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The genus *Zelurus* Hahn, 1826, in Brazilian caves: description of new species and comments on the potential distribution of the genus in South America

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Abstract

A survey on species of the genus *Zelurus* Hahn, 1826 (Reduviidae) occurring in Brazilian caves is provided. *Zelurus tambejua* **sp. n.** and *Zelurus gerevatinga* **sp. n.** collected from caves in Brazil are described. Comments about the current and potential distribution of the genus as a whole and of species of *Zelurus* found in caves for South America are also provided.

Key words: *Zelurus*, Reduviidae, Hemiptera, Cave

Introduction

Reduviidae comprises the largest family of heteropteran terrestrial predators (Gil-Santana & Zeraik 2003). Such organisms have great ecological importance as predators and are potentially useful in agriculture for biological pest control (Gil-Santana & Zeraik 2003). About 25 subfamilies are recognized, although there is a lack of consensus on some of these concepts (Maldonado Capriles 1990, Schuh & Slater 1995, Gil-Santana *et al.* 2015).

Reduviinae currently includes 14 Neotropical genera, among which *Zelurus* Hahn, 1826 is the largest genus, with approximately 130 species and some subspecies (Gil-Santana *et al.* 2015), almost all of which are restricted to the Neotropics (Maldonado Capriles 1990). The revision of this genus by Costa Lima (1940) (as *Spiniger* Burmeister, 1835) included a key to the species. This key is outdated because of numerous subsequent taxonomic changes, including the description of many new species (Costa Lima 1941, Martins 1942, Seabra & Hathaway 1943, Lent & Wygodzinsky 1945, 1947a,b, 1951a,b,c, 1954, 1955a,b,c, 1957, 1966, 1968, Costa Lima & Costa Leite 1950, Hussey 1953 and Martínez 1974).

Most members of Reduviinae are thought to be general insect or arthropod predators and are nocturnal (Schuh & Slater 1995). There are few data on the ecology and biology of Neotropical Reduviinae and *Zelurus* spp., which has been summarized by Gil-Santana *et al*. (2015). Regarding the cave environment, a species of *Zelurus* was reported to be a predator of harvestmen (*Goniosoma* sp., Arachnida, Opiliones, Gonyleptidae) in most caves studied by Machado *et al*. (2003). *Goniosoma spelaeum* (Mello-Leitão) was observed to be the prey of cave-dwelling *Zelurus travassosi* (Costa Lima, 1940) (Trajano & Bichuette 2010). *Zelurus travassosi* was also considered as the most important predator of the trogloxene species *G. spelaeum* in the Brazilian state of São Paulo and the troglophile species *Daguerreia inermis* Soares & Soares (Arachnida, Opiliones, Gonyleptidae) in the state of Paraná (Gnaspini 1996, Pinto-da-Rocha 1996, Machado *et al*. 2003) (Gil-Santana *et al*. 2015).

Although different species of *Zelurus* can take shelter in very different habitats, among these, cave environments stand out, in which certain species are commonly found. Caves comprise environments that tend to be more stable than the external systems. The humidity and temperature tend to be constant, as well as having low or no luminosity. Brazil currently presents around 16,000 caves (CECAV, 2016), but this may represent only 10% of the potential number of caves existing in the country. The limestone caves are the most studied, although other lithologies are also important regarding the number of caves, as the ferruginous rocks (Souza-Silva et al. 2011a). In

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caves, species of *Zelurus* have considerable ecological importance, since they are predators and may eventually act on population control of other invertebrates (Ferreira *et al.* 2000; Prous *et al.* 2015).

Despite almost 190 years after the first description of one *Zelurus* species (Maldonado Capriles 1990), great part of the knowledge regarding the genus is essentially taxonomic, thus remaining large gaps to be filled especially related to the biology and distribution of the group. In this context, Ecological Niche Modelling (ENM) comprise tools that may improve the knowledge about several groups, especially in cases of species with scarce records of collections. The software uses statistical tools to generate predictive models of geographical distribution based on occurrence data, then it is possible to predict, at different scales, places with environmental characteristics adequate to the occurrence of a given group or species (Phillips *et al*. 2006).

The generation of models through strategies of Ecological Niche Modelling (ENM) requires several environmental parameters, which came from field collections and are freely available (Hijmans *et al.* 2005). Such potential models of geographical distribution, when used together with environmental data, have provided excellent results, thus solving issues regarding ecology and conservation, response of fauna to climatic factors, assessment of invasive potential of exotic species, global effects of climatic changes on species, niche divergence between two or more taxonomic groups, among others (Anderson *et al*. 2002, Peterson & Holt 2003, Engler *et al*. 2004, Thomas *et al*. 2004, Arif *et al*. 2007, McCormack *et al*. 2010, Rinnhofer *et al*. 2012; Amaro *et al*. 2013).

In the present work, two new species of *Zelurus* are described from Brazilian caves. In addition, we provide some comments regarding the current and potential distribution of the species found in caves and the genus in South America.

Material and methods

The 95 specimens studied in this work are deposited in the Subterranean Invertebrates collection (ISLA) of the Universidade Federal de Lavras" (Minas Gerais, Brazil). These specimens come from various research projects conducted over the last 15 years by the Subterranean Biology Research Center team in different regions of Brazil. In total, over 1,000 caves were sampled. The collection method was through direct search. Individuals collected were stored in vials with 70% alcohol.

Dissections of the male and female genitalia were made by firstly removing the pygophore or the genital segments, respectively, from the abdomen with a pair of forceps and then clearing them in KOH solution for 24 hours. The dissected structures were studied in glycerol. Drawings were made using a camera lucida. General morphological terminology mainly follows Schuh & Slater (1995), however, the (visible) segments of the labium are numbered as II to IV, given that the first segment is lost or fused to the head capsule in Reduviidae (Weirauch 2008, Schuh *et al*. 2009). Terminology applied to genital characteristics follows Lent & Wygodzinsky (1979). However, regarding the male genitalia, "vesica" as recognized by those authors has been considered to be absent in reduviids. The assumed equivalent structure in reduviids is a somewhat sclerotized appendage of the phallosoma of the endosoma (Forero & Weirauch 2012), but not the homologous vesica that occurs in other heteropterans such as Pentatomomorpha (Rédei & Tsai 2011). Thus, this term is not used here for the median process of the endosoma, which is named as such. The terminology of female genitalia portions, after dissection, follows also Lent & Jurberg (1975) and Gil-Santana (2012). Therefore, all of these sources should be consulted for a more detailed description of the parts.

The acronyms used for the institutions and collections cited in this paper are as follows: Coleção de Triatomíneos do Instituto Oswaldo Cruz (CTIOC), Rio de Janeiro, Brazil, and Coleção de Invertebrados Subterrâneos da Universidade Federal de Lavras (ISLA), Minas Gerais, Brazil.

The measurements were made through a magnifying glass with its own ruler (Stemi 2000—ZEISS). Photos of living species were taken with a camera at the time of collection. For the description of new species, photographs were taken through a magnifying glass with a built-in Leica M205 camera with the use of the "Leica Application Suite self montage" to combine the images.

The ecological niche modelling for the group was prepared using the method of maximum entropy, through the free software Maxent, version 3.3.3K (Phillips *et al.* 2006). This software works to attempt occurrence prediction of habitats favorable to the existence of a target species taking into account only data on presence, derived from a number of environmental variables analyzed in isolation and jointly (for details see Elith *et al.* 2011).

The settings used for the Maxent were “the logistic output format”, “regularization multiplier” = 1, “maximum interations” = 1,000, “convergence threshold” = 10^{-5} and “maximum number of background points” = 30,000. For repetitions used in the "cross validate test" the number of occurrence points for each species was considered (Phillips & Dudík 2008).

For the environmental parameters it was decided to initially use a set of 19 variables and altitude data of the geographic target area, making up 20 variables which were obtained from the database available at Worldclim in a generic grid (raster) format (Hijmans *et al*. 2005; found at http://www.worldclim.org). Climatic data provided by Worldclim were generated from a data interpolation obtained in climatic seasons between the 1950 and 2000 (Hijmans *et al*. 2005). The resolution of the grid used in the environmental variables was 5 arcminutes.

Only the species occurring in Brazilian caves were used in the models (those ten species presented in this work). Furthermore, we only used South America in the modelling. To avoid multicollinearity among several environmental predictions, a correlation test was performed using arcgis (Johnston *et al*. 2001) to reduce the 20 variables. We used r> 0.80 (Pearson correlation coefficient) as the cutoff point for determining the exclusion of highly correlated variables. Thus, in the end, only 7 variables were considered for the preparation of the models: temperature seasonality (BIO 4), mean temperature of the warmest quarter (BIO 10), annual seasonality (BIO 15), precipitation of the driest quarter (BIO 17), precipitation of the warmest quarter (BIO 18), precipitation of the coldest quarter (BIO 19) and altitude.

To obtain the environmental suitability model only presence data (true events) was used, since absences may mean inappropriately collected samples, or locals with sampling deficiencies. The occurrence data from caves was obtained from the specimens registered in the subterranean invertebrate collection (ISLA) of the Subterranean Biology Study Center (CEBS/UFLA) and literature data (Pinto-da-Rocha 1995; Ferreira & Martins 1999; Prous 2005; Ferreira *et al*. 2011; Souza-Silva *et al*. 2011b; Iniesta *et al*. 2012). However, for the Ecological Niche Modelling analysis, we used not only records from caves, but also from external environments, obtained from literature. In many cases, there were no geographic coordinates of the collection site of a given species. In those cases, the occurrence points were determined from a reference site, such as a city, the central region of a protected area, town or other surrounding geographical point that could be recognized and had been cited by the author.

