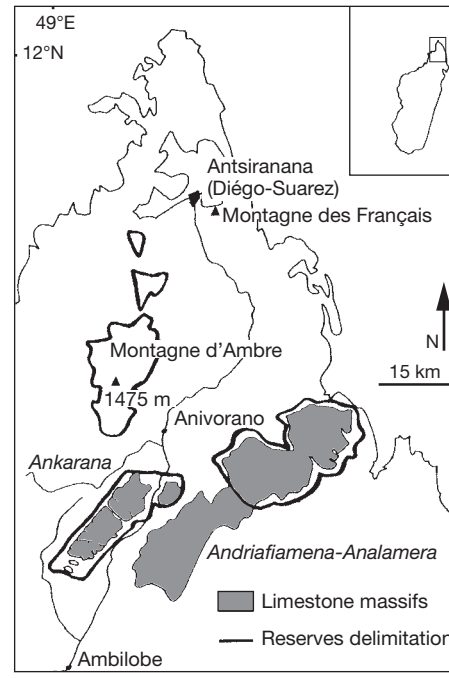

FIG. 1. — Map of the northern portion of Madagascar showing the region of the Ankarana Massif.

TROGLOBITIC SCORPIONS

Troglobitic scorpions (i.e. species which complete their entire biological cycle within caves) are rare across the world. In fact, Vandel (1964) stated: "Aucun scorpion ne mène une vie vraiment cavernicole." It was not until the late 1960s that the first truly troglobitic scorpions were described from Mexican caves (Mitchell 1968): *Typhlochactas rhodesi* Mitchell, 1968 and *T. reddelli* Mitchell, 1968. By the mid-1980s the number of troglobite species had increased to 13 species (Lourenço & Francke 1985). Of these, 11 are from Mexico, and mainly belong to the families Diplocentridae Karsch, 1880, Euscorpiidae Laurie, 1896, Superstitioniidae Stahnke, 1940, and Vaejovidae Thorell, 1876. The two non-Mexican species belong to the families Troglotayosicidae Lourenço, 1998 and Chaerilidae Pocock, 1893 and are from Ecuador and Sarawak, respectively. Subsequently, other troglobitic scorpions have been described from Mexico and Sulawesi, most being members of the families Superstitionidae and Chaerilidae. Exceptions are the recent descriptions of troglobitic species belonging to the families Buthidae C. L. Koch, 1837, Liochelidae Fet & Bechly, 2001, Pseudochactidae Gromov, 1998 and Urodacidae Pocock, 1893, respectively from Brazil, Christmas Island (Indian Ocean), Laos and Australia (Volschenk *et al*. 2001; Lourenço *et al* 2004; Lourenço 2007; Volschenk & Prendini 2008). The last example in date is the liochelid *Opisthacanthus pauliani* n. sp., described in this paper. Other scorpion species have been recorded from caves, but most are certainly not true troglobites.

Scorpions belonging to the family Buthidae have been found in caves. In most cases, however, they have been considered only as trogloxenes (i.e. species which incidentally penetrate in caves, but have their biological cycle outside), or trogrophile elements (i.e. species that are regularly found outside caves). Further, at the same site there can be a mixture of animals with different habitat requirements. For example, two troglobitic species, *Troglotayosicus vachoni* Lourenço, 1981 from Ecuador and *Chaerilus chapmani* Vachon & Lourenço, 1985 from Sarawak, have been found at sites with buthid species that

normally occur outside caves (Lourenço 1981; Vachon & Lourenço 1985).

When Fage (1946) described *Babycurus gracilis* from the Ankarana Massif, it was noted as having been collected in the "grotte des Fanihys", and the only collected specimen was found deep within the cave; this locality is presumably the "grotte des Chauves-souris", which is a short distance from the village of Mahamasina and is also locally known as "Andavampanihy". Fage (1946) suggested that this species probably represented a true troglobitic element. Subsequently, Vachon (1979) transferred *B. gracilis* to the genus *Tityobuthus* Pocock, 1893 as *T. gracilis*. More recently, a precise study of the type specimen of *B. gracilis*, together with specimens of *Tityobuthus*, lead to the creation of a new genus, *Troglotityobuthus* to accommodate this species (Lourenço 2000).

THE SCORPIONS OF THE RÉSERVE SPÉCIALE D'ANKARANA

In his studies on the scorpions of Madagascar, Fage (1929, 1946) made mention to those of the Ankarana Massif, principally *Opisthacanthus madagascariensis* Kraepelin, 1894, found outside the principal portion of the massif, and the locally occurring *Grosphus* spp. He suggested that two distinct populations of the later genus, closely related to *G. flavopiceus* Kraepelin, 1900, were in the area. This has been supported with the recent description of a new taxon, *G. ankarana* Lourenço & Goodman, 2003, which shows notable differences from *G. flavopiceus*.

Other new species were discovered and described from the Ankarana region, including *Tityobuthus rakotondravonyi* Lourenço & Goodman, 2003, *Ankaranocharmus pauliani* Lourenço, 2004, now transferred to the genus *Microcharmus* Lourenço, 1995 as *M. pauliani* (Lourenço *et al.* 2006), and *M. violaceus* Lourenço, Goodman & Fisher, 2006. All these recently described species appear to be endemic to the Ankarana Massif. In the present contribution two new species of *Opisthacanthus* Peters, 1861 are described from caves of the principal portion of the massif, one of which, *Opisthacanthus pauliani* n. sp., may represent the second troglobitic scorpion species found in Madagascar.

