

A REAPPRAISAL OF THE GEOGRAPHICAL DISTRIBUTION OF THE GENUS *OPISTHACANTHUS* PETERS, 1861 (SCORPIONES: LIOCHELIDAE) IN MADAGASCAR, INCLUDING THE DESCRIPTION OF FOUR NEW SPECIES

Wilson R. Lourenço¹ & Steven M. Goodman²

¹ Département de Systématique et Evolution, USM 0602, Section Arthropodes (Arachnologie), Muséum national d'Histoire naturelle, CP 053, 61 rue Buffon 75005 Paris, France: e-mail: arachne@mnhn.fr

² Field Museum of Natural History, 1400 South Lake Shore Drive, Chicago, Illinois 60605, USA, and WWF, BP 738, Antananarivo (101), Madagascar: e-mail: sgoodman@fieldmuseum.org

Abstract: A review of the geographical distribution of the Malagasy species of the genus *Opisthacanthus* Peters (Scorpiones, Liochelidae) is presented. Four new species, *Opisthacanthus luciennae* sp. n., *Opisthacanthus maculatus* sp. n., *Opisthacanthus darainensis* sp. n., and *Opisthacanthus piceus* sp. n. are described. The total number of species in this genus on Madagascar is now raised to five and the known geographical distribution encompasses much of the drier forest zones of the island.

Key word: Scorpion, Geographical distribution, new species of *Opisthacanthus*, Liochelidae, Madagascar.

Revisión de distribución geográfica del género *Opisthacanthus* Peters, 1861 (Scorpiones: Liochelidae) en Madagascar, incluida la descripción de cuatro nuevas especies

Resumen: Se presenta una revisión de la distribución geográfica de las especies malgaches del género *Opisthacanthus* Peters (Scorpiones, Liochelidae). Cuatro nuevas especies, *Opisthacanthus luciennae* sp. n., *Opisthacanthus maculatus* sp. n., *Opisthacanthus darainensis* sp. n., y *Opisthacanthus piceus* sp. n. son descritas. El número total de especies en este género en Madagascar se eleva ahora a cinco y la distribución geográfica conocida abarca gran parte de las zonas del bosque más secas de la isla.

Palabras clave: Scorpion, distribución geográfica, nuevas especies de *Opisthacanthus*, Liochelidae, Madagascar.

Taxonomy / Taxonomía:

Opisthacanthus luciennae sp. n.

Opisthacanthus maculatus sp. n.

Opisthacanthus darainensis sp. n.

Opisthacanthus piceus sp. n.

Introduction

Scorpions of the family Liochelidae (formerly Ischnuridae) have been the subject of several studies and taxonomic revisions during the last 20 years (Lourenço, 1983, 1985, 1987, 1989, 1997; Monod, 1999; Striffler, 2001). Nevertheless, new discoveries are inevitable on an island such as Madagascar that is so poorly known from a biodiversity perspective, and an excellent example is the recent description of a new endemic liochelid genus, *Palaeocheloctonus* (Lourenço, 1996). However, the composition of most liochelid genera has remained relatively stable in recent years with few new species described from the genera *Opisthacanthus* (Lourenço, 1980, 1981, 2003; Lourenço & Fé, 2003), *Liocheles* (Francke & Lourenço, 1991; Monod, in preparation), *Iomachus* (Bastawade, 1986; Lourenço, 2003), and *Chiomachetes* (Lourenço, 1997).

The present study focuses on a large number of liochelid scorpions of the genus *Opisthacanthus*, subgenus *Monodopisthacanthus* from Madagascar, held in the collections of the California Academy of Sciences (CAS) and the Muséum national d'Histoire naturelle (MNHN, Paris), which contain four previously unrecognised species. These animals were collected from the extreme southeast to the extreme northeast, and are related to *O. madagascariensis* Kraepelin, 1894, which was the only species previously known on the island. Some comments on the geographic distribution and the ecology of the Malagasy species of *Opisthacanthus* are included in the paper. The family name Liochelidae and the familial classifications proposed by Lourenço (2000) and Prendini (2000) for this group are

maintained. Moreover, in a recent publication, Prendini and Wheeler (2005) re-established the Liochelidae as a family. In our opinion this is the most justified decision, and it is adopted here.

The composition of the genus *Opisthacanthus* Peters, 1861

The classification given below takes into account some recent taxonomic modifications proposed for the genus: (a) the revalidation of *O. heurtaultae* Lourenço (Lourenço, 1995) as an endemic element of the fauna of French Guiana, (b) the description of the subgenus *Monodopisthacanthus* Lourenço to accommodate the Malagasy species (Lourenço, 2001), and (c) the confirmation of *O. punctulatus* Pocock, 1896 as a junior synonym of *O. madagascariensis*.

Subgenus *OPISTHACANTHUS* Peters, 1861

I. *cayaporum* group

Opisthacanthus cayaporum Vellard, 1932

Opisthacanthus heurtaultae Lourenço, 1980

Opisthacanthus weyrauchi Mello-Leitão, 1948

II. *lepturus* group

Opisthacanthus lepturus (Beauvois, 1805)

Opisthacanthus elatus (Gervais, 1844)

Opisthacanthus valerioi Lourenço, 1980

Opisthacanthus borboremai Lourenço & Fé, 2003

III. *lecomtei* group

Opisthacanthus lecomtei (Lucas, 1858)

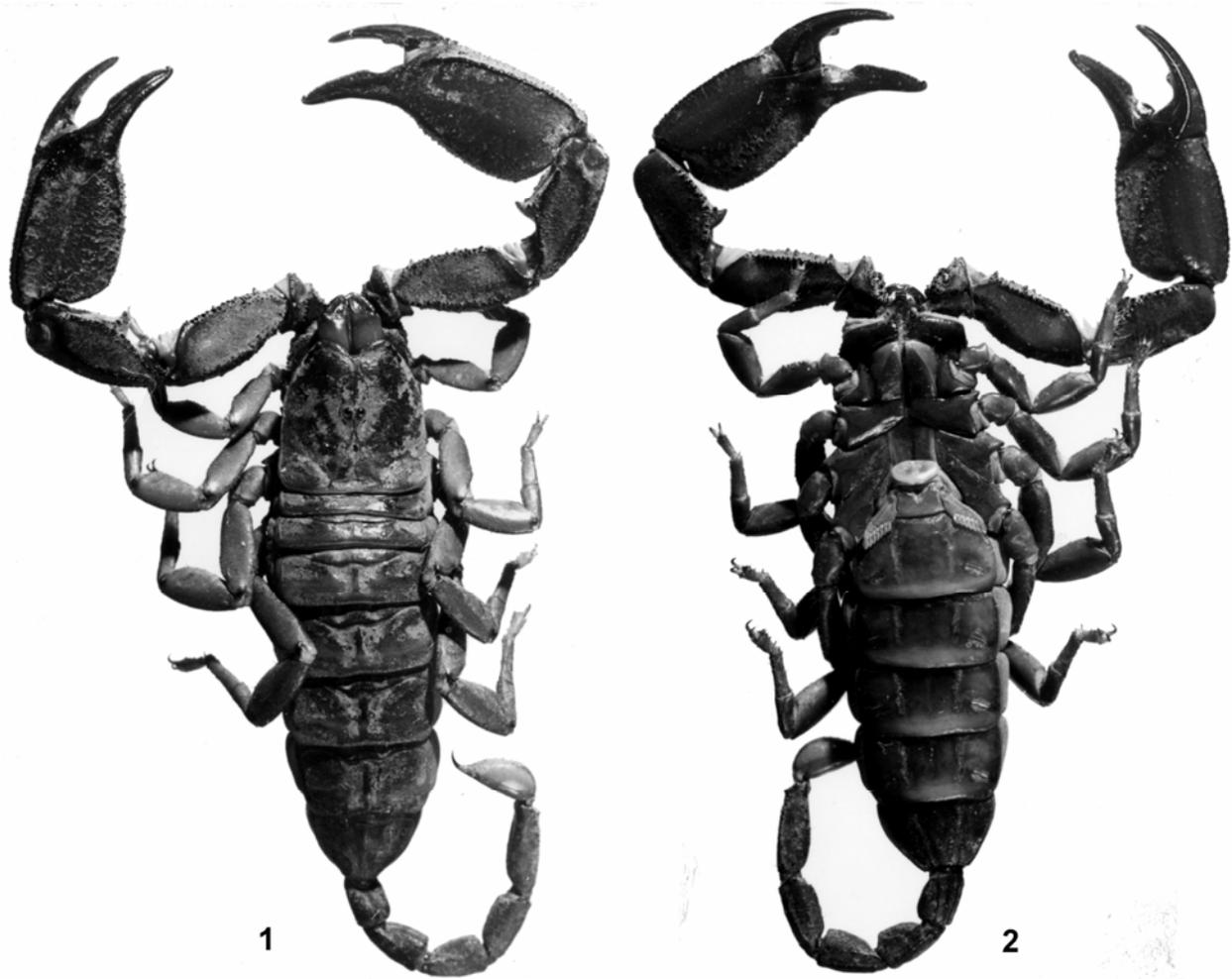


Fig. 1-2. *Opisthacanthus madagascariensis*. Female holotype, dorsal and ventral aspects.

Subgenus *NEPABELLUS* Francke, 1974

I. africanus group

- Opisthacanthus africanus africanus* Simon, 1876
- Opisthacanthus africanus pallidus* Lourenço, 2003
- Opisthacanthus capensis* Thorell, 1876
- Opisthacanthus diremptus* (Karsch, 1879)

II. asper group

- Opisthacanthus asper* (Peters, 1861)
- Opisthacanthus basutus* Lawrence, 1955
- Opisthacanthus rugiceps* Pocock, 1897

III. laevipes group

- Opisthacanthus laevipes* (Pocock, 1893)

IV. rugulosus group

- Opisthacanthus lamorali* Lourenço, 1981
- Opisthacanthus rugulosus* Pocock, 1896

V. validus group

- Opisthacanthus piscatorius* Lawrence, 1955
- Opisthacanthus validus* Thorell, 1876

Subgenus *MONODOPISTHACANTHUS* Lourenço, 2001

I. madagascariensis group

- Opisthacanthus madagascariensis* Kraepelin, 1894
- Opisthacanthus luciennae* sp. n.
- Opisthacanthus maculatus* sp. n.
- Opisthacanthus darainensis* sp. n.
- Opisthacanthus piceus* sp. n.

