

Two new species of the millipede family Paradoxosomatidae from Bahia state, northeastern Brazil, including a remarkable presumed troglobiont (Diplopoda: Polydesmida)

Два новых вида многоножек-диплопод семейства Paradoxosomatidae из штата Баиа (северо-восточная Бразилия), включая примечательного вероятного троглобионта (Diplopoda: Polydesmida)

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КЛЮЧЕВЫЕ СЛОВА: таксономия, подземный биотоп, *Iulidesmus*, *Onciurossoma*, полуаридный климат.

ABSTRACT. *Iulidesmus silvestrii* sp.n. and *Onciurossoma troglobium* sp.n. are described from limestone caves in Bahia state, northeastern Brazil. Both species are new and represent the first formal records of the family Paradoxosomatidae from Bahia. The former species seems to be a troglophile, although it has been recorded yet only from a cave, whereas the latter species looks sufficiently troglomorphic and occurs only inside the Gruta Sumidouro do João Baio cave. Both regions generally support a typical dry tropical climate, but the caves represent sites with high humidity, this being essential for the survival of these and other species.

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РЕЗЮМЕ. Описаны *Iulidesmus silvestrii* sp.n. и *Onciurossoma troglobium* sp.n. из карстовых пещер в штате Баиа (северо-восто Бразилии). Оба вида — новые и представляют собой первые формальные находки семейства Paradoxosomatidae в штате Баиа. Первый из видов, очевидно, троглофил, зотя и найден пока только в одной пещере, тогда как второй вид снаружи достаточно трогломорфен и отмечен лишь в пещере Gruta Sumidouro do João Baio. Оба карстовых района с типичным сухим тропическим климатом, но данные пещеры — это места с высо-

кой влажностью воздуха, необходимой для выживания этих и других видов.

Introduction

The Diplopoda, or millipedes, is the third largest among the terrestrial arthropod classes following the Insecta and the Arachnida, presently counting ca 12,000 described species in ca 3,000 genera, ca 150 families and 16 orders [Shelley, Golovatch, 2011; Brewer *et al.*, 2012; Minelli, Golovatch, 2017]. The Polydesmida, the largest order of Diplopoda, accounts for almost half of the global species diversity of the class [Enghoff *et al.*, 2015], with the family Paradoxosomatidae being among the largest and currently comprising 1000+ species from 200+ genera and 22 tribes (e.g., Nguyen & Sierwald [2013], Enghoff *et al.* [2015], Golovatch & Liu [2020]). This family is nearly worldwide in distribution, yet being conspicuously almost absent from the Nearctic [Jeekel, 1968], with a species each in Panama, Costa Rica and Dominica, Lesser Antilles being the only exceptions [Hoffman, 1977, 2000]. Paradoxosomatidae are especially diverse in and even dominate the diplopod faunas of Indo-Australia [Golovatch, Liu, 2020]. Paradoxically, among the hundreds of millipede inclusions in the Cretaceous amber of Myanmar (= burmite), 99–100 Mya, not a single paradoxosomatid has been encountered yet [Wesener, Moritz, 2018].

The Neotropical fauna of Diplopoda south of central Mexico is very wealthy and diverse, counting 46 families in 13 orders [Trajano *et al.*, 2000]. In Brazil, it

is especially rich and varied in the Andean regions, still being very strongly understudied and presently composed of ca 500 species, ca 130 genera, 29 families, and nine orders [Golovatch *et al.*, 2022]. The fauna is known to be dominated by the families Rhinocricidae (Spirobolida), Spirostreptidae (Spirostreptida), and Chelodesmidae (Polydesmida), each family with dozens of component species involved, the latter family also with dozens of genera, and all three closely followed by the only slightly subordinate family Paradoxosomatidae (Polydesmida) and Pseudonannolenidae (Spirostreptida) (e.g., Enghoff *et al.* [2015]). Yet their cave-dwelling representative species, let alone genera, are typically few, if any [Trajano *et al.*, 2000; Golovatch *et al.*, 2022]. Thus, no Rhinocricidae has ever been encountered in caves, including Brazilian ones (*vs.* a single cave-dweller, *Yukatobolus spukilensis* Chamberlin, 1938, from Yukatan, Mexico [Hoffman, 2000]), *vs.* only a few marginal records of Spirostreptidae from Brazil and elsewhere, none of which likely troglomorphic though [Hoffman, 2000; Trajano *et al.*, 2000; Trajano, Bichuette, 2009]. Truly troglomorphic Paradoxosomatidae appear to be especially common in southern China, quite some also being characteristic of Southeast Asia and the Mediterranean region [Golovatch, Liu, 2020], marginally present in New Guinea and Australia as well [Hoffman, 1977/1978; Harvey *et al.*, 1993; Golovatch, Stoev, 2011]. No Paradoxosomatidae have been recorded so far from Bahia, Brazil. Nor has any cave-dwelling paradoxosomatid been described from the entire Neotropical Region, although a few marginal records from Brazilian caves, such as either the subcosmopolitan *Oxidus gracilis* (C.L. Koch, 1847) or *Catharosoma* spp. indet., or *Mestosoma* (= *Iulidesmus*) spp. indet., are available. Yet none of them is clearly troglomorphic [Trajano *et al.*, 2000].

In South America, two major centres of Paradoxosomatidae diversification are distinguished, one in the area of southern Brazil, Paraguay, and northern Argentina, the other in Peru, northern Bolivia and possibly Ecuador. In contrast, the vast regions of northern Brazil, Guiana, Venezuela, and Colombia appear to support surprisingly few species [Jeekel, 1963, 2002; Golovatch, 2005].

The entire Neotropical paradoxosomatid fauna is strongly dominated by relatively few (about a dozen) genera of the endemic tribe Catharosomatini [Jeekel, 1963, 1968; Golovatch, 2005], whereas the remaining two tribes containing indigenous South American genera and species, Graphisternini and Eviulisomatini, are small. Thus, the Graphisternini Verhoeff, 1941, with two genera and ten species, is endemic to Peru, whereas the Eviulisomatini contains several genera and very numerous species in East Africa, one genus with two dozen species or subspecies in West Africa, and only a single genus and seven described species north of the Amazon in South America [Nguyen, Sierwald, 2013]. Such a peculiar trans-Atlantic disjunction of Eviulisomatini, i.e. West Africa and northern South America, invites speculations that, in the geological past, when

both continents were united within the supercontinent Gondwana, the Eviulisomatini already existed and split following the continental drift [Jeekel, 1968, 2002].

The paradoxosomatid fauna of South America, including the northernmost representatives from Costa Rica and Dominica Island (?introduced), has been reviewed and largely keyed [Jeekel, 1963, 1968, 2002; Hoffman, 1977], whereas the fauna of the southern diversification centre of South American Paradoxosomatidae has been reviewed, updated and mostly keyed even more recently [Golovatch, 2005; Rodrigues *et al.*, 2020].

Materials and Methods

The material treated in this paper was generously sent to SIG by MEB on loan for identification. It belongs to and will entirely be returned to the scientific collection of cave fauna of the Laboratório de Estudos Subterrâneos (LES), Universidade Federal de São Carlos, São Carlos (Curator: Maria E. Bichuette), São Paulo state, Brazil. The samples are preserved in 75% ethanol.