The occurrence of troglobitic scorpions in the Ankarana warrants a few comments. According to Fage (1946), *Troglotityobuthus gracilis* was collected from deep in the cave, in the dark zone. Since 2001 bat inventories within numerous Ankarana caves have been conducted (Goodman *et al*. 2005; Cardiff 2006). Literally hundreds of hours have been spent in several cave systems in the reserve, including the grotte des Chauves-souris, where *T. gracilis* was presumably collected, and the Andrafiabe Cave system. At the former site, in 2001, trails for tourists were installed in the dark zone of the cave and a considerable number of rocks were moved, and no evidence of any scorpion deep within the cave was found (S. G. Cardiff pers. comm.). Finally, a second specimen of *T. gracilis* was recently observed and filmed deep inside the grotte des Chauves-souris (S. G. Cardiff pers. comm.), which brings new evidence that this species is truly troglobitic.

THE ELEMENTS OF THE GENUS *OPISTHACANTHUS* PETERS, 1861 IN MADAGASCAR

Scorpions of the genus *Opisthacanthus* have been the subject of several studies and taxonomic revisions during the last 20 years (Lourenço 1983, 1987, 1989). New discoveries are inevitable on an island such as Madagascar, that is biotically so diverse and relatively poorly known, and amongst liochelids scorpions, these include several new species of *Opisthacanthus* (Lourenço & Goodman 2006). At present, this genus on Madagascar comprises the following species:

Genus *Opisthacanthus* Peters, 1861
- Subgenus *Monodopisthacanthus* Lourenço, 2001
  - *Opisthacanthus madagascariensis* group
    - *Opisthacanthus madagascariensis* Kraepelin, 1894
    - *Opisthacanthus lucienneae* Lourenço & Goodman, 2006
    - *Opisthacanthus maculatus* Lourenço & Goodman, 2006
    - *Opisthacanthus darainensis* Lourenço & Goodman, 2006
    - *Opisthacanthus piceus* Lourenço & Goodman, 2006
    - *Opisthacanthus milloti* n. sp.
    - *Opisthacanthus pauliani* n. sp.

HISTORICAL ACCOUNT ABOUT THE MALAGASY SPECIES OF *OPISTHACANTHUS*

Opisthacanthus madagascariensis was described by Kraepelin (1894) from Majunga (Mahajanga). Subsequently, a second species, *O. punctulatus*, was named by Pocock (1896) from south-central Madagascar. In a revision of the genus, Kraepelin (1911) considered *O. punctulatus* as a junior synonym of *O. madagascariensis*. This position was followed for several years by subsequent authors (e.g., Fage 1929; Lourenço 1989).

Lourenço (1996b) attempted to characterize these two species, based on older specimens in the MNHN, and the question of their validity was readdressed. The principal taxonomical problem being that the broad distribution of the genus in Madagascar could not be correlated with a precise distribution of a single species (Lourenço 2004) and this was further confounded by most of the older specimens lacking precise collection site details.

Recently collected specimens, from a variety of sites on the island, provide the needed material to elucidate aspects of intra-population variability in *O. madagascariensis*, and have resulted in *O. punctulatus* being placed as a junior synonym of *O. madagascariensis*. Careful examination of the new material revealed that several non-described species of *Opisthacanthus* were present in Madagascar, and that in several cases they had been previously misidentified as juvenile *O. madagascariensis*, but examination of their internal genitalia confirmed that they are indeed adults. Therefore, the broad distribution previously assigned to *O. madagascariensis* (Lourenço 1996b, 2002) corresponds to several different taxa. These taxonomic studies also clarified the existent patterns of intra- and interspecific variation among Malagasy members of the genus *Opisthacanthus*.

The geographical distribution of *O. madagascariensis*, as currently understood, ranges from the vicinity of the Manongarivo Massif in the northwest south to the Onilahy River in the southwest. Previous records of *O. madagascariensis* in the extreme south of the island, as for example the Parc national d'Andohahela (Lourenço & Goodman 1999), can now be attributed to the species *O. lucienneae*. Other recently described species, including, for example, *O. darainensis* and *O. piceus*, represent new geographic records of the genus *Opisthacanthus* on the island. A detailed distributional map of Malagasy members of this genus is provided by Lourenço & Goodman (2006: fig. 58). Amongst the Ankarana specimens housed in the MNHN, are two new species, which are described here.

SYSTEMATICS

Opisthacanthus milloti n. sp.
(Figs 2-4)

TYPE MATERIAL. — **Madagascar.** Antsiranana Province, Réserve spéciale d'Ankarana, in the entry of the grotte des Chauve-souris, found resting on soil under stone, IX.2001, W. R. Lourenço coll., 1 ♂ holotype, 1 ♂, 1 ♀ paratypes (MNHN).

DIAGNOSIS. — Small size scorpions: males 36 mm and female 32 mm in total length. Coloration reddish-yellow to reddish-brown with some blackish areas over pedipalp carinae. Pectines with 6-6 teeth in males and female. Hemispermatophore small, with the distal lamina weakly enlarged and longer than that observed for *O. darainensis* (Fig. 2C). Female genital operculum large, with an almost oval-shape, and lacking incision in the base (Fig. 3B). Trichobothrial pattern of type C, orthobothriotaxy.