Taxonomic treatment

Historical account

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

More recently, in a monograph devoted to the scorpion fauna of Madagascar, Lourenço (1996), attempted to characterize these two species, based upon his observations on some old collections of the MNHN. In a more recent publication (Lourenço, 2004), the question of the validity of these two species was reopened, and it appeared evident that the very broad distribution of the genus in Madagascar could not be correlated with a precise distribution pattern of a single species. The difficulty in resolving this taxonomic problem was associated with the fact that most of the specimens from older collections lacked precise details about their provenance.

Recently obtained samples provide the needed material to allow for the recognition of some intra-population

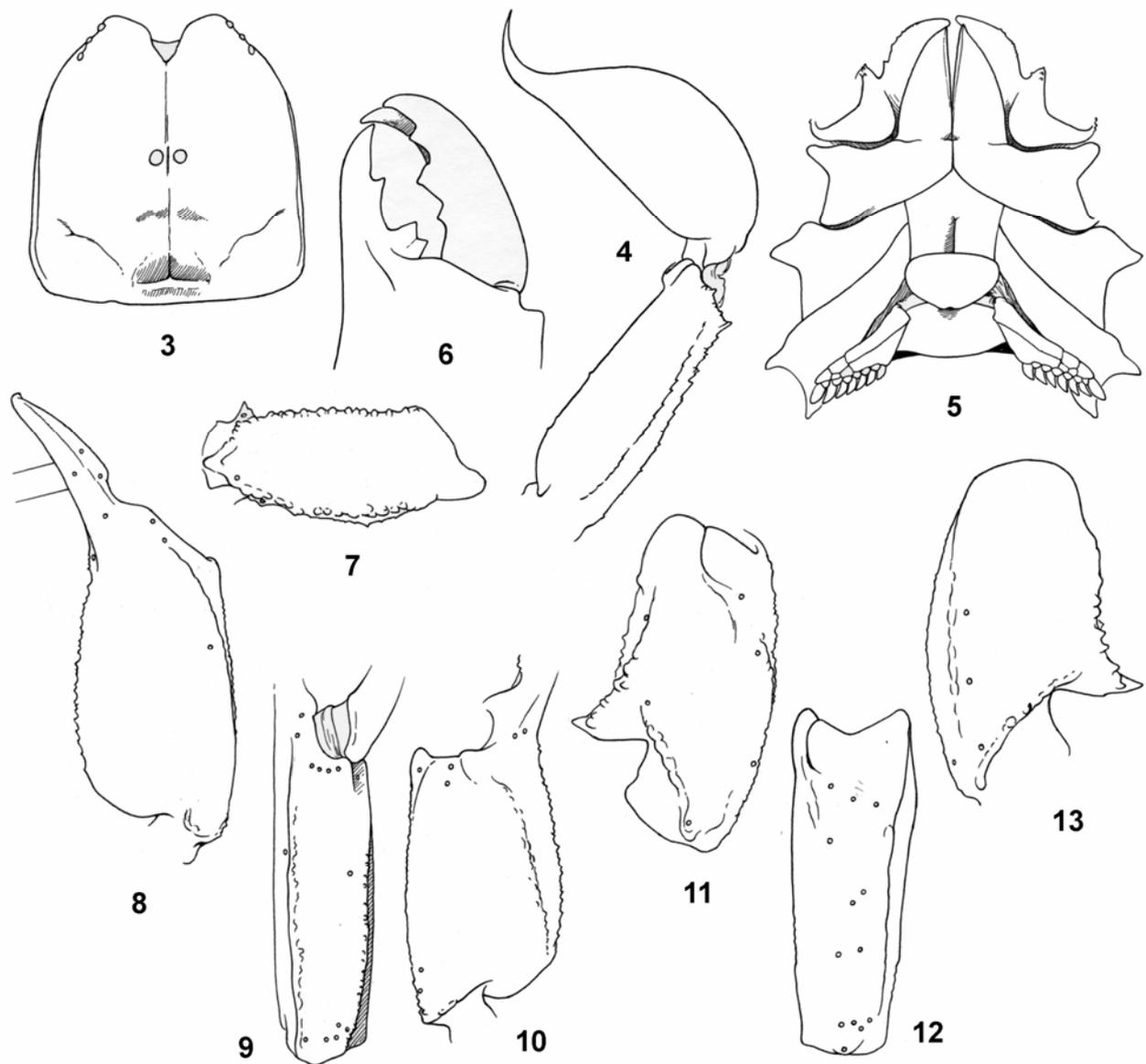


Fig. 3-13. *Opisthacanthus madagascariensis*. Female holotype. 3. Carapace. 4. Metasomal segment V and telson, lateral aspect. 5. Ventral aspect, showing Coxapophysis, sternum, the shape of the genital operculum plate and pectines. 6. Chelicera. 7-13. Trichobothrial pattern. 7. Femur, dorsal aspect. 8-10. Chela, dorso-external, external and internal aspects. 11-13. Patella, dorsal, external and ventral aspects.

variability in *O. madagascariensis*. This led to the confirmation of the synonymy: *O. punctulatus* = *O. madagascariensis*. Detailed examination of these new samples revealed that non-described species of *Opisthacanthus* were present in Madagascar. These new taxa were in previous studies misidentified as possible juvenile forms of *O. madagascariensis*, but the subsequent study of their internal genitalia confirmed that they are adults. Therefore, the broad distribution previously assigned to *O. madagascariensis* (Lourenço, 1996, 2002) corresponds in fact to several different taxa. The geographical distribution of *O. madagascariensis* ranges from the vicinity of the Manongarivo Massif in the northwest (Lourenço, 2002) to south of 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 a new species described herein. Two of the new species described in this

paper, namely *O. darainensis* sp. n. and *O. piceus* sp. n., represent, however, totally new geographic records of the genus *Opisthacanthus* on Madagascar.

***Opisthacanthus madagascariensis* Kraepelin, 1894**

Figs. 1-16. Table I.

REVISED DIAGNOSIS: Medium to large size scorpions: males 62 mm and females 68 mm in total length. Coloration. Basically reddish brown to dark brown with some blackish zones on the pedipalp carinae and metasomal segments. Metasomal segments darker than prosoma and mesosoma; vesicle reddish-yellow; aculeus dark reddish on the tip. Chelicerae reddish-brown; base of fingers blackish; the whole surface with dark variegated spots; fingers dark with reddish teeth. Pedipalps blackish-brown. Venter and sternites reddish-yellow to reddish-brown; pectines and genital operculum paler than sternites; legs yellowish to reddish-

Table I. Measurements (in mm) of the male and female of *Opisthacanthus madagascariensis*, the male holotype and female paratype of *Opisthacanthus luciennae* sp. n., the male holotype and female paratype of *Opisthacanthus maculatus* sp. n. and *Opisthacanthus darainensis* sp. n., and the male holotype of *Opisthacanthus piceus* sp. n.

	<i>Opisthacanthus</i>									
	<i>madagascariensis</i>		<i>luciennae</i> sp. n.		<i>maculatus</i> sp. n.		<i>darainensis</i> sp. n.		<i>piceus</i> sp. n.	
	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀
Total length	61.2	68.5	35.5	42.9	36.2	35.7	39.5	43.1	53.5	
Carapace:										
- length	11.2	11.9	6.8	7.5	6.4	6.6	6.7	7.2	8.5	
- anterior width	7.4	7.5	4.4	4.8	4.0	4.1	4.4	4.5	5.4	
- posterior width	10.8	12.0	6.6	7.2	6.4	6.6	6.7	7.2	8.4	
Metasomal segment I:										
- length	4.2	3.8	2.1	2.3	2.2	2.2	2.2	2.2	3.0	
- width	2.8	2.8	1.7	1.9	1.6	1.6	1.7	2.0	2.0	
Metasomal segment V:										
- length	7.2	6.8	4.6	4.7	4.3	4.0	4.4	4.5	5.0	
- width	2.1	1.9	1.3	1.4	1.3	1.2	1.4	1.4	1.5	
- depth	2.6	2.2	1.4	1.5	1.4	1.3	1.5	1.5	1.8	
Vesicle:										
- width	2.4	2.1	1.7	1.7	1.5	1.2	1.8	1.7	1.4	
- depth	2.9	2.5	2.0	2.0	1.6	1.4	2.0	1.8	1.7	
Pedipalp:										
- Femur length	15.1	11.9	7.0	6.6	6.2	5.6	6.5	5.8	8.6	
- Femur width	4.8	5.2	2.8	2.9	2.6	2.6	2.6	2.7	3.4	
- Patella length	14.2	11.0	7.3	6.8	6.3	5.8	7.1	6.3	7.9	
- Patella width	4.7	4.9	2.6	2.7	2.7	2.6	2.6	2.7	3.4	
- Chela length	25.2	22.1	12.2	13.2	11.1	10.8	11.8	11.9	15.7	
- Chela width	6.4	7.5	3.9	5.1	3.8	4.1	4.2	4.8	4.7	
- Chela depth	6.2	6.5	2.5	3.2	2.6	2.9	2.4	3.4	3.2	
Movable finger:										
- length	10.9	11.2	5.9	6.9	5.1	4.8	5.2	5.8	7.2	

yellow with very diffused spots. Morphology. Body and appendages weakly granulated, almost smooth and with punctuations. Sternum wider than long. Genital operculum formed by two semi-oval plates in males, and one single heart-like shaped plate in females, with a small incision in the base. Pectinal tooth count 7 to 8 in males and 6 to 8 in females; mode 8 in males, 7 in females. Trichobothriotaxy type C; orthobothriotaxic (Vachon, 1974). Legs: tarsi with 3 lateral rows of spines, surrounded by some long setae. Hemispermaphore as in Figures 15-16 with the distal lamina long and complex.

