

## A NEW SPECIES OF SCORPION IN THE “CHARMUS” GROUP FROM INDIA (SCORPIONES: BUTHOIDEA)

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**Abstract:** A new species, *Thaicharmus lowei* sp. n., is described from India. This is the second described species of *Thaicharmus*, a genus previously known only from Thailand. The genus, a member of the “Charmus” group of the superfamily Buthoidea, is compared to other genera in its group. The taxonomic placement of the “Charmus” group is discussed in connection with the overall phylogeny of the superfamily Buthoidea.

**Key words:** Scorpiones, Buthoidea, *Thaicharmus lowei* sp. n., India.

**Una nueva especie de escorpión del grupo “Charmus”, de la India, (Scorpiones: Buthoidea)**

**Resumen:** Se describe una nueva especie de escorpión de la India, *Thaicharmus lowei* sp. n. Esta es la segunda especie descrita del género *Thaicharmus*, conocido previamente tan solo de Tailandia. Se compara el género, perteneciente al grupo “Charmus” de la superfamilia Buthoidea, con otros géneros del grupo. Se discute la posición taxonómica del grupo “Charmus” y sus relaciones filogenéticas dentro de la superfamilia Buthoidea.

**Palabras clave:** Scorpiones, Buthoidea, *Thaicharmus lowei* sp. n., India.

**Taxonomy/Taxonomía:** *Thaicharmus lowei* sp. n.

### Introduction

A new species of the genus *Thaicharmus* Kovařík, 1995 is described and compared to the only other species in this genus, *T. mahunkai* Kovařík, 1995. *Thaicharmus*, a member of the “Charmus” group of superfamily Buthoidea (Fet *et al.*, 2005), is compared to the other two genera assigned to this group, *Charmus* Karsch, 1879 and *Somalicharmus* Kovařík, 1998. New characters defining this group are described and the taxonomic placement of this group within superfamily Buthoidea is discussed, based on the original analysis presented in Fet *et al.* (2005). Biogeographical considerations are presented, further supporting the “Charmus” group.

The subject of sternum “shape” is revisited as it applies to *Thaicharmus* and related genera, showing again, as demonstrated in Soleglad & Fet (2003a), that depicting the sternum by “shape” is completely bogus leading to entirely superficial taxonomic relationships.

### Methods and Material

#### Terminology and conventions

The systematics adhered to in this paper is current and therefore follows the classification as established in Fet & Soleglad (2005) and buthoid group affiliation follows that suggested in Fet *et al.* (2005). Trichobothria terminology follows that established in Vachon (1974, 1975). Terminology describing pedipalp chelal carination and finger dentition follows that described and illustrated in Soleglad & Sissom (2001). The sternum terminology follows that in Soleglad & Fet (2003a). The metasomal and pedipalp carination, and leg tarsus armature terminology follows that described and illustrated in Soleglad & Fet (2003b).

#### Cladistic analysis software packages

Software package PAUP\* Version 4 (beta) (Swofford, 1998) was used for Maximum Parsimony (MP) analysis of morphology-based character codings. The cladogram from PAUP\* was generated by TreeView (Win 32) Version 1.5.2 (Page, 1998).

#### Systematics

Order **SCORPIONES** C. L. Koch, 1850

Suborder **Neoscorpiones** Thorell et Lindström, 1885

Infraorder **Orthosterni** Pocock, 1911

Parvorder **Buthida** Soleglad et Fet, 2003

Superfamily **Buthoidea** C.L. Koch, 1837

Family **Buthidae** C.L. Koch, 1837

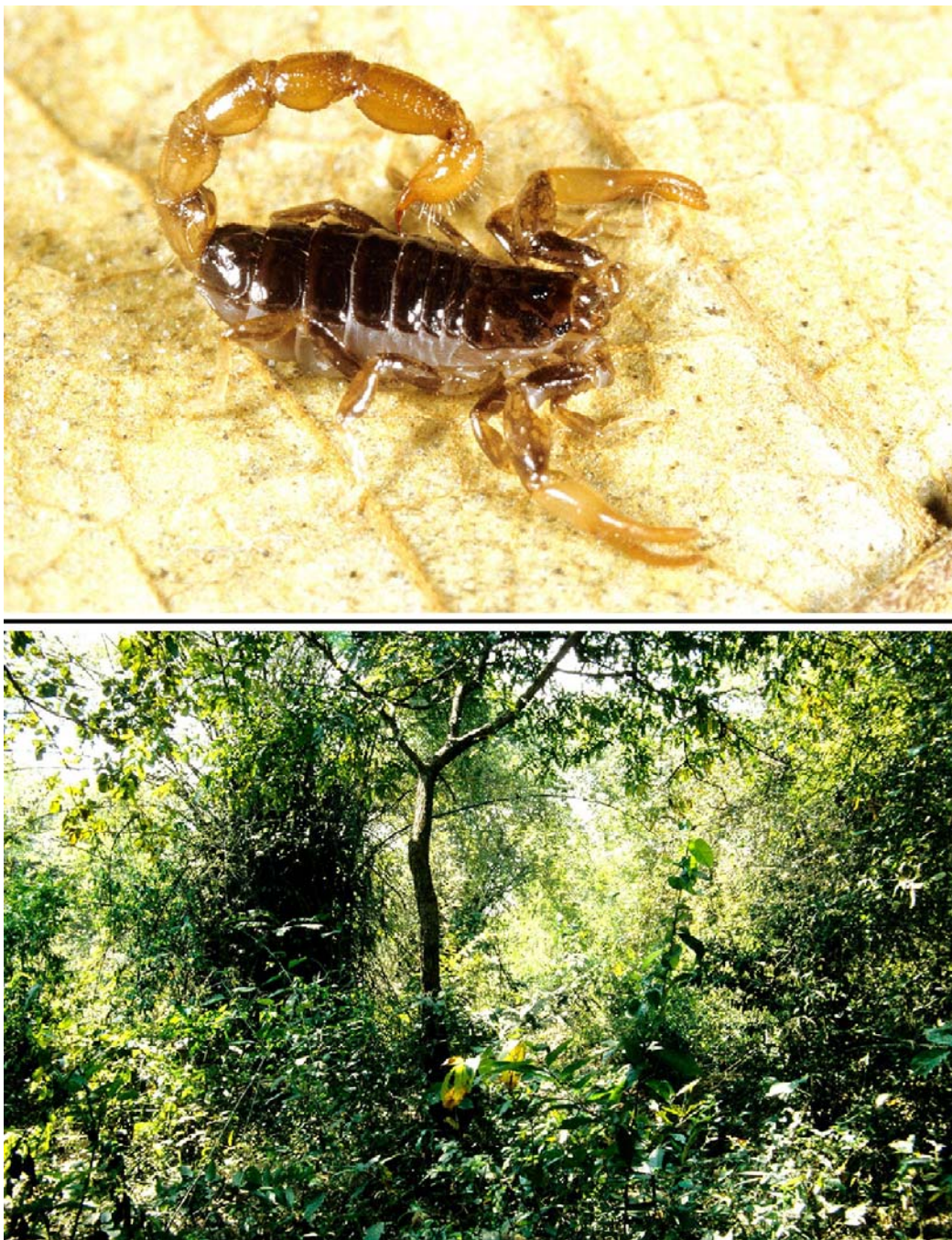
#### *Thaicharmus lowei* sp. nov.