The pictures of the fixed samples were taken with a Canon EOS 5D digital camera and stacked using Zerene Stacker software. Final image processing was performed with Adobe Photoshop CC. The map was prepared using QGIS Desktop 3.6.0 software. The line drawings were executed by SIG.

Abbreviations used to denote particular structures of the specimens are explained both in the text and figure captions.

Study Area

The Central municipality in northern Bahia state belongs to the Una Geomorphological group and is delimited by quartzites of the Espinhaço Supergroup, generally forming depressed areas with a shallow relief [Rubbioli *et al.*, 2019]. The depressed zones of the Una Geomorphological group support the Caatinga formation, which comprises white limestone a few million years in geological age [Rubbioli *et al.*, 2019]. The region is semi-arid with caatinga vegetation. According to Koeppen's [1958] classification, the climate is tropical with a dry winter (Aw) and a rainy season in summer [Peel *et al.*, 2007; Alvares *et al.*, 2014]. The annual precipitation is around 700–1000 mm, with rainfall lasting from December to February, and the annual temperature averages 26 °C [Alvares *et al.*, 2014].

The new, presumably troglomorphic *Iulidesmus* species (see below) was found inside the Toca do Waldemar cave, in the twilight zone, where it is associated with rock, clay and roots. The cave has several entrances, being partially illuminated and strongly influenced by the epigeal habitat (Fig. 1). Despite this, the climate inside the cave is mild, with the temperature ca 25 °C and a high-level (65%) air humidity. People using the cave as a shelter for hunting activities render a severe impact on the cave. This cave is on private property and remains unprotected by Brazilian law.

The João Rodrigues River system in the São Desidério municipality, southwestern Bahia is remarkable for its geodiversity, biodiversity, and scenic beauty [Lobo *et al.*, 2013]. This region comprises Phanerozoic sediments of the Uruçuia group, which overlap the Neoproterozoic metasedimentary rocks of the Bambuí Geomorphological group, both represented by the São Desidério and Serra da Mamona formations [Campos, Dardenne, 1997; Lobo *et al.*, 2013;

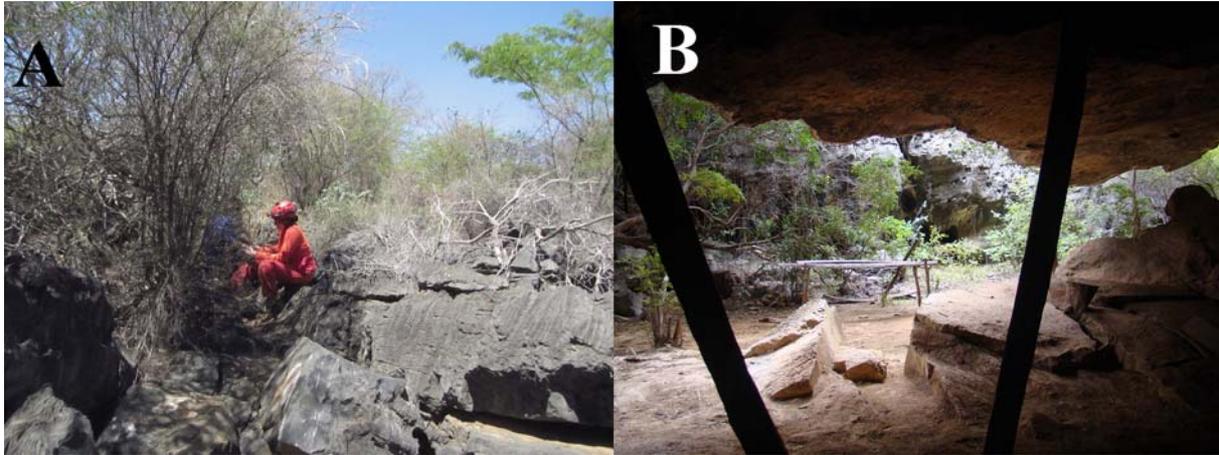


Fig. 1. Limestone landscape forms and Caatinga vegetation of Central region, Bahia state (A), and the Toca do Waldemar cave showing the impacts and influence of epigeal habitats (B). The type locality of *Iulidesmus silvestrii* sp.n. Photographs by J.E. Gallão.

Рис. 1. Формы известкового ландшафта и растительность Саatinga в центральном районе штата Баия (А) и пещера Тоса до Валдемар с показом воздействия и влияния наземных биотопов (В). Типовой локалитет *Iulidesmus silvestrii* sp.n. Фотографии: J.E. Gallão.



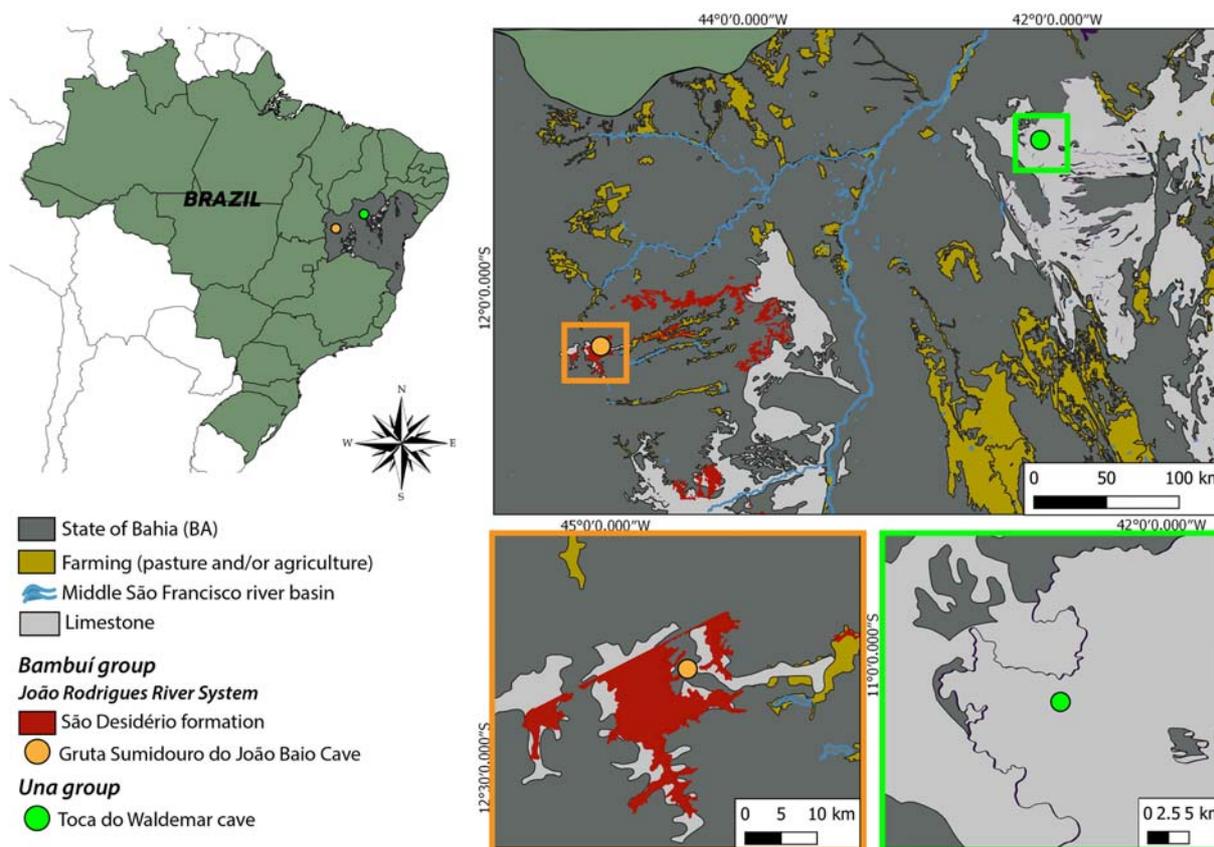
Fig. 2. Limestone landscape forms of the João Rodrigues River system, São Desidério municipality, Bahia state (A), and a gallery of the Gruta Sumidouro do João Baio cave showing subterranean drainage which maintains high humidity so crucial for the occurrence of millipedes (B). The type locality of *Onciuerosoma troglobium* sp.n. Photographs by J.E. Gallão.

