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## On the Troglomorphic Scorpion *Troglotayosicus humiculum* (Scorpiones, Troglotayosicidae), with First Description of the Adults

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### ABSTRACT

The endemic Colombian troglomorphic scorpion, *Troglotayosicus humiculum* Botero-Trujillo and Francke, 2009, previously known only from the juvenile holotype, is redescribed based on newly collected adults of both sexes. New data on basitarsal spination, telotarsal setation, and carination of the metasoma and pedipalps, together with the first description of the hemispermatophore and a revised interpretation of the trichobothria, are provided, along with brief discussions of the ecology and distribution of the species.

### INTRODUCTION

A new genus, *Troglotayosicus* Lourenço, 1981, and species, *Troglotayosicus vachoni* Lourenço, 1981, were created for a single troglobite female scorpion collected from under a stone in a cave during the 1976 British-Ecuadorian expedition to Los Tayos caves, in the Amazonian Region of southeast-

ern Ecuador. In discussing the phylogenetic affinities of *Troglotayosicus*, Lourenço (1981) noted problems with the delimitation of Chactidae Pocock, 1893 and Vaejovidae Thorell, 1876. Based on the absence of median eyes, Lourenço (1981) considered *Troglotayosicus* most closely related to *Belisarius* Simon, 1879, another monotypic chactid genus endemic to the Pyrenees of France and

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Spain, and provisionally assigned *Troglotayosicus* to the chactid subfamily Chactinae Pocock, 1893, where *Belisarius* was accommodated at the time.

The placement of *Troglotayosicus* in Chactidae remained uncontested (vide Lourenço and Francke, 1985; Sissom, 1990) until Stockwell (1992) transferred it and *Belisarius* to the family Superstitioniidae Stahnke, 1940 (as Superstitionidae), newly elevated from its former rank as a subfamily of Chactidae, which he in turn restricted to the nominate subfamily. Stockwell (1992) based these decisions on an unpublished phylogenetic analysis (Stockwell, 1989), wherein he proposed the new subfamily Troglotayosinae, which he placed as sister to (Typhlochactinae + Belisariinae). The characters uniting Troglotayosinae, Typhlochactinae, and Belisariinae in a monophyletic group in Stockwell's (1989) analysis were mostly troglomorphies (morphological adaptations to life in cavernicolous habitats, e.g., the absence of eyes).

Sissom and Cokendolpher (1998) tentatively agreed with Stockwell's (1992) recognition of Superstitioniidae, but expressed reservations about the transferal of *Troglotayosicus* and *Belisarius* to this family, which in their opinion was not based on strong evidence. Lourenço (1998) also disagreed with the placement of *Troglotayosicus* in Superstitioniidae, but agreed with Stockwell (1989) about its close relationship with *Belisarius*. Lourenço (1998) therefore created a new family, Troglotayosicidae Lourenço, 1998 (as Troglotayosidae), with two monotypic subfamilies, Troglotayosicinae Lourenço, 1998 (as Troglotayosinae) and Belisariinae Lourenço, 1998 (as Belisarinae), to accommodate the two genera, justifying their inclusion in the same family solely on the basis of their troglomorphic habitus and relictual distribution.

In the *Catalog of the Scorpions of the World*, Sissom (2000a, 2000b) and Fet and Sissom (2000) reiterated that the transferal of *Troglotayosicus* and *Belisarius* from Chactidae to Superstitioniidae was weakly justified and Troglotayosicidae was not supported by solid characters. Lourenço (2000, 2001) continued to recognize Troglotayosicidae, however.

In a paper on the high-level classification of extant scorpions, Soleglad and Fet (2003)

returned *Belisarius* to Chactidae and *Troglotayosicus* to Superstitioniidae, and synonymized Troglotayosicidae with Superstitioniidae, among other changes. Soleglad and Fet (2003) thus considered *Troglotayosicus* to be a superstitioniid as previously suggested by Stockwell (1989, 1992)—and within Superstitioniidae as the sister group to *Superstitionia* Stahnke, 1940, together comprising Superstitioniinae—but did not consider *Belisarius* closely related to these taxa, thus rejecting the concept of Troglotayosicidae as defined by Lourenço (1998). Coddington et al. (2004) independently drew the same conclusion in questioning the monophyly of Troglotayosicidae, and suggesting that *Belisarius* may be more closely related to Euscorpidae Laurie, 1896 or Chactidae than to *Troglotayosicus*, which might be a superstitioniid. According to the hypotheses proposed by Soleglad and Fet (2003) and Coddington et al. (2004), troglomorphism evolved independently in *Troglotayosicus* and *Belisarius*.

Prendini and Wheeler (2005) identified many problems with the cladistic analysis on which Soleglad and Fet's (2003) revised classification was based and, pending a rigorous and unbiased analysis, reverted to a classification reflected by the most recent peer-reviewed, published treatments that recognized, inter alia, the family Troglotayosicidae as proposed by Lourenço (1998). In response, Fet and Soleglad (2005) reinstated their previous classification (Soleglad and Fet, 2003), but it was not universally accepted. Lourenço (2006), for example, suggested that *Troglotayosicus* should be retained in Troglotayosicidae or considered incertae sedis in Chactoidea, while Volschenk and Prendini (2008), Botero-Trujillo and Francke (2009), Vignoli and Prendini (2009) and Prendini et al. (2010) also recognized Troglotayosicidae. Prendini et al. (2010) confirmed the monophyly of *Troglotayosicus*, but its phylogenetic relationships with other chactoid families remain to be rigorously tested.

*Troglotayosicus humiculum* Botero-Trujillo and Francke, 2009, the second species of this controversial genus, was described from southwestern Colombia, almost 30 years after the type species. Although displaying similar levels of troglomorphism to *T. vachoni*, the

holotype of *T. humiculum* was collected from leaf litter in a Winkler trap, not from a cave. The holotype was a juvenile male and was insufficiently well preserved to allow all characters to be adequately described. During a recent expedition to the Nariño Department of Colombia by the first two authors, additional specimens of *T. humiculum*, including adults of both sexes, were collected. In the present contribution, we redescribe and fully illustrate the morphology of *T. humiculum* based on the newly collected adults of both sexes, provide new data on basitarsal spination, telotarsal setation, and carination of the metasoma and pedipalps, the first description of the hemispermatophore, a revised interpretation of the trichobothria, and brief discussions of the ecology and distribution of this remarkable species.

#### MATERIAL AND METHODS

Data reported here were obtained during a field expedition to Colombia in 2008. Specimens were collected at night by ultraviolet (UV) light detection (Stahnke, 1972). Point locality records were georeferenced in the field with a portable Garmin GPS V.

Material is deposited in the following collections: Instituto de Ciencias Naturales, Universidad Nacional de Colombia, Bogotá, Colombia (ICN); Instituto de Investigación de Recursos Biológicos Alexander von Humboldt, Villa de Leyva, Colombia (IAvH); Museo Javeriano de Historia Natural "Lorenzo Uribe S. J.," Pontificia Universidad Javeriana, Bogotá, Colombia (MPUJ).

Morphological terminology follows Vachon (1952) and Prendini (2000) for pedipalp carinae, abbreviated as follows: internomedian (IM), digital (D), dorsointernal (DI), dorsomedian (DM), dorsoexternal (DE), dorsomarginal (DMA), dorsal secondary (DS), external (E), externomedian (EM), ventroexternal (VE), ventromedian (VM), ventrointernal (VI), dorsal patellar process (DPP), ventral patellar process (VPP); a modified version of Prendini (2004) for tergal, sternal, and metasomal carinae, abbreviated as follows: dorso-submedian (DSM), dorsolateral (DL), lateral suprmedian (LSM), median lateral (ML), lateral inframedian (LIM), ventrolateral (VL),

ventrosubmedian (VSM), ventromedian (VM); and Stahnke (1970) for other characters. Trichobothrial notation follows Vachon (1974), but we adopt a reinterpretation of *Typhlochactas* trichobothrial patterns proposed by Prendini and Wheeler (2005) and Vignoli and Prendini (2009). Furthermore, the trichobothrial notation used in this contribution does not necessarily imply homology with other species (i.e., trichobothria with the same designation in other species are not necessarily considered homologous); see Prendini et al. (2010) for trichobothrial notation in *T. humiculum* defined strictly on the basis of positional homology (the "placeholder approach").

Measurements were recorded and illustrations produced using a Nikon SMZ-1500 stereomicroscope fitted with an ocular micrometer and camera lucida. Measurements are presented in millimeters and were obtained following the methodology of Sissom et al. (1990). Photographs of preserved specimens were taken under UV and visible light using a Microptics™ ML-1000 digital imaging system, and the focal planes fused with CombineZM (©Alan Hadley, 2008; <http://hadleyweb.pwp.blueyonder.co.uk/>). Distribution maps were generated using DIVA-GIS Version 5.4 (<http://www.diva-gis.org/>) by superimposing georeferenced point locality records on a digital elevation dataset from the CGIAR Consortium for Spatial Information (<http://srtm.csi.cgiar.org>) (CGIAR-CSI).