Figs. 1–14; Table I.

**HOLOTYPE.** Female, Sanguem, Goa, India; semidry monsoon forest, under a rock, Feb 2005 (V. Fura & B. Velas). Deposited in the private collection of František Kovařík (Prague, Czech Republic).

**MALE** unknown.

**DIAGNOSIS.** Small scorpion with distinct dark variegated patterns on carapace, mesosoma, pedipalpal femur and patella, and trochanter, femur and patella of legs; metasoma with pale variegated patterns dorsally and ventrally on posterior aspect. Three lateral eyes; metasomal segment V lacking broad posterior process that partially overlaps telson; chelal movable finger with 11 denticle groups (inclu-



**Fig. 1.** *Thaicharmus lowei*, **sp. nov.**, female holotype (top) and collection locality, Sanguem, Goa, India (bottom). Photos by V. Fura.

ding basal group); chelal trichobothria *eb* and *esb* positioned at finger base. Pedipalp chelae not particularly slender, movable finger only 1.5 times as long as palm.

**DISTRIBUTION.** Known only from type locality.

**ETYMOLOGY.** Named after our colleague and friend Graeme Lowe, who has contributed to our knowledge of scorpions in many areas, in particular the systematics of family Buthidae.

**DESCRIPTION** based on holotype female, Figure 1.

**FEMALE.**

**Measurements** of holotype are presented in Table I.

**Coloration** (Figs. 1, 2, 5, 7, 11–13). Carapace and

mesosoma medium brown, with dark brown variegated patterns. Pedipalpal femur and patella light brown with medium to dark brown variegated patterns; chelae pale brown to yellow, lacking patterns. Cheliceral palm light brown with medium brown variegated patterns. Sternites light brown, essentially lacking patterns. Metasomal segment I pale brown with medium brown variegated pattern dorsally, other segments with subtle patterns or lacking altogether dorsally; dusky patterns occur on posterior aspects of segments II–V, extending ventromedially (Fig. 7). Telson light yellow-orange, lacking patterns, with subaculear tubercle and aculeus brown. Leg trochanters, femurs and patellae with medium brown variegated patterns.

**Carapace** (Fig. 2). Anterior edge exhibiting very broad

**Table 1: Measurements (in mm) of *Thaicharmus lowei* sp. nov.**  
Female holotype from Sanguem, Goa, India.

Characters	♀ Holotype
Total Length	15.80
Carapace Length	1.75
Mesosoma Length	5.60
Metasoma Length	6.45
Metasomal Segment I Length/Width	0.95/1.15
Metasomal Segment II Length/Width	1.10/1.05
Metasomal Segment III Length/Width	1.20/1.05
Metasomal Segment IV Length/Width	1.40/1.05
Metasomal Segment V Length/Width	1.80/1.05
Telson Length	2.00
Vesicle Length/Width/Depth	1.35/0.90/0.85
Pedipalp length	5.65
Femur Length/Width	1.30/0.55
Patella Length/Width	1.70/0.70
Chela Length	2.65
Palm Length/Width/Depth	1.10/0.65/0.65
Movable Finger Length	1.65
Leg II Coxa Length	0.80
Leg III Coxa Length	1.07
Leg IV Coxa Length	1.52
Sternum Length	0.55
Anterior/Posterior Width	0.40/0.55
Apex Lateral Side Length	0.28
Pectinal Basal Plate Length/Width	0.50/0.50
Pectinal Teeth	15/14

subtle indentation with a conspicuous epistome present medially. Surface somewhat lustrous with scattered minute granules occurring primarily on the variegated patterns. Lateral eyes, in straight line, numbering three, basal eye slightly larger than others. Median eye tubercle and eyes somewhat large, situated well anterior of middle with the following length and width formulas: 55|175 (anterior edge to medium tubercle middle|carapace length) and 38|142 (width of median tubercle including eyes|width of carapace at that point).

**Mesosoma** (Figs. 5 and 9). Tergites I–VII lustrous, essentially lacking granulation; tergite VII (Fig. 5) with two pairs of carinae, granulate on posterior half. Sternites smooth and lustrous, sternite V (VII?) lacking carinae. Stigmata (Fig. 9) are short and oval-like.

