

## THE IDENTITY OF *TITYOBUTHUS BARONI* (POCOCK, 1890) (SCORPIONES, BUTHIDAE) AND DESCRIPTION OF THREE NEW SPECIES FROM MADAGASCAR

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**Abstract:** New taxonomic considerations on the endemic Malagasy genus *Tityobuthus* Pocock, 1893 are presented. The identity and precise distribution of *T. baroni* (Pocock, 1890) and the type species of the genus *Tityobuthus* are discussed. The population of *Tityobuthus* most frequently associated with the name *T. baroni* is demonstrated to be an unnamed species, whereas *T. lucileae* Lourenço, 1996, described from parc de l'Est, Antsirabe, in the Central Highlands, is shown to be a synonym of *T. baroni*. Three new species, *Tityobuthus mccarteri* sp. n., *Tityobuthus chelbergorum* sp. n., and *Tityobuthus betschi* sp. n., are described, respectively, from the provinces of Toamasina, Fianarantsoa and Toliara.

**Key words:** Scorpiones, Buthidae, *Tityobuthus*, *Tityobuthus baroni*, true identity, new species, taxonomy, Madagascar.

### La identidad de *Tityobuthus baroni* (Pocock, 1890) (Scorpiones, Buthidae) y descripción de tres nuevas especies de Madagascar

**Resumen:** Se presentan nuevas consideraciones taxonómicas sobre el género endémico de Madagascar *Tityobuthus* Pocock, 1893. Se discute la identidad y distribución precisa de *T. baroni* (Pocock, 1890), así como la especie tipo del género *Tityobuthus*. Se demuestra que la población de *Tityobuthus* habitualmente asociada con el nombre *T. baroni* es una especie innominada, considerando que *T. lucileae* Lourenço, 1996, descrita de parc de l'Est, Antsirabe, en las Central Highlands, es un sinónimo de *T. baroni*. Tres nuevas especies, *Tityobuthus mccarteri* sp. n., *Tityobuthus chelbergorum* sp. n. y *Tityobuthus betschi* sp. n., se describen, respectivamente, de las provincias de Toamasina, Fianarantsoa y Toliara.

**Palabras clave:** Scorpiones, Buthidae, *Tityobuthus*, *Tityobuthus baroni*, verdadera identidad, nueva especie, taxonomía, Madagascar.

**Taxonomy/Taxonomía:** *Tityobuthus mccarteri* sp. n., *Tityobuthus chelbergorum* sp. n. y *Tityobuthus betschi* sp. n.

### Introduction

When Vachon (1980) published his analysis of the genus *Tityobuthus* Pocock, only two species were regarded as valid, both endemic to Madagascar: *T. baroni* (Pocock, 1890) and *T. gracilis* (Fage, 1946). This remained unchanged until Lourenço (1995) named two new species in this genus: *T. guillaumeti* and *T. pococki*. Further, several other species of *Tityobuthus* have been subsequently described from the island (Lourenço, 1996a,b, 1997; Lourenço & Goodman, 1999a, 2003, 2004).

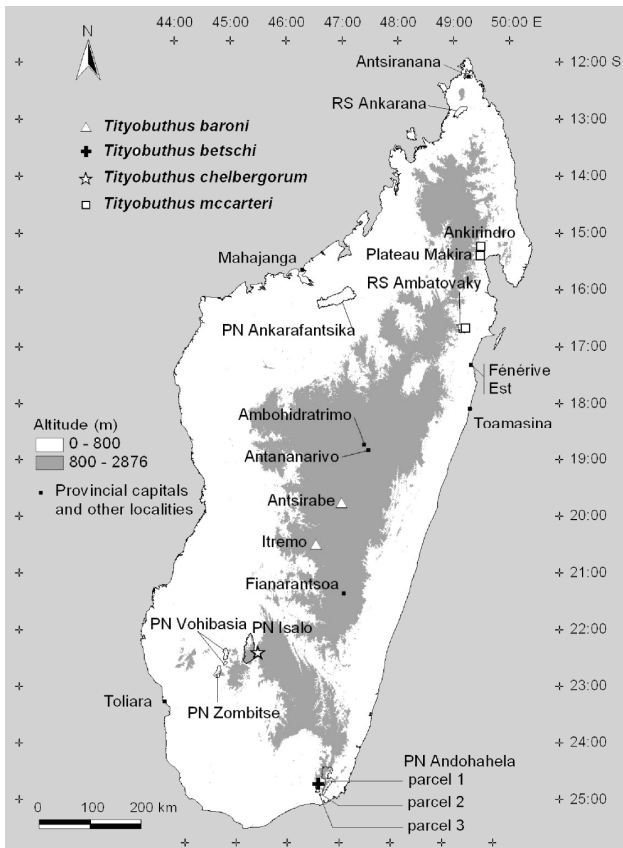
Lourenço (2000) revised the taxonomic position of the Buthoidea of Madagascar, with particular reference to *Tityobuthus*, in which a revised diagnosis of this genus was given and three new species were described from the eastern portion of the island. Further, two species previously placed within *Tityobuthus* were assigned to new genera -- *Troglotityobuthus* Lourenço for *Tityobuthus gracilis* (Fage, 1946) (described as *Babycurus gracilis*) and *Palaeogrosphus* Lourenço for *T. copalensis* Lourenço, 1996.

In this current paper, some new taxonomic aspects are presented for *Tityobuthus* and, in particular, associated with the name *T. baroni*, which is redescribed; three new species to science are named from Madagascar. Finally, a revised key to the known species of *Tityobuthus* is provided.

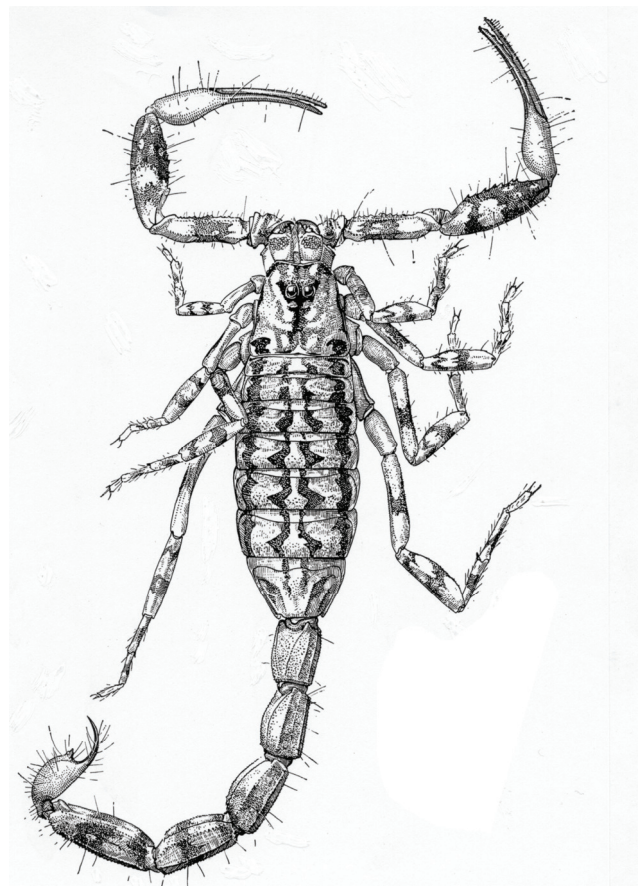
### Taxonomic history of the genus *Tityobuthus* and the identity of *T. baroni*

The genus *Tityobuthus* was established as a replacement name for *Rhoptrurus baroni* (Pocock, 1890) by Pocock (1893). The generic name *Rhoptrurus* Karsch, 1886, was preoccupied by that of the snake genus *Rhoptrura* Peters, 1858 (Vachon 1980). Further, confusion existed between the genera *Tityobuthus* Pocock, 1893, *Pseudobuthus* Pocock, 1893, and *Odonturus* Karsch, 1879, until they were revised by Vachon (1980). The latter author included only two species in the genus *Tityobuthus*, *T. baroni* and *T. gracilis*.

The type species of the genus *Tityobuthus*, *Rhoptrurus baroni*, was described based on three specimens, obtained in Madagascar by the Reverend Richard Baron; no details of the original collection locality were given by Pocock. Subsequently, specimens of *Tityobuthus* gathered at different localities on the island, and from diverse biotopes, have been assigned to *T. baroni* (Fage, 1929; Vachon, 1980). In several cases, these records proved to be misidentified specimens of different species of this complex genus (Lourenço, 1996a, 2000). One important question, however, remained unanswered: from what region of Madagascar was the type material of *T. baroni* collected? Frequently, *Tityo-*



**Fig. 1.** Map of Madagascar showing the area of distribution of *Tityobuthus baroni* and, the type localities of the new species described in this paper: *Tityobuthus mccarteri* sp. n.; *Tityobuthus chelbergorum* sp. n.; *Tityobuthus betschi* sp. n. PN=Parc National, RS = Réserve Spéciale.



**Fig. 2.** Habitus of a female specimen of *Tityobuthus* from Fénérive-Est, Province de Tamatave [=Toamasina], published as *T. baroni* by Vachon (1980). This identification was followed in subsequent publications by Lourenço. This habitus represents in fact, a female of the new species *Tityobuthus mccarteri* sp. n.

