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A new species of *Thraulodes* Ulmer (Ephemeroptera: Leptophlebiidae) from the Atlantic Forests of Southeastern Brazil

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Abstract

A new species of *Thraulodes* Ulmer, 1920 (Ephemeroptera: Leptophlebiidae) from Southeastern Brazil is described based on male imago and nymphs. The new species is apparently related to *T. luisae* Souto, Da-Silva & Nessimian, 2014*, T. pinga* Souto, Da-Silva & Nessimian, 2014, *T. pelicanus* Mariano & Froehlich, 2011, and *T. flinti* Domínguez, 1987, but can be distinguished from them and from the other species of the genus based on the following characteristics: male imagos with two cross-veins basal to bullae, terga II–V with a spot close to posterior margin, penes short with spines long and narrow; nymphs are distinguished by the presence of 8–9 denticles on tarsal claws, pre-apical denticle much larger than others, and terga II–VI brown with a single posteromedial dark mark.

Key words: mayflies, taxonomy, Neotropics, South America, Atalophlebiinae

Introduction

Thraulodes Ulmer, 1920 is a widespread Pan-American genus of Atalophlebiinae (Ephemeroptera: Leptophlebiidae). The genus is most diverse in the Neotropical region (Traver & Edmunds 1967), where it represents an important component of the benthos (Chacón *et al*. 1999). Approximately 60 species of *Thraulodes* have been described until now, 41 species are known from South America (Barber-James *et al*. 2008; Souto *et al.* 2014; Gama-Neto *et al*. 2018; Boldrini *et al*. 2018; Campos & Mariano 2019) - most of them known only at the adult stages.

Despite the high number of species described from South America, only 23 species are known from Brazil. The species are: *T. alapictus* Mariano & Lima, 2013; *T. amanda* Mariano & Froehlich, 2011; *T. bonito* Gonçalves, Da-Silva & Nessimian, 2013; *T. calori* and *T. catoles* Campos & Mariano, 2019; *T. cochunaensis* Domínguez, 1987; *T. daidaleus* Thew, 1960; *T. itatiajanus* Traver & Edmunds, 1967; *T. jones* Gonçalves, Da-Silva & Nessimian, 2010; *T. limbatus* Navás, 1936; *T. luisae* Souto, Da-Silva & Nessimian, 2014; *T. luizgonzagai* Lima, Mariano & Pinheiro, 2013; *T. marreroi* Chácon, Segnini & Domínguez, 1999; *T. pelicanus* Mariano & Froehlich, 2011; *T. pinga* Souto, Da-Silva & Nessimian, 2014; *T. pinhoi* Mariano & Lima, 2013; *T. rodrigoi* Boldrini, Dantas & Lima, 2018; *T. schlingeri* Traver & Edmunds, 1967; *T. sternimaculatus* Lima, Mariano & Pinheiro, 2013; *T. subfasciatus* Navás, 1924; *T. traverae* Thew, 1960; *T. ulmeri* Edmunds, 1950; *T. xavantinensis* Mariano & Froehlich, 2011. Except for *T. schlingeri, T. cochunaensis, T. itatiajanus, T. jones*, and *T. bonito* the remaining species recorded from Brazil are known exclusively at the adult stages.

Herein a new species of *Thraulodes* is described based on male adults and nymphs from the states of Minas Gerais and Espírito Santo, Southeastern Brazil. Some comments regarding the biology of the new species are also provided.

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Material and methods

Pictures of habitus of preserved specimens were taken using a Leica M165C stereomicroscope with a DFC420 digital camera or a Leica S6 D stereomicroscope with a EC 3 digital camera. In order to produce final images with enhanced depth of field a series of stacked images were processed with the program Helicon Focus®. Living specimens were photographed in the field with a Nikon D800, a 105 mm objective and a Nikon macro flash. The free software QGIS 3.8 (http://qgis.org/) was used to make the distribution map of the species. The terms used to describe the genitalia follow Traver & Edmunds (1967). The examined material is housed in the following institutions: Museu de Entomologia, Universidade Federal de Viçosa (UFVB), Viçosa, Brazil; and Coleção Entomológica Prof. José Alfredo Pinheiro Dutra, Departamento de Zoologia, Universidade Federal do Rio de Janeiro (DZRJ), Rio de Janeiro State, Brazil. Permanent slides were prepared using Euparal® as mounting media.

