

ARTÍCULO:

## SCORPIONS FROM THE DARAINA REGION OF NORTHEASTERN MADAGASCAR, WITH SPECIAL REFERENCE TO THE FAMILY HETEROSCORPIONIDAE KRAEPELIN, 1905

Wilson R. Lourenço & Steven M. Goodman

### Abstract

Recent fieldwork conducted in the forested region of Daraina in northeastern Madagascar resulted in the collection of ten scorpions belonging to two different genera, *Heteroscorpion* Birula (Heteroscorpionidae) and *Tityobuthus* Pocock (Buthidae). Both represent new species to science that are most probably endemic to the Daraina region, where the remaining forested zones contain unique transitional habitats. The most remarkable aspect of the new species of *Heteroscorpion*, is its overall size, with adults ranging from 140 to 180 mm in total length, making it the largest scorpion ever found in Madagascar. The results of the study of pectine structures, using scanning electron microscopy, are also commented on.

**Key words:** Scorpiones, Heteroscorpionidae, Buthidae, *Heteroscorpion*, *Tityobuthus*. new species, Daraina, Madagascar.

### Taxonomy:

*Heteroscorpion magnus* sp. n.  
*Tityobuthus darainensis* sp. n.

### Scorpions de la région de Daraina au Nord-Est de Madagascar, avec une attention spéciale à ceux de la famille des Heteroscorpionidae Kraepelin, 1905

### Résumé

Dans une mission récente, réalisée dans la région forestière de Daraina située dans le Nord-Est de Madagascar, dix scorpions appartenant à deux genres distincts, *Heteroscorpion* Birula (Heteroscorpionidae) et *Tityobuthus* Pocock (Buthidae) ont été collectés. Les deux espèces, nouvelles pour la science, sont très probablement endémiques de la région de Daraina où les zones de forêt restantes correspondent à des habitats transitionnels uniques. L'aspect le plus remarquable de la nouvelle espèce de *Heteroscorpion* est sa taille globale, avec des adultes pouvant mesurer de 140 à 180 mm, ce qui fait de cette espèce le plus gros scorpion jamais trouvé à Madagascar. Les résultats de l'étude des peignes à l'aide d'un microscope électronique à balayage sont également commentés.

**Mots-clés:** Scorpiones, Heteroscorpionidae, Buthidae, *Heteroscorpion*, *Tityobuthus*, nouvelle espèce, Daraina, Madagascar.

### Taxonomie:

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### Escorpiones de la región de Daraina, en el noreste de Madagascar, con especial referencia a la familia Heteroscorpionidae Kraepelin, 1905

### Resumen

El trabajo de campo llevado a cabo recientemente en la zona boscosa de Daraina, en el noreste de Madagascar, ha permitido la recogida de diez escorpiones pertenecientes a dos géneros diferentes, *Heteroscorpion* Birula (Heteroscorpionidae) y *Tityobuthus* Pocock (Buthidae). En ambos hay especies nuevas para la ciencia que serán con toda probabilidad endémicas de la región de Daraina, donde los fragmentos de bosque que quedan contienen hábitats de transición únicos. El aspecto más notable de la especie nueva de *Heteroscorpion* es su tamaño, al oscilar los adultos entre 140 y 180 mm de longitud, que lo convierte en el mayor escorpión encontrado hasta ahora en Madagascar. También se comentan los resultados del estudio de las estructuras pectinales, llevado a cabo con microscopio electrónico.

**Palabras clave:** Escorpiones, Heteroscorpionidae, Buthidae, *Heteroscorpion*, *Tityobuthus*, nueva especie, Daraina, Madagascar.

### Taxonomía:

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### Scorpions from the Daraina region of northeastern Madagascar, with special reference to the family Heteroscorpionidae Kraepelin, 1905

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**Revista Ibérica de Aracnología**  
ISSN: 1576 - 9518.  
Dep. Legal: Z-2656-2000.  
Vol. 6, 31-XII-2002  
Sección: Artículos y Notas.  
Pp: 53-68.

Edita:

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## Introduction

Studies on the scorpion fauna of Madagascar began with the description of *Scorpio madagascariensis* by Gervais (1844), which was later transferred to the genus *Groshus* Simon. Pocock (1889) named a second species for the island, *Buthus limbatus*, which was also transferred to the genus *Groshus*. At about this same period several other species were described for the Malagasy fauna, and the contributions of Kraepelin (1894, 1896, 1900), Pocock (1896), and Birula (1903) are particularly noteworthy.

At the beginning of the 20<sup>th</sup> century, the Malagasy scorpion fauna was composed of two families: the Scorpionidae (subfamily Ischnurinae) with two genera: *Opisthacanthus* Peters and *Heteroscorpion* Birula with one species each, and the Buthidae with four genera: *Groshus* with seven species, *Odonturus* Karsch (= *Tityobuthus*) with one species, *Uroplectes* Peters with one species, and the cosmopolitan species *Isometrus maculatus* (Degeer). The presence of the genus *Uroplectes* on Madagascar was subsequently demonstrated to be a misidentification (Lourenço, 1995, 1996c).

Fage (1929) published the first monographic study of the Malagasy scorpion fauna. He mainly considered only previously described taxa and described a new subspecies (variety), *Groshus limbatus annulata*. His publication was, however, the first comprehensive work on Malagasy scorpions. In the following years Roewer (1943) named an enigmatic new species, *Isometrus madagassus*, the status of which remained uncertain for a long period. Soon thereafter, Fage (1946) described *Babycurus gracilis*, a cave-dwelling scorpion. Over the course of the following 30 years several syntheses were published on the island's scorpion fauna, but few taxa were described (Millot, 1949/1953; Vachon, 1969; Legendre, 1972). The single new form named during this period was *Groshus griveaudi* by Vachon (1969).

Starting in the middle of the 1990s new contributions were published by Lourenço (e.g., 1995, 1996a, 1996b), with the description of three new genera and six new species. These taxonomic treatments were synthesized by Lourenço (1996c) in the "Fauna of Madagascar", where one new genus and nine new species were described. Furthermore, one new subfamily, the Microcharminae, was created and the subfamily Heteroscorpioninae was raised to the rank of family. After the publication of this monograph, faunal inventories in previously unexplored or poorly known areas of the island led once again to a series of new descriptions, including three new genera, one new subgenus, and 11 new species. Moreover, the subfamily Microcharminae was raised to the rank of family (Lourenço, 1997a, 1998a, 1998b, 1999a, 1999b, 2000a, 2000b, 2001a, 2001b; Lourenço & Goodman, 1999a, 1999b).

In their contributions to the Malagasy scorpion fauna, authors such as Fage (1929) and Millot (1949/1953) most certainly overrated the extent of contemporary knowledge of the island's fauna. Fage (1929, p. 639, translated from the French) stated "since scorpion

species are of large size and have been collected in all the regions of the island, it is possible to estimate that we know all the populations of the island as well as their relative density and distribution." Millot (1949/1953, p. 127, translated from the French) followed this up by claiming, "Scorpions are the best known Arachnida of Madagascar. Because of their large size they can easily be observed and collected. Therefore, most of the species of the Great Island are certainly identified at present."

It is often true that as with different zoological groups, when more species are described and the taxa appear to be well known, there is the subsequent discovery and description of smaller species, and the average body size of the group is reduced (Fenchel, 1993; Blackburn & Gaston, 1994). The recent discovery and description of several new genera and species, and even of one new family (Microcharmidae) in Madagascar refer, in most cases, to microscorpions whose existence had not previously been suspected. Some exceptions, however, can be mentioned with the descriptions of the new genus *Palaeocheloctonus* Lourenço (Ischnuridae) from the southwest, or the new species *Heteroscorpion goodmani* Lourenço from the southeast. In both cases these scorpions represent large species, ranging in total length from 65 to 100 mm.

Some recent fieldwork conducted in the forested region of Daraina in the northeastern portion of the island resulted in the collections of ten scorpions belonging to two different genera, *Heteroscorpion* (Heteroscorpionidae) and *Tityobuthus* (Buthidae). Both represent new species to science that are most probably endemic to the Daraina area, a zone of rather unique transitional forested habitat. The most remarkable aspect of the new species of *Heteroscorpion*, is its overall size, with adults ranging from 140 to 180 mm in total length, making it the largest scorpion ever found in Madagascar.