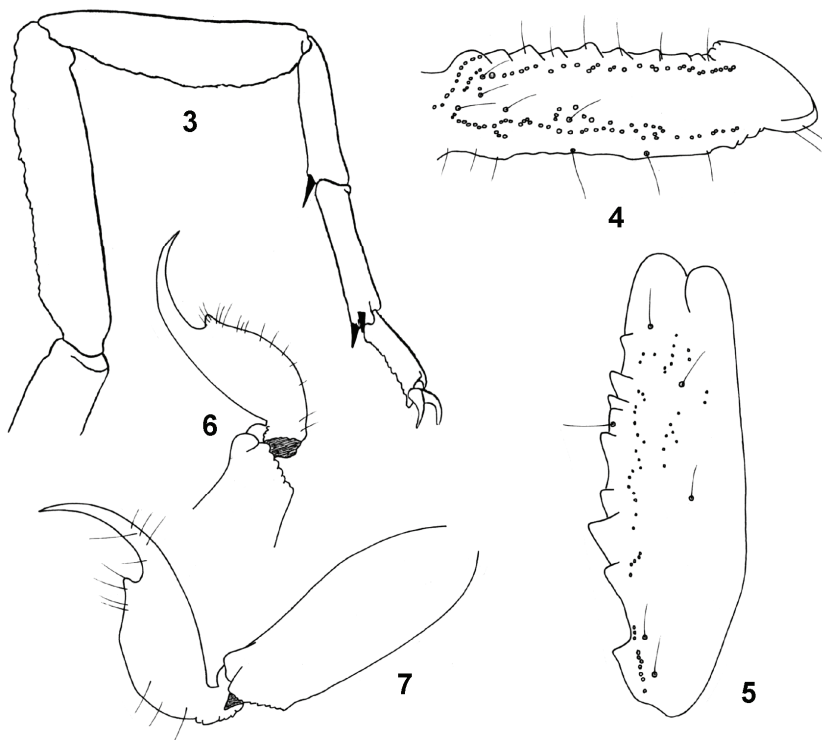
*buthus* obtained in the northeastern lowland portion of the Province of Toamasina were associated with the name *T. baroni* (Fage, 1929; Vachon, 1980); however, these identifications were made in the absence of comparative study of the *T. baroni* type series.

One year before the naming of *T. baroni*, Pocock (1889) published a detailed description of another scorpion: *Buthus limbatus* (= *Grosphus limbatus*), on the basis of four specimens obtained by Rev. R. Baron in Madagascar, once again without giving any precise collection locality. Fage (1929) subsequently identified *G. limbatus* from several different localities. More recently, a detailed study of several species of *Grosphus* similar to *G. limbatus*, demonstrated examples of animals misidentified by Fage (1929), and confirmed this species distributional area as being confined to the Central Highlands (Lourenço, 2003a), the portion of the island generally defined as above 800 m (Fig. 1).

Rev. R. Baron arrived in Madagascar in 1872 and was associated with the London Missionary Society and remained on the island for the subsequent 35 years (Dorr, 1987). He made considerable plant collections. He lived for a portion of this period near Fianarantsoa and Ambohidratrimo (near Antananarivo) in the Central Highlands (Fig. 1); the majority of his plant collections bear the ambiguous locality “Imerina, Betsileoland and Tanala” (Baker, 1908). He did visit other portions of the island, where at least plants were collected (Dorr, 1987).

Without having access to the original type series of *T. baroni*, Lourenço (2004) disregarded the possibility of this species occurring in the Central Highlands, where another species, *T. lucileae* Lourenço, 1996, was named (Lourenço, 1996b). Further, Lourenço (2004) followed the suggestion of Vachon (1980) in which he cited, among other specimens, a female collected at Fenérive-Est (Fenoarivo-Antsinanana), Province of Toamasina, by R. Legendre (Fig. 2) and identified as *T. baroni*. The external morphology and characters of this specimen corresponds with Pocock’s (1890) description for this species. Further, Toamasina was during the 19<sup>th</sup>-century the major harbor on the island, particularly for foreign travelers arriving by boat. Based on these arguments, Lourenço (2004) concluded that the Province of Toamasina was visited by the Rev. Baron during his time in Madagascar, and that specimens on which the description of *T. baroni* was based, could have been obtained in this eastern lowland region.

The underlying problem in resolving these inferences is derived from not being able to locate and study the type series of *T. baroni* deposited in The Natural History Museum, London. However, in 2006 the type series of *T. baroni* was located and all three specimens originally studied by Pocock were examined by the senior author. Subsequently, it was clear that the type material of *T. baroni* perfectly matches specimens of *T. lucileae* described from the Central Highlands. Consequently, *T. baroni* was originally collected



**Fig. 3-7.** *Tityobuthus baroni*, 3-6. Male lectotype. 7. Female paralectotype. 3. Leg IV, showing well marked tibial spurs. 4-5. Femur and patella, dorsal aspect, showing trichobothria. 6. Metasomal segment V and telson, lateral aspect. 7. Idem for female.

by Rev. Baron in the Central Highlands, probably in the vicinity of Antananarivo or Fianarantsoa, and *T. lucileae* is a junior synonym of *T. baroni*. Hence, the *Tityobuthus* found in the lowland portions of the Province of Toamasina is a previously unnamed form, which is described herein.

### 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 mm. Trichobothrial notations follow Vachon (1974) and morphological terminology mostly follows Hjelle (1990).

Specimens used in this taxonomic work come from the Muséum national d'Histoire naturelle, Paris (MNHN), The Natural History Museum, London (BMNH), Field Museum of Natural History, Chicago (FMNH), California Academy of Sciences, San Francisco (CAS), and Museo Regionale di Scienze Naturali, Torino (MRSN).

### Redescription of *Tityobuthus baroni* (Pocock, 1890) (Fig. 3-18)

*Rhoptrurus baroni* Pocock, 1890: 140.

*Tityobuthus baroni* Pocock, 1893: 312; Vachon, 1980: 219 (in part); Lourenço, 1996a: 20 (in part).

*Odonturus baroni* Kraepelin, 1899: 34; Fage, 1929: 675 (in part).

*Tityobuthus lucileae* Lourenço, 1996b: 270 (new synonymy); Lourenço, 1996a: 22.

**MATERIAL.** Madagascar, 1 male, 2 females (types) (Pocock), Rev. R. Baron. BM 1888-12. Male herewith designated as lectotype, females as paralectotypes (BMNH). Parc de l'Est, Antsirabe, 16/IX/1973 (C. Duval leg.), male holotype, female allotype of *Tityobuthus lucileae* (MRSN 50.1-50.2). Fianarantsoa, Forêt d'Atsirakambiaty, 7.6 km WNW

Itremo, 1550 m (20°35'36"S-46°33'48"E), montane rain-forest (Fisher, Griswold et al.), 22-26/I/2003, 1 female (CAS).

**DIAGNOSIS:** Scorpion of moderate to large size (with respect to the genus) and with 24-27 mm in total length. Carapace with a moderately pronounced concavity, forming a weak angle; granulations moderately to strongly marked. Cheliceral dentition with basal teeth of movable fingers reduced. Pectines with 20 to 22 teeth and the presence of fulcra. Sternites smooth with moderately elongated spiracles. Telson with a long but moderately curved aculeus; subaculear tooth weak and slightly spinoid without basal granules. Tibial spurs strongly marked. Pedipalp fixed and movable fingers with 8-9 slightly oblique, almost straight rows of granules. Trichobothrial pattern of type A- $\alpha$  (alpha) - orthobothriotaxic.

Redescription based on type material and on the other available specimens. Measurements presented in Table I.

**Coloration.** Basically yellow, symmetrically marbled with dark reddish-brown pigment, producing an overall spotted appearance. Prosoma: carapace yellowish and heavily spotted; eyes surrounded by black pigment. Mesosoma: yellowish with three longitudinal brown stripes; the median one divided by a longitudinal yellow strip. Metasoma: segments I to III yellowish; IV and V reddish; vesicle reddish-yellow but lighter than segment V. Venter yellow with a number of spots on sternites III to VII. Chelicera yellowish with dark spots interiorly and laterally; fingers dark reddish. Pedipalps yellowish with several spots on femur and patella; chela less densely spotted; fingers much darker than chela, reddish-brown. Legs yellowish with diffuse fuscous spots.

**Morphology.** Carapace moderately to strongly granular; anterior margin with a weak to moderate median concavity. Anterior median superciliary and posterior median carinae moderate to weak. All furrows moderate to weak. Median