Results

***Thraulodes borun* sp. nov.**
(Figures 1 to 10)

Diagnoses: Male imagos of the new species can be distinguished from the other species of *Thraulodes* based on the following characteristics: fore femora with a band and a macula; two cross veins basal to bullae; abdominal terga I to VI translucid and with an anterolateral dark mark and a submedial extensive single mark closer to the posterior margin; styliger plate with posterior median projection short and apically rounded; penes short and wide with lateral pouch present, penes spines long and narrow. Nymphs can be diagnosed by the presence of 8–9 denticles on tarsal claws, pre-apical denticle much larger than others, and terga II–VI brown with a single posteromedial dark mark.

Male imago (in alcohol) (Figs. 1–4)

Length body: 7.8–8.0 mm; forewings: 6.8 mm; hind wings: 1.3 mm.

General coloration: yellowish white, wings hyaline.

Head (Figs. 1–2 and 4): Brown, upper portion of eyes orange brown; lower portion grayish-black. Ocelli surrounded with gray. Antennae: scape and pedicel brown washed with gray; flagellum light grayish.

Thorax (Figs. 1–2 and 4): Pronotum whitish, median zone washed with gray and lateral margins dark gray. Mesonotum brown, posterior scutal protuberance washed with gray. Metanotum brown slightly washed with gray. Pleurae and sterna of prothorax whitish transparent, pleurae and sterna of meso and metathorax dark brown.

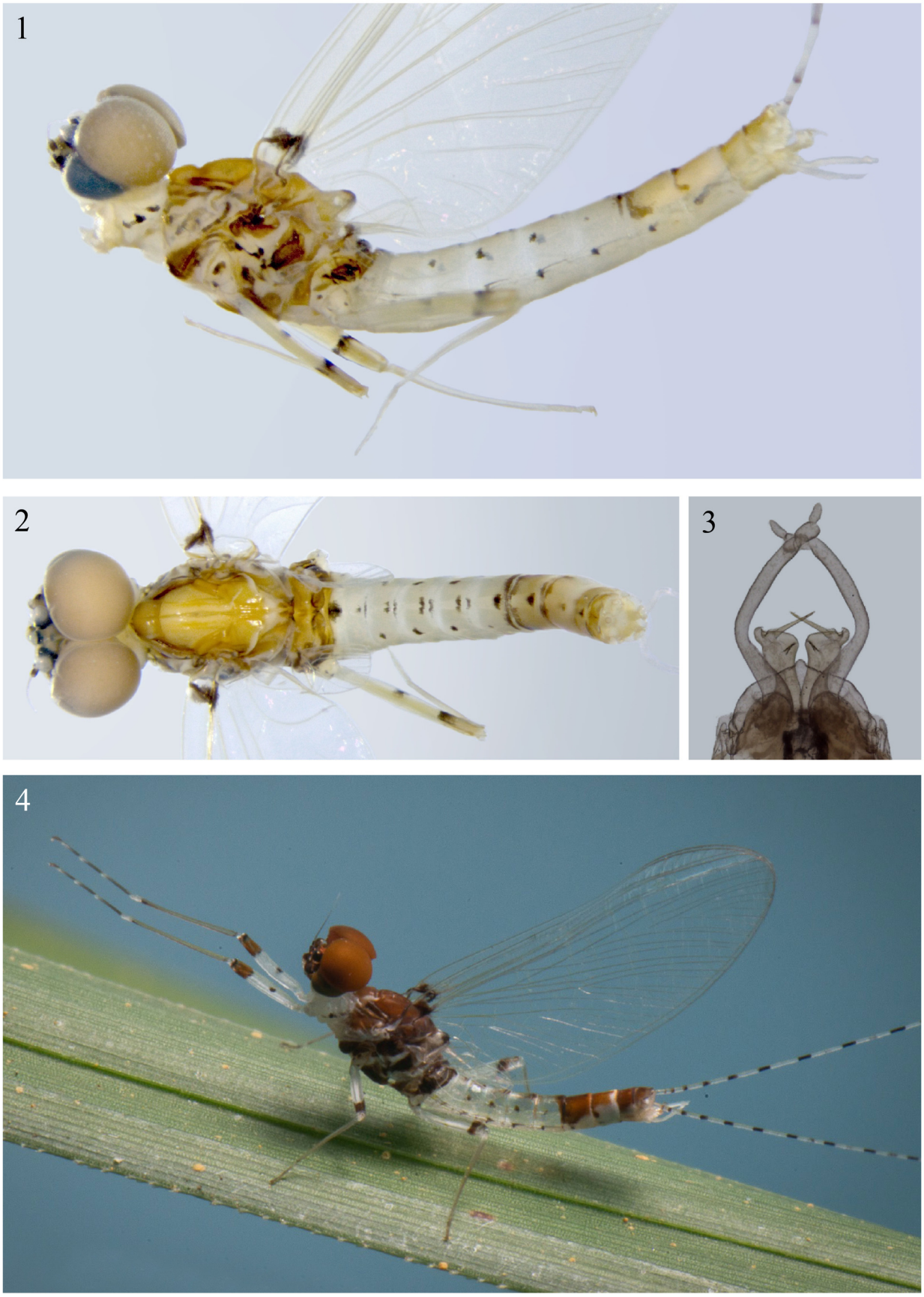
Legs (Fig. 4): Forelegs with coxae, trochanters and femora white; apex of femora with orange brown band, surrounded with gray and a submedian brown maculae; tibiae and tarsi whitish gray, apex of tibiae dark orange brown. Mid and hind legs similar to forelegs, except for absence of mark on tibiae.