## Ecology and Biogeography of the Daraina Forest

The eastern portion of Madagascar is composed of a broad zone of humid forest habitat running nearly the complete length of the island. However, in the north, at about the latitude of Vohemar or Iharana (13.5° S), there is a relatively abrupt zone of more arid conditions and humid forests recommente further north at Montagne d'Ambre, near the tip of the island. This zone of habitat transition, which falls in the vicinity of Daraina, is indicated on Humbert and Cours Darne's (1965) vegetational maps of Madagascar and is clearly related to bioclimatic parameters (Cornet, 1972). The natural forests of this area have been extensively degraded and fragmented associated with human activities, but almost certainly originally extended towards the western side of the island. This zone is notably intricate in geological formations (Besairie, 1964), and when these factors are overlaid on the considerable topographical and orogra-

phical variation of the area, vegetational structure and composition is highly variable. Just to the south of this transitional zone there is a band of humid forests, which is known as the northern highlands, that link the east and west coasts, passing across the mountainous region of Marojejy, Anjanaharibe-Sud, Tsaratanana, and Manongarivo. Given the waxing and waning of different vegetational types on the island during the Quaternary (Burney, 1997), notably accentuated in montane regions, and the geographically close association of this transitional zone to the northern highlands and associated lowland humid forests, it is reasonable to assume that the forests of Daraina have been in recent geological history an important zone of biotic exchange.

Little is known about the biota of the Daraina region. This zone was brought to the attention of biologists and conservationists less than two decades ago with the description of a large diurnal species of lemur new to science, *Propithecus tattersalli*, that is endemic to these forests (Simmons, 1988; Vargas *et al.*, 2002). On the basis of recent biological exploration of one forest block in the zone, the forest of Binara, it is clearly rich in previously undescribed species of animals and forming a distinct and remarkable biogeographic crossroads between humid and deciduous forests (Goodman and Raselimanana unpublished). This is the site the current scorpion material reported on here is from.

The Binara Forest occurs along the slopes of a massif with the same name. The forest commences at about 300 m above sea-level and terminates at the summit slightly under 1100 m. The lower portion of forested habitat shows floristic associations with drier deciduous habitats occurring in the western portion of the island. With increasing elevation there is an augmentation of eastern or humid forest elements in the flora. The summatal area of the massif is largely typical of eastern montane forest. Thus, in many regards the zone of only a few kilometers from the base to the summit of the massif is similar to a transect from the eastern to western coasts of the northern portion of the island, a distance of about 200 km.

## Taxonomic Treatment

### I. Family HETEROSCORPIONIDAE Kraepelin, 1905

#### Genus *Heteroscorpion* Birula, 1903

**DIAGNOSIS:** Scorpions of large size, with adults reaching 60 to 145 mm in females and 90 to 185 mm in males (Figs. 1-2). Sexual dimorphism strongly marked, mainly by the allometric growth shown in males (Fig. 1). Two pairs of lateral eyes. Metasomal segments I to IV very flattened laterally with a single ventral median carinae (Fig. 6). Telson weakly elongated in both sexes (Figs. 7-8). Dentate margin on fingers with numerous granules randomly arranged on their basal 2/3rds, and forming two vestigial parallel series of granules on its distal portion; a few stronger accessory granules may be

present (Fig. 3). Trichobothriotaxy of type C, neobothrioxic majorante (+) (Figs. 15-20) plethotaxic in one species on the patella and chela (chela + fixed finger) (Figs. 21, 24-25). Hemispermatophore as in Figs. 4-5. Venomous glands simple.

**GEOGRAPHIC DISTRIBUTION.** Endemic to Madagascar.

#### *Heteroscorpion opisthacanthoides* (Kraepelin)

(Figs. 1-9, 10b, 11, 15-17, 26-29)

*Hadogenes opisthacanthoides* Kraepelin, 1896: 136.

*Hadogenes opisthacanthoides*; Kraepelin, 1899: 146.

*Heteroscorpion madagascarensis*; Birula, 1903: 10 (junior synonym)

*Heteroscorpion opisthacanthoides*; Fage, 1929: 682; Fage, 1946: 260; Lourenço, 1996c: 31.

**DIAGNOSIS:** Scorpions of large size, with adults reaching 110 mm in females and 140 mm in males. Coloration, basically reddish-brown with the legs paler than the body. Trichobothriotaxy of type C, neobothrioxic majorante (+); patella with 17-19 external trichobothria, and 10-11 ventral trichobothria; chela (chela + fixed finger) with 8-9 ventral trichobothria. Hemispermatophore as in Figs. 4-5. Venomous glands simple.

**HABITAT:** Humid lowland forest.

**GEOGRAPHIC DISTRIBUTION.** Madagascar, northwestern region, Province d'Antsiranana (Diego-Suarez), Nosy Be, Nosy Komba, and Ambilobe region.

#### *Heteroscorpion goodmani* Lourenço

(Figs. 10a, 12, 18-20, 30-33)

*Heteroscorpion goodmani* Lourenço, 1996c: 32.

**DIAGNOSIS:** Scorpions of moderate to large size, with adults reaching 60 mm in females and 115 mm in males. Coloration, basically blackish with the legs paler than the body. Trichobothriotaxy of type C, neobothrioxic majorante (+); patella with 17 external trichobothria, and 8-9 ventral trichobothria; chela (chela + fixed finger) with 9 ventral trichobothria. Hemispermatophore report to Figs. 4-5. Venomous glands simple.

**HABITAT:** Humid lowland forest.

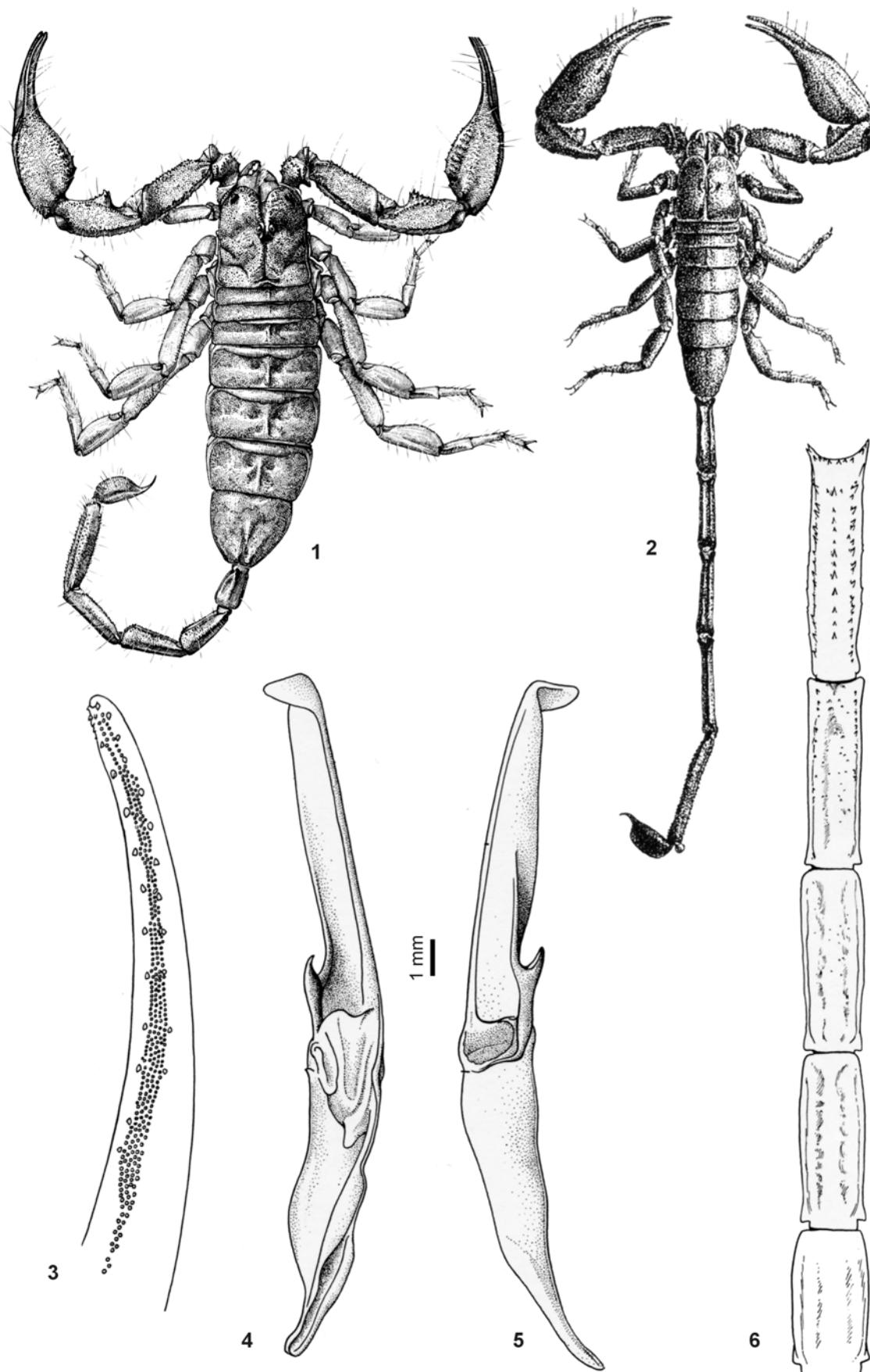
**GEOGRAPHIC DISTRIBUTION.** Madagascar, southeastern region, Province de Toliara (Tuléar), Réserve naturelle intégrale n° 11 de l'Andohahela (parcel 1).