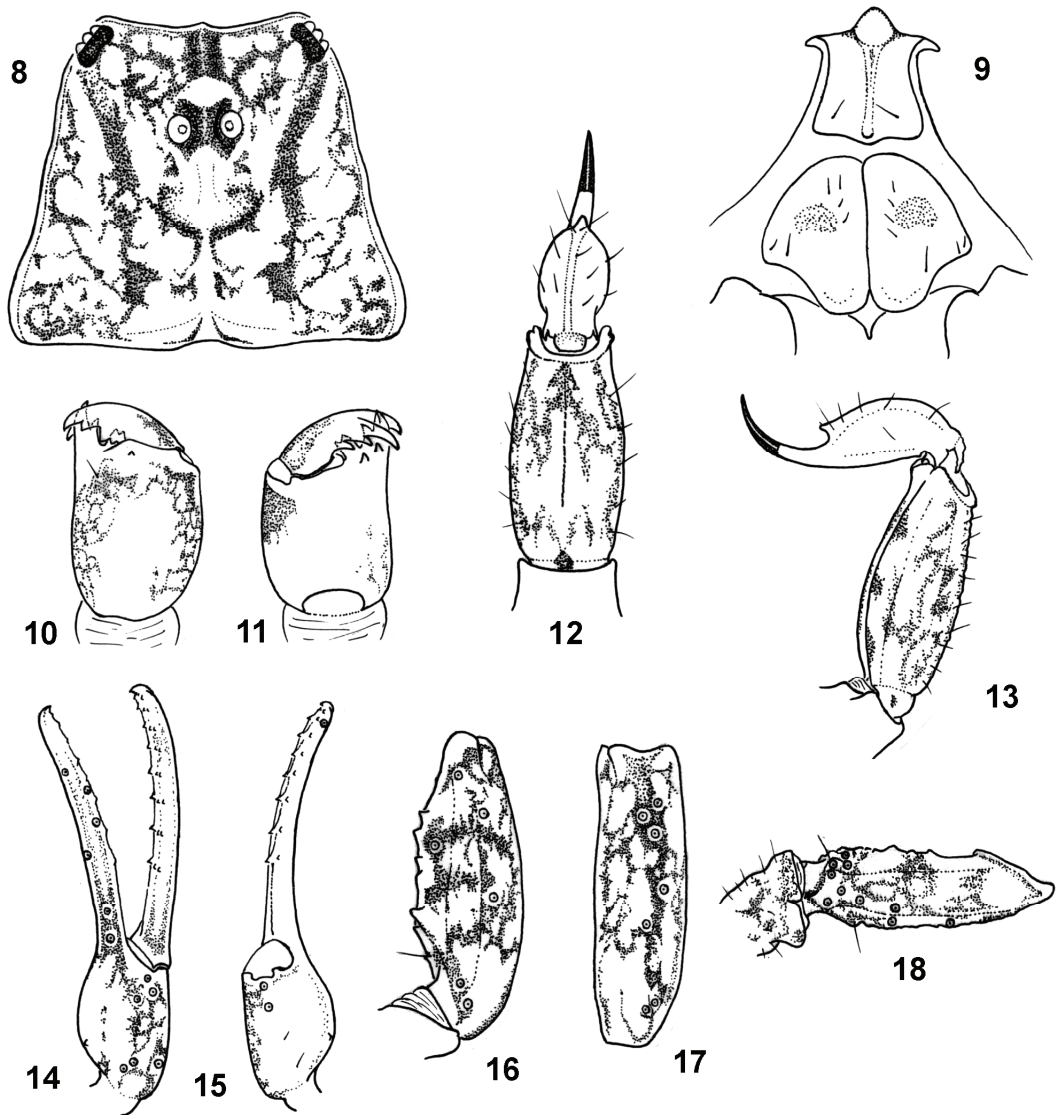


Fig. 8-18. *Tityobuthus baroni*, female from Forêt d'Atsirakambiaty. 8. Carapace, 9. Sternum and genital operculum. 10-11. Chelicerae, dorsal and ventral aspects. 12-13. Metasomal segment V and telson, ventral and lateral aspects. 14-18. Trichobothrial pattern. 14-15. Chela, dorso-external and ventral aspects. 16-17. Patella, dorsal and external aspects. 18. Femur, dorsal aspect.

Table I. Morphometric values in mm of the described species of *Tityobuthus*. A = *T. baroni* (male holotype and female allotype of *T. lucileae*); B = *T. mccarteri* sp. n. (male holotype/female paratype); C = *T. chelbergorum* sp. n. (female holotype); D = *T. betschi* sp. n. (male holotype/female paratype).

	A	B	C	D
Total length	24.7/26.3	23.7/29.6	27.8	12.7/13.7
Carapace:				
- length	3.1/3.4	2.7/3.6	3.3	1.9/1.8
- anterior width	2.2/2.4	1.8/2.6	2.3	1.3/1.4
- posterior width	3.4/4.5	2.6/3.8	3.5	1.8/2.0
Metasomal segment I:				
- length	1.8/2.2	2.0/2.2	1.9	1.0/1.0
- width	1.2/2.1	1.4/1.8	1.9	0.9/1.0
Metasomal segment V:				
- length	4.4/4.6	3.7/4.3	4.1	2.2/2.3
- width	1.8/2.0	1.2/1.5	1.5	0.8/0.9
- depth	1.3/1.6	1.2/1.6	1.4	0.8/0.8
Vesicle:				
- width	0.9/1.0	0.9/1.2	1.1	0.6/0.7
- depth	0.8/0.9	1.0/1.3	1.2	0.6/0.7
Pedipalp:				
- Femur length	2.7/3.0	3.2/3.6	2.9	1.3/1.3
- Femur width	0.9/0.9	0.7/1.0	0.9	0.5/0.6
- Patella length	3.5/3.6	3.7/4.3	3.7	1.8/1.8
- Patella width	1.2/1.2	0.9/1.4	1.3	0.7/0.8
- Chela length	5.3/5.7	4.8/6.3	5.5	2.7/2.7
- Chela width	1.2/1.1	0.8/1.2	1.0	0.6/0.6
- Chela depth	1.1/1.0	0.7/1.0	1.0	0.5/0.5
Movable finger:				
- length	3.4/3.7	3.4/4.6	3.8	1.9/1.9



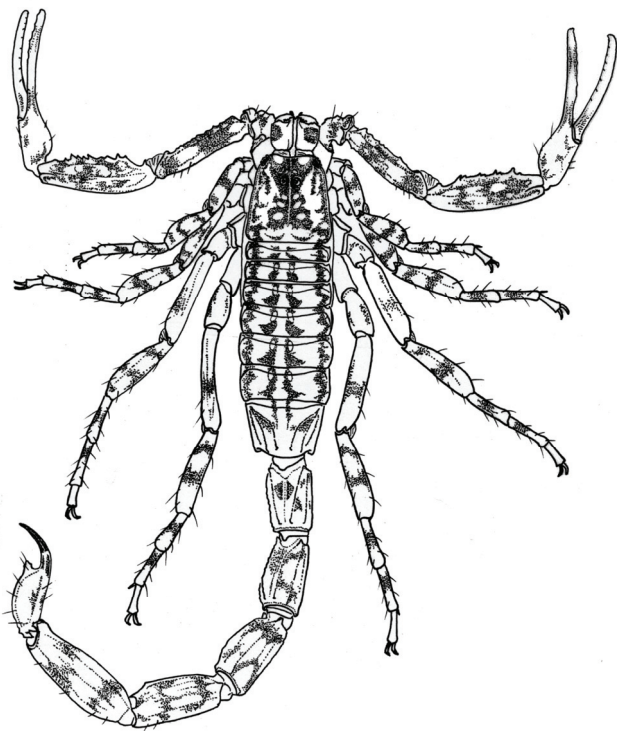


Fig. 19. *Tityobuthus mccarteri* sp. n., male holotype. Habitus.

ocular tubercle distinctly anterior to the center of carapace; median eyes separated by more than one ocular diameter. Three pairs of lateral eyes. Sternum subtriangular to subpentagonal. Mesosoma: tergites weakly to moderately granular. Median carina moderate in all tergites. Tergite VII pentacarinata. Venter: genital operculum divided longitudinally. Pectines: pectinal tooth count 20 to 22 in both males and females; basal middle lamella of the pectines not dilated; presence of fulcra. Sternites smooth with moderately elongate spiracles; VII without carinae. Metasoma: segments I to III with 10 carinae, crenulate. Intercarinal spaces weakly granular. Segment V smooth and rounded, especially in males. Telson smooth with a long and moderately curved aculeus; subaculear tooth weak and slightly spinoid without basal granules. Cheliceral dentition characteristic of the family Buthidae (Vachon, 1963); basal teeth of movable fingers reduced and of same size; ventral aspect of both finger and manus with dense, long setae. Pedipalps: femur pentacarinata; patella and chela with some carinae but moderately crenulate; internal face of patella with 4 to 5 strong spinoid granules; all faces moderate to weakly granular. Movable fingers with 8-9 almost oblique rows of granules; internal and external accessory granules present. Trichobothriotaxy; orthobothriotaxy A- $\alpha$  (alpha) (Vachon, 1974, 1975). Legs: tarsus with very numerous median fine setae ventrally. Tibial spurs strongly marked on legs III and IV.

**DIFFERENT FEMALE CHARACTERS:** Coloration and pigmentation similar to that of the male, but slightly paler. Morphology: the same as for the male, but slightly more stocky-built. Morphometric differences presented in Table I. Smaller pectines; tooth count 20 to 22 as for males; basal middle lamellae not dilated.

**DISTRIBUTION AND ECOLOGY.** Given the lack of information associated with the collection locality of the Baron specimens, nothing can be inferred about the site these ani-

mals were obtained. Other specimens referred to this taxon include those from Antsirabe and near Itremo. The first site is at about 1200 m elevation and, before large-scale anthropogenic change of the area, was characterized by montane forest and areas of granitic domes, often with rupicolous vegetation. The Itremo area is higher in elevation, with the collection site being at 1550 m, and composed of montane forest with extensive crystalline rock outcrops.

Although the Central Highlands, representing nearly 40% of the surface area of the island, have been considerably prospected, the number of species occurring across this vast area is uncertain and include: *Grosphus limbatus*, *Tityobuthus ivohibe* Lourenço & Goodman, 1999, and *T. griswoldi* Lourenço, 2000.

### Description of three new species

#### *Tityobuthus mccarteri* sp. n. (Fig. 19-40)

*Tityobuthus baroni*: Fage, 1929: 675 (in part – misidentification); Vachon, 1980: 219 (in part – misidentification); Lourenço, 1996a: 20 (in part – misidentification); 1996b: 270 (misidentification); 2002: 333 (misidentification); 2003b: 578 (in part – misidentification); 2004: 386 (misidentification).