Wings (Fig. 4): Membrane of fore wings hyaline, with brownish spot at base; two basal cross-veins and 9 to 12 cross-veins distal to bullae. Main veins light yellowish brown; cross-veins whitish. Membrane of hind wings hyaline, with brownish spot at base. Veins whitish, except for basal 1/3 of Sc, brown lighter toward apex.

Abdomen (Figs. 1–2 and 4)*:* Terga I–VI whitish translucent and terga VII–X yellow whitish; tergum I with a central mark; terga II–V with a spot close to posterior margin, weakly marked or missing in some specimens; terga VII–VIII with posterior margin strongly marked; terga II–IX with a median posterior dark mark larger on segments VI and VII; terga III–VI with a pair of midway spots; terga II–VIII with a pair of stigmatic dots. Sterna I–VI whitish translucent; sterna VII–IX whitish. Caudal filaments whitish, segments washed with dark-brown in the middle, intersegmental joints darker in all segments.

Genitalia (Fig. 3): Styliger plate triangular and hyaline, with posterior median projection short and apically rounded. Forceps hyaline, with strong constriction near the middle of segment I; inner margin of segment I with several short setae basal to constriction. Penes short and wide with lateral pouch present; apicolateral area rounded with ear-like projection; inner apical margin with recurved fold heavily marked; penes spines long and narrow, projected medially and posteriorly.

Variations: Some specimens show color patterns overall darker (Fig. 4) or lighter (Fig. 1), due to alcohol fixation period.



FIGURES 1–4. *Thraulodes borun* **sp. nov.,** male imago: 1) lateral view; 2) dorsal view; 3) general aspect of genitalia, ventral view; 4) living male imago (terminal filament missing).

Nymph (putative) (Figs. 5 to 9).

Mature. Length: body, 6.8–7.0 mm; caudal filaments, 12.0–14.0 mm.

General coloration light brown.

Head (Fig. 5): brownish-yellow with area between compound eyes and ocelli brownish, remaining of head capsule lighter; an open V-shaped black stripe from lateral ocelli to median ocellus. Labrum (Fig. 6b) wider than clypeus, yellowish with central area blackish; width 3 times its length; anterior margin with wide and shallow emargination. Mandibles whitish, central and basal area blackish; incisors and molars yellow; row of long simple setae on apical third of outer margin extending to level of outer incisor; prosthecae well developed. Left mandible (Fig. 6a): both incisors with 3 denticles. Right mandible (Fig. 6c): outer incisor with 3 apical denticles, inner incisor with 2 apical ones and with serrated outer margin. Maxillae (Fig. 6e and 6g): yellowish translucent, external margin more brownish. Hypopharynx (Fig. 6d): whitish, except for center of superlingua brownish and apical setae yellow; lingua yellowish translucent. Labium (Fig. 6f): yellowish translucent, apical setae yellowish.