ECOLOGY AND DISTRIBUTION: This species has a broad distribution across portions of south-central, western, and southern Madagascar and is known from several different types of vegetation formations. Several of the collection sites are in zones of transitional humid and dry deciduous forest and often with canyons that create locally more mesic conditions (e.g., Analalava, Namoroka, Bemaraha) or specifically in gallery forest bordered by distinctly drier formations (e.g., Mahavavy River, Fiherenana River, Antafoky). It is also known from the dry deciduous forests of Kirindy (CFPF) and the Baie du Baly, as well as some of the driest regions of the island, including zones with spiny bush (e.g., Itampolo, near Mitoho Cave, forêt de Mite). All of the sites it has been recorded from in the southern portion of its range are to the north of the Onilahy River, with the exceptions of Itampolo and Mitoho Cave. On the basis of these records, *O. madagascariensis* is a species that tolerates a considerable range of ecological conditions, but is unknown from the humid forest portions of the island.

MATERIAL EXAMINED DURING THIS STUDY: Madagascar: (46) Fianarantsoa Province, Forêt d'Analalava, 29.6 km 280° W Rano-

hira, 700 m alt. (22° 35' 30" S, 45° 7' 42" E), 1-5/II/2003 (Fisher & Griswold *et al.*), general collecting, tropical dry forest, 2 males (CAS). (33) Fianarantsoa Province, Forêt d'Analalava, 29.6 km 280° W Rano- hira, 700 m alt. (22° 35' 30" S, 45° 7' 42" E), 1-5/II/2003 (Fisher & Griswold *et al.*), general collecting, tropical dry forest, 1 female + 29 offspring (CAS). (18) Mahajanga Province, Parc National de Namoroka, 16.9 km 317° NW Vilanandro, 100 m alt. (16° 24' 24" S, 45° 18' 36" E), 12-16/XI/2002 (Fisher & Griswold *et al.*), general collecting, tropical dry forest, 1 male, 1 female (CAS). (11) Mahajanga Province, Mahavavy River, 62 km 145° SE Mitsinjo, 20 m alt. (16° 03' 06" S, 45° 54' 30" E), 1-5/XII/2002 (Fisher & Griswold *et al.*), general collecting, in gallery forest, 3 males, 6 females (CAS). (8) Mahajanga Province, Parc National de Baie de Baly, 12.4 km 337° NNW Soalala, 10 m alt. (16° 00' 36" S, 45° 15' 54" E), 26-30/XI/2002 (Fisher & Griswold *et al.*), general collecting, tropical dry forest, 8 males, 3 females (CAS). (4) Mahajanga Province, Parc National Tsingy de Bemaraha, 3.4 km 95° E Bekopaka, Tombeau Vazimba, 50 m alt. (19° 8' 31" S, 44° 49' 41" E), 6-10/XI/2001 (Fisher & Griswold *et al.*), general collecting, tropical dry forest, 1 male (CAS). (19) Mahajanga Province, Parc National Tsingy de Bemaraha, 3.4 km 93° E Bekopaka, Tombeau Vazimba, 50 m alt. (19° 8' 31" S, 44° 49' 41" E), 6-10/XI/2001 (Fisher & Griswold), general collecting, tropical dry forest, 3 males, 1 female (CAS). (0) Mahajanga Province, Parc National Tsingy de Bemaraha, 2.5 km 62° ENE Bekopaka, Ankidrodra River, 100 m alt. (19° 7' 56" S, 44° 48' 53" E), 11-15/XI/2001 (Fisher & Griswold *et al.*), 2 males, 1 female (MNHN). (45) Mahajanga Province, Parc National de Namoroka, 16.9 km 317° NW Vilanandro, 100 m alt. (16° 24' 24" S, 45° 18' 36" E), 12-16/XI/2002 (Griswold & Fisher *et al.*), tropical dry forest, EF33-BLF6585, 1 male (CAS). (47) Mahajanga Province, Parc National de Namoroka, 9.8 km 300° WNW Vilanandro, 140 m alt. (16° 28' 00" S, 45° 21' 00" E), 4-8/XI/2002 (Fisher & Griswold *et al.*), general collecting, tropical dry forest, 1 male, 2 females (CAS). (49) Mahajanga Province, Parc National Tsingy de Bemaraha, 2.5 km 62° ENE Bekopaka, Ankidrodra River, 100 m alt. (19° 7' 56" S, 44° 48' 53" E), 11-

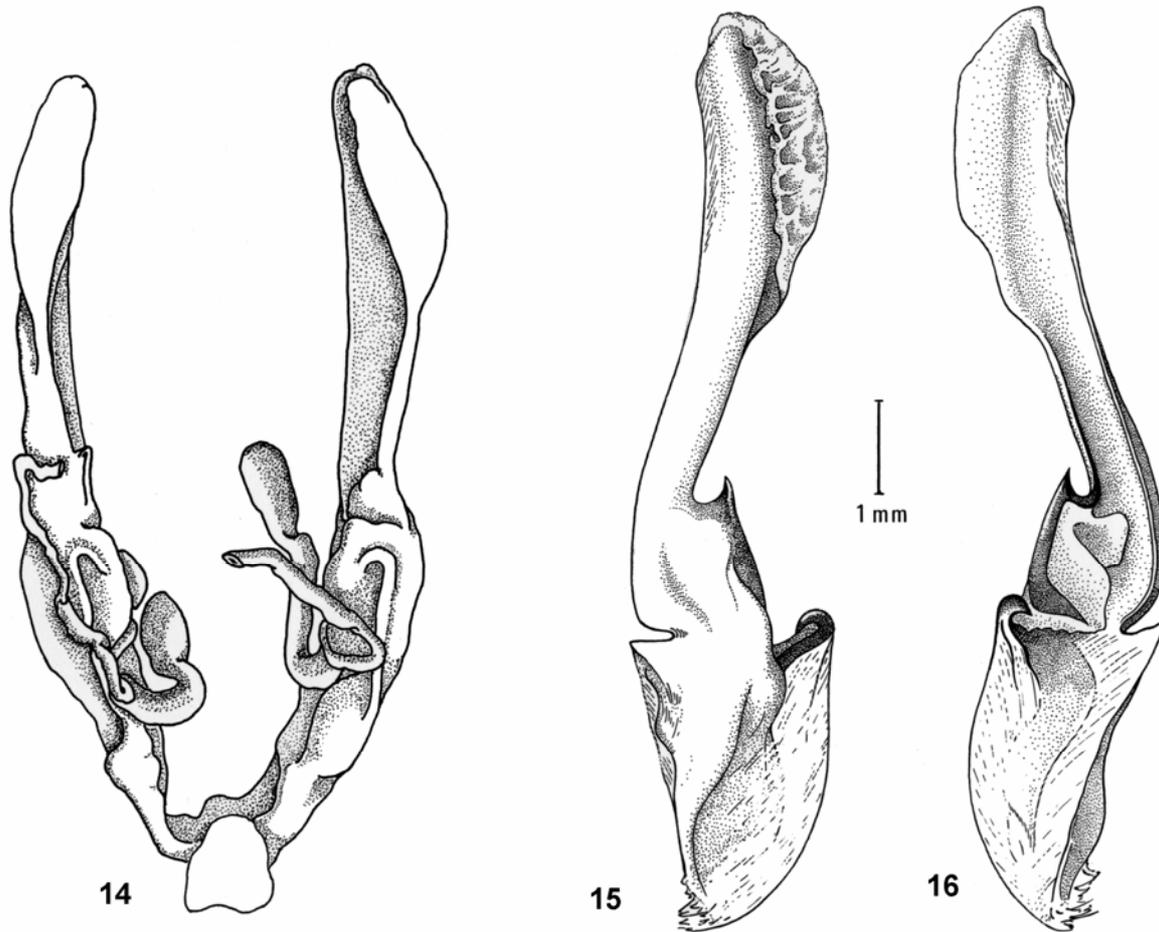


Fig. 14-16. *Opisthacanthus madagascariensis*. Male. 14. Paraxial organ. 15-16. Hemispermatophore, external and internal aspects.

15/XI/2001 (Fisher *et al.*) tropical dry forest on *tsingy*, general collecting, ground spiders, 1 male (CAS). (50) Mahajanga Province, Parc National Tsingy de Bemaraha, 10.6 km 23° ESE Antsalova, 150 m alt. (19° 42' 34" S, 44° 43' 5" E), 16-20/XI/2001 (Fisher & Griswold *et al.*), general collecting, tropical dry forest on *tsingy*, 1 male (CAS). (51) Mahajanga Province, Parc National de Namoroka, 17.8 km 329° WNW Vilanandro, 100 m alt. (16° 22' 36" S, 45° 19' 36" E), 8-12/XI/2002 (Fisher & Griswold *et al.*), general collecting, tropical dry forest, 2 females (CAS). (50) Mahajanga Province, Parc National Tsingy de Bemaraha, 10.6 km 123° ESE Antsalova, 150 m alt. (19° 42' 34" S, 44° 43' 5" E), 16-20/XI/2001 (Fisher & Griswold *et al.*), pitfall trap, tropical dry forest on *tsingy*, 1 male (CAS). (1) Toliara Province, Mahafaly Plateau, 6.2 km 74° ENE Itampolo, 80 m alt. (24° 39' 13" S, 43° 59' 40" E), 21-25/II/2002 (Fisher & Griswold *et al.*), general collecting, spiny forest thicket, 2 females (CAS). (3) Toliara Province, Parc National de Tsimanampetsotsa, Mitoto Cave, 6.4 km 77° ENE Efoetse, 17.4 km 170° S Beheloka, 40 m alt. (24° 2' 50" S, 43° 45' 11" E), 18-22/III/2002 (Fisher & Griswold *et al.*), general collecting, spiny forest thicket, 2 males, 3 females (CAS). (9) Toliara Province, Forêt de Mite, 20.7 km 29° WNW Tongobory, 75 m alt. (23° 31' 27" S, 44° 7' 17" E), 27/II/3/III/2002 (Fisher & Griswold), general collecting, gallery forest, 4 males, 3 females (CAS). (24) Toliara Province, Antafoky, 60 m alt. (23° 28' 45" S, 44° 3' 59" E), 1/VII-31/XII/2001 (Frontier Project, [MGF ##]), gallery forest, pitfall traps, 2 males, 1 female (CAS). (15) Toliara Province, Fiherenana River valley, 50 m alt. (23° 13' 17" S, 43° 52' 52" E), 17/XI/2002 (Frontier Project, MGF 046), sifted litter, leaf mold, rotten wood, 2 females (CAS). (48) Toliara Province, Forêt de Kirindy (CFPF), 15.5 km 64° ENE Marofandilia, 100 m alt. (20° 2' 43" S, 44° 39' 44" E), 28/XI-3/XII/2001 (Fisher & Griswold *et al.*), general collecting, tropical dry forest, 2 males (CAS).

