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Hidden in the caves: a new troglobitic species of *Spaeleoleptes* and the type species redescription (Opiliones, Laniatores)

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Abstract. The genus *Spaeleoleptes* was proposed by H. Soares in 1966 to accommodate the first Brazilian troglobitic species of harvestmen, *Spaeleoleptes spaeleus* H. Soares, 1966. In this work, we redescribe this species, including digital images of the type material and drawings of the male genitalia. Since its description, *Spaeleoleptes* has remained monotypic, and after 56 years, herein is described the second species of the genus, the troglobitic *Spaeleoleptes gimli* sp. nov. Both species share sexually dimorphic legs I and II with modified regions and swelling on the tibiae and patellae I and II; a penis with robust conductors covering all or part of the capsula interna and a capsula interna with two lateral projections. They are clearly separated by the shape of the modified region of the tibia; by the presence of an apical projection on the apical lamina of the pars distalis in *S. spaeleus*; and the lateral projections of the capsula interna, which is flattened in *S. gimli*. *Spaeleoleptes gimli* greatly increases the distributional range of the genus, as it is now recorded from caves located in two Brazilian phytophysiognomies from the Cerrado of Minas Gerais to the Caatinga of Bahia.

Keywords: Neotropical, Zalmoxoidea, relict, sexual dimorphism, cave-dwellers.

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Introduction

Escadabiidae Kury & Pérez-González in Kury, 2003 is a small South American family of Opiliones Laniatores proposed to contain four genera originally described in the family Phalangodidae: *Baculigerus* H. Soares, 1979, *Jim* H. Soares, 1979, *Recifesius* H. Soares, 1978, and the type genus *Escadabius* Roewer, 1949. Subsequently, two other monotypic genera were included in Escadabiidae: *Spaeleoleptes* H. Soares, 1966 and *Brotasus* Roewer, 1928 (Kury & Pérez-González 2007; Kury *et al.* 2010) leaving the current composition of the family restricted to six genera and eight species (Kury *et al*. 2015, 2022).

From this group of escadabiids, the current work focuses on the study of the poorly known and cavernicolous species of the genus *Spaeleoleptes*. The genus was originally described by H. Soares (1966) to accommodate *Spaeleoleptes spaeleus* H. Soares, 1966, a troglobitic species collected in Lapa Nova do Maquiné cave, Cordisburgo municipality, state of Minas Gerais, in Brazil. It was originally described as a member of the polyphyletic Phalangodidae, subfamily Minuinae (=Kimulidae), but Kury (2003) asserted that the description was insufficient to provide a reliable familial assignment and considered the taxon as a Grassatores incertae sedis. The current family allocation was first proposed by Kury & Pérez-González (2007), but the authors did not provide details about the elements supporting the familiar assignment nor did they provide a redescription under modern standards of opilionological taxonomy. In the original description of *Spaeleoleptes spaeleus*, Soares used highly convergent characters to identify the species, such as troglomorphism. Despite the relatively good illustrations of the body, leg I and pedipalp, no description or illustration of male genital structures was made, structures that are currently considered essential for the proposition of new genera and species (Martens 1976). Moreover, the examination of the genital morphology is crucial in placing taxa into families belonging to the clade Samooidea+Zalmoxoidea (Pérez-González *et al.* 2016); therefore, a thorough description of *Spaeleoleptes spaeleus* including a detailed study of the male genital morphology is still missing for this species. This work, in part, will cover this deficiency in order to support their placement in Escadabiidae.

Nowadays, we know that harvestmen are one of the most successful groups of animals to colonize the subterranean environment and are well represented in all categories of subterranean classification: trogloxenes, troglophiles, and troglobites (Pinto-da-Rocha 1995; Gallão & Bichuette 2018). In Brazil there are 14 troglobitic species of Laniatores harvestmen distributed in the families Cryptogeobiidae, Escadabiidae, Gerdesiidae, Gonyleptidae, and Kimulidae. *Spaeleoleptes spaeleus* was the first troglobitic harvestman species described from Brazil, paving the way for major speleological discoveries of the group (Pinto-da-Rocha 1995). Despite this, after 56 years, the species is redescribed herein for the first time, including digital images of the type material and illustrations of the male genitalia. Furthermore, the monotypy of the genus has ended with the description of a second troglobitic species, *Spaeleoleptes gimli* sp. nov., from specimens collected in a cave in Bahia State, also representing a substantial increase of the distributional range of this remarkable group of Brazilian harvestmen.

Material and methods

Description of the sampling localities

The Gruta Natal cave (Figs 1–2) is located in the the carbonatic rocks of the Una Group, in the Una-Utinga metasedimentary Basin, in the state of Bahia. The climate is semiarid, and the vegetation type is the "Caatinga" interspersed by Atlantic Forest. These carbonatic rocks are inserted on the Salitre Formation at about 600 m a.s.l. Caves in the Itaetê region present labyrinth patterns with large conducts and the presence of lakes or water bodies; some of these localities are know worldwide, such as Poço Encantado, Poço Azul de Milu, and Lapa do Bode, with intense touristic frequentation (Rubbioli *et al.* 2019; Pereira 2022). Gruta Natal is not visited by tourists, and is outside the protected area of Chapada Diamantina National Park, on a private property. Its surroundings are highly impacted

Fig. 1. A–C. Lapa Nova de Maquiné, Cordisburgo, state of Minas Gerais. **D–F**. Gruta Natal cave, Itaetê, state of Bahia. **A**. Touristic entrance of the cave. **B**. Artificially illuminated touristic gallery. **C**. Touristic gallery with pools. **D**. Cave entrance. **E**. Cave gallery with rocky and silty substrates. **F**. Impacts in the surroundings of the cave; the native vegetation was preserved only in the outcrops. Photos: A–C: M.E. Bichuette; D–F: R.F.G.A. Pereira, October 2022.