#### *Heteroscorpion magnus* sp. n.

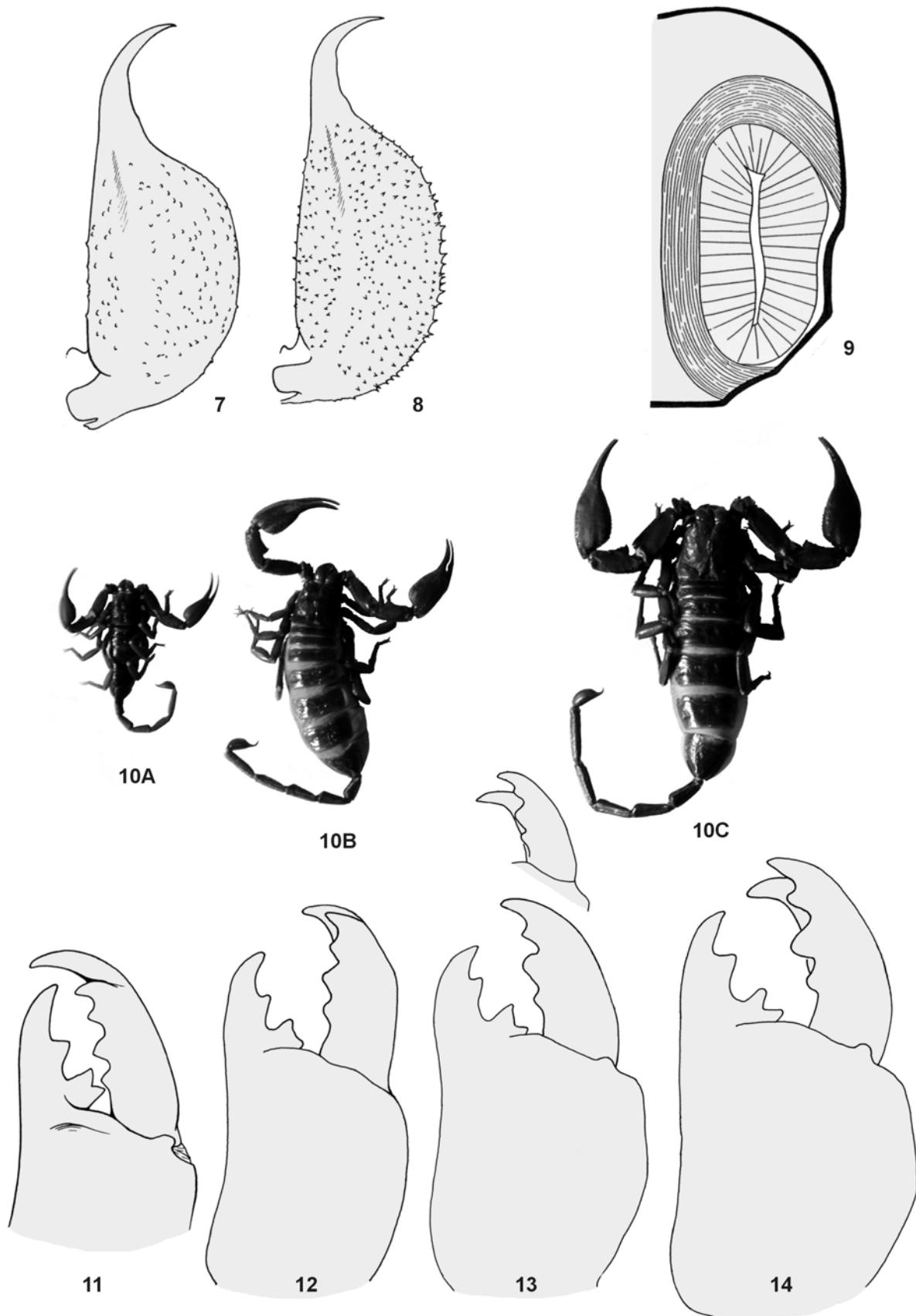
(Figs. 10c, 13-14, 21-25, 34-37)

**TYPE MATERIAL.** Madagascar, Province d'Antsiranana, Forêt de Binara, near Analamazava River, 7.5 km southwest of Daraina, 13° 15.3'S, 40° 37.0'E, 325-600 m. (S. M. Goodman). 1& **holotype** (SMG 12375).

**Paratypes:** 3&& (SMG 12311, 12373, 12374), 2% - juvenile (SMG 12372, 12376), in disturbed (cattle) eastern humid lowland forest with some elements of dry forest, found during day under rocks. 1& (SMG 12324), 2% (SMG 12325, 12326), in undisturbed eastern humid lowland forest with some elements of dry forest, found during day under rocks along riverbed.



Figs. 1-6. *Heteroscorpion opisthacanthoides*. 1. habitus of female and 2. male, dorsal aspect. 3. Movable finger of chela pedipalp (female). 4-5. Hemispermophore, internal and external aspects. 6. Metasoma, ventral aspect (female).



**Figs. 7-9.** *Heteroscorpion opisthacanthoides*. 7-8. Female and male telson, lateral aspect. 9. Venom gland, internal schematic view. **Fig. 10.** Females in dorsal view. From left to right, *Heteroscorpion goodmani*, *H. opisthacanthoides*, and *H. magnus*. **Figs. 11-14.** Chelicerae, dorsal aspect. 11. *Heteroscorpion opisthacanthoides* (male). 12. *H. goodmani* (male). 13-14. *H. magnus* sp. n. 13. Female holotype, 14. Male paratype.

**Table I**  
**Comparative morphometric values (in mm) of the three species of *Heteroscorpion***

<b>Character</b>	<i>H. opisthacanthoides</i>		<i>H. goodmani</i>		<i>H. magnus</i> sp.n.	
	%	&	%	&	%*	&
Total length	142.0	110.0	115.0	63.0	132.0**	144.0
Carapace:						
length	14.1	14.0	10.2	11.4	13.7	19.4
anterior width	8.6	8.9	6.2	7.0	8.8	11.6
posterior width	14.2	14.1	9.3	10.0	13.8	19.6
Metasomal segment I:						
length	15.6	7.0	10.0	5.4	10.8	10.7
width	3.8	4.2	2.3	3.1	3.2	4.2
Metasomal segment V:						
length	23.3	12.3	17.2	10.2	15.8	16.2
width	2.3	2.6	1.8	2.4	2.3	2.8
depth	3.2	3.2	2.4	2.6	2.8	3.4
Vesicle:						
width	4.0	3.4	2.8	3.0	2.5	3.3
depth	5.2	3.6	3.1	3.0	3.1	4.2
Pedipalp:						
Femur length	12.4	12.1	10.9	10.7	13.6	18.4
Femur width	4.5	4.8	3.4	3.6	5.3	7.1
Patella length	13.8	13.2	10.3	10.7	13.4	18.1
Patella width	6.3	6.6	4.5	4.7	6.8	9.7
Chela length	27.4	25.6	20.9	21.5	29.0	39.1
Chela width	9.5	9.0	6.0	7.5	7.2	11.4
Chela depth	7.2	6.9	5.0	5.3	5.4	8.2
Movable finger:						
length	15.2	14.2	11.8	11.9	15.4	19.2

\* Subadult.

\*\* If allometric values are similar between the new species and the other two species of *Heteroscorpion*, adult males of *H. magnus* would reach a total length of 180.0 to 186.0 mm.

**Depositories:** Holotype and five paratypes in the Field Museum of Natural History, Chicago. Two paratypes in the Muséum d'Histoire Naturelle, Genève, and one paratype in the Muséum National d'Histoire Naturelle, Paris.