The new species can be distinguished from *O. darainensis*, described from the more southerly Loky-Manambato (= Daraina) region, by the following characters: 1) smaller global size; 2) distinct morphometric values (see Table 1); 3) presence of four moderate carinae on sternite VII; and 4) distal lamina of hemispermatophore narrower and elongated.

ETYMOLOGY. — Patronym in honour of the late Prof. Jacques Millot, who devoted many years of his life to the study of the Malagasy fauna.

DESCRIPTION

(based on ♂ holotype and ♀ paratype)

Coloration

Basically reddish-yellow to reddish-brown with some blackish areas on the pedipalp carinae. Carapace reddish-brown with a paler section on the posterior edge; median and lateral eyes surrounded with black pigment. Tergites reddish-brown with two vestigial longitudinal pale yellow spots. Metasomal segments reddish-brown, with some vestigial yellowish

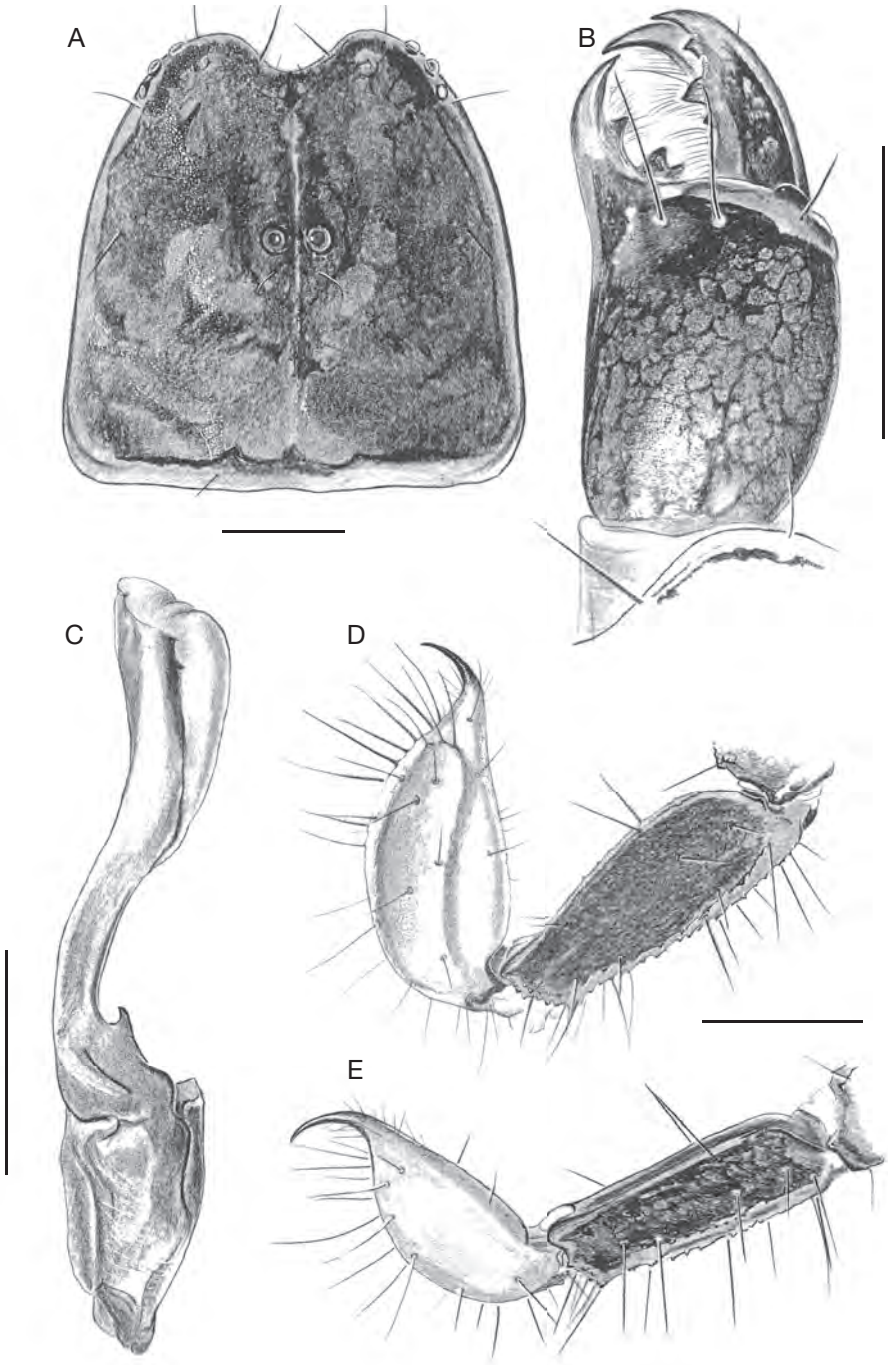

FIG. 2. — *Opisthacanthus milloti* n. sp., ♂ holotype and ♀ paratype: **A**, carapace; **B**, chelicera; **C**, hemispermatophore external aspect (♂); **D**, **E**, metasomal segment V and telson, lateral aspect (♂ and ♀). Scale bars: 2 mm.

variegated areas; vesicle yellowish, with lateral reddish bands on males, but absent on female; aculeus dark reddish. Chelicerae reddish-brown; base of fingers blackish; the whole surface with diffuse variegated dark spots; fingers blackish with reddish teeth. Pedipalps reddish-brown; most carinae blackish. Venter: sternites brownish-yellow; coxapophysis and sternum reddish-brown; pectines and genital operculum yellowish; legs reddish-yellow with diffused dark spots.