Taxonomy

Family Reduviidae

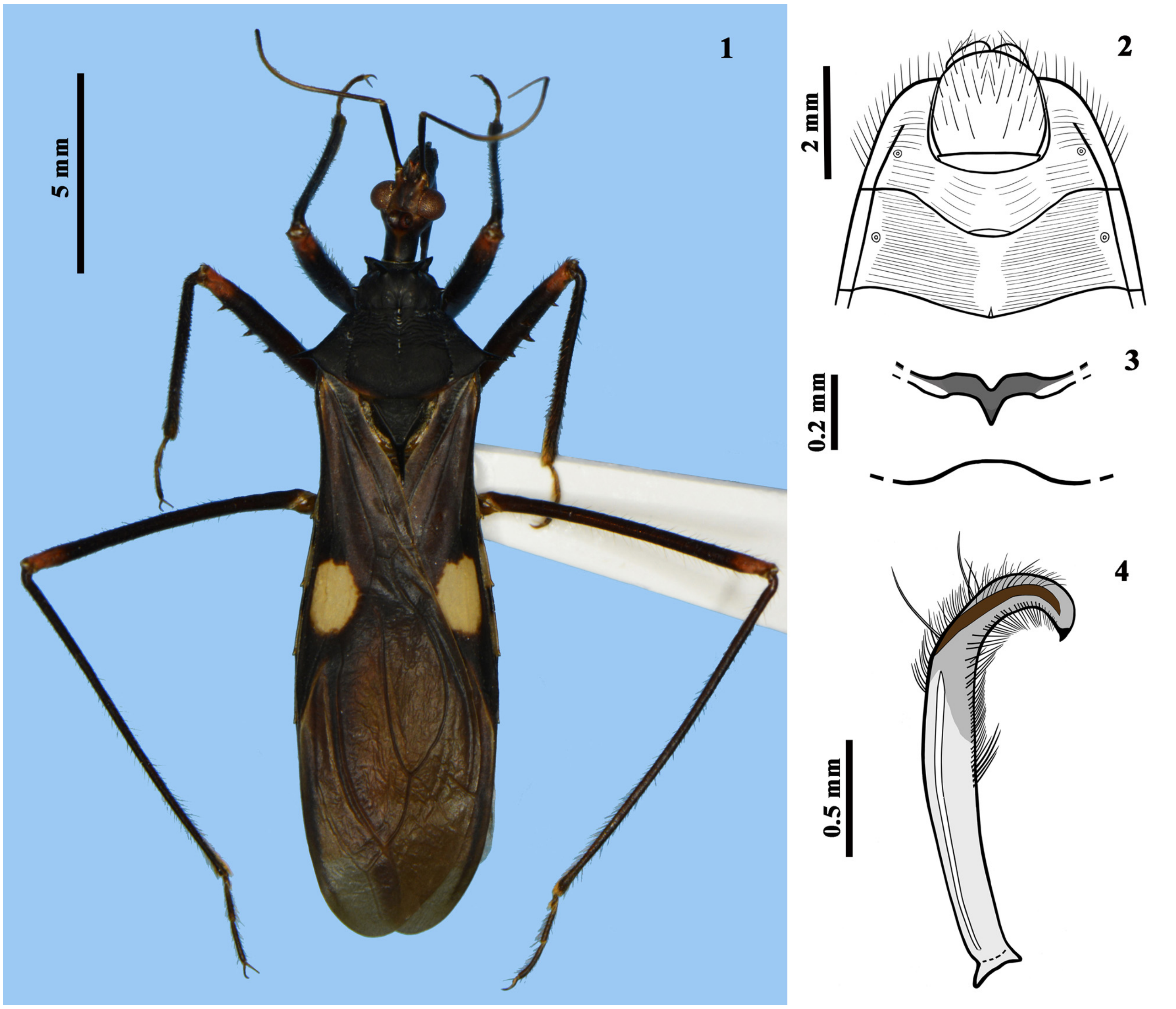
Subfamily Reduviinae

Genus *Zelurus* Hahn, 1826

Zelurus gerevatinga sp. nov.

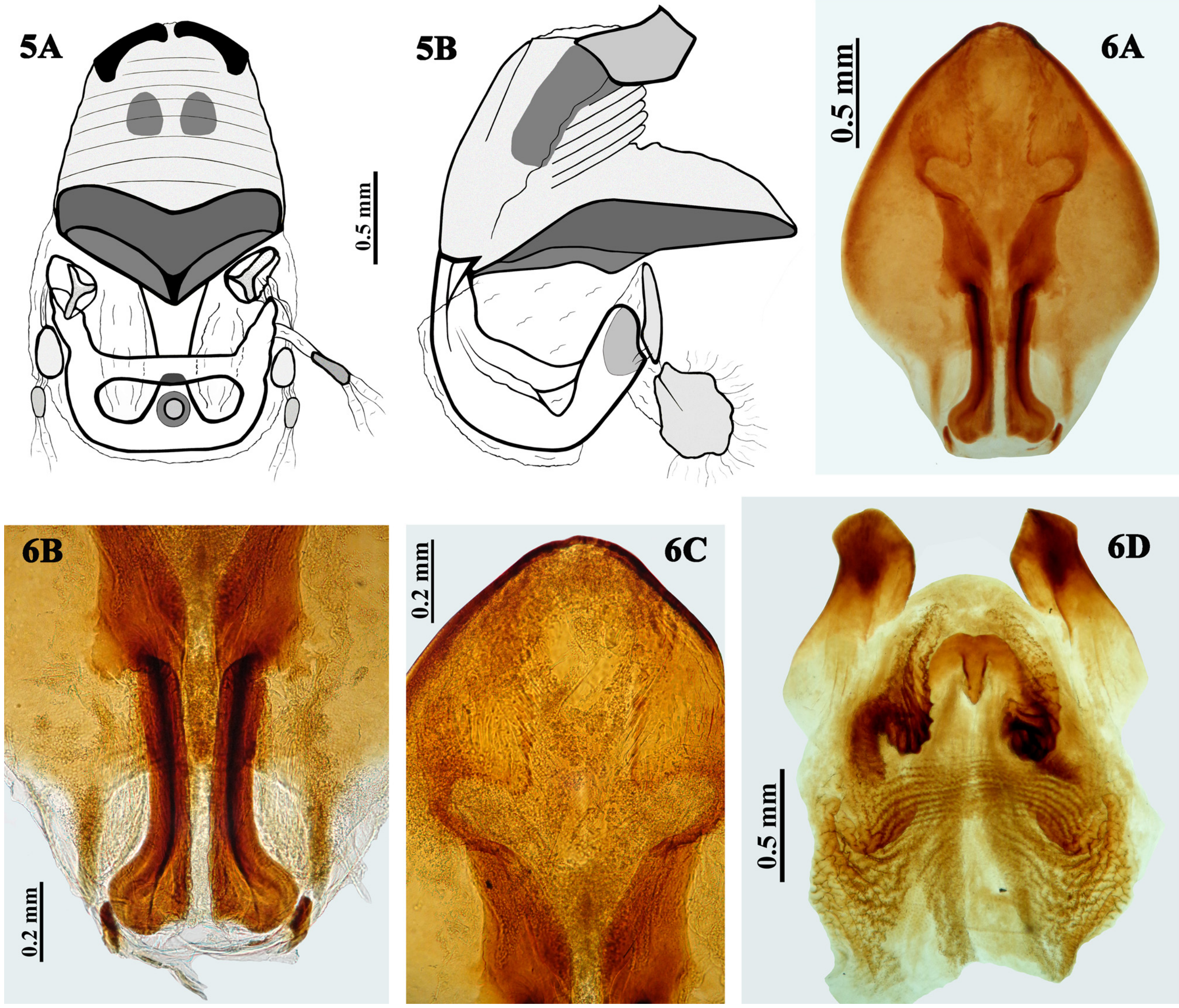
(Figs. 1–13)

Diagnosis. This species can be separated from other species of the genus by the following set of characters: general coloration dark brown; apices of femora with a reddish (holotype) to yellowish (paratypes) tinge; hemelytra with a conspicuous suboval pale to yellowish spot on distal half of corium (Figs. 1, 7). Fore lobe of pronotum with a pair of moderately long spines and short acute prominences laterally (Figs. 1, 7, 10); a moderately long and strong spine on each humeral angle (Figs. 1, 7, 10). Scutellum with an apical, moderately long, posteriorly directed spine (Fig. 10). Fore (Fig. 11) and mid femora with three thick spines on postero-ventral portion, in which two larger spines lie on distal half and the smaller spine lies basally but near the median portion of the respective femur; a large group, sometimes forming irregular rows, of thin short and acute sclerotized spines on antero-ventral surface of the mid femur; fore tibia with a ventral median row of single denticles on midline, which are absent at extreme base and on the area in which the spongy fossa occur; mid tibia with two median ventral rows of denticles somewhat parallel, which are absent at extreme base and on the area in which the spongy fossa occur. Spongy fossa on ventral portion of apex of fore (Fig. 11) and mid tibia at approximately 1/3 of the length of fore tibia and 1/4 of mid tibia, respectively. Postero-lateral angles of connexival segments II to V with a small spiny protuberance (Fig. 1).