**ETYMOLOGY:** The specific name is in reference to this species' large size.

**DIAGNOSIS:** Scorpions of large size, with adults reaching 140 mm in females and 180 mm in males. Coloration, basically reddish-brown with the legs paler than the body. Trichobothriotaxy of type C, neobothriotaxic majorante (+) plethotaxic; patella with 31-40 external trichobothria, and 14-19 ventral trichobothria; chela (chela + fixed finger) with 12-15 ventral trichobothria. Hemispermatophore unknown. Venomous glands simple.

**RELATIONSHIPS:** *Heteroscorpion magnus* sp. n., can be recognized from the others species in the genus *Heteroscorpion* by the following features: (i) a much longer total length, averaging 140 mm for females and 180 mm for males, (ii) a neobothriotaxic (plethotaxic) trichobothrial pattern, (iii) a much less marked spinoid granulation in the telson of males.

**HABITAT:** All of the individuals of *Heteroscorpion magnus* sp. n. where obtained in the lower elevation and more deciduous portion of the Binara Forest. The vast majority of these specimens where found in the narrow

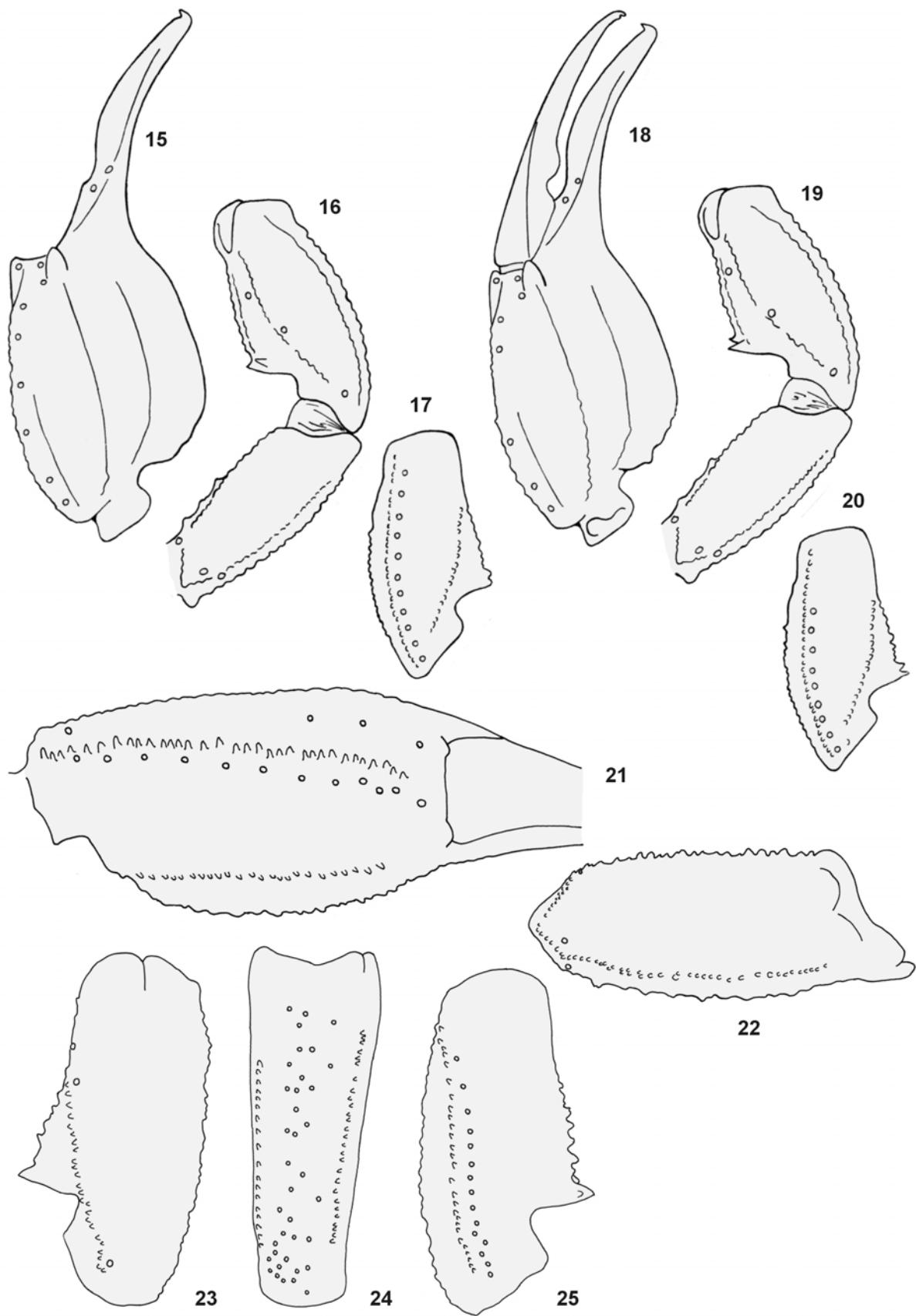
fissures between layers of splintered but still standing exposed rock. In many cases a thin layer of soil and other organic material had been deposited in these crevices, and virtually all, excluding two individuals were solitary. One branch of the Analamazava River commences towards the summital region of the massif and passed close to the campsite at the lower limit of the forest. Here there where numerous exposed small rock outcrops, and in all cases *Heteroscorpion magnus* specimens were found at such sites that where shaded by the forest canopy.

**GEOGRAPHIC DISTRIBUTION:** Only known from the type locality.

#### DESCRIPTION BASED ON FEMALE HOLOTYPE:

##### Measurements in Table I.

**Coloration.** Body basically reddish-brown. Prosoma: carapace dark-brown, except the posterior zone that is reddish-brown; some blackish nearby the eyes; furrows paler than the rest of the carapace. Mesosoma: tergites brownish, lighter than carapace, with a median longitudinal brown-yellowish stripe; sternites III-VI reddish-yellow; sternite VII darker than the others. Coxapophysis and sternum reddish-brown; genital operculum and pectines yellowish. Metasoma: all segments reddish-brown, with some blackish pigment over dorsal and ventral carinae; vesicle reddish-brown; aculeus reddish-brown at the base and blackish at the extremity. Chelicerae reddish without any variegated dark spots; fingers



**Figs. 15-20.** Trichobothrial pattern. **15-17.** *Heteroscorpion opisthacanthoides*. **15.** Chela, ventral aspect. **16.** Femur and patella, dorsal aspect. **17.** Patella, ventral aspect. **18-20.** Idem, *H. goodmani*. **Figs. 21-25.** Trichobothrial pattern of *Heteroscorpion magnus* sp. n. **21.** Chela, ventral aspect. **22.** Femur, dorsal aspect. **23-25.** Patella, dorsal, external and ventral aspects.

reddish-brown with blackish teeth. Pedipalps: femur, patella and chela dark-reddish-brown with the presence of blackish pigment over the carinae. Legs reddish-brown, with tarsi yellowish; presence of blackish over the carinae.

**Morphology.** Carapace lustrous and acarinate with some thin to moderate sparse granules; anterior margin with a strongly pronounced concavity; carinae practically absent; posterior furrows strongly pronounced; median ocular tubercle distinctly anterior to the center of the carapace; two pairs of moderate to small lateral eyes, about half the size of median eyes. Mesosoma: sternum pentagonal, higher than wider. Tergites acarinate, smooth and shiny (lustrous) without granulations; tergite VII with several punctuations. Venter: genital operculum formed by a single plate with an oval shape. Pectines: pectinal tooth count 11-11 (see table II for variation); fulera fused with median lamellae. Sternites smooth and shiny, with two longitudinal parallel furrows on III to VI; spiracles linear and conspicuous. Metasoma with all segments flattened laterally; dorsal carinae smooth on segments I-II, granular on segments III-V; granulation becomes spiniform on segments IV-V; ventral and latero-ventral carinae smooth on segments I-III, granular on IV and intensely spinoid on V; ventral surface of segment V with a strong spinoid granulation; all intercarinal surfaces weakly granular to smooth. Telson weakly elongated with some moderately marked granules; aculeus proportionally very short and strongly curved. Cheliceral dentition characteristic of the Scorpinoidea (Vachon, 1963); movable finger with two subdistal teeth of the same size and a basal tooth reduced. Pedipalps with a thin granulation, almost smooth; femur with four carinae, all complete; patella with six carinae complete, and a very strong apophysis on the internal aspect; chela with six carinae; dentate margin on fingers with numerous granules randomly arranged on their basal 2/3, and forming two vestigial parallel series of granules on its distal portion; presence of a few stronger accessory granules. Trichobothriotaxy of type C; neobothiotaxic + (plethotaxic) (Vachon, 1974); patella with 16 ventral and 37/38 external trichobothria; chela with 14 ventral trichobothria (see Table III for variation). Legs: tarsi of legs III and IV with three internal and two external spines arranged in three series.