Thorax (Fig. 5): pronotum light-brown with yellowish-translucent lateral margin; a yellowish-white median line wider at anterior and posterior ends; two spots near anterior margin and median line, and a dark brownish mark near posterolateral margin. Mesonotum light-brown with two lateral yellowish-white marks near midline; dark brownish spots present near anterior margin. Pleurae and sterna yellowish-white. Legs (Fig. 7): femora of all legs yellowish-white variably tinged with brown and dark brown. Hind femur more tinged with brown than mid femora, and mid femora more tinged than fore femora; internal surface with two brown spots; tibiae and tarsi light-brown with brown stripe. Foreleg (Fig. 7a): femur with fringe of long simple setae along outer margin; few short clavate setae along apical half of outer margin, and few short bristles scattered on dorsal surface; tibia with fringe of simple setae and row of short bristles on outer margin and a row of short bristles along inner margin; tarsus scattered with minute simple setae on outer margin. Mid leg (Fig. 7b): femur with dense fringe of very long simple setae along outer margin and short and long clavate setae at apical half of outer margin; short bristles along inner margin and many short bristles scattered on dorsal surface; tibia and tarsus with fringe of simple setae along outer margin. Hind leg (Fig. 7c): similar to mid leg, except for fewer number of bristles on dorsal surface of femur. Tarsal claw with 8–9 denticles, pre-apical denticle much larger than others (Fig. 8).

Abdomen (Fig. 5): tergum I light brown; terga II–VI brown with a pair of lateral apical dark spots, a single posteromedial dark mark and a pair of lateral and median yellowish-white spots. Terga VII–VIII light brown with a median dark spot and two pairs of lateral and median yellowish-white spots; tergum IX yellowish with a pair of yellowish-white spots and a medium dark mark and terga X light brown. Posterior margin of terga with row of spines. Sterna yellowish-white. Gills with lamellae symmetrical, tapering gradually toward apex; length to width ratio 5–6:1; gills gray, main trachea strongly pigmented (Fig. 9).

Biology. Subimagos were collected at light trap between 18:00 and 20:00. The emergence of the imagos were in the afternoon of the next day. Most of the nymphs of *T. borun* sp. nov. were found in riffle litter in two streams at the Rio Doce State Park. The streams were 8 to 10 m wide, about 40 to 45 cm deep, with sand bottom, some vegetal debris in pool areas and riffle litter retained at some large woody debris. The vegetation in both localities was pristine native forest.

Life cycle associations. Nymphs and adults were collected in the same localities and share the same abdominal color pattern.

Etymology. Borun, language of the Krénak people, a small indigenous tribe that still inhabits the region of the Rio Doce Valley and belongs to the Macro-Jê linguistic group.

Distribution. Brazil, Minas Gerais and Espírito Santo (Fig. 10).

Type material. Brazil, Minas Gerais State: *Holotype*: Rio Doce State Park, Rio Turvo, 19º 41' 908" S / 42º 30' 959" W, 253 m, 16.x.2005, Francischetti, C.N., Salles, F.F. leg., 1 male imago (UFVB); *Paratypes*: same data as holotype, 4 male imagos (DZRJ); Rio Doce State Park, Rio Turvo, 19º 41' 908" S / 42º 30' 959" W, 253 m, 8.vi.2005, riffle litter, Francischetti, C.N. leg. 24 nymphs (UFVB); Rio Doce State Park, Rio Turvo, 19º 41' 908" S / 42º 30' 959" W, 253 m, 6.ix.2005, riffle litter, Francischetti, C.N. leg., 24 nymphs (DZRJ); Timóteo, Ribeirão Belém, 28.viii.2018, 2 male imagos (UFVB). Brazil, Espírito Santo State, Domingos Martins, Rio Jucu, Panelas, 20º 18' 59.5" S / 40º 39' 24.4" W, 10-11.v.2017, UV, Salles, F.F, Novais, M. and Paresque, R. leg., 3 male imagos (UFVB).