***Opisthacanthus lucienneae* sp. n.**

Figs. 17-27. Table I.

DIAGNOSIS: Medium to small size scorpions: males 36 mm and females 43 mm in total length. Coloration yellowish to reddish-yellow, with some dark variegated zones on carapace and metasomal segments. Pectines with 7 to 9 teeth in males and females; mode 8 in males and 7 in females. Hemispermatophore as in Figure 23 with the distal lamina shorter than in *O. madagascariensis* and not as enlarged. Female genital operculum large and slightly heart-like shaped, without an incision in the base. Trichobothrial pattern of type C, orthobothriotaxy.

MATERIAL STUDIED: Madagascar: (7) Toliara Province, Réserve Spéciale de Cap Sainte Marie, 14.9 km 261° W Marovato, 160 m alt. (25° 35' 40" S, 45° 8' 49" E), 13-19/II/2002 (Fisher & Griswold), Malaise trap in spiny forest thicket. 1 male holotype, 3 females paratypes (CAS). (5) Toliara Province, Réserve Spéciale de Cap Sainte Marie, 12.3 km 262° W Marovato, 200 m alt. (25° 34' 54" S, 45° 10' 6" E), 11-15/II/2002 (Fisher & Griswold *et al.*), general collecting in spiny forest thicket. 1 male, 2 females paratypes (MNHN). (6) Toliara Province, Parc National d'Andohahela (parcel 2), Forêt de Manantalinjo, 33.6 km 63° ENE Amboasary-Sud, 7.6 km 99° E Hazofotsy, 150 m alt. (24° 49' 1" S, 46° 36' 36" E), 12-16/I/2002 (Fisher & Griswold *et al.*), pitfall trap, spiny forest thicket. 2 males, 1 female paratypes (CAS). (13) Toliara Province, Parc National d'Andohahela (parcel 2), Forêt d'Ambohibory, 1.7 km 61° ENE Tsimelaha, 36.1 km 308° NW Tolagnaro, 300 m alt. (24° 55' 48" S, 46° 38' 44" E), 16-20/I/2002 (Fisher & Griswold *et al.*), general collecting, tropical

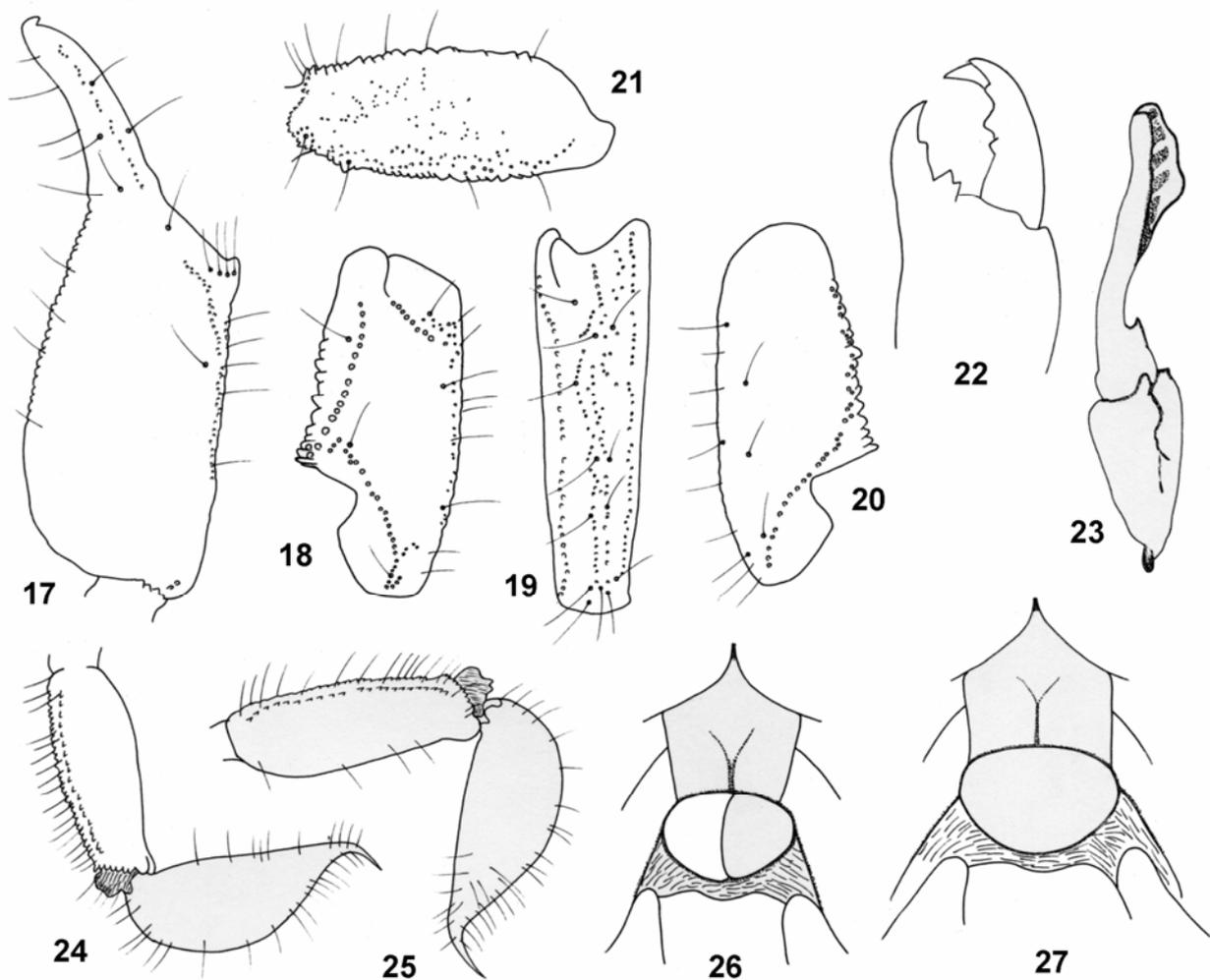


Fig. 17-27. *Opisthacanthus luciennae* sp. n. Male holotype and female paratype. **17-21.** Trichobothrial pattern (male). **17.** Chela, dorso-external aspect. **18-20.** Patella, dorsal, external and ventral aspects. **21.** Femur, dorsal aspect. **22.** Chelicera, dorsal aspect (male). **23.** Hemispermatophore, external aspect. **24-25.** Metasomal segment V and telson, lateral aspect (male & female). **26-27.** Sternum and genital operculum (male & female).

dry forest. 2 males, 2 females paratypes (CAS). (15) Toliara Province, Réserve privée de Berenty, Forêt d'Anjapolo, 21.4 km 325° NW Amboasary-Sud, 65 m alt. (24° 55' 47" S, 46° 12' 36" E), 7/II/2002 (Fisher & Griswold *et al.*), general collecting, spiny forest thicket. 1 male paratype (CAS). (16) Toliara Province, Parc National d'Andohahela (parcel 2), Forêt de Manantalinjo, 33.6 km 63° ENE Amboasary-Sud, 7.6 km 99° Hazofotsy, 150 m alt. (24° 49' 1" S, 46° 36' 36" E), 12-16/I/2002 (Fisher & Griswold *et al.*), general collecting, spiny forest thicket. 3 males, 5 females + 18 offspring paratypes (CAS). (20) Toliara Province, Forêt de Mahavelo, Isantoria River, 110 m alt. (24° 45' 30" S, 46° 9' 26" E), 28/I-1/II/2002 (Fisher & Griswold *et al.*), general collecting, spiny forest thicket. 1 male, 3 females paratypes (CAS). (30) Toliara Province, Réserve privée de Berenty, Forêt de Bealoka, Mandraré River, 14.6 km 329° NNW Amboasary-Sud, 35 m alt. (24° 57' 25" S, 46° 16' 17" E), 3-8/II/2002 (Fisher & Griswold *et al.*), general collecting in gallery forest. 1 female paratype.

ETYMOLOGY: Patronym in honour of Lucienne Wilmé, a naturalist residing on Madagascar and specializing in ornithology and aspects of Madagascar's biogeography. Over many years she has been an important collaborator in our research.

DESCRIPTION based on male holotype and female paratype. **Coloration.** Basically yellowish to reddish-yellow with

some dark variegated zones on the carapace and metasomal segments. Carapace reddish-yellow with dark variegated spots; median and lateral eyes surrounded with black pigment. Tergites yellowish with vestigial dark variegated spots. Metasomal segments yellowish, with dark intense variegated spots; vesicle yellowish; aculeus dark reddish. Chelicerae reddish-yellow; base of fingers dark; the whole surface with diffuse variegated spots; fingers reddish-brown with reddish teeth. Pedipalps reddish-yellow to dark reddish; most carinae blackish. Venter and sternites yellowish to reddish-yellow; pectines and genital operculum paler than sternites, sternum and coxapophysis; legs yellowish with some internal carinae reddish.