**MALE PARATYPE:** Coloration similar to that of female holotype. See also Tables II and III for variation.

#### DIAGNOSIS:

The three species belonging to the genus *Heteroscorpion* can be distinguished by the following characters:

	Color	Adult total length	Trichobothrial pattern
<i>H. opisthacanthoides</i>	reddish	110-180 mm	Patella with 10-11 ventrales and 17-19 externales. Chela with 8-9 ventrales.
<i>H. goodmani</i>	blackish	60-100 mm	Patella with 8-9 ventrales and 17 externes. Chela with 9 ventrales.
<i>H. magnus</i> sp. n.	blackish	145-185 mm	Patella with 14-19 ventrales and 31-40 externales. Chela with 12-15 ventrales.

**Table II**  
**Variation in pectinal tooth count in *H. magnus* sp. n.**

Number of teeth	%	&&
11	1	2
12	1	7
13	3	-
14	2	1
15	1	-

**Table III**  
**Variation in the number of trichobothria for *Heteroscorpion opisthacanthoides* and *Heteroscorpion magnus* sp. n.**  
Random variation is observed in both males and females.

P.V.A. = Patella (ventral aspect). P.E.A. = Patella (external aspect). T.V.A. = Chela (ventral aspect)

	P.V.A.	P.E.A.	T.V.A.
<i>H. opisthacanthoides</i>	10	17	8
	10	17	8
	10	17	8
	10	17	8
	10	17	8
	10	17	8
	10	17	8
	10	17	8
	10	17	8
	10	17	8
	10	18	8
	11	18	8
	11	18	8
	11	18	8
	11	18	8
	11	18	8
	11	18	9
	11	18	9
	11	19	9
	11	19	9
<i>H. magnus</i>	14	31	12
	14	31	12
	14	33	12
	15	33	12
	15	36	12
	15	36	13
	15	36	13
	15	37	13
	16	37	13
	16	37	13
	16	38	13
	16	38	14
	16	38	14
	16	39	14
	17	40	14
	17	40	14
	17	40	15
	19	40	15

**KEY TO THE SPECIES OF *HETEROSCORPION***

1. Scorpions of large size, adults ranging from 110 to 180 mm in total length; coloration reddish-brown; patella with 10 to 19 trichobothria ..... 2
- Scorpions of moderate to large size, adults ranging from 60 to 110 mm in total length; coloration, blackish; patella with 8-9 trichobothria ..... *H. goodmani*
2. Adults ranging from 110 to 140 mm in total length; patella with 17-19 external trichobothria ..... *H. opisthacanthoides*
- Adults ranging from 140 to 180 mm in total length; patella with 31-40 external trichobothria ..... *H. magnus* sp. n.

**RESULTS OF THE STUDY OF PECTINE STRUCTURES, USING SCANNING ELECTRON MICROSCOPY (Figs. 30-47)**

The general morphology of *Heteroscorpion* pectines is very similar in the three known species, but some differences are notable (Figs. 26, 30, 34). The size of the pectines teeth vary in size between the different species. The pectines of *H. goodmani* have larger teeth in relation to the marginal and median lamellae (Fig. 30), while both lamellae are strongly developed in *H. magnus* (Fig. 34). The surface recovered with the peg sensilla on each tooth, is similar anthem three species (Figs. 27-28, 31, 35), as is the shape of individual pegs (Figs. 29, 32-33, 36-37). The individual peg size varies little among the three species, even given that the total size of each species is rather different (see Table II).

Comparison with the two ischnurid genera present in Madagascar, *Opisthacanthus* Peters and *Palaeoche-loctonus* Lourenço, showed also some interesting aspects. The pectines of both *O. madagascariensis* Kraepelin (Fig. 38) and *P. pauliani* Lourenço (Fig. 42) have quite different sizes and shapes. The number of pectinal teeth is much more reduced in these two species as compared to *Heteroscorpion*. Both marginal and median lamellae are also much less developed in both *Opisthacanthus* and *Palaeoche-loctonus* as compared to *Heteroscorpion* species.

The surface covered with peg sensilla on each tooth in both *O. madagascariensis* and *P. pauliani* (Figs. 39-40, 44) is equivalent to that for the three species of *Heteroscorpion*. The shape of individual pegs of *O. madagascariensis* and *P. pauliani* looks superficially similar to those of *Heteroscorpion*, but are in fact more flattened and less cylindrical (Figs. 41, 45-47). The individual peg size in the ischnurid species is small, even if the total body size of these species is similar to that of *H. goodmani*.

**II. Family BUTHIDAE C.L. Koch, 1837****Genus *Tityobuthus* Pocock, 1893**

In the last few years, and in particular after the scorpion fauna of Madagascar was summarized by Lourenço (1996c), numerous new species have been described in the genus *Tityobuthus*. The same phenomenon has already been observed in other micro-scorpion genera

such as *Ananteris* Thorell from the Neotropical region – the number of species known in that genus increased from 3 to 24 within twenty years (Lourenço, 2001c). The recent discovery of three additional new species of *Tityobuthus* pointed to the necessity to revise this genus (Lourenço, 2000a). At present another new species of this genus is described, in this case from the Daraina region.

***Tityobuthus darainensis* sp. n.**

(Figs. 48-53)

**TYPE MATERIAL:** Female **holotype**, Madagascar, Province d'Antsiranana, Forêt de Binara, near Analamazava River, 7.5 km southwest of Daraina, 13° 15.3'S, 40° 37.0'E, 325-600 m. (S. M. Goodman), in undisturbed eastern humid lowland forest with some elements of dry forest. **Deposited** in the Field Museum of Natural History, Chicago.

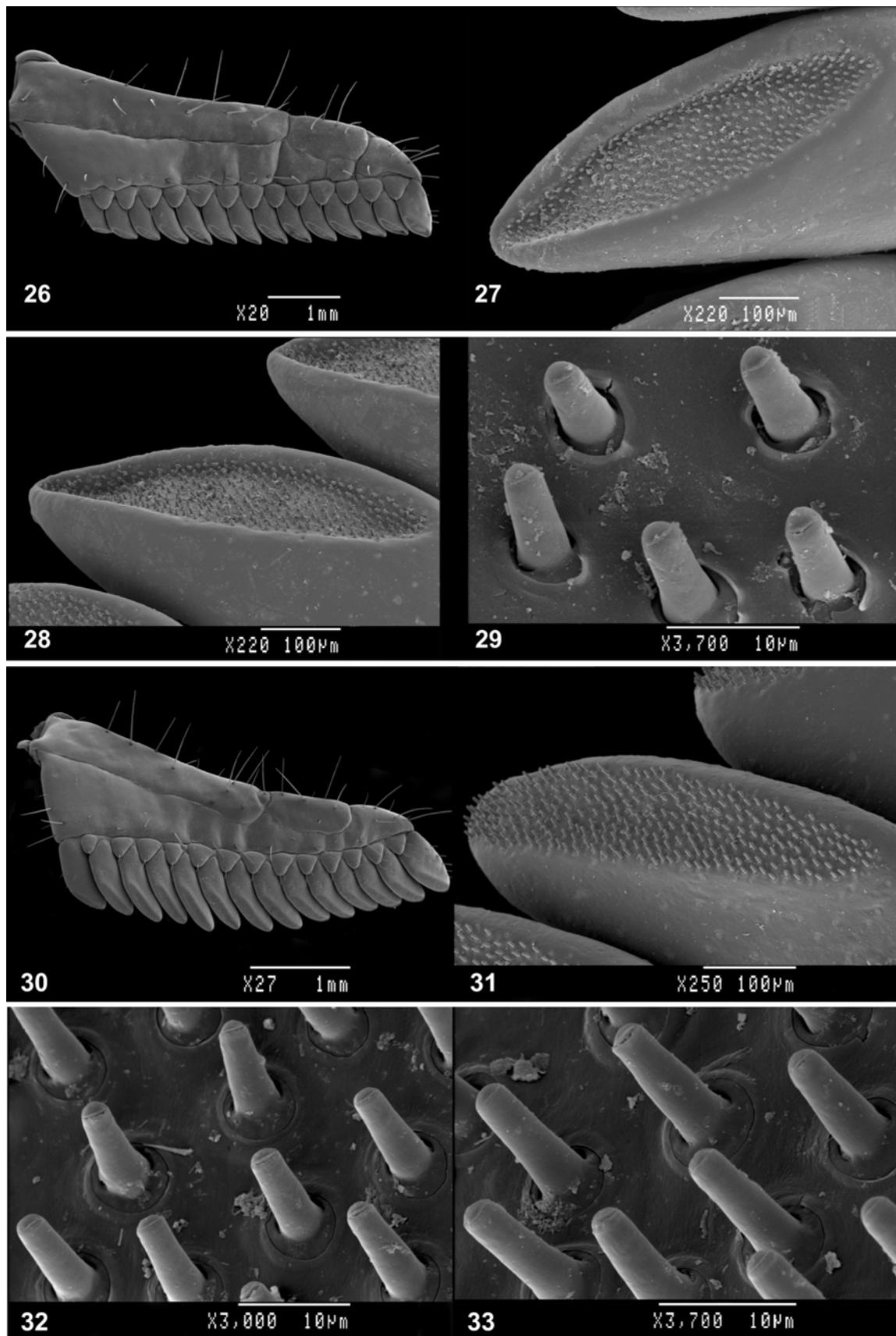
**ETYMOLOGY:** The specific name makes reference to the type locality.