FIGURES 1–4. *Zelurus gerevatinga* **sp. nov.**, male holotype, 1, dorsal view, 2, apex of abdomen including pygophore and parameres, ventral view, 3–4, male genitalia, 3, median process of pygophore, dorsal view, 4, paramere,

Description. *Male*. MEASUREMENTS (holotype/paratype): Total length: 18.100/19.188; head: length (excluding collum): 3.268/2.856; width across the eyes: 1.837/2.077; antennal segments length: I: 1.671/2.033; II: 4.750/4.456; III: 3.555/4.016; IV: 1.762/2.698; labial segments length: II (first visible): 1.592/1.655; III: 1.568/1.592; IV: 0.525/0.644. Thorax: pronotum length: 3.556/3.487; maximum width: 5.176/5.405; length of median spine of fore lobe: 0.601/0.765; length of spine of humeral angles: 0.652/1.182; length of scutellar spine:1.143/1.881. Legs length: fore legs: femur: 4.675/4.806; tibia: 4.840/5.728; spongy fossa on apex of tibia: 1.820/1.812; tarsus: 1.263/1.212; middle legs: femur: 4.448/5.276; tibia: 5.549/5.428; spongy fossa on apex of tibia: 1.360/1.416; tarsus: 1.430/1.829; hind legs: femur: 7.827/7.064; tibia: 9.569/8.490; tarsus: 2.534/2.210. Abdomen maximum width: 5.158/5.522. COLORATION: general coloration dark brown, with blackish or light brown areas and pale markings (Fig. 1). **Head:** brownish, clearer on mandibular plates, around eyes on dorsal portion and post-ocular region, on a median longitudinal line of post-ocular region, and on joints of labium. Antenna: first segment brownish, somewhat clearer at base; second segment pale with large subbasal and subapical brownish rings; third and fourth segments pale. Eyes blackish. **Thorax**: pronotum and pleura blackish; posterior margin of pronotum, above lateral portions of scutellum base and somewhat laterally over clavus base, lightly brownish; posterior border of hind lobe of pronotum clear, almost yellowish; sterna and legs brownish; somewhat paler rounded spots on center of each pleura and on lateral surface of each supracoxal lobe; apices of coxa, trochanters and base of femora somewhat clearer; apices of femora with a reddish (holotype) or yellowish (paratype) tinge; spongy fossa on fore and mid tibia and tarsi somewhat clearer. Hemelytra dark with a conspicuous suboval pale to yellowish spot on distal half of corium (Fig. 1); a thin and short light brownish stripe on basal portion of corium adjacent to costal area but below claval suture; another two similar but longer stripes with similar coloration on basal half and lateral area of membrane, running parallel and adjacent to basal half of outer vein of external cell and lateral margin of the membrane. **Abdomen**: brownish; most of connexival segment II, except its base, and posterior half of remaining segments of connexivum clearer to pale; median portion of sternites somewhat clearer. VESTITURE: **Head**: anteocular portion with sparse numerous small adpressed pale setae; long fairly stout darkened setae scattered on labium, labrum, clypeus and some on dorsal, lateral and ventral portions of head; these are more numerous on last segment of labium and anterior portion of head adjacent to insertion of the labium; antennifers with few stiff setae laterally; a group of small adpressed golden setae near posterior half of margins of eyes and some scattered ones posteriorly; interocular region, lateral and dorsal portions of post-ocular region almost or completely glabrous. Antenna: first segment glabrous basally, with scattered, somewhat stout and curved red-brownish setae, which are more numerous towards apex; second segment with scattered, short, somewhat curved and stout brownish setae and numerous shorter, thinner yellowish to whitish setae, which are more sparse and a little longer on approximately basal fourth of the segment; about four isolated thin, clear and somewhat longer straight setae on posterior surface; remaining segments covered with numerous thin shorter declivous yellowish to whitish setae, which are somewhat longer towards apex of fourth segment and with somewhat curved and stout brownish setae longer than in preceding segments. **Thorax**: pronotum mostly glabrous, with numerous very short, thin, whitish setae on anterior margin of collar; scattered few adpressed thin curved yellowish setae on fore and hind lobe; some brownish long thin setae on anterior and lateral portions; numerous short straight thin yellowish setae between posterior margin of pronotum and lateral base of scutellum; long spines of pronotum almost glabrous, with few thin curved short setae. Scutellum: basal portion with numerous small adpressed clear setae, mainly on lateral margins; spine with long fine straight darkened setae on ventral portion and some few curved short clear setae on dorsal and lateral surfaces. Pleurae, lateral portion of mesosternum and posterior half of metasternum almost glabrous, with very sparse thin short clear adpressed setae; some longer setae on propleura and median posterior margin of metasternum; prosternum, median portion of mesosternum and anterior half of metasternum covered with small adpressed clear setae; blunt tubercles on prosternum with a tuft of stout long brownish setae. Legs: coxae with scattered long brownish setae, somewhat more numerous on anterior and lateral surfaces, and thicker on fore coxae. Few scattered stout brownish setae on all trochanters; fore trochanter with two parallel rows of numerous curved moderately stout yellow-brownish setae ventrally; an anterior row of numerous somewhat thinner setae ventrally. Basal extremity of fore femur with two ventral parallel rows of numerous curved moderately stout yellow-brownish setae, with the posterior row denser than the anterior; all femora covered with several stout darkened, brownish to brown reddish long stout setae; stouter, longer, brownish setae scattered on ventral surface of femora, more numerous on fore and mid femora; all tibiae covered with irregular rows of numerous stout darkened somewhat short to long setae, and with tufts of short clearer setae apically; tarsi covered with darkened or clearer setae, more numerous on ventral surface. Hemelytra: corium with scattered short adpressed clear thin setae, somewhat more numerous and long on the costal margin, including the inclined portion at basal portion; membrane glabrous. **Abdomen**: sternites with scattered long, slender, erect, straight and yellowish setae; some longer setae on posterior and lateral margins of the last sternite (Fig. 2). Genital segments covered with long and somewhat shorter yellowish setae. STRUCTURE: **Integument:** opaque; moderately shiny on first two antennal segments, long spines of pronotum and scutellum, lateral portions of meso and metasternum and sternites. **Head**: around 1.5 times as long as wide across eyes, shorter than pronotum, anteocular portion somewhat longer than postocular and strongly declivous; mandibular plate prominent, subacute; maxillary plate with apex rounded. Eyes prominent, projecting laterally. Transverse sulcus shallow. Ocelli large and prominent, the anterior margin just behind transverse sulcus and posterior edge of eyes. Antennifers somewhat elongate. Antenna: first segment somewhat curved, enlarged towards apex, thicker and shorter than other segments; second segment the longest, thinner than the first but thicker than the third and fourth, somewhat curved at median third; segments III and IV the thinnest. Labium curved, thick; segments II and III (first two visible) subequal in length; segment IV somewhat half shorter than the previous segment, tapering. **Thorax**: Pronotum: anterolateral angles prominent, with apex acute; anterior collar moderately large; fore lobe with a pair of moderately long spines and short acute prominences laterally; transverse sulcus shallow; longitudinal sulcus imperceptible on anterior portion of fore lobe and posterior margin of hind lobe, but linear on posterior portion of fore lobe and anterior 2/3 of hind lobe; anterior portion of disc of hind lobe with thin transverse tortuous striations, which gives a rugous appearance to this area; a pair of sublateral shallow sulci on posterior half of hind lobe; a moderately long and strong spine on each humeral angle (Fig. 1). Scutellum triangular, moderately large; disc with a somewhat rugous surface bordered by



FIGURES 5–6. *Zelurus gerevatinga* **sp. nov.**, male holotype, 5, phallus, A, dorsal view, B, lateral view. 6, phallosoma portions, A–C, dorsal phallothecal plate and struts, dorsal view, B, basal portion, C, median portion of apical third, D, endosoma and endosoma processes, ventral view.

distinct carina, with an apical, moderately long, posteriorly directed spine. Stridulitrum elongated, occupying the entire median portion of prosternum; a pair of anterior blunt short tubercles beside stridulitrum and anterior to fore acetabula. Legs (Fig. 1): long and slender; hind femora and tibia longer than the others; fore femora somewhat thicker than mid femora, which are somewhat thicker than hind femora too; fore and mid femora with three thick spines on postero-ventral portion, in which the larger spines lie on distal half and the smaller spine lies basally but near the median portion of the respective femur; few small dark tubercles at base of stronger straight darkened setae on antero-ventral surface of fore femur; irregular rows of thin short and acute sclerotized spines on antero-ventral surface of the mid femur; fore tibia with a ventral median row of denticles on midline, which are absent at extreme base and on the area in which the spongy fossa occurs; mid tibia with two median ventral rows of denticles somewhat parallel, which are absent at extreme base and on the area in which the spongy fossa lies on. Tarsi three-segmented, in which the first segment is much shorter than the others, claws symmetrical and slender. A small comb on mesal surface of apex of fore tibia. Spongy fossa on ventral portion of apex of fore and mid tibia with about 1/3 of the length of fore tibia and 1/4 of mid tibia, respectively. Hemelytra surpassing tip of abdomen for approximately 0.5 mm. **Abdomen**: moderately elongate, suboval. Posterolateral angles of connexival segments II to V with a small spiny protuberance. Posterolateral angles of connexival segment VI with a small blunt protuberance. A median keel on sternites II (first visible) to IV and anterior half of V; sutures between sternites thin, except the thicker suture between sternites II and III. Sternites with fine transverse striations, somewhat more marked on sternite II and around genitalia on sternite VII (Fig. 2). **Male**

genitalia (Figs. 2–6): pygophore rounded; parameres apices close in resting position (Fig. 2). Median process of pygophore sclerotized, subtriangular, in dorsal view, apex acute (Fig. 3). Parameres symmetrical, elongate, very curved at apical third, with a short apical tooth; numerous moderately long setae on apical half of internal surface; more sparse setae, a few of which are longer than others on apical third of external surface (Fig. 4). Phallus (Figs. 5, A–B) with articulatory apparatus short, subretangular; basal bridge well developed. Dorsal phallothecal plate (Figs. 6, A–C) very sclerotized, suboval in shape, apex rounded. Struts (Figs. 6, A–C) separated, enlarged and somewhat rounded at base, subparallel at basal third; enlarged, sickle-shaped and diverging at middle third; at distal third, half-rimmed and flattened toward apex (Figs. 6, A–C). In the middle of endosoma there is a pair of somewhat sclerotized processes between which occurs a cupular median process (Fig. 6, D). The latter has a pointed median process (Fig. 6, D). Endosoma wall sclerotized with a pair of flat heavily sclerotized subrectangular, lateral lobes on external surface, apically (Figs. 5, A–B, 6, D).

Female. MEASUREMENTS: Total length: 21.054–21.776; head: length (excluding collum): 2.749–2.826; width across the eyes: 1.925–1.938; antennal segments length: I: 1.515–1.927; II: 3.827–3.973; III: 3.209; IV: 2.165; labial segments length: II [first visible]: 1.757–1.877; III: 1.745–1.579; IV: 0.514–0.558. Thorax: pronotum length: 3.698–3.921; maximum width: 6.002–6.367; length of median spine of fore lobe: 0.805–0.829; length of spine of humeral angles: 0.813–0.865; length of scutellar spine: 1.226–1.344. Legs length: fore legs: femur: 4.314–5.537; tibia: 5.023–5.128; spongy fossa on apex of tibia: 1.751–1.820; tarsus: 1.520–1.664; middle legs: femur: 4.625–4.687; tibia: 5.140–5.310; spongy fossa on apex of tibia: 1.360–1.416; tarsus: 1.587–1.780; hind legs: femur: 8.292–8.538; tibia: 9.599–10.180; tarsus: 2.262–2.498. Abdomen maximum width: 5.889–5.915. Similar to male (Figs. 7–10). A large group of thin short and acute sclerotized spines occupying most of the antero-ventral surface of the mid femur, much more numerous than in the males examined. On anterior half of sternite VII, a pair of lateral round, low protuberances present, between which the midline portion is somewhat elevated but without forming a distinct keel (Fig. 12, A). Only the posterolateral connexival angle of segment II with a small spiny protuberance. **Female genitalia**: external genitalia as in Figs. 12, A–B; gonocoxite and gonapophysis VIII, gonocoxite IX, and gonapophysis IX as shown in Figs. 13A, 13B and 13C, respectively.