#### FAMILY TROGLOTAYOSICIDAE Lourenço, 1998

*Troglotayosicus* Lourenço, 1981

*Troglotayosicus humiculum*  
Botero-Trujillo and Francke, 2009

Figures 1–12, table 1

*Troglotayosicus humiculum* Botero-Trujillo and Francke, 2009: 3–9, figs. 1–24, map 1, table 1; Vignoli and Prendini, 2009: 11, fig. 4; Prendini et al., 2010: 119, 120, 123, 125–129, 133, 135, 137, figs. 6K, 7K, 8E, F, L, 9, 10, table 2.

TYPE MATERIAL: Holotype: 1 juv. ♂ (IAvH-E 100809); **COLOMBIA:** Nariño **Department:** *Municipio de Ricaurte:* La Planada Natural Reserve, permanent plot,

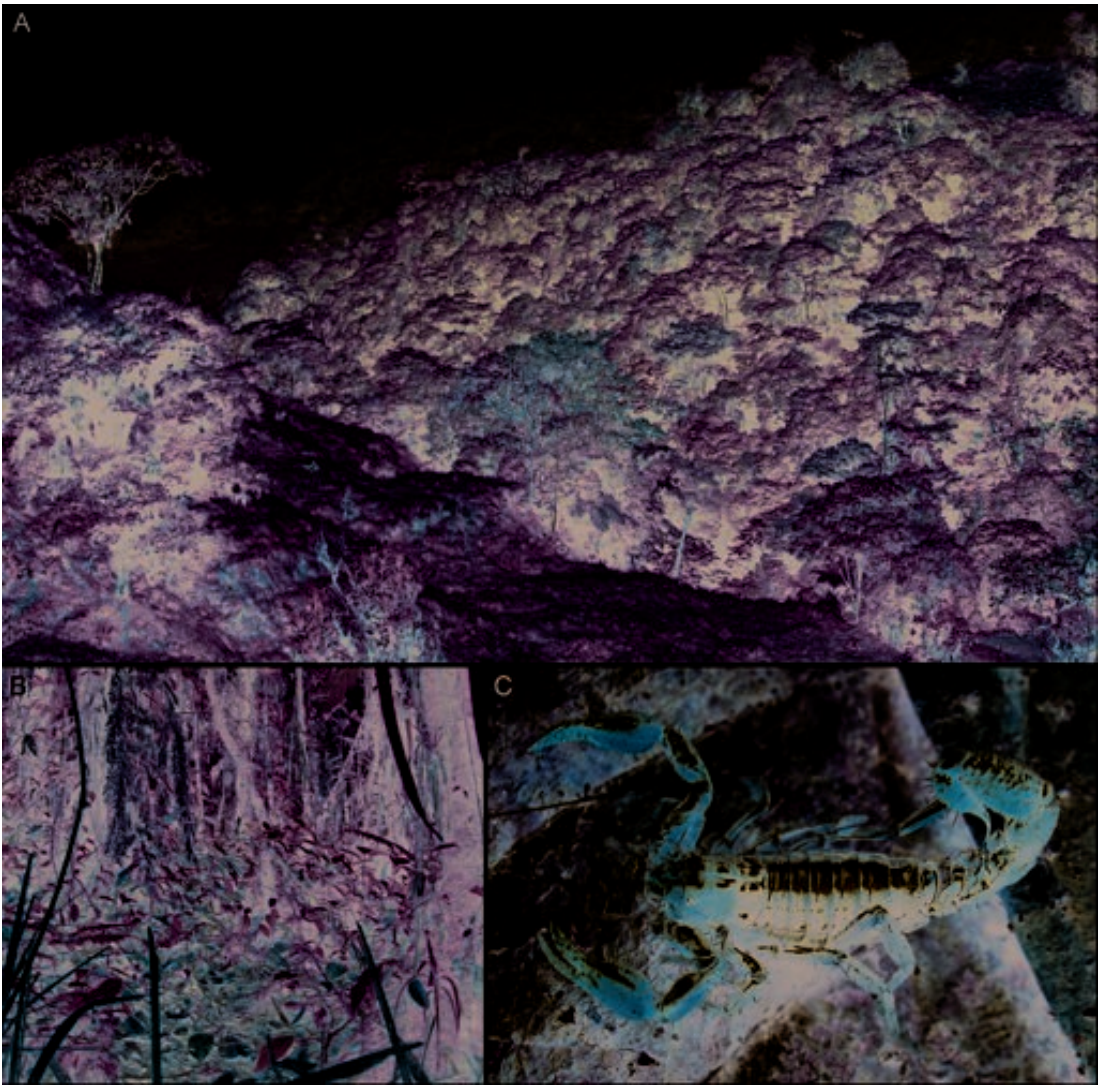


Fig. 1. *Troglotayosicus humiculum* Botero-Trujillo and Francke, 2009. **A.** Collection locality in the Ricaurte municipality, Nariño Department, southwestern Colombia. **B.** Habitat. **C.** ♀, habitus in life.

01°15'N 78°15'W, 1885 m, Winkler trap, 16–20.v.2000, G. Oliva (examined).

**NEW RECORDS: COLOMBIA: Nariño Department: Municipio de Ricaurte:** Vereda Alto Cartagena, Finca Nueva Estrella, 01°13'15.7"N 77°58'08.6"W, 1617 m, 12.ix.2008, R. Botero-Trujillo, J.P. Botero and J.A. Ochoa, 1 ♂, 3 ♀, 1 juv. (ICN); 1 ♂, 3 ♀, 1 juv. (MPUJ).

**DIAGNOSIS:** *Troglotayosicus humiculum* differs morphologically from *T. vachoni*, the only other species in the genus, in the following

respects. The carapace anterior margin is sublinear, with a weak median projection (epistome; fig. 3B), and there are three pairs of lateral ocelli (the median ocellus is present but greatly reduced) in *T. humiculum*, whereas the anterior margin is convex, with a pronounced epistome, and there are two pairs of lateral ocelli (the median ocellus is absent) in *T. vachoni*. The setae on the ventral surfaces of telotarsi I–IV are regularly arranged into a pair of parallel ventrosubmedian rows in *T.*



Fig. 2. *Troglotayosicus humiculum* Botero-Trujillo and Francke, 2009, habitus. A, B. ♂ (MPUJ). C, D. ♀ (MPUJ). A, C. Dorsal aspect. B, D. Ventral aspect. Scale bars = 5 mm.