Morphology. Carapace with some rare granulations and with punctuation; almost smooth; furrows shallow. Anterior margin with a strong concavity reaching as far as the level of the 2nd lateral eye. Median ocular tubercle flattened and almost in the centre of the carapace; median eyes moderate, separated by a little less than one ocular diameter; three pairs of large lateral eyes. Sternum pentagonal, wider than long. Genital operculum formed by two semi-oval plates in males, and one single slightly heart-like shaped plate in females; without any incision in the base. Tergites with only

a vestigial median carina, smooth and with punctuations. Pectinal tooth count 8-7 in male holotype and 7-7 in female paratype. Sternites smooth and shiny; VII acarinate with a few punctuations. Metasomal segments I to V longer than wide, with some thin but intense granulations. All carinae weakly marked in segments I-IV; segment V rounded with some spinoid granules on the ventral surface. All segments with moderate chetotaxy. Telson with a pear-like shape; smooth and covered with strong chetotaxy. Pedipalps: femur with dorsal internal, dorsal external, ventral internal, and ventral external carinae strong, tuberculate; dorsal face with very thin granulation; ventral face smooth; internal face moderately granulose. Patella with internal and external faces moderately granulated; dorsal and ventral faces smooth and lustrous; dorsal internal, ventral internal, ventral external, and external carinae strong; other carinae less well marked. Chela strongly granular except on internal face; dorsal marginal, external secondary, ventrointernal and ventral median carina strong; other carinae less well marked. Chelicerae typical of Scorpionoidea (Vachon, 1963); teeth moderately sharp. Trichobothriotaxy type C; orthobothriotaxic (Vachon, 1974). Legs: tarsi with two lateral rows of spines, surrounded by a few long setae. Spurs moderate. Hemispermatophore as in Figure 23 with the distal lamina short and moderately enlarged.

RELATIONSHIPS: The new species can be distinguished from *O. madagascariensis* by the following characters: (i) smaller overall size, (ii) a much paler coloration, (iii) apophysis in the internal face of patella less developed, and (iv) hemispermatophore smaller with distal lamella less enlarged and less complex.

ECOLOGY AND DISTRIBUTION: This animal is an inhabitant of the dry forests and spiny bush of the extreme southern and southeastern portion of the island. This area is one of the driest zones on the island and often with little organic material in the thin layer of soil. Within its range, which based on current information is non-overlapping with *O. madagascariensis*, it occurs in different habitat types including the dwarf and wind-swept vegetation of Cap Sainte Marie, the spiny bush of Andohahela, Berenty, and the Forêt de Mahavelo near Ifotaka.

***Opisthacanthus maculatus* sp. n.**

Figs. 28-38. Table I.

DIAGNOSIS: Medium to small size scorpions: males 36 mm and females 35 mm in total length. Coloration reddish-brown to dark brown, with some blackish zones. Pectines with 5 to 7 teeth in males and females; mode 7 in males and 6 in females. Hemispermatophore as in Figure 34 with the distal lamina shorter, moderately enlarged, and not complex. Female genital operculum large and heart-like-shaped with a very small incision in the base. Trichobothrial pattern of type C, orthobothriotaxy.

MATERIAL STUDIED: Madagascar: (27) Toliara Province, Ranobe, 30 m alt. (23° 02' 56" S, 43° 36' 38" E), 21-28/I/2003 (Frontier Project, MGF 059), general collecting, spiny forest thicket. 1 male holotype, 4 males, 3 females paratypes (CAS). (28) Toliara Province, Forêt de Beroboka, 5.9 km 131° SE Anki-dranoka, 80 m alt. (22° 13' 59" S, 43° 21' 59" E), 12-16/V/2002 (Fisher & Griswold *et al.*), general collecting, tropical dry forest. 5

males, 1 female (MNHN). (29) Toliara Province, Lake Ranobe, 20 m alt. (23° 2.412' S, 43° 36.567' E), 25-29/IV/2003 (Frontier Project, MGF 069), general collecting, degraded riparian forest, near lake edge. 1 female paratype (CAS). (32) Toliara Province, Forêt de Tsinjoriaky, 6.2 km 84° Tsifota, 70 m alt (22° 48' 8" S, 43° 25' 14" E), 6-10/III/2002 (Fisher & Griswold *et al.*), general collecting, spiny forest thicket. 5 males, 8 females paratypes (CAS).

ETYMOLOGY: The specific name makes reference to the intense dark spotted pigmentation of the new species.

DESCRIPTION based on male holotype and female paratype.

Coloration. Basically reddish-brown to dark brown with some blackish zones on the pedipalp carinae. Carapace dark brown with a paler zone on the posterior edge; median and lateral eyes surrounded with black pigment. Tergites dark brown with two longitudinal series of yellowish spots. Metasomal segments blackish-brown, darker in females; vesicle yellowish with lateral reddish spots; aculeus dark reddish. Chelicerae reddish-brown; the whole surface with blackish variegated spots; fingers brownish with reddish teeth. Pedipalps blackish-brown. Venter and sternites reddish-yellow; sternite VII with dark spots; pectines and genital operculum paler than sternites; legs reddish-yellow with diffused dark spots.

Morphology. Carapace with a thin but not intense granulation and no punctuation; furrows shallow. Anterior margin with a strong concavity reaching as far as the level of the 2nd lateral eye. Median ocular tubercle flattened and almost in the centre of the carapace; median eyes moderate, separated by almost one ocular diameter; three pairs of large lateral eyes. Sternum pentagonal, wider than long. Genital operculum formed by two semi-oval plates in males, and one single heart-like shaped plate in females, with a small incision in the base. Tergites with only a vestigial median carina, and with a thin granulation. Pectinal tooth count 7-7 in male holotype and female paratype. Sternites smooth and shiny; VII acarinate with a few punctuations. Metasomal segments I to V longer than wide, with a weak to moderate granulation. All carinae weak to vestigial in segments I-IV; segment V rounded with spinoid granules on ventro-lateral and ventral carinae. All segments with strong chetotaxy, more notable in males. Telson with a pear-like shape, less rounded than in other species; smooth and covered with strong chetotaxy. Pedipalps: femur with dorsal internal, dorsal external, ventral internal, and ventral external carinae strong, tuberculate; dorsal face with thin granulation; ventral face smooth; internal face moderately granulose. Patella with all surfaces strongly granulated excepted for the ventrum, which is smooth with punctuations; dorsal internal, ventral internal, ventral external, and external carinae strong; other carinae less well marked. Chela strongly granular except on internal face; dorsal marginal, external secondary, ventro-internal, and ventral median carina strong; other carinae less well marked. Chelicerae typical of Scorpionoidea (Vachon, 1963); teeth sharp. Trichobothriotaxy type C; orthobothriotaxic (Vachon, 1974). Legs: tarsi with three lateral rows of spines, surrounded by a few long setae. Spurs moderate. Hemispermatophore as in Figure 34 with the distal lamina short and moderately enlarged; not complex.

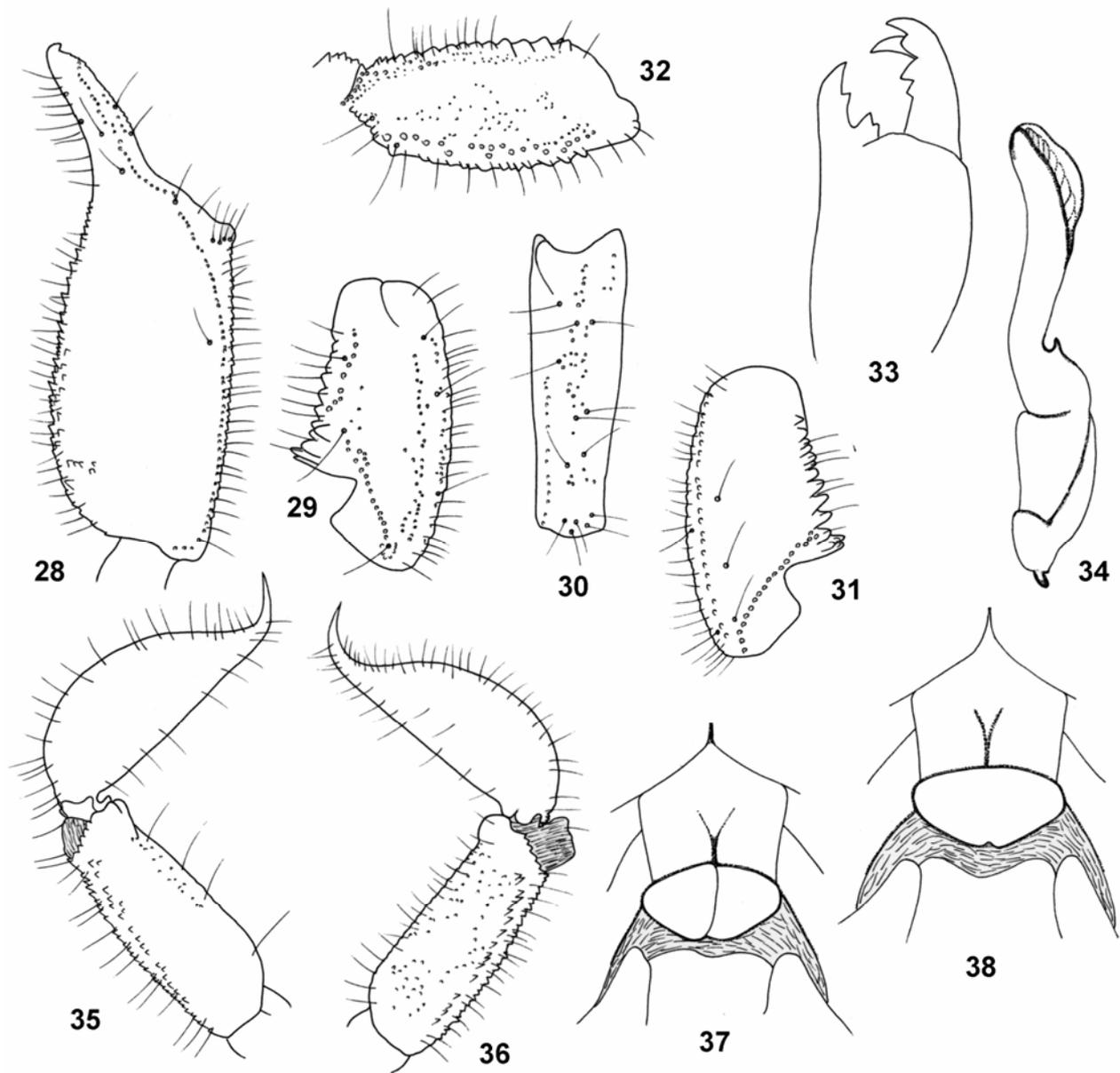


Fig. 28-38. *Opisthacanthus maculatus* sp. n. Male holotype and female paratype. 28-32. Trichobothrial pattern (male). 28. Chela, dorso-external aspect. 29-31. Patella, dorsal, external and ventral aspects. 32. Femur, dorsal aspect. 33. Chelicera, dorsal aspect (male). 34. Hemispermaphore, external aspect. 35-36. Metasomal segment V and telson, lateral aspect (male & female). 37-38. Sternum and genital operculum (male & female).

