Catalogue of the scorpions of Paraguay, with an illustrated key and biogeographical assessment (Arachnida: Scorpiones: Ananteridae, Bothriuridae, Buthidae)

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ABSTRACT: We review and map the current distribution of the Paraguayan scorpion fauna using a hierarchical system of reliability, differentiating specimens examined, specimens not examined and photographic records. One new species (*Bothriurus* sp.), two new national records (*Brachistosternus simoneae* and *Ananteris mariaterezae*), and nineteen new departmental distribution records are reported. The national fauna is concluded to be composed of at least fifteen species in five genera and three families, with one other species considered to be of hypothetical occurrence and a further two of probable occurrence. An illustrated key suitable for identifying Paraguayan material is included, and comments regarding taxonomy and systematic problems that remain to be resolved, together with proven and potential medical significance, are provided.
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KEY WORDS: *Ananteris*, biogeography, *Bothriurus*, *Brachistosternus*, *Timogenes*, *Tityus*.

Каталог скорпионов Парагвая с иллюстрированным определителем и биогеографической оценкой (Arachnida: Scorpiones: Ananteridae, Bothriuridae, Buthidae)

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РЕЗЮМЕ: С учетом исследованных и неисследованных экземпляров, а также находок по фотографиям дан обзор фауны и карты распространения скорпионов Парагвая. Отмечен один новый для науки вид (*Bothriurus* sp.), две новых находки для Парагвая (*Brachistosternus simoneae* и *Ananteris mariaterezae*), а также 19 новых находок для разных департаментов страны. Фауна страны представлена по крайней мере 15 видами скорпионов из 5 родов и 3 семейств; еще один вид встречается гипотетически, а находки еще двух вероятны. Даны ключ для определения скорпионов Парагвая, а также комментарии по их таксономии и доказанному и возможному медицинскому значению.
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КЛЮЧЕВЫЕ СЛОВА: *Ananteris*, биогеография, *Bothriurus*, *Brachistosternus*, *Timogenes*, *Tityus*.

Introduction

With thirteen species reported in three families (Ananteridae, Buthidae, and Bothriuridae), the scorpion fauna of Paraguay has been described as comparatively less diverse in comparison to neighbouring countries (Lourenço, 1994; Dupré, 2016; Borges *et al.*, 2025). When compared to the at least 50 species recorded from Argentina (Ojanguren-Affilastro, 2005), 24 from Bolivia (Acosta, Ochoa, 2002; Humboldt-Papusatchis, 2023) and approximately 180 from Brazil (Porto *et al.*, 2010, Bertani *et al.*, 2025), its biodiversity appears significantly lower. However, this comparison may be misleading given the vast differences in geographic area among these countries, as well as Paraguay's limited orographic complexity. Low topographic relief, combined with marked gradients of aridity and seasonality, are known to influence speciation in South American scorpions, particularly in taxa associated with open and dry environments (Barraza *et al.*, 2025).

Although Paraguay is commonly subdivided into five major ecoregions based primarily on floristic criteria, recent biogeographic analyses have identified 129 areas of endemism for insects, reptiles, amphibians, and birds within the country (Ávila-Torres *et al.*, 2023). This fine-scale biogeographic structuring suggests that Paraguay may harbor unrecognized scorpion diversity, including cryptic or narrowly distributed species, especially in transitional zones between the Chaco, Cerrado, Pantanal, and Atlantic Forest domains.

Accurate delimitation of the distribution of medically important scorpion species, especially *Tityus* spp., is needed in Paraguay and across the region, given the increasing public health significance of scorpion envenomation (SE) in the Southern Cone of the Americas. Historically, SE has been recognized in Paraguay since the 1950s and 1960s (Gatti, 1956; Canese, 1966), but changes in its epidemiological dynamics — driven by anthropic interventions (including deforestation) and climate change — have led to an increase in incidence in urban centres (Borges *et al.*, 2024). With an estimated mortality rate of 58.27 deaths per 100,000 inhabitants for the period 2022–2023, considerably higher than that of neighboring Argentina and Brazil, and primarily associated with the parthenogenetic species *Tityus confluens* and the sexual species *Tityus trivittatus* (Borges *et al.*, 2024), the need to refine the distribution map of Paraguayan species to better delineate envenomation risk areas is evident.

Additionally, growing genetic, morphometric, and toxinological evidence has revealed extensive cryptic diversity in scorpions, resulting in species-specific (Borges *et al.*, 2020b) as well as population-specific (Safdarian *et al.*, 2022)

venom lineages which may produce divergent clinical outcomes and response to antivenoms. Knowledge of the distribution of other scorpion species prevalent in Paraguay, supposedly lacking medical importance, such as *Bothriurus* spp. and *Brachistosternus* spp. is also relevant as they produce toxins that can elicit manifestations in hypersensitive individuals (Brito, Borges, 2015; Dos Santos *et al.*, 2016). Our work aligns with this need by providing a baseline diversity map to support the control, prevention, and species-targeted treatment of SE.

One undescribed species, two new national records and a total of nineteen new departmental records are published for the first time here from the previously unpublished Colección Zoológica Para La Tierra, including the first specimen records from the departments of Ñeembucú and San Pedro, in the Humid Chaco and Cerrado ecoregions respectively.

Historical overview of scorpion studies in Paraguay

There has historically been very limited interest in the national scorpion fauna shown by either biologists resident in, or visiting, Paraguay. The first scorpion species to be documented for Paraguay were thus two newly described species by Karl Kraepelin: *Tityus paraguayensis* Kraepelin, 1895 and *T. trivittatus* Kraepelin, 1898. Kraepelin (1899) also referred to Paraguay in the distribution of *Zabius fuscus* (Thorell, 1876), taking the number to three species. This species was subsequently included in other major reviews of South American scorpions that referenced Paraguayan fauna (Mello-Leitão, 1945; Maury, 1984a; Lourenço, 1994). However, the basis for its inclusion in the national list was never clearly established and it is now considered to have been included in error.

The first major scorpion collection from Paraguay resulted from Dr. Alfredo Borelli's second South American expedition, conducted between July and August of 1893. The specimens were later published by Borelli himself (Borelli, 1899, 1901). Borelli documented three or four additional species, making a total of 5 or 6 species from Paraguay: *Ananteris festae* (probably = *A. balzanii* Thorell, 1891), *Tityus bahiensis* (Perty, 1834), *T. paraguayensis*, *T. trivittatus*, *Bothriurus bonariensis* (= potentially *B. jesuita* Ojanguren Affilastro, 2003 and *B. guarani* Maury, 1984), representing almost half of the species known to occur in the country today. None, however, were described as new for science.

Günther Reimoser then collected scorpions for the Hofmuseum of Vienna during 1907 and 1908, with Paraguayan specimens dated from October 1907 until April 1908. His collection was published by Penther (1913) and contained six species under five names: *Ananteris balzanii*, *Tityus paraguayensis*, *T. trivittatus*, *Brachistosternus weijenberghi* (= *B. ferrugineus* (Thorell, 1876)) and *Bothriurus vittatus* (=*B. jesuita* and *B. guarani*). He was the first author to use the name *Ananteris balzanii* in preference to *A. festae* Borelli, 1899, which is a species now considered endemic to Ecuador (Brito, Borges, 2015). Some of the specimens assigned to the name *Bothriurus vittatus* from Estancia Foncierre, Concepción department, would later form part of the type series of *B. guarani* (Maury, 1984b). The total number of species recorded under various synonyms until this point was thus at least seven, with the missing species largely associated with the Chaco region west of the Paraguay River, which was virtually unexplored at that time.

The first modern list of Paraguayan species to make reference to museum specimens and specific localities was by Maury (1984a) and included twelve species, with *Bothriurus moojeni* Mello-Leitão, 1945, *Timogenes elegans* (Mello-Leitão, 1931) (Bothriuridae), *Tityus confluens* Borelli, 1899 and *Tityus mattogrossensis* Borelli, 1901 (Buthidae), all being cited for Paraguay the first time in this work. As well as compiling previously published records, this work drew heavily on new material from the collections in the Paraguayan Chaco by Dr. Jorge Cranwell (Museo Argentino de Ciencias Naturales, MACN), in the 1940s and on the expeditions of the Geneva Museum of Natural History (MHNG) coordinated by Carlo Dlouhy, which began in 1979 (Vallotton, Smith, 2021). The first key to Paraguayan species was the next major publication, including the same species with minor nomenclatural changes (Lourenço, 1994). Both of these lists however, continued to include the doubtful species *Zabius fuscus*, despite questioning the validity of its inclusion. The two final Paraguayan species to be added were *Timogenes dorbignyi* (Guérin-Méneville, 1843), one of four species collected during the

Hamburg Museum expedition to the Dry Chaco between January and February of 2001 (Ziegler, Lourenço, 2002) and the medically important *Tityus carrilloi* Ojanguren Affilastro *et al.*, 2021 from urban areas in southern Paraguay (Borges *et al.*, 2025).

The first Paraguayan published zoological work dealing with scorpions was not until Kochalka *et al*. (1996) provided a preliminary list of material housed in the Museo Nacional de Historia Natural del Paraguay. Only two species names were used (*Timogenes elegans* and *Tityus trivittatus*) and one generic name *Bothriurus* sp., all identified by Oscar F. Francke in 1984. A third family Vaejovidae was erroneously included but no species or genera were listed under it, though Guerrero & Kochalka (2015) later confirmed this referred to a specimen of *Ananteris balzanii* (Catalogue Number IBNP-Invert.-JAK-CR-000.027.001).

Major advances were the publication of modern reviews of the distribution of the genera *Ananteris*, *Tityus*, *Brachistosternus* and *Timogenes* based on material deposited in the Museo Nacional de Historia Natural del Paraguay (Guerrero, Kochalka, 2015; Guerrero *et al*., 2017). These key works greatly improved our knowledge of the biodiversity and biogeography of Paraguayan scorpions, and updated the taxonomy. Guerrero *et al*. (2017) also provided the first detailed biogeographical discussion of the Bothriurid genera it reviewed.

The most recent national list by Dupré (2016) unfortunately provides no reference to specimens, but does present a departmental distribution for 12 species. This list differs from previous lists by including both *Bothriurus chacoensis* (presumably following Maury & Acosta, 1993) and *B. jesuita* (source not stated), and excluding *Zabius fuscus* and *B. moojeni*. Whilst we consider these decisions largely reasonable, the lack of explanation for the taxonomic decisions taken left many questions unanswered, and with scorpion taxonomy in a constant state of flux, many gaps still remain to be filled.

Taking the list by Dupré (2016) as a base line, and following a revision of museum specimens, we add three further species to the national list here: *Bothriurus* sp., *Brachistosternus simoneae* Lourenço, 2000 (Bothriuridae) and *Ananteris mariaterezae* Lourenço, 1984 (Ananteridae); and remove one other *Bothriurus chacoensis*. With this publication we aim to set an updated base line for future studies by summarising what is known, what remains unknown and what requires further clarification.

Material and Methods

We reviewed the Paraguayan scorpion literature and previously unpublished specimens deposited in the Colección Zoológica Para La Tierra (CZPLT-Ar; Curator Rebbeca L. Smith) (218 specimens) supplemented with a few specimens from the Museo Nacional de Historia Natural del Paraguay (MNHNP; Curator John Kochalka) (8 specimens) (Suppl. table 1). Identifications were made using the primary literature (see references cited), and the diagnostic characteristics found to be useful for identification of Paraguayan material specifically were used to produce an illustrated identification key. Specimens were examined using a AmScope SZM stereo microscope with AmScope software and photographs of specimens were taken using an AmScope MU1003 10MP digital camera. Morphological nomenclature follows Stahnke (1971).

We examined online sources of photographs (iNaturalist, pybio.org and faunaparaguay.com) with specific Paraguayan localities and, where these could be confidently assigned to species, we included records in the distribution. Nonetheless, non-specimen records and specimens not examined by the authors are considered to be subject to a much greater likelihood of misidentification, and thus these are differentiated on the mapped distributions. Political departments in Paraguay are shown in Map 1.

Museum codes: AMNH — American Museum of Natural History; CZPLT-Ar — Colección Zoológica Para La Tierra, Pilar, Paraguay; IBSP — Instituto Butantan, São Paulo, Brazil; MACN — Museo Argentino de Ciencias Naturales, Buenos Aires, Argentina; MHNG — Museum d'Histoire Naturelle, Geneva, Switzerland; MIZT — Museo di Istituto di Zoologia Sistematica, Torino, Italy; MNHNP — Museo Nacional de Historia Natural del Paraguay, Asunción; MTD — Staatliche Naturhistorische Sammlungen Dresden (Museum für Tierkunde), Germany; NHM — Natural History Museum, London, UK; NMV — Naturhistorisches Museum Wien, Vienna, Austria; ZMH — Zoologisches Museum Hamburg, Germany.

ANANTERIDAE Pocock, 1900
Genus *Ananteris* Thorell, 1891

Chaco yellow-fingered scorpion *Ananteris balzanii* Thorell, 1891
Figs 1a,b, 3a–d, Map 2.

A.[nanteris] balzanii Thorell, 1891: 66.



Map 1. Map showing the Paraguayan political departments. Departments as follows: Chaco region — Alto Paraguay (APY), Boquerón (BOQ), Presidente Hayes (PHA); Oriental region — Amambay (AMA), Alto Paraná (APA), Caaguazú (CAA), Canindeyú (CAN), Caazapá (CAZ), Central (CEN), Concepción (CON), Cordillera (COR), Guairá (GUA), Itapúa (ITA), Misiones (MIS), Ñeembucú (ÑEE), Paraguarí (PAR), San Pedro (SPE).

Type locality: "Mato Grosso", Brazil.

Ananteris festae — Borelli, 1899; Penther, 1913; Maury, 1984a.

Examined specimens (n=1)

BOQUERÓN: Fortín Toledo (CZPLT-Ar 178).

Specimens not examined

CONCEPCIÓN: Between Estancia Estrellas and Estancia Primavera (MHNG) (Maury, 1984a); Horqueta (MNHNP) (Guerrero, Kochalka, 2015); Puerto Foncierre (NMV) (Penther, 1913; Maury, 1984a).

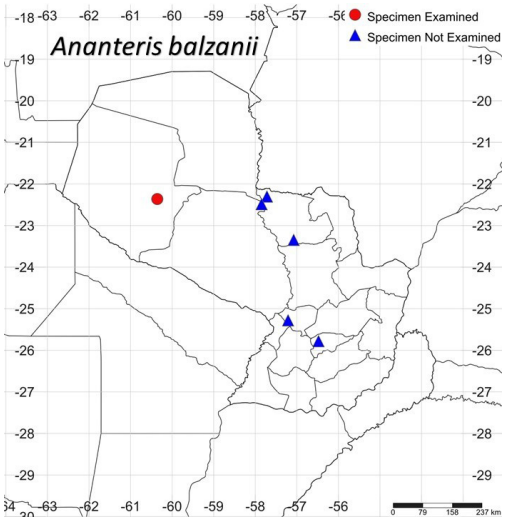
CORDILLERA: Atyrá (MNHNP) (Guerrero, Kochalka, 2015).

GUAIRÁ: Villarrica (MIZT) (Borelli, 1899; Maury, 1984a).

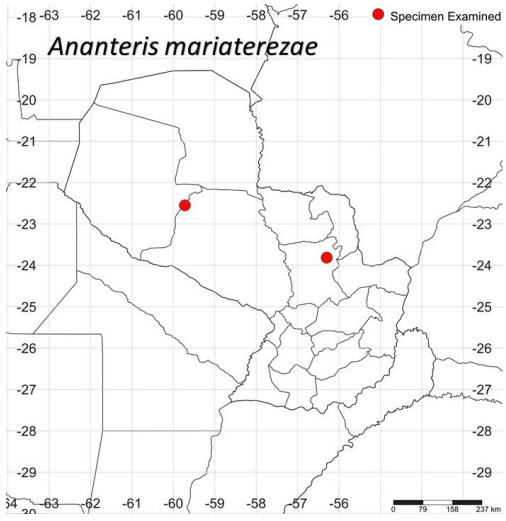
Kraepelin (1899) lists it for "northern Paraguay".

Distribution in neighbouring countries: ARGENTINA: Salta, Santiago del Estero (Ojanguren Affilastro, 2005); BOLIVIA: Santa Cruz (Montaño *et al.*, 2024); BRAZIL: Paraná, São Paulo, Minas Gerais, Mato Grosso, Mato Grosso do Sul, Goiás, Pará (Giupponi *et al.*, 2009; Carvalho *et al.*, 2017).

Comments: This is the first record of the species in the Chaco region of Paraguay with a specimen from Boquerón department. Dupré (2016) listed this species only from Concepción. Guerrero *et al.* (2018) illustrate an individual identified as "*Ananteris* sp. 1" and map a locality in Cordillera department which may refer to the specimen listed here for that department. We were unable to examine this specimen but concur in that it differs phenotypically from the two species of



Map 2. Paraguayan distribution of *Ananteris balzanii*.



Map 3. Paraguayan distribution of *Ananteris mariaterezae*.

Ananteris documented for Paraguay and that it may indeed represent a third species. However, further studies are required to confirm its identity.

Cerrado yellow-fingered scorpion *Ananteris mariaterezae* Lourenço, 1982
Figs A, 2a,b, 3a–d, Map 3.

Ananteris mariaterezae Lourenço, 1982: 124.

Type locality: "Brésil: Goiás, Ilha do Bananal, Parque Nacional do Araguaia" = Ilha do Bananal, Tocantins, Brazil.

Examined specimens (n=25)

PRESIDENTE HAYES: Laguna Capitán (CZPLT-Ar 173, 868).

SAN PEDRO: Rancho Laguna Blanca (CZPLT-Ar 66, 90–94, 96–98, 111–113, 143–144, 151, 165A–G, 182) (Fig. A)

Distribution in neighbouring countries: BRAZIL (Mato Grosso, Mato Grosso do Sul, Tocantins) (Lourenço, 1982; Carvalho *et al.*, 2017).

Comments: This is the first record of this species from Paraguay where it was collected in sandy soil Cerrado in the Oriental region and at the interface of Humid Chaco/Dry Chaco habitats west of the Paraguay River. Presence in similar habitats in Amambay and Alto Paraguay departments, and perhaps eastern Concepción and extreme northern Canindeyú departments might be suspected.



Fig. A. *Ananteris mariaterezae* Rancho Laguna Blanca, San Pedro department. (Olga Petko).



Fig. B. *Tityus bahiensis* Barrio Villas del Carmen, 24 km W of Encarnación on Ruta I, Itapúa department. (Yasmine Maluff).