**MATERIAL.** Madagascar, Province de Toamasina, Montagne d'Akirindro, NW d'Ambinanitelo, [presumed to be 15°17'3"S-49°32'9"E, cf. Heterick, 2006], 600 m, forêt humide, III/1969 (J.-M. Betsch), 1 male holotype (MNHN); Réserve Spéciale d'Ambatovaky, 450 m, rain forest, 31/I/2006 (L. R. de Roland), 4 females, 1 juvenile paratypes (FMNH); Plateau de Makira, Forêt de Vohitaly (site F), 5 km SE village Anjiahely (15°26'58"S-49°32'06"E), 540-680 m, pitfall vial marked "C9 site F Vohitaly" no date (V. Andrianjakarivelo), SMG 13641, 2 female paratypes (FMNH, MNHN).

**ETYMOLOGY:** Patronym in honor of John W. McCarter, Jr., President of the Field Museum of Natural History, Chicago.

He has advanced bold initiatives for helping to establish new programs for field biology in Madagascar, as well as other tropical countries.

**DIAGNOSIS:** Scorpion of moderate size (with respect to the genus) and with a total length of 24 mm for the male holotype and 29 mm on average for the females. Carapace with a very weak concavity, almost straight. Cheliceral dentition with basal teeth of movable fingers reduced and of same size. Pectines with 13 to 15 teeth on males and females and, reduced fulcra. Sternites smooth; sternite V of males with a bright white zone on posterior edge. Telson with a long curved aculeus; subaculear tooth strong and slightly spinoid with two weak basal granules. Tibial spurs absent. Pedipalp fixed and movable fingers with 8-9 slightly oblique, almost straight rows of granules. Trichobothrial pattern of type A- $\alpha$  (alpha) - orthobothriotaxic.

**RELATIONSHIPS:** From general morphology, *Tityobuthus mccarteri* sp. n. appears to have some affinities to *T. raketondravonyi* Lourenço & Goodman, 2003, described from the dry deciduous forests of the Réserve Spéciale d'Ankarana in the extreme northern portion of the island. The new species can be readily distinguished from the latter by the following features: (i) a distinct pigmentation pattern. *T. raketondravonyi* has dark spots covering the anterior margin of the chelicerae at the base of fingers, the carapace

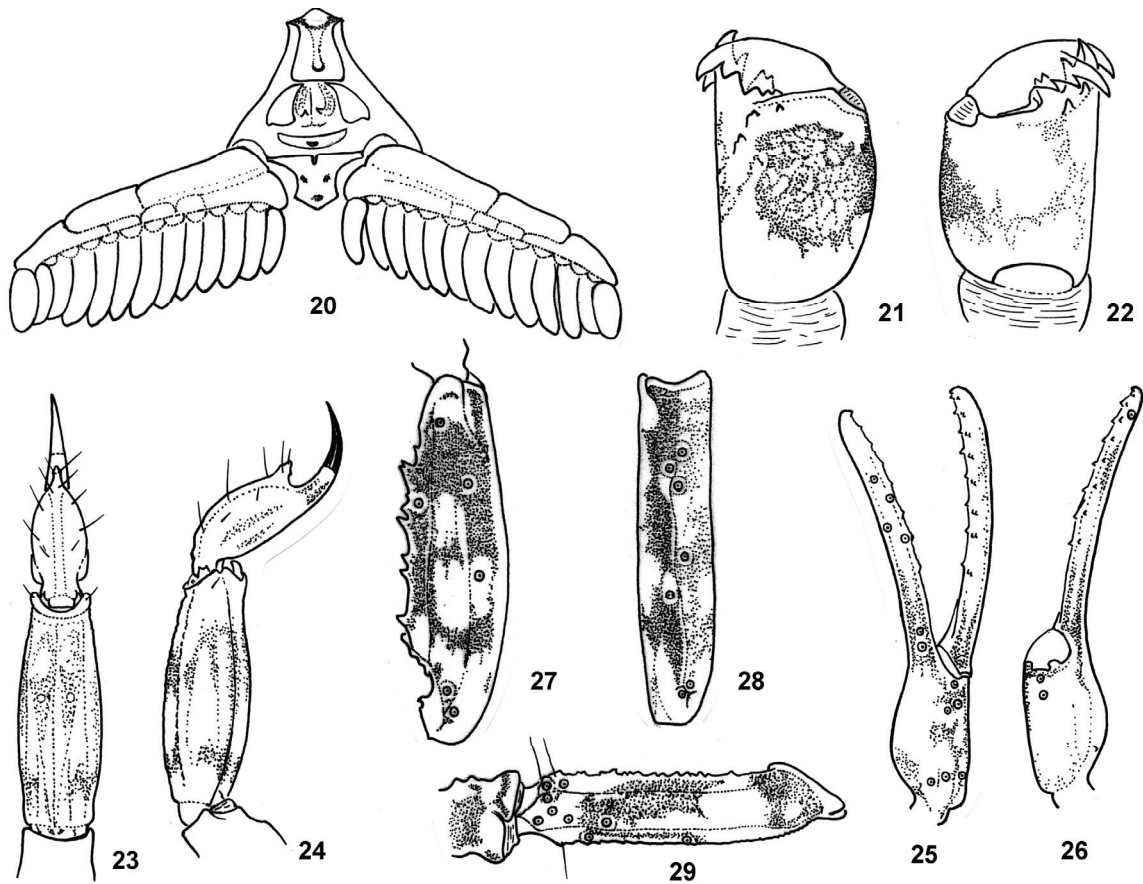


Fig. 20-29. *Tityobuthus mccarteri* sp. n., male holotype. 20. Sternum, genital operculum and pectines. 21-22. Chelicerae, dorsal and ventral aspects. 23-24. Metasomal segment V and telson, ventral and lateral aspects. 25-29. Trichobothrial pattern. 25-26. Chela, dorso-external and ventral aspects. 27-28. Patella, dorsal and external aspects. 29. Femur, dorsal aspect.

and tergites are weakly spotted, and metasomal segments IV-V are very dark almost blackish. In *T. mccarteri* sp. n. the dark spots envelop almost the total chelicerae surface; carapace and tergites are heavily spotted and metasomal segments IV-V are only partially spotted; (ii) the two species inhabit notably different habitats (see distribution and ecology section).

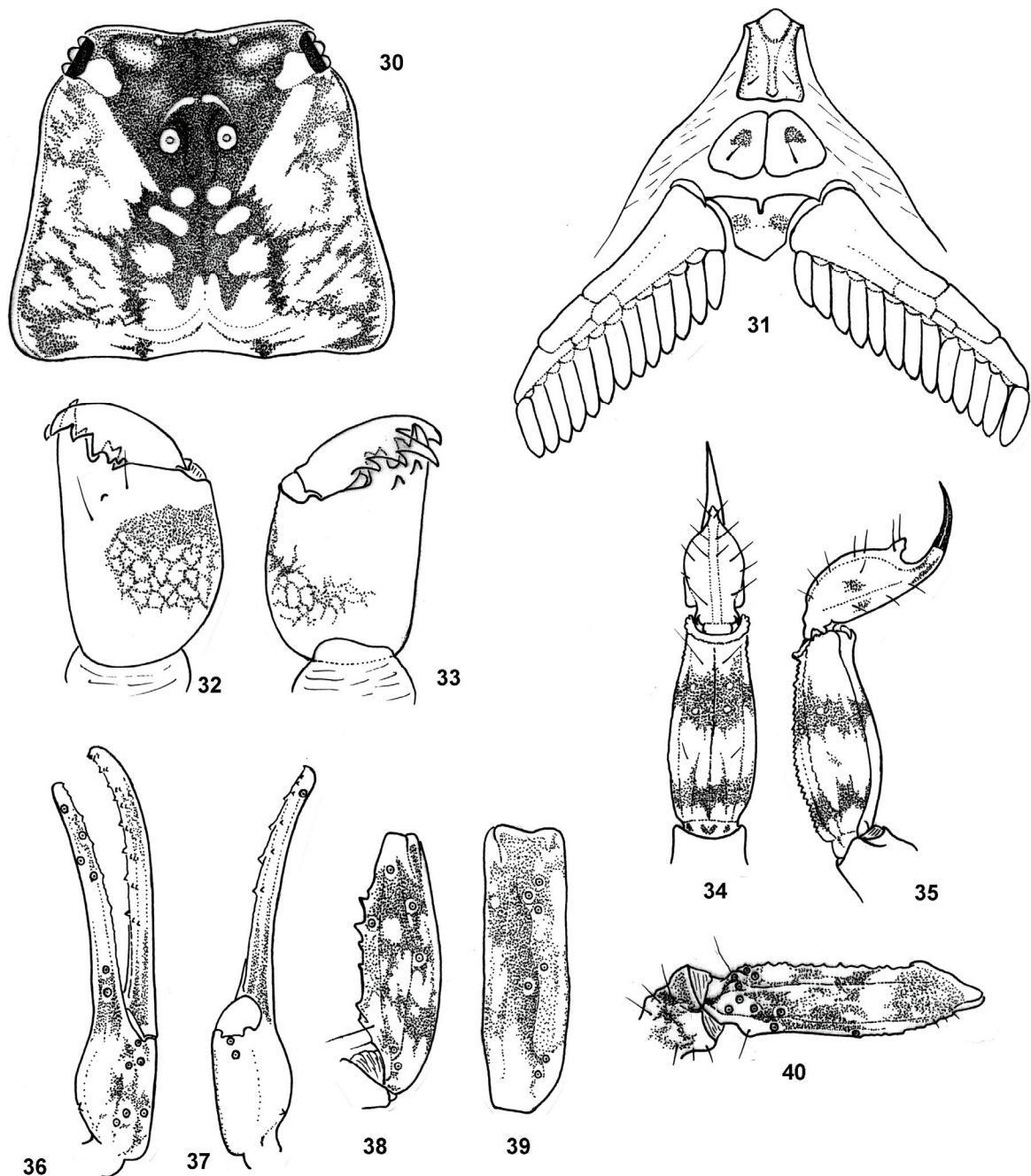
DESCRIPTION based on male holotype and female paratype.