Рис. 2. Формы известкового ландшафта речной системы João Rodrigues (муниципалитет São Desidério, штат Баия) (А) и галерея пещеры Gruta Sumidouro do João Baio с показом дренажа, которая обеспечивает высокую влажность, столь необходимую для существования диплопод (В). Типовой локалитет *Onciuerosoma troglobium* sp.n. Фотографии: J.E. Gallão.

Godinho, 2020]. According to Koeppen's [1958] classification, the type of climate in the region is warm (Caw) with a dry and cold season from May to September, and a warm and rainy season from October to April, with temperatures averaging between 20 and 26 °C [Lobo *et al.*, 2013]. Rain-fall varies between 900 and 1100 mm per year; the relative humidity average is 70%, with a maximum of 80% in December and a minimum of 50% in August [Lobo *et al.*, 2013]. The dominant vegetation is Cerrado with portions of transition with Caatinga, and it has rapidly been replaced by monocultures or pastures to support beef cattle breeding [Galvão *et al.*, 2012]. In addition, mining, with emphasis put

on limestone extraction, constitutes a productive activity with great potential for territorial intensification and expansion [Galvão *et al.*, 2012], coupled with road constructions over the João Rodrigues River system. Therefore, the João Rodrigues River system can be considered threatened due to its proximity to urban areas, road traffic lines, and pollution of the subterranean drainage [Lobo *et al.*, 2013; Gallão, Bichuette, 2018].

The new, presumed troglobitic *Onciuerosoma* species was found inside the Gruta Sumidouro do João Baio cave (Fig. 2), in the aphotic zone, associated with vegetable debris and clay. The specimens occurred in a highly humid place, ca



Map. Locations of the Toca do Waldemar and Sumidouro do João Baio caves in Bahia state, northeastern Brazil. Author: L. de Assis.
 Карта. Местоположения пещер Тоса до Валдемар и Sumidouro do João Baio в штате Баиа (Северо-Восточная Бразилия).
 Автор: L. de Assis.

76%, and temperatures ranging between 26 and 28°C. This cave lies outside the boundaries of the two conservation units in the municipality: the São Desidério Environmental Protection Area, with about 10,000 ha, created by State Decree No. 10,020 of 06/05/2006; and the Lagoa Azul Municipal Park, with smaller relative dimensions and partially within the limits of the APA, created in 2005 by Municipal Decree n°007 [Galvão *et al.*, 2012]. Consequently, it also remains unprotected by Brazilian law.

The locations of both regions concerned in presented on Map.

Taxonomic part

Family Paradoxosomatidae Daday, 1889
 Tribe Catharosomatini Brolemann, 1929
 Genus *Iulidesmus* Silvestri, 1895
 (= *Mestosoma* Silvestri, 1897)

Type species: *Iulidesmus typicus* Silvestri, 1895, from Bolivia, by monotypy.

Other species included (after Hoffman [2012]):

1. *Iulidesmus acollae* (Kraus, 1957), Peru;
2. *Iulidesmus albipes* (Verhoeff, 1941), Peru;
3. *Iulidesmus alticola* (Attems, 1931), Peru;
4. *Iulidesmus andinus* (Verhoeff, 1941), Peru;

5. *Iulidesmus andresensis* (Kraus, 1957), Peru;
6. *Iulidesmus apex-galeae* (Brolemann, 1902), Brazil;
7. *Iulidesmus araguanus* (Chamberlin, 1952), Venezuela;
8. *Iulidesmus balzanii* (Silvestri, 1895), Bolivia;
9. *Iulidesmus bicolor* (Silvestri, 1898), Paraguay, Brazil;
10. *Iulidesmus boliviae* (Chamberlin, 1957), Bolivia;
11. *Iulidesmus borellii* (Silvestri, 1895), Argentina, Paraguay;
12. *Iulidesmus camerani* (Silvestri, 1895), Argentina;
13. *Iulidesmus carioca* (Schubart, 1945), Brazil;
14. *Iulidesmus consocius* (Chamberlin, 1955), Peru;
15. *Iulidesmus contumnus* (Chamberlin, 1955), Peru;
16. *Iulidesmus crassipes* (Golovatch, 2005), Paraguay;
17. *Iulidesmus cuzconus* (Chamberlin, 1952), Peru;
18. *Iulidesmus derelictus* (Silvestri, 1895), Bolivia;
19. *Iulidesmus differens* (Kraus, 1956), Bolivia;
20. *Iulidesmus escaramucensis* (Schubart, 1944), Brazil;
21. *Iulidesmus ethophor* (Chamberlin, 1955), Peru;
22. *Iulidesmus ethophorinus* (Kraus, 1959), Peru;
23. *Iulidesmus femoralis* (Schubart, 1943), Brazil;
24. *Iulidesmus flavius* (Chamberlin, 1955), Peru;
25. *Iulidesmus forsteri* (Kraus, 1956), Bolivia;
26. *Iulidesmus frater* (Chamberlin, 1955), Peru;
27. *Iulidesmus huallagae* (Chamberlin, 1955), Peru;
28. *Iulidesmus hylaeicus* (Jeckel, 1963), Brazil;
29. *Iulidesmus isthmianus* (Loomis, 1961), Panama;
30. *Iulidesmus junki* (Golovatch et Hoffman, 2003), Peru;