BUTHIDAE C.L. Koch, 1837
Genus *Tityus* C.L. Koch 1836

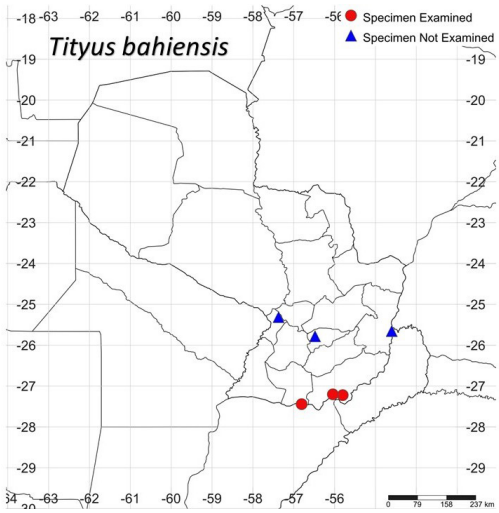
"*bahiensis*" group of Lourenço & Pézier (2002)

Bahía thick-tailed scorpion *Tityus bahiensis* (Perty, 1834)
Figs B, 3d, 4a,b, 10a–b, Map 4.

Scorpio bahiensis Perty, 1834: 200.
Type locality: "Bahiam" (=Bahía), Brazil.

Examined specimens (n=4)

ITAPÚA: Barrio Villas del Carmen, 24 km W of Encarnación on Ruta I (CZPLT-Ar 952, 957) (Fig. B); Capitán Miranda (CZPLT-Ar 973); Isla Yacyretá near Estancia Melgarejo (MNHNP 27.069) (Guerrero, Kochalka 2015).



Map 4. Paraguayan distribution of *Tityus bahiensis*.

Specimens not examined

ALTO PARANÁ: Puerto Bertoni (MIZT) (Borelli, 1901; Maury, 1984a).

CORDILLERA: San Bernardino (Penther, 1913; Maury, 1984a).

GUAIRÁ: near Villarrica (MIZT) (Borelli, 1899; Maury, 1984a).

Distribution in neighbouring countries: ARGENTINA: Corrientes, Misiones, Santa Fe (Ojanguren Affilastro, 2005); BRAZIL: Goiás, Mato Grosso do Sul, Minas Gerais, Paraná, São Paulo (Lourenço, 2015; Carvalho *et al.*, 2017).

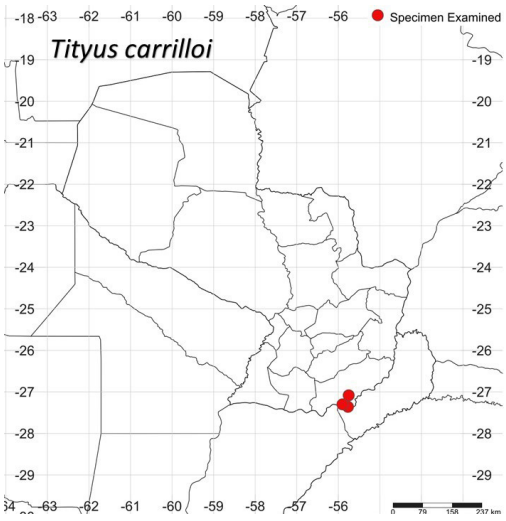
Comments: *Tityus bahiensis* is regarded as an uncommon species in Paraguay, and, within the national context, is encountered less frequently than other peridomestic *Tityus* scorpions of potential medical importance. Dupré (2016) listed this species from Alto Paraná, Cordillera, Guairá and Itapúa. Although *T. bahiensis* is considered medically important in Brazil, where it contributes to scorpion envenomation cases, its venom is generally less toxic than that of the widespread and highly medically significant *Tityus serrulatus* (Lourenço, 2015). In Paraguay, the relative public health impact of *T. bahiensis* compared to other local *Tityus* species has not been rigorously assessed.

"*trivittatus*" group of Ojanguren Affilastro *et al.*, (2017)

Two-lined thick-tailed scorpion *Tityus carrilloi* Ojanguren Affilastro, Kochalka, Guerrero-Orellana, Garcete-Barrett, de Roodt, Borges et Ceccarelli, 2021
Figs C, 3d, 5, 10a–c, Map 5.



Fig. C. *Tityus carrilloi* Cambyretà, Itapùa department. (Matthew Owen).



Map 5. Paraguayan distribution of *Tityus carrilloi*.

Tityus carilloi Ojanguren Affilastro *et al*., 2021: 31.
Type locality: "Chaco Province, Paraje La Armonia", Argentina.

Examined specimens (n=8)

ITAPÚA: Cambyretá (CZPLT-Ar 869, 897, TCA039) (Fig. C) (Borges *et al.*, 2025); Encarnación (TCA005–006, TCA020, TCA044); Hohenau (TCA046).

Distribution in neighbouring countries: Near the banks of the Upper Paraná River in northeastern ARGENTINA: Chaco, Corrientes, and Misiones (Ojanguren Affilastro *et al.*, 2021; Borges *et al.*, 2025).

Comments: TCA codes refer to captive live animals, which will be subsequently housed in CZPLT. A peridomestic species recently split from *T. trivittatus* (which it closely resembles), this species was recently confirmed to be present in Paraguay (Borges *et al.*, 2025). *T. carrilloi* and *T. trivittatus*, despite morphological similarities, have been shown to diverge in terms of species-specific toxins and venom recognition by therapeutic antivenoms (Borges *et al.*, 2020a).

Chaco thick-tailed scorpion *Tityus confluens* Borelli, 1899
Figs D, E, 3d, 6a,b, 10a–c, Map 6.

Tityus trivittatus var. *confluens* Borelli, 1899: 5.
Type locality: "Caiza, (Chaco Boliviano)", Bolivia.

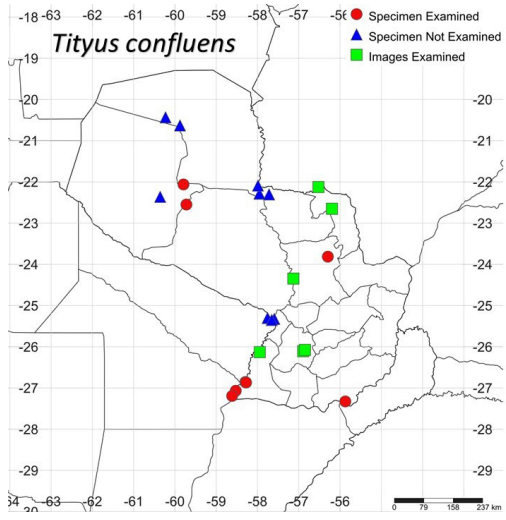
Specimens examined (n=22)

BOQUERÓN: Comunidad Indígena Tunokojai (CZPLT-Ar 119).

ITAPÚA: Encarnación (CZPLT-Ar 899–900, 902–903).

ÑEEMBUCÚ: Humaitá (CZPLT-Ar 888); Paso Canoa (CZPLT-Ar 825); Pilar (CZPLT-Ar 816, 828, 832, 834, 866, 889–891); Yegros Paso (CZPLT-Ar 948).

PRESIDENTE HAYES: Laguna Capitán (CZPLT-Ar 171) (Fig. D).



Map 6. Paraguayan distribution of *Tityus confluens*.



Fig. D. *Tityus confluens* with dark fingers and metasoma, Laguna Capitán, Presidente Hayes department. 24 IX 2014 (Paul Smith).



Fig. E. *Tityus confluens* with pale fingers and metasoma, Parque Nacional Cerro Corà, Amambay department. 23 X 2024 (Carlos Ortega).

SAN PEDRO: Rancho Laguna Blanca (CZPLT-Ar 64, 69, 135, 149, 898).

Specimens not examined

ALTO PARAGUAY: Fortín Madrejón (MNHNP) (Guerrero, Kochalka, 2015); Parque Nacional Defensores del Chaco (MNHNP) (Guerrero, Kochalka, 2015); Puerto Casado (MACN) (Maury, 1974b, 1984); No exact locality (MNHNP) (Guerrero, Kochalka, 2015).

BOQUERÓN: Fortín Toledo (MTD) (Ziegler, Lourenço, 2002).

CENTRAL: Asunción (IBSP, MNHNP) (Bertani *et al.*, 2005; Guerrero, Kochalka, 2015); Fernando de la Mora (MNHNP) (Guerrero, Kochalka, 2015); Lambaré (MNHNP) (Borges, Rojas de Arias, 2019).

CONCEPCIÓN: Between Estancia Estrellas and Estancia Primavera (MHNG) (Maury, 1974b, 1984a); Río Apa (AMNH) (Maury, 1974b, 1984a).

Images examined

AMAMBAY: Bella Vista del Norte (José Maciel); Parque Nacional Cerro Corá (Carlos Ortega) (Fig. E).

CORDILLERA: Minas Cue (Joaquín Movia, https://www.inaturalist.org/observations/70245462).

ÑEEMBUCÚ: Zanjita Yvy Ata (Ulf Drechsel, https://www.pybio.org/en/216/scorpiones/).

PARAGUARÍ: Parque Nacional Ybycuí (Guillermo Menéndez https://www.inaturalist.org/observations/318553021).

SAN PEDRO: Rio Paraguay due west of Comunidad Indigena Las Palmas Urukuy (Dominic Oviedo Löwen https://inaturalist.ala.org.au/observations/262742405).

Distribution in neighbouring countries: Northwestern and west-central ARGENTINA: Catamarca, Chaco, Córdoba, Corrientes, Formosa, Jujuy, La Rioja, Salta, Santa Fe, Santiago del Estero, Tucumán (Ojanguren Affilastro, 2005); Southeastern BOLIVIA: Santa Cruz, Tarija (Acosta, Ochoa, 2002; Humboldt Paputsachis, 2003; Montaño *et al.*, 2024); BRAZIL: Ceará, Mato Grosso, Mato Grosso do Sul, Paraná, Piauí, Tocantins (Carvalho *et al.*, 2017; Goldoni *et al.*, 2025b); URUGUAY: Colonia (Dupré, 2016).



Fig. F. *Tityus trivittatus:* dark morph (left), Rancho Laguna Blanca, San Pedro department. I 2015 (Olga Petko, Fundación Para La Tierra); pale morph (right) Villa Florida, Misiones department VIII 2026 (Paul Smith).

Comments: These are the first records of the species from Amambay, Cordillera, Itapúa, Ñeembucú, Paraguarí, Presidente Hayes and San Pedro departments. *T. confluens* is an abundant, human-associated species, and recent records from across Paraná state in Brazil (Goldoni *et al.*, 2025b) suggest that future sampling will demonstrate that the Paraguayan distribution extends to urban areas throughout the Oriental region of the country.

Tityus confluens is known to have both parthenogenetic and sexually reproductive populations which may show some geographical variation (Seiter, 2012). Perhaps of note here is that the vast majority of examined Paraguayan specimens were female, including all of those from Ñeembucú (n=11), Itapúa (n=4), Boquerón (n=1) and Presidente Hayes (n=1), whilst those from San Pedro (n=5) consisted of two males and three females. The parthenogenicity of Paraguayan populations (proven in the case of Argentinian specimens) remains to be determined, but such skewed sex ratios suggest that further study in this area might prove fruitful.

This species has been associated with four infant deaths in the period 2022–2023 in several locations of eastern Paraguay (Borges *et al.*, 2024).

Three-lined thick-tailed scorpion *Tityus trivittatus* Kraepelin, 1898
Figs F, 3d, 9a,b, 10a–c, Map 7.

Tityus trivittatus Kraepelin, 1898: 43.

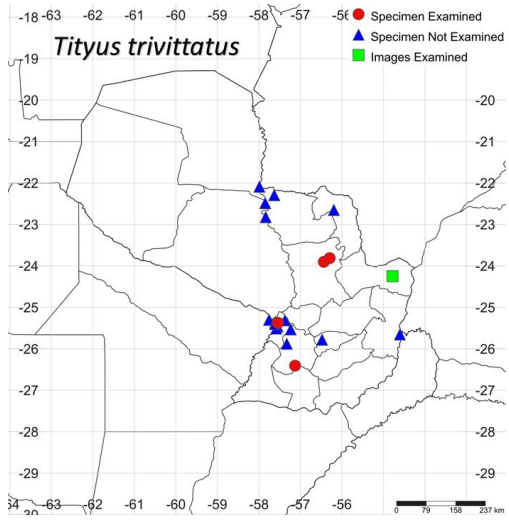
Type locality: "Paraguay (San Salvador am Paraguayfluß).", Paraguay.

Specimens examined (n=8)

CENTRAL: Capiatá (MNHNP 27.079) (Guerrero, Kochalka, 2015).

MISIONES: Villa Florida (TTR 030BI-032BI)

SAN PEDRO: Comunidad Naranjito, Rio Verde (CZPLT-Ar 874); Rancho Laguna Blanca (CZPLT-Ar 139, 158, 163) (Fig. F).



Map 7. Paraguayan distribution of *Tityus trivittatus*.

Specimens not examined

ALTO PARANÁ: Puerto Bertoni (MACN, MIZT) (Maury, 1984a).

AMAMBAY: Parque Nacional Cerro Corá (MNHNP) (Guerrero, Kochalka, 2015).

CENTRAL: Asunción (MHNG, MIZT, MNHNP) (Borelli, 1899; Maury, 1970, 1984a; Lourenço, 1994; Guerrero, Kochalka, 2015; Borges, Rojas de Arias, 2019); Colonia Thompson, Ypané (MHNG) (Maury, 1984a); Ñemby (MNHNP) (Guerrero, Kochalka, 2015); San Lorenzo (MHNG, MNHNP) (Maury, 1984a; Lourenço, 1994; Guerrero, Kochalka, 2015); Villeta (MNHNP) (Guerrero, Kochalka, 2015).

CONCEPCIÓN: Estancia Centurión (NMV) (Penther, 1913; Maury, 1984a); Puerto Foncierre (NMV) (Penther, 1913; Maury, 1984a); Rio Apa (MIZT) (Borelli, 1899; Maury, 1984a); San Salvador (ZMH, Type) (Kraepelin, 1898).

CORDILLERA: Piribebuy, Naranjo (MNHNP) (Guerrero, Kochalka, 2015); San Bernardino, (NMV) (Penther, 1913; Maury, 1984a).

GUAIRÁ: Villarrica (MIZT) (Borelli, 1899; Maury, 1984a).

PARAGUARÍ: Roque González de Santa Cruz (MNHNP) (Guerrero, Kochalka, 2015).

Images examined

CANINDEYÙ: Katueté (wjunniorw, https://www.inaturalist.org/observations/41443341).

Distribution in neighbouring countries: Northeastern and east-central ARGENTINA: Buenos Aires, Chaco, Córdoba, Corrientes, Entre Ríos, La Rioja, San Juan, Santa Fe, Santiago del Estero, Tucumán (Ojanguren Affilastro, 2005); BRAZIL: Mato Grosso do Sul, Paraná (Carvalho *et al.*, 2017; Goldoni *et al.*, 2025a).

Comments: TTR codes refer to live animals in captivity which will be subsequently housed in CZ-PLT. The type locality refers to a now defunct village on the banks of the Paraguay River (at 22°49′00″S 57°47′00″W), Concepción department, not the current town of San Salvador, Guairá department, which does not lie on the Paraguay River and which was founded in 1951 (Maury, 1970; Lourenço, 1980; Ojanguren Affilastro *et al.*, 2020).

Dupré (2016) reports the species from Alto Paraguay without details or precise locality. If correct this would represent the only report west of the Paraguay River. These are the first reports of the species from Canindeyú, Misiones and San Pedro departments. This species, prevalent in domiciles of the Greater Asunción area, produces a venom with high lethality in animal models, and should be considered of medical importance (Borges *et al.*, 2020a).

Occurs in two colour morphs in Paraguay, a dark morph (Fig. F, left) with reduced pale markings on the dorsum, and the typical pale morph (Fig. F, right) with conspicuous dorsal lines. Both of these morphs may occur at the same locality.

"*clathratus*" group of Lourenço & Pézier (2002)

Mato Grosso thick-tailed scorpion *Tityus mattogrossensis* Borelli, 1901
Figs G, H, 3d, 7a,b, 10a–c, Map 8.

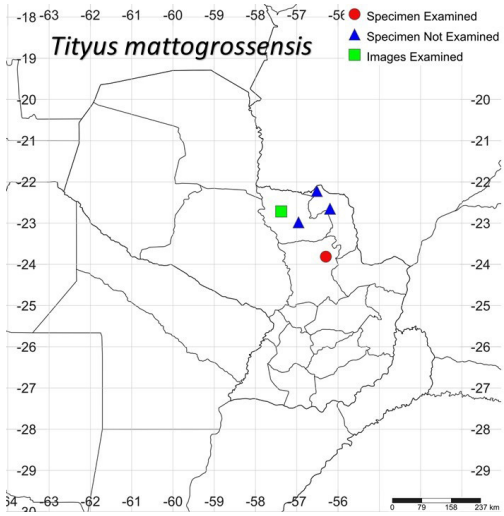
Tityus mattogrossensis Borelli, 1901: 6.



Fig. G. *Tityus mattogrossensis* Rancho Laguna Blanca, San Pedro department. (Olga Petko, Fundación Para La Tierra).



Fig. H. *Tityus mattogrossensis* Estancia Garay Cue, Concepción department. (Ulf Drechsel, www.pybio.org).



Map 8. Paraguayan distribution of *Tityus mattogrossensis*.

Type locality: "Coxipò (Cuyaba), Matto Grosso", Brazil.

Examined specimens (n=3)

SAN PEDRO: Rancho Laguna Blanca (CZPLT-Ar 51, 138, 142) (Fig. G).

Specimens not examined

AMAMBAY: 10 km S of Bella Vista Norte (MHNG) (Maury, 1984a; Lourenço, 1994); Parque Nacional Cerro Corá (MNHNP) (Guerrero, Kochalka, 2015).

CONCEPCIÓN: Estancia Aguerito (MACN) (Maury, 1984a).

Images examined

CONCEPCIÓN: Estancia Garay Cue (Ulf Drechsel, https://www.pybio.org/en/216/scorpiones/) (Fig. H).

Distribution in neighbouring countries: BRAZIL: Bahia, Goiás, Mato Grosso, Mato Grosso do



Fig. I. *Tityus paraguayensis* Estancia Piraty, Itapùa department. (Matthew Owen).

Sul, Minas Gerais (Porto *et al.*, 2010; Carvalho *et al.*, 2017; Mattos *et al.*, 2018).