**Coloration.** Ground color yellowish, symmetrically marbled with a dark reddish brown, giving an overall spotted appearance. Prosoma: carapace yellowish, moderately spotted, more intensely on the anterior and posterior margins; 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 V yellowish, with brownish spots, better marked in female. Vesicle yellowish. Venter yellowish, with spots on sternite VII. Chelicerae yellowish, with dark spots on the anterior and central zones; fingers reddish-yellow. Pedipalps: yellowish, with several dark spots on femur and patella; chela yellowish with some diffuse dark spots; fingers brownish with darker zones on their base. Legs yellowish, with diffuse dark spots.

**Morphology.** Carapace moderately granular; anterior margin with a very weak median concavity, almost straight. Anterior median superciliary, posterior median carinae weak to obsolete; furrows weak. Median ocular tubercle distinctly anterior to the center of the carapace; median eyes

separated by a little more than one ocular diameter. Three pairs of lateral eyes. Sternum subtriangular. Mesosoma: tergites weakly granular. Median carina weak to obsolete on all tergites; absence of other carinae. Tergite VII pentacarinata. Venter: genital operculum longitudinally divided, each half being semi-oval-shape. Pectines: pectinal tooth count 13-13 on male holotype, 13 to 14 on females paratypes; basal middle lamellae not dilated; fulcrum present. Sternites I to VI smooth with small, elongate spiracles; VII with four carinae weak to obsolete. Sternite V of male with a smooth or bright zone on posterior edge. Metasoma: segments I-II with 10 carinae, moderately crenulate. Segments III-IV with 8 carinae, moderately crenulate. Intercarinal spaces weakly to moderately granular. Segment V with five carinae, rounded and moderately to weakly granular. Telson smooth, without punctuations, with a long curved aculeus; subaculear tooth strong and slightly spinoid with two basal granules. Cheliceral dentition characteristic of the family Buthidae (Vachon, 1963); basal teeth of movable fingers reduced and of same size; ventral surfaces of finger and manus with setae. Pedipalps: femur pentacarinata; patella and chela with some carinae, moderately crenulate; internal face of patella with 9 to 10 spinoid granules in male, 5 to 6 in female; all faces weakly granular; fixed and movable fingers with 8-9 almost oblique rows of granules. Trichobothriotaxy; orthobothriotaxy A- $\alpha$  (alpha) (Vachon, 1974, 1975). Legs: tarsus with numerous fine median setae ventrally. Pedal spurs moderate, tibial spurs absent.





**Fig. 30-40.** *Tityobuthus mccarteri* sp. n., female paratype. 30. Carapace. 31. Sternum, genital operculum and pectines. 32-33. Chelicerae, dorsal and ventral aspects. 34-35. Metasomal segment V and telson, ventral and lateral aspects. 36-40. Trichobothrial pattern. 36-37. Chela, dorso-external and ventral aspects. 38-39. Patella, dorsal and external aspects. 40. Femur, dorsal aspect.

**DISTRIBUTION AND ECOLOGY.** All of the specimens referred herein to *Tityobuthus mccarteri* sp. n. were obtained in lowland forests of the Province of Toamasina along the eastern and northeastern flank of the island at elevations below 700 m. The habitat this species is known from was formerly extensive across the province, but in recent decades, associated with human disturbance, has been substantially reduced (Nelson & Horning, 1993). In contrast, *T. rakotondravonyi* has been collected in the karst limestone dry deciduous forests of the Ankarana Massif at the northern end of the island. These presumed sister taxa occur in very different biomes on Madagascar.

The lowland forests of the Province of Toamasina have been incompletely prospected for scorpions and the known local fauna remains only partially known. Only *Grosphus madagascariensis* (Gervais, 1843) has been documented from the eastern lowland forests of this province (Lourenço & Goodman, 2006a).

***Tityobuthus chelbergorum* sp. n. (Fig. 41-51)**

**MATERIAL.** Madagascar, Province de Fianarantsoa, Parc National d'Isalo, 8-9 km N Ranohira (22°28'59"S-45°27'38"E), 700-730 m, nearby "forêt gallerie", 8/IX/2004 (W. R. Lourenço), female holotype (MNHN).



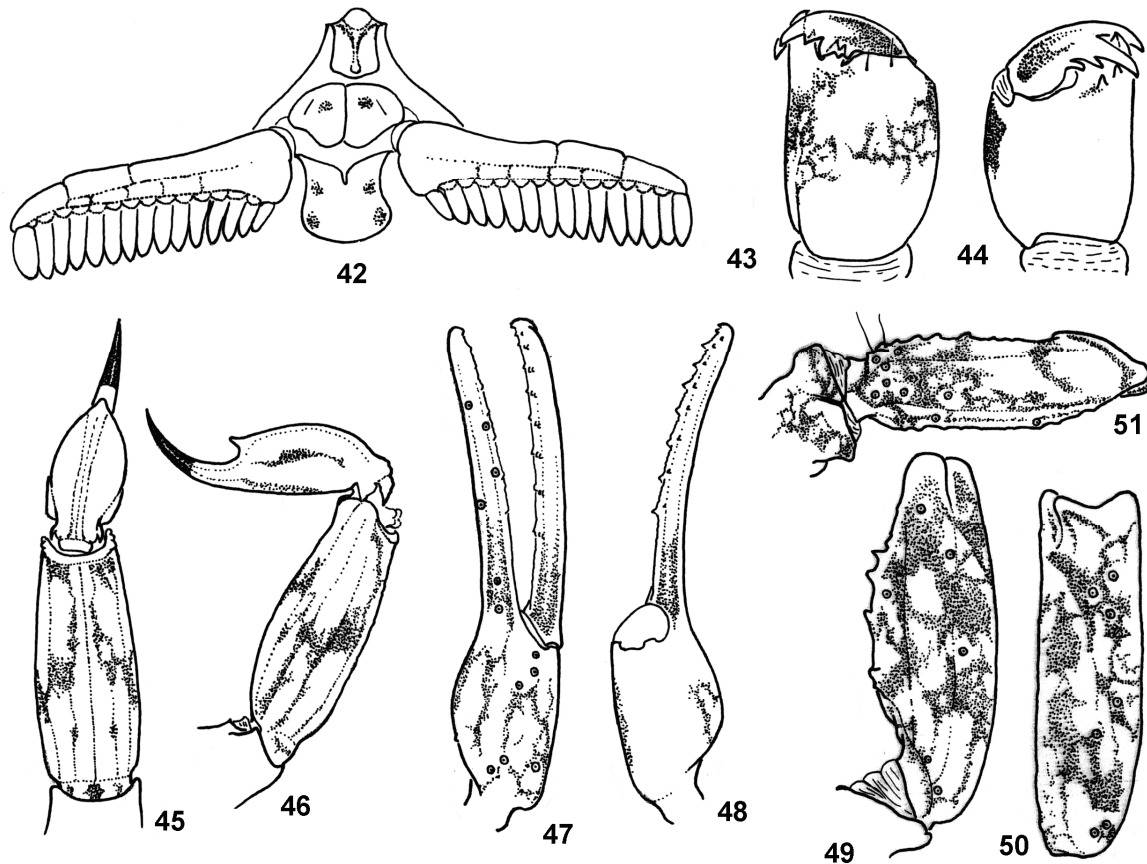


Fig. 42-51. *Tityobuthus chelbergorum* sp. n., female holotype. 42. Sternum, genital operculum and pectines. 43-44. Chelicerae, dorsal and ventral aspects. 45-46. Metasomal segment V and telson, ventral and lateral aspects. 47-51. Trichobothrial pattern. 47-48. Chela, dorso-external and ventral aspects. 49-50. Patella, dorsal and external aspects. 51. Femur, dorsal aspect.

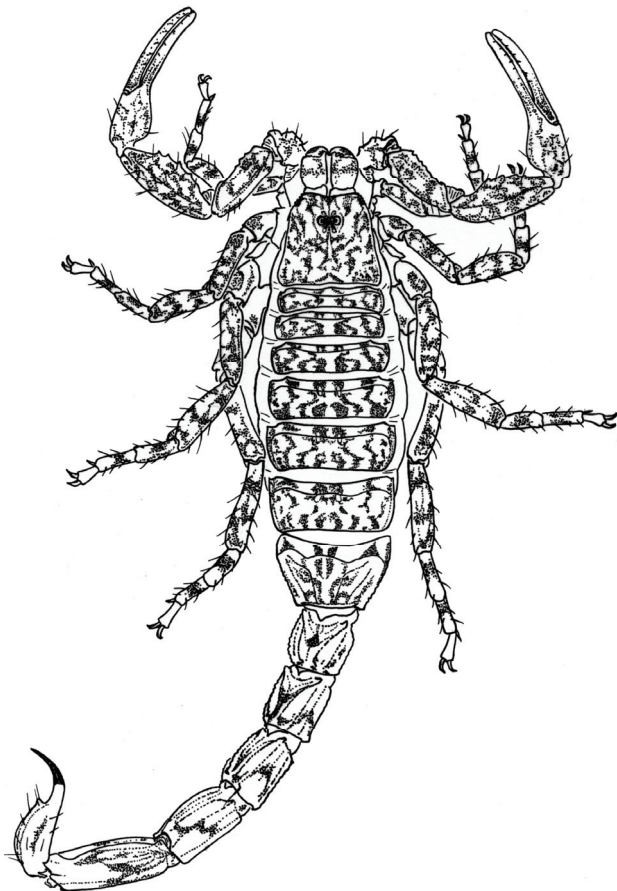


Fig. 41. *Tityobuthus chelbergorum* sp. n., female holotype. Habitus.