**DIAGNOSIS:** Scorpion of large size (with respect to the genus) and 35 mm in total length. Carapace with a moderately pronounced concavity, forming a weak angle. Cheliceral dentition with basal teeth of movable fingers reduced. Pectines with 17-18 teeth and the presence of fulcra. Sternites smooth; V without any bright zone on posterior edge. Telson with a long but moderately curved aculeus; subaculear tooth strong and spinoid with two basal granules. Tibial spurs present but reduced. Pedipalp fixed and movable fingers with 8/9 slightly oblique, almost straight rows of granules. Trichobothrial pattern of type A-α - orthobothrioxic.

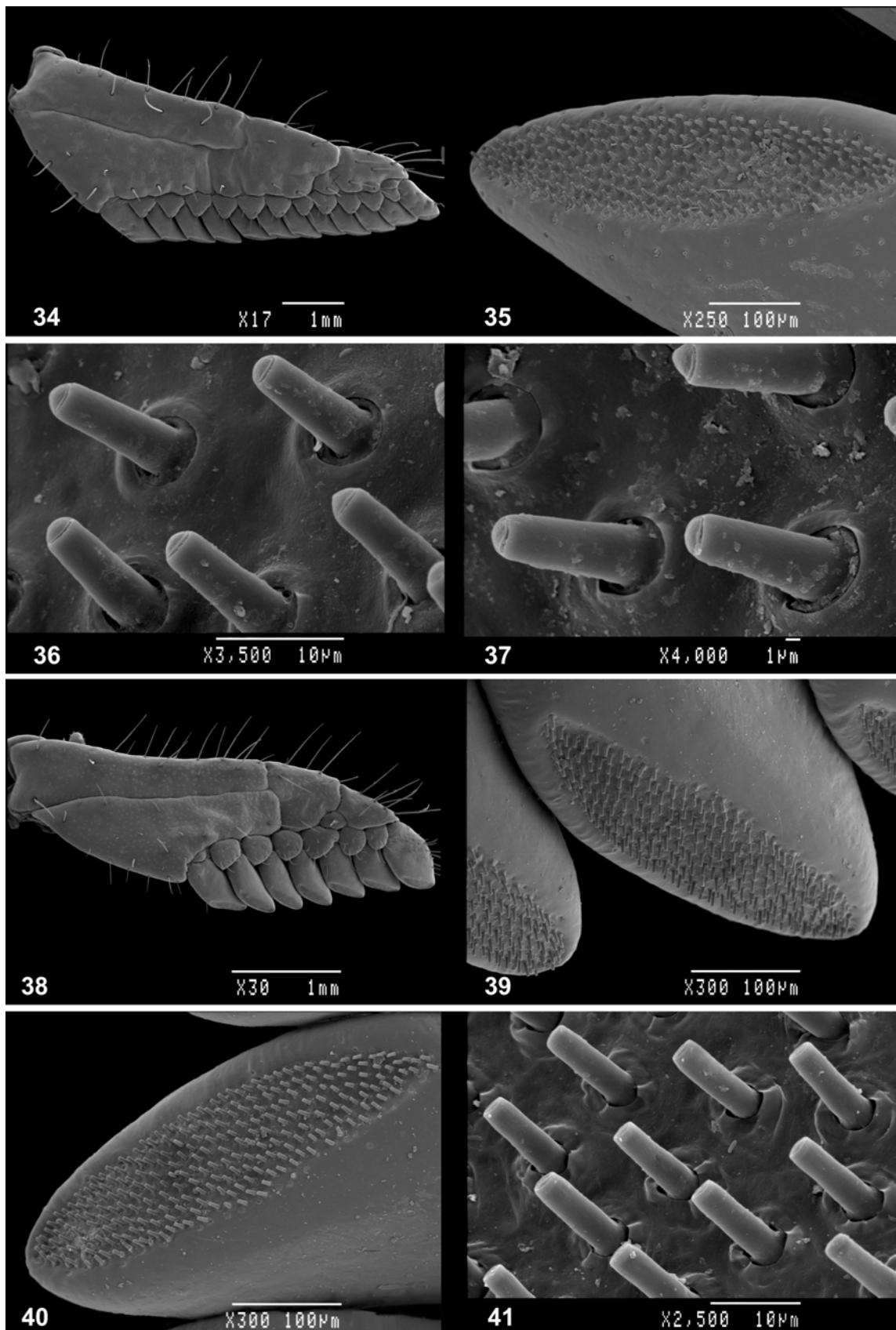
**RELATIONSHIPS:** From general morphology *Tityobuthus darainensis* sp. n. appears to be most closely related to *T. baroni* Pocock. The two can be readily distinguished by the following features: (i) *T. darainensis* has dark spots covering the anterior margin of the chelicerae at the base of fingers whereas the spots in *T. baroni* envelop almost the total chelicerae surface, (ii) *T. darainensis* has reduced tibial spurs, whereas these are completely absent in *T. baroni*.