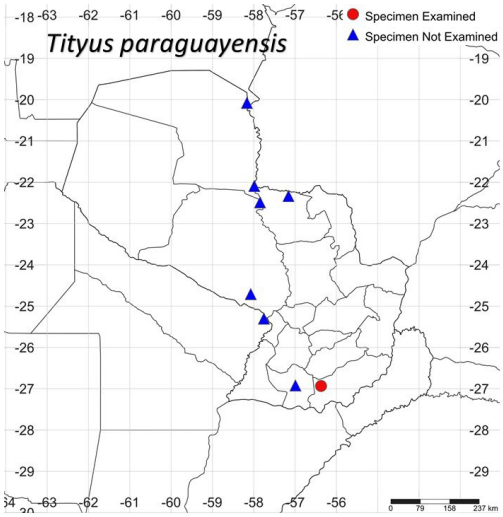
Comments: This is the first record of the species from San Pedro department. As in neighbouring Brazil this species is associated strongly with the Cerrado ecoregion (Porto *et al.*, 2010).

Paraguayan thick-tailed scorpion *Tityus paraguayensis* Kraepelin, 1895
Figs I, 3d, 8a,b, 10a–c, Map 9.

T.[ityus] paraguayensis Kraepelin, 1895: 91.
Type locality: Not stated. Restricted to "Paraguay" by Kraepelin (1899).

Examined specimens (n=3)

ITAPÙA: Estancia Pirity (CZPLT-Ar 884–886) (Fig. I).



Map 9. Paraguayan distribution of *Tityus paraguayensis*.

Specimens not examined

ALTO PARAGUAY: Estación Los Tres Gigantes (MNHNP) (Guerrero, Kochalka, 2015).

CENTRAL: Asunción (NHM) (Maury, 1984a).

CONCEPCIÓN: Estancia Foncierre (NMV) (Penther, 1913; Maury, 1984a); Estancia (NMV) (Penther, 1913; Maury, 1984a); Rio Apa (Borelli, 1899; Maury, 1984a).

MISIONES: 30 km S of San Juan Bautista (MHNG) (Maury, 1984a).

Images examined

PRESIDENTE HAYES: Near Estancia Lamber (Ulf Drechsel, https://www.pybio.org/en/216/scorpiones/).

Distribution in neighbouring countries: Northern ARGENTINA: Buenos Aires, Chaco, Formosa, Santa Fe (Ojanguren Affilastro, 2005); BRAZIL: Mato Grosso, Mato Grosso do Sul, Paraná (Carvalho *et al.*, 2017; Mattos *et al.*, 2018).

Comments: These are the first reports of the species from Itapúa and Presidente Hayes departments. Specimens from the former department were found inside a termite mound in a floodable grassland area that had recently burned. *T. paraguayensis*, along with *T. mattogrossensis*, belong to the *Archaeotityus* subgenus (Lourenço, 2006), whose species are known to produce sodium-channel active toxins and thus they are considered of potential medical importance (Borges *et al.*, 2012).

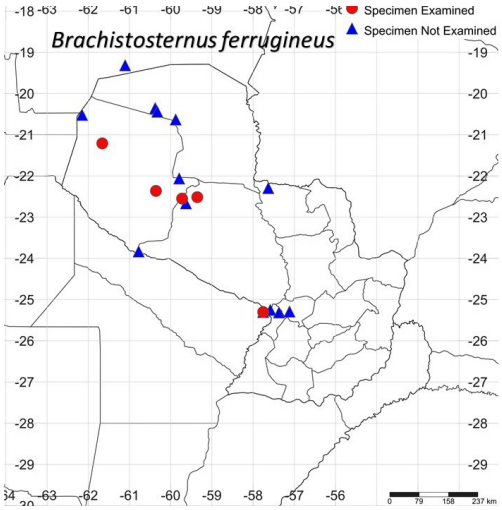
BOTHRIURIDAE Símon, 1880
Genus *Brachistosternus* Pocock, 1893

Chaco small-handed scorpion
Brachistosternus (*Ministernus*) *ferrugineus*
(Thorell, 1876)
Figs J, 11a,b, 13a–c, Map 10.

T.[elegonus] ferrugineus Thorell, 1876: 176.
Type locality: "Argentina".



Fig. J. *Brachistosternus* (*Ministernus*) *ferrugineus* Parque Nacional Teniente Enciso, Boquerón department. 9 X 2004 (Paul Smith).



Map 10. Paraguayan distribution of *Brachistosternus* (*Ministernus*) *ferrugineus*.

Brachistosternus weijenberghi — Kraeplin, 1899, Penther, 1913.

Specimens examined (n=62)

BOQUERÓN: Fortín Toledo (CZPLT-Ar 125–129, 175–177, 179); Parque Nacional Teniente Enciso (CZPLT-Ar 120–124, 174, 901A–D) (Fig. J).

CENTRAL: Asunción (MIZT), (MNHNP 27.011) (Maury, 1984a; Guerrero *et al.*, 2017).

PRESIDENTE HAYES: Chaco Lodge (CZPLT-Ar 879-883); Laguna Capitán (CZPLT-Ar 132–134, 172A–B, 892–895, 896A–Z, 896A–AB).

Specimens not examined

ALTO PARAGUAY: Cerro León (MNHNP) (Guerrero *et al.*, 2017); Palmar de las Islas (MACN) (Maury, 1984a); Fortín Madrejón (MNHNP) (Guerrero *et al.*, 2017); Misión Cué Tribu Nueva, Parque Nacional Defensores del Chaco (MNHNP) (Guerrero *et al.*, 2017); Palmar de las Islas, Estancia San José (MNHNP) (Guerrero *et al.*, 2017).

BOQUERÓN: Comunidad Indígena Tunokojai (MNHNP) (Guerrero *et al.*, 2017); Destacamento Militar General Eugenio A. Garay (MNHNP) (Guerrero *et al.*, 2017); Estancia Centurión (MTD) (Ziegler, Lourenço, 2002); Jesudi, Tunokojai (MNHNP) (Guerrero *et al.*, 2017).

CENTRAL: Asunción (MIZT) (Maury, 1984a; Guerrero *et al.*, 2017); Jardín Botánico, Asunción (MNHNP) (Guerrero *et al.*, 2017).

CORDILLERA: Cerro Tobatí (MNHNP) (Guerrero *et al.*, 2017); San Bernardino (Penther, 1913).

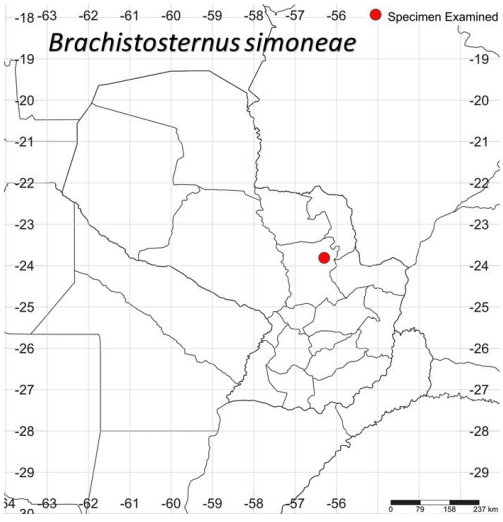
PRESIDENTE HAYES: Campo Verde (MNHNP) (Guerrero *et al.*, 2017); Estación Agrícola Escalante (MACN) (Maury, 1974a, 1984a).

Distribution in neighbouring countries: Northeastern and east-central ARGENTINA: Buenos Aires, Catamarca, Chaco, Córdoba, Formosa, Jujuy, La Pampa, La Rioja, Mendoza, Salta, San Luis, Santa Fe, Santiago del Estero (Ojanguren Affilastro, 2005); Eastern BOLIVIA: Santa Cruz (Acosta, Ochoa, 2002).

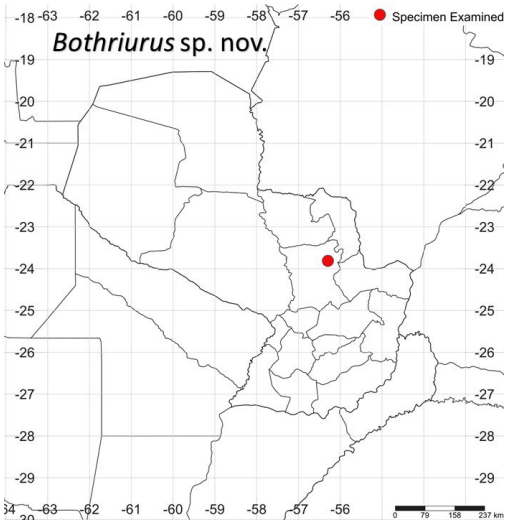
Comments: This is the most abundant scorpion species in most of the Dry Chaco. On 30 April 2025, two individuals at Parque Nacional Teniente Enciso, Boquerón department were observed grasping each other's pedipalps, in what was presumably pre-mating courtship behaviour**.**



Fig. K. *Brachistosternus* (*Ministernus*) *simoneae* Rancho Laguna Blanca, San Pedro department. (Paul Smith).



Map 11. Paraguayan distribution of *Brachistosternus* (*Ministernus*) *simoneae*.



Map 12. Paraguayan distribution of *Bothriurus* sp.

Cerrado small-handed scorpion
Brachistosternus (*Ministernus*) *simoneae*
Lourenço, 2000
Figs K, 12a,b, 13a–d, Map 11.

Brachistosternus simoneae Lourenço, 2000: 94.

Type locality: "Brésil, Etat de Goiás, Serranópolis (Pousada das Araras)".

Specimens examined (n=38)

SAN PEDRO: Rancho Laguna Blanca (CZPLT-Ar 49, 52–54, 57–60, 62–63, 65, 67–68, 70–71, 74–88, 95, 101–103, 114–115, 166B, 180) (Fig. K).

Distribution in neighbouring countries: BRAZIL: Goiás, Mato Grosso do Sul **(**Lourenço, 2000).

Comments: *B. simoneae* Lourenço, 2000 was described from sandy soil Cerrado habitats in Goiás and Mato Grosso do Sul in adjacent Brazil. Ojanguren Affilastro & Ramírez (2009) stated that *B. ferrugineus* is a highly variable species and that the diagnostic characters reported for *B. simoneae* by Lourenço (2000) have been found in some specimens of *B. ferrugineus*. They thus treated *B. simoneae* as a *nomen dubium* pending examination of the holotype. Nonetheless, a later molecular study by the same authors recovered a mixed result (Ojanguren-Affilastro *et al.*, 2016). We note that the specimens we examined conform both morphologically and ecologically to the two species concept, with those in Cerrado areas showing characteristics of *B. simoneae* and those in Chaco areas showing characteristics of *B. ferrugineus*. However, studies of a larger and geographically wider sample are required to discover the exact limits between the two species in Paraguay. This species may be expected to also occur in Cerrado habitats of Amambay, and potentially eastern Concepción and northern Canindeyú departments.

Genus *Bothriurus* Peters, 1861

"*bonariensis*" group of Maury & Acosta (1993)

Laguna Blanca black scorpion *Bothriurus* sp.
Figs 16a,b, 17a–c, Map 12.

Undescribed species with description in prep.

Type locality: "Rancho Laguna Blanca, San Pedro department, Paraguay."

Specimens examined (n=4)

SAN PEDRO: Rancho Laguna Blanca (CZPLT-Ar 56, 136–137, 147).

Distribution in neighbouring countries: This undescribed species is known only from its type locality.

Comments: Specimens from Laguna Blanca do not conform to any known species of *Bothriurus*, but are clearly part of the *bonariensis* group. They show (amongst other autapamorphies) a low number of pectinal teeth, metasomal macrosetae patterns that are intermediate between *Bothriurus pora* and *B. jesuita*, a unique circular macrosetae pattern on metasomal segment four (Fig. 17c), as well as differences in colouration and pedipalp morphology which, in conjunction with the differing ecological setting of the type locality, are consistent with species level differentiation. These characteristics provisionally identify the new species, but the study of these specimens is ongoing. No nomenclatorial acts in reference to this species are proposed in this work and a formal scientific description will be forthcoming.



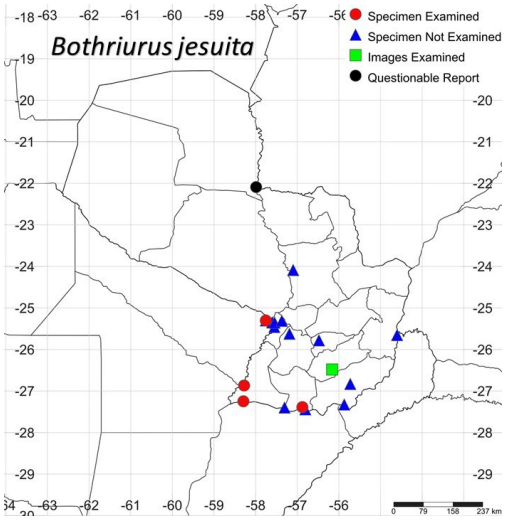
Fig. L. *Bothriurus jesuita* Itá Cora, Ñeembucú department. (George Hicks, Fundación Para La Tierra).

Jesuit black scorpion *Bothriurus jesuita*
Ojanguren Affilastro, 2003
Figs L, 15a,b, 17a–c, Map 13.

Bothriurus jesuita Ojanguren Affilastro, 2003: 56.
Type locality: "Misiones Province: Loreto", Argentina.
Bothriurus vittatus — Borelli, 1899, 1901; Penther, 1913 in part.
Bothriurus bonariensis — Maury, 1984a; Lourenço, 1994.
Bothriurus chacoensis — Garcete-Barrett, Molinas Gonzàlez, 2021.

Specimens examined (n=11)
CENTRAL: Asunción (MNHNP 27.065, 27.066).
MISIONES: Ayolas (MNHNP 27.067).
ÑEEMBUCÚ: Ita Cora (CZPLT-Ar 817–823) (Fig. L); Yegros Paso (CZPLT-Ar 867).

Specimens not examined
ALTO PARANÁ: Puerto Bertoni (MACN, MIZT) (Borelli, 1901; Maury, 1984a).



Map 13. Paraguayan distribution of *Bothriurus jesuita*.

CENTRAL: Asunción (MIZT) (Borelli, 1899; Maury, 1984a); Colonia Thompson, Ypané (MHNG) (Maury, 1984a); San Lorenzo (MHNG) (Maury, 1984a; Lourenço, 1994); Villa del Maestro (MHNG) (Maury, 1984a).
CONCEPCIÓN ?: Rio Apa (MIZT) (Borelli, 1899; Maury, 1984a).
CORDILLERA: San Bernardino (NMV) (Penther, 1913; Maury, 1984a).
GUAIRÁ: Villarrica (MIZT) (Borelli, 1899; Maury, 1984a).
ITAPÚA: Encarnación (MIZT) (Maury, 1984a); Isla Yacyretá (MACN) (Maury 1984a); San Benito-Pastoreo (MHNG) (Maury, 1984a).
MISIONES: Panchito López (MIZT, NHM) (Borelli, 1899; Maury, 1984a).
PARAGUARÍ: Paraguarí (MIZT) (Borelli, 1901; Maury, 1984a).
SAN PEDRO: San Pedro (MIZT) (Borelli, 1899; Maury, 1984a).

Images examined
CAAZAPÁ: 3 de Mayo (Joselí Maciel).

Distribution in neighbouring countries: Northeastern ARGENTINA: Corrientes, Misiones (Ojanguren Affilastro, 2005).

Comments: Paraguayan "black *Bothriurus*" have been historically assigned to *Bothriurus vittatus* (Guérin-Menéville 1838) and later *B. bonariensis* (Koch, 1843), however species diversity in the genus has since been demonstrated to be much greater than was thought at that time, and the range of neither of these species is now thought to reach Paraguay (Mattoni, 2002; Ojanguren Affilastro, 2003). Ojanguren Affilastro (2003) noted a strong ecoregion affiliation of the members of the genus within the *bonariensis* species group in Argentina, with *B. chaocoensis* associated with the Chaco/Espinal region, *B. jesuita* in the Paranaense region and *B. bonariensis* in the Pampean region, whilst records of *B. guarani* (of the *araguayae* species group) suggest a similar association with the Cerrado ecoregion. Based on the localities cited in

Table 1. Meristic values for *Bothriurus chacoensis* and *B. jesuita*.

Source	Total length (mm)	Pectinal teeth	Chela length	Chela height	Chela width	Chela length/ Chela width ratio	Chela length/ Chela height ratio
Bothriurus. chacoensis (Ojanguren Affilastro, 2003)	males 28–35 (mean = 31.5); females 30–36 (mean = 33.8)	males 17–23 females 14–17	NA	NA	NA	males 2.6–3.02 (mean = 2.74) females 3.12–3.36 (mean = 3.24)	males 1.84–2.22 (mean = 1.97) females 2.33–2.52 (mean = 2.4)
Bothriurus jesuita (Ojanguren Affilastro, 2003)	males 39–47 (mean = 44.7); females 52–59 (mean = 55.3)	males 20–23 females 18	NA	NA	NA	males 2.25–2.56 (mean = 2.47) females 2.89–3.01 (mean = 2.93)	males 1.68–1.80 (mean = 1.76) females 2.15–2.24 (mean = 2.21)
CZPLT-Ar 817 (Ñeembucú)	44	21	6.6	3.8	2.8	2.36	1.74
CZPLT-Ar 818 (Ñeembucú)	39	23	7.1	4	2.9	2.45	1.78
CZPLT-Ar 819 (Ñeembucú)	46	20	6.7	3.9	2.7	2.48	1.72
CZPLT-Ar 820 (Ñeembucú)	48	20	7.1	4	2.8	2.54	1.78
CZPLT-Ar 821 (Ñeembucú)	48	21	7.4	4.3	2.9	2.55	1.72
CZPLT-Ar 822 (Ñeembucú)	48	20	7.2	4.2	2.8	2.54	1.69
CZPLT-Ar 823 (Ñeembucú)	47	22	7.3	4.1	2.9	2.52	1.78
CZPLT-Ar 867 (Ñeembucú)	42	21	6.9	3.8	3	2.30	1.82
MNHNP 27.065 (Central)	NA	NA	8	3.7	2.7	2.96	2.16
MNHNP 27.066 (Misiones)	45	21	6.4	3.6	2.6	2.46	1.78
MNHNP 27.067 (Central)	43	20	7.2	4.1	2.8	2.57	1.76

Note that for a confirmed diagnosis both ratios must correspond. All the examined specimens are males except MNHNP 27.065 which is female.

Borelli (1901) his *B. vittatus* represents a multiple mixed species sample, and this probably accounts for at least some of the "great variation" that Borelli (1899, 1901) observed.