FIGURES 5–6. *Thraulodes borun* **sp. nov.,** nymph: 5) habitus; 6) mouthparts (a- left mandible; b- labrum; c- right mandible; d- hypopharynx; e- left maxilla; f- labium; g- right maxilla).

FIGURES 7–9. 7) legs (a- foreleg; b- mid leg; c- hind leg); 8) tarsal claw of mid leg (arrow showing large pre-apical denticle); 9) gill.

Additional non-type material (UFVB). Brazil, Minas Gerais, Rio Doce State Park, Rio Mombassa, 19º 48' 326" S / 42º 32' 918" W, 253 m, 29.ix.2005, Francischetti, C.N. leg., 1 male imago; Rio Doce State Park, Rio Belém, 19º 35' 076" S / 42º 33' 980" W, 257 m, 29.vi.2005, riffle litter, Francischetti, C.N. leg., 13 nymphs; Rio Doce State Park, Rio Belém, 19º 35' 076" S / 42º 33' 980" W, 257 m, 14.vii.2005, riffle litter, Francischetti, C.N. leg., 14 nymphs; Rio Doce State Park, Rio Belém, 19º 34' 942" S / 42º 33' 777" W, 250 m, 1.x.2005, riffle litter, Francischetti, C.N. leg., 9 nymphs; Brazil, Espírito Santo; Alfredo Chaves, Nova Mantova, 20º 39' 41.7" S / 40º 50' 24.3" W, 371m, 21.iii.2008, luminosa, R. B leg., 1 male imago; Viana/ Domingos Martins, Estrada para Biriricas, 20º 20' 56.3" S / 40º 35' 26.8" W, 25.vi.2016, 1 male imago; Domingos Martins, Cachoeira I, 20º 14' 48.3" S / 40º 43' 31.2" W, 27.viii.2010, Ceunes leg., 1 nymph; Alfredo Chaves, Junção Benevente, 20º 32' 58.9" S / 40º 51' 18.8" W, 28.x.2010, Bertazo, K. leg., 1 nymph.

Discussion

Thraulodes borun sp. nov. is similar to several species of the genus (i.e., *T. luisae; T. pinga*; *T. pelicanus*; and *T. flinti* Domínguez, 1987) in which abdominal terga I to VI are translucid and present an anterolateral dark mark and a submedial extensive mark closer to the posterior margin. In *T. borun* sp. nov., however, the

submedial marks are medially united and, thus, form a single mark. Among the species of the genus with a single medial mark, *T. borun* is more similar to *T. flinti* from Northern Argentina and *T. daidaleus* from Southern Brazil and Uruguay. *Thraulodes borun* sp. nov. can be distinguished from them based on the morphology of the penis: in *T. daidaleus* the apicolateral area is extremely expanded (Fig. 188B from Domínguez *et al*. 2006) while in *T. flinti* the lateral pouch is absent (Fig. 188D from Domínguez *et al*. 2006). The number of cross veins basal to bullae can also aid to distinguish the three species: in *T. borun* two cross veins are present, in *T. flinti* four, and in *T. daidaleus* there are no cross veins.