RELATIONSHIPS: The new species can be distinguished from *O. madagascariensis* and other species of Malagasy *Opisthacanthus* by the following characters: (i) a rather dark general coloration, (ii) apophysis in the internal face of patella stronger than in *O. luciennae* sp. n., (iii) vesicle weakly rounded, (iv) female genital operculum plate with a weak incision in its base, and (v) carapace and tergites more strongly granulated than in *O. luciennae* sp. n.

ECOLOGY AND DISTRIBUTION: *Opisthacanthus maculatus* has a limited distribution within the region known as the Mikea Forest, between Toliara and Morombe. This is a zone of transitional spiny-bush and dry deciduous forest.

***Opisthacanthus darainensis* sp. n.**

Figs. 39-50. Table I.

DIAGNOSIS: Medium to small size scorpions: males 39 mm

and females 43 mm in total length. Coloration reddish-brown to dark brown, with some blackish zones. Pectines with 5-7 teeth in males and females; mode 6 in males and females. Hemispermaphore small and short as in Figure 50; distal lamina less enlarged and complex than in the other species. Female genital operculum larger than wide, with an almost oval-shape, and without any incision in the base. Trichobothrial pattern of type C, orthobothriotaxy.

MATERIAL STUDIED: Madagascar: (12) Antsiranana Province, Forêt de Bekaraoka, 6.8 km 60° ENE Daraina, 150 m alt. (13° 11' 00" S, 49° 42' 36" E), 7/XII/2003 (B. Fisher), general collecting, tropical dry forest. 1 male holotype, 18 males paratypes, 21 females paratypes (CAS). (10) Antsiranana Province, Forêt d'Ampondrabe, 26.3 km 10° NNE Daraina, 175 m alt. (12° 58' 12" S, 49° 42' 00" E), 10/XII/2003 (B. Fisher), tropical dry forest. 20 males, 12 females paratypes (CAS). (22) Antsiranana Province, Réserve Spéciale d'Analamerana, 28.4 km 99° Anivorano-

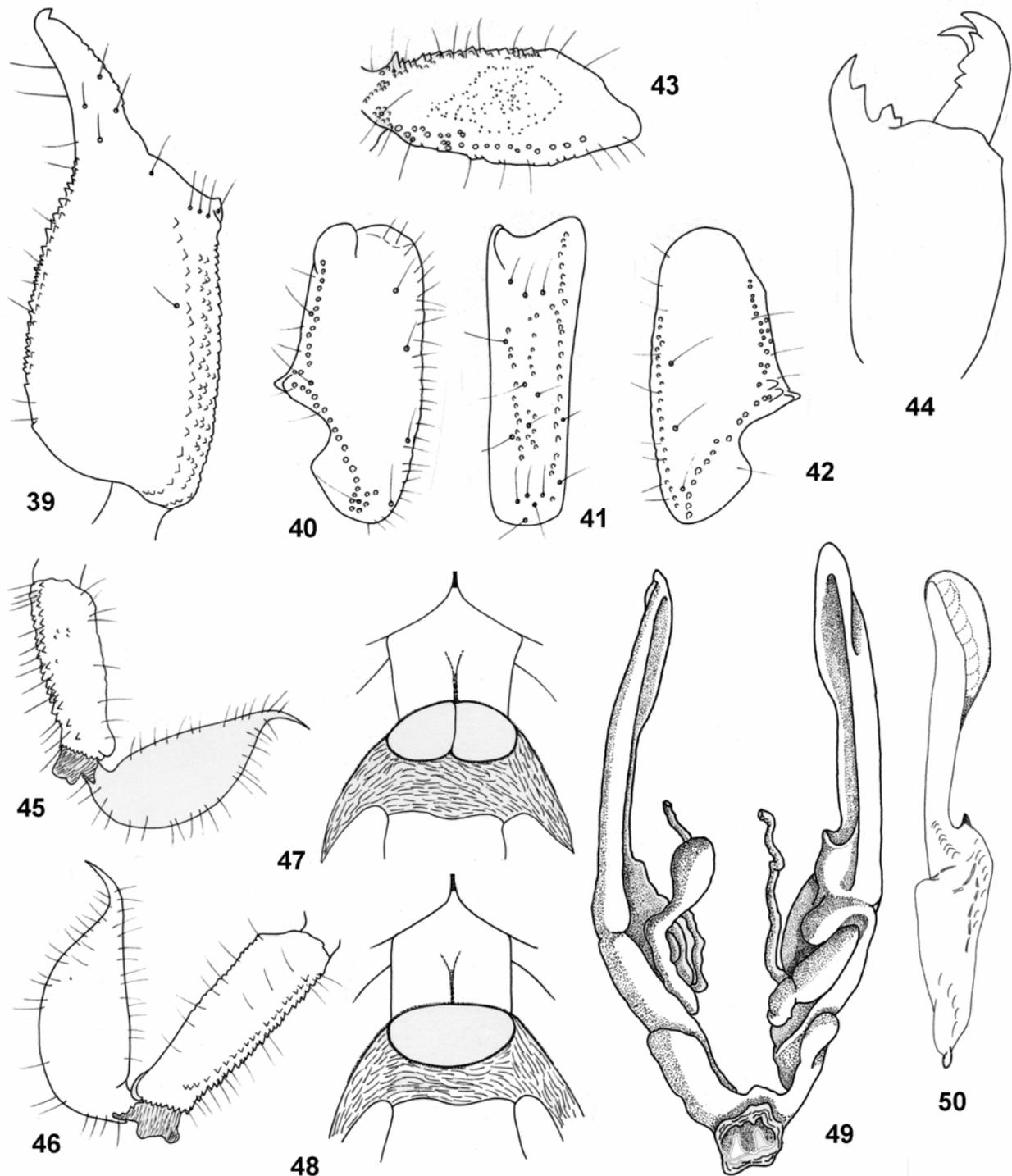


Fig. 39-50. *Opisthacanthus darainensis* sp. n. 39-48. Male holotype and female paratype. 39-43. Trichobothrial pattern (male). 39. Chela, dorso-external aspect. 40-42. Patella, dorsal, external and ventral aspects. 43. Femur, dorsal aspect. 44. Chelicera, dorsal aspect (male). 45-46. Metasomal segment V and telson, lateral aspect (male & female). 47-48. Sternum and genital operculum (male & female). 49. Paraxial organ. 50. Hemispermatophore, external aspect.

Nord, 60 m alt. (12° 44.80' S, 49° 29.69' E), 5-7/XII/2004 (B. Fisher), tropical dry forest. 12 males, 10 females paratypes (MNHN). (23) Antsiranana Province, Réserve Spéciale d'Analamerana, 16.7 km 123° Anivorano-Nord, 225 m alt. (12° 48.3' S, 49° 22.4' E), 2-5/XII/2004 (B. Fisher), tropical dry forest. 10 males, 18 females paratypes (CAS).

ETYMOLOGY: The specific name makes reference to the type locality of the new species.

DESCRIPTION based on male holotype and female paratype. **Coloration.** Basically reddish-brown to dark brown with some blackish zones on the pedipalp carinae. Carapace reddish-brown with a paler zone on the posterior edge; median and lateral eyes surrounded with black pigment. Tergites reddish-brown with two vestigial longitudinal series of yellowish spots. Metasomal segments reddish-brown, with some vestigial yellowish variegated zones; vesicle dark

yellow, with one lateral reddish band; aculeus dark reddish. Chelicerae reddish-brown; base of fingers blackish; the whole surface with diffuse variegated dark spots; fingers blackish with reddish teeth. Pedipalps blackish-brown. Venter and sternites reddish; sternite VII reddish-brown; pectines and genital operculum yellowish; legs reddish-yellow with blackish spots on the internal face.

Morphology. Carapace smooth with intense punctuation; lateral edges with some minute granulations; furrows shallow. Anterior margin with a strong concavity reaching as far as the level of the 2nd lateral eye. Median ocular tubercle flattened and almost in the centre of the carapace; median eyes moderate, separated by less than one ocular diameter; three pairs of large 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. Tergites with one vestigial median carina, and with intense punctuation. Pectinal tooth count 7-6 in male holotype and 6-8 in female paratype. Sternites smooth and shiny, with punctuations laterally; VII acarinate. Metasomal segments I to V longer than wide, almost smooth, except for some sparse granulations. All carinae weakly marked in segments I-IV; segment V slightly rounded with spinoids granules on latero-ventral and ventral carinae. All segments with moderate chetotaxy, better marked in males. Telson with a pear-like shape; smooth and covered with strong chetotaxy. Pedipalps: femur with dorsal internal, dorsal external, ventral internal and ventral external carinae strong, tuberculate; dorsal face with very thin granulation; ventral face smooth with punctuations; internal face moderately granulate. Patella with internal and external faces weakly granulated; dorsal and ventral faces smooth and lustrous, with punctuations; dorsal internal, ventral internal, ventral external, and external carinae strong; other carinae less well marked. Chela strongly granular on dorso-internal and external faces; other faces punctuated; dorsal marginal, external secondary, ventro-internal and ventral median carina moderate to strong; other carinae less well marked. Chelicerae typical of Scorpionoidea (Vachon, 1963); teeth sharp. Trichobothriotaxy type C; orthobothriotaxic (Vachon, 1974). Legs: tarsi with two lateral rows of spines, surrounded by a few long setae. Spurs moderate. Hemispermaphore as in Figure 50 with the distal lamina short and weakly enlarged.

RELATIONSHIPS: The new species can be distinguished from *O. madagascariensis*, *O. lucienneae* sp. n., and *O. maculatus* sp. n., by the following characters: (i) smaller global size, (ii) distinct morphometric values, (iii) dark coloration overall, (iv) smaller number of pectinal teeth (see modes), and (v) female genital operculum plate large, oval-shaped, and without an incision in base.

ECOLOGY AND DISTRIBUTION: *Opisthacanthus darainensis* has a restricted range in the dry deciduous forests of extreme northeastern Madagascar and is known from sites in the Daraina region (Bekaraoka and Ampondrabe) and the limestone zone of Analamerana. The Andrafiarana Mountain chain links these two regions.