31. *Iulidesmus kallistus* (Attems, 1898), Brazil;
32. *Iulidesmus luctuosus* (Silvestri, 1897), Bolivia;
33. *Iulidesmus lugubris* (Silvestri, 1897), Argentina, Uruguay;
34. *Iulidesmus maquisi* (Kraus, 1956), Peru;
35. *Iulidesmus montanus* (Silvestri, 1895), Bolivia;
36. *Iulidesmus moorei* (Hoffman, 1977), Costa Rica;
37. *Iulidesmus orobius* (Kraus, 1960), Peru;
38. *Iulidesmus perfidus* (Schubart, 1943), Brazil;
39. *Iulidesmus pseudomorphus* (Silvestri, 1895), Paraguay;
40. *Iulidesmus pulvillatus* (Attems, 1898), Paraguay;
41. *Iulidesmus punae* (Chamberlin, 1955), Peru;
42. *Iulidesmus rayanus* (Chamberlin, 1957), Peru;
43. *Iulidesmus recurvatus* (Verhoeff, 1941), Peru;
44. *Iulidesmus salvadorii* (Silvestri, 1895), Argentina, Paraguay;
45. *Iulidesmus schindleri* (Kraus, 1956), Bolivia;
46. *Iulidesmus semirugosus* (Pocock, 1888), Dominica Island;
47. *Iulidesmus shuaro* (Kraus, 1956), Peru;
48. *Iulidesmus simplex* (Golovatch, 2005), Paraguay;
49. *Iulidesmus sphinx* (Verhoeff, 1941), Peru;
50. *Iulidesmus spinulosus* (Kraus, 1959), Peru;
51. *Iulidesmus taulisensis* (Kraus, 1955), Peru;
52. *Iulidesmus titicacaensis* (Kraus, 1954), Peru, Bolivia;
53. *Iulidesmus tricuspis* (Verhoeff, 1938), Paraguay;
54. *Iulidesmus truncatus* (Schubart, 1943), Brazil;
55. *Iulidesmus venezuelanus* (Verhoeff, 1938), Venezuela;
56. *Iulidesmus vittatus* (Attems, 1898), Paraguay;
57. *Iulidesmus yamango* (Kraus, 1956), Peru.

Most of them were originally described in *Mestosoma* Silvestri, 1897, a genus that Hoffman [2012] sank under *Iulidesmus*.

Jeekel [1963] listed and keyed most of the 73 species he recognized in his broader concept of ex-*Mestosoma*, also arranging them between several species groups, some of which being treated as independent genera since. Golovatch [2005] keyed all 14 genera and 63 species of Paradoxosomatidae that occur in northern Argentina, Paraguay and southern Brazil, including 24 species of ex-*Mestosoma* alone. *Iulidesmus* is by far the largest among the Neotropical paradoxosomatid genera, the southern South American genus *Catharosoma* Silvestri, 1897, with its only 18 currently known species, being the second largest [Rodrigues *et al.*, 2020].

DIAGNOSIS. One of the genera of Eviulisomatini with the paraterga and transverse metatergal sulci, both strongly reduced (the former mostly still discernible at least due to a dorsal sulcus, the latter often completely suppressed) and, above all, by the presence of various sternal and leg modifications (including tarsal brushes, usually also adenostyles on some femora, but excluding a distinct, sternal, axial depression) before the gonopods, each of which shows a long and subcylindrical coxite, a relatively short prefemoral (= densely setose) portion (= clearly shorter than femorite), and enlarged, and untwisted, rather complex femorite (**fe**), both femorites sometimes constricted near midway (**cs**), crossing each other mesally and each with the seminal groove running entirely on the mesal side; each acropodite in situ curved, subfalcate, clearly set off from femorite by a sulcus or cingulum, divided into two long, prominent, subequal branches, a solenomere branch (**sl**) and a single solenophore branch (**sph**), the latter to sheathe/support the distal, flagelli-

form part of **sl** between two more or less distinct and rounded lobes of **sph**, one corresponding to a lamina lateralis (**ll**) and the other to a lamina medialis (**lm**) [Jeekel, 1963; Golovatch, 2005].

Iulidesmus silvestrii Golovatch et Gallo, **sp.n.**

Figs 3–15.

HOLOTYPE ♂ (LES 0027936), Brazil, Bahia State, Central Municipality, Toca do Waldemar cave, twilight zone, S11°03'04.8", W42°06'38.5", 14.III.2017, M.E. Bichuette, J.E. Gallão, T. Zepon leg.

PARATYPES: 2 ♀♀ (LES 0027939), same locality, together with holotype.

NAME. To honour Filippo Silvestri (1873–1949), the author of the genus and one of the most active and famous specialists in the systematics of Diplopoda of the time globally [Viggiani, 1973]. Among many other research papers, he published numerous important contributions to the millipede fauna of Brazil.

DIAGNOSIS. Using the most detailed key to *Iulidesmus* (= *Mestosoma*) species by Jeekel [1963], first refined by Hoffman [1977], and later updated and restricted to only the southern part of the distribution area of the genus [Golovatch, 2005], *I. silvestrii* sp.n. keys out either to *I. andinus* (Verhoeff, 1941) or a deadend in couplet 8 which implies a vivid colour pattern. However, the new species differs from all congeners by the uniformly dark brown torso devoid of a colour pattern (Figs 3–8), coupled with mostly conigerous sterna, adenostyles (small distoventral knobs) present only on ♂ femora 3 and 4 (like in *I. andinus*), and the gonopods (Figs 6–15) showing the femorite (**fe**) clearly constricted (**cs**) near midway, a very strong and long solenomere branch (**sl**) which is very clearly arched and well removed in basal half from the solenophore branch (**sph**), **sl** gradually attenuating, its distal half being flagelliform and supported by a similarly long, lamellar **sph**, the latter with only very moderately developed lateral and medial lobes (= a lamina lateralis and a lamina medialis, or **ll** and **lm**, respectively) partly sheathing the distal third of **sl** inside a gutter between both **ll** and **lm** (Figs 14, 15).

DESCRIPTION. Length of ♂ holotype ca 21 mm, width of midbody pro- and metazonae 0.8 and 0.9 mm, respectively. Length of ♀ paratypes ca 22 or 23 mm, width of midbody pro- and metazonae 2.0 and 2.2 mm, respectively. Coloration uniformly dark chocolate grey-brown to dark brown, strongly contrasting to very light grey-brown to nearly pallid legs or largely very light brown antennae; head mostly lighter brown; gonopods intense yellow (Figs 3–13).

Body subcylindrical, with 20 rings (Figs 3–5). Tegument generally smooth and shining. Head densely setose all over clypeolabral region, vertex nearly bare, epicranial suture faint; isthmus between antennae ca 1.1 times broader than diameter of antennal socket (Fig. 6). Antennae long and slender, *in situ* projecting past ring 3 dorsally (♂, ♀); in length, antennomeres 2–6 > 1=7 (Figs 3–6). Genae round, gnathochilarium without peculiarities (Fig. 6).

In width, ring 2 = 3 < collum = 4 < 5=15 < head (♂), starting with ring 16, body gradually tapering towards telson (Figs 3–5). Paraterga set high (at about upper 1/3 midbody height), very faint, almost missing, traceable as small, regularly rounded and declivous flaps on collum or as flat squarish bars, a little thicker/higher on pore-bearing rings than on poreless ones, delimited by slight sulci both dorsally and, in caudal half only, ventrally (Figs 3–6). Pore formula normal,