ETYMOLOGY: Patronym in honor of Bruce S. and Joyce E. Chelberg for all of their aid in field and educational programs on Madagascar and in the establishment of the Association Vahatra.

DIAGNOSIS: Scorpion of moderate to large size (with respect to the genus) and with 27.8 mm in total length. Carapace with a moderately pronounced concavity, forming a very weak angle. Cheliceral dentition with basal teeth of movable fingers very reduced and almost fused. Pectines with 15-15 teeth and the presence of fulcra. Sternites smooth, except for VII, which shows some granulations. Telson with a long but moderately curved aculeus; subaculear tooth moderate and rhomboid, without basal granules. Tibial spurs reduced on legs III and IV. Pedipalp fixed and movable fingers with 8-9 slightly oblique, almost straight rows of granules. Trichobothrial pattern of type A- $\alpha$  (alpha) - orthobothriotaxic.

RELATIONSHIPS: From general morphology *Tityobuthus chelbergorum* sp. n. seems to be associated with *T. petrae* Lourenço, 1996, described from the Forêt de Vohibasia, 50 km NE of Sakaraha and specimens of this taxon have been collected in the extreme south at the Réserve Spéciale de Cap Sainte Marie. Although these two species occur in southern Madagascar, in dry forest biomes, they can be readily distinguished by the following features: (i) a distinct

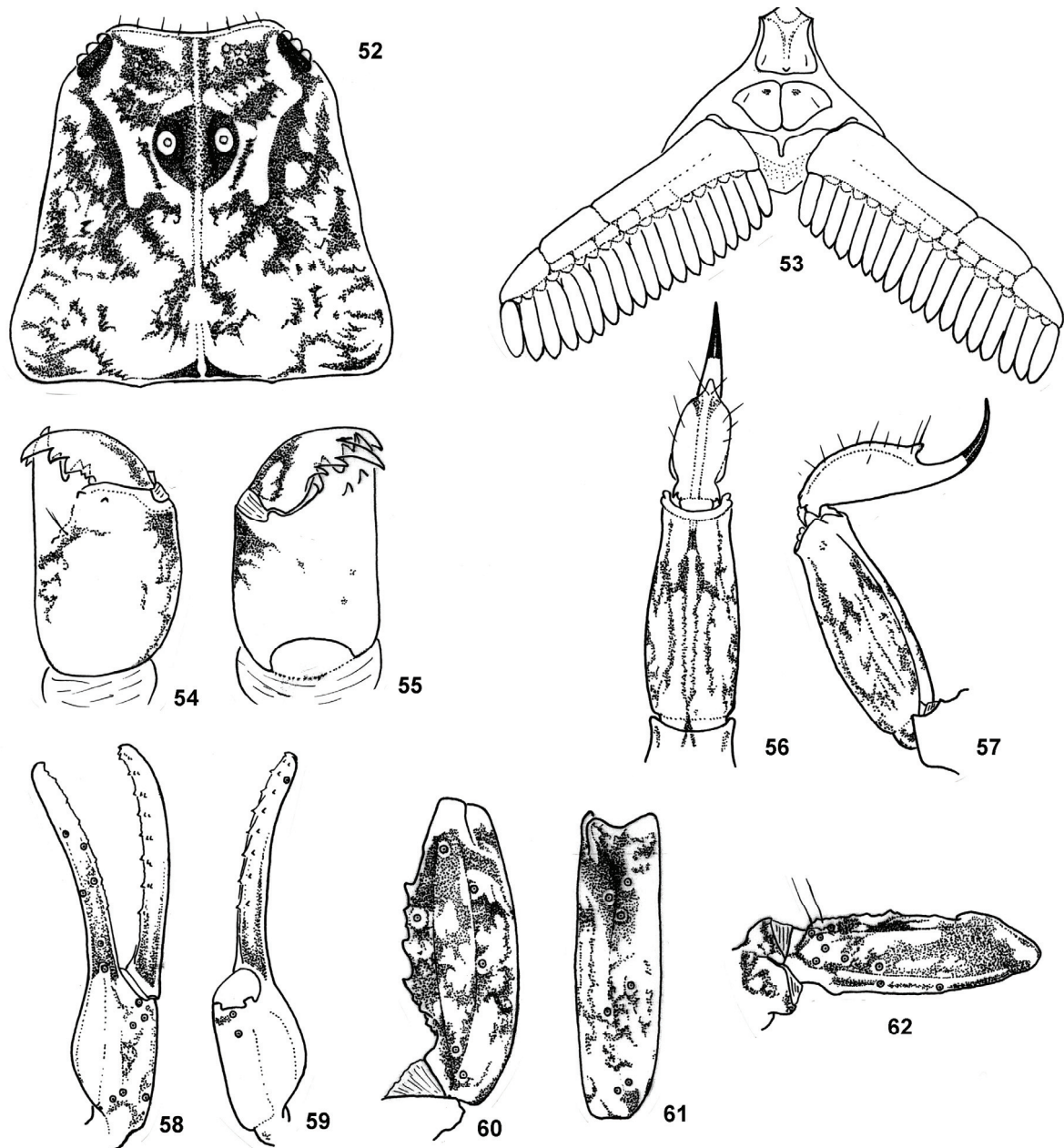


Fig. 52-62. *Tityobuthus petrae*, male from Ranohira (for comparison with *T. chelbergorum* sp. n.). 52. Carapace, 53. Sternum, genital operculum and pectines. 54-55. Chelicerae, dorsal and ventral aspects. 56-57. Metasomal segment V and telson, ventral and lateral aspects. 58-62. Trichobothrial pattern. 58-59. Chela, dorso-external and ventral aspects. 60-61. Patella, dorsal and external aspects. 62. Femur, dorsal aspect.

pigmentation pattern. *T. petrae* has dark spots covering the lateral margins of the chelicerae; in *T. chelbergorum* sp. n. dark spots envelop most of the central zone of chelicerae surface; (ii) female pectines of *T. chelbergorum* sp. n. have 15-15 teeth whereas those of *T. petrae* have 17 to 19 teeth. Since *T. petrae* shows also morphological affinities with *T. dastychi* Lourenço, 1996, described from the Parc National d'Ankarafantsika, and to better evaluate their different pigmentation patterns, both species are also illustrated in figures 52 to 73.

DESCRIPTION based on female holotype.

**Coloration.** Ground color yellowish, symmetrically marbled with a dark reddish brown, giving an overall spotted appearance. Prosoma: carapace yellowish, intensely spotted,

better marked 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 V yellowish; vesicle yellowish; all segments and telson with brownish spots. Venter yellowish, with all sternites heavily spotted. Chelicerae yellowish, with dark diffused spots on the central zone; fingers reddish-yellow, with blackish spots. Pedipalps: yellowish, with several dark spots on femur and patella; chela yellowish with some diffuse dark spots; fingers brown to blackish with darker zones on their base. Legs yellowish, with diffuse dark spots.

**Morphology.** Carapace moderately granular; anterior margin with a moderately pronounced median concavity, forming a weak angle. Anterior median superciliary, posterior