Morphology

Carapace smooth with intense punctation; lateral edges, in males, with some minute granulations; furrows shallow. Anterior margin with a strong concavity reaching as far as the level of the second lateral eye (Fig. 2A). Median ocular tubercle flattened and almost in the center of the carapace; median eyes moderate to small, separated by less than one ocular diameter; three pairs of lateral eyes. Sternum pentagonal, wider than long. Genital operculum formed by two semi-oval plates in males, and one single large, almost oval-like shaped plate in females (Fig. 3). Tergites with one vestigial median carina, and with intense punctation. Pectinal tooth count 6-6 in male holotype and in female paratype. Sternites smooth and shiny, with punctations laterally; VII with four moderate carinae. Metasomal segments I to V longer than wide with sparse granulations. All carinae weakly developed in segments I-IV of male, moderately evident in female; segment V slightly rounded with spinoids granules on ventro-lateral and ventro-median carinae. All segments with moderate setation, more pronounced in males. Telson with a pear-like shape; smooth and covered with strong setation (Fig. 2D, E). Pedipalps: femur with dorsal internal, dorsal external, ventral internal, and ventral external carinae strong, tuberculate; dorsal face with moderately marked granulation; ventral face with a thin granulation; internal face moderately granulose. Patella with internal and external faces weakly granulated; dorsal and ventral faces smooth and lustrous, with punctations; dorsal internal, dorsal external, ventral internal, ventral external, and external carinae moderate to strong; other carinae less well-marked. Chela strongly granular on dorso-internal and external faces; other faces punctated; dorsal marginal, external secondary, ventro-internal and ventral median carina moderate to strong; other carinae less well-marked.

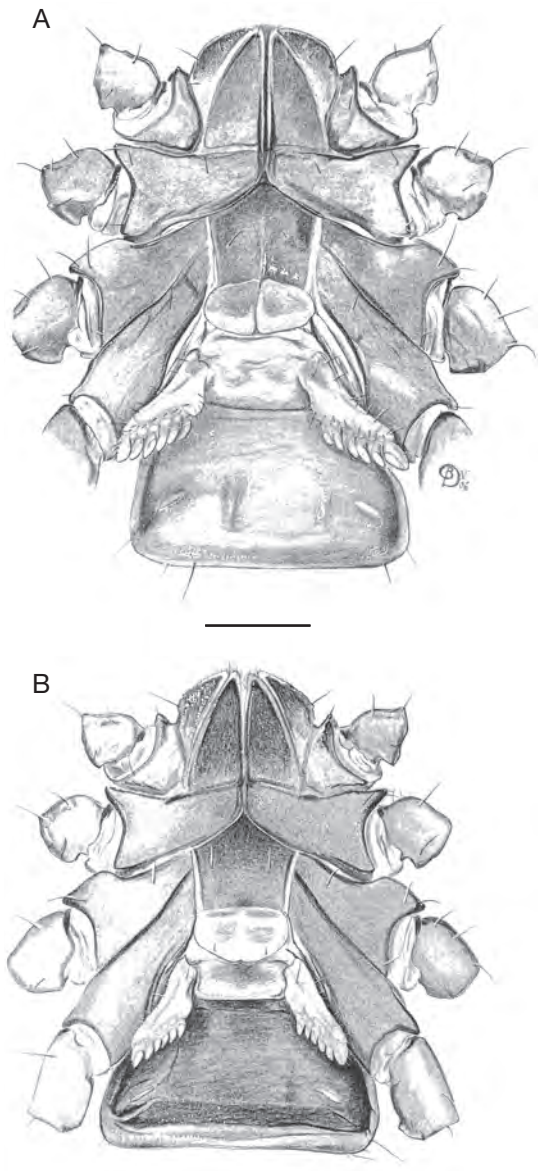

FIG. 3. — *Opisthacanthus milloti* n. sp., ventral aspect, showing coxapophysis, sternum, genital operculum, pectines and sternite III: **A**, ♂ holotype; **B**, ♀ paratype. Scale bar: 2 mm.