***Opisthacanthus piceus* sp. n.**

Figs. 51-57. Table I.

DIAGNOSIS: Medium to large size scorpions: male 53.5 mm in total length. Coloration globally blackish. Pectines with 9-9 teeth in male holotype. Hemispermaphore unknown. Male genital operculum large and rounded. Trichobothrial pattern of type C, orthobothriotaxy.

MATERIAL STUDIED: Toliara Province, Parc National d'Andohahela (parcel 1), Forêt humide, S Vohibaka, 520 m alt., XI/1971 (J. M. Betsch – RCP 225). 1 male holotype deposited in the Muséum national d'Histoire naturelle, Paris.

ETYMOLOGY: The specific name makes reference to the blackish colour of the new species.

DESCRIPTION based on male holotype.

Coloration. Basically blackish. Carapace blackish with paler zones on the anterior and posterior edge; median and lateral eyes totally surrounded with black pigment. Tergites blackish with two longitudinal series of paler spots. Metasomal segments blackish; vesicle blackish; aculeus dark reddish. Chelicerae reddish-brown; base of fingers blackish; the whole surface with a variegated blackish colour; fingers blackish with reddish teeth. Pedipalps blackish-brown. Venter and sternites reddish-brown; pectines and genital operculum paler than sternites, but also with blackish spots; legs blackish-brown with the extremities of tarsi reddish-yellow.

Morphology. Carapace with a thin inconspicuous granulation and a few punctuations; furrows shallow. Anterior margin with a strong concavity reaching as far as the level between the 2nd and the 3rd lateral eyes. Median ocular tubercle flattened and almost in the centre of the carapace; median eyes moderate, separated by a little less than one ocular diameter; three pairs of large lateral eyes. Sternum pentagonal, wide as long. Genital operculum formed by two large round to oval plates in male. Tergites with one vestigial median carina; smooth with punctuations. Pectinal tooth count 9-9 in male holotype. Sternites smooth and shiny; VII acarinate with a few weak punctuations. Metasomal segments I to V longer than wide, with some vestigial granulations, almost smooth. All carinae weak to vestigial in segments I-IV; segment V rounded with latero-ventral and ventral carinae with spinoid granules. All segments with strong chetotaxy. Telson with a pear-like shape; smooth and covered with strong chetotaxy. Pedipalps: femur with dorsal internal, dorsal external, ventral internal, and ventral external carinae strong, tuberculate; dorsal face with very thin granulation; ventral face smooth; internal face moderately granulate. Patella with all faces moderately granulated except for the ventral face which is smooth; dorsal internal, ventral internal, ventral external, and external carinae strong; other carinae less well marked. Chela strongly granular except on internal face; dorsal marginal, external secondary, ventrointernal, and ventral median carina strong; other carinae less well marked. Chelicerae typical of Scorpionoidea (Vachon, 1963); teeth moderately sharp. Trichobothriotaxy type C; orthobothriotaxic (Vachon, 1974). Legs: tarsi with three lateral rows of spines, surrounded by a few long setae. Spurs moderate. Hemispermaphore unknown.

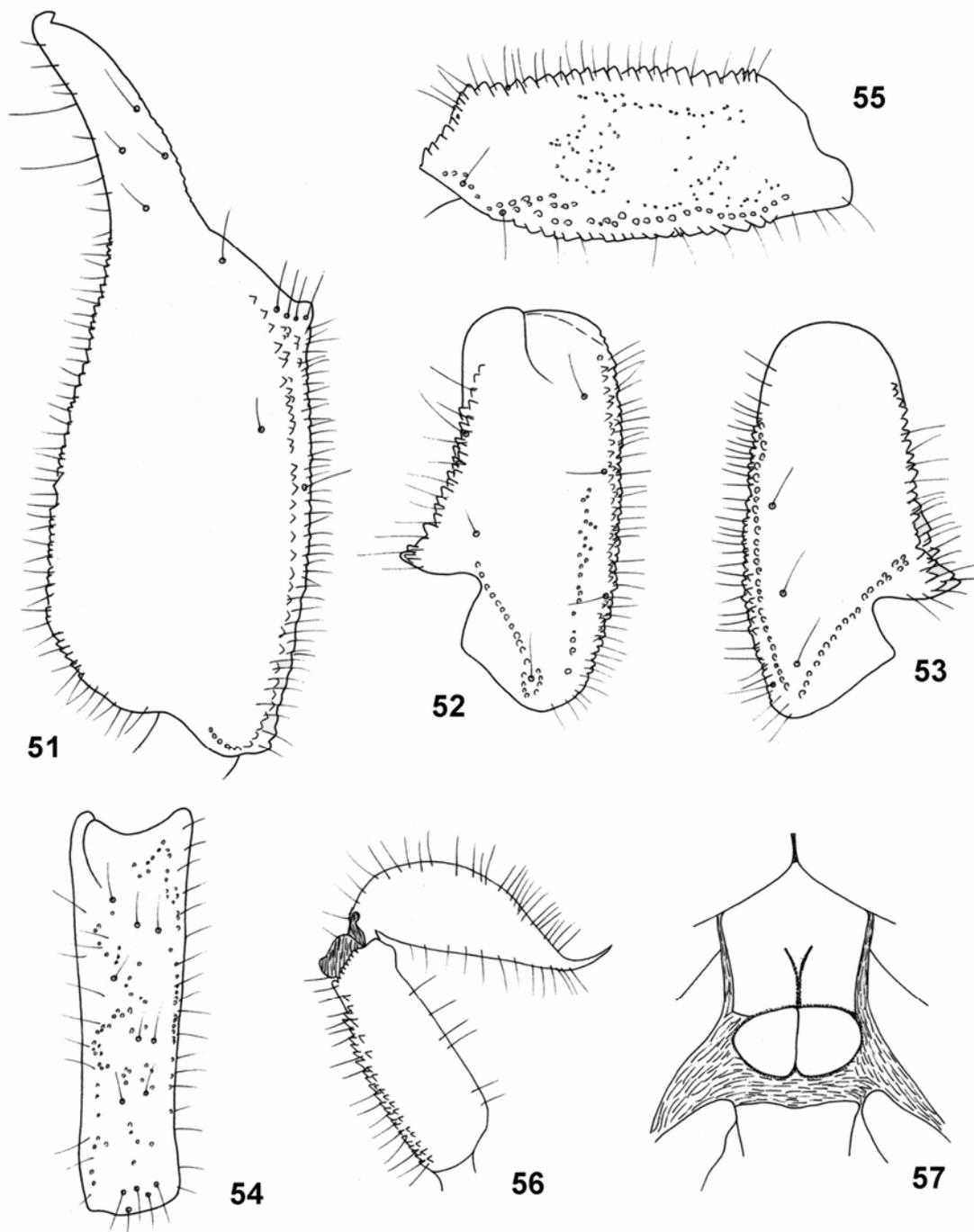


Fig. 51-57. *Opisthacanthus piceus* sp. n. Male holotype. **51-55.** Trichobothrial pattern. **51.** Chela, dorso-external aspect. **52-54.** Patella, dorsal, ventral and external aspects. **55.** Femur, dorsal aspect. **56.** Metasomal segment V and telson, lateral aspect. **57.** Sternum and genital operculum.

RELATIONSHIPS: The new species can be distinguished from *O. madagascariensis* and from the other Malagasy species by the following characters: (i) a very intense global blackish coloration, (ii) different morphometric values, and (iii) genital operculum formed by two large round to oval plates.

ECOLOGY AND DISTRIBUTION: This species is known only from the holotype site in the Vohibaka Forest at the northern limit of parcel 1 of the National Park of Andohahela. While Vohibaka is indeed in the humid forest parcel of this protected area, this site is found on the western slopes of the

Anosyennes Mountains and within a few kilometres of a dramatic ecotone between humid and dry forest (Goodman *et al.*, 1997). Further, given the geographical position of the site it would experience a notable dry season during the southern winter months. *O. luciennae* occurs in the spiny bush forest within a few tens of kilometres from the type locality of *O. piceus*. Hence, of the members of the genus *Opisthacanthus* recorded on Madagascar, *O. piceus* is the only species recorded from mesic forest, but it is found at the geographical limit of this biome and in an area of transition to dry forest formations.

Key to the Malagasy species of *Opisthacanthus*

1. Adult scorpions with 53 to 68 mm in total length 2
 - Adult scorpions with 35 to 45 mm in total length 3
2. Coloration reddish-brown to dark brown
 -*O. madagascariensis*
 - Coloration globally blackish, including vesicle; blackish spots on pectines and genital operculum...*O. piceus* sp. n.
3. Coloration pale; yellowish to reddish-yellow
 -*O. luciennae* sp. n.
 - Coloration dark; reddish-brown to dark-brown 4
4. Female genital operculum with an almost oval-shape, and without any incision in the base
 -*O. darainensis* sp. n.
 - Female genital operculum heart-like shaped with a small incision in the base*O. maculatus* sp. n.

Summary of the geographical distribution of the Malagasy species of *Opisthacanthus*

Opisthacanthus madagascariensis is found in dry to semi-dry formations on the west coast of Madagascar, ranging from the Manongarivo Massif region (Lourenço, 2002) to the south, with a possible natural limit just to the south of the Onilahy River.

Opisthacanthus luciennae sp. n. appears to have a parapatric distribution with *O. madagascariensis*. Its distribution ranges from Cap Sainte Marie, the extreme southern point of the island, east to the spiny forest zone (parcel 2) of the PN d'Andohahela, which forms the eastern limit of this habitat.

Opisthacanthus maculatus sp. n. has a partially parapatric distribution with *O. madagascariensis*, but its range is notably less extensive and limited to the central and slightly south-central western lowland sites.

Opisthacanthus darainensis sp. n. is only known from the forests of near Daraina and surrounding areas and is presumed to represent another microendemic species of this region (Lourenço & Goodman, 2002).

Opisthacanthus piceus sp. n. is only known from its type locality, and represents the only element of the genus *Opisthacanthus* from Madagascar collected in a mesic forest formation, although the holotype site is at the edge of this biome and borders drier forest types.