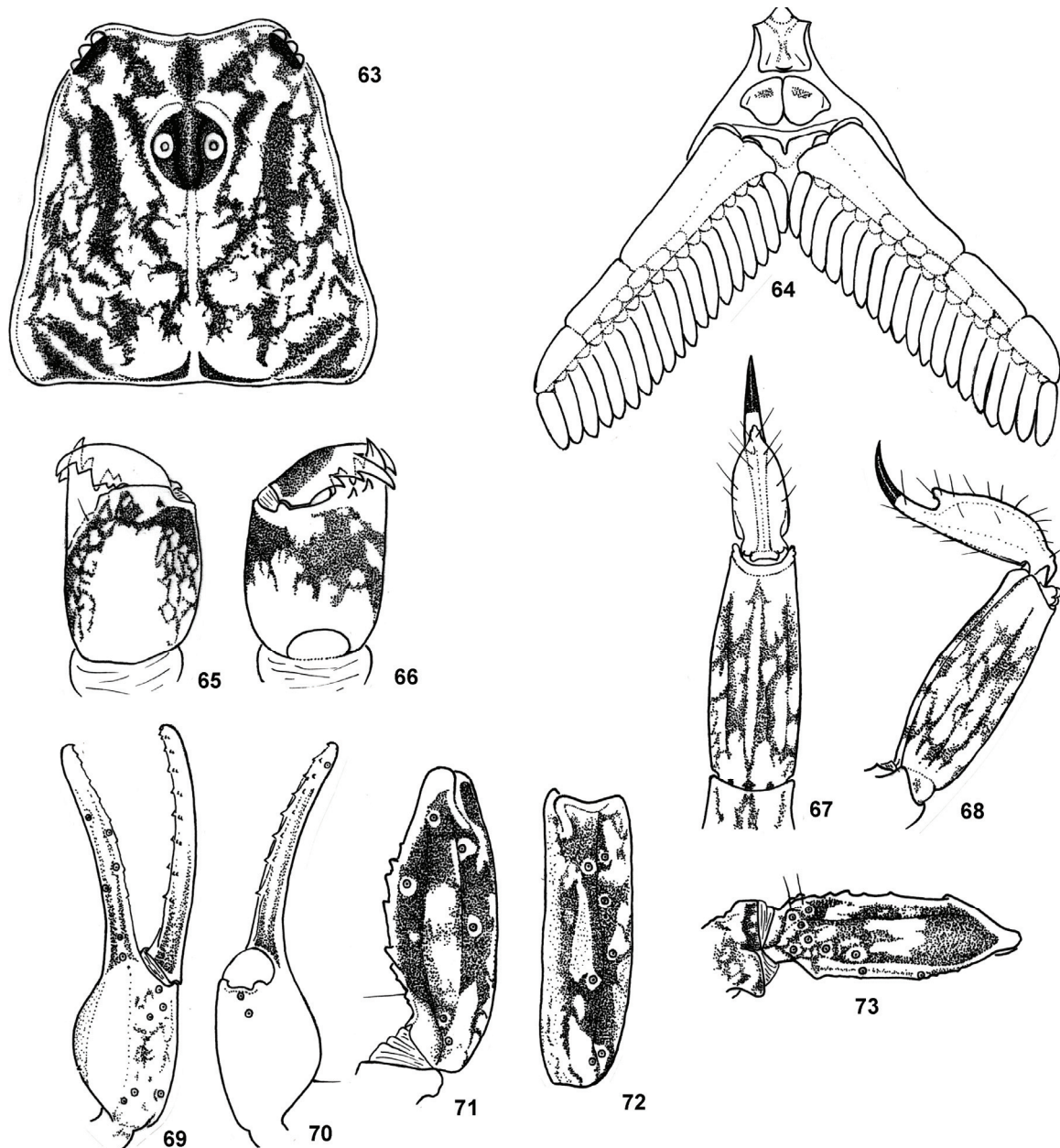


Fig. 63-73. *Tityobuthus dastychi*, male from Réserve Spéciale d'Ankarafantsika (for comparison with *T. chelbergorum* sp. n.). 63. Carapace, 64. Sternum, genital operculum and pectines. 65-66. Chelicerae, dorsal and ventral aspects. 67-68. Metasomal segment V and telson, ventral and lateral aspects. 69-70. Chela, dorso-external and ventral aspects. 71-72. Patella, dorsal and external aspects. 73. Femur, dorsal aspect.

median carinae weak to obsolete; furrows moderate to weak. Median ocular tubercle distinctly anterior to the center of the carapace; median eyes separated by about one ocular diameter. Three pairs of lateral eyes. Sternum subtriangular to subpentagonal. Mesosoma: tergites moderately granular. Median carina moderate to weak on all tergites; absence of other carinae. Tergite VII pentacarinat. Venter: genital operculum longitudinally divided, each half being semi-oval-shape. Pectines: pectinal tooth count 15-15; basal middle lamellae not dilated; fulcra present. Sternites smooth, excepted for VII, which shows some minute granulations; spiracles small and elongate. Metasoma: segments I to III with 10 carinae, crenulate. Segment IV with eight carinae, crenulate. Intercarinal spaces weakly granular. Segment V with five carinae, rounded and weakly granular. Telson smooth, without punctuations, with a long but mode-

rately curved aculeus; subaculear tooth moderate and rhomboid, without basal granules. Cheliceral dentition characteristic of the family Buthidae (Vachon, 1963); basal teeth of movable fingers very reduced and almost fused; ventral surfaces of finger and manus with setae. Pedipalps: femur pentacarinat; patella and chela with some carinae, moderately crenulate; internal face of patella with 4 to 5 spinoid granules; all faces weakly granular; fixed and movable fingers with 8-9 almost oblique rows of granules. Trichobothriotaxy; orthobothriotaxy A- $\alpha$  (alpha) (Vachon, 1974, 1975). Legs: tarsus with numerous fine median setae ventrally. Pedal spurs moderate and tibial spurs reduced on legs III and IV.

DISTRIBUTION AND ECOLOGY. *Tityobuthus chelbergorum* sp. n. is only known from the Isalo Massif, an extensive large



sandstone outcrop, the exposed portions of which have sparse vegetational cover and the deep canyons more mesic biotypes. The holotype is the only known specimen referable to this taxon. Other confirmed species for the sandstone regions of the Isalo formation are: *Grosphus grandidieri* Kraepelin, 1900, and *Opisthacanthus madagascariensis* Kraepelin, 1894 (Lourenço & Goodman, 2006b; Lourenço et al., 2007).

***Tityobuthus betschi* sp. n. (Fig. 74-84)**

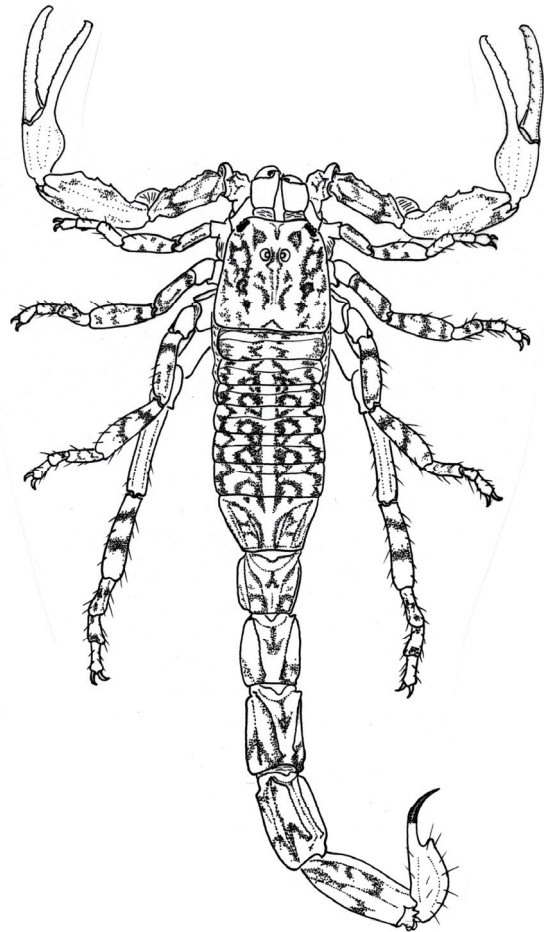
**MATERIAL.** Madagascar, Province de Toliara, Parc National d'Andohahela parcel 2, Forêt de Manantalinjo, 24°49'01"S-46°36'36"E (cf. Lourenço & Goodman, 2006c), 150-300 m, V/1972 (J.-M. Betsch); "extraction dans forêt sèche" (spiny bush forest), male holotype, 1 male, 1 female paratype (MNHN).

**ETYMOLOGY:** Patronym in honor of Prof. Jean-Marie Betsch, Muséum national d'Histoire naturelle, Paris, who collected the type material.

**DIAGNOSIS:** Scorpion of small size (with respect to the genus) and with 12-14 mm in total length. Carapace with a weakly pronounced concavity, forming a weak angle. Cheliceral dentition with basal teeth of movable fingers very reduced. Pectines with 17 to 19 teeth and the presence of fulcra. Sternites smooth. Telson with a long but moderately curved aculeus; subaculear tooth moderate and slightly spinoid without basal granules. Tibial spurs moderate. Pedipalp fixed and movable fingers with 8-9 slightly oblique, almost straight rows of granules. Trichobothrial pattern of type A- $\alpha$  (alpha) - orthobothriotic.

**RELATIONSHIPS:** From general morphology *Tityobuthus betschi* sp. n. appears to have affinities to *T. parrilloi* Lourenço, 1996, also distributed in the PN d'Andohahela, but found in the more easterly humid forest portion of the park (parcel 1). The new species can be readily distinguished from the latter species by the following features: (i) a distinct pigmentation pattern. *T. betschi* sp. n. has almost no dark spots covering the chelicerae, and only some minute spots are present at the base of fingers; the carapace and tergites are weakly spotted, and metasomal segments are yellowish with only very diffused spots. In *T. parrilloi* dark spots envelop internal and central zones of chelicerae surface; carapace, tergites and metasomal segments are heavily spotted; (ii) pectines of *T. betschi* sp. n. have 17 to 19 teeth whereas those of *T. parrilloi* have 12 to 14 teeth.

**DESCRIPTION** based on male holotype and female paratype. **Coloration.** Ground color pale yellow to yellowish, symmetrically marbled with reddish-brown, giving an overall spotted appearance, better marked in female. Prosoma: carapace yellowish, moderately to weakly spotted; 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: all segments pale yellow, with diffused spots. Vesicle yellowish. Venter yellowish, with spots on sternite VII. Chelicerae yellowish, with only minute spots on the anterior margin at the base of fingers; fingers reddish-yellow. Pedipalps: yellowish, with diffused spots on femur and patella; chela yellowish; fingers yellowish, with diffused brownish spots on female. Legs yellowish, with diffuse dark spots.