**Metasoma** (Fig. 7). Segments I–IV: dorsal carinae granulate on posterior half; dorsolateral carinae granulate on posterior third of segment I, posterior quarter of segments II–IV, with terminus on IV somewhat flared; lateral, ventrolateral and ventromedian carinae essentially obsolete. Segment V: dorsolateral carinae rounded and granulate; lateral, ventrolateral and ventromedian carinae essentially obsolete. Posteroventral aspect of all segments somewhat punctated and granulated in areas where variegated patterns occur, the most exaggerated on metasomal segment V (Fig. 7). Segments I–IV covered with minute short setae.

**Telson** (Fig. 13). Vesicle somewhat bulbous with a short and highly curved aculeus, the vesicle/aculeus juncture quite distinct. A short, non-granulated, but distinct subaculear tooth present on posterior aspect of vesicle. Vesicle surface covered ventrally and laterally with somewhat large granules and numerous minute setae.

**Pectines** (Fig. 6). Well developed sclerites, length|width

formula 330|150 (length taken at anterior lamellae|width at widest point including teeth). Sclerite arrangement somewhat complex with three anterior lamellae and irregular shaped middle lamellae, the largest located basally; fulcra present. Minute short setae extend from edge of anterior lamellae. Teeth, numbering 15/14, short basally, lengthening distally and then terminating with a shorter ovoid-shaped tooth. Basal piece composed of a single sclerite, large and square, almost as long as sternum, with wide deep V-shaped indentation along anterior edge.

**Genital Operculum**. Sclerites oval in shape vertically, showing slight separation at both anterior and posterior junctures.

**Sternum** (Fig. 8). Type 1, exhibiting minimal horizontal compression; concave region slightly larger than the posterior depression; outer ridge wide and only occurring on posterior edge; conspicuous apical “button” present. Sternum posteriorly as wide as long, apex lateral edge relatively long, approximately one half the sternum length.

**Chelicerae**. Movable finger dorsal edge with one large subdistal (*sd*) denticle; subbasal (*sb*) denticles quite small and close together; ventral edge with two ventral accessory (*va*) denticles. Ventral distal denticle (*vd*) approximately same length as dorsal (*dd*) counterpart. Ventral surface of fixed finger base with two pigmented *va* denticles.

**Pedipalps** (Figs. 3, 10–12). Somewhat small appendages, chelal movable finger shorter than carapace and metasomal segment V, and 1.5 times as long as palm; conspicuous pale non-pigmented chela is in strong contrast to femur and patella with dark variegated patterns. **Femur** (Fig. 11): Dorso-internal carina granulated, ventrointernal carinae serrate, other carina essentially obsolete. Surfaces smooth except for internal, which exhibits six scattered serrated granules.

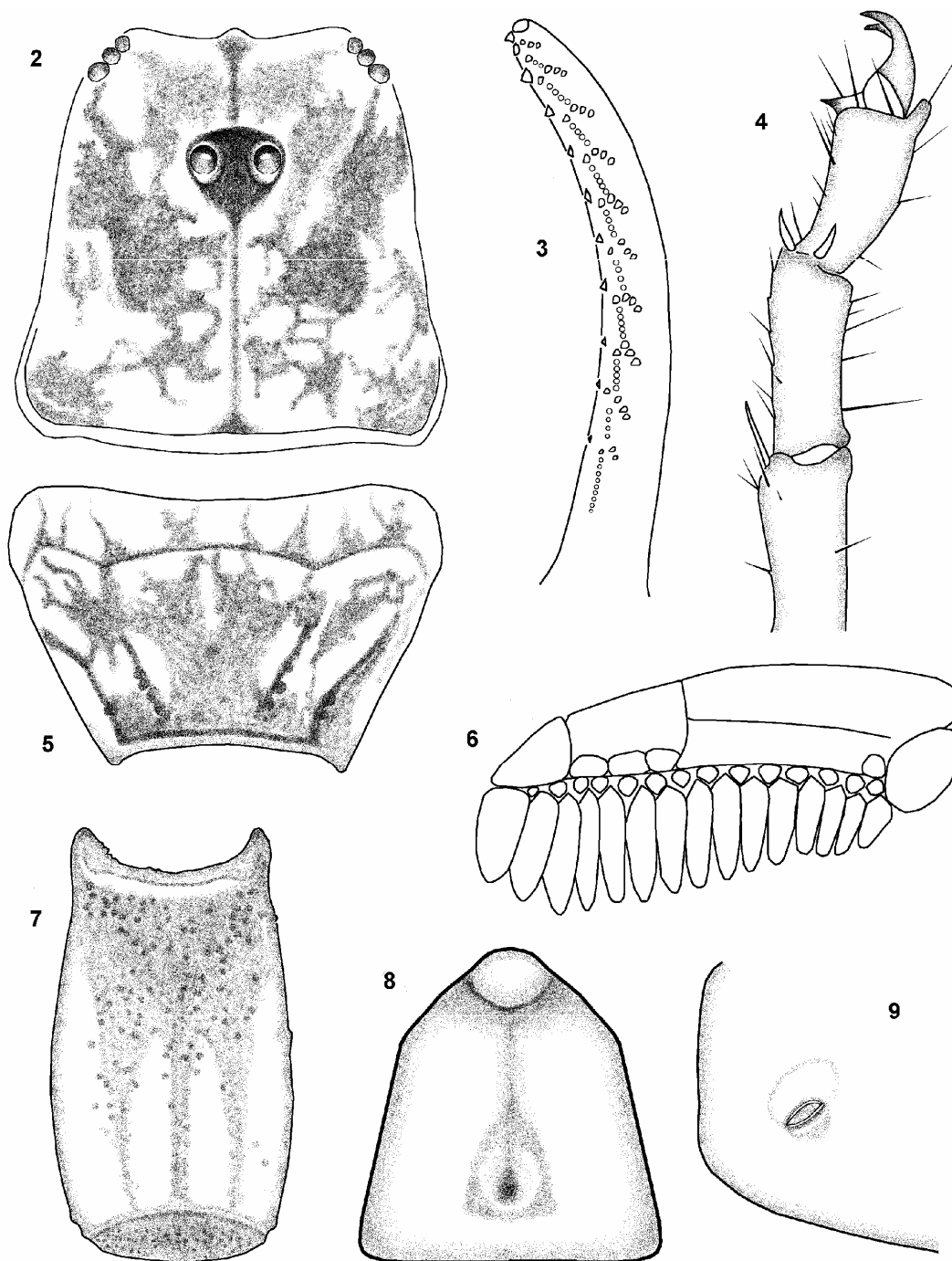
**Patella** (Fig. 12): All carinae are smooth to obsolete except for well developed Dorsal Patellar Spur (*DPS<sub>c</sub>*) carina, exhibiting six serrated granules, and the Ventral Patellar Spur (*VPS<sub>c</sub>*) carina with five serrated granules. All surfaces smooth. **Chelal carinae**: All carinae are essentially weak to obsolete except for the dorsomarginal (*D4*) carina which is rounded with scattered granulation. **Chelal finger dentition** (Fig. 3): median denticle (*MD*) row groups aligned obliquely and imbricated, numbering eleven for both fixed and movable fingers, including apical and basal groups. Both fingers with eleven inner (*ID*) denticles.