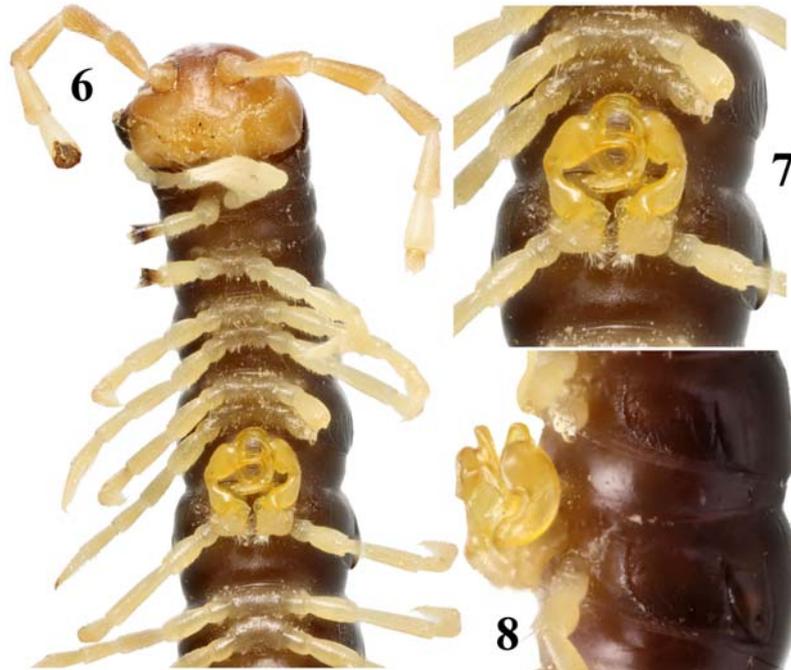
Figs 3–5. *Iulidesmus silvestrii* sp.n., ♂ holotype, habitus, dorsal, lateral and ventral views, respectively. Photographs by K.V. Makarov, taken not to scale.

Рис. 3–5. *Iulidesmus silvestrii* sp.n., голотип ♂, внешний вид, соответственно сверху, сбоку и снизу. Фотографии: К.В. Макаров, снято без масштаба.

ozopores on peritremata sunken inside round pits invariably only a little removed off caudal corners of paraterga, these corners nearly always being rounded (subdentiform only in rigs 17–19) and never produced past rear tergal margin. Dorsum smooth and regularly convex, devoid of transverse metatergal sulci, but surface just above paraterga on collum and below paraterga on following rings finely, but densely and arcuately striolate. Tergal setae mostly abraded, short, ca 1/4–1/5 as long as metatergum, setation pattern mostly vague, traceable as 2+2 insertion points at least across anterior 1/4–1/5 metatergum. Stricture between pro- and meta-

zonae wide, rather shallow and smooth. Pleurosternal carinae mostly faint and beaded ridges, increasingly obliterate and line-shaped towards body middle to 2/3 (Figs 3–6). Epiproct rather short, conical, finger-shaped; tip faintly concave between apical papillae; pre-apical lateral papillae small (Figs 3–5). Hypoproct roundly triangular, setiferous papillae at caudal corners small and rather well separated (Fig. 5).

Sterna broad, densely setose, cross-impressions distinct, axial impressions being weaker than transverse ones; sterna between coxae 3–5 and behind coxae 8 each with 1+1 small, but increasingly evident and spiniform caudolateral cones,



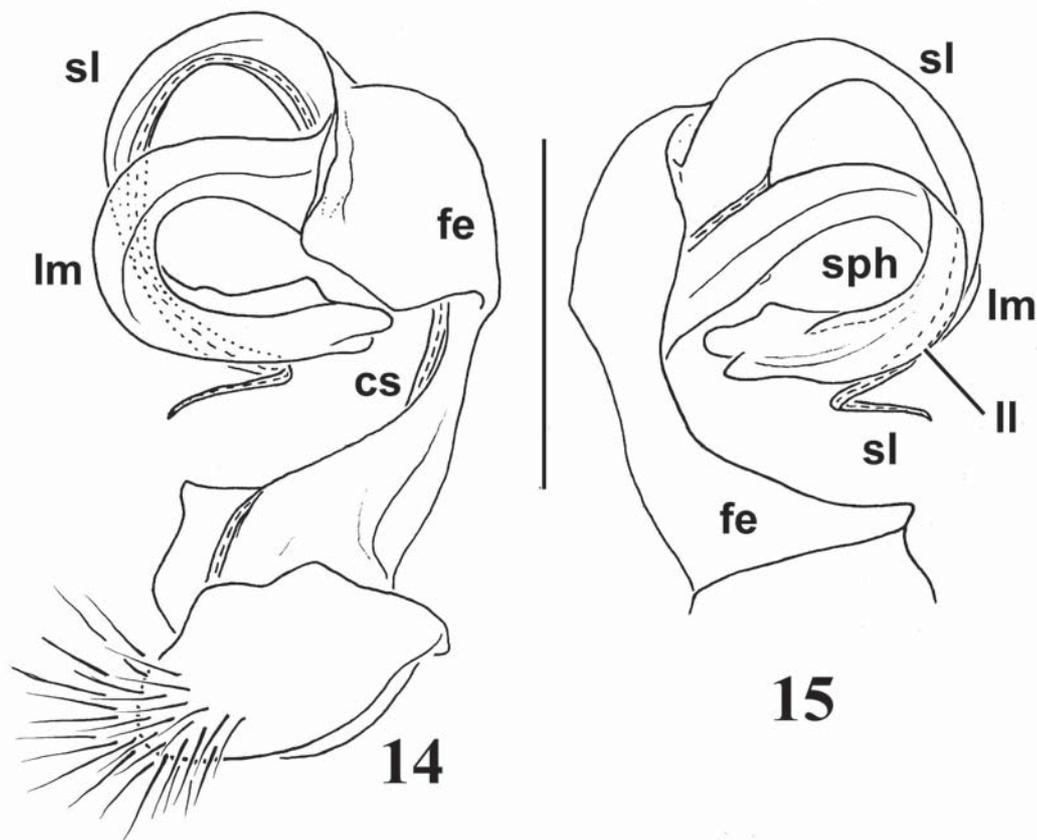
Figs 6–8. *Iulidesmus silvestrii* sp.n., ♂ holotype. 6 — anterior part of body, ventral view; 7, 8 — body ring 7 with intact gonopods, ventral and lateral views, respectively. Photographs by K.V. Makarov, taken not to scale.

Рис. 6–8. *Iulidesmus silvestrii* sp.n., голотип ♂. 6 — передняя часть тела, снизу; 7, 8 — туловищный сегмент 7 с гоноподами на месте, соответственно снизу и сбоку. Фотографии: К.В. Макаров, снято без масштаба.



Figs 9–13. *Iulidesmus silvestrii* sp.n., ♂ holotype, right gonopod, mesal, ventral, lateral, subcaudal and suboral views, respectively. Photographs by K.V. Makarov, taken not to scale.

Рис. 9–13. *Iulidesmus silvestrii* sp.n., голотип ♂, соответственно изнутри, снизу, сбоку, почти сзади и почти спереди. Фотографии: К.В. Макаров, снято без масштаба.



Figs 14, 15. *Iulidesmus silvestrii* sp.n., ♂ holotype, right gonopod, caudal and oral views, respectively. Abbreviations: cs — midway constriction; fe — femorite; lm — lamina medialis; ll — lamina lateralis; sl — solenomere; sph — solenophore. Scale bar: 0.5 mm.

Рис. 14, 15. *Iulidesmus silvestrii* sp.n., голотип ♂, правый гонопод, соответственно сзади и спереди. Обозначения: cs — срединная перетяжка; fe — феморит; lm — lamina medialis; ll — lamina lateralis; sl — соленомер; sph — соленофор. Масштаб: 0,5 мм.

each posterior pair being slightly longer and stronger than each anterior pair (Figs 5, 6). Legs long and slender, mostly 1.3–1.4 x (♂) or 1.1–1.2 x (♀) midbody height. In length, femur >> tarsus > prefemur = postfemur = tibia > coxa. Prefemora subcylindrical, not bulged laterad. Tibiae 1–6 and tarsi 1–11 with ventral brushes. Femora 3 and 4 each with a small, but distinct distoventral knob/adenostyle (Fig. 6).