We were unable to examine all of the specimens cited here (see methods), but we were able to examine several specimens from Central, Misiones and Ñeembucú departments (n=11), the area of Paraguay directly adjacent to the interface of records of *B. chacoensis* and *B. jesuita* in Argentina (Ojanguren Affilastro, 2003). All these departments are in grassy and swampy Humid Chaco-like habitat east of the Paraguay River, which acts as a natural geographic barrier. All these specimens from Ñeembucú were assignable to *B. jesuita* (Table 1), suggesting strongly that *B. chacoensis* does not cross the Paraguay or Paraná Rivers into the Oriental region of Paraguay. We thus tentatively assign all Paraguayan specimens from the Oriental region that were previously assigned to *Bothriurus bonariensis* or *B. chacoensis* to *B. jesuita* pending a modern review of these specimens. These are the first records of the species from Ñeembucú department. The meristic characteristics for differentiating this species from *B. chacoensis* are detailed in Table 1. (See comments under *B. chacoensis*).

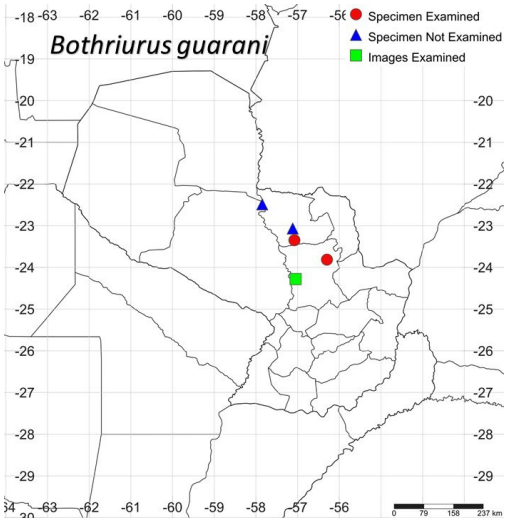
Nonetheless, we note that specimens from Concepción department (Borelli, 1899) might prove to be *Bothriurus guarani*, and recommend that they be re-examined by researchers with access to the material. This hypothesis is based on the comments on ecoregion associations provided by Ojanguren Affilastro (2003) and the fact that, for example Penther (1913) cites *Bothriurus vittatus* from the type locality of *B. guarani* (Foncierre, Concepción department). Furthermore, some specimens that were unavailable for examination, particularly from the eastern portion of the Oriental region, could potentially correspond to other species, such as *B. moojeni* (see comments under that species). Confirmation of these records is required before they can be included in the national species list.

A photographic record from Caazapá department of a female with somewhat reddish pedipalps was considered to belong to *B. jesuita* because of its entirely black colouration including the three distal leg segments and the lack of pale spots on the cephalothorax anterior to the median eyes.

"*araguayae*" group of Lourenço & Maury (1979)

Guarani black scorpion *Bothriurus guarani* Maury, 1984
Figs 14a,b, 17a,b, Map 14.

Bothriurus guarani Maury, 1984b: 194.
Type locality: "Foncierre, departamento Concepción", Paraguay.



Map 14. Paraguayan distribution of *Bothriurus guarani*.

Bothriurus vittatus — Penther, 1913, in part.
Specimens examined (n=27)
CONCEPCIÓN: Horqueta (MNHNP 27.022, 27.042).
SAN PEDRO: Rancho Laguna Blanca (CZPLT-Ar 72–73, 89, 99, 100, 104–110, 145–146, 150, 166A, 167A–F, 181, 836A–B).
Specimens not examined
CONCEPCIÓN: Estancia Foncierre (MACN, NMV Types) (Penther, 1913; Maury, 1984a, b); Estancia Laguna Negra (MHNG) (Lourenço, 1994).
Images examined
SAN PEDRO: Volendam (Dominic Oviedo Löwen https://www.inaturalist.org/observations/143965691).
Distribution in neighbouring countries: This species is endemic to Paraguay.
Comments: See comments under *Bothriurus jesuita*. These are the first records of the species from San Pedro department and the first reported female specimens. This species is associated strongly with the Cerrado ecorregion.

Genus *Timogenes* Simon, 1880

Elegant yellow scorpion *Timogenes elegans* (Mello-Leitão, 1931)
Figs M, 19a,b,c, 20a,b, Map 15.

Bothriurus elegans Mello-Leitão, 1931: 87.
Type locality: "La Rioja", Argentina.
Specimens examined (n=5)
BOQUERÓN: Comunidad Indígena Tunokojai (CZPLT-Ar 116–118).
PRESIDENTE HAYES: Lindendorf, 3 V 2025 (CZPLT-Ar 904–905) (Fig. M).

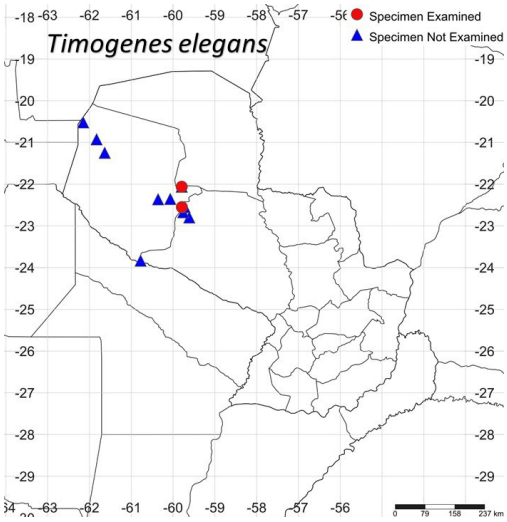


Fig. M. *Timogenes elegans* Lindendorf, Presidente Hayes department. (Matthew Owen).

Specimens not examined

BOQUERÓN: 5 km SE of the administration Parque Nacional Teniente Enciso (MNHNP) (Guerrero *et al.*, 2017); 30 km W of Parque Nacional Teniente Enciso (MNHNP) (Guerrero *et al.*, 2017); Comunidad Indígena Tunokojai (MNHNP) (MNHNP) (Guerrero *et al.*, 2017); Destacamento Militar General Eugenio A. Garay (MNHNP) (Guerrero *et al.*, 2017); Filadelfia (MNHNP) (Guerrero *et al.*, 2017); Fortín Toledo (MTD) (Ziegler, Lourenço, 2002).

PRESIDENTE HAYES: 25 Leguas (MNHNP) (Guerrero *et al.*, 2017); Cruce de Los Pioneros (MNHNP) (Guerrero *et al.*, 2017); Estación Agrícola Escalante (Maury, 1982, 1984a); Laguna Capitán (MNHNP) (Guerrero *et al.*, 2017).



Map 15. Paraguayan distribution of *Timogenes elegans*.

Distribution in neighbouring countries: ARGENTINA: Buenos Aires, Catamarca, Chaco, Córdoba, Entre Ríos, Formosa, Jujuy, La Pampa, La Rioja, Mendoza, Río Negro, Salta, San Juan, San Luis, Santa Fe, Santiago del Estero, Tucumán (Ojanguren Affilastro, 2005); Southeastern BOLIVIA: Tarija (Acosta, Ochoa, 2002).

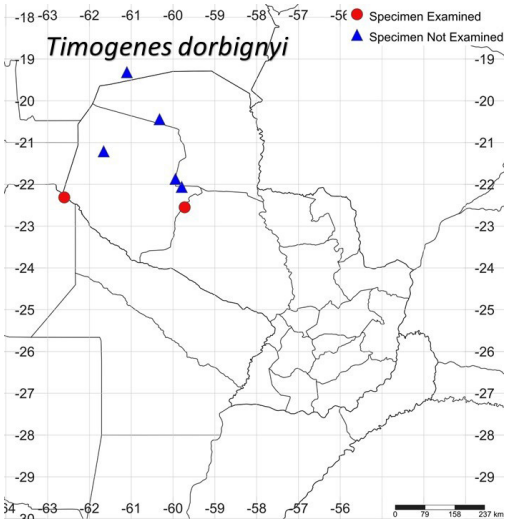
Comments: Paraguayan specimens of the pale ("*forma clara*") and dark forms ("*forma oscura*") referred to by Maury (1982) were examined, with the vast majority of specimens being of the pale form. Maury (1982) seemed to suggest geographic differentiation in the distribution of the two forms, with the dark form occurring in the Argentine precordilleran provinces of Catamarca, La Rioja, San Juan and Mendoza, and the pale form in the Chaco provinces of Formosa, Chaco and Santiago de Estero. The specimens here confirm that the two forms occur sympatrically in the Paraguayan Chaco.

D'Orbigny's yellow scorpion *Timogenes dorbignyi* (Guérin-Méneville, 1843)
Figs N, 18a–c, 20a, Map 16.

Scorpio (*Buthus* Leach) *d'Orbignyi* Guérin-Méneville, 1843: 10.



Fig. N. *Timogenes dorbignyi* Laguna Capitán, Presidente Hayes department. (Matthew Owen).



Map 16. Paraguayan distribution of *Timogenes dorbignyi*.

Type locality: "Bolivie", (=Bolivia).

Specimens examined (n=14)

BOQUERÓN: Prefectura Naval Pozo Hondo (CZPLT-Ar 835).

PRESIDENTE HAYES: Laguna Capitán (CZPLT-Ar 130–131, 170A–C, 870–873, 875–878) (Fig. N).

Specimens not examined

ALTO PARAGUAY: Misión Cué Tribu Nueva, Parque Nacional Defensores del Chaco (MNHNP) (Guerrero *et al.*, 2017); Palmar de las Islas (MNHNP) (Guerrero *et al.*, 2017).

BOQUERÓN: Comunidad Indígena Tunokojai (MNHNP) (Guerrero *et al.*, 2017); Jesudi (MNHNP) (Guerrero *et al.*, 2017); Parque Nacional Teniente Enciso (MNHNP) (Guerrero *et al.*, 2017).

PRESIDENTE HAYES: Laguna Capitán (MTD) (Ziegler, Lourenço, 2002).

Distribution in neighbouring countries: Western and west-central ARGENTINA: Catamarca, Córdoba, Formosa, Jujuy, La Rioja, Mendoza, Salta, San Juan, San Luis, Santiago del Estero, Tucumán (Ojanguren Affilastro, 2005); Lowland eastern BOLIVIA: Beni?, Santa Cruz, Tarija (Acosta, Ochoa, 2002).

Comments: Confined to the more arid areas of the Dry Chaco west of the Paraguay River where it is apparently more common than the largely sympatric *T. elegans*.

Hypothetical species

These are species that have been previously reported to occur in Paraguay but for which we could find no supporting evidence. Nonetheless, with additional sampling and revision of collections unavailable to us we think there exists the possibility that the species could occur in Paraguay.

Chaco black scorpion *Bothriurus chacoensis* Maury et Acosta, 1993

Bothriurus chacoensis Maury et Acosta, 1993: 114.

Type locality: "3 km N Eufrasio Loza, camino hacia Gutemberg, provincia de Córdoba, Argentina."

Distribution in neighbouring countries: ARGENTINA: Catamarca, Chaco, Córdoba, Corrientes, Entre Ríos, Formosa, Salta, Santa Fe, Santiago del Estero, Tucumán (Ojanguren Affilastro, 2005); BOLIVIA: Tarija (Acosta, Ochoa, 2002).

Comments: This species has been regularly included on the Paraguay list, but the source of most of these records seems to be nomenclatural as a catch all name for dark *Bothriurus*, in much the same way that *B. vittatus* and *B. bonariensis* had been used previously. Dupré (2016) made a modern reference to a specimen supposedly of this species from Paraguarí department but provides no information as to the basis of the record and provides no information to support the identification. We suspect that the source is the specimen in the species description that was examined by Maury & Acosta (1993). However, we highlight that this publication predates the descriptions of *B. jesuita* and *B. pora*. Paraguarí lies at the interface of the Paranaense and Chaco ecological zones and with *B. jesuita* associated with the former and *B. chacoensis* associated with the latter (Ojanguren Affilastro, 2003), this area is a potential zone of ecological overlap. We thus prefer to await confirmed specimens before including Paraguarí within the Paraguayan range of the species, and tentatively assign this specimen to *B. jesuita* as all specimens that we examined west of this locality were attributable to that species (see *B. jesuita*).

We are unaware if any material in the MNHNP confirms the presence of *B. chacoensis* in Paraguay,

but do note that published localities for the species in the country are all from the Oriental region and do not conform to existing biogeographic hypotheses about the ecology of the species or the genus and its association with largely Dry Chaco environments (Ojanguren Affilastro, 2003). Nonetheless, we do not discount the possible presence of the species in Paraguay, though might expect it to occur in arid regions of the Chaco in Boquerón and department, or along the Pilcomayo River region of Presidente Hayes department. The meristic characteristics for differentiating this species from *B. jesuita* are detailed in Table 1 (which see for further comments).

Ponta Pora black scorpion *Bothriurus pora* Mattoni et Acosta, 2005

Bothriurus pora Mattoni et Acosta, 2005: 736.
Type locality: "Ponta Pora", Mato Grosso do Sul, Brazil.

Distribution in neighbouring countries: BRAZIL: Mato Grosso do Sul (Mattoni, Acosta, 2005).

Comments: Described on the basis of a single specimen (now lost) showing distinctive hemispermatophore morphology, this species is in the *Bothriurus bonariensis* group which presents considerable identification challenges. The species description lists minor morphological differences from the very similar *bonariensis* group (represented in Paraguay by *B. jesuita* and *B.* sp.), these being chiefly in a more granular ventral surface of metasoma segment V (versus smooth in the *bonariensis* group), patterns of metasomal macrosetae (Fig. 17c) and the dorsal gland of the male telson not being in a large depression (the depression being present in other members of the *bonariensis* group).

We note that the male Paraguayan specimens of *B. jesuita* we examined showed a granular surface of metasoma segment V similar to that described for *B. pora*, though they also showed a prominent depression on the dorsal side of the telson and the metasomal macrosetae pattern expected for the species. Thus, we assigned them to *B. jeusita*. The type locality Ponta Pora, Mato Grosso do Sul, Brazil is a border city contiguous with the city of Pedro Juan Caballero in Paraguay, suggesting that the presence of this species in Paraguay is probably inevitable.

Moojen's black scorpion *Bothriurus moojeni* Mello-Leitão, 1945

Bothriurus moojeni Mello-Leitão, 1945: 179.
Type locality: "Iguaçu, Paraná", Brazil.

Distribution in neighbouring countries: BRAZIL: Paraná.

Comments: Previously reported for Puerto Bertoni, Alto Paraná department (MACN, MIZT) by Maury (1984a). Dupré (2016) omitted this species from the Paraguay list but provided no reason for doing so. However, we tentatively follow this decision as we were unable to examine any Paraguayan specimens of this species and the last Paraguayan report predates the description of the other species of *Bothriurus* species documented in Paraguay. Furthermore, Maury (1984a) simultaneously reports *B. bonariensis* (=*B. jesuita*?) from the exact same locality based on specimens housed in the exact same museums. Aware that this could represent a duplicate record, and being unable to examine the specimens in question, we tentatively assign the specimens to *B. jesuita* following the rationale explained under comments for that species and pending confirmation of the species presence in Paraguay. We reaffirm that this is a deliberately conservative approach, and that we strongly suspect that *B. moojeni* (or a similar species) could be present in the eastern Oriental region of Paraguay.

Mello-Leitão (1945) described *B. moojeni* as entirely black with the three distal segments of the legs yellow, noting that females have 14 pectin teeth and males 16 pectin teeth. We note that the illustration of what is presumably the type specimen by Mello-Leitão (1945) shows 17 pectinal teeth on the right pectin and 16 on the left one. Further complicating matters is the description of the extremely similar *Bothriurus berthae* Ábalos, 1955 with type locality "Iguazú, Misiones", the Argentine side of the same binational park, with *B. moojeni* described from the Brazilian side. We have not been able to examine any specimens of this species, but we find the descriptions of the two to be very similar, and concur with San Martín (1967) and Ojanguren Affilastro (2003) in that they are likely synonyms. Given the uncertainty regarding the possible presence of either of these species in Paraguay, and even the correct nomenclature that would be applicable to them, we refrain from including it on the Paraguayan list until confirmatory material can be examined. Nonetheless, we note that in colouration an unidentified black *Bothriurus* with pale terminal leg segments and a hint of an abdominal midline, that was photographed at Parque Nacional Cerro Corá, Amambay department (Dulcy Vazquez, https://spain.inaturalist.org/observations/249082496), could conceivably refer to one of these two species.

Rejected species

These are species that have been previously reported to occur in Paraguay but for which we could find no supporting evidence. However, we also conclude that they were cited in error, and that the possibility of their occurrence in Paraguay is virtually non-existent.

Mountain blue scorpion *Zabius fuscus* (Thorell, 1876)

I.[sometrus] fuscus Thorell, 1876: 140.

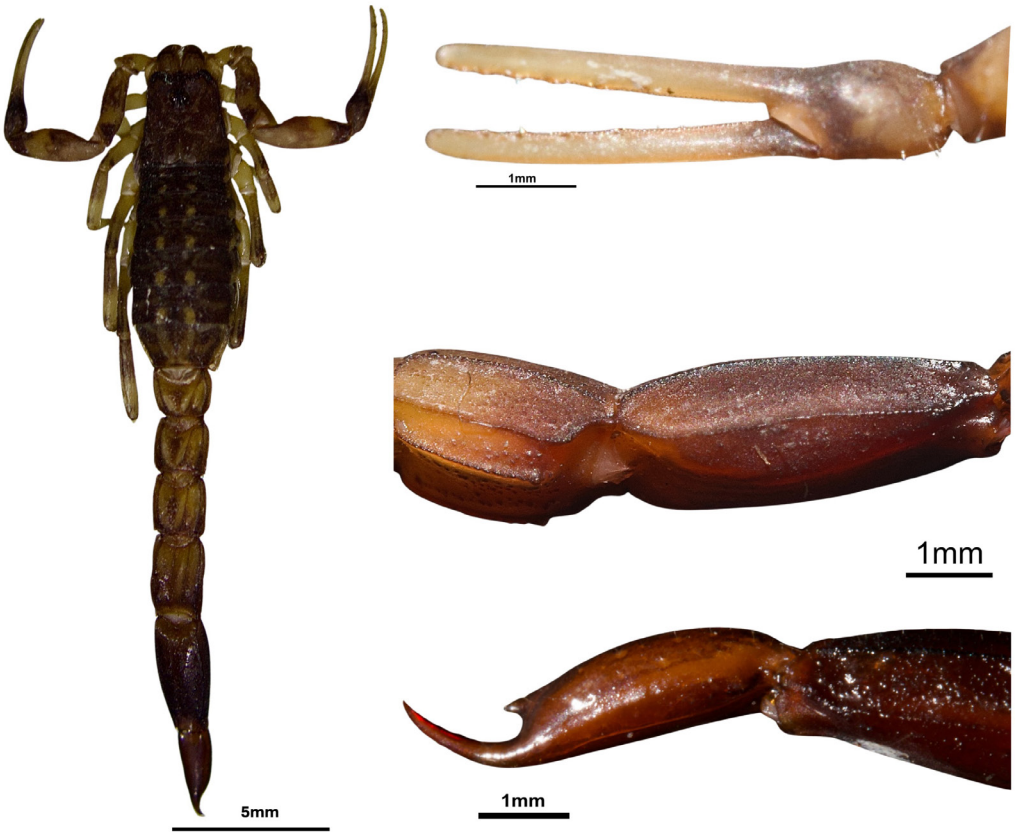


Fig. 1a. *Ananteris balzanii* Thorell, 1891. Left dorsal habitus of CZPLT-Ar-178. Right column pedipalp (top), lateral view of 4th and 5th metasomae (middle), lateral view of telson (bottom).