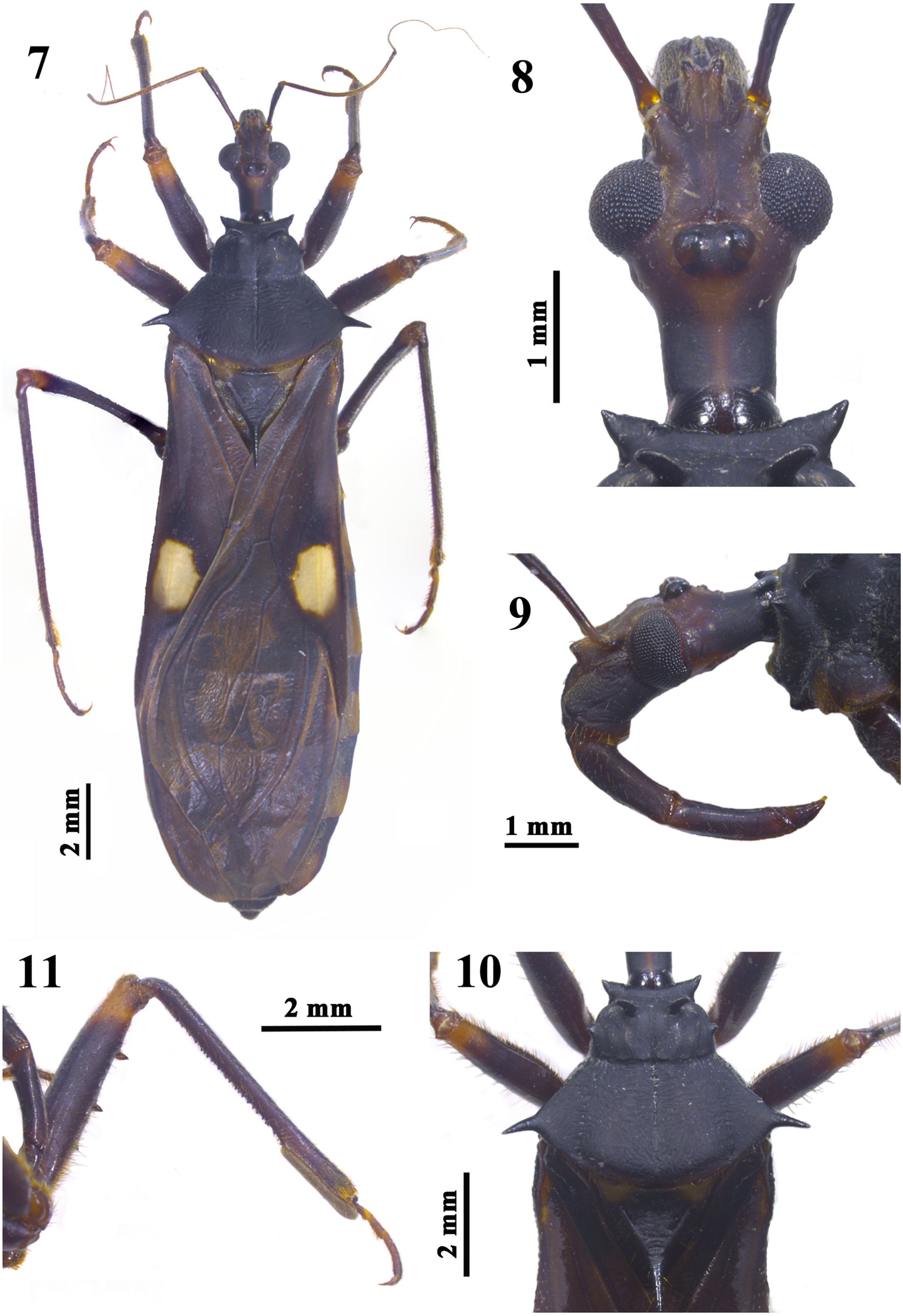
Distribution. Brazil, state of Minas Gerais.

Etymology. The specific epithet refers to the combination of two indigenous words (Tupi-Guarani): "*gereva*", meaning "spotted" and "*tinga*" which means "white." The epithet refers to the condition observed on the hemelytra of the specimen, featuring distinct white spots.

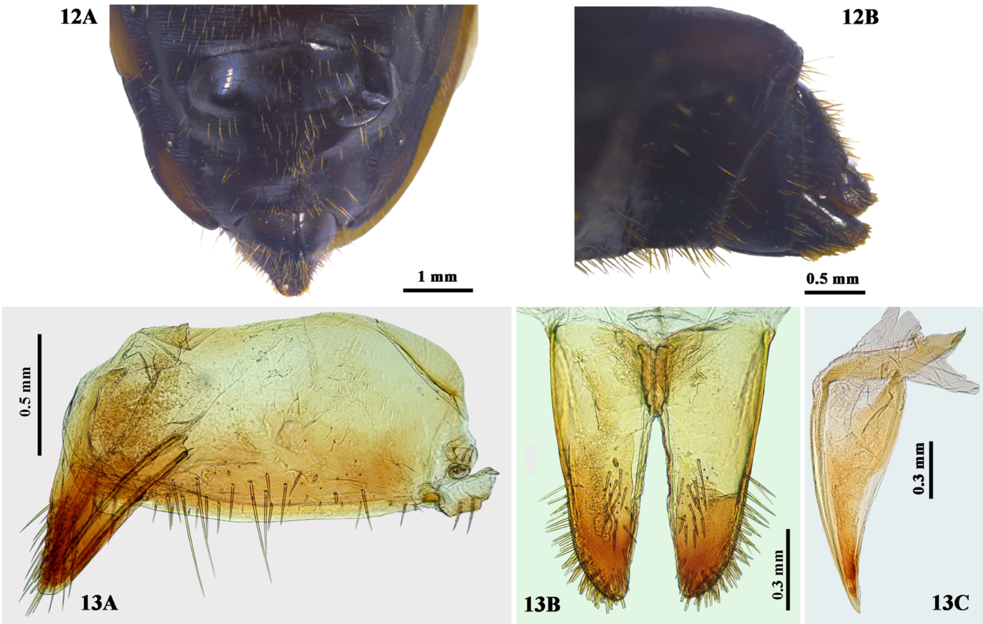
Specimens examined. ***Zelurus gerevatinga* sp. nov. BRAZIL, Minas Gerais,** Pains, Gruta [cave] da Sangueira, 28.XI. 1999, Ferreira *leg*., ISLA 12080, **male holotype**; Gruta [cave] do Brejão, 11.X.2000, Ferreira *leg*., ISLA 12079, male paratype; Gruta [cave] da Torre, 27.XI.1999, Ferreira *et al*. *leg*., ISLA 9501, female paratype; Gruta [cave] Massarambará, 12.X.2000, Ferreira *leg*., ISLA 12078, female paratype; [ISLA].

***Zelurus transnominalis* Lent & Wygodzinsky. BRAZIL, Mato Grosso** [currently, Mato Grosso do Sul], Bodoquena, XI.1941, Com. I.O.C. [*leg*.], P. Wygodzinsky. + H. Lent det., 447, 449, HEMIPTERA, Inst. Oswaldo Cruz, female paratype, male paratype [CTIOC].

Discussion. Among all species of *Zelurus*, judging by external features of adults, *Z. gerevatinga* **sp. nov.** seems closer to *Z. transnominalis* Lent & Wygodzinsky, 1947. They share several similarities: hemelytra with a conspicuous pale spot on distal half of corium; fore lobe of pronotum with a pair of moderately long spines and short acute prominences laterally; a moderately long and strong spine on each humeral angle; scutellum with an apical, moderately long, posteriorly directed spine; fore and mid tibia with ventral row of denticles and spongy fossa on fore tibia approximately 1/3 of the length of the tibia. On the other hand, other several prominent features distinguish *Z. gerevatinga* **sp. nov.** and *Z. transnominalis*: *Z. gerevatinga* **sp. nov.** has a much darker general coloration and larger size. *Zelurus transnominalis* besides the distal spot has an additional pale large spot on the basal portion of the corium of hemelytra, the femora and the connexivum are uniformly colored, and a median keel on sternites II–VI (males) or II–VII (females), whereas *Z. gerevatinga* **sp. nov.** has the basal portion of the corium almost completely dark, apices of femora distinctly pale, connexivum bicolored, and the median keel on sternites restricted to segments II–IV and anterior half of V.



FIGURES 7–11. *Zelurus gerevatinga* **sp. nov.**, female paratype, 7, dorsal view, 8–9, head, 8, dorsal view, 9, lateral view, 10, pronotum and scutellum, dorsal view, 11, fore leg, lateral view.