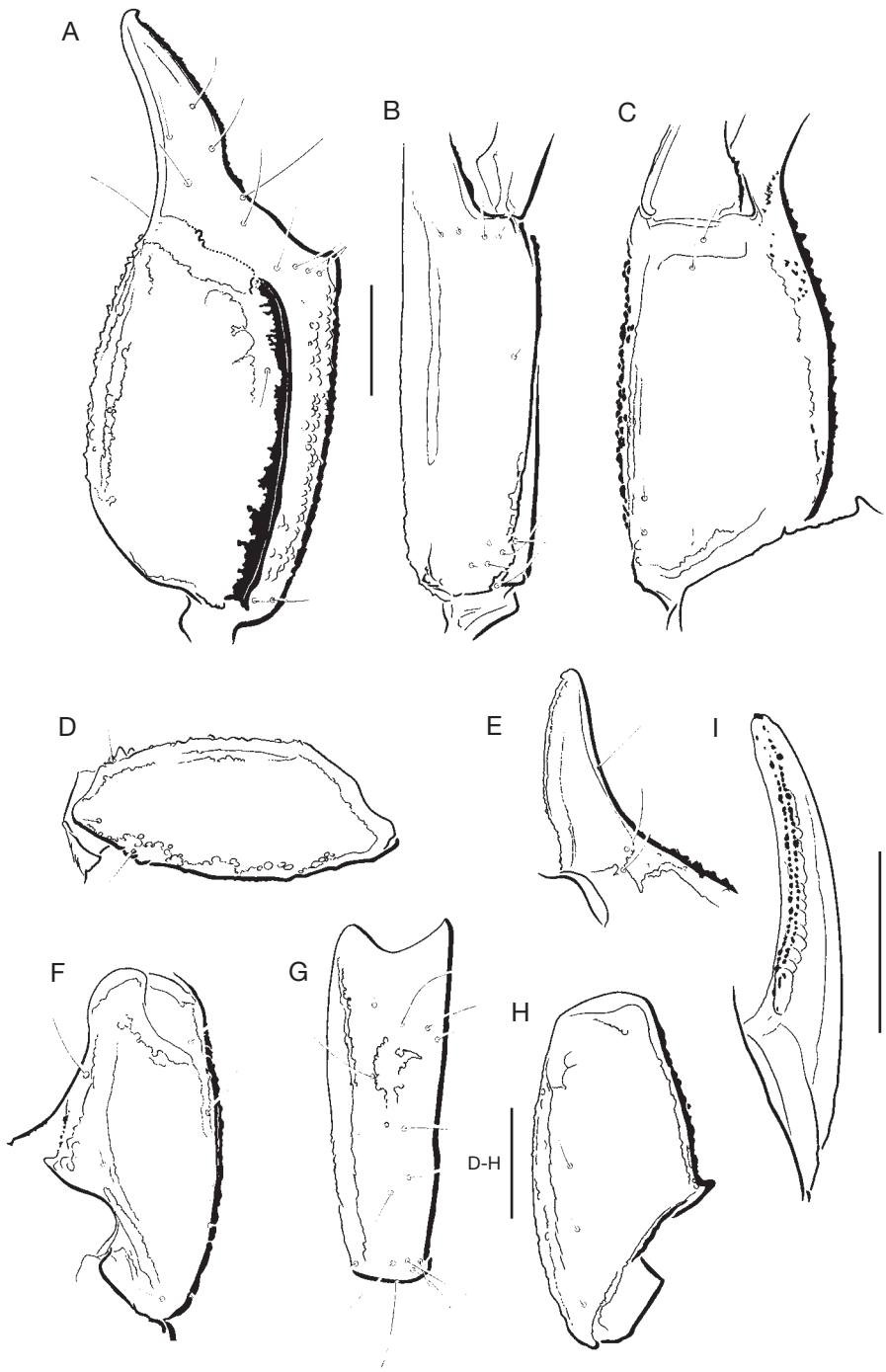

FIG. 4. — *Opisthacanthus milloti* n. sp., ♂ holotype, trichobothrial pattern: **A**-**C**, chela dorso-external, external and ventral aspects; **D**, femur, dorsal aspect; **E**, fixed finger, internal aspect; **F**-**H**, patella, dorsal, external and ventral aspects; **I**, cutting edge of movable finger with rows of granules. Scale bars: 2 mm.