Type locality: "America merid., Argentina (Cordóva)" = Córdoba, Argentina.

Distribution in neighbouring countries: Central-west ARGENTINA: Catamarca, Córdoba, La Rioja, San Luis and Santiago del Estero (Ojanguren-Affilastro, 2005).

Comments: The first association of this Buthid with Paraguay is by Kraepelin (1895) who gives the distribution as "Argentinien, Paraguay" based on a supposed specimen in ZMH. This has been repeated by subsequent authors (Mello-Leitão, 1945), though Maury (1984a) noted that the species is characteristic of central Argentina and that its presence in Paraguay requires confirmation; this sentiment was later repeated by Lourenço (1994), Guerrero & Kochalka (2015) and Dupré (2016). Given that this species is distributed in mountainous areas of central Argentina, that its documented distribution does not approach Paraguay (Ojanguren-Affilastro, 2005; Avigliano, 2011), and that the specimen (if it exists) lacks an exact locality, we see no reason to retain this species as part of the national fauna.

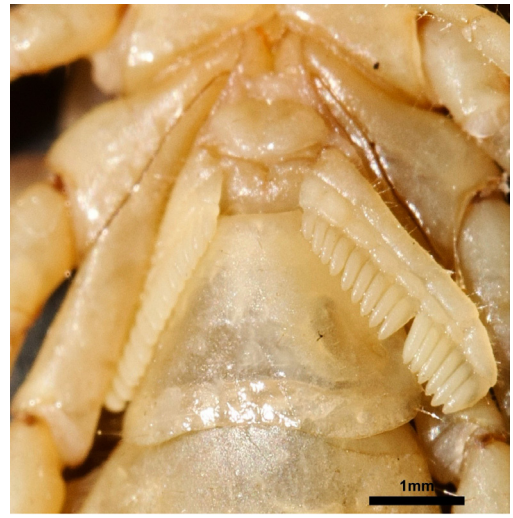


Fig. 1b. Triangular sternum of *Ananteris balzanii* Lourenço, 1982 lacking fulcrae and showing 14 + 15 pectin teeth (CZPLT-Ar-178).

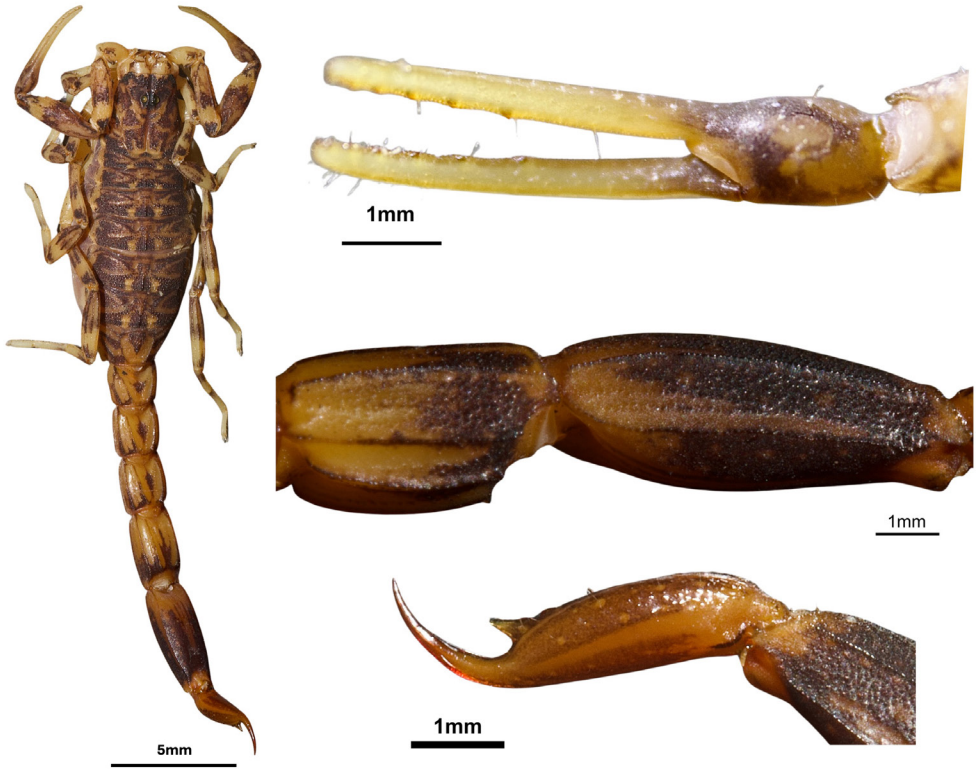


Fig. 2a. *Ananteris mariaterezae* Lourenço, 1982. Left dorsal habitus of CZPLT-Ar-143. Right column pedipalp (top), lateral view of 4th and 5th metasomae (middle), lateral view of telson (bottom).

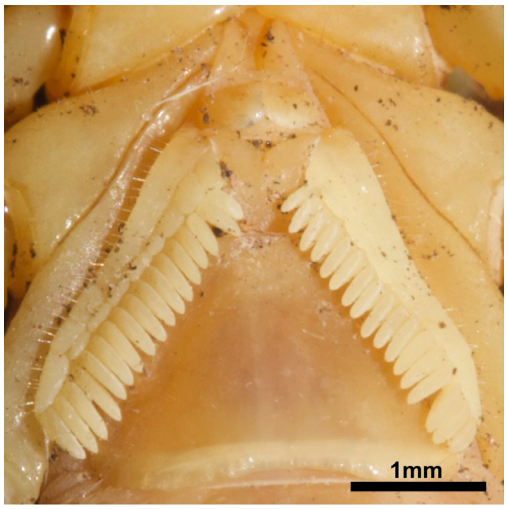


Fig. 2b. Triangular sternum of *Ananteris mariaterezae* Lourenço, 1982 lacking fulcrae and showing 17 pectin teeth (CZPLT-Ar-143).

Key to adults of known Paraguayan species

Application of the key will in some cases require a specimen and magnifying material. Colouration of adults (including dorsal and leg markings) is often useful in Buthidae, but is more subtle in Bothriuridae. For Bothriuridae there are considerable morphological differences in the morphology of the telson and fourth and fifth metasomal segments which are of diagnostic value for Paraguayan species, and in some cases the number of pectinal teeth is also discriminatory in genera with multiple species.

Please note that this key is designed for the identification of Paraguayan material and does not necessarily discern extralimital species that are not included in the key as of "hypothetical" occurrence.



Fig. 3a. Comparative chelicerae and cephalothorax patterns for *Ananteris balzanii* (left) and *A. mariaterezae* (right).



Fig. 3b. Telson of *Ananteris balzanii* (top) and *A. mariaterezae* (bottom).

1a. Pectines without fulcra (Figs 1b, 2b); 3rd and 4th pairs of legs with a tibial spur (Fig. 3d)..... .....**Family Ananteridae 2**

1b. Pectines with fulcra (Figs 4b, 5b, 6b, 7b, 8b, 9b, 11b, 12b, 14b, 15b, 16b); 3rd and 4th pairs of legs without a tibial spur (Figs 3d, 18c, 19c)..... ..... **Families Buthidae and Bothriuridae 3**

2a Chelicerae pale yellow with dark markings restricted to the anterior edge and sides (Fig. 3a right). Base colour yellow, mottled darker (Fig. 3c bottom), with a notable dark "mask" surrounding the median eyes on the cephalothorax (Fig. 3a right). Telson elongate in lateral view with a sharp, triangular sub-spine and long, curved spine (Fig. 3b bottom). Pectin teeth of examined Paraguayan specimens 15–17 (n=26)..... ..... ***Ananteris mariaterezae***



Fig. 3c. Comparative tergite patterns for *Ananteris balzanii* (top) and *A. mariaterezae* (bottom).



Fig. 3d. Tibial spur on the fourth leg of *Ananteris* (left), absent in *Tityus* (right).

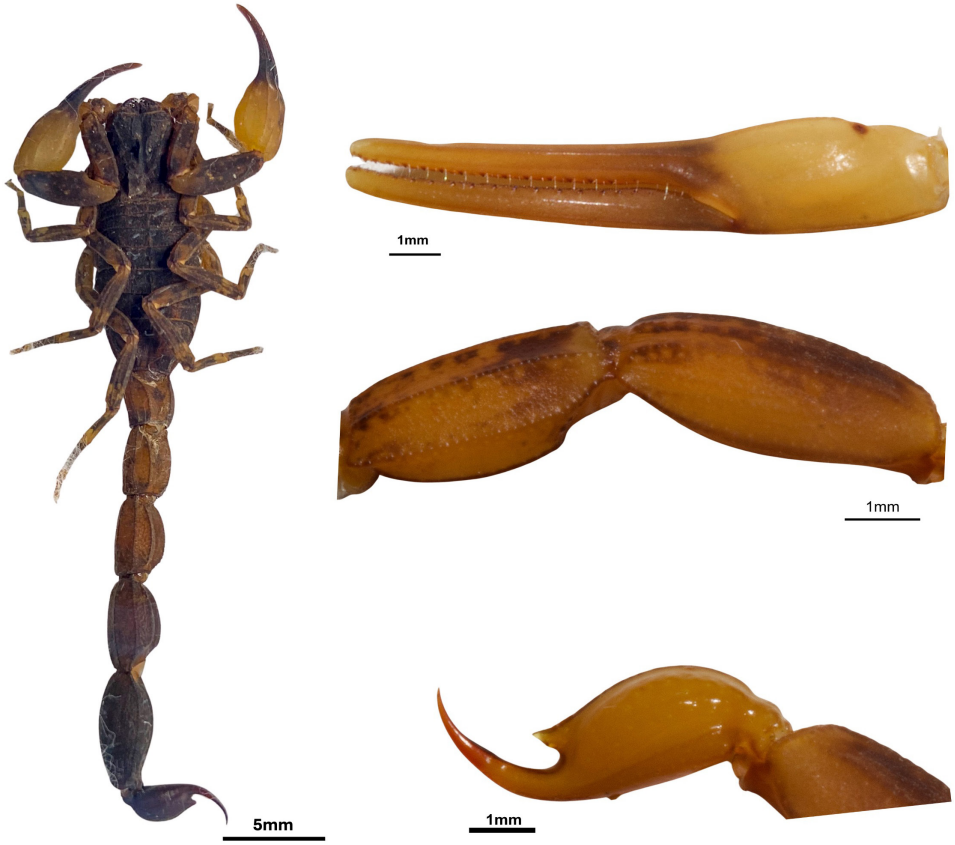


Fig. 4a. *Tityus bahiensis* (Perty, 1834). Left dorsal habitus. Right column pedipalp (top), lateral view of 4th and 5th metasomae (middle), lateral view of telson (bottom) of female specimen in MNHNP.

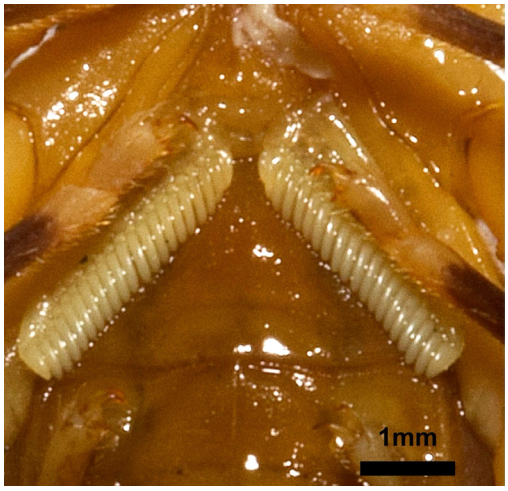


Fig. 4b. Triangular sternum of female *Tityus bahiensis* (Perty, 1834) with fulcrae and showing 21 + 20 pectin teeth (MNHNP).

2b Chelicerae dark with reticulated markings extending medially and basally (Fig. 3a left). Base colour dark, mottled paler (Fig. 3c top) with a mainly dark cephalothorax lacking an obvious "mask" surrounding the median eyes (Fig. 3a left). Telson less elongate in lateral view with a small, blunt sub-spine and short, somewhat straight spine (Fig. 3b top). Pectin teeth of examined Paraguayan specimens 16 (n=1).....***Ananteris balzanii***

3a. Fingers long and slender, as long as, or longer than the manus (Figs 4a, 5a, 6a, 7a, 8a, 9a); tibia of pedipalps without ventral trichobothria; sternum large, subtriangular (Figs 4b, 6b, 7b, 8b, 9b); subaculear spine present telson (Fig. 10a)..... .....**Family Buthidae (Genus *Tityus*) 4**

3b. Manus either narrow with long fingers (Figs 11a, 12a), or robust and boxing-glove like, with short fingers (Figs 14a, 15a, 16a, 18a, 19a); tibia of pedipalps with ventral trichobothria; sternum very small, rectangular or nearly absent (Figs 11b, 12b, 14b, 15b, 16b, 18c, 19c); subaculear spine

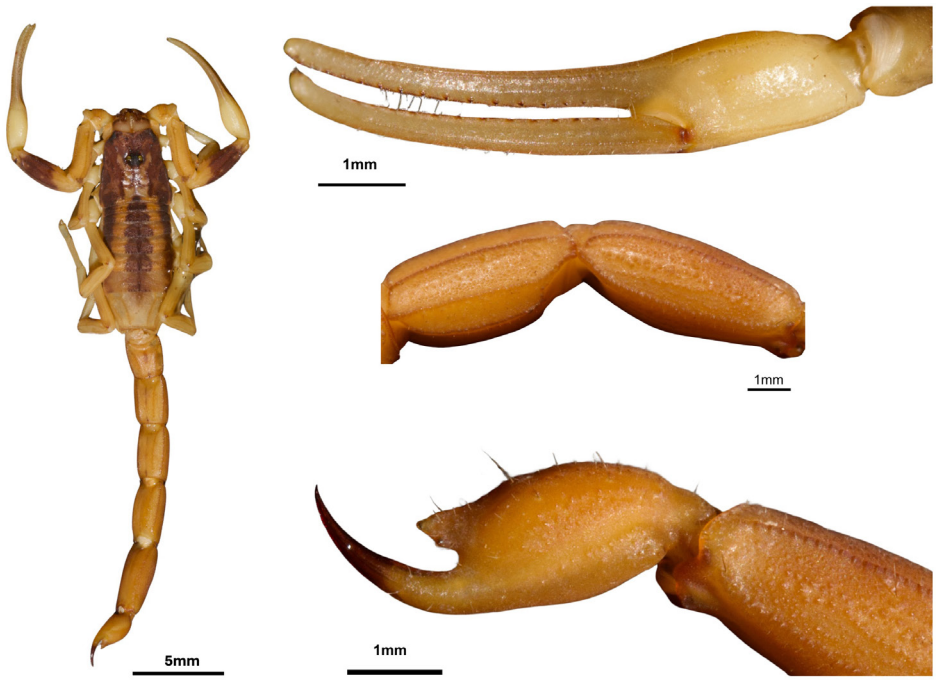


Fig. 5. *Tityus carrilloi* Ojanguren Affilastro *et al.*, 2021. Left dorsal habitus of female CZPLT-Ar-897. Right column pedipalp (top), lateral view of 4th and 5th metasomae (middle), lateral view of telson (bottom).

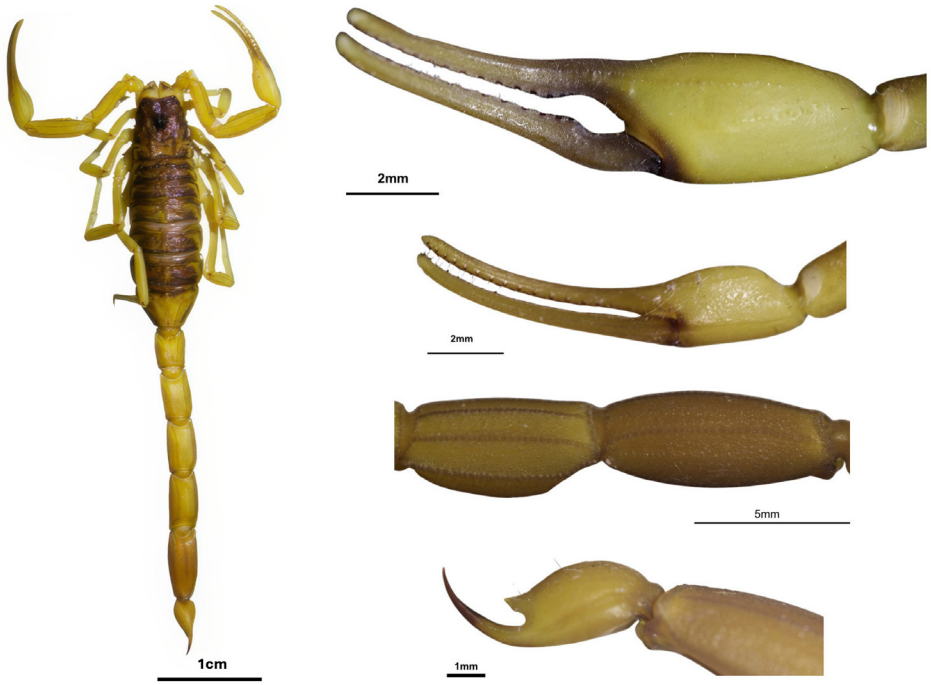


Fig. 6a. *Tityus confluens* Borelli, 1899. Left dorsal habitus of female CZPLT-Ar-834. Right column pedipalp of male CZPLT-Ar-898 (top), pedipalp of female (top middle) lateral view of 4th and 5th metasomae (bottom middle), lateral view of telson (bottom).