**DESCRIPTION BASED ON FEMALE HOLOTYPE:**

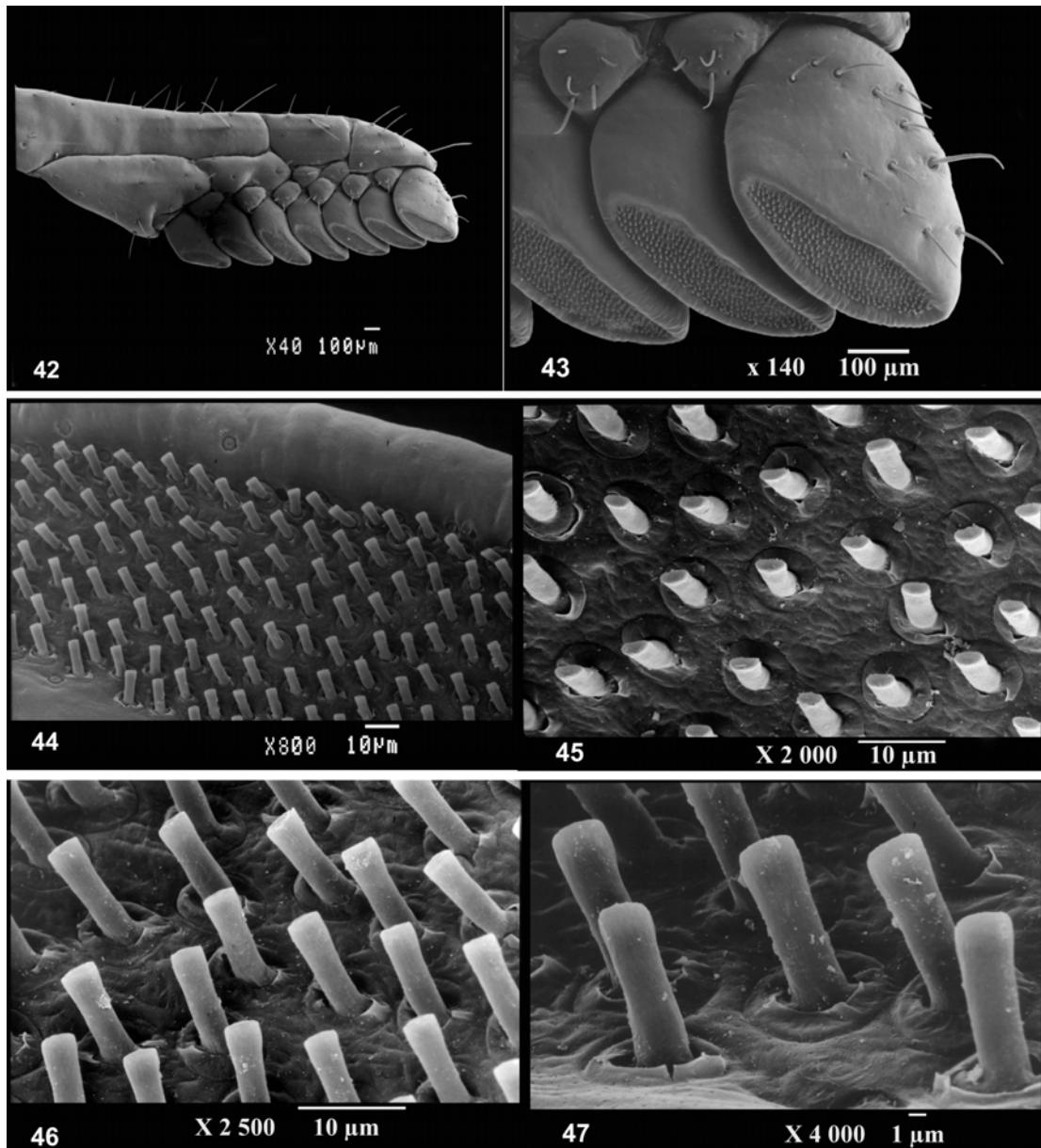
**Coloration.** Ground color yellowish, symmetrically marbled with a dark reddish brown, giving an overall



**Figs. 26-29.** *Heteroscorpion opisthacanthoides*. 26. Female pecten, global view. 27-28. Microstructure of peg sensilla on teeth. 29. Peg sensilla in detail. **Figs. 30-33.** *Heteroscorpion goodmani*. 30. Female pecten, global view. 31. Microstructure of peg sensilla on tooth. 32-33. Peg sensilla in detail.



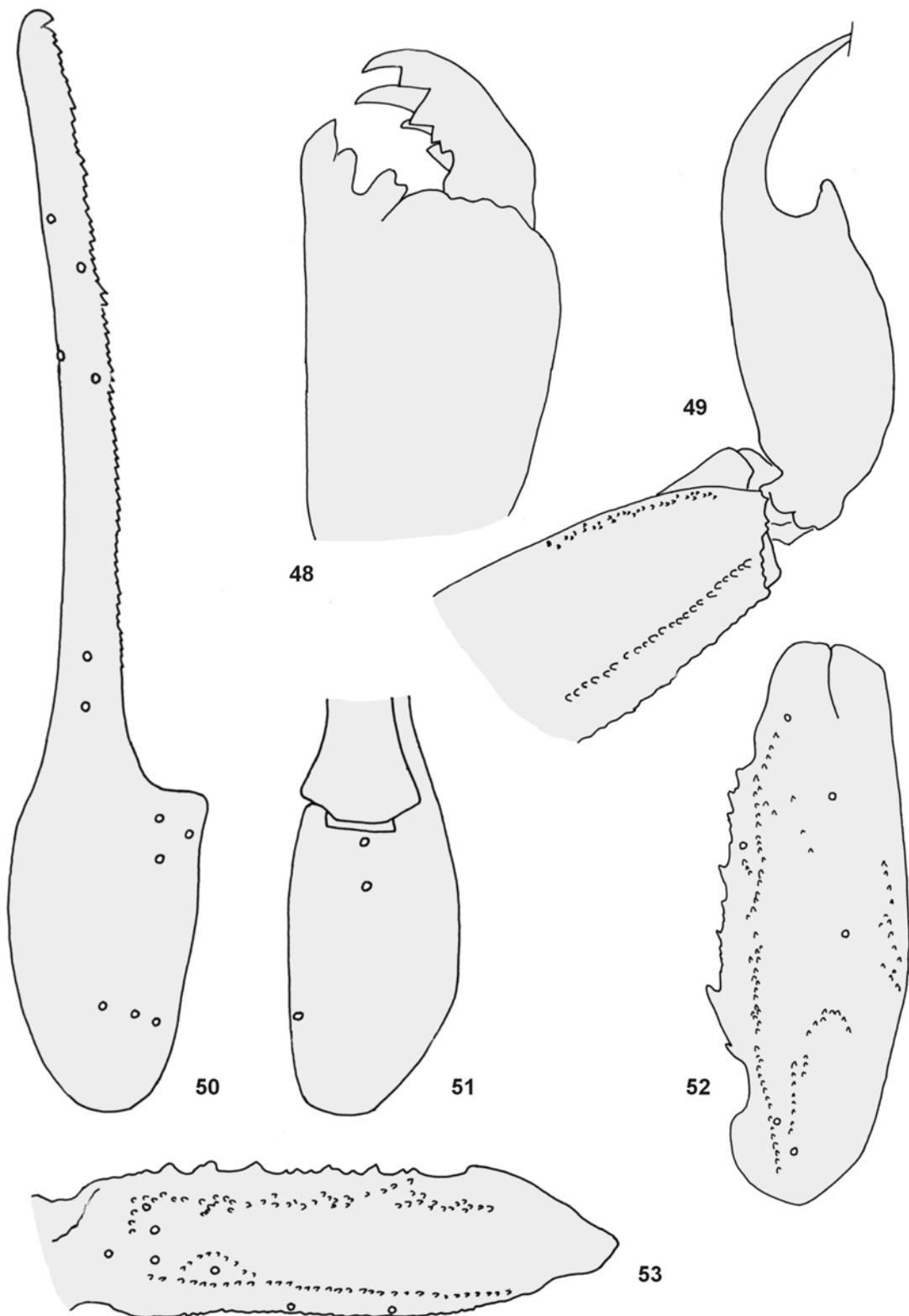
**Figs. 34-37.** *Heteroscorpion magnus* sp. n. **34.** Female pecten, global view. **35.** Microstructure of peg sensilla on tooth. **36-37.** Peg sensilla in detail. **Figs. 38-41.** *Opisthacanthus madagascariensis* (Ischnuridae). **38.** Female pecten, global view. **39-40.** Microstructure of peg sensilla on teeth. **41.** Peg sensilla in detail.



**Figs. 42-47.** *Palaeocheloctonus pauliani* (Ischnuridae). **42.** Female pecten, global view. **43.** Distal teeth in detail. **44.** Microstructure of peg sensilla on tooth. **45-47.** Peg sensilla in detail.

spotted appearance. Prosoma: carapace yellowish, moderately spotted, more intensely on the anterior margin; eyes surrounded by black pigment. Mesosoma: yellowish, with four longitudinal brown stripes, i.e. two central and two lateral ones; the central are separated by a yellow band. Metasoma: segments I to IV yellowish; V yellowish to reddish-yellow. Vesicle as segment V. Venter yellowish, without spots; only furrows on sternites III to VII are slightly darker. Chelicerae yellowish, with dark spots on the anterior margin at the base of fingers; fingers reddish-yellow. Pedipalps: yellowish, with several dark spots on femur and patella; chela less densely spotted; chela yellowish with one external dark spot; fingers reddish-yellow with dark zones on their base. Legs yellowish, with diffuse dark spots.