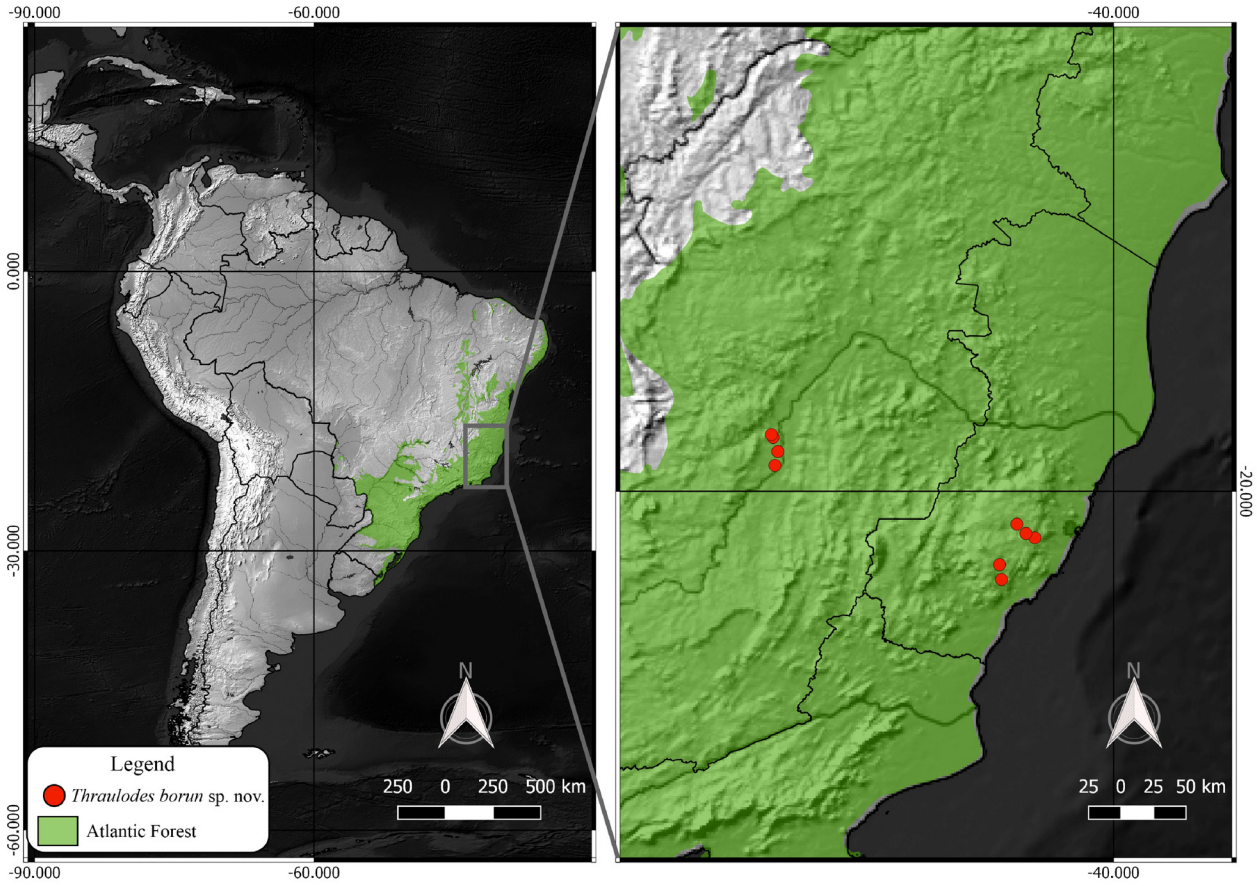


FIGURE 10. Map of Brazil with details of the eastern portion of Minas Gerais and Espírito Santo showing the distribution of *Thraulodes borun* **sp. nov.**

Among the species of *Thraulodes* from the Atlantic forest of Southeastern Brazil, *T. borun* sp. nov. is very similar to *T. luisae*, both sharing the same general pattern of abdominal coloration, fore femora with a band and a macula, and two cross veins basal to bullae. In the updated key to the male imagos of *Thraulodes* from Brazil (Campos & Mariano 2019), the new species keys out as *T. luisae*. In this species, however, the submedial marks on abdominal terga II to VI are not united and the spines of the penis are shorter.

The probable nymph of *T. borun* sp. nov., on the other hand, can be immediately separated from the other known species of the genus known by the size of the pre-apical denticle of the tarsal claw, much larger than the others (Fig. 8). Traditionally, the diagnoses proposed for *Thraulodes* has always considered nymphs with tarsal claws having the apical denticle subequal to the others (see Domínguez *et al*. 2006), although in *T. bolivianus*, *T. consortis* and *T. itatiajanus* it is slightly larger (Domínguez 1986, 1987; Da-Silva 2003).

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