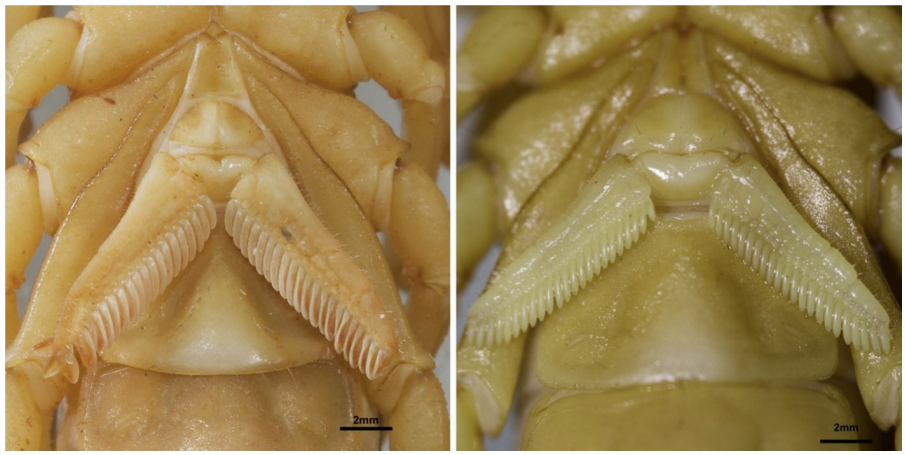


Fig. 6b. Triangular sternum of male CZPLT-Ar-898 (left) and female CZPLT-Ar-834 (right) *Tityus confluens* Borelli, 1899 with fulcrae and showing 19 + 21 (male) and 23 + 22 (female) pectin teeth.

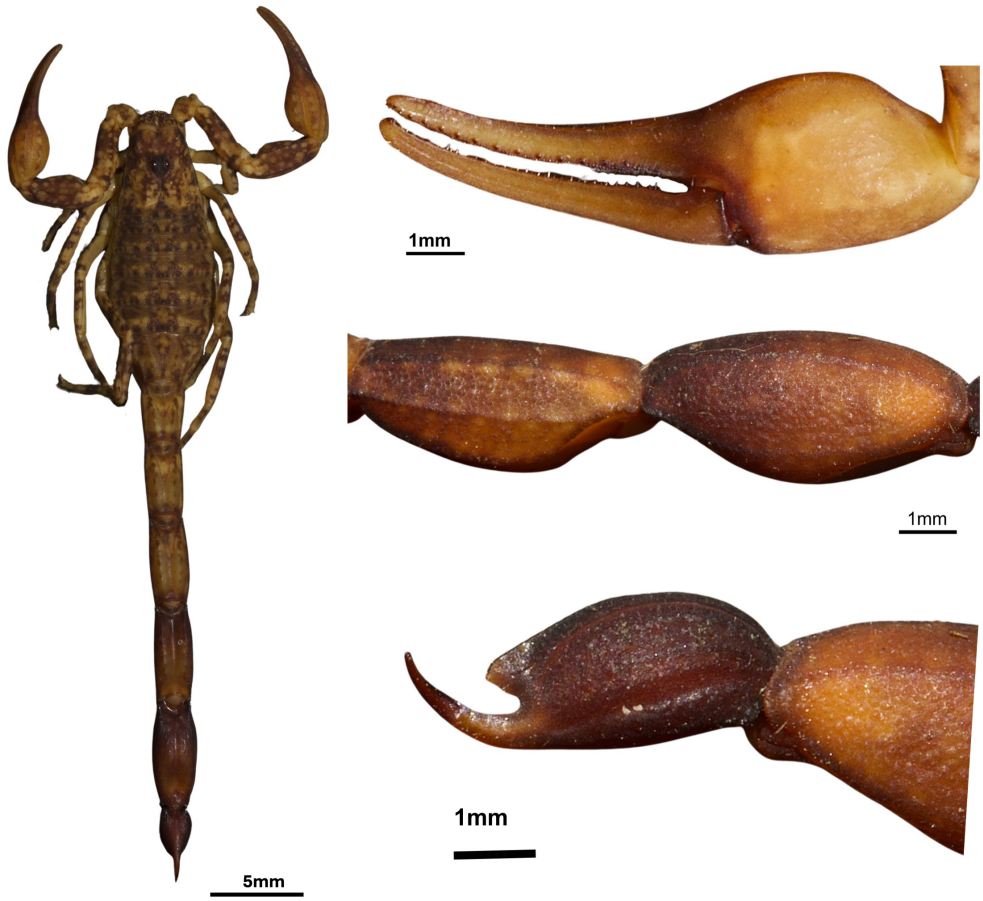


Fig. 7a. *Tityus mattogrossensis* Borelli, 1901. Left dorsal habitus of CZPLT-Ar-51. Right column pedipalp (top), lateral view of 4th and 5th metasomae (middle), lateral view of telson (bottom).

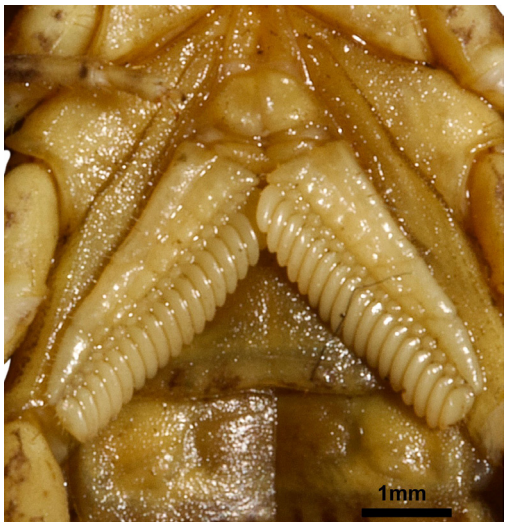


Fig. 7b. Triangular sternum of CZPLT-Ar-51 *Tityus mattogrossensis* Borelli, 1901 with fulcrae and showing 16 + 17 pectin teeth.



Fig. 8b. Triangular sternum of female CZPLT-Ar-884 *Tityus paraguayensis* Kraepelin, 1895 with fulcrae and showing 12 pectin teeth.



Fig. 8a. *Tityus paraguayensis* Kraepelin, 1895. Left dorsal habitus of female CZPLT-Ar-884. Right column pedipalp (top), lateral view of 4th and 5th metasomae (middle), lateral view of telson (bottom).

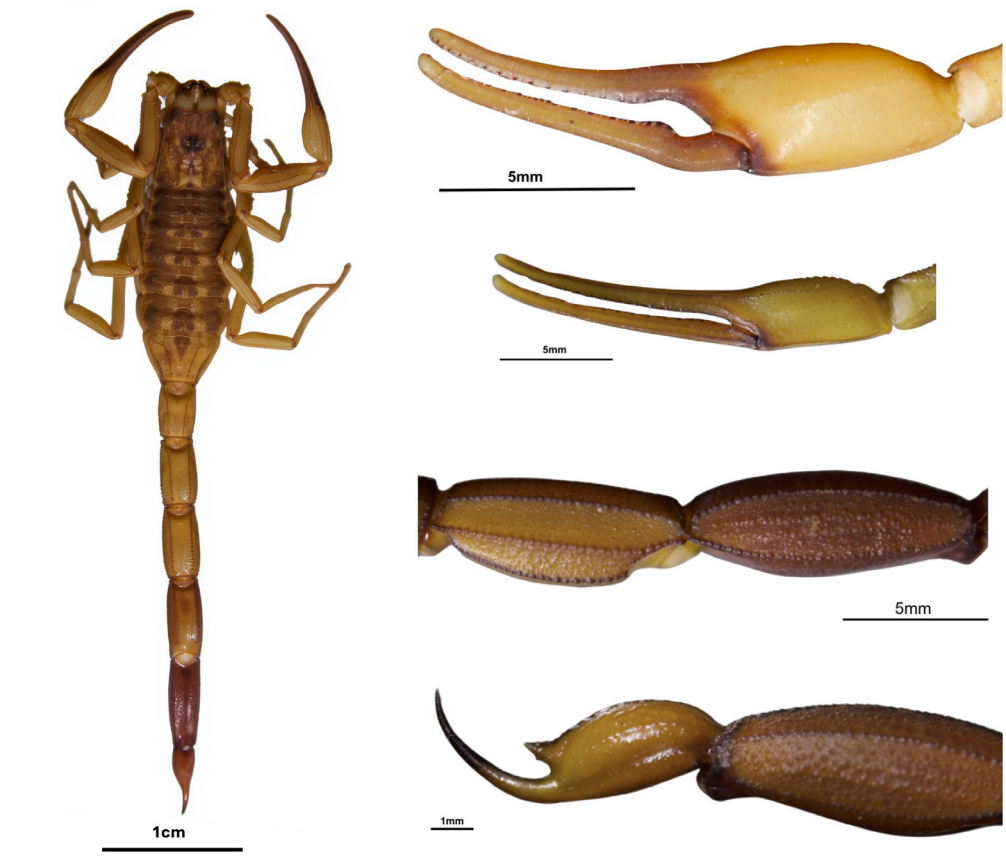


Fig. 9a. *Tityus trivittatus* Kraepelin, 1898. Left dorsal habitus of female dark morph CZPLT-Ar-874. Right column pedipalp of female CZPLT-Ar-874 (top), pedipalp of female (top middle) lateral view of 4th and 5th metasomae (bottom middle), lateral view of telson (bottom).

absent (Figs 13b, 17a, 18a, 19a). ....**Family Bothriuridae 9**

4a. Small scorpions (adult total length < 40 mm); dorsal colouration highly variegated with irregular dark spotting; manus dark, concolorous with fingers (Fig. 10c); subaculear spine rhomboidal, lacking accessory spine on aculeus (Fig. 10a); pectines ≤ 19 teeth (Figs 7b, 8b). Usually non-peridomestic, inhabiting open formations. ....**"*clathratus*" group 5**

4b. Medium-sized to large scorpions (adult total length > 50 mm); dorsal coloration brown to reddish-brown, not strongly variegated; manus pale, concolorous with or paler than fingers (Fig. 10c); subaculear spine spinoid with small accessory spine on aculeus (Fig. 10a); pectines ≥ 19 teeth (Figs 4b, 6b, 9b). Common, often peridomestic species.....**6**

5a. Dorsal base colour dark; metasomal segments IV–V uniformly dark brown to black or slightly paler towards the base (Fig. 8a); pectinal teeth

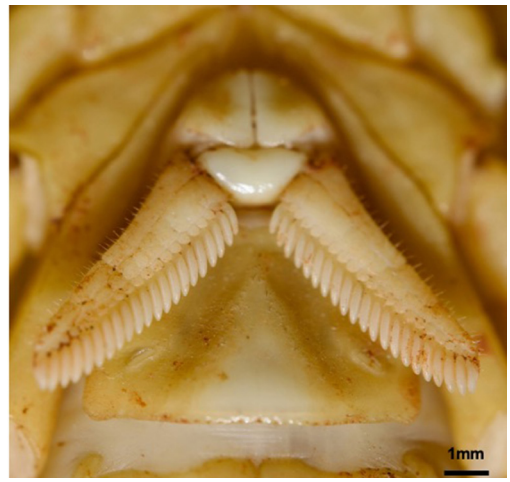


Fig. 9b. Triangular sternum of female CZPLT-Ar-874 *Tityus trivittatus* Kraepelin, 1898 with fulcrae and showing 21 pectin teeth.



Fig. 10a. Comparative lateral views of telson of genus *Tityus* in Paraguay. From top to bottom: *T. bahiensis*, *T. carrilloi*, *T. confluens*, *T. trivittatus*, *T. mattogrossensis* and *T. paraguayensis*.

11–15 (Examined female Paraguayan specimens 11 to 13, n=3) (Fig. 8b).. ***Tityus paraguayensis***

5b. Dorsal base colour pale; metasomal segments IV–V bicoloured, reddish distally and dark proximally (Fig. 7a); pectinal teeth 15–19 (Examined male Paraguayan specimens 16–19, n=3) (Fig. 7b). ... . ***Tityus mattogrossensis***

6a. Mesosoma with distinct pale longitudinal stripes (Figs 5, 9a)..... **7**

6b. Mesosoma predominantly dark (Figs 4a, 6a), without clear pale longitudinal stripes (at most with faint, broken spotting). **8**

7a. Three pale longitudinal stripes on mesosoma (continuous or broken into a series of spots) (Fig. 9a); patella concolorous with manus (Fig. 10c); legs pale, lacking dark markings; telson with lateral groove and numerous trichobothria (Fig. 10a); dorsal median carina of tergites I–VI incomplete anteriorly. Pectines with 19–23 teeth (Examined Paraguayan specimens male 20–21, n=2; females 20–21, n=3) (Fig. 9b)..... ***Tityus trivittatus***

7b. Two pale sublateral stripes on mesosoma (Fig. 5); vertebral stripe dark; patella with dark patch contrasting with pale manus (Fig. 10c).; dorsal median carina of tergites I–VI complete. Pectines with 19–22 teeth (Examined Paraguayan specimens 19, n=1). ..... ***Tityus carrilloi***

8a. Legs pale yellow, without dark markings; patella pale, concolorous with manus (Fig. 10c); metasoma IV lacking dorsal spines; telson smooth (Fig. 10a); pectinal teeth 18–26 (examined Paraguayan specimens male 20–21, n=2; female 19–24, n=20) (Fig. 6b). Widely distributed either side of the Paraguay River, especially in dry regions. ....***Tityus confluens***

8b. Legs orange to reddish-brown with dark markings (Fig. 4a); pedipalp patella with dark patch contrasting with paler manus (Fig. 10c); metasoma IV darker than I–III; metasoma IV lacking dorsal spines; pectinal teeth 19–24 (examined female Paraguayan specimen 20, n=1) (Fig. 4b). Restricted to Oriental region..... ..... ***Tityus bahiensis***

9a. Pedipalps slender, manus narrow with long fingers (Figs 11a, 12a); tarsi bearing ventral bristles but no spines (Fig. 13d); telson without evident lateral groove (Fig. 13b); pectinal teeth > 25 (Figs 11b, 12b)..... **Genus *Brachistosternus* 10**

9b. Pedipalps robust ("boxing gloves") (Figs 14a, 15a, 16a, 18a, 19a); manus swollen, fingers short relative to manus length; tarsi with two ventral rows of strong spines in addition to bristles (Fig. 20b); telson with or without lateral groove (Figs



Fig. 10b. Comparative views of tergites of genus *Tityus* in Paraguay. From top to bottom: *T. carrilloi*, *T. confluens*, *T. mattogrossensis* and *T. paraguayensis* and *T. trivittatus*.



Fig. 10c. Comparative dorsal views of arms of genus *Tityus* in Paraguay. From top to bottom: Left side *T. bahiensis*, *T. carrilloi*, *T. confluens*. Right side *T. mattogrossensis T. paraguayensis*, and *T. trivittatus*.

17a, 18a, 19a); pectinal teeth variable. ....**Genera *Timogenes* or *Bothriurus* 11**

10a. Metasoma dark brown with pale median line and lateral lunules on each tergite; cephalothorax mostly dark (Fig. 11a); chelicerae with dark reticulation (Fig 13a left); coxa and femur of legs with dark shading (Fig. 13c left); telson dark and robust with few short trichobothria (Fig. 13b top); pectinal teeth 25–34 (Examined Paraguayan specimens males 25–31, n=27; females 25–30, n=33) (Fig. 11b). Chaco and Paraguay River Basin..... .....***Brachistosternus ferrugineus***

10b. Metasoma pale brown, without lateral lunules; cephalothorax contrastingly pale (Fig. 12a); chelicerae without reticulation (Fig 13a right); coxa and femur of legs pale (Fig. 13c right); telson pale and slender with multiple long trichobothria (Fig. 13b bottom); pectinal teeth 25–32 (Examined Paraguayan specimens males 27–32, n=11; females 25–30, n=24) (Fig. 12b). Cerrado only. ..... ***Brachistosternus simoneae***

11a. Large to very large scorpions; coloration predominantly pale yellow (though uncommon dark phase occurs in both species) (Figs 18b, 19b); manus

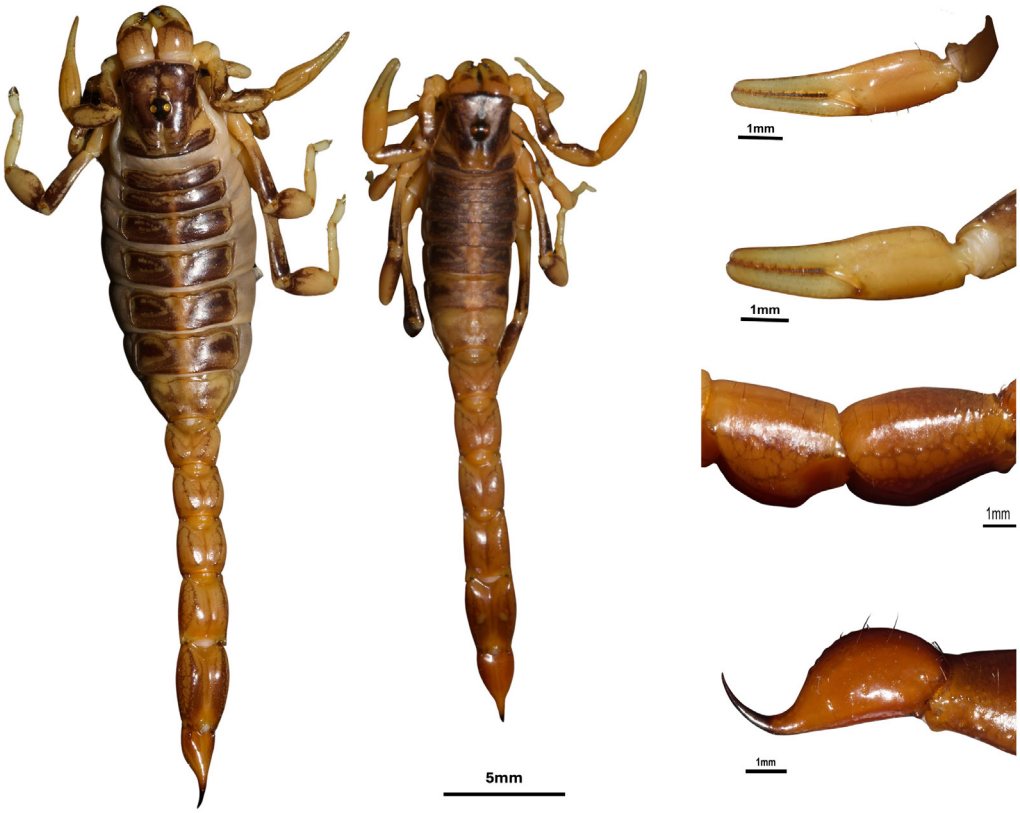


Fig. 11a. *Brachistosternus* (*Ministernus*) *ferrugineus* (Thorell, 1876). Left column left dorsal habitus of female CZPLT-Ar-896E. Right dorsal habitus of male CZPLT-Ar-896G. Right column pedipalp of male CZPLT-Ar-896G (top), pedipalp of female (top middle) lateral view of 4th and 5th metasomae (bottom middle), lateral view of telson (bottom).