**Trichobothrial patterns** (Figs. 10–12): Type A, orthobothriotaxic, femur with *alpha* pattern with trichobothrium *d<sub>2</sub>* located on dorsal surface (i.e., characteristic of “Charmus” group). Femur: trichobothrium *e<sub>1</sub>* proximal to *d<sub>5</sub>*. Patella: *d<sub>3</sub>* trichobothrium positioned on ventral half of segment, presumably external to obsolete *DM<sub>c</sub>* carina; external trichobothrium *em* aligned horizontally between *est* and *et* in a straight line angling distally towards ventral edge. Chela: trichobothria *eb* and *est* positioned basally on fixed finger; trichobothria *Eb<sub>1</sub>–Eb<sub>2</sub>–Eb<sub>3</sub>* juncture angles distally forming an upside down V-shape.

**Legs** (Fig. 4). Both pedal spurs present, tibial spur present on legs III–IV. Tarsus with scattered setae on ventral surface. Coxae not elongated, exhibiting length ratios of 80|107|152 for legs II, III and IV, respectively.

**COMPARISON TO OTHER SPECIES IN GENUS**. Besides being members of the “Charmus” group in Buthoidea (see discussion below), *Thaicharmus lowei* and *T. mahunkai* Kovařík,



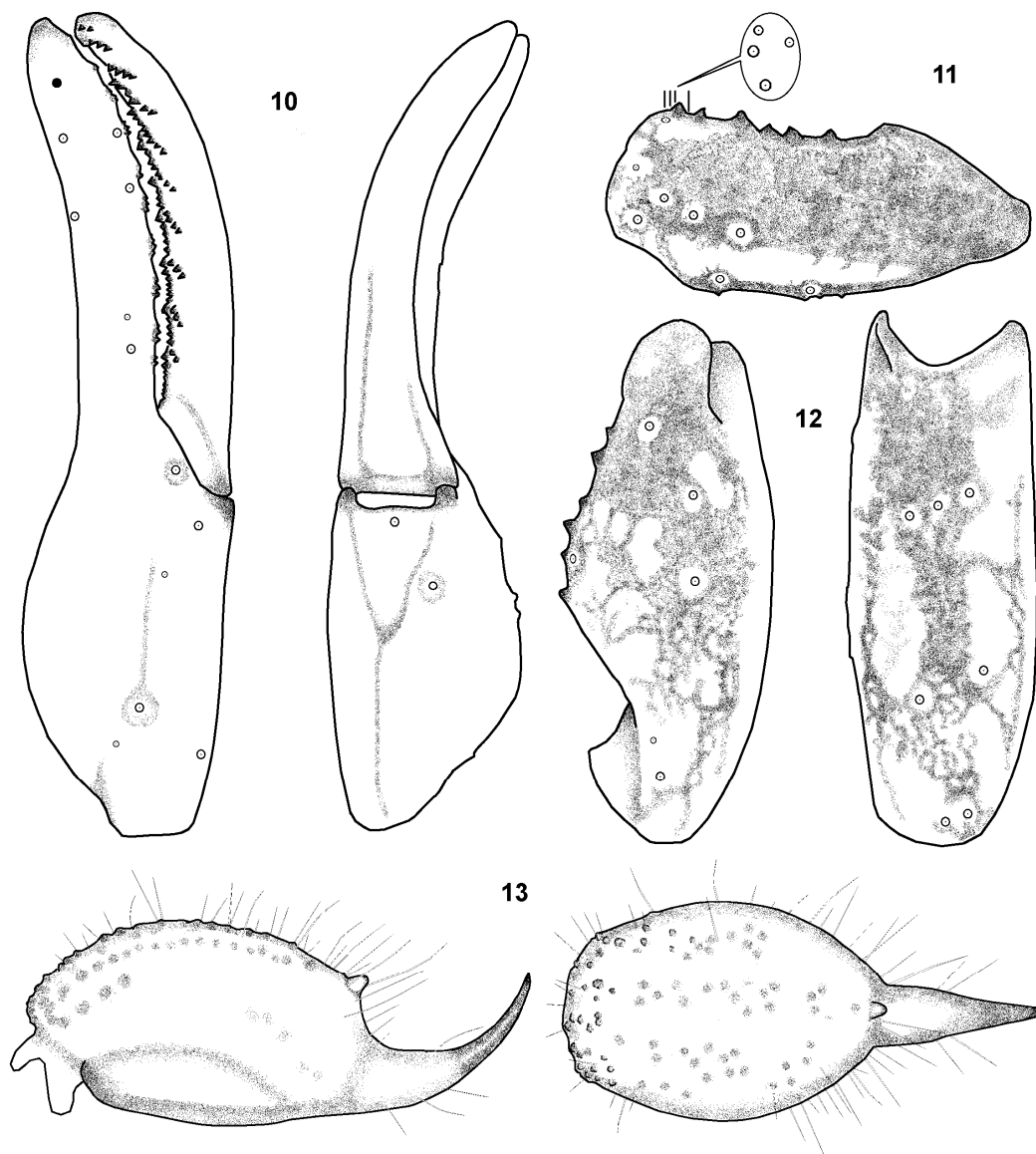


**Fig. 2-9.** *Thaicharmus lowei* Kovařík, Soleglad & Fet, **sp. nov.**, holotype. **2.** Carapace, showing epistome. **3.** Chelal movable finger showing dentition. **4.** Leg IV showing pedal spurs and tibial spur. **5.** Tergite VII showing carinae. **6.** Right pecten. **7.** Metasomal segment V, ventral view. **8.** Sternum, showing reduced posterior depression and apical "button". **9.** Sternite III (partial) showing right stigma.

1995, share the following important characters: Both species exhibit an epistome on the carapace anterior edge and both have a somewhat robust globular telson equipped with a small but distinct subaculear tubercle. Their pedipalp patellar trichobothria *est*, *em*, and *et* are aligned in a straight line angled distally towards the ventral edge; femoral trichobothrium *e<sub>l</sub>* is positioned proximal to *d<sub>5</sub>*. Their sternum is roughly as wide as long exhibiting minor horizontal compression (Sternum<sub>I</sub>/Sternum<sub>PW</sub>: *T. lowei* = 1.000, *T. mahunkai* = 1.029); and leg coxae III–IV are short, not elongated as typically exhibited in the Buthoidea (Coxa