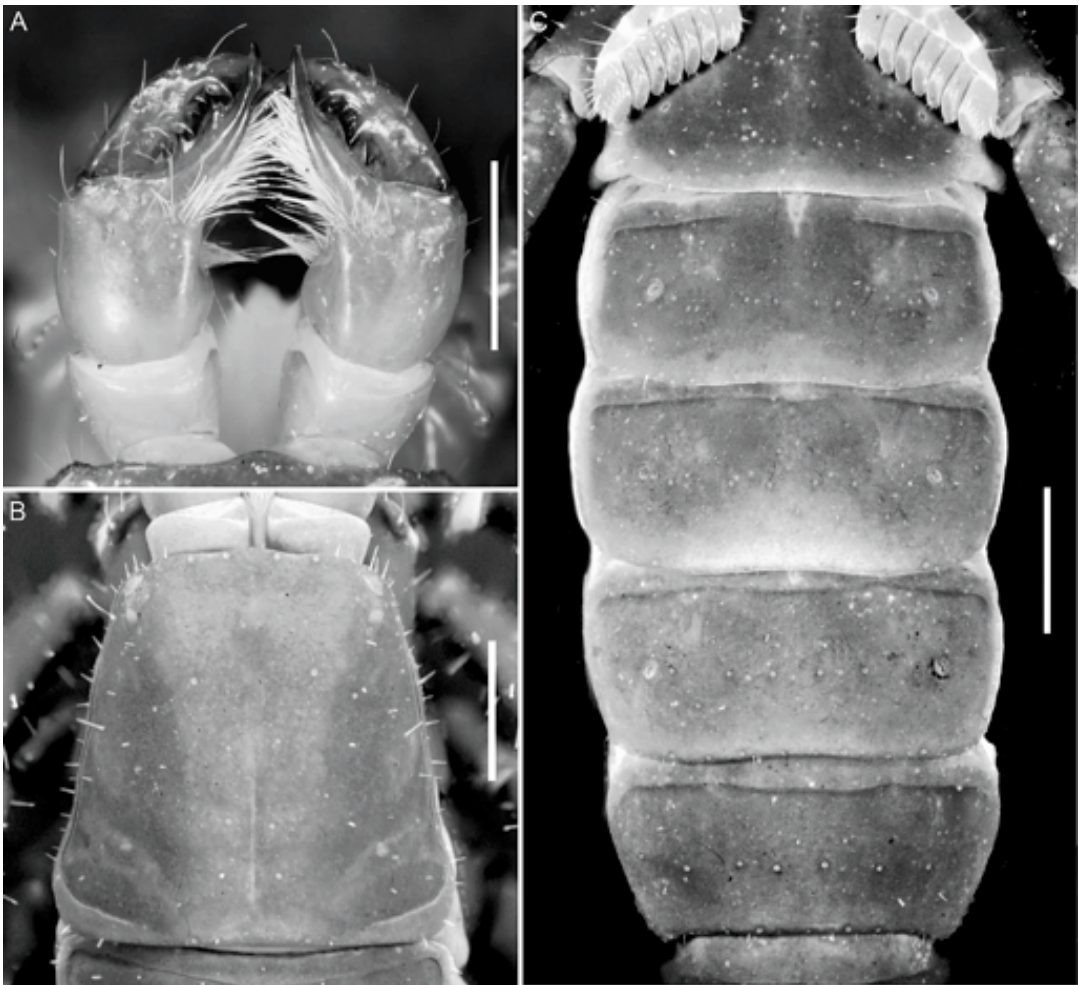


Fig. 3. *Troglotayosicus humiculum* Botero-Trujillo and Francke, 2009. **A.** Chelicerae, dorsal aspect, ♂ (MPUJ). **B.** Carapace, ♀ (MPUJ). **C.** Sternites III–VII, ♀ (MPUJ). Scale bars = 1 mm.

*humiculum* (fig. 8), but are irregularly arranged in *T. vachoni*. The pedipalpal and metasomal carinae differ as follows: four carinae (DI, DE, VI, VE) are evident on the pedipalp femur of *T. humiculum* (fig. 7C, E), compared with only three carinae (DE, DI and VI) in *T. vachoni*; at least the DS, DMA and DI carinae are evident, albeit obsolete (identified only by granulation and subtle differences in angles between adjacent surfaces), on the pedipalp chela of *T. humiculum* (figs. 5, 6), whereas the chela is entirely smooth and acarinate in *T. vachoni*; the VL carinae of metasomal segments I and II are absent in *T. humiculum*

(fig. 9C) but present in *T. vachoni*. We have not examined the holotype of *T. vachoni*, but judging from the original description, the chelicerae, tergites, pectines, trichobothrial pattern, and carination of metasomal segments IV and V appear to be similar in both species. It is impossible to unequivocally identify all petite trichobothria in *T. vachoni* from Lourenço's (1981) figures 46–52, but the vestigial LSM carinae (fig. 10B, F) are clearly illustrated in Lourenço's (1981) figure 41. The two species also differ markedly in their ecology: *T. humiculum* is endogean whereas *T. vachoni* is hypogean.

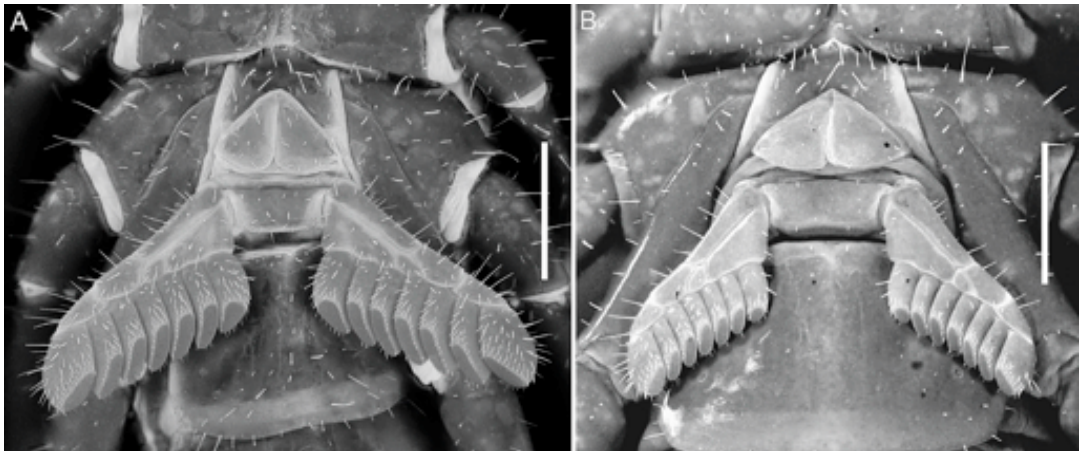


Fig. 4. *Troglotayosicus humiculum* Botero-Trujillo and Francke, 2009, sternum, genital operculum and pectines. A. ♂ (MPUJ). B. ♀ (MPUJ). Scale bars = 1 mm.

**DESCRIPTION:** Based on two adult males, six adult females and two juveniles. Measurements are recorded in table 1.

**Color:** Base color, chelicerae and legs yellowish (♂ and juveniles) or light chestnut (♀); carapace, tergites, metasoma, and pedipalps yellowish to pale orange (♂ and juveniles) or carapace and pedipalps dark chestnut, becoming slightly darker on tergites and metasomal segments (adult ♀; fig. 1C); sternites and coxosternal region yellowish; pectines whitish. Carapace and pedipalps unpigmented (♂) or with weak brown pigmentation, slightly darker than base color, remaining areas unpigmented (♀).

**Chelicerae:** Manus, dorsoexternal surfaces smooth, sparsely setose; ventral and internal surfaces densely setose. Fixed finger, dorsal margin with four teeth (distal, subdistal, median, and basal); median and basal teeth separate, not fused into bicuspid. Movable finger, internal distal and external distal teeth not opposable, internal distal tooth at most partially overlapping external distal tooth in dorsal view; dorsal margin with four teeth (internal distal, subdistal, median, and basal; fig. 3A); ventral surface with long, well-developed serrula.

**Carapace:** Anterior margin sublinear, with weak median projection (epistome) and 6–7 macrosetae (fig. 3B); several granules evident along margin immediately anterior to lateral ocelli. Posterior margin sublinear, with few

macrosetae. Median ocelli absent; three pairs of lateral ocelli present, anterior pair largest, median pair greatly reduced, posterior pair slightly smaller than anterior pair. Median longitudinal sulcus well developed; posterolateral and posterior transverse sulci obsolete. Surfaces acarinate, mostly smooth, except for fine granulation laterally (more pronounced in ♂); two submedian setae evident in anterior half.

**Pedipalps:** Femur tetracarinate; DI carina complete, granular; DE carina restricted to proximal two-thirds of segment, granular (fig. 7C); VI carina discontinuous, comprising two or three granules proximally and four or five granules in distal third; VE carina obsolete, restricted to proximal third of segment (♂) or vestigial (♀) (fig. 7E); dorsal and external intercarinal surfaces with few scattered granules; internal surface with five or six prominent granules and four additional granules on proximal margin (less developed in ♀); ventral surface smooth except for few granules in proximal third; all surfaces sparsely setose. Patella tricarinate; DI and VI carinae complete, granular (more so in ♂; fig. 7A, B, F); DPP and VPP each with one or two granules proximally; DE carina restricted to median two-thirds of segment (♂) or absent (♀) (fig. 7A, B); all other carinae absent; intercarinal surfaces smooth. Chela manus very slightly incrassate, fingers shorter than (♂) or subequal to (♀) manus length. Chelal