Fig. 11b. Ventral side of male CZPLT-Ar-896G (left) and female CZPLT-Ar-896E (right) *Brachistosternus* (*Ministernus*) *ferrugineus* (Thorell, 1876) with reduced sternum, fulcrae present and showing 30 + 29 (male) and 26 + 26 (female) pectin teeth.

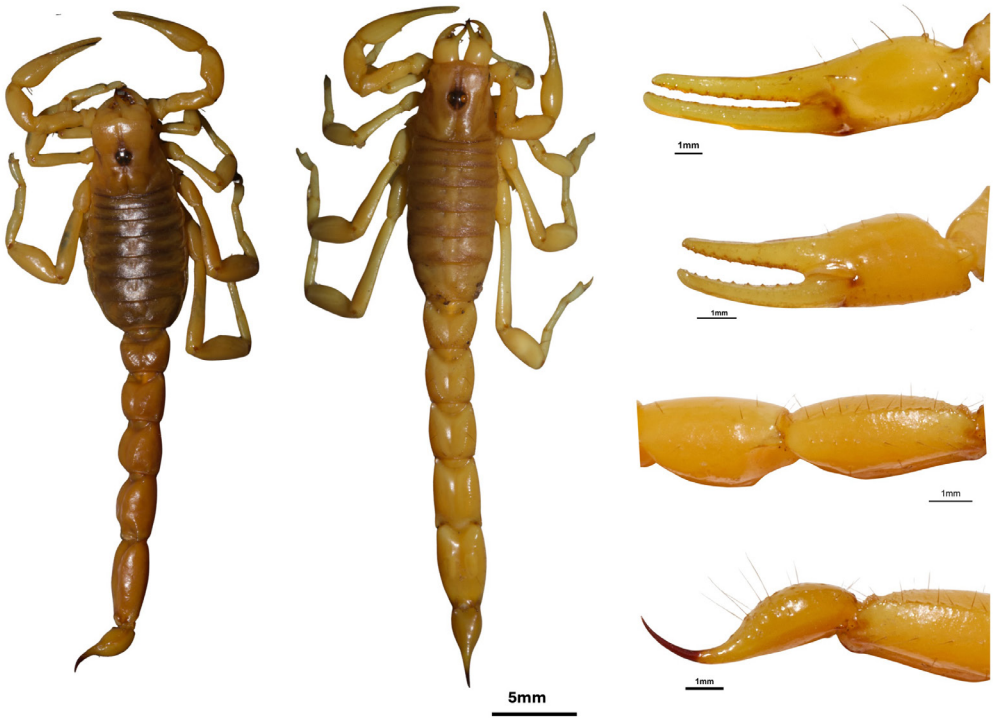


Fig. 12a. *Brachistosternus* (*Ministernus*) *simoneae* Lourenço, 2000. Left column left dorsal habitus of female CZPLT-Ar-87. Right dorsal habitus of male CZPLT-Ar-57. Right column pedipalp of male CZPLT-Ar-57 (top), pedipalp of female (top middle) lateral view of 4th and 5th metasomae (bottom middle), lateral view of telson (bottom).

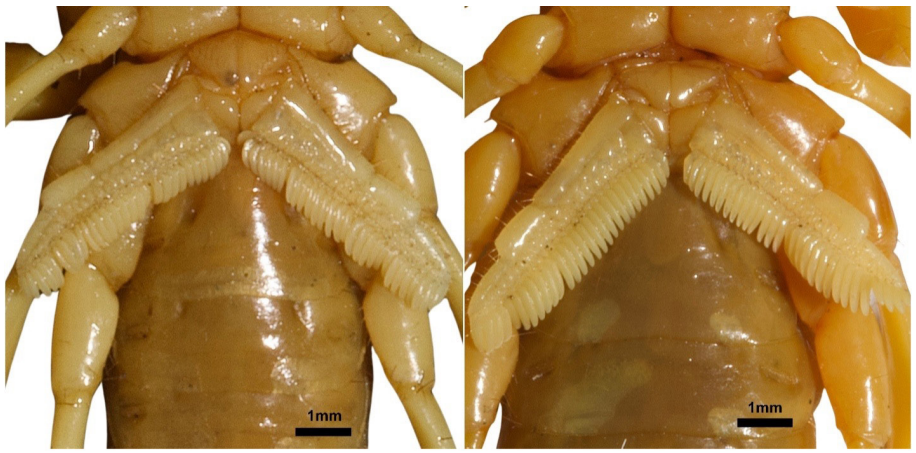


Fig. 12b. Ventral side of male CZPLT-Ar-57 (left) and female CZPLT-Ar-87 (right) *Brachistosternus* (*Ministernus*) *simoneae* Lourenço, 2000 with reduced sternum, fulcrae present and showing 30 + 29 (male) and 28 + 29 (female) pectin teeth.



Fig. 13a. Comparative chelicerae and cephalothorax patterns for *Brachistosternus* (*Ministernus*) *ferrugineus* (left) and *Brachistosternus* (*Ministernus*) *simoneae* (right).



Fig. 13b. Telson of *Brachistosternus* (*Ministernus*) *ferrugineus* (top) and *Brachistosternus* (*Ministernus*) *simoneae* (bottom).



Fig. 13c. Comparative fourth leg colouration of *Brachistosternus* (*Ministernus*) *ferrugineus* (left) and *Brachistosternus* (*Ministernus*) *simoneae* (right).

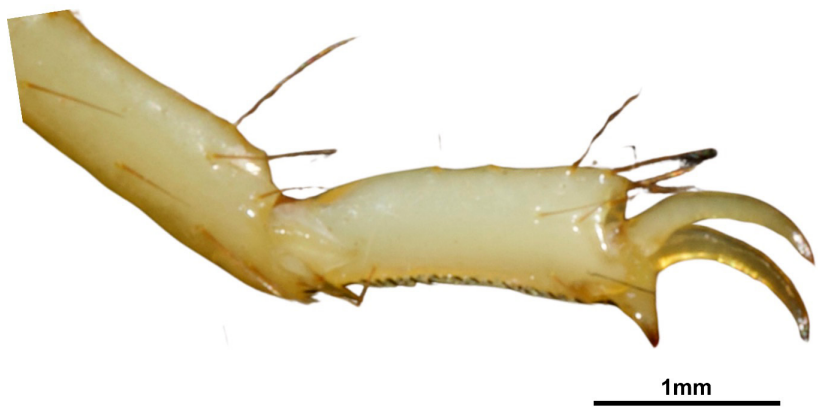


Fig. 13d. Tarsus of *Brachistosternus* (*Ministernus*) *simoneae* showing bristles, but not spines, on the ventral side.

of male without a process on the inner side at the base of the fixed finger, but with a semicircular depression. (Figs 18a, 19a). ventral surface of metasomal segment V bisected by a transverse keel (Fig. 20a); telson bulbous, without lateral groove (Figs 18a, 19a). Pectin teeth 14–32. Chaco region only. ..... **Genus *Timogenes* 12**

11b. Medium-sized to small scorpions; coloration dark brown to black (Figs 14a, 15a, 16a); manus of male with a process on the inner side, at the base of the fixed finger (Figs 14a, 15a, 16a); ventral surface of metasomal segment V not bisected by transverse keel; telson elongate with lateral groove (Fig. 17a). Pectin teeth < 24. ..... **Genus *Bothriurus* 13**

12a. Very large species (55–120 mm); depression on manus of male small, not reaching midpoint of manus (Fig. 19a); metasomal segment IV with supramedial lateral keel (Fig. 20a right); caudal glands absent; pectines with 18–32 teeth (Examined Paraguayan specimens males 27–30, n=2; females 24–25, n=3) (Fig. 19c). .... ***Timogenes elegans***

12b. Medium-sized species (35–65 mm); depression on manus of male large and circular, passing mid-



Fig. 14a. *Bothriurus guarani* Maury, 1984. CZPLT-Ar-836A. Left dorsal habitus of male. Right column pedipalp of male (top), pedipalp of female (top middle) lateral view of 4th and 5th metasomae (bottom middle), lateral view of telson (bottom).

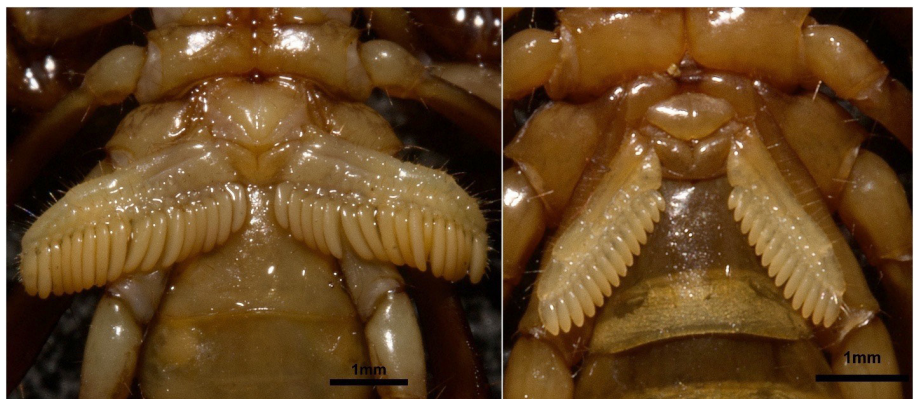


Fig. 14b. Ventral side of male CZPLT-Ar-836A (left) and female CZPLT-Ar-107 (right) *Bothriurus guarani* Maury, 1984 with reduced sternum, fulcrae present and showing 16 (male) and 14 + 13 (female) pectin teeth.



Fig. 15a. *Bothriurus jesuita* Ojanguren Affilastro, 2003. CZPLT-Ar-821. Left dorsal habitus of male. Right column pedipalp of male (top), pedipalp of female (top middle) lateral view of 4th and 5th metasomae (bottom middle), lateral view of telson (bottom).



Fig. 15b. Ventral side of male CZPLT-Ar-821 *Bothriurus jesuita* Ojanguren Affilastro, 2003 with reduced sternum, fulcrae present and showing 21 + 20 pectin teeth.

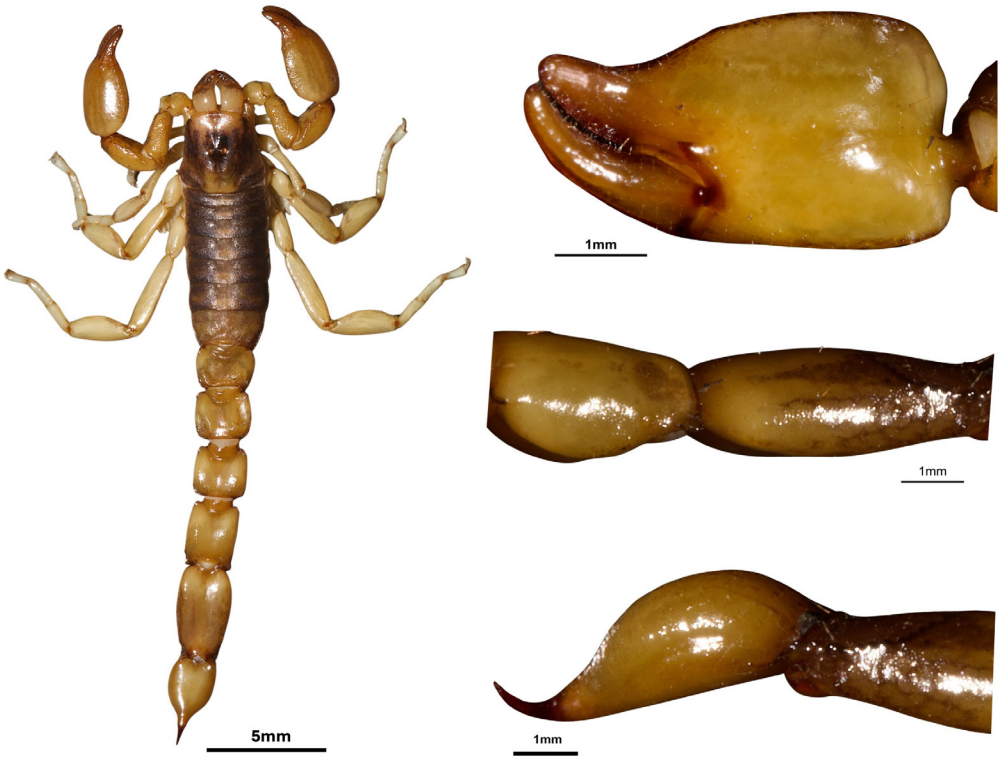


Fig. 16a. *Bothriurus* sp. CZPLT-Ar-136. Left dorsal habitus of male. Right column pedipalp of male (top), lateral view of 4th and 5th metasomae (middle), lateral view of telson (bottom).

point of manus (Fig. 18a); metasomal segment IV without supramedial lateral keel (Fig. 20a left); caudal glands present in males; pectines with 14–27 teeth (Examined Paraguayan specimens males 20–23, n=6; females 17–22, n=8) (Fig. 18c). ..... ***Timogenes dorbignyi***

13a. Cephalothorax anterior to median eyes concolorous and darker than chelicerae (Fig. 15a); no median pale stripe on tergites (Fig. 17b); posterior end of metasoma V dorsally flattened with transverse arch of granules; ventral macrosetae pattern of segment IV (4+0+4) in two rows (Fig. 17c); three distal segments of the legs dark; pectinal teeth males 20–23 (Examined Paraguayan specimens 20–23, n=10) (Fig. 15b), females 18. .... ***Bothriurus jesuita***

13b. Cephalothorax anterior to median eyes with pale spots concolorous with chelicerae (Figs 14a, 16a); median pale stripe on tergites present; three distal segments of the legs pale. **14**

14a. Median stripe broad, composed of disconnected spots (Figs 16a, 17b); telson short and weakly bulbous with very short aculeus (Fig. 17a); pos-

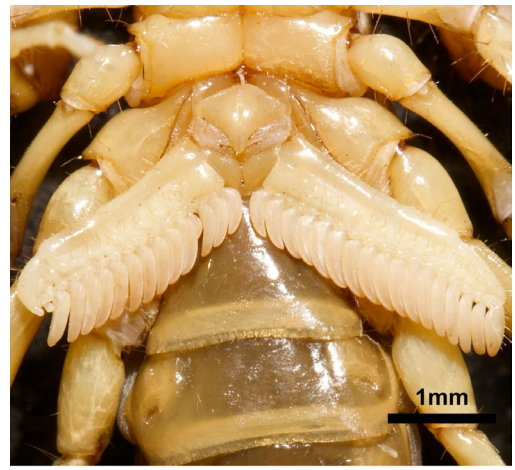


Fig. 16b. Ventral side of male CZPLT-Ar-136 *Bothriurus* sp. with reduced sternum, fulcrae present and showing 16 + 17 pectin teeth.



Fig. 17a. Comparative lateral views of telsons of *Bothriurus* in Paraguay. From top to bottom: *Bothriurus guarani*, *B. jesuita*, and *Bothriurus* sp.

terior tip of metasoma V not dorsally flattened and lacking transverse arch of granules (Fig. 16a); ventral macrosetae pattern of segment IV diffuse, vaguely circular (Fig. 17c); pectinal teeth males 17–19 (n=4), females unknown (Fig. 16b). .... ***Bothriurus* sp.**

14b. Median stripe narrow and continuous (Figs 14a, 17b); telson elongate with short aculeus (Fig. 17a); posterior tip of metasoma V dorsally flattened with transverse arch of granules (Fig. 14a); ventral macrosetae pattern of segment IV linear; pectinal teeth males 14–19 (examined Paraguayan specimens 15–18, n=18), females 13–18 (examined Paraguayan specimens 13–18, n=9) (Fig. 14b).....***Bothriurus guarani***

Discussion

Broad biogeographical patterns (Table 2)

Guerrero *et al*. (2018) provided an assessment of ecoregion association in Paraguayan scorpions based on the ecoregion definitions of Dinerstein *et al*. (1995), finding the greatest diversity in



Fig. 17b. Comparative views of tergites of genus *Bothriurus* in Paraguay. From top to bottom: *Bothriurus* sp., *B. guarani* and *B. jesuita*.

the Humid Chaco (12 species) and Atlantic Forest (8 species) ecoregions, with much lower diversity in the Dry Chaco (4 species), Cerrado (2 species) and Pantanal (1 species). However, this analysis was hampered by a virtual lack of sampling from the Cerrado ecoregion, known as one of the highest diversity ecoregions for scorpions in neighbouring Brazil (Lourenço, 2001). We provide a slightly refined version of this analysis here (Table 3), taking into account other factors such as distribution west and east of the Paraguay River, and latitude to attempt to define basic ecological boundaries for the Paraguayan species.

We consider that the ecoregions as defined by Dinerstein *et al*. (1995) are not adequate for describing scorpion assemblages. We note, for example, that the remarkably high diversity of 8 species reported by Guerrero *et al*. (2018) for the Atlantic Forest ecoregion is misleading when considering the mapped ranges provided by those authors. Most species mapped for this ecoregion by those authors have only marginal occurrence within it and are absent from the interior of it, whilst the historical forest coverage of the ecoregion is now greatly reduced (Mohebalian *et al.*, 2022) so that records within this region need not have any association with Atlantic Forest at all. Indeed, sampling within well-preserved Atlantic Forest habitats in Paraguay have yielded little or no scorpion presence at all. Thus, we redefine the Paraguayan scorpion assemblages as follows:

Dry Chaco species (corresponding approximately to Dinerstein`s region): Five species, two strictly associated with the ecoregion (*Timogenes dorbignyi* and *T. elegans*), and three loosely associated with the ecoregion (*Ananteris mariaterezae*, *Tityus confluens* and *Brachistosterus ferrugineus*). Only one of these species is considered to be periurban (*Tityus confluens*).

Humid Chaco and Paraguay River Basin (corresponding approximately to Dinerstein`s Humid Chaco and Pantanal ecoregions combined, but not extending so far east along the Paraná into Misiones department or along the Apa River into eastern Concepción and Amambay departments): Nine species, one strongly associated with the ecoregion (*Bothriurus jesuita*) and eight loosely associated with the ecoregion (*Ananteris balzanii*, *Tityus bahiensis*, *T. confluens*, *T. mattogrossensis*, *T. paraguayensis*, *T. trivittatus*, *Bothriurus guarani* and *Brachistosterus ferrugineus*). Three of these, *Tityus bahiensis*, *T. confluens* and *T. trivittatus*, may be mainly periurban species.