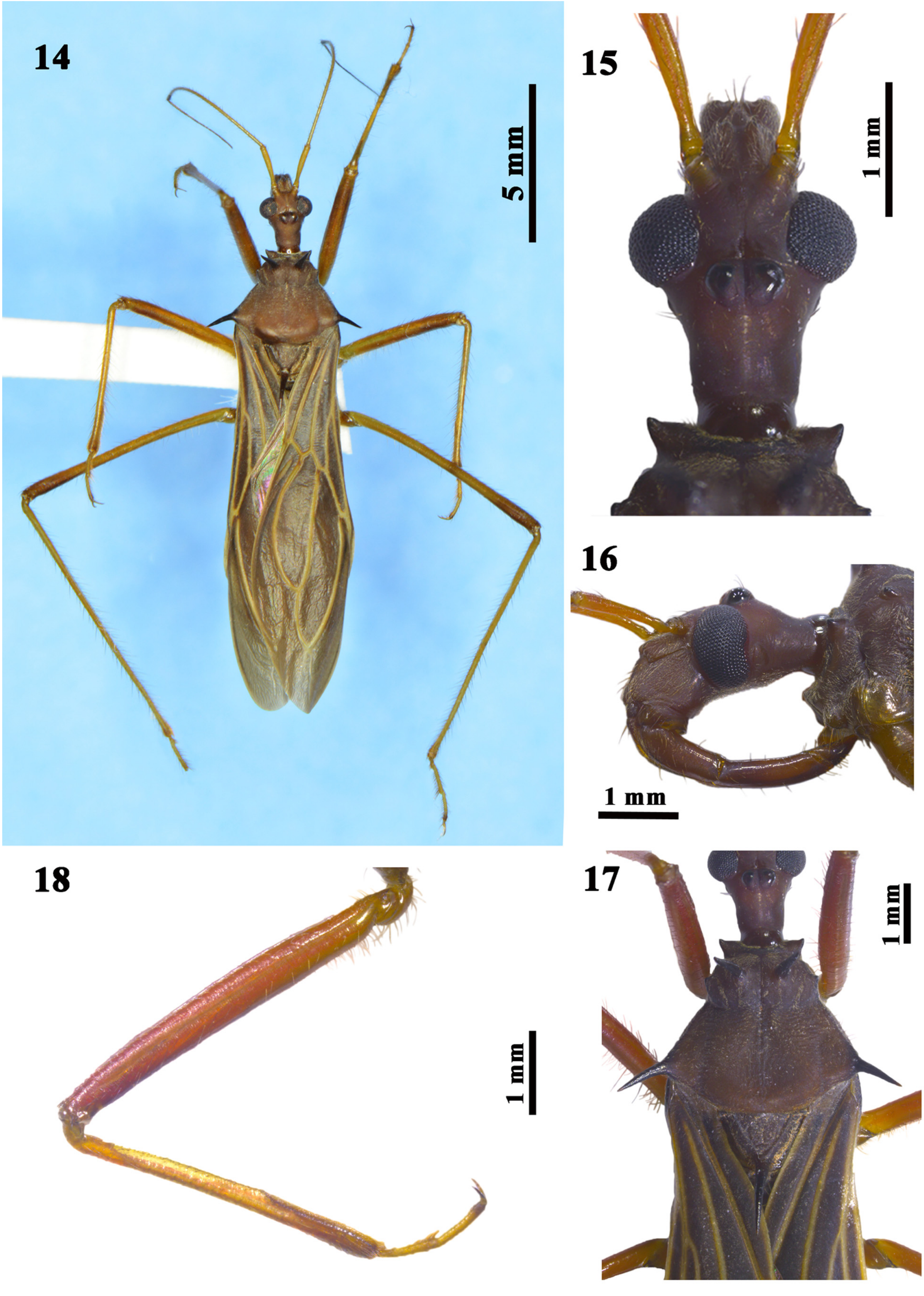


FIGURES 12–13. *Zelurus gerevatinga* **sp. nov.**, female paratype, 12, apex of abdomen, including genital segments, A, ventral view, B, lateral view. 13, genital segments, A, gonocoxite and gonapophysis VIII, B, gonocoxites IX, C, gonapophysis IX.

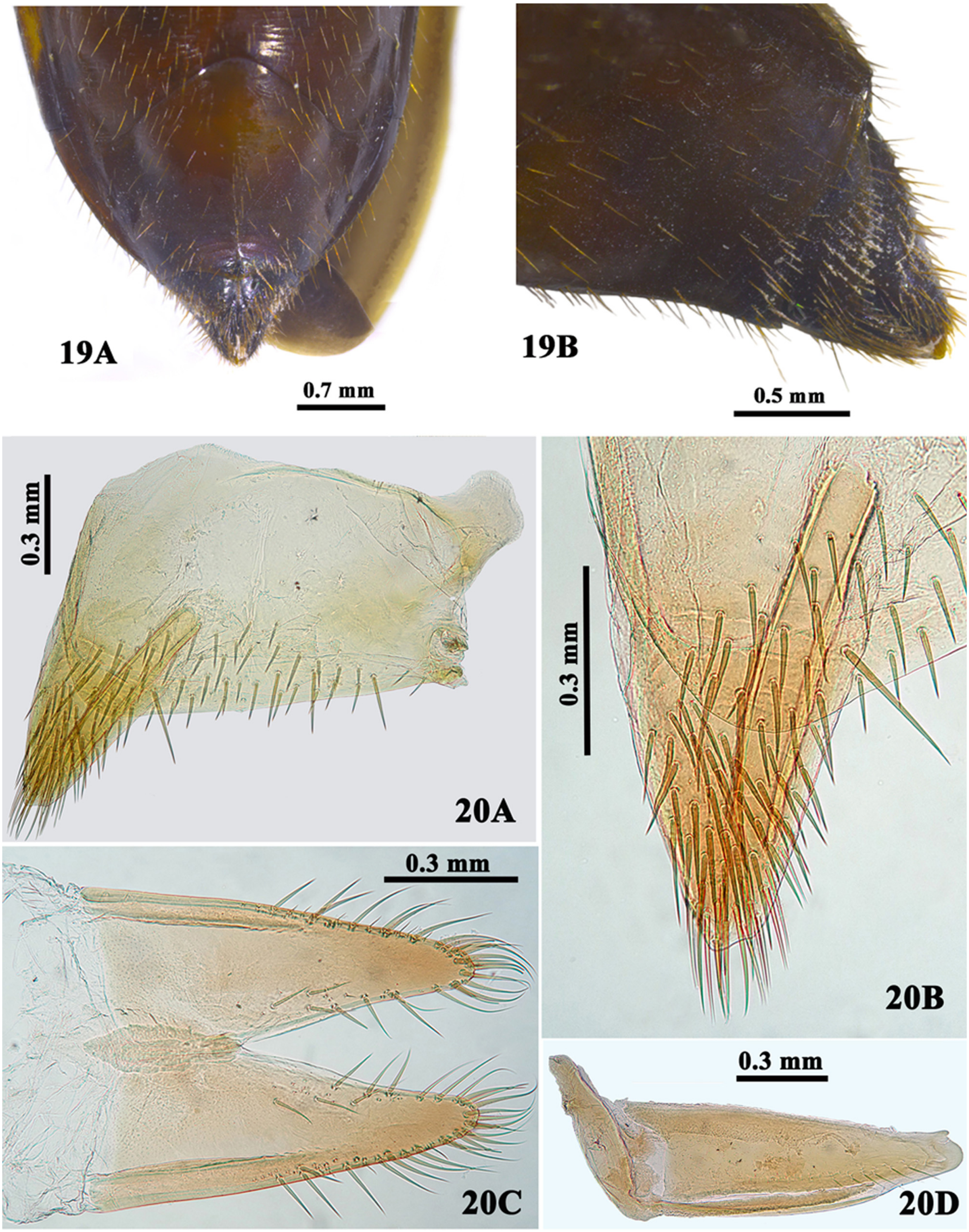
Zelurus tambejua **sp. nov.**
(Figs. 14–20)

Diagnosis. This species can be separated from their congeneric by the following set of characters: general coloration dark brown, ochraceous brownish to bright ochraceous; hemelytra brownish, with the veins pale, somewhat yellowish (Figs. 14–18). Pronotum: fore lobe with a pair of median long spines and short acute prominences laterally; a long and strong spine on each humeral angle of hind lobe (Figs. 14, 17). Scutellum with an apical, long, strong and posteriorly curved spine (Fig. 17). Legs: fore trochanters with two parallel rows of very short numerous brownish spines ventrally, a group of about thirty similar very short brownish spines on base of fore femora ventrally. Spongy fossa on ventral portion of apex of fore (Fig. 18) and mid tibia somewhat longer than 1/3 of the length of the respective tibia.

Description. *Female*. MEASUREMENTS (holotype): Total length: 16.147; head: length (excluding collum): 2.382; width across the eyes: 1.640; antennal segments length: I: 1.621; II: 5.369; III: 4.417; IV: absent; labial segments length: II (first visible): 1.042; III: 1.104; IV: 0.564. Thorax: pronotum length: 3.013; maximum width: 4.962; length of median spine of fore lobe: 1.207; length of spine of humeral angles: 0.889; length of scutellar spine: 1.586. Legs length: fore legs: femur: 4.229; tibia: 4.241; spongy fossa on apex of tibia: 1.711; tarsus: 1.443; middle legs: femur: 4.330; tibia: 4.602; spongy fossa on apex of tibia: 1.729; tarsus: 1.501; hind legs: femur: 7.715; tibia: 9.194; tarsus: 2.225. Abdomen maximum width: 4.044. COLORATION: general coloration dark brown, ochraceous brownish to bright ochraceous (Figs. 14–18). First and second antennal segments bright ochraceous, with the apex of the second segment darkened; third antennal segment darkened, fourth segment absent. Eyes blackish. Spines of pronotum and scutellum somewhat darkened (Figs. 14, 17). Hemelytra brownish, with the veins pale, somewhat yellowish (Fig. 14). Coxae, trochanters and femora ochraceous brown; apical portion of femora faintly darker; tibiae and tarsi clearer, with apex of the former and apices of third segments of the latter, darkened (Fig. 18). VESTITURE: **head**: anteocular and ventral portions of head with numerous small adpressed golden setae; long fairly stout darkened setae scattered on labium, labrum, clypeus and some on lateral portions of head; antennifers with four stiff setae laterally; interocular region and dorsal surface of post-ocular region almost completely glabrous, with a group of small adpressed golden setae near posterior half of margins of eyes and some scattered ones posteriorly; lateral region of post-ocular region glabrous; antenna with somewhat long darkened stout setae, which are less numerous on first segment; second and third segments (fourth absent) covered with very numerous



FIGURES 14–18. *Zelurus tambejua* **sp. nov.**, female holotype, 14, dorsal view, 15–16, head, 15, dorsal view, 16, lateral view, 17, pronotum and scutellum, dorsal view, 18, fore leg, lateral view.