III<sub>L</sub>/Coxa II<sub>L</sub> and Coxa IV<sub>L</sub>/Coxa II<sub>L</sub>: *T. lowei* = 1.338 and 1.900, *T. mahunkai* = 1.308 and 2.000). See Soleglad & Fet (2003a: table 2) for a comparison with 30 other buthoid genera. The pectines are constructed similarly with enlarged basal middle lamellae, and both exhibit fulcra.

*T. lowei* is a smaller species than *T. mahunkai* (16 mm in length for the former species, 29 mm for the latter) with more distinct variegated patterns and less punctations on the metasomal surface. *T. lowei* is equipped with three lateral eyes whereas *T. mahunkai* exhibits four; *T. lowei* lacks the distally expanded metasomal segment V found in *T. ma-*



**Fig. 10-13.** *Thaicharmus lowei* Kovařík, Soleglad & Fet, **sp. nov.**, holotype. **10-12.** Pedipalp trichobothrial pattern. **10.** Chela, external and ventral views; closed circle on chelal fixed finger external view designates internal trichobothrium *i*. **11.** Femur, dorsal view; circled area shows internal trichobothria of femur from an internal perspective. **12.** Patella, dorsal and external views. **13.** Telson, lateral and ventral views, showing subaculear tooth.

*hunkai*; and the pedipalp chela in *T. lowei* are not as elongate as in *T. mahunkai*, the movable finger only 1.5 times longer than the palm, whereas in *T. mahunkai*, it is over 2 times longer. Presumably due to the shorter fingers in *T. lowei*, trichobothria *eb* and *est* are positioned near the finger base, not midfinger as seen in *T. mahunkai*.

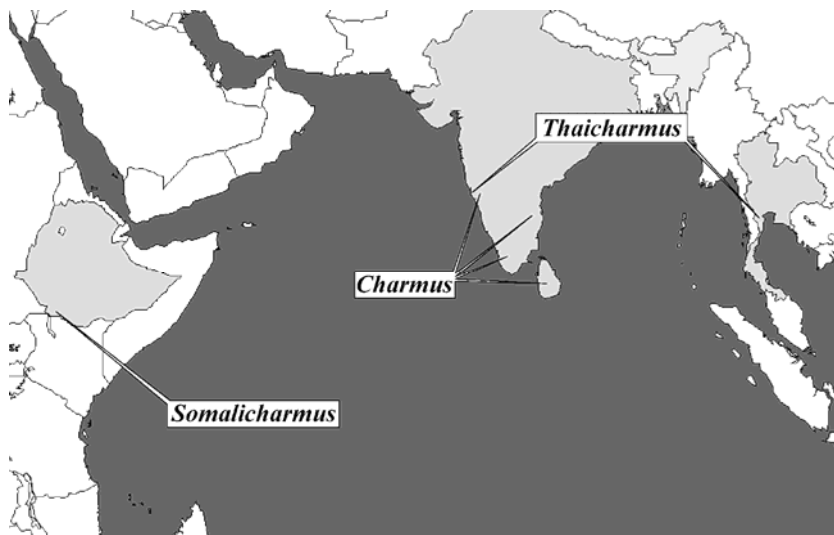
Due to the structural differences such as the number of lateral eyes, the structure of metasomal segment V, and the elongated chelal fingers with different locations for trichobothria *eb* and *esb*, as well as their somewhat disjoint geographical locations, the two species of *Thaicharmus* may represent two distinct genera. But, since each is only represented by a single species, it is best to wait until additional material is collected from both India and Thailand. If further species are isolated that preserve the differences stated above, then at that time the breakup into two genera would be prudent.