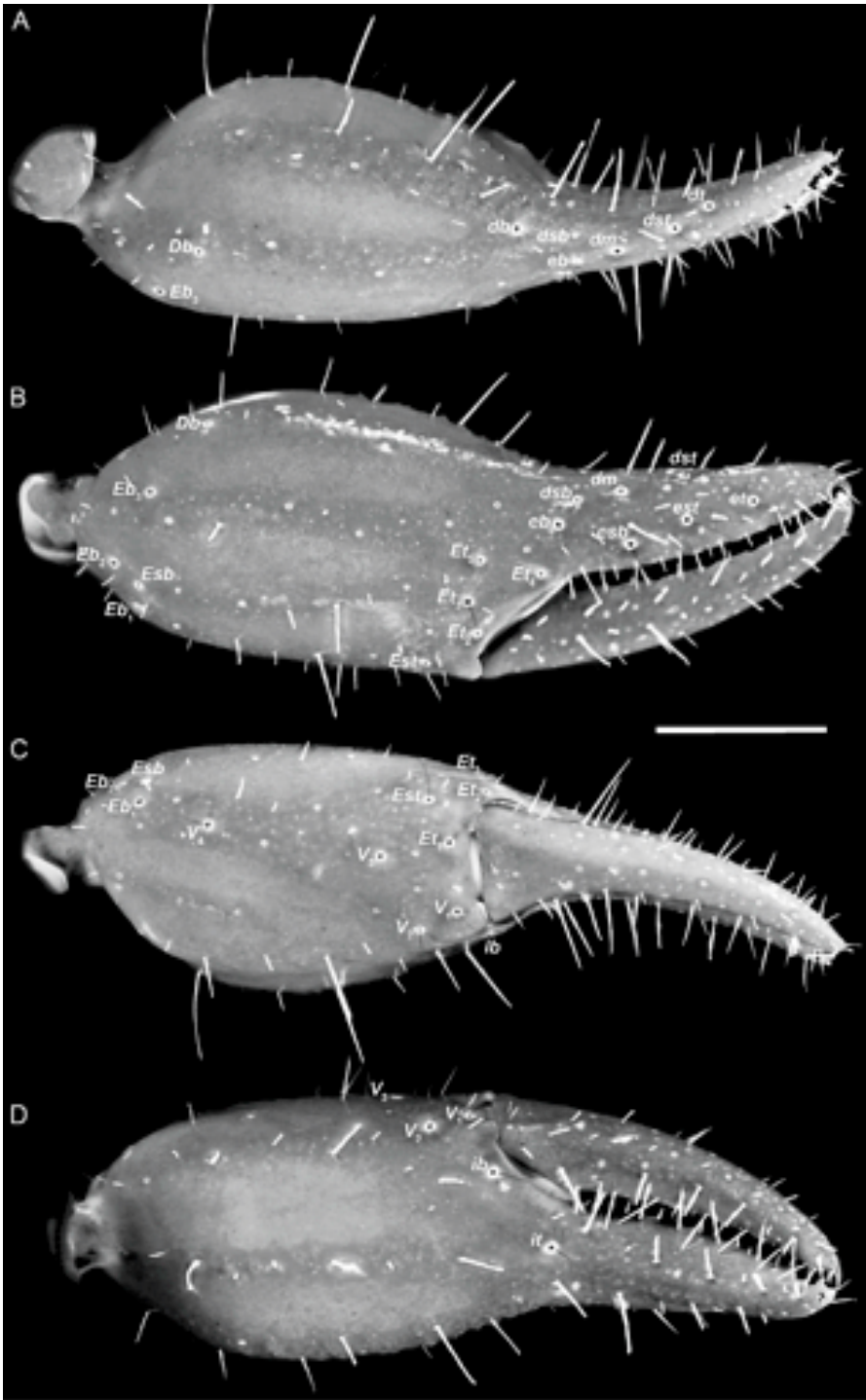


Fig. 5. *Troglotayosicus humiculum* Botero-Trujillo and Francke, 2009, dextral pedipalp chela, ♂ (MPUJ). A. Dorsal aspect. B. External aspect. C. Ventral aspect. D. Internal aspect. Annotations: Trichobothrial notation after Vachon (1974). Scale bar = 1 mm.



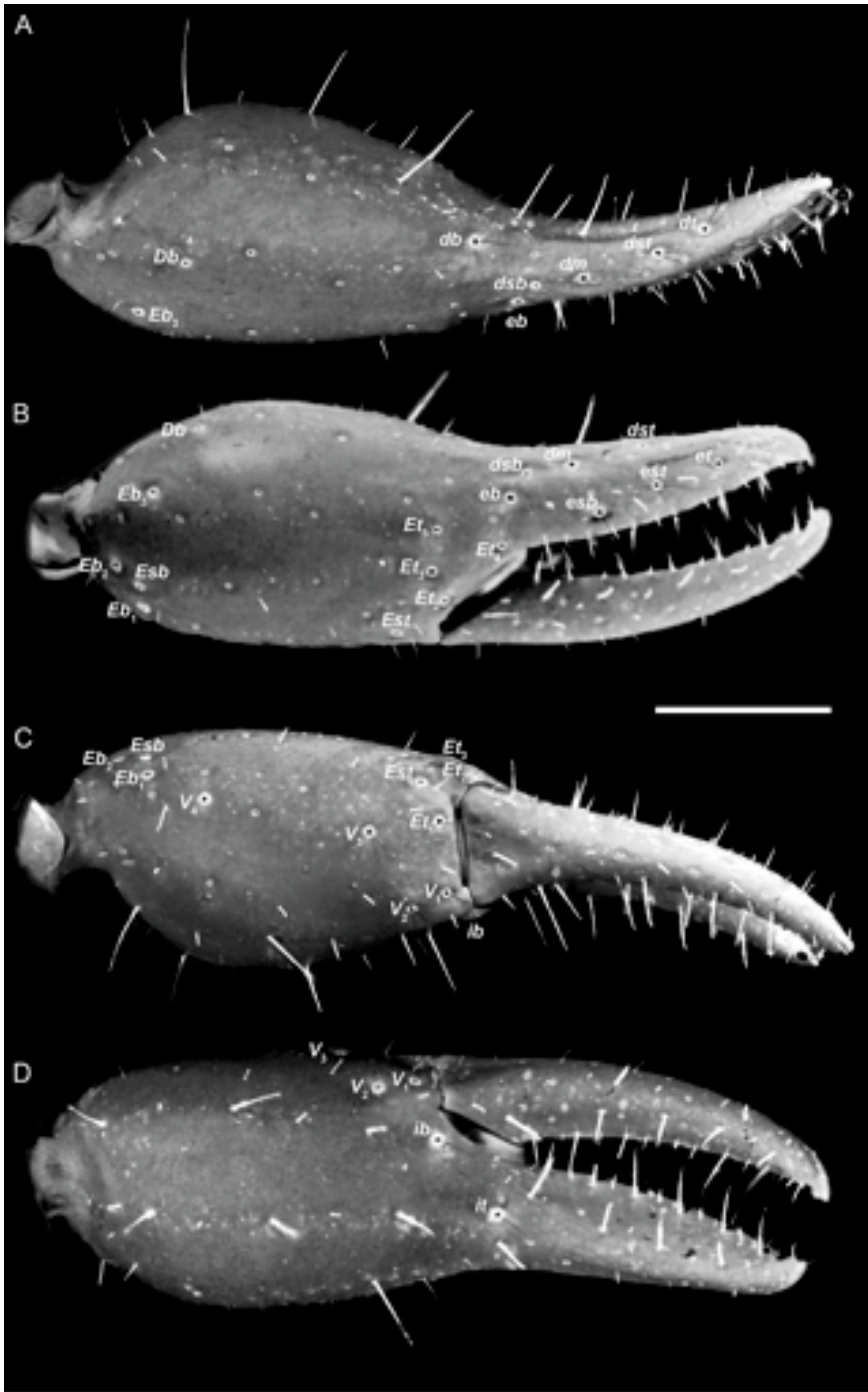


Fig. 6. *Troglotayosicus humiculum* Botero-Trujillo and Francke, 2009, dextral pedipalp chela, ♀ (MPUJ). **A.** Dorsal aspect. **B.** External aspect. **C.** Ventral aspect. **D.** Internal aspect. Trichobothrial notation after Vachon (1974). Scale bar = 1 mm.

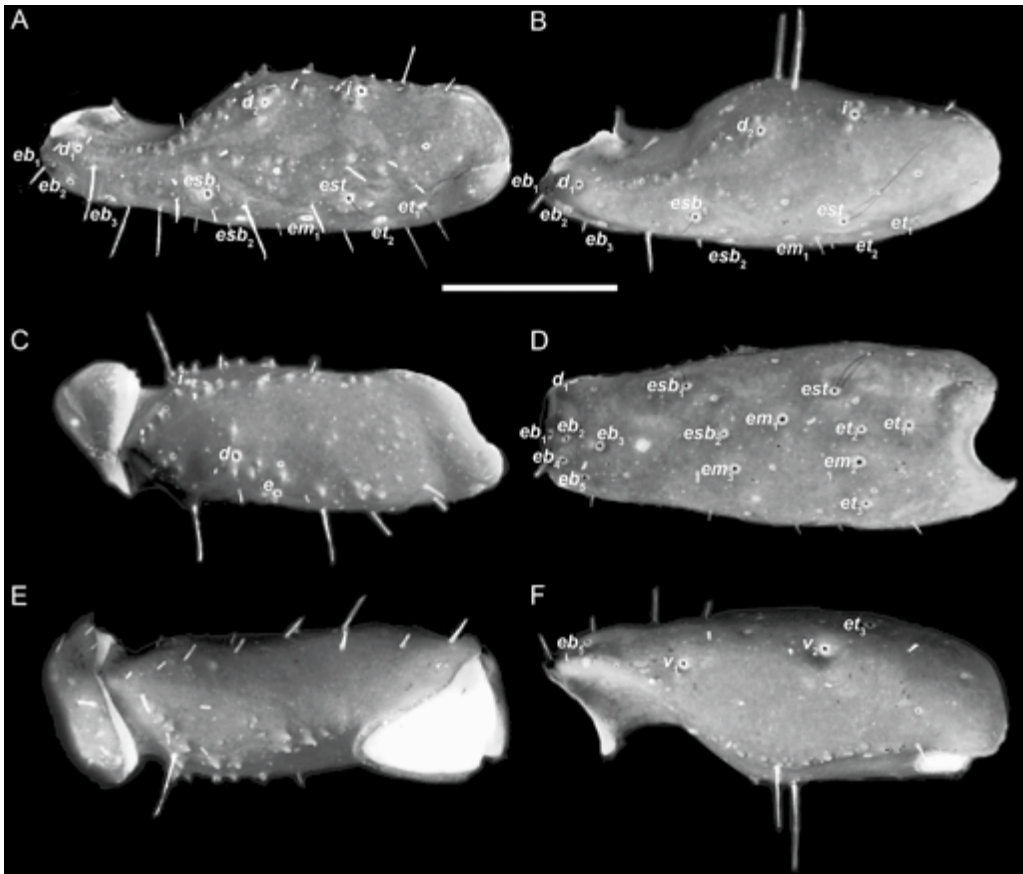


Fig. 7. *Troglotayosicus humiculum* Botero-Trujillo and Francke, 2009, dextral pedipalp segments. **A.** Patella, dorsal aspect, ♂ (MPUJ). **B–F.** Femur and patella, ♀ (MPUJ). **B.** Patella, dorsal aspect. **C.** Femur, dorsal aspect. **D.** Patella, external aspect. **E.** Femur, ventral aspect. **F.** Patella, ventral aspect. Annotations: Trichobothrial notation after Vachon (1974). Scale bar = 1 mm.