FIGURES 19–20. 19–20, *Zelurus tambejua* **sp. nov.**, female holotype, 19, apex of abdomen, including genital segments, A, ventral view, B, lateral view, 20, genital segments, A, gonocoxite and gonapophysis VIII, B, gonapophysis VIII, C, gonocoxites IX, D, gonapophysis IX.

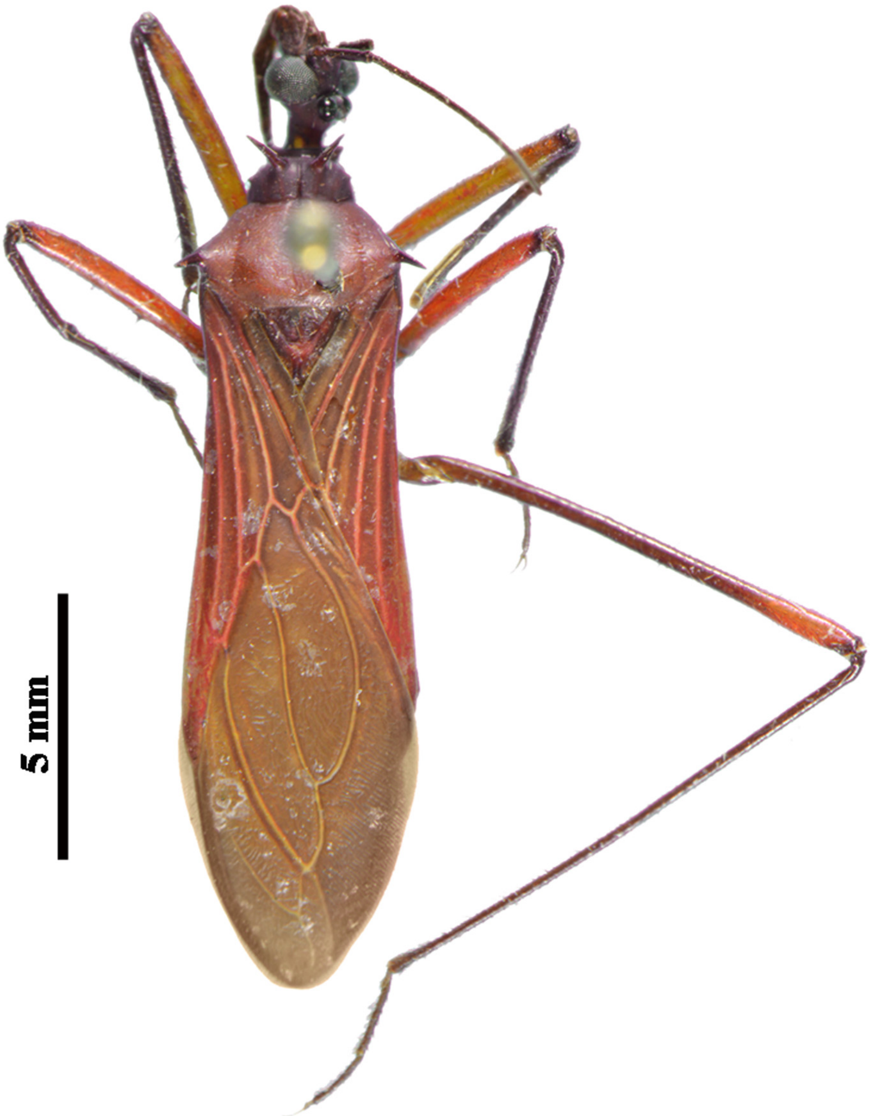


FIGURE 21. *Zelurus fosteri* Lent & Wygodzinsky, male, dorsal view.

shorter, thinner, yellowish to whitish setae. **Thorax**: pronotum: numerous very short, thin, whitish setae on anterior margin of collar; anterior portion of fore lobe and lateral portions of pronotum with numerous small adpressed golden setae, which form a pair of lines on posterior portion of fore lobe; these setae are sparser and scattered on hind lobe, except on posterior margin, where they become more numerous; lateral portion of hind lobe with long fine sparse clear setae; long spines of pronotum almost glabrous, with few thin curved short yellowish setae. Scutellum: basal portion with numerous small adpressed golden setae; spine with long fine straight darkened setae on ventral portion and some few curved short yellowish setae on dorsal and lateral surfaces. Pleura, prosternum, median portion of mesosternum and metasternum covered with small adpressed golden setae; blunt tubercles on prosternum with approximately five stout straight darkened setae. Legs: coxae with scattered long and fine yellowish setae; fore and mid trochanters covered on ventral surface with very numerous long and fine yellowish setae; these setae, somewhat less numerously, are present on ventral surface of basal half to basal 2/3 of fore and mid femora; all femora covered with several stout darkened long setae; all tibiae covered with irregular rows of numerous stout darkened somewhat short to long setae, and with tufts of short clear setae apically; tarsi covered with darkened or clearer setae, more numerous on ventral surface. Hemelytra: corium almost glabrous, with few short curved yellowish setae on basal portion and lateral (costal) margin; membrane glabrous. **Abdomen**: sternites with scattered long, slender, erect, straight and yellowish setae. Genital segments covered with shorter and more numerous setae (Fig. 19). STRUCTURE: **Integument**: opaque; moderately shiny on first two antennal segments, long spines of pronotum and scutellum, lateral portions of meso and metasternum, and legs; shiny on sternites. **Head** (Figs. 15–16): approximately 1.5 times as long as wide across eyes, shorter than pronotum, anteocular portion somewhat longer than postocular and strongly declivous; mandibular and maxillary plates with apex rounded, the former more prominent. Eyes prominent, projecting laterally. Transverse sulcus shallow. Ocelli large and prominent; their anterior margin lies just behind transverse sulcus and posterior edge of the eyes. Antennifers somewhat elongated. Antenna: first segment somewhat curved, enlarged towards apex, thicker and shorter than others; second segment the longest, thinner than the first but thicker than the third, somewhat curved at median third. Labium (Fig. 16): curved, thick; segments II and III (first two visible) subequal in length; segment IV somewhat half shorter than the previous segment, tapering. **Thorax**: Pronotum (Figs. 14, 17): antero-lateral angles prominent, with apex acute; anterior collar moderately large; fore lobe with a pair of median long spines and short acute prominences laterally; transverse sulcus shallow; a distinct narrow longitudinal sulcus, which is absent on anterior collar and posterior portion of hind lobe; anterior portion of disc of hind lobe with faint transverse thin tortuous striations, which gives a subtle rugous aspect to this area; a pair of sublateral shallow sulci on posterior half of hind lobe; a long and strong spine on each humeral angle. Scutellum triangular, moderately large; disc with a somewhat rugous surface bordered by distinct carina, with an apical, long, strong and posteriorly curved spine (Fig. 17). Stridulitrum elongate, occupying the entire median portion of prosternum; a pair of anterior blunt tubercles beside stridulitrum and anterior to fore acetabula. Legs: long and slender; hind femora and tibiae longer than the others; fore femora somewhat thicker than mid femora, which are somewhat thicker than hind femora too; tarsi three-segmented, in which the first segment is much shorter than the others, claws symmetrical and slender. All trochanters with a basal and strong spine on medial portion; fore trochanters with two parallel rows of very short numerous brownish spines ventrally; a group of about thirty similar very short brownish spines on base of fore femora ventrally. A small comb on mesal surface of apex of fore tibiae. Spongy fossa on ventral portion of apex of fore (Fig. 18) and mid tibia somewhat longer than 1/3 of the length of each tibia. Hemelytra surpassing tip of abdomen for approximately 0.5 mm. **Abdomen**: moderately elongate, suboval, with a median keel on sternites II to IV, which is fainter on sternite IV; sutures between sternites thin, suture between II and III thicker and with small transverse striations along posterior margin; sternites with very fine transverse striations, somewhat more marked on sternite II and around genitalia on sternite VII, but fainter on anterior half of the latter. The midline of anterior half of sternite VII is somewhat elevated but without forming a distinct keel. **Female genitalia**: external genitalia as in Figs. 19, A–B; gonocoxite and gonapophysis VIII, gonocoxite IX, and gonapophysis IX as shown in Figs. 20A–B, 20C and 20D, respectively.

Distribution. Brazil, state of Tocantins.

Etymology. The specific epithet refers to "tambeju'a", an indigenous word (Guarani) whose meaning is insect, assassin bug.

Specimens examined. ***Zelurus tambejua* sp. nov.: Holotype female: BRAZIL, Tocantins,** Dianópolis, Toca da Onça/PCH Areia cave (11°42'25.84"S 46°42'42.57"W), 14.XI.2012, R.L. Ferreira *leg*., ISLA 9501 [ISLA].

***Zelurus fosteri* Lent & Wygodzinsky**. **[BRAZIL], Mato Grosso** [currently, Mato Grosso do Sul], Bodoquena, XI.1941, Com. I.O.C. [*leg*.] / "*Zelurus fosteri* n. sp.", 6/[19]46, "Wygod. + H. Lent det." / N. 569, HEMIPTERA, Inst. Oswaldo Cruz / "Holotipo" [red label], [CTIOC], **Holotype** male; **São Paulo**, Ribeirão Preto, Faz. [farm] da Pedra, Rio [river] Tamanduá, 9/11.x.[1]953, Travassos & Barreto [*leg*.]/ N. 1364, HEMIPTERA, Inst. Oswaldo Cruz, 1 male, [CTIOC].

Discussion. Among all species of *Zelurus*, by external features of adults, *Z. tambejua* **sp. nov.** can be considered close to *Z. fosteri* Lent & Wygodzinsky, 1947 (Fig. 21). Both species have a similar length; veins of hemelytra evident (Figs. 14, 21); fore lobe of pronotum with a pair of median long spines and short acute prominences laterally (Figs. 14, 17, 21); a long and strong spine on each humeral angle of hind lobe (Figs. 14, 17, 21); scutellum with an apical, long, strong and posteriorly curved spine (Figs. 14, 17, 21); legs: fore trochanters with two parallel rows of very short numerous brownish spines ventrally, a group of about thirty similar very short brownish spines on base of fore femora, ventrally; spongy fossa at apex of fore and mid tibiae longer than 1/3 of the length of the respective tibia.