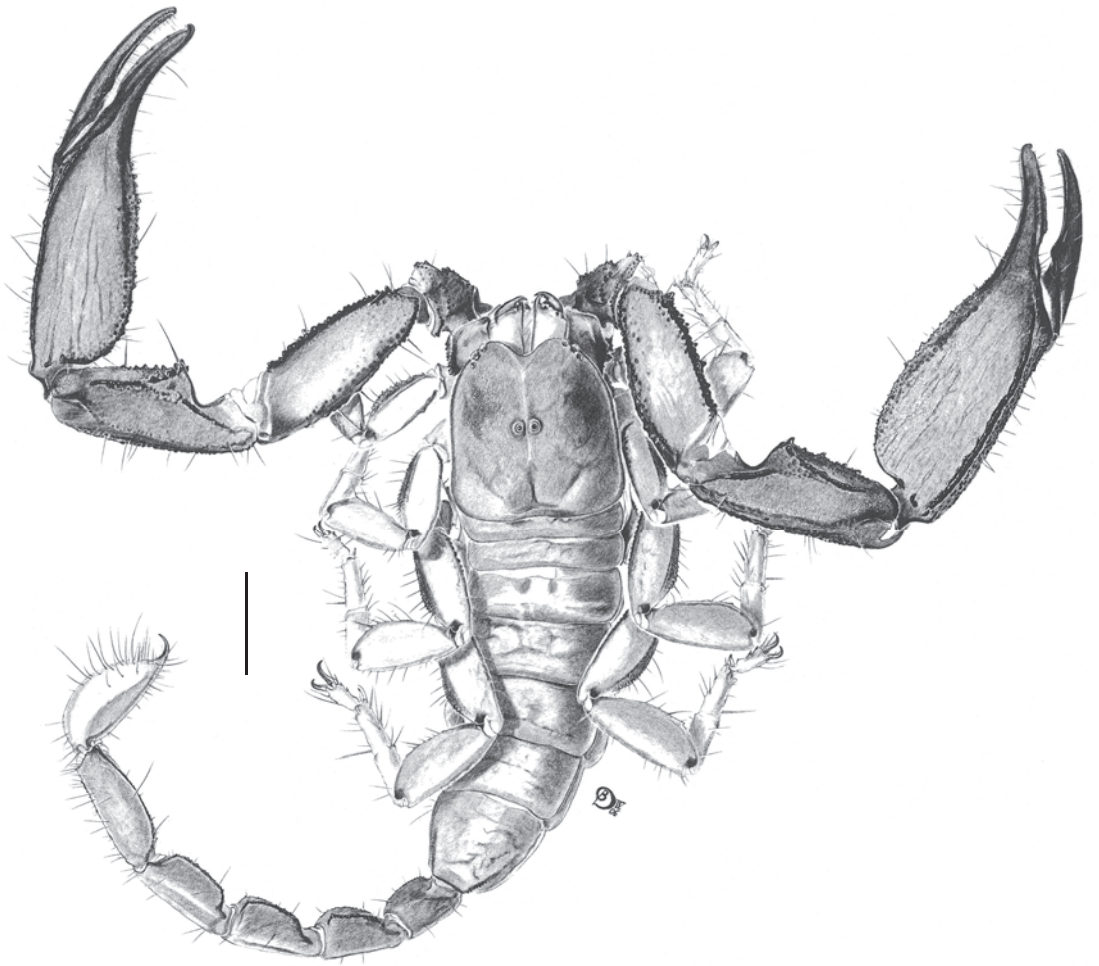

FIG. 5. — *Opisthacanthus pauliani* n. sp., ♂ holotype, habitus. Scale bar: 5 mm.

Chelicerae typical of Scorpionoidea (Vachon 1963); teeth sharp (Fig. 2B). Trichobothriotaxy type C (Fig. 4A-H); orthobothriotaxic (Vachon 1974). Legs: tarsi of legs III and IV with two prolateral and two retrolateral spines, surrounded by a few long setae. Spurs moderate. Hemispermatophore as in Figure 2C with the distal lamina elongated and weakly enlarged.

Ecology and distribution

This new species is only known from its type locality. Because it was collected at the cave entrance only, it is not to be considered as a troglobitic element.

Opisthacanthus pauliani n. sp.
(Figs 5-7)

MATERIAL EXAMINED. — **Madagascar.** Antsiranana Province, Réserve spéciale d'Ankarana, grotte d'Ambatoharana, 30 m from the entry, XI.1949, J. Millot leg., 1 ♂ holotype, 1 ♂ paratype (MNHN).

DIAGNOSIS. — Medium size scorpions: male 52 mm in total length. Coloration yellowish to slightly reddish-yellow, with some dark zones on pedipalp carinae. Pectines with 7-7 teeth in males. Hemispermatophore as in Figure 6D. Male genital operculum large and slightly heart-like shaped (Fig. 6C). Trichobothrial pattern of type C, orthobothriotaxy.