### Discussion: the “Charmus” Group of Buthoidea

The “Charmus” group of Buthidae was suggested by Fet *et al.* (2005) based on the analysis of a small but important set of characters, primarily composed of pedipalp femur and patellar trichobothria. Members of this group can be defined as follows: patellar trichobothrium *d*<sub>3</sub> is positioned external to the dorsomedian (*DM*<sub>c</sub>) carina; femoral trichobothria *d*<sub>1</sub>, *d*<sub>3</sub>, and *d*<sub>4</sub> comply with the *alpha* pattern (Vachon, 1975), and *d*<sub>2</sub> is located on the *dorsal* surface of the segment. To complete this definition, in the context of Fet *et al.* (2005), members of the “Charmus” group also exhibit tibial spurs on legs III–IV.

### Genera distinction

Presently three genera comprise the “Charmus” group: *Charmus* and *Thaicharmus* from Asia, and *Somalicharmus* from Africa (see map in Figure 14). [Note: The type locality of *Somalicharmus whitmanae* Kovařík, 1998 (El Meti) has



**Fig. 14.** Distribution of “Charmus” group of superfamily Buthoidea. General distribution of genus *Charmus* based on Lourenço (2002: fig. 15, in part). Countries Ethiopia, India, Sri Lanka and Thailand are shaded.

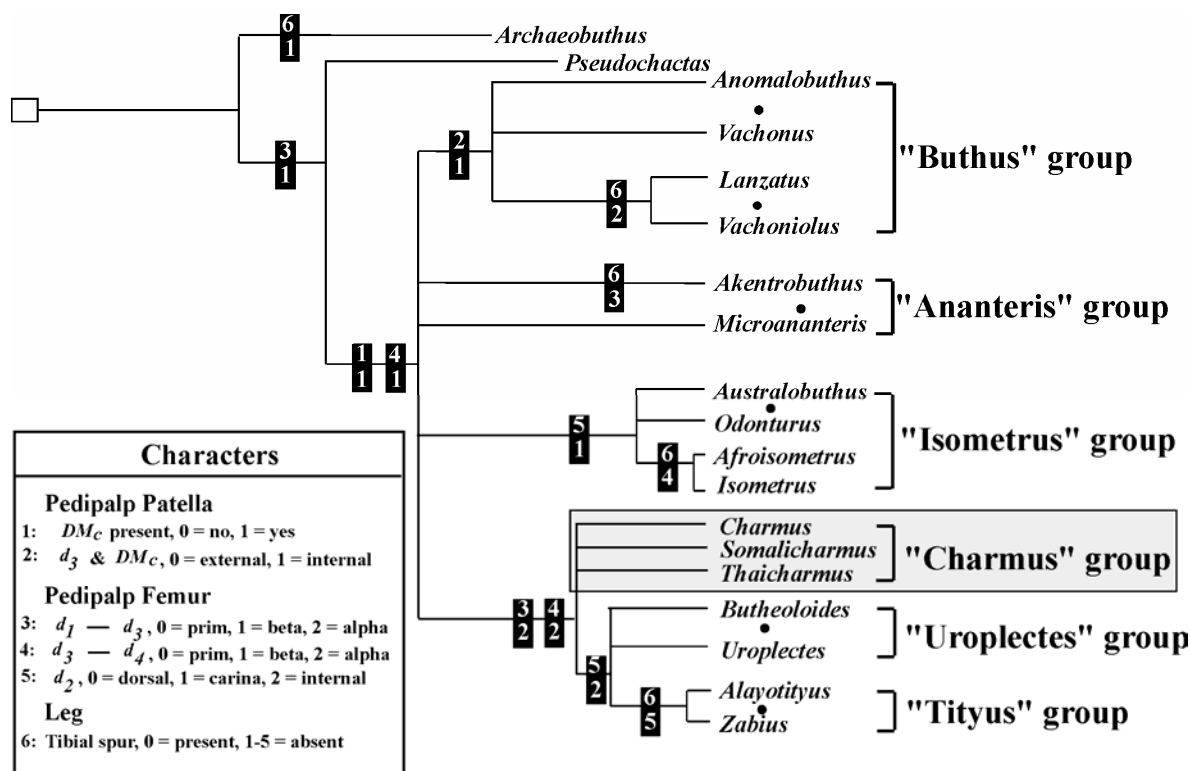
been confirmed to be in Ethiopia (Kovářík & Whitman, 2005: 112) rather than Somalia (Kovářík, 1998). This specimen was collected by the Missione Biologica Sagan-Omo led by Edoardo Zavattari, which in 1939 explored the Borana region from Dolo westwards to Lake Stephanie and the Omo River (Largen, 2001). According to Largen (2001), El Meti is located at 04°58'N 37°08'E, at an altitude of 1500 m.]

All three genera comply to the characters stated above, as well as with other characters listed here. We will first list additional characters shared by these three genera, and will then contrast them with their specific differences. These three genera share a somewhat wide sternum which exhibits minimal horizontal compression, the posterior depression and concave region are minimal and a distinct apical “button” is present (see Fig. 7 for an example of this sternum; also see Kovářík, 1995: fig. 13; Tikader & Bastawade, 1983: figs. 387, 405; Sreenivasa-Reddy, 1966: fig. 10). Lourenço (2002: fig. 4) reports in his description of *Charmus minor* “... Sternum pentagonal, but strongly flattened; three times wider than long ...” Clearly this species has a very wide sternum but in Lourenço’s fig. 4, leg coxa II hangs over the sternum apex and the genital operculum covers a portion of the posterior edge (note, the outer ridge is not visible), so this sternum is definitely a little longer than depicted, but still quite wide. The sterna in *Thaicharmus* and *Somalicharmus* are approximately as wide as long,  $\text{Sternum}_L/\text{Sternum}_{PW} = 0.933\text{--}1.029$ . These genera exhibit some of the least horizontal compression attributes for leg coxae as discussed in Soleglad & Fet (2003a: table 2), where *Thaicharmus* and *Somalicharmus* (leg coxae data for *Charmus* is not available) comprise the shortest leg coxae III and IV of the 32 buthoid genera so far studied:  $\text{Coxa III}_L/\text{Coxa II}_L = 1.231\text{--}1.330$  and  $\text{Coxa IV}_L/\text{Coxa II}_L = 1.900\text{--}2.000$ . The femoral trichobothrium  $e_1$  is placed somewhat basal in these three genera, proximal to trichobothrium  $d_5$ . Since these three diverse genera occur in distinct disjunct geographic locations (i.e., India and Sri Lanka, Thailand, and Ethiopia; see Fet & Lowe, 2000; Lourenço, 2000, 2002; Kovářík & Whitman, 2005), we consider these sternum and leg coxae attributes as well as the femoral trichobothria locations, as potential synapomorphies for the “Charmus” group of Buthidae (see cladistic discussion below).