On the other hand, these species can be promptly distinguished by the general coloration, which is dark brown, ochraceous brownish to bright ochraceous with hemelytra brownish, with the veins pale, somewhat yellowish in *Z. tambejua* **sp. nov.** (Fig. 14), while *Z. fosteri* (Fig. 21) has a reddish general coloration, the veins in hemelytra being concolorous with adjacent portions and without a contrasting clearer coloration as in the new species. In the latter the femora are faintly darker apically and tibiae are clearer with apex darkened (Fig. 18), whereas in *Z. fosteri* the hind femora are darkened with a clearer reddish subapical band and the tibiae are almost all darkened (Fig. 21).

FIGURE 22. *Zelurus* species occurring in Brazilian caves, live specimens. A, *Z. ochripennis*, B, *Z. gerevatinga* **sp.nov.**, C, *Z. sipolisi*, D, *Z. zikani*, E, *Z. festivus*, F, *Z. variegatus*, G, *Z. diasi*, H, *Z. femoralis longispinis*, I, *Z. travassosi*.

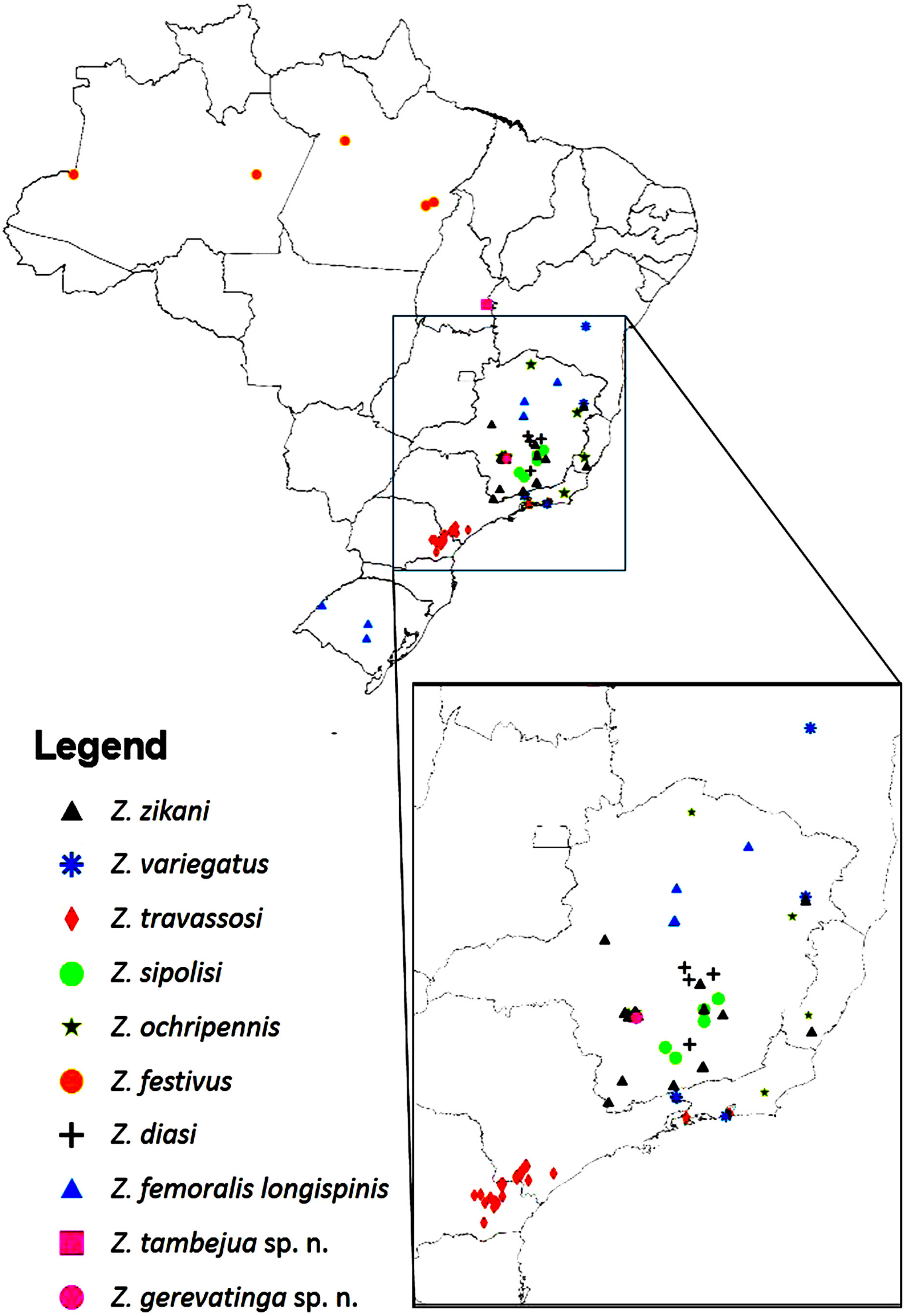


FIGURE 23. Distribution map of *Zelurus* species in Brazilian caves.

Synopsis of the *Zelurus* species for Brazilian caves

There are currently records of 8 species of *Zelurus* occurring in Brazilian caves (Pinto-da-Rocha 1995; Ferreira & Martins, 1999; Prous 2005; Zampaulo & Ferreira 2009; Ferreira *et al*. 2011; Souza-Silva *et al*. 2011b; Iniesta *et al*. 2012). Photos of living specimens of all species recorded for Brazilian caves (excluding *Z. tambejua*) are shown in figure 22. It is believed that the species in the present study are troglophile species, thus, can complete their life cycle inside, as well as outside the caves. Although some studies have indicated that *Zelurus* species are preferentially found in cave's entrances and nearby areas (Trajano & Gnaspini-Netto 1990), more recent studies have shown that these animals can be found throughout the cave environment (Prous 2005). The species (and subspecies) recorded in Brazilian caves are listed below:

Zelurus diasi (Costa Lima, 1940): Minas Gerais state
Zelurus femoralis longispinis Lent & Wygodzinsky, 1954: Minas Gerais state
Zelurus festivus (Stål, 1859): Pará and Amazonas states
Zelurus gerevatinga **sp. n.**: Minas Gerais state
Zelurus ochripennis (Stål, 1854): Minas Gerais, Rio de Janeiro and Espírito Santo states
Zelurus sipolisi (Fallou, 1888): Minas Gerais state
Zelurus tambejua **sp. n.**: Tocantins state
Zelurus travassosi (Costa Lima, 1940)*:* Minas Gerais, São Paulo, Paraná and Rio de Janeiro states
Zelurus variegatus (Costa Lima, 1940): Bahia, Minas Gerais and Rio de Janeiro states
Zelurus zikani (Costa Lima, 194)0*:* Minas Gerais state

Distribution of *Zelurus* species in Brazilian caves

Despite the subfamily not having many occurrences in Neotropical region, the genus is almost exclusive to this region (Maldonado Capriles 1990). In Brazil, the distribution of most species found in caves overlaps, with rare exceptions like the case of *Z. festivus*, restricted to the Amazon region (Fig. 23). However, despite the widespread occurrences of most species, we can highlight the state of Minas Gerais as an area of great overlap, being the habitat of 8 cave dwelling species. The lithological diversity of this region associated with the presence of two major biomes (Atlantic Forest and Cerrado – Brazilian savanah) may make up the determining factors for this high species richness. Most species have a distribution concentrated in the southeast-south axis, with the exception of *Z. festivus*. Another fact worth mentioning is the preferred distribution of species in forest biomes (Atlantic Forest and Amazon), with rare exceptions occurring in the Cerrado and Caatinga. In addition, the habit of taking shelter in caves may possibly have been intensified by the fragmentation of external habitats. As the species found in caves seems to prefer forest habitats (more humid and shaded), considering the data from specimens in Brazilian collections, which indicates that *Zelurus* species have been found only in forest environments, an expected fragmentation effect would be the refuge of these species in damp, dark habitats, such as caves. Thus, this demonstrates the need for further studies that could contribute to the knowledge about the genus, especially for cave-dwelling species.

Potential distribution of cave species of the genus *Zelurus* for South America

From the analysis of each individual cave species map, it can be seen that some species have very similar potential distribution areas, for example, the species *Z. diasi* and *Z. sipolisi*; and *Z. ochripennis*, *Z travassosi* and *Z. zikani* (Fig. 24 and 25).

Among the seven environmental variables used to generate the models, the largest contribution is made by the variables temperature seasonality (BIO 4), precipitation of the driest quarter (BIO 17), precipitation of the warmest quarter (BIO 18), precipitation of the coldest quarter (BIO 19) and altitude. The environmental variables with the highest gain for models, when isolated, were temperature seasonality (BIO 4), precipitation of the warmest quarter (BIO 18) and precipitation of the coldest quarter (BIO 19). The environmental variables that decreased the models most when excluded were temperature seasonality (BIO 4), mean temperature of the warmest quarter (BIO 10), annual seasonality (BIO 15), precipitation of the driest quarter (BIO 17) and precipitation of the warmest quarter (BIO 18).

All these data demonstrate the importance of both seasonality and rainfall for the occurrence of these animals according to the generated models. This fact confirms the preference for humid regions, which ultimately makes up an important pre-adaptation of these species to the subterranean environment. Moreover, as mentioned above, the caves may comprise important refuges for many species of the genus, especially in light of fragmentation and loss of external habitats.

Z. diasi has higher potential for occurrence in the states of Bahia and Pará, in addition to central Argentina and Bolivia; and the coasts of Peru and Ecuador (Figure 24A). Among the eight environmental variables used to generate the model the largest contributions were made by BIO 18 (41.3%) and BIO 19 (29%). The environmental variable with the greatest gain for the model, when isolated, was BIO 19, and the environmental variable that decreased the model most, when deleted, was BIO18.