carinae obsolete or absent; DS, DMA and DI carinae identified by granulation and subtle differences in angles between surfaces (more pronounced in ♂; figs. 5, 6); DS carina complete, weakly granular; DMA and DI carinae complete, densely granular; VI carina weakly granular (♂) or smooth (♀); D and E carinae evident only as subtle differences in angles between adjacent surfaces. Manus, intercarinal surfaces smooth, covered with scattered macro- and microsetae, becoming more numerous on fingers. Fixed finger, median denticle row comprising six oblique, slightly imbricate primary subrows of denticles, flanked by six external and five internal denticles; terminal denticle considerably larger than preceding denticles, hooklike, fingertips

interlocking unevenly when closed such that movable finger displaced to exterior. Movable finger, median denticle row comprising seven oblique, slightly imbricate primary subrows of denticles, flanked by six external and six internal denticles; terminal denticle enlarged, hooklike, accommodated in subdistal diastema (notch) of fixed finger.

*Trichobothria:* Femur with three trichobothria (fig. 7C): one external (*e*), one dorsal (*d*), one internal (*i*). Patella with 19 trichobothria (fig. 7B, D, F), two petite (*et*<sub>2</sub>, *esb*<sub>2</sub>), one accessory (*em*<sub>3</sub>): two ventral (*v*<sub>1</sub>, *v*<sub>2</sub>); 14 external (*et*<sub>1</sub>–*et*<sub>3</sub>, *est*, *em*<sub>1</sub>–*em*<sub>3</sub>, *esb*<sub>1</sub>, *esb*<sub>2</sub>, *eb*<sub>1</sub>–*eb*<sub>5</sub>); two dorsal (*d*<sub>1</sub>, *d*<sub>2</sub>); one internal (*i*). Chela with 26 trichobothria (figs. 5, 6), five petite (*Et*<sub>4</sub>, *Et*<sub>5</sub>, *Esb*, *Db*, *dsb*), one accessory

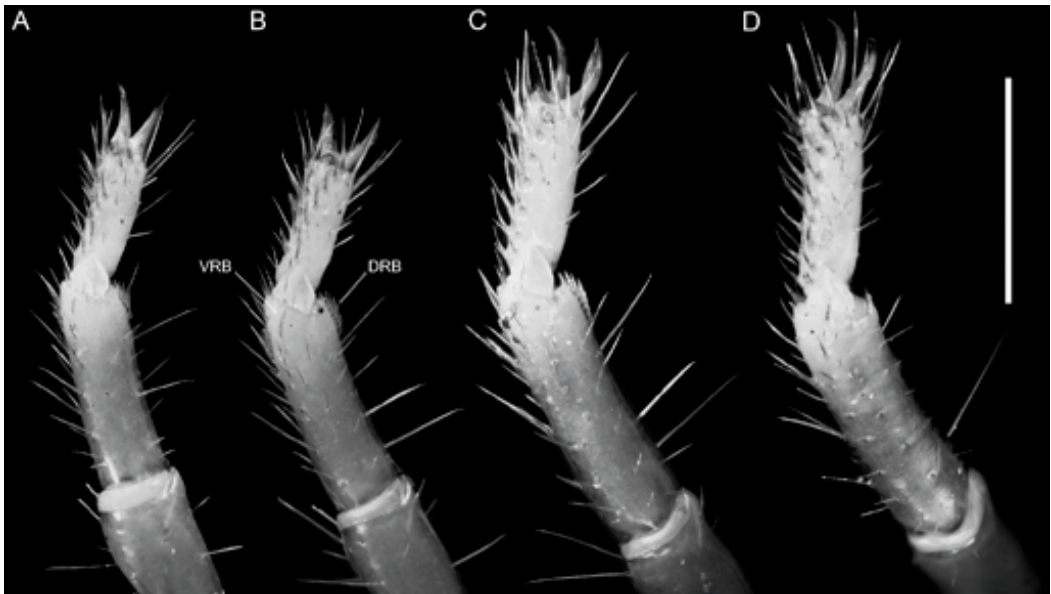


Fig. 8. *Troglotayosicus humiculum* Botero-Trujillo and Francke, 2009, dextral legs I-IV, basitarsi and telotarsi, retrolateral aspect, ♀ (MPUJ). A. Leg I. B. Leg II. C. Leg III. D. Leg IV. Annotations: DRB, dorsal retrolateral brush; VRB, ventral retrolateral brush. Scale bar = 1 mm.

(*dm*): 15 on manus, four ventral ( $V_1$ - $V_4$ ), ten external ( $Et_1$ - $Et_5$ ,  $Est$ ,  $Esb$ ,  $Eb_1$ - $Eb_3$ ), one dorsal ( $Db$ ); 11 on fixed finger, four external ( $et$ ,  $est$ ,  $esb$ ,  $eb$ ), five dorsal ( $dt$ ,  $dst$ ,  $dm$ ,  $dsb$ ,  $db$ ), two internal ( $it$ ,  $ib$ ). The petite condition of  $Et_4$  in *Troglotayosicus* is recognized here for the first time and results in a trichobothrial interpretation with greater similarity to typhlochactid species (all of which also exhibit petite  $Et_4$  and  $Et_5$ ; Vignoli and Prendini, 2009) than that presented by Botero-Trujillo and Francke (2009); see Prendini et al. (2010) for trichobothrial notation in *T. humiculum* defined strictly on positional homology (the “placeholder approach”).

**Legs:** Legs I-IV, carination more developed on III and IV than I and II; femur tetracarinate (less pronounced in ♀), VI and EM carinae continuous, granular, DI carina restricted to proximal third, fusing with VI carinae medially; patellar DE carinae continuous (♂) or restricted to distal third (♀), comprising small, sparse granules. Tibia sparsely setose, tibial spurs absent. Basitarsi I-IV setose, each with one dorsal and two or three ventral rows of brushlike spinules distally (fig. 8); dorsal retrolateral brush usually well developed on legs I-III, vestigial on

IV; median prolateral brush well developed on I-III, absent on IV; ventral prolateral brush well developed on I and II, absent on III and IV; ventral retrolateral brush obsolete on legs I and II, obsolete or absent III, absent on IV; prolateral pedal spurs present; retrolateral pedal spurs vestigial. Telotarsi I-IV, dorsomedian lobe with one large microseta; ventral surface without spinules, subspiniiform setae regularly arranged into pair of parallel ventrosubmedian rows (fig. 8), comprising 5-6 prolateral and 6-7 retrolateral setae on I, 6/7 on II, 7-8/7-8 on III, 8/8-9 on IV; ungues well developed, curved, equal in length; dactyl shorter than ungues.

**Tergites:** Pretergites smooth. Posttergites I-VI, surfaces finely granular (♂) or almost smooth with sparse, fine granules (♀). Posttergite VII, surface finely granular (more so in ♂), posterior half with scattered granules in position of DSM carinae; DL carinae present in posterior half, each terminating in tubercle comprising four or five granules; posterior margin coarsely granular.

**Sternum:** Shape subpentagonal with rounded apex and lateral margins converging anteriorly such that posterior width greater than length; posterior depression shallow.