The three “Charmus” group genera can be separated by the following characters. Genus *Charmus* does not have a subaculear tooth on the telson, whereas *Thaicharmus* and *Somalicharmus* exhibit a small but distinct subaculear tooth. Patellar trichobothria *em*, *est*, and *et* are aligned in a straight line in genus *Thaicharmus* (*em* distal to *est*) whereas in *Charmus* and *Somalicharmus*, the *est*–*em*–*et* juncture angles basally on the segment (in particular, it is quite exaggerated in *Somalicharmus*, *em* located almost midsegment, closer to *esb*<sub>1</sub>–*esb*<sub>2</sub>). *Somalicharmus* can be separated from *Charmus* and *Thaicharmus* by several unusual trichobothrial subpatterns and positions: chelal trichobothria *Eb*<sub>1</sub>–*Eb*<sub>2</sub>–*Eb*<sub>3</sub> juncture angles basally, not distally as in the other two genera; *d*<sub>1</sub>–*d*<sub>2</sub> and *eb*–*et* are located on the basal half of the fixed finger, whereas in the other genera, *db*–*dt* and sometimes *eb*–*et*, are positioned on the distal half of the finger; and chelal trichobothrium *i* is positioned midfinger in *Somalicharmus* (unusual in buthoids) whereas in the other genera, it is placed on the distal aspect of fixed finger’s inner edge.

### The “pentagonal” sternum

The genus *Charmus* has been a controversial taxon ever since Birula (1917: 160–163) considered it a member of family Vaejovidae, based *solely* on the “shape” of the sternum. Sreenivasa-Reddy (1970) perpetuated this theme of the sternum shape further, in his argument that *Charmus* was indeed a buthid, by showing that *Charmus* exhibited other buthoid characters, in contrast to Vaejovidae, therefore implicitly agreeing that *Charmus* and Vaejovidae exhibited the same sternum structure. He even hypothesized a “stress” force that explained the transformation from a “pentagonal” sternum to a “triangular” sternum, thus attempting to minimize their difference. Interestingly, this same theory was independently discussed in detail in Soleglad & Fet (2003a) in their reevaluation of the sternum in scorpions where they used the term “horizontal compression”. Of course, Soleglad & Fet (2003a) considered only Type 1 sterna for this hypothesis, having shown that the sternum in family Vaejovidae (and all other Recent scorpion families in parvorder Iurida, termed a type 2 sternum) has an entirely different structure than that found in the Buthoidea, Pseudochactidae, and Chaerilidae. Namely, it is *not* pentagonal, but instead is formed as a concaved hexagon (= six sides), the



**Fig. 15.** Cladogram (after Fet *et al.*, 2005: fig. 25, in part) showing upper-level phylogeny of superfamily Buthoidea with characters distributed. Polarity of character-2 is *external* (= 0) and character-5 is represented with three states, dorsal, internal or on carina, and internal. “Charmus” group is contained in gray rectangle. Character number depicted on top and character state on bottom.

posterior edge bifurcated into two edges. See Soleglad & Fet (2003a: fig. 2) for a detailed description of these two distinct sternum types.

Germane to the genera discussed in this paper is the “sternum shape” used in the key to Buthidae genera presented in Sissom (1990: 93–100). We see that genus *Charmus* (along with *Karasbergia* Hewitt, 1913 and *Butheoloides* Hirst, 1925) is separated from genus *Buthoscorpio* Werner, 1936 (= *Pocockius* Francke, 1985 in Sissom, 1990) by its “subpentagonal” sternum in contrast to a “subtriangular” sternum in *Buthoscorpio*. This is interesting indeed since Vachon (1961) states for *Stenochirus* (= *Buthoscorpio*) *politus*: “... Sternum court, pentagonal (resseinblant a celui d’un Scorpionidae) ...” The sterna are quite similar in these two genera, the sternum in *Buthoscorpio* is slightly longer than wide thus termed “subtriangular” by some and “subpentagonal” by others. Of course, to be truly “triangular” the two apex lateral sides would have to be absent, a condition *not* found in any known buthid. To further emphasize this point, as discussed in Soleglad & Fet (2003a), a new vaejovid genus *Physoctonus* Mello-Leitão, 1934 was named from a single specimen, based on its “pentagonal” sternum. As it turned out, this scorpion was a small buthid species (23 mm in length) of *Rhopalurus* whose sternum is less compressed due to its small size (Francke, 1977: 128, fig. 13).