**Morphology.** Carapace moderately to weakly granular; anterior margin with a moderately pronounced median concavity, forming a weak angle. Anterior median supraciliary, posterior median carinae weak; furrows moderate. Median ocular tubercle distinctly anterior to the center of the carapace; median eyes separated by one ocular diameter. Three pairs of lateral eyes. Sternum subtriangular. Mesosoma: tergites weakly granular. Median carina weak on all tergites; absence of other carinae. Tergite VII pentacarinate. Venter: genital operculum almost round, longitudinally divided. Pectines: pectinal tooth count 17-18; basal middle lamellae not dilated; fulcra present. Sternites smooth with small, elongate stigmata; VII with four vestigial carinae. Sternite V without any smooth or bright zone on posterior edge. Metasoma: segments I to III with 10 carinae,



**Figs. 48-53.** *Tityobuthus darainensis* sp. n. (female holotype). **48.** Chelicera. **49.** Metasomal segment V and telson, lateral aspect. **50-53.** Trichobothrial pattern. **50-51.** Chela, external and ventral aspects. **52.** Patella, dorsal aspect. **53.** Femur, dorsal aspect.

crenulate. Segment IV with 8 carinae, crenulate. Inter-carinal spaces weakly to moderately granular. Segment V with five carinae, rounded and weakly granular. Telson smooth, without punctuations, with a long but moderately curved aculeus; subaculear tooth strong and spinoid with two basal granules. Cheliceral dentition characteristic of the family Buthidae (see Vachon, 1963); basal teeth of movable fingers reduced and of same size; ventral surfaces of finger and manus with setae. Pedipalps: femur pentacarinate; patella and chela with some carinae, moderately crenulate; internal face of patella with seven spinoid granules; all faces weakly granular; fixed and movable fingers with 8/9 oblique

rows of granules. Trichobothriotaxy; orthobothriotaxy A- $\alpha$  (cf. Vachon, 1974, 1975). Legs: tarsus with numerous fine median setae ventrally. Pedal spurs moderate and tibial spurs reduced.

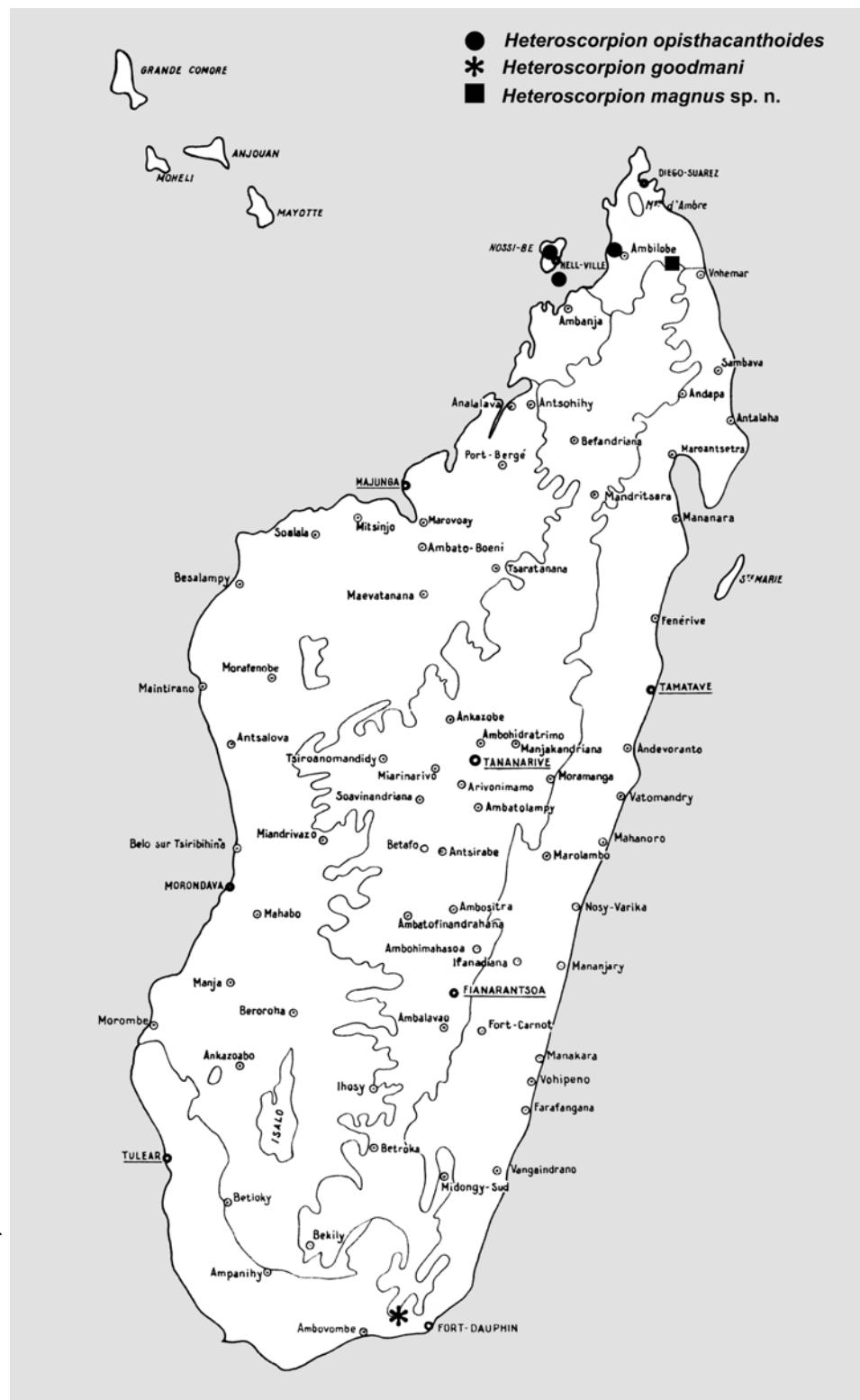
**Morphometric values of the female holotype** (in mm). Total length: 35.1; carapace length: 4.0, anterior width: 2.9, posterior width: 4.4; metasomal segment I length: 2.3, width: 2.2; metasomal segment V length: 4.9, width: 1.9, depth: 1.7; vesicle width: 1.2, depth: 1.3; pedipalp: femur length: 4.0, width: 1.0; patella length: 5.0, width: 1.6; chela length: 7.7, width: 1.2, depth: 1.1; movable finger length: 5.5.

#### KEY TO THE SPECIES OF *TITYOBUTHUS*

- |  |                              |
|--|------------------------------|
| 1. Pectines with fulcra vestigial or absent .....  | 2                            |
| — Pectines with well developed fulcra .....  | 3                            |
| 2. Fulcra vestigial .....  | <i>T. monodi</i>             |
| — Fulcra absent .....  | <i>T. guillaumeti</i>        |
| 3. Tibial spurs absent .....   | <i>T. baroni</i>             |
| — Tibial spurs present .....   | 4                            |
| 4. Chelicerae without spots or pigmentation .....  | <i>T. judsoni</i>            |
| — Chelicerae with dark spots and pigmentation .....  | 5                            |
| 5. Pectines with 20 or more teeth .....  | 6                            |
| — Pectines with less than 20 teeth .....   | 8                            |
| 6. A conspicuous smooth, white and bright central zone on sternite V .....   | <i>T. manonae</i>            |
| — No such zone on sternite V .....   | 7                            |
| 7. Body, pedipalps and legs heavily spotted; pedipalpal chela short and robust; internal face of patella with four spinoid granules .....            | <i>T. lucileae</i>           |
| — Body, pedipalps and legs with only vestigial spots; pedipalpal chela long and slender; internal face of patella with 5 or 6 spinoid granules ..... | <i>T. pococki</i>            |
| 8. Pectines with 11 teeth .....  | <i>T. ivohibe</i>            |
| — Pectines with 12 to 19 teeth .....   | 9                            |
| 9. Pectines with 12 to 14 teeth .....  | 10                           |
| — Pectines with 15 to 19 teeth .....   | 11                           |
| 10. A smooth with a white central zone on sternite V and two small rounded smooth white zones laterally .....  | <i>T. griswoldi</i>          |
| — Sternite V without any smooth white zone .....   | <i>T. parrilloi</i>          |
| 11. Sternite V with a reduced or conspicuous smooth white zone; total length averaging 20 mm .....   | 12                           |
| — Sternite V without any smooth white zone; total length averaging 35 mm .....   | <i>T. darainensis</i> sp. n. |
| 12. Sternite V centrally with a single conspicuous smooth white zone .....   | <i>T. dasychi</i>            |
| — Sternite V with a reduced smooth white central zone associated with two small rounded smooth white zones laterally .....                           | <i>T. petrae</i>             |

#### Acknowledgements

Funds for the fieldwork in the Daraina region were kindly provided by the Volkswagen Foundation and logistic support from World Wide Fund for Nature and Fanamby. Achille Raselimanana and Hery Rakotondravony assisted with the collection of scorpions during the Daraina inventory. We are very grateful to Régis Cleva and Laurent Albenga, Laboratoire de Zoologie Arthropodes, for their help with the preparation of SEM illustrations.



**Fig. 54.** Map of Madagascar showing the distribution of the species of the family Heteroscorpionidae.

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