Z. festivus has greater potential distribution in the states of Maranhão, Pará, Amazonas and Roraima (Fig. 24B); which goes against the current knowledge of the distribution of this species, with records only for the Amazon region (Fig. 23). Other sites that appear on the map are the coastal regions of Venezuela and Colombia; and the central region of Bolivia and Peru. Among the environmental variables used, the largest contributions were made by BIO 4 (95.3%) and BIO 18 (3.5%). The environmental variable with the greatest gain for the model, when isolated, was BIO 4, as well as being the environmental factor that most decreased the model when deleted.

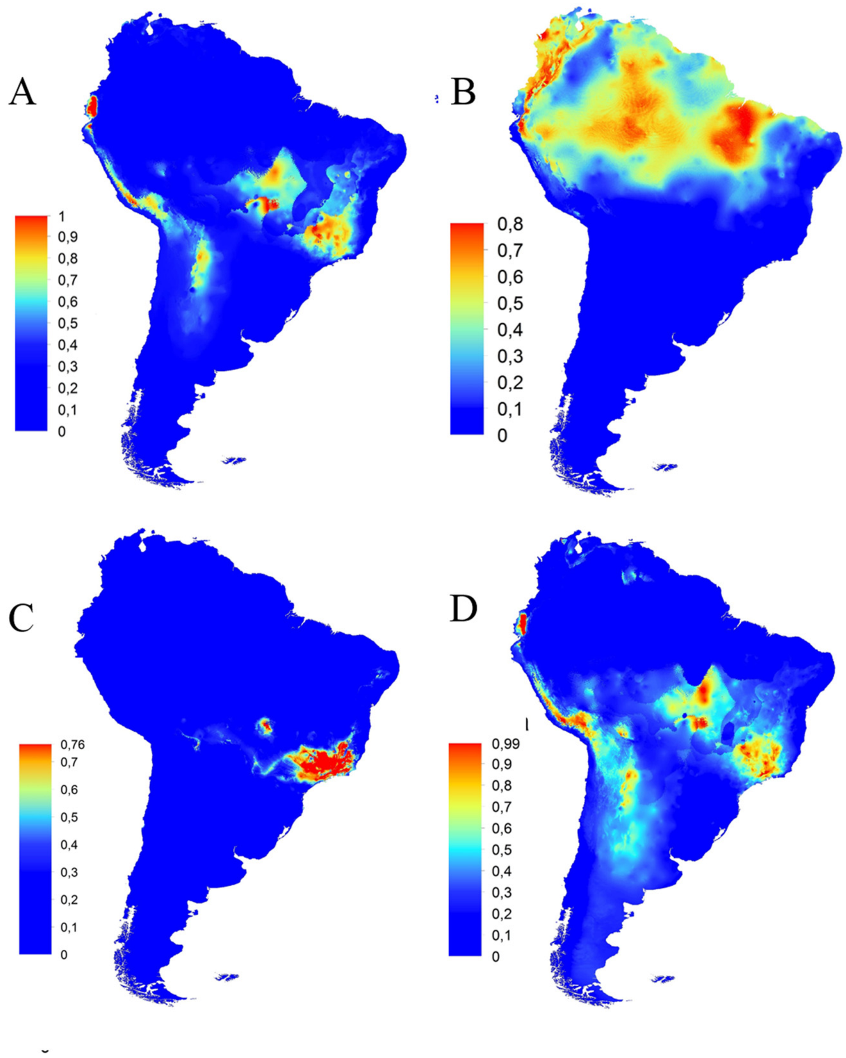


FIGURE 24. Potential distribution map of *Zelurus* species, A, *Z. diasi*, B, *Z. festivus*, C, *Z. ochripennis*, D, *Z. sipolisi*.

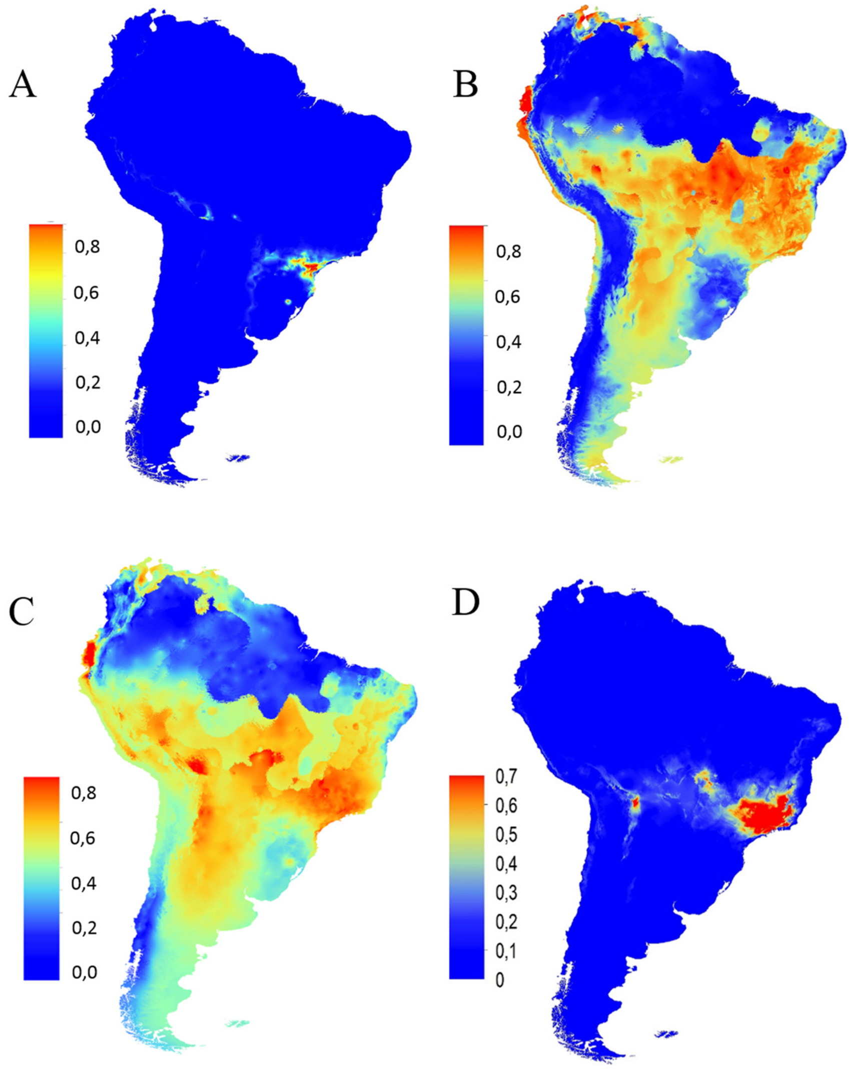


FIGURE 25. Potential distribution map of *Zelurus* species, A, *Z. travassosi*, B, *Z. variegatus*, C, *Z. zikani*, D, *Z. femoralis longispinis*.

Z. ochripennis has greater distribution in the states of São Paulo, Rio de Janeiro, Espírito Santo and Minas Gerais, and in a small portion in central Goiás (Fig. 24C). A small area also appears in central Bolívia. Among the variables used, the largest contributions were made by BIO 4 (34%) and BIO 18 (33.6%). The environmental variable with the greatest gain for the model, when isolated, was BIO 4, as well as being the environmental factor that most decreased the model when deleted.

Z. sipolisi has the potential distribution for the states of Pará, Mato Grosso and Minas Gerais (Fig. 24D). It also has great likelihood for occurrence in Argentina, Bolivia, Peru and Ecuador, and in some small areas in Venezuela. Among the variables used, the largest contributions were made by BIO 18 (46.9%) and BIO 19 (34.5%). The environmental variable with the greatest gain for the model, when isolated, was BIO 19, and the environmental variable that decreased the model most when deleted was BIO 10.

For the *Z. travassosi* species, the analyzes show that the potential high occurrence area is centered in the South-Southeast: Santa Catarina, Paraná, São Paulo and southern Minas Gerais states (Fig. 25A). Small areas also appear in Rio Grande do Sul, Uruguay, Paraguay and Bolivia. Among the variables used, the largest contribution was made by BIO 17 (27.3%) and BIO 4 (25.3%). The environmental variable with the greatest gain for the model, when isolated, was BIO 4, and the environmental variable that decreased the model most, when deleted, was BIO 17.

Z. variegatus appeared with a large potential distribution covering almost the entire map of South America, excluding only some areas, such as part of Amazonas, Pará and Amapá states (Figure 25B). Parts of Venezuela and Colombia are excluded, in addition to the Andes Cordillera. This wide coverage of the potential distribution of the species can be explained by the low receiver-operating characteristic that generated an unreliable graph. To improve reliability, it is important to have a higher number of geographic occurrence points for this species. Among the variables used, the largest contribution is made by BIO 19 (74.2%) and altitude (13.4%). The environmental variable with the greatest gain for the model, when isolated, was BIO 19, as well as being the environmental variable, that decreased the model most when deleted.

Z. zikani has potential occurrence for Minas Gerais, Rio de Janeiro and Goiás states, in addition to a small region of Bolivia (Fig. 25C). Among the variables used to generate the model, the largest contribution was made by BIO 18 (33.9%) and altitude (24%). The environmental variable with the greatest gain for the model, when isolated, was BIO 4, and the environmental variable that decreased the model most when deleted was BIO 15.

Z. femoralis longispinis also appeared with a large potential distribution covering almost the entire map of South America, as observed for *Z. variegatus*, excluding only some areas in Amazon (Brazil, Guiana, Colombia, Peru and Venezuela) and Andes Cordillera (especially in Chile and Colombia) (Fig. 25D). This wide coverage of the potential distribution of the species can be explained by the low receiver-operating characteristic that generated an unreliable graph. To improve reliability, it is important to have a higher number of geographic occurrence points for this species, as for *Z. variegatus*. Among the variables used, the largest contribution is made by BIO 19 (52.2%) and BIO 18 (42.1%). The environmental variable with the greatest gain for the model, when isolated, was BIO 19, as well as being the environmental variable, that decreased the model most when deleted.

From this work, it can be inferred that the genus has high potential distribution in Brazil, which demonstrates the need for inventories in scientifically unexplored locations in order to obtain greater knowledge of these animals. Thus, the description of new species or new occurrences indicate the biological importance of subterranean habitats for many species of the genus, increasing possibilities for Brazilian cave preservation, caves currently threatened by numerous anthropogenic activities.

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