Gonopods (Figs 14, 15) rather simple, telopodites *in situ* directed mesad and fully crossing distally. Coxites subcylindrical, nearly twice as long as prefemoral (= densely setose) portions of telopodites, sparsely and poorly setose distodorsally; cannula as usual, not modified. Femoral parts (fe) of telopodites voluminous and very considerably constricted near midway (cs), about as long as two-branched, strongly curved and subcircular acropodites. Solenomere branch (sl) very strong and long, strongly arched and well removed in basal half from solenophore branch (sph), sl gradually attenuating, its distal half being flagelliform and supported by a similarly long, lamellar sph, the latter with only very moderately developed lateral and medial lobes (= a lamina lateralis and a lamina medialis, or ll and lm, respectively) partly sheathing the distal third of sl inside a gutter between both ll and lm.

REMARKS. The monotypic genus *Iulidesmus* Silvestri, 1895 and its type species, *I. typicus* Silvestri, 1895, had been described so succinctly [Silvestri, 1895] that both had immediately fallen in complete oblivion until Hoffman [2012]

revised the ♀ holotype of *I. typicus*, corrected some errors in the original description and, considering the provenance (from between Coroico and Chulumani, 1600 m a.s.l., La Paz Department, Bolivia) and certain morphological details (e.g., 22 mm long, 2.0 mm wide; paraterga delimited by only very shallow sulci), he managed to deduce/reveal its identity. He showed that, because *Mestosoma* Silvestri, 1897, a very large genus with numerous species ranging across southern Central and entire South America, was a junior subjective synonym of *Iulidesmus*, all erstwhile 57 species of *Mestosoma* he listed had to be transferred to *Iulidesmus*. Moreover, considering that only very few *Iulidesmus* species (and no other genera of Paradoxosomatidae!) occur in that particular region of Bolivia, only recollecting male topotypic material of *I. typicus* between Coroico and Chulumani, both towns located amidst foothills on the east versant of the Andes, would finally allow for the identity of that species to be resolved. This is quite possible because keys to most of the ex-*Mestosoma* (= *Iulidesmus*) species are available [Jeekel, 1963; Golovatch, 2005], also considering the later information that missed the keys [Hoffman, 1977].

Tribe Eviulisomatini Brölemann, 1916
Genus *Onciurossoma* Silvestri, 1932

Type species: *Onciurossoma neotropicum* Silvestri, 1932, from Venezuela, by original designation.



Figs 16–18. *Onciurosoma troglobium* sp.n., ♂ holotype, habitus, dorsal, lateral and ventral views, respectively. Abbreviation: j — cones between coxae 4. Photographs by K.V. Makarov, taken not to scale.

Рис. 16–18. *Onciurosoma troglobium* sp.n., голотип ♂, внешний вид, соответственно сверху, сбоку и снизу. Обозначение: j — конусы между тазиками 4. Фотографии: К.В. Макаров, снято без масштаба.

Other species included (after Golovatch [1992] and Jeekel [2002]):

1. *Onciurosoma acisternum* Silverstri, 1932, Guyana;
2. *Onciurosoma adisi* Golovatch, 1992, Central Amazonia, Brazil;
3. *Onciurosoma affine* Golovatch, 1992, Central Amazonia, Brazil;
4. *Onciurosoma alamellatum* Golovatch, 1992, Central Amazonia, Brazil;
5. *Onciurosoma cumbrense* (Brölemann, 1898), Venezuela;
6. *Onciurosoma crassipes* Jeekel, 1963, Suriname.

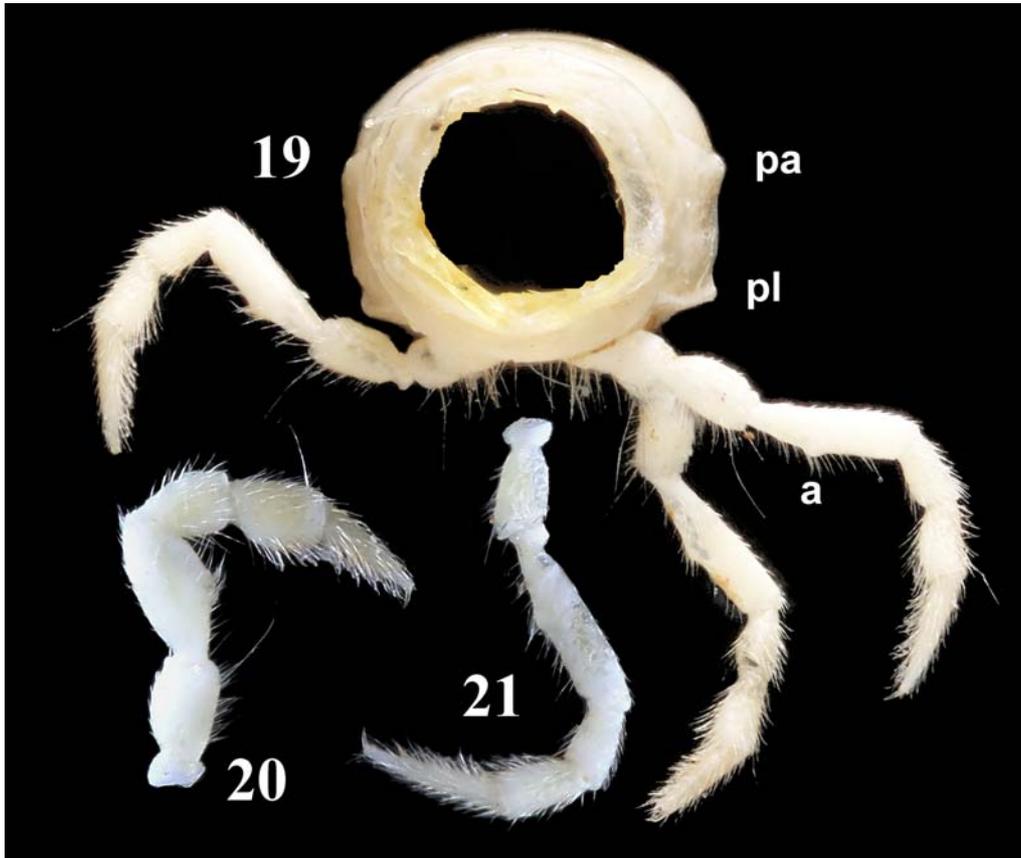
DIAGNOSIS. The only Neotropical genus of Eviuliso-matini with clearly reduced, but still quite visible paraterga, mostly with two apical unci/hooks directed ventrad on the

epiproct, a distinct sternal lobe between ♂ coxae 4, devoid of clear-cut adenostyles on certain often enlarged pregonopodal femora, and with suberect and twisted gonopodal telopodites, in which the prefemoral (= densely setose) portion is shorter than to subequal in length to the femorite, the latter being often accompanied by a more or less distinct, mesal, solenophore lobe g [Jeekel, 1963, 2002; Golovatch, 1992].