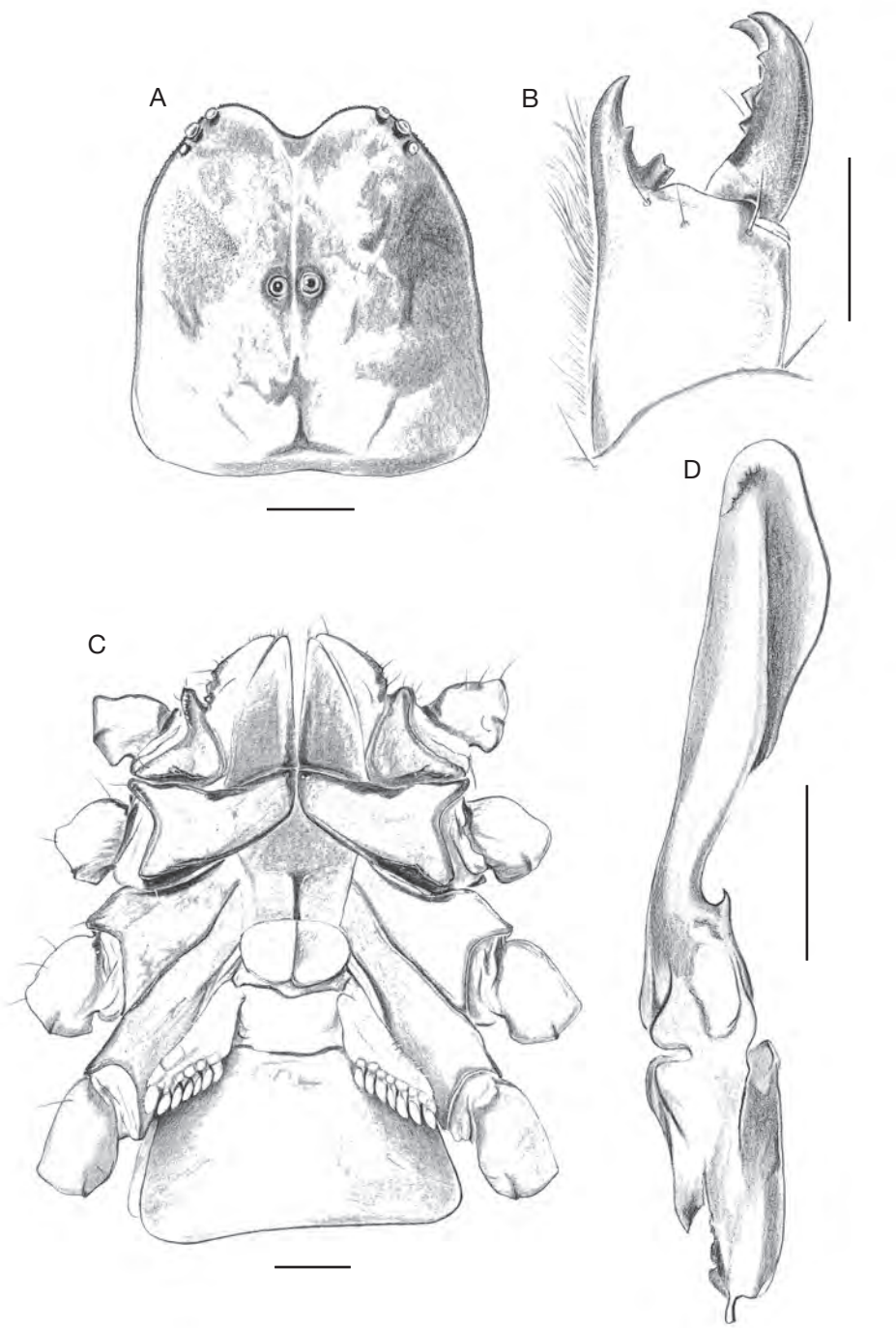

Fig. 6. — *Opisthacanthus pauliani* n. sp., ♂ holotype: **A**, carapace; **B**, chelicera; **C**, ventral aspect, showing coxapophysis, sternum, genital operculum, pectines and sternite III; **D**, hemispermatophore, external aspect. Scale bars: 2 mm.