Acknowledgements

We are very grateful to Lucienne Wilmé, for the preparation of the map and to the late M. Gaillard, Paris, who prepared some of the illustrations. Specimens were made available by Frontier-Madagascar (Society for Environmental Exploration) through Hannah Thomas and Annette Olsson. Field collections were funded in part by National Science Foundation (USA) awards to Brian L. Fisher and Charles E. Griswold (DEB-0072713) and to Brian L. Fisher and Phil S. Ward (DEB-0344731).

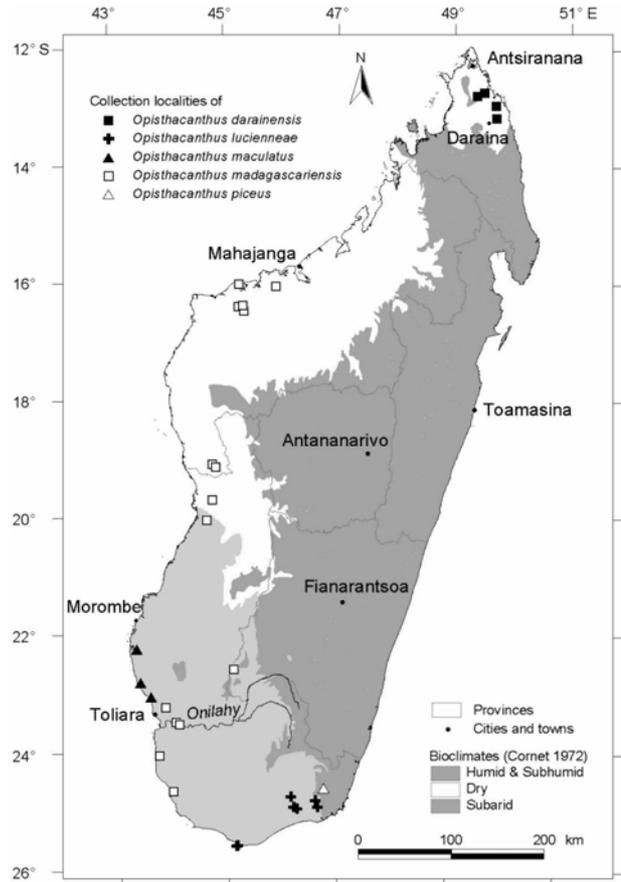


Fig. 58. Map of Madagascar showing the distribution of the Malagasy species of *Opisthacanthus* (subgenus *Monodopisthacanthus*).

References

- BASTAWADE, D. B. 1986. The first record of the family Ischnuridae (Scorpionida: Arachnida) from Maharashtra with the description of a new species of the genus *Iomachus* Pocock. *Entomon*, **12**(2): 101-104.
- FAGE, L. 1929. Les Scorpions de Madagascar. Faune des Colonies françaises 3. *Société d'Éditions Géographiques, Maritimes et Coloniales, Paris*, pp. 637-694.
- FRANCKE, O. F. & W. R. LOURENÇO 1991. Scorpions (Arachnida) from Rennel Island. Pp. 199-204, *In*: T. Wolff (Ed.), *The natural history of Rennel Island, British Solomon islands*. Copenhagen Univ. Press. Copenhagen.
- GOODMAN, S. M., M. PIDGEON, A. F. A. HAWKINS & T. S. SCHULENBERG 1997. The birds of southeastern Madagascar. *Fieldiana: Zoology*, new series, **87**: 1-132.
- KRAEPELIN, K. 1894. Revision der Scorpione. II. Scorpionidae und Bothriuridae. *Beiheft zum Jahrbuch der Hamburgischen wissenschaftlichen Anstalten*, **11**: 1-248.
- KRAEPELIN, K. 1911. Neue Beiträge zur Systematik der Glieder-spinnen. *Mitteilungen aus dem Naturhistorischen Museum* (2. Beiheft zum Jahrbuch der Hamburgischen wissenschaftlichen Anstalten, 1910), **28**(2): 59-107.
- LOURENÇO, W. R. 1980. A propósito de duas novas espécies de *Opisthacanthus* para a região neotropical. *Opisthacanthus valerioi* da 'Isla del Coco', Costa Rica e *Opisthacanthus heurtaultae* da Guiana francesa (Scorpionidae). *Revista nordestina de Biologia*, **3**(2): 179-194.

- LOURENÇO, W. R. 1981. *Opisthacanthus lamorali*, nouvelle espèce de Scorpionidae pour la région Afrotropicale (Arachnida: Scorpionida). *Annals of the Natal Museum*, **24**(2): 625-634.
- LOURENÇO, W. R. 1983. Considérations sur les genres *Liocheles*, *Ischnurus*, *Opisthacanthus*, *Hormurus*, *Hadogenes* et *Chirromachus* appartenant à la sous-famille des Ischnurinae (Scorpiones, Scorpionidae). *Annals of the Natal Museum*, **25**(2): 403-411.
- LOURENÇO, W. R. 1985. Essai d'interprétation de la distribution du genre *Opisthacanthus* (Arachnida, Scorpiones, Ischnuridae) dans les régions Néotropicale et Afrotropicale. Etude taxinomique, biogéographique, évolutive et écologique. Thèse de Doctorat d'Etat, Université Pierre et Marie Curie: 287 pp. Paris.
- LOURENÇO, W. R. 1987. Révision systématique des scorpions du genre *Opisthacanthus* (Scorpiones, Ischnuridae). *Bulletin du Muséum national d'Histoire naturelle*, Paris, 4e sér., **9**(A4): 887-931.
- LOURENÇO, W. R. 1989. Rétablissement de la famille des Ischnuridae, distincte des Scorpionidae Pocock, 1893, à partir de la sous-famille des Ischnurinae Pocock, 1893 (Arachnida, Scorpiones). *Revue Arachnologique*, **8**(10): 159-177.
- LOURENÇO, W. R. 1995. Nouvelles considérations sur la classification et la biogéographie des *Opisthacanthus* néotropicaux (Scorpiones, Ischnuridae). *Biogeographica*, **71**(2): 75-82.
- LOURENÇO, W. R. 1996. *Scorpions (Chelicerata, Scorpiones)*. In: Faune de Madagascar. n° **87**. 102 pp. Muséum national d'Histoire naturelle, Paris.
- LOURENÇO, W. R. 1997. Considérations taxinomiques sur le genre *Chirromachetes* Pocock, 1899 (Chelicerata, Scorpiones, Ischnuridae). *Zoosystema*, **19**(1): 81-89.
- LOURENÇO, W. R. 2000. Panbiogéographie, les familles des scorpions et leur répartition géographique. *Biogeographica*, **76**(1): 21-39.
- LOURENÇO, W. R. 2001. Nouvelles considérations sur la phylogénie et la biogéographie des scorpions Ischnuridae de Madagascar. *Biogeographica*, **77**(2): 83-96.
- LOURENÇO, W. R. 2002. Chapter 9. Scorpions of the Réserve Spéciale de Manongarivo, Madagascar. Pp. 329-337, In: L. Gautier & S. M. Goodman (Eds). Inventaire Floristique et Faunistique de la Réserve Spéciale de Manongarivo (NW Madagascar). *Boissiera*
- LOURENÇO, W. R. 2003. About two species of liochelid scorpions collected in Western Africa (Scorpiones, Liochelidae). *Entomologische Mitteilungen aus dem Zoologischen Museum Hamburg*, **14**(168): 137-148.
- LOURENÇO, W. R. 2004. Scorpions du sud-ouest de Madagascar et en particulier de la forêt des Mikea. Pp. 25-35, In: A. P. Raselimanana & S.M. Goodman (Eds). *Inventaire floristique et faunistique de la forêt de Mikea: Paysage écologique et diversité biologique d'une préoccupation majeure pour la conservation*. Recherche pour le développement, Série Sciences Biologiques, Antananarivo, no. 21.
- LOURENÇO, W. R. & N. FÉ 2003. Description of a new species of *Opisthacanthus* Peters (Scorpiones, Liochelidae) to Brazilian Amazonia. *Revista Ibérica de Aracnologia*, **8**: 81-88.
- LOURENÇO, W. R. & S. M. GOODMAN 1999. Taxonomic and ecological observations on the scorpions collected in the Réserve Naturelle Intégrale d'Andohahela, Madagascar. Pp. 149-153, In: S. M. Goodman (Ed.). A floral and faunal inventory of the Réserve Naturelle Intégrale d'Andohahela, Madagascar: With reference to elevational variation. *Fieldiana: Zoology*, new series, **94**.
- LOURENÇO, W. R. & S. M. GOODMAN 2002. Scorpions from the Daraina region of northeastern Madagascar, with special reference to the family Heteroscorpionidae Kraepelin, 1905. *Revista Ibérica de Aracnologia*, **6**: 53-68.
- MONOD, L. 1999. Révision systématique du genre *Liocheles* (Scorpiones, Ischnuridae). Mémoire "DEA". Université de Genève, 143 pp.
- POCOCK, R. I. 1896. Notes on some Ethiopian species of Ischnurinae contained in the collection of the British Museum. *Annals and Magazine of Natural History*, (6), **17**: 312-319.
- PRENDINI, L. 2000. Phylogeny and classification of the superfamily Scorpionoidea Latreille 1802 (Chelicerata, Scorpiones): An exemplar approach. *Cladistics*, **16**: 1-78.
- PRENDINI, L. & W.C. WHEELER 2005. Scorpion higher phylogeny and classification, taxonomic anarchy, and standards for peer review in online publishing. *Cladistics*, **21**: 446-494.
- STRIFFLER, B. 2001. Revision of the genus *Iomachus* Pocock, 1893 (Scorpiones, Ischnuridae). MSc. Dissertation, Rheinischen Friedrich-Wilhelms-Universität, Bonn: 78 pp.
- 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, 2è sér. **35**(2): 161-166.
- VACHON, M. 1974. Etude des caractères utilisés pour classer les familles et les genres de Scorpions (Arachnides). I. La trichobothriotaxie en arachnologie. Sigles trichobothriaux et types de trichobothriotaxie chez les Scorpions. *Bulletin du Muséum national d'Histoire naturelle*, Paris, 3è sér., n° 140, Zool., **104**: 857-958. Paris.