Onciurosoma troglobium Golovatch et Gallo, **sp.n.**

Figs 16–26.

HOLOTYPE ♂ (LES 0027937), Brazil, Bahia State, São Desidério Municipality, Gruta Sumidouro do João Baio cave, S12°22'27.6", W44°53'31.7", aphotic zone, vegetable debris in



Figs 19–21. *Onciurosoma troglobium* sp.n., ♂ paratype. 19 — cross-section of ring 6 with legs 6 and 7, oral view; 20 — leg 3, lateral view; 21 — leg 9, lateral view. Abbreviations: a — adenostyle; pa — paratergum; pl — pleurosternal carina. Photographs by K.V. Makarov, taken not to scale.

Рис. 19–21. *Onciurosoma troglobium* sp.n., паратип ♂. 19 — поперечный разрез туловищного сегмента 6 с ногами 6 и 7, спереди; 20 — нога 3, сбоку; 21 — нога 9, сбоку. Обозначения: а — аденостиль; ра — паратергит; пл — плейростеральный гребень. Фотографии: К.В. Макаров, снято без масштаба.

clay, 2.XI.2011, M.E. Bichuette, J.E. Gallão, C.S. Fernandes, D.R. Pedroso leg.

PARATYPE: 1 ♂ (LES 0027938), same place, together with holotype.

NAME. To emphasize cave-dwelling, the first presumed troglobiont Paradoxosomatidae to be described not only from Bahia, but also from entire Brazil and South America.

DIAGNOSIS. Using the detailed keys to *Onciurosoma* species by Jeekel [1963] and Golovatch [1992], slightly updated by Jeekel [2002], *O. troglobium* sp.n. keys out to *O. cumbrense* (Brölemann, 1898), from several places in Venezuela [Jeekel, 2000], because both species share the lack of terminal unci on the epiproct, but the new species differs from all congeners by the lack of transverse metatergal sulci, the small and biconical sternal lobe between ♂ coxae 4, the similarly modified and stout ♂ legs 3–7, and the very prominent gonopodal prefemoral portion and solenophore lobe *g* (Figs 16–26). See also Remarks under this species.

DESCRIPTION. Length ca 12 mm, width of midbody pro- and metazonae 0.8 and 1.0 mm, respectively (both holotype and paratype). Coloration of head and torso uniformly very light beige, legs pallid (Figs 16–18).

Body subcylindrical, with 20 rings (Figs 16–18). Tegument generally smooth and moderately shining to finely shagreened, texture micro-alveolate. Head densely setose all over clypeolabral region, vertex poorly setose; epicranial

suture faint; isthmus between antennae about as broad as diameter of antennal socket (Fig. 18). Antennae moderately and slightly clavate, *in situ* projecting past ring 3 dorsally (♂); in length, antennomeres $3 = 6 > 2 = 4 = 5 > 7 > 1$ (Figs 16–18). Genae round, gnathochilarium without peculiarities.

In width, ring $2 = 3 < \text{collum} = 4 < 5 = 15 < \text{head}$ (♂), starting with ring 16, body gradually tapering towards telson (Figs 16–18). Paraterga (**pa**) set high (at about upper 1/3 midbody height), faint, visible as small, rounded and declivous flaps on collum or as flat squarish to slightly arcuate bars, a little thicker/higher on pore-bearing rings than on poreless ones, delimited by sulci both dorsally and, even more faintly, ventrally (Figs 16–19). Pore formula normal, ozopores on peritremata sunken inside ovoid grooves invariably only a little removed off caudal corners of paraterga/peritremata, these corners mostly being subdentiform, often sharp and very slightly produced past rear tergal margin. Dorsum regularly convex, devoid of transverse metatergal sulci, surface invariably smooth. Tergal setae often abraded, retained ones short, ca 1/3–1/4 as long as metatergum, setation pattern mostly vague, traceable as 2+2 insertion points at least across anterior 1/4–1/5 metatergum. Stricture between pro- and metazonae wide, shallow and smooth. Pleurosternal carinae (**pl**) mostly faint ridges, increasingly obliterate towards telson, each with a small, often sharp caudal



Figs 22–24. *Onciurosoma troglobium* sp.n., ♂ paratype, left gonopod, lateral, ventral and mesal views, respectively. Abbreviations: cx — coxite; fe — femorite; g — mesal solenophore lobe; lo — apical lobule; pfe — prefemorite. Photographs by K.V. Makarov, taken not to scale.

Рис. 22–24. *Onciurosoma troglobium* sp.n., паратип ♂, левый гонопод, соответственно сбоку, снизу и изнутри. Обозначения: cx — коксит; fe — феморит; g — внутренняя пластина соленофора lobe; lo — вершинная пластинка; pfe — префеморит. Фотографии: К.В. Макаров, снято без масштаба.

tooth (Figs 16–19). Epiproct rather short, conical, finger-shaped; tip faintly concave between two small apical papillae; pre-apical lateral papillae likewise small (Figs 16–18). Hypoproct roundly triangular, setiferous papillae at caudal corners small and well separated (Fig. 18).

Sterna broad, densely setose, mostly flat, cross-impressions being indistinct; sterna between most coxae with increasingly evident and spiniform caudolateral cones, each posterior pair being slightly longer and stronger than each anterior pair (Figs 17, 18); sternum between coxae 4 with a pair of small, setigerous, basally contiguous cones (Fig. 18, j). Legs long and slender, mostly 1.7–1.8 x midbody height (♂). In length, femur > tarsus > prefemur = postfemur = tibia > coxa. Prefemora subcylindrical, not bulged laterad. All tibiae and tarsi with ventral brushes. Legs 1–3 stouter than following ones (Fig. 20), femora 2–7 each with a small, more or less distinct, ventral, setose bulge or knob (a) in basal 1/3, this knob being only barely traceable on femur 9 (Fig. 21), but a much more clear bulge on particularly stout legs 3 (Figs 19–21).

Gonopods (Figs 22–26) complex, telopodites rather stout, *in situ* suberect, directed forward. Coxite (cx) subcylindrical, as usual, about as long as each of prefemoral (= densely setose, pfe) and femoral (fe) portions of telopodite; pfe unusually densely setose; mesal solenophore lobe (g) at base of fe prominent, rounded, ca 2/3 as long as fe; seminal groove (sg) recurved laterad at base of fe to move shortly after that onto a free flagelliform solenomere squeezed between a prominent lamina lateralis (ll) and a far less conspicuous lamina medialis (lm), and virtually fully sheathed and concealed until a small, rounded, apical lobule (lo).