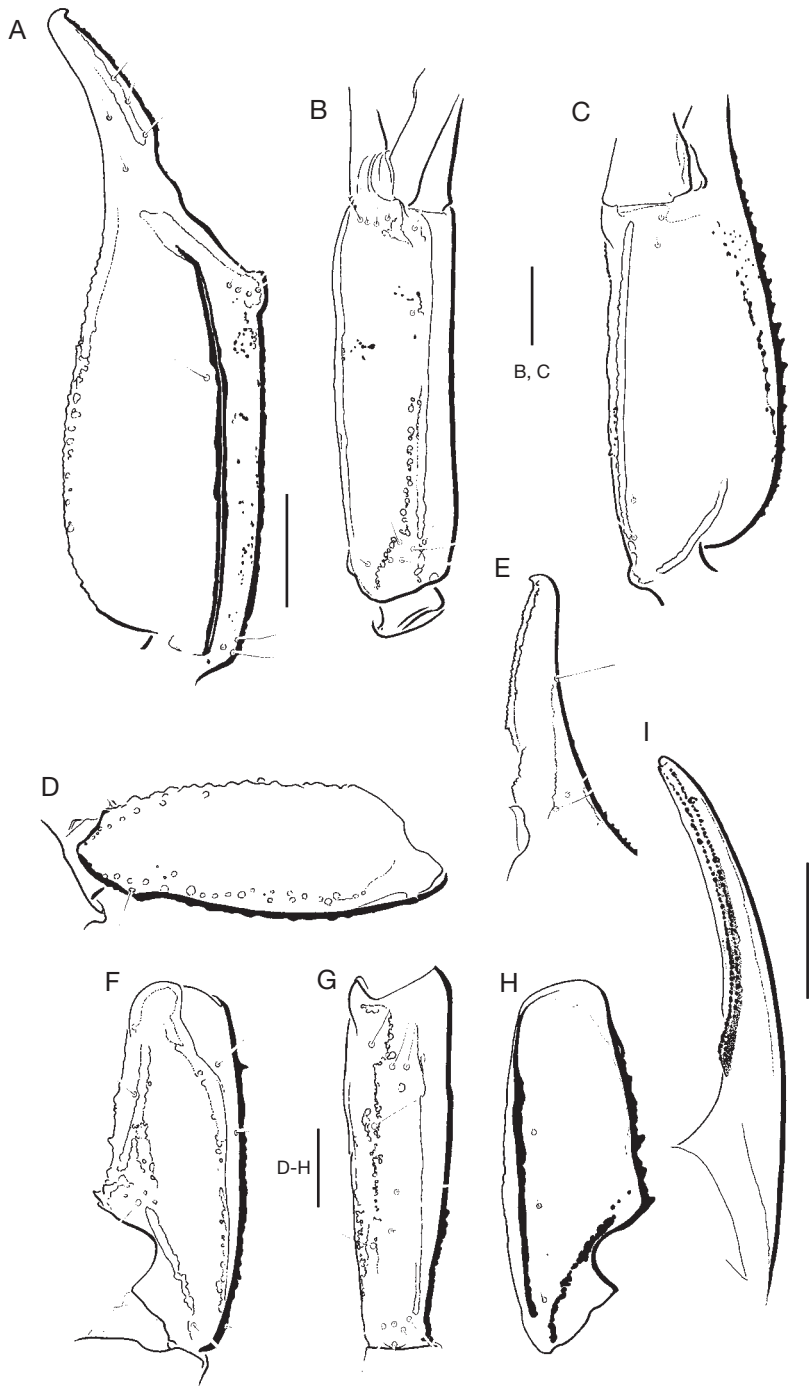

FIG. 7. — *Opisthacanthus pauliani* n. sp., ♂ holotype, trichobothrial pattern: **A**-**C**, chela dorso-external, external and ventral aspects; **D**, femur, dorsal aspect; **E**, fixed finger, internal aspect; **F**-**H**, patella, dorsal, external and ventral aspects; **I**, cutting edge of movable finger with rows of granules. Scale bars: 2 mm.

The new species can be distinguished from *O. madagascariensis* and the other Malagasy species of *Opisthacanthus* by the following characters: 1) a very much paler general coloration; 2) reduction of the median and lateral eyes of about 25% of their size; and 3) hemispermatophore with the distal lamina shorter than in *O. madagascariensis* and not as enlarged.

ETYMOLOGY. — Patronym in honour of the late Prof. Renaud Paulian, who devoted many years of his life to the study of numerous aspects of the Malagasy fauna. He was of paramount importance in launching the modern era of zoological studies on the island.

DESCRIPTION

(based on ♂ holotype and ♂ paratype)

Coloration

Basically yellowish with some dark zones on pedipalp carinae (Fig. 5). Carapace yellowish with two slightly reddish zones laterally; median and lateral eyes surrounded with dark pigment. Tergites yellowish. Metasomal segments yellowish, with reddish zones on dorsal carinae and dorsal furrow of segments II to IV; vesicle pale yellow; aculeus reddish. Chelicerae pale yellow; fingers yellowish with pale reddish teeth. Pedipalps yellowish to reddish-yellow; most carinae dark. Venter and sternites yellowish; pectines and genital operculum pale yellow; legs yellowish with some internal carinae reddish.

Morphology

Carapace with some rare thin granulations laterally and with punctation; almost smooth; furrows shallow. Anterior margin with a strong concavity reaching the level of the second lateral eye (Fig. 6A). Median ocular tubercle flattened and almost in the center of the carapace; median eyes moderate, separated by less than one ocular diameter; three pairs of lateral eyes. Sternum pentagonal, wider than long (Fig. 6C). Genital operculum large formed by two semi-oval plates slightly heart-like shaped. Tergites with only a vestigial median carina, and with some minute granulations; almost smooth and with several punctations. Pectinal tooth count 7-7 in male holotype and male paratype. Sternites smooth and shiny; VII acarinate with several punctations. Metasomal segments I to V longer than wide, with some rare and thin granulations. All carinae weakly marked in segments I-IV; segment V rounded with some spinoid granules on the ventral surface. All segments with weak setation. Telson with a pear-like shape; smooth and covered with strong setation (Fig. 5). Pedipalps: femur with dorsal internal, dorsal external, ventral internal, and ventral external carinae strong, tuberculate; dorsal face with very thin granulation; ventral face with some minute granulations, almost smooth; internal face moderately granulose. Patella with internal and external faces moderately granulated; dorsal and ventral faces smooth and lustrous; dorsal internal, dorsal external, ventral internal, ventral external, and external carinae strong; other carinae less well-marked. Chela moderately to strongly granular on internal and external faces; dorsal marginal, external secondary, ventro-internal and ventral median carina strong; other carinae less well-marked. Chelicerae typical of Scorpionoidea (Vachon 1963); teeth weakly sharp (Fig. 6B). Trichobothriotaxy type C (Fig. 7); orthobothriotaxic (Vachon 1974). Legs: tarsi of legs III and IV with two prolateral and two retrolateral spines, surrounded by a few long setae. Spurs moderate. Hemispermatophore has the distal lamina short and moderately enlarged, as in Figure 6D.

Ecology and distribution

In contrast to *O. milloti* n. sp., *O. pauliani* n. sp. was found inside the cave, and probably is an obligate cave-dwelling animal. This species is only known from the type locality.

KEY TO THE MALAGASY SPECIES OF *OPISTHACANTHUS*

Note: the stability of the characters used in the key have been demonstrated in the study by Lourenço & Goodman (2006), in which a few hundreds specimens have been examined.

1. Adult scorpions with 52 to 68 mm in total length 2
— Adult scorpions with 35 to 45 mm in total length 4

2. Coloration reddish-brown to dark brown or globally blackish 3
— Coloration globally yellowish to pale yellow ..... *O. pauliani* n. sp.

3. Coloration reddish-brown to dark brown ..... *O. madagascariensis*
— Coloration globally blackish, including vesicle; blackish spots on pectines and genital operculum ..... *O. piceus*

4. Coloration yellowish to reddish-yellow ..... *O. lucienneae*
— Coloration dark; reddish-brown to dark brown 5

5. Female genital operculum with an almost oval-shape, and without any incision in the base 6
— Female genital operculum heart-like shaped with a small incision in the base .... *O. maculatus*

6. Sternite VII without carinae ..... *O. darainensis*
— Sternite VII with four moderate carinae ..... *O. milloti* n. sp.

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