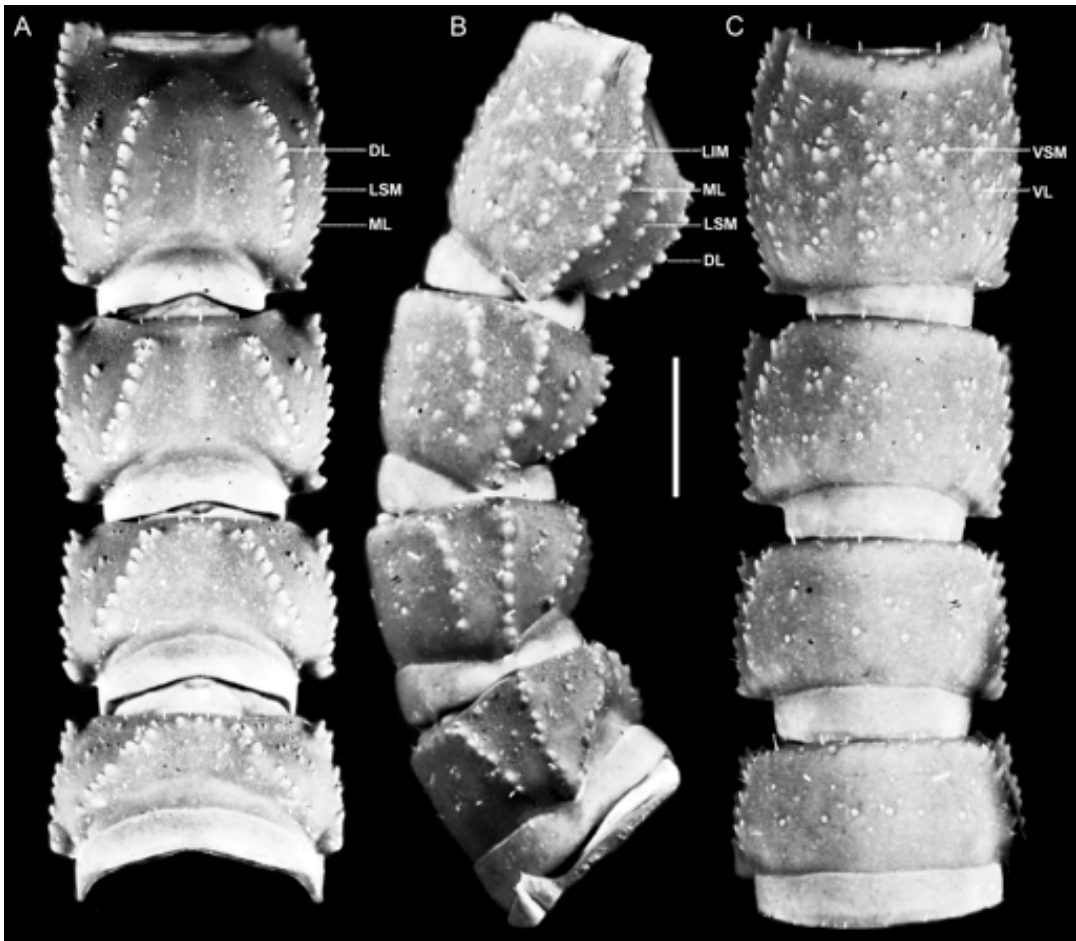


Fig. 9. *Troglotayosicus humiculum* Botero-Trujillo and Francke, 2009, metasomal segments I–IV, ♀ (MPUJ). **A.** Dorsal aspect. **B.** External aspect. **C.** Ventral aspect. Annotations: DL, dorsolateral carinae; LSM, lateral supramedian carinae; ML, median lateral carinae; LIM, lateral inframedian carinae; VL, ventrolateral carinae; VSM, ventrosubmedian carinae. Scale bar = 1 mm.

Surface with 6–8 macrosetae and several microsetae (fig. 4).

**Pectines:** Pectinal plate, surface with several macrosetae situated mediolaterally. Lamella comprising five segments. Tooth count, 7–7 in all specimens; proximal and distal teeth slightly larger than others (fig. 4).

**Sternites:** Sternites III–VI, surfaces smooth, each with pair of small, rounded spiracles, situated mediolaterally; VII, surface smooth, acarinate; III–VII each with transverse row of six macrosetae medially and row of 6–10 (usually 10) macrosetae along posterior margin (fig. 3C).

**Metasoma:** Segments I–V progressively increasing in length (table 1). Segments I–IV, dorsal and lateral intercarinal surfaces entirely densely and finely granular (♂) or sparsely and finely granular in posterior half only (♀; fig. 9B); ventral intercarinal surfaces smooth on segments I and II, sparsely granular on III, densely and coarsely granular on IV (fig. 9C). Segment V, dorsal intercarinal surfaces sparsely and finely granular; lateral and ventral surfaces densely and coarsely granular, granules increasing in size posteriorly (fig. 10A–C, F). DL carinae complete, costate-granular, converging distally on segments I–IV (fig. 9),

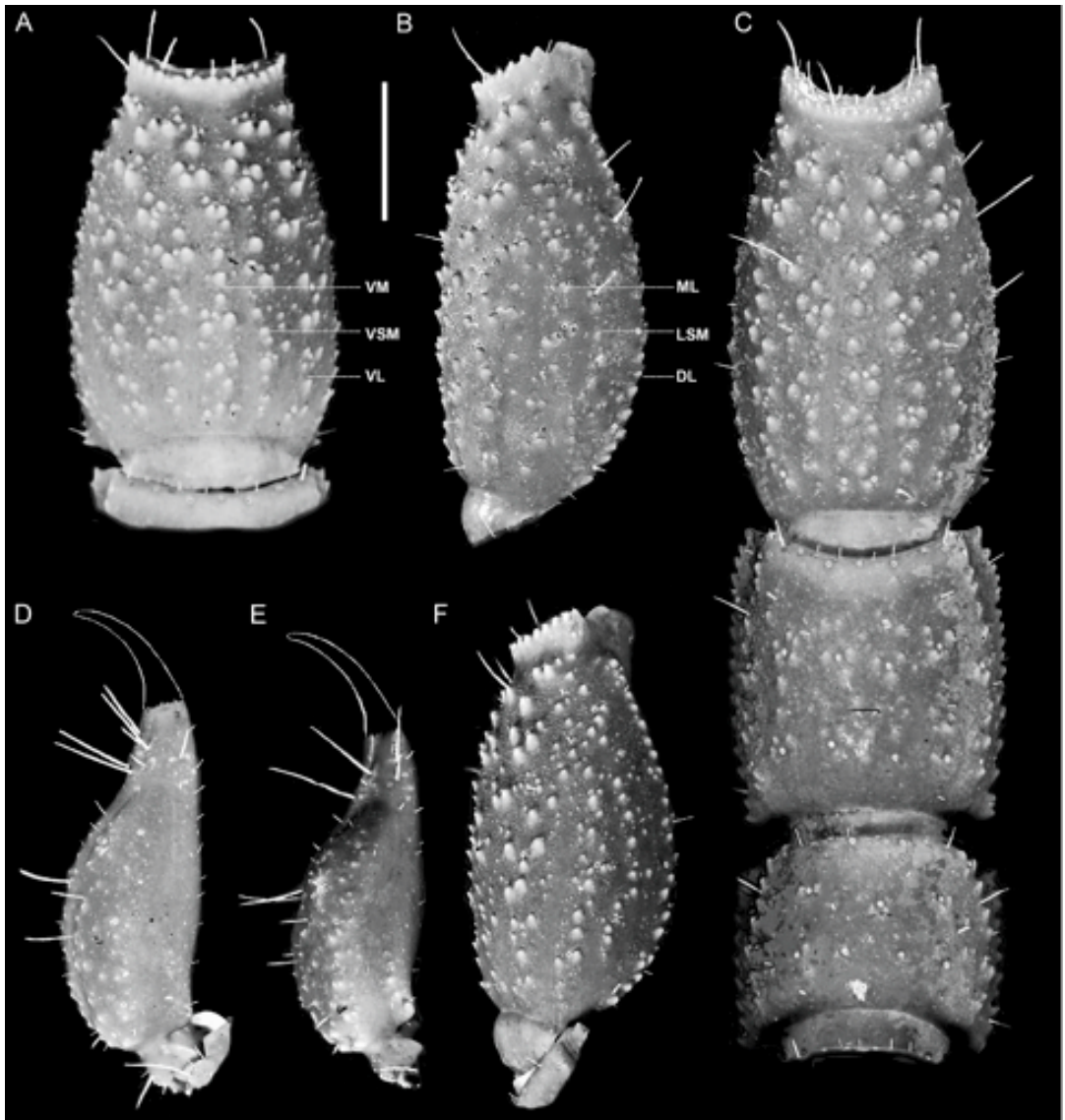


Fig. 10. *Troglotayosicus humiculum* Botero-Trujillo and Francke, 2009, metasomal segments and telson. **A, E, F.** ♀ (MPUJ). **B–D.** ♂ (MPUJ). **A.** Metasomal segment V, ventral aspect. **B.** Metasomal segment V, lateral aspect. **C.** Metasomal segments III–V, ventral aspect. **D.** Telson, lateral aspect. **E.** Telson, lateral aspect. **F.** Metasomal segment V, lateral aspect. Annotations: DL, dorsolateral carinae; LSM, lateral supramedian carinae; ML, median lateral carinae; VL, ventrolateral carinae; VSM, ventrosupramedian carinae; VM, ventromedian carinae. Scale bar = 1 mm.

complete, granular on V; LSM carinae vestigial, comprising row of small granules between DL and ML carinae, in medial third of segments I–IV, more pronounced on III and IV than on I and II (fig. 9A, B), weakly granular and restricted to medial third of V