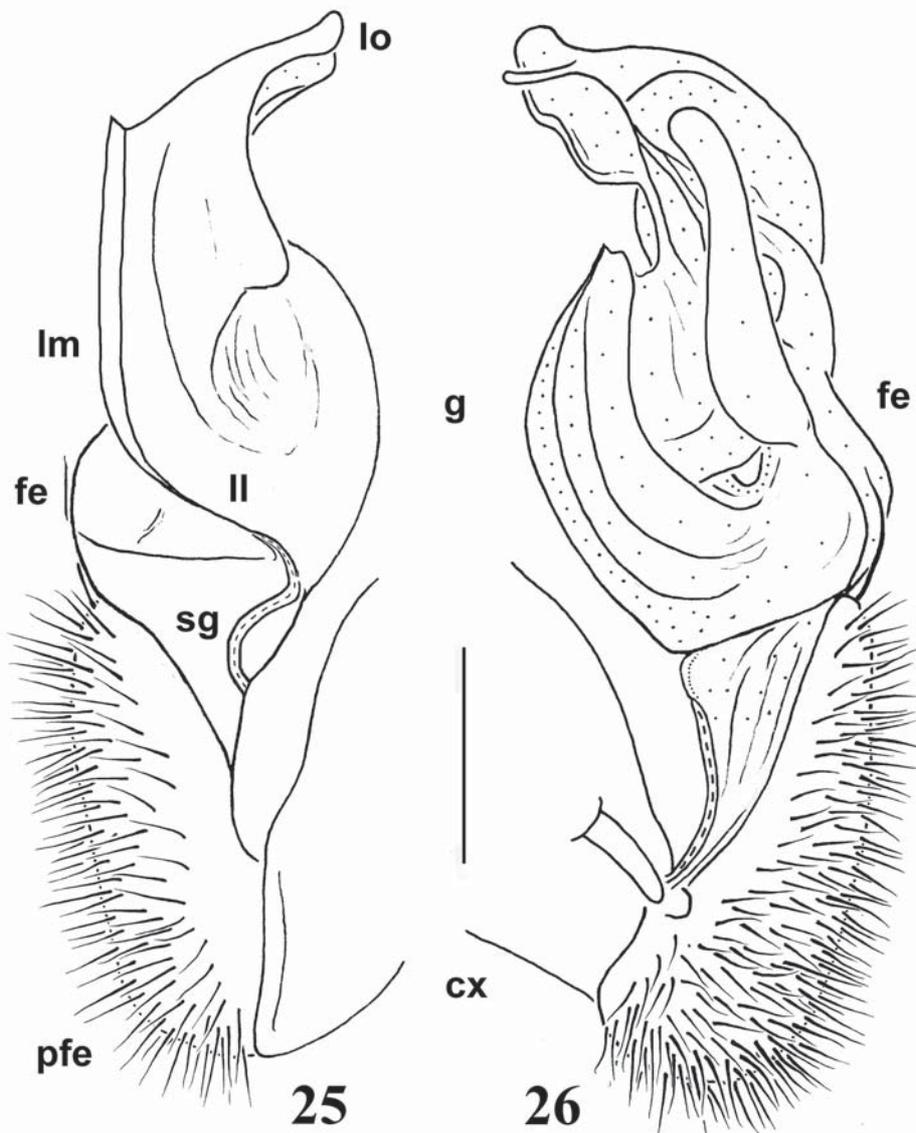
REMARKS. The unpigmented and highly fragile body, as well as the fairly long legs and antennae seem to be troglomorphic traits that may be evidence of this species being a troglobiont, even though it is among the smallest congeners. Golovatch's [1992] earlier analysis of the rela-

tions between the species of *Onciurosoma* allows us to refer *O. troglobium* sp.n. to a group joining three species, *O. adisi*, *O. crassipes* and *O. neotropicum*, in all of which the solenophore (lobe g) is particularly prominent, deemed to reflect an apomorphic state of this character. Through *O. cumbrense* as an intermediate condition, the remaining species *O. acisternum*, *O. affine* and *O. alamellatum* seem to share a vestigial g, apparently a symplesiomorphy. Another distinct apomorphy in *Onciurosoma*, which accounts for the generic name, is the presence in most species (except *O. cumbrense* and *O. troglobium* sp.n.) of characteristic terminal unci on the epiproct. The same concerns the absence of sternal cones, an obvious plesiomorphy observed only in *O. cumbrense*. In other words, like any other congener, *O. troglobium* sp.n. shows a mixture of plesio- and apomorphies in all meaningful characters, both somatic and gonopodal (see also Diagnosis above).

What seems particularly important is that *O. troglobium* sp.n. seems to represent the first troglobiont Parasoxosomatidae to be reported not only from Bahia and Brazil, but also the entire Neotropical Realm. *Onciurosoma* currently appears to be restricted to the northern quarter of South America, Bahia thereby representing the southeastern range limit of this genus.

Conservation remarks

The caves of Central municipality and their surroundings are impacted by subsistence agriculture (deforestation), potential impacts from mining activities, and wind energy installations in the karst landscapes (M.E. Bichuette & J.E. Gallão, personal communication). In addition, the type locality is used by people as a shelter for hunting activities (Fig. 1). In this context, we performed a preliminary evaluation of the conser-



Figs 25, 26. *Onciurosoma troglobium* sp.n., ♂ paratype, left gonopod, lateral and mesal views, respectively. Abbreviations: cx — coxite; fe — femorite; g — mesal solenophore lobe; lm — lamina medialis; ll — lamina lateralis; lo — apical lobule; pfe — prefemorite; sg — seminal groove. Scale bar: 0.2 mm.

Рис. 25, 26. *Onciurosoma troglobium* sp.n., паратип ♂, левый гонопод, соответственно сбоку и изнутри. Обозначения: cx — коксит; fe — феморит; g — внутренняя пластина соленофора lobe; lm — lamina medialis; ll — lamina lateralis; lo — вершинная пластинка; pfe — префеморит; sg — семенной проток. Масштаб: 0,2 мм.

vation status of the presumed troglophilic *Iulidesmus silvestrii* sp.n. following the IUCN (International Union of the Conservation of Nature) classification based on all of the above-mentioned threats. As a result, this millipede and its habitat may be considered Endangered (EN) by the criteria B2ab(iii). The B means restricted in geographical distribution, B2 meaning occupation area with less than 500 sq. km; a with location less or equal to five, and b(iii) representing a continuous decline in habitat quality. *Iulidesmus silvestrii* sp.n. is the first cave millipede described for the Central region of Bahia.

The João Rodrigues River system is threatened, in addition to potential mining projects (limestone exploitation), by the road construction activities that can collapse the rock, the pollution of subterranean drainage [Galvão, Bichuette, 2018], and irrigation projects [Galvão *et al.*, 2012]. These infrastructure works are advanced across the São Desidério municipality, attending the increasing necessity to flow agricultural production, prioritizing local economic development, and exerting intense pressure on environmental resources [Galvão *et al.*, 2012]. Natural threats are also a

problem to the entire Bahia state, especially climate change, with reduced rainfalls and extended dry periods [Bichuette, Gallão, 2021].

Based on these conditions, *Onciurossoma troglobium* sp.n. and its habitat are also evaluated following the IUCN classification and may be considered Critically Endangered (CR) by the criteria B1ab(iii). The B means restricted geographical distribution; B1 with an occurrence extension less than 100 sq. km; a represented by a single location, and b(iii) represents a continuous decline in habitat quality. This species is presently restricted to its sole and type locality, being narrowly endemic and consistently associated with organic matter and high humidity. The only troglobitic species known for São Desidério municipality is the aquatic planarian *Girardia desiderensis* Souza et Leal-Zanchet, 2016, from the Gruta da Baixa Fria cave. *Onciurossoma troglobium* sp.n. is the first troglobitic millipede described and the second known from the João Rodrigues River system. We hope this can help the protection of the region and its cave fauna.

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