### Buthoidea “Charmus group”: Phylogenetic Considerations

The present classification of Buthoidea is unclear (Soleglad & Fet, 2003b; Fet *et al.*, 2005); no subfamilies or tribes of Buthidae are defined, and, in addition, relationship of Microcharmidae and Buthidae is not resolved. Fet *et al.* (2005) based their definition of six buthoid groups of genera primarily on the position of patellar trichobothrium  $d_3$  with respect to the  $DM_c$  carina (external or internal to) and the *alpha/beta* disposition of the dorsal femoral trichobothria  $d_1$ – $d_5$ . They performed a complete cladistic analysis of these six characters (which also included the presence/absence of the leg tibial spur) sequencing through all possible polarities of the  $d_3/DM_c$  character, using the relic genus *Pseudochactas* Gromov, 1998 to test its polarity (see Fet *et al.* 2005: 19–26, figs. 23–25, for a detailed description of this process). Since the Fet *et al.* (2005) paper, additional data has become available on the  $d_3/DM_c$  character with the recent reanalysis of the fossil scorpion *Archaeobuthus estephani* Lourenço, 2001 (Baptista *et al.* 2006: figs. 4, 18, 19). In particular, a *complete* reevaluation of trichobothria patterns of *Archaeobuthus* was conducted and it was established, that, (a) the  $DM_c$  carina is absent in this genus, (b) patellar trichobothrium  $d_3$  is positioned extremely external to the segment midpoint. Based on this, and the somewhat external position of  $d_3$  in genus *Pseudochactas*, it was suggested by these authors as well as adopted in this paper, that the primitive state for the  $d_3/DM_c$  character is an *external* posi-

tion. Consequently, from the four topologies based on the polarity of this character as exercised in Fet *et al.* (2005), we now obtain the topology depicted in Figure 15.

As recommended in Fet *et al.* (2005: 24, fig. 2) in their discussion of homoplasy, we adopt the splitting of the character representing the position of femoral trichobothrium  $d_2$  into three states: (1) dorsal, the primitive state; (2) located either on the internal surface or on the dorso-internal carina, the “Isometrus” group; and (3) is always located on the internal surface, the “Uroplectes” and “Tityus” groups. Therefore, the “Charmus” group in this topology, based on this minimal character set, is undefined (i.e., it has no synapomorphies). However, as discussed above, additional characters are being evaluated for this small buthoid group. It is clear that the group is further defined by their somewhat primitive sternum, lacking significant horizontal compression, and the short non-elongated leg coxae III and IV. We suggest here that these characters, and probably others, will prove to be synapomorphic for this small buthoid group. Of course these characters must be analyzed for the other buthoids as well before this can be established.

The topology represented in Fig. 15 is quite interesting for several reasons. Now that we have hypothesized the primitive state for the  $d_3/DM_c$  character, we see that the “Buthus” group of genera is defined with a synapomorphy,  $d_3$  positioned internal to the  $DM_c$  carina. The “Isometrus” group is defined with its internal placement of the femoral  $d_2$  trichobothrium, otherwise it is a *beta* group. The “Charmus”, “Uroplectes”, and “Tityus” groups are defined with the fundamental *alpha* pattern, and the latter two groups by a complete *alpha* pattern (i.e.,  $d_2$  located on the internal surface of the femur). And finally, the “Tityus” group is defined by the consistent loss of the tibial spur, considered important for these New World buthoids, more so than its hypothesized independent loss seen in other groups.

The position of the “Charmus” group in the cladogram depicted in Fig. 15 is quite revealing. We see that it represents the *most* primitive form of the *alpha* pattern, with femoral trichobothrium  $d_2$  still located on the dorsal surface as it is in the more primitive *beta* buthoids, and therefore, forms the plesiomorphic sister group to the pure *alpha* buthoids (i.e., the “Uroplectes” and “Tityus” groups).

The three genera of the “Charmus” group, found in India (*Charmus*), Southeast Asia (*Thaicharmus*) and Ethiopia (*Somalicharmus*), present an obvious biogeographic disjunction between Africa and Asia. However, one does not have to assign the age of this disjunction to the original Gondwana fragmentation. According to the new model for the tectonic evolution of the Indian plate by Chatterjee and Scotese (1999), in Late Cretaceous (75–70 Mya), India and Africa became temporarily joined by a landbridge, named Greater Somalia. The plate tectonic model of Chatterjee and Scotese (1999) indicates that biotic interchange via Greater Somalia could have been available until about 60 Mya. This connection allowed immigration of many taxa, including dinosaurs, into India from Africa and Europe, and accounts for some spectacular disjunctions (Hedges, 2003; Bossuyt *et al.* 2006). It is possible that the common ancestor of *Charmus* and *Thaicharmus* entered India from Africa, where related *Somalicharmus* still dwells. This direction seems most plausible than the reverse, since most other groups of

Buthoidea appear to have diverged in continental Africa, with further dispersal and differentiation (Fet *et al.*, 2005). Absence of “Charmus” group from the well-studied Madagascar could confirm this dispersal scenario (rather than reverse), since separation of the block including Madagascar and India from Africa is dated 165–121 Mya (late Jurassic-early Cretaceous) (Vences *et al.*, 2001; Chakrabarty, 2004).

According to our phylogenetic reconstruction (Soleglad & Fet, 2003b; Fet *et al.*, 2005; Baptista *et al.*, 2006), Buthida diverged from other orthostern parvorders in the late Paleozoic, and diversified through the Mesozoic; note, however, that we place Cretaceous fossil orthosterns *Archaeobuthus* and *Palaeoburmesebuthus* well outside parvorder Buthida (with its sole superfamily Buthoidea) (Baptista *et al.*, 2006). By late Cretaceous, all six groups of buthoid scorpions outlined by Fet *et al.* (2005) should have been already present in various fragments of Laurasia and Gondwanaland. Fet *et al.* (2005) indicated, for instance, that the Tertiary Baltic (Laurasian) genus *Palaeoakentrobuthus* could be tentatively included in “Charmus” group. It is obvious that some of the African lineages of Buthoidea could migrate to India via Greater Somalia before or after the K-T extinction (65 Mya), much earlier than the Indian subcontinent joined Asia (ca. 45 Mya). Since the Greater Somalia connection was severed in the Middle Paleocene (60 Mya), this date could be used as a rough calibration for the minimal age of African/Asian disjunction presented by the genera of the extant “Charmus” group.

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