(fig. 10B); ML carinae complete, costate-granular on segments I–IV, less pronounced on IV, and complete, but obscured by dense granulation on lateral surfaces of V (fig. 10B); LIM carinae less pronounced than DL and LSM carinae, comprising isolated granules,

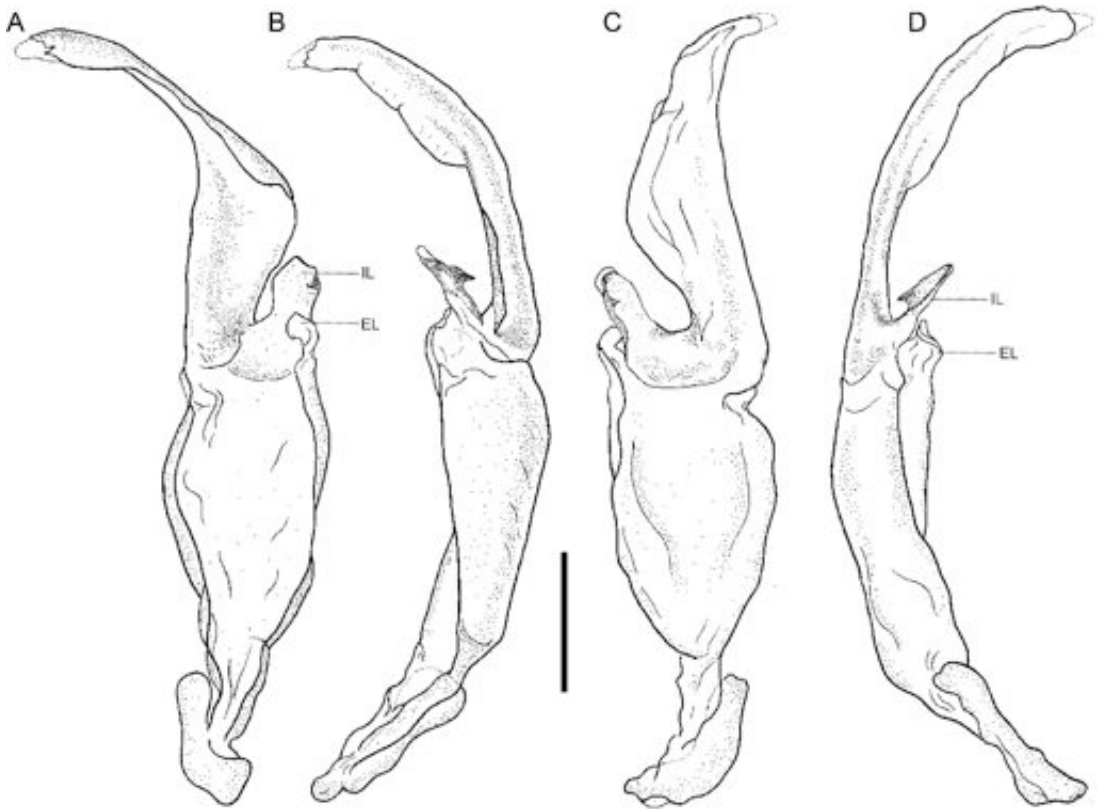


Fig. 11. *Troglotayosicus humiculum* Botero-Trujillo and Francke, 2009, sinistral hemispermaphore, ♂ (MPUJ). **A.** Ental aspect. **B.** Dorsal aspect. **C.** Ectal aspect. **D.** Ventral aspect. Annotations: IL, internal lobe; EL, external lobe. Scale bar = 0.5 mm.

complete on segments I–III, complete or restricted to posterior two-thirds of IV, absent on V; VL and VSM carinae absent on segments I and II, comprising a few granules on III (VSM often absent on III in ♀), and a row of coarse granules in median third of IV; VL, VSM and VM carinae restricted to anterior half of segment V, obscured by scattered granulation in posterior half (fig. 10A, C). DL carinae each with one macroseta on segments I–III, two macrosetae on IV, five (sometimes fourth is a microseta) on V; LM carinae each with one or two macrosetae on segment I, two on II–IV, four on V; LIM carinae each with two macrosetae on segments I–III, three on IV, one situated posteriorly on V; two macrosetae in place of each VL carina on segment I, three on II–IV, five on V; ventral surface, segment I with four transverse macrosetae, II with 3–4, III and IV

each with four (usually in two rows), V with 10–12; posterior margin, segments I–IV each with 4–6 additional setae, V with 6–8.

*Telson:* Vesicle elongated; anterodorsal lateral lobes present (fig. 10D, E); surfaces smooth dorsally and laterally, coarsely granular ventrally; with scattered long macrosetae and several short microsetae. Aculeus long, gently curved.

*Hemispermaphore:* Lamelliform (fig. 11A–D). Lamina pale and weakly sclerotized, especially distally; apex elongated, without crests, wider medially, conical distally, inclined ventrointernally; dorsal margin, distal half inclined towards ventrointernal surface; ventral margin well developed; articular flexure present; basal portion and foot well developed but weakly sclerotized. Capsule simple; external lobe reduced with a small dorsal process, inclined towards internal surface; internal lobe

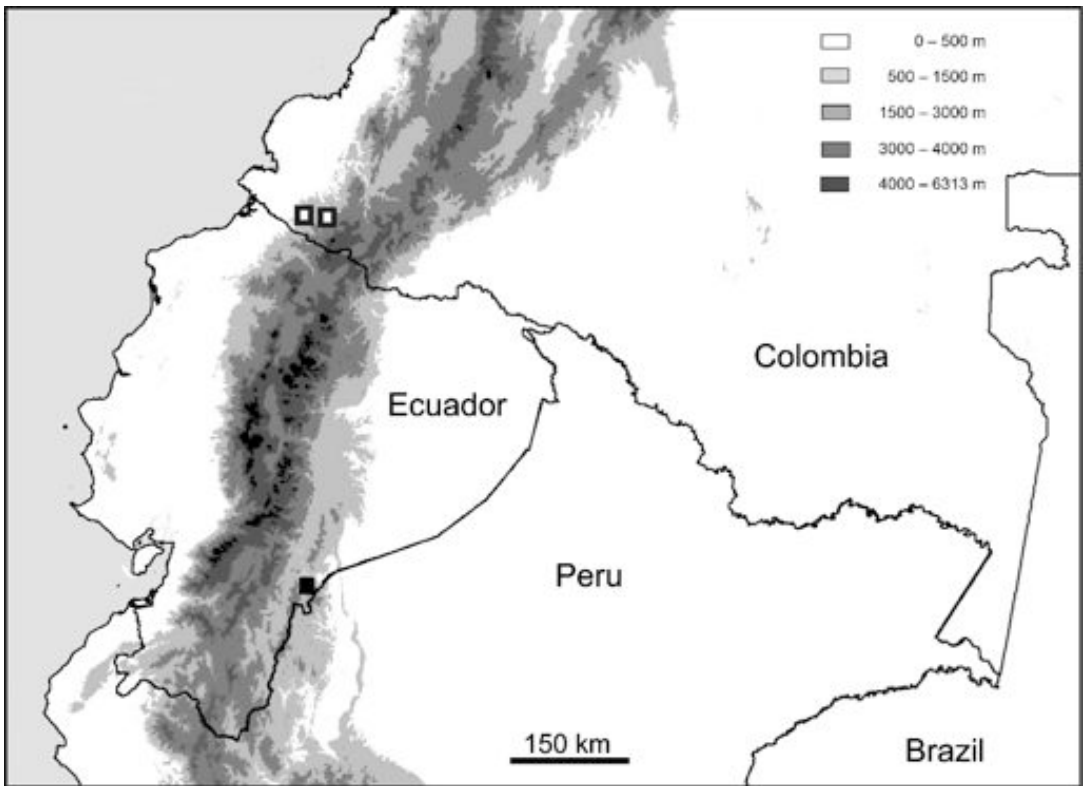


Fig. 12. Map plotting known locality records of *Troglotayosicus* Lourenço, 1981 in northwestern South America. *Troglotayosicus humiculum* Botero-Trujillo and Francke, 2009, open squares. *Troglotayosicus vachoni* Lourenço, 1981, solid square.

more pronounced than external lobe, with one sclerotized external spurlike projection. Male specimens of *T. vachoni* are unknown, but the hemispermatophore of *T. humiculum* appears most similar to that of the endemic Colombian chactid, *Vachoniochactas humboldti* Flórez et al., 2008, based on the structure of the capsule (Flórez et al., 2008). The capsular lobes are similarly developed, possessing one or more external spurlike projections on the internal lobe, in both species. However, the shape of the lamina differs in the two species. It is straight and truncated distally in *V. humboldti*, but inclined towards the ventrointernal surface and narrowed distally in *T. humiculum*.