**Fig. 74.** *Tityobuthus betschi* sp. n., male holotype. Habitus.

**Morphology.** Carapace weakly granular; anterior margin with a weakly pronounced median concavity, forming a weak angle. Anterior median superciliary, posterior median carinae weak to obsolete; furrows weak. Median ocular tubercle distinctly anterior to the center of the carapace; median eyes separated by a little more than one ocular diameter. Three pairs of lateral eyes. Sternum subtriangular to subpentagonal. Mesosoma: tergites weakly granular. Median carina weak on all tergites; absence of other carinae. Tergite VII pentacarinata. Venter: genital operculum longitudinally divided, each half being semi-oval-shape. Pectines: pectinal tooth count 18-19 in male holotype, 17-17 in female paratype; basal middle lamellae not dilated; fulcra present. Sternites smooth with small, elongate spiracles; VII with vestigial carinae. Metasoma: segments I to III with 10 carinae, moderately crenulate. Segment IV with 8 carinae, moderately crenulate. Intercarinal spaces weakly granular. Segment V with five carinae, rounded and weakly granular. Telson smooth, without punctuations, with a long but moderately curved aculeus; subaculear tooth moderate and slightly spinoid without basal granules. Cheliceral dentition characteristic of the family Buthidae (Vachon, 1963); basal teeth of movable fingers reduced and of same size; ventral surfaces of finger and manus with setae. Pedipalps: femur pentacarinata; patella and chela with some carinae, moderately crenulate; internal face of patella with 3 to 4 spinoid granules; all faces weakly granular to smooth; fixed and

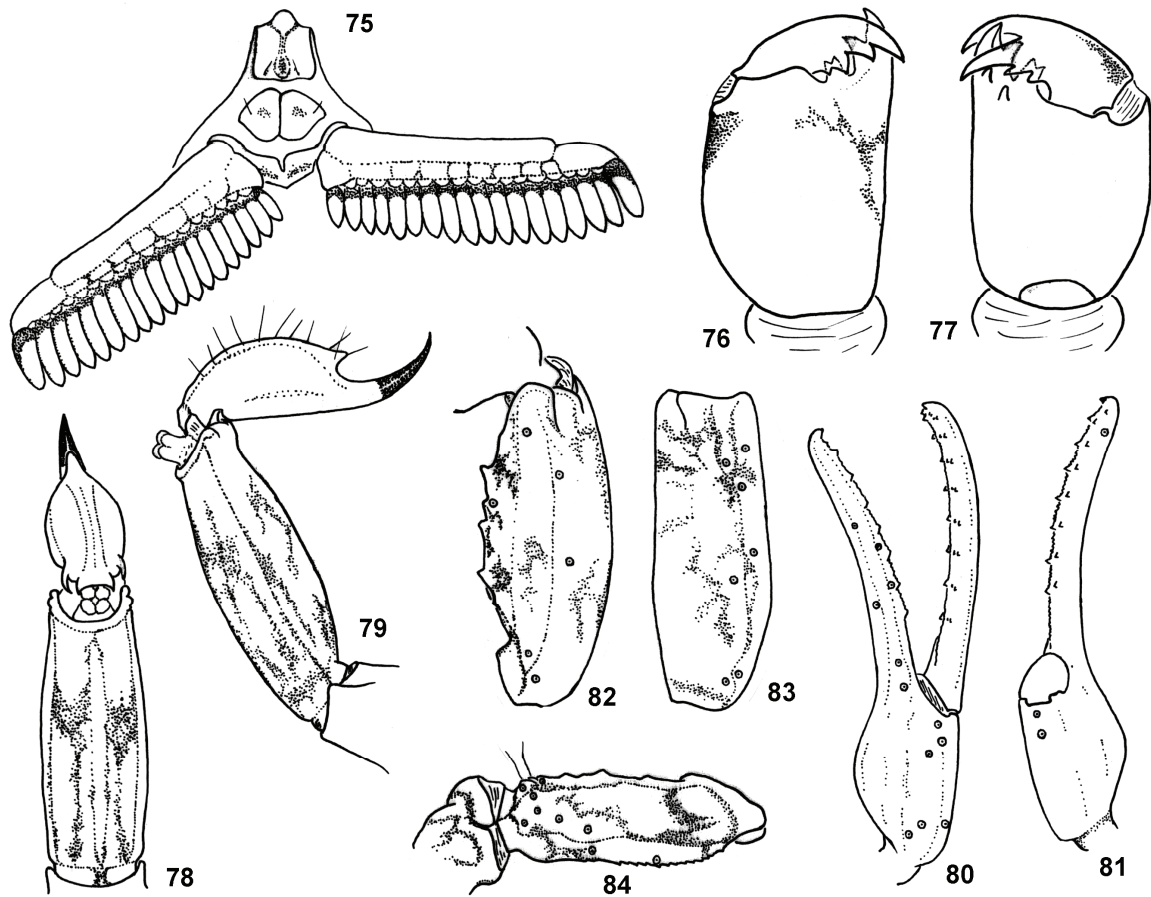


Fig. 75-84. *Tityobuthus betshi* sp. n., male holotype. 75. Sternum, genital operculum and pectines. 76-77. Chelicerae, dorsal and ventral aspects. 78-79. Metasomal segment V and telson, ventral and lateral aspects. 80-84. Trichobothrial pattern. 80-81. Chela, dorso-external and ventral aspects. 82-83. Patella, dorsal and external aspects. 84. Femur, dorsal aspect.

movable fingers with 8-9 almost oblique rows of granules. Trichobothriotaxy; orthobothriotaxy A- $\alpha$  (alpha) (Vachon, 1974, 1975). Legs: tarsus with numerous fine median setae ventrally. Pedal and tibial spurs moderate.

DISTRIBUTION AND ECOLOGY. *Tityobuthus betshi* sp. n. is only known from the spiny bush forest of parcel 2 of the PN d'Andohahela. This is a zone with very distinct vegetation, both structurally and floristically, as well as high levels of species endemism (Rakotomalaza & Messmer, 1999). In contrast, the reputed sister taxon, *T. parrilloi*, is known from the nearby humid forest of the park (parcel 1), which has a remarkably different flora (Rakotomalaza & Messmer, 1999) from the spiny forest habitat, particularly given that these localities are separated by about 20 km direct distance. Other confirmed species for the PN d'Andohahela are: Parcel 2 -- *Grosphus grandidieri*, *Opisthacanthus lucienneae* Lourenço & Goodman, 2006 (previously identified as *O. punctulatus* Pocock, 1896), and *Pseudouroplectes pidgeoni* Lourenço & Goodman, 1999. Parcel 1 -- *Heteroscorpion goodmani* Lourenço, 1996, *G. mandena* Lourenço, 2005 (previously identified as *G. madagascariensis*), *T. parrilloi*, and *O. piceus* Lourenço & Goodman, 2006 (Lourenço & Goodman, 1999b, 2006b).

#### Key to the species of *Tityobuthus*

Note: This key should be considered only as a preliminary approach to species identification. The reader should also refer to the original descriptions and to the ecological characteristics of the habitats of each species.

1. Pectines with fulcra vestigial or absent.....2  
– Pectines with well developed fulcra .....3
2. Fulcra vestigial .....*T. monodi*  
– Fulcra absent..... *T. guillaumeti*
3. Tibial spurs absent or very reduced .....4  
– Tibial spurs present.....5
4. Metasomal segments IV-V yellowish with only diffused spots.....*T. mccarteri* sp. n.  
– Metasomal segments IV-V almost blackish.....  
..... *T. rakotondravonyi*
5. Chelicerae without spots or pigmentation.....6  
– Chelicerae with dark spots and pigmentation .....7
6. Pedipalp chela globular; fingers short..... *T. judsoni*  
– Pedipalp chela slender; fingers elongated....*T. pallidus*

7. Pectines with 20 or more teeth.....8  
 – Pectines with less than 20 teeth ..... 10
8. A conspicuous smooth, white and bright central zone on sternite V ..... *T. manonae*  
 – No such zone on sternite V .....9
9. Body, pedipalps and legs heavily spotted; pedipalpal chela short and robust; internal face of patella with 4/5 spinoid granules ..... *T. baroni*  
 – Body, pedipalps and legs with only vestigial spots; pedipalpal chela long and slender; internal face of patella with 5 or 6 spinoid granules..... *T. pococki*
10. Pectines with 11 teeth ..... *T. ivohibe*  
 – Pectines with 12 to 19 teeth ..... 11
11. Pectines with 12 to 14 teeth ..... 12  
 – Pectines with 15 to 19 teeth ..... 13
12. A smooth and white central zone on sternite V and two small rounded smooth white zones laterally .....  
 ..... *T. griswoldi*  
 – Sternite V without any smooth white zone .....  
 ..... *T. parrilloi*
13. Sternite V with a reduced or conspicuous smooth white zone ..... 14  
 – Sternite V without any smooth white zone ..... 15
14. Sternite V centrally with a single conspicuous smooth white zone..... *T. dastychi*  
 – Sternite V with a reduced smooth white central zone associated with two small rounded smooth white zones laterally ..... *T. petrae*
15. Adults total length less than 20 mm..... *T. betschi* sp. n.  
 – Adults total length more than 20 mm..... 16
16. Adults total length ranging from 25 to 28 mm.....  
 ..... *T. chelbergorum* sp. n.  
 – Adults total length averaging 35 mm..... *T. darainensis*

### Acknowledgements

We are very grateful to Janet Beccaloni, The Natural History Museum, London, for the loan of the type specimens of *Tityobuthus baroni*. For field collections and making specimens available for this study, we acknowledge Vonjy Andrianjakarivelo, Jean-Marie Betsch, Brian Fisher, and Lily Rene de Roland. Laurence Dorr kindly made available some literature. Lucienne Wilmé kindly prepared figure 1.

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Vols. 1 (1993) a 36 (2005).

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