Mesopotamian Grassland and Paraná River Basin (corresponding to grassland areas of Misiones, Itapúa and Caazapá departments): Six species, one strictly associated with the ecoregion (*Tityus carrilloi*) and five loosely associated with the ecoregion (*Tityus confluens*,

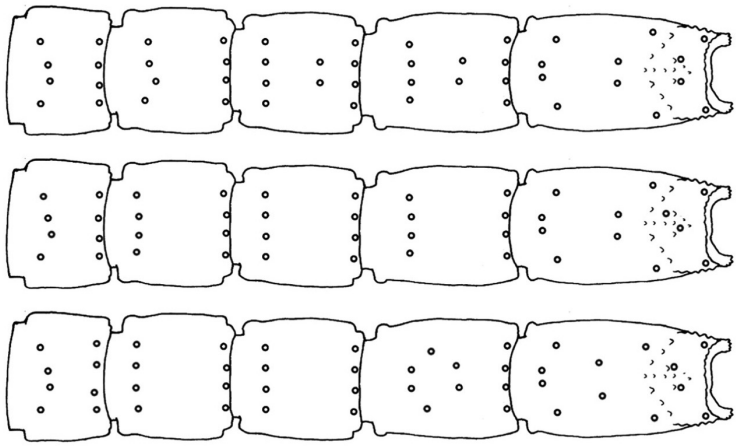


Fig. 17c. Comparative macrosetae patterns on metasoma of genus *Bothriurus*. From top to bottom: *Bothriurus pora*, *B. jesuita* and *Bothriurus* sp.



Fig. 18a. *Timogenes dorbignyi* (Guérin-Méneville, 1843). CZPLT-Ar-835. Left dorsal habitus of light morph female. Right column pedipalp of male (top), pedipalp of female (top middle) lateral view of 4th and 5th metasomae (bottom middle), lateral view of telson (bottom).



Fig. 18b. Dark (CZPLT-Ar-130) (right) and light (CZPLT-Ar-870) (left) morphs of male *Timogenes dorbignyi*.

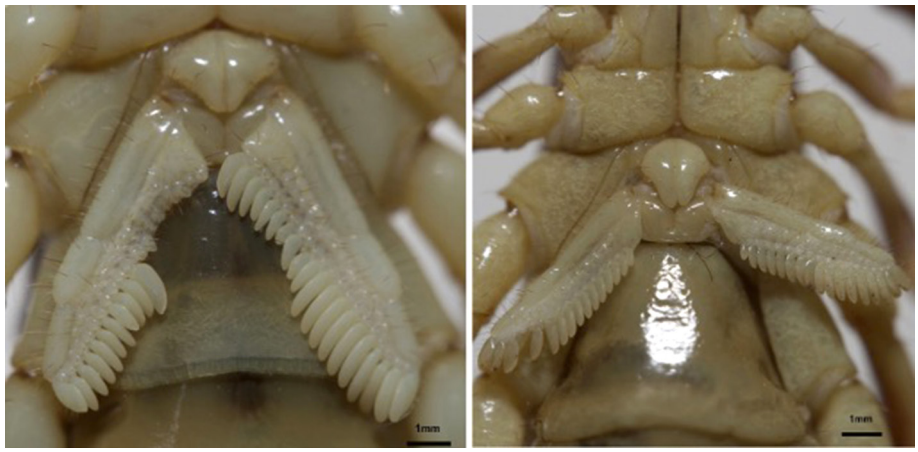


Fig. 18c. Ventral side of male CZPLT-Ar-870 (left) and female CZPLT-Ar-835 (right) *Timogenes dorbignyi* (Guérin-Méneville, 1843) with reduced sternum, fulcrae present and showing 20 (male) and 16 + 17 (female) pectin teeth.



Fig. 19a. *Timogenes elegans* Mello-Leitão, 1931. CZPLT-Ar-904. Left dorsal habitus of light morph male. Right column pedipalp of male (top), pedipalp of female (top middle) lateral view of 4th and 5th metasomae (bottom middle), lateral view of telson (bottom).

T. paraguayensis, *T. trivittatus*, *T. bahiensis* and *Bothriurus jesuita*). All of these species except *Tityus paraguayensis* and *Bothriurus jesuita* may be considered largely periurban species

Cerrado (extended to include Cerrado matrices in Amambay, eastern Concepción, eastern San Pedro and northern Canindeyú departments): Seven species, five strongly associated with the ecoregion (*Ananteris mariaterezae*, *Bothriurus* sp., *Bothriurus guarani*, *Brachistosternus simoneae* and *Tityus mattogrossensis*), and two loosely associated with the ecoregion (*Tityus confluens* and *trivittatus*). Both of these species, *T. confluens* and *T. trivittatus*, are considered largely periurban.

Atlantic Forest (corresponding approximately to Dinerstein`s Atlantic Forest ecoregion but not incorporating Cerrado or Mesopotamian Grassland areas within it): Three species loosely associated with the ecoregion, *Bothriurus jesuita* and the generalist periurban scorpions *Tityus bahiensis* and *Tityus trivittatus*. Nonetheless, the probable presence of at least one further unidentified *Bothriurus* species in Alto Paraná department (which may or may not correspond to *B. moojeni*) suggests that other species that are more strictly associated with this ecoregion may occur.

Species diversity across Paraguayan ecoregions is as follows (format: total species [strong association + weak association]; (percentage of strongly associated species in parentheses):

(i) Dry Chaco: 5 [2 + 3] (40% strongly associated)

(ii) Humid Chaco and Paraguay River Basin: 9 [1 + 8] (11% strongly associated)

(iii) Mesopotamian Grassland and Paraná River Basin: 6 [1 + 5] (17% strongly associated)

(iv) Cerrado: 7 [5 + 2] (71% strongly associated)

(v) Atlantic Forest: 3 [0 + 3] (0% strongly associated)



Fig. 19b. Dark (CZPLT-Ar-117) (right) and light (CZPLT-Ar-116) (left) morphs of female *Timogenes elegans*.

The highest species richness occurs in the mosaic of habitats comprising the Humid Chaco and Paraguay River Basins, although regional endemism in this area is relatively low. In contrast, regional endemism is highest in the greatly under-sampled Cerrado ecoregion where the vast majority of species are strongly associated with this ecoregion, and this area should be considered a national hotspot for scorpion diversity and conservation. Species richness is lowest in the mesic, densely forested Atlantic Forest ecoregion, where recorded species are generalist, often periurban, and not strictly associated with the original forest cover. The proportions of strongly associated species emphasize that the Cerrado harbours more habitat-specialist scorpions, while the Humid Chaco and Atlantic Forest are dominated by species with broader ecological tolerances.

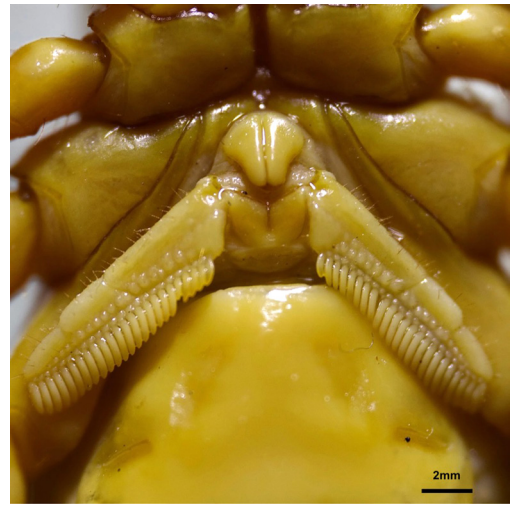


Fig. 19c. Ventral side of female *Timogenes elegans* Mello-Leitão, 1931with reduced sternum, fulcrae present and showing 24 + 23 pectin teeth.



Fig. 20a. Ventral and dorsal surfaces of metasomae IV and V of *Timogenes dorbignyi* (left) and *Timogenes elegans* (right).



Fig. 20b. Tarsus of *Timogenes elegans* showing bristles in addition to spines, on the ventral side.

Generic biogeographical patterns

Five genera of scorpions occur in Paraguay and we will provide a brief discussion of their biogeographical patterns in Paraguay based on the available data. A clear biogeographic association is shown between the genus *Timogenes* and Dry Chaco, and there is a similarity in the distributions of the two respective species of *Brachistosternus* and *Ananteris*, with each of these represented by a widespread Chaco species occurring in the tropics on both sides of the Paraguay River, and a more localized, mainly Cerrado species found principally in the tropical Oriental region.

The genus *Tityus* is widespread in Paraguay, and these medically important species are often ecologically plastic, allowing them to rapidly colonise peridomestic areas, thus increasing the potential threat that they pose. Of the six Paraguayan species, four of these may be considered to be largely peridomestic in their distribution. *Tityus confluens* is widespread and common in the Chaco and Paraguay River Basin (but further sampling will likely prove it to have extended throughout the country), while *T. trivittatus* is widespread and common in the Oriental region (with a southern limit around 26.5°S) and overlaps with it in the Paraguay River Basin, but has not crossed the Paraguay River into the Chaco region.

Table 2. Scorpions records from Paraguay.

ANANTERIDAE																		
	iucn	APY	APA	AMA	BOQ	CAA	CAZ	CAN	CEN	CON	COR	GUA	ITA	MIS	ÑEE	PAR	PHA	SPE
Ananteris balzanii	LC				*													
Ananteris mariaterezae	VU																1	1
BUTHIDAE																		
	iucn	APY	APA	AMA	BOQ	CAA	CAZ	CAN	CEN	CON	COR	GUA	ITA	MIS	ÑEE	PAR	PHA	SPE
Tityus bahiensis	LC																	
Tityus carrilloi	CR																	
Tityus confluens	LC			*							* iN		*		*		*	*
Tityus mattogrossensis	VU																	*
Tityus paraguayensis	LC												*				* py	
Tityus trivitattus	LC							* iN										*
BOTHRIURIDAE																		
	iucn	APY	APA	AMA	BOQ	CAA	CAZ	CAN	CEN	CON	COR	GUA	ITA	MIS	ÑEE	PAR	PHA	SPE
Brachistosternus ferrugineus	LC																	
Brachistosternus simoneae	CR																	1
Bothriurus sp.	CR																	1
Bothriurus jesuita	LC		?							?	?	?	?		*	?		?
Bothriurus guarani	EN																	*
Timogenes dorbignyi	VU																	
Timogenes elegans	VU																	
Totals		4	3/4?	3	5	0	0	1	5	6/7?	6	4	5	3	2	2	6	7/8?

iN — photo on iNaturalist only; py — photo on pybio only. * — new departmental record in this paper. ? — reports requiring confirmation. 1 — species reported for Paraguay for the first time in this paper. Departments as follows: Chaco region — Alto Paraguay (APY), Boquerón (BOQ), Presidente Hayes (PHA); Oriental region — Amambay (AMA), Alto Paraná (APA), Caaguazú (CAA), Canindeyú (CAN), Caazapá (CAZ), Central (CEN), Concepción (CON), Cordillera (COR), Guairá (GUA), Itapúa (ITA), Misiones (MIS), Ñeembucú (ÑEE), Paraguarí (PAR), San Pedro (SPE).

Table 3. Ecological parameters associated with the distribution of Paraguayan scorpions.

ANANTERIDAE	
Ananteris balzanii	Both regions. Tropical/Subtropical. Humid Chaco/Paraguay River Basin.
Ananteris mariaterezae	Both regions. Tropical. Cerrado/Dry Chaco.
BUTHIDAE	
Tityus bahiensis	Oriental region. Subtropical. Mesopotamian Grassland/Paraná River Basin and periurban within Atlantic Forest.
Tityus carrilloi	Oriental region. Subtropical. Periurban within Paraná River Basin.
Tityus confluens	Both regions. Tropical/Subtropical. Periurban within Dry and Humid Chaco/ Paraguay River Basin region/Paraná River Basin.
Tityus mattogrossensis	Oriental region. Tropical. Cerrado/Humid Chaco.
Tityus paraguayensis	Both regions. Tropical/Subtropical. Humid Chaco/Paraguay River Basin/ Paraná River Basin.
Tityus trivittatus	Oriental región south to 26.5 ºS. Tropical/Subtropical. Periurban within Atlantic Forest/Cerrado/Paraguay River Basin/Paraná River Basin.
BOTHRIURIDAE	
Bothriurus sp.	Oriental region. Tropical. Cerrado.
Bothriurus jesuita	Oriental region. Subtropical. Humid Chaco/Paraguay River Basin/Atlantic Forest.
Bothriurus guarani	Oriental region. Tropical. Cerrado/Humid Chaco.
Brachistosternus ferrugineus	Both regions. Tropical/ marginally Subtropical to 25 ºS. Dry and Humid Chaco/ Paraguay River Basin.
Brachistosternus simoneae	Oriental region. Tropical. Cerrado.
Timogenes dorbignyi	Chaco region. Tropical/marginally Subtropical to 24 ºS. Dry Chaco.
Timogenes elegans	Chaco region. Tropical/Subtropical. Dry Chaco.

Both of these belong to the "*trivittatus*" group of Ojanguren Affilastro *et al*. (2017). Two species, *T. bahiensis* and *T. carrilloi* are as yet known from few records in Paraguay, but both are peridomestic and exhibit the potential for future expansion of their range through urban transfer (though *T. bahiensis* is more associated with peridomestic rural rather than fully urban habitats). The latter is also a member of the "*trivittatus*" group, while the former is the sole Paraguayan representative of the "*bahiensis*" group of Lourenço & Pézier (2002). The two remaining species of *Tityus*, *T. paraguayensis* and *T. mattogrossensis*, belong to the "*clathratus*" group of Lourenço & Pézier (2002) (subgenus *Archaeotityus*; Lourenço, 2006) and are associated with more open and natural formations, with less tendency towards periurbanism. Nonetheless, they still present a risk to rural populations because of the potentially potent neurotoxic venom that they possess.

The Paraguayan biogeography of the genus *Bothriurus* is the least clear because of historic confusion over the identification of individuals, and the large number of poorly-described and recently described taxa. A plethora of names have been used for Paraguayan individuals, many of these representing dated usage, and a lack of clarity on characteristics for identification has further complicated the understanding of the Paraguayan literature. We take a conservative approach here and document three species, whilst accepting that this may underestimate and/or oversimplify the true diversity. We were influenced to do this by the specimens that we were able to personally examine, and recognition of the strong ecoregional associations and general lack of sympatry of *Bothriurus* species from within any one species group that is observed in neighbouring countries with greater diversity (Ohanguren Affilastro, 2003).

We were unable to locate any confirmed specimens of *Bothriurus chacoensis*, a reddish-brown species of the "*bonariensis*" species group associated largely with dry Chaco formations in Argentina. The suspected occurrence of this species in the Paraguayan Chaco has not been supported with specimen data, but the likelihood of its presence west of the Paraguay River must be considered fairly high. It is replaced east of the Paraguay River in Humid Chaco habitats and the Paraguay River Basin by another member of the "*bonariensis*" species group, the black *B. jesuita*, which apparently extends into grassland mosaics with the Atlantic Forest ecoregion. The dense forests of this ecoregion may have represented a historical barrier to the dispersal of this open-country species in the past. East of here, in the tropical, dry Cerrado ecoregion, a third member of the "*bonariensis*" species group occurs, a reddish-brown species which we are in the process of describing as new. This species occurs sympatrically in the Cerrado with the smaller *Bothriurus guarani* of the "*araguayae*" species group, and the latter may also overlap with *B. jesuita* in the Paraguay River Basin (although this remains to be confirmed with specimens). Here it is worthy of note that unconfirmed reports exist of another member of the "*araguayae*" species group from the Atlantic Forest ecoregion, *B. moojeni/bertae*, and it may be hypothesized that that species might replace *B. guarani* in that ecoregion and perhaps occur sympatrically with *B. jesuita*. Thus, we hypothesise that there is a pattern of allopatry within *Bothriurus* species groups, with the common pattern being co-occurrence of one member of the *chacoensis* group with another of the *araguayae* group, the paired composition of which depends on the ecoregion. Additional sampling of specimens of confirmed identity is required to test this theory.

Assessing conservation threats to Paraguayan scorpions

Smith (2022) proposed a simple method for a basic, preliminary conservation assessment for invertebrates following IUCN criteria but for application where limited or incomplete knowledge of distribution is available. Applying that here gives the following provisional results:

Critically Endangered (3): *Tityus carrilloi*, *Brachistosternus simoneae*, *Bothriurus* sp. However, the tendency of *T. carrilloi* to exhibit peridomestic habits suggests that its conservation concern may be reduced once the species' distribution and potential for expansion are better understood.

Endangered (1): *Bothriurus guarani*

Vulnerable (4): *Ananteris mariaterezae*, *Tityus mattogrossensis*, *Timogenes elegans*, *T. dorbignyi*

Least Concern (7): *Ananteris balzanii*, *Tityus bahiensis*, *T. confluens*, *T. paraguayensis*, *T. trivittatus*, *Brachistosternus ferrugineus*, *Bothriurus jesuita*. Further examination of specimens of *Ananteris balzanii* may prove that this is a complex of more than one species, in which case upgrading may be necessary. This grouping also contains the vast majority of the peridomestic species which benefit from human association.

Concluding remarks

The information presented here is a summary of the available data and the hypotheses presented are based upon it and should be considered provisional. We expect these hypotheses to be refined as further sampling increases the dataset, and we strongly encourage field workers to do so to improve our knowledge of Paraguayan scorpions. Particular attention should be given to species of medical importance, which currently include three representatives of the genus *Tityus* (T. *trivittatus*, *T. confluens*, and *T. carrilloi*), while recognizing that additional taxa may be implicated in human envenomation as new evidence emerges. The documentation of one new species and two new country records from the Cerrado region, for genera previously thought to be represented by a single species associated with Chaco habitats (*Brachistosternus* and *Ananteris*), highlights how many scorpion species show strong affiliations with ecoregions and the specific microhabitats within them. This ecoregion has been chronically under-sampled for scorpions in Paraguay and we provide the first specimen data here, highlighting the high degree of endemism seen in this region. More intensive and focused sampling in the distinct Paraguayan ecoregions might be expected to reveal a much greater diversity than is currently recognised.

Additional data will be critical for identifying potential conservation threats to these species. Our preliminary assessment suggests

that a substantial proportion of Paraguayan species could potentially be facing national conservation threats. Although future data may revise these assessments, such early indications should not be overlooked. A coordinated and interdisciplinary effort will therefore be essential to better understand the biogeographic patterns of Paraguayan scorpions, particularly those associated with human envenomation, and to support the development of risk maps that can inform both conservation and public health strategies.

Supplementary Data.

Supplementary table. List of examined scorpion material from CZPLT-Ar and MNHNP.

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