**Sexual dimorphism:** Adult males and females differ in the following proportions (table 1). Total length: ♂, 19.1–19.6 mm ( $n = 2$ ); ♀, 18.95–19.90 mm (mean = 19.19 mm,  $n = 6$ ). Pedipalp chela, length/width ratio: ♂, 3.03–3.09 ( $n = 2$ ); ♀, 3.15–3.38 (mean = 3.26,  $n = 6$ );

length/height ratio: ♂, 2.77–2.83 ( $n = 2$ ); ♀, 2.89–3.19 (mean = 3.02,  $n = 6$ ). Pedipalp femur, length/width ratio: ♂, 2.74–2.94 ( $n = 2$ ); ♀, 2.72–2.85 (mean = 2.78,  $n = 6$ ). Metasomal segment I, length/width ratio: ♂, 0.49–0.50 ( $n = 2$ ); ♀, 0.46–0.50 (mean = 0.48,  $n = 6$ ). Metasomal segment II, length/width ratio: ♂, 0.58–0.61 ( $n = 2$ ); ♀, 0.52–0.56 (mean = 0.55,  $n = 6$ ). Metasomal segment III, length/width ratio: ♂, 0.65–0.66 ( $n = 2$ ); ♀, 0.58–0.61 (mean = 0.60,  $n = 6$ ). Metasomal segment IV, length/width ratio: ♂, 0.93–0.95 ( $n = 2$ ); ♀, 0.80–0.89 (mean = 0.84,  $n = 6$ ). Metasomal segment V, length/width ratio: ♂, 1.55–1.56 ( $n = 2$ ); ♀, 1.35–1.45 (mean = 1.42,  $n = 6$ ). Metasomal segment V, length/height ratio: ♂, 1.97–2.00 ( $n = 2$ ); ♀, 1.67–1.94 (mean = 1.80,  $n = 6$ ). Telson, length/height ratio: ♂, 3.57–3.75 ( $n = 2$ ); ♀, 3.24–3.60 (mean = 3.41,  $n = 6$ ).

**Ontogenetic variation:** The pedipalpal and metasomal carinae are more developed in

TABLE 1  
 Selected measurements (mm) of adult specimens of *Troglotayosicus humiculum*  
 Botero-Trujillo and Francke, 2009

Specimen								
Sex	♂	♂	♀	♀	♀	♀	♀	♀
<b>Carapace</b>								
Length	3.05	3.05	3.10	3.05	3.05	3.20	3.00	3.00
Anterior width	2.05	1.95	2.15	1.95	1.95	2.10	1.95	1.95
Posterior width	3.00	2.95	3.10	3.15	3.15	3.25	3.05	3.15
<b>Chela</b>								
Length	4.85	4.95	4.85	5.00	4.95	5.20	4.90	4.95
Width	1.60	1.60	1.50	1.50	1.50	1.65	1.45	1.55
Height	1.75	1.75	1.55	1.70	1.70	1.80	1.60	1.60
Movable finger length	2.60	2.55	2.65	2.80	2.75	2.95	2.60	2.70
<b>Patella</b>								
Length	2.90	2.95	2.90	3.00	2.95	3.10	2.95	3.00
Width	1.00	1.00	1.05	1.05	1.10	1.15	1.10	1.15
<b>Femur</b>								
Length	2.50	2.50	2.40	2.40	2.45	2.60	2.42	2.45
Width	0.85	0.85	0.87	0.85	0.90	0.92	0.85	0.90
<b>Mesosoma</b>								
Total length	3.65	3.50	4.00	3.70	3.90	4.15	3.95	4.00
<b>Metasoma I</b>								
Length	1.10	1.05	1.05	1.10	1.10	1.20	1.05	1.10
Width	2.20	2.15	2.25	2.30	2.35	2.40	2.25	2.30
<b>Metasoma II</b>								
Length	1.25	1.25	1.20	1.25	1.20	1.25	1.20	1.20
Width	2.20	2.05	2.15	2.25	2.30	2.35	2.20	2.20
<b>Metasoma III</b>								
Length	1.45	1.35	1.25	1.35	1.35	1.40	1.35	1.35
Width	2.20	2.10	2.15	2.20	2.25	2.30	2.20	2.20
<b>Metasoma IV</b>								
Length	2.10	1.95	1.75	1.85	1.80	1.95	1.90	1.90
Width	2.20	2.10	2.15	2.20	2.25	2.20	2.20	2.25
<b>Metasoma V</b>								
Length	3.25	3.20	2.90	3.05	3.15	3.00	3.05	3.20
Width	2.10	2.05	2.15	2.15	2.20	2.15	2.10	2.20
Height	1.65	1.60	1.65	1.70	1.70	1.80	1.70	1.65
<b>Telson</b>								
Total length	3.75	3.75	3.70	3.60	3.40*	3.75	3.55	3.60
Vesicle length	2.40	2.45	2.35	2.25	2.30	2.30	2.25	2.30
Vesicle width	1.40	1.50	1.40	1.45	1.45	1.50	1.45	1.45
Vesicle height	1.00	1.05	1.05	1.00	1.05	1.15	1.05	1.05
Aculeus length	1.35	1.30	1.35	1.35	1.10*	1.45	1.30	1.30
<b>Metasoma</b>								
Total length	12.90	12.55	11.85	12.20	12.00	12.55	12.10	12.35
<b>Total length</b>	<b>19.60</b>	<b>19.10</b>	<b>18.95</b>	<b>18.95</b>	<b>18.95</b>	<b>19.90</b>	<b>19.05</b>	<b>19.35</b>

\*Aculeus broken.



adult specimens than in the juvenile holotype. The adults possess four carinae (DI, DE, VI and VE) on the femur, at least two carinae (DI and VI) on the patella, and at least three (DS, DMA, and DI always granular) on the chela. The carinae of the holotype are obsolete on the femur and absent on the patella and chela. However, in other juveniles examined, the DMA and DI carinae of the chela and the VI carinae of the patella are present but less developed than in adults. Similar differences are evident between the metasomal carination and granulation of adults and juveniles. Metasomal segments III and IV possess VL carinae in adults, but these carinae are absent in juveniles (including the holotype). Metasomal segment V is markedly granular ventrally and laterally in adults, with VM, VSM, and VL carinae evident in the anterior half of the segment and obscured by dense granulation in the posterior half, compared with juveniles (including the holotype) in which ventral granulation is present only in the posterior half. Vestigial LSM carinae are present on metasomal segments III and IV in all specimens (including juveniles), a character not reported in the original description by Botero-Trujillo and Francke (2009). Base coloration also differs between adults and juveniles, varying from dark chestnut in females to yellowish in males and juveniles.

**ECOLOGY:** *Trogloyosicus humiculum* is a troglomorphic endogean (humicolous) species, one of only four troglomorphic scorpions known from South America, the others being *T. vachoni* from Ecuador, the chactid *Broteochactas trezzii* (Vignoli and Kovarik, 2003) from Venezuela, and the buthid *Trogloorhopalurus translucidus* Lourenço et al., 2004, from Brazil (Vignoli and Kovarik, 2003; Lourenço et al., 2004; Volschenk and Prendini, 2008). The holotype of *T. humiculum* was collected in a Winkler trap in primary rainforest (Botero-Trujillo and Francke, 2009). The new specimens reported here were collected by hand in a small patch of mountain rainforest (humid premontane forest sensu Holdridge, 1987) surrounded by deforested grassland (fig. 1A). The specimens were captured at night between 21:00 and 02:00 hours by disturbing leaf litter and scanning the disturbed area with UV light.

All specimens were taken from underneath a deep layer of leaf litter (10–20 cm below the surface). The area in which they were collected had a very steep slope, and specimens were found only where the greatest amount of leaf litter had accumulated, usually at the base of large trees (fig. 1B). No specimens were observed actively moving, but were always found immobile. Upon detection, they usually remained still for a second before tucking in their appendages and turning the metasoma over the body, allowing them to tumble downslope as an escape strategy. Three other scorpion species, *Ananteris dorae* Botero-Trujillo, 2008, *Tityus cuellari* Lourenço, 1994, and *Teuthraustes* sp., were collected in sympatry with *T. humiculum*.

**DISTRIBUTION:** *Trogloyosicus humiculum* is currently known only from the Nariño Department of southwestern Colombia (fig. 12). The holotype was collected in La Planada Natural Reserve, at an elevation of 1885 m on the western slopes of the Andes, close to the border with Ecuador. The new specimens of *T. humiculum* were collected in the Ricaurte Municipality at an elevation of 1617 m. Both records fall within the northwestern Andean montane forests, a region with unusually high diversity and endemism due to the Andean topography and a pronounced period of isolation. Botero-Trujillo and Francke (2009) suggested that La Planada could be a center of scorpion endemism because the three scorpion species described from there (*A. dorae*, *T. cuellari*, and *T. humiculum*) had not been collected elsewhere. This suggestion was falsified by the 2008 expedition to Nariño Department, during which all three species were collected at other localities, suggesting that this region is poorly sampled and the putatively restricted distributions of the three species are a sampling artifact.

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