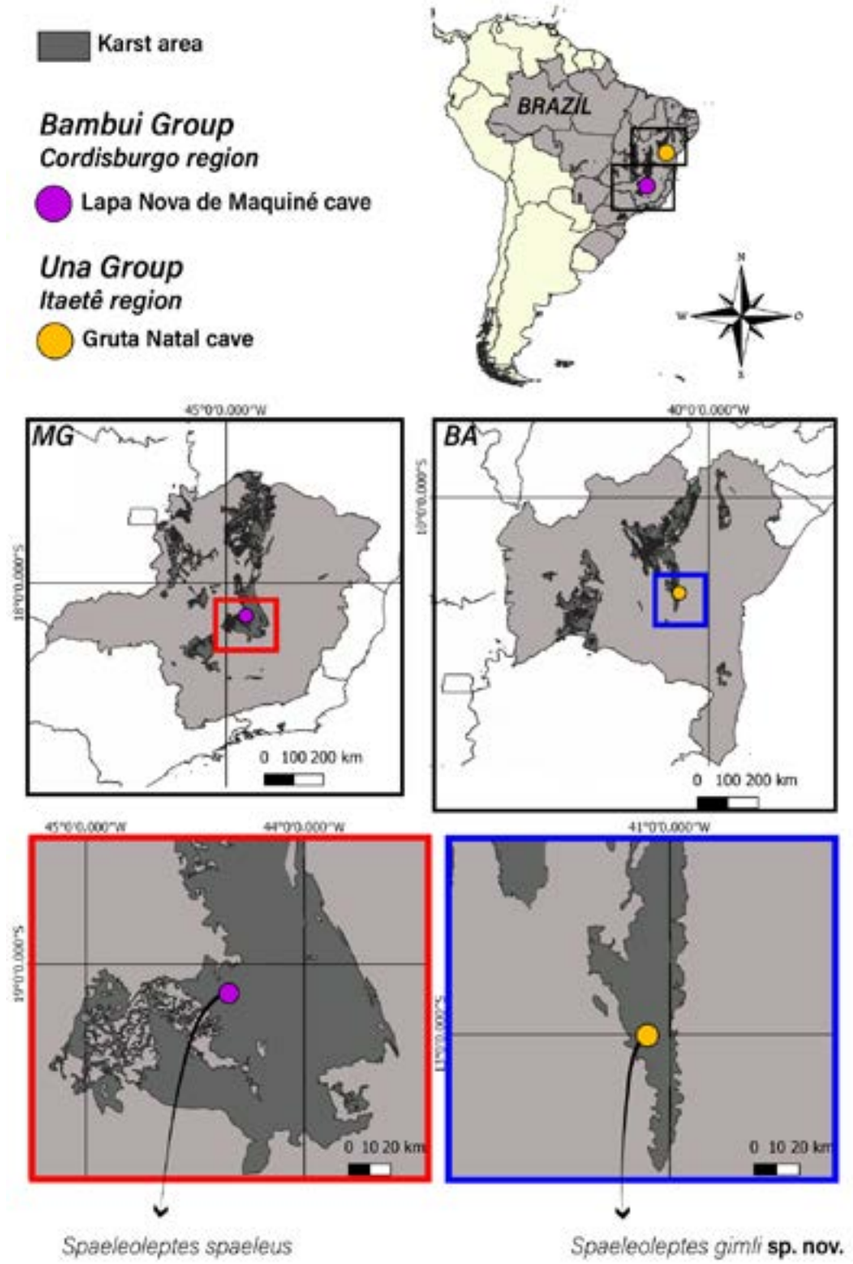

Fig. 2. Distribution map of *Spaeleoleptes* H. Soares, 1966 species. The purple circle is the Lapa Nova do Maquiné cave, locality of the type species *S. spaeleus* H. Soares, 1966. The yellow circle is the Gruta Natal cave, locality of the new species *S. gimli* sp. nov. Dark grey, karst areas. Abbreviations: MG = Minas Gerais State; BA = Bahia State.

nowadays, mainly by deforestation for plantations and pastures. It is a highly humid cave, since there is a large lake formed by phreatic waters. This lake is inhabited by the Brazilian cave catfish *Rhamdiopsis krugi*, a threatened species.

The Lapa Nova de Maquiné cave (Figs 1–2) is a limestone cave located in the Cordisburgo region, state of Minas Gerais. This cave is the scene of important scientific discoveries by the Danish paleontologist Peter Wilhelm Lund, in the second half of the 19th century. It is a cave with ca 1300 m of mapped passageways, inserted in the Bambuí Group, Lagoa do Jacaré Formation (Rubbioli *et al.* 2019) of the Upper Proterozoic. The local climate can be included in the tropical regime with two well-defined seasons, characteristic of the Cerrado Domain. The cave has been intensively studied by geologists and biologists. It is a touristic cave, with a speleological management plan. The main impacts are the suppression of the vegetation in the surroundings of the cave by agriculture and *Eucalyptus* forestry, as well as the artificial lighting in part of the cave (visited) that favors the growth of exotic organisms to the cave habitat. Lapa Nova do Maquiné and its immediate surroundings is a state Conservation Unit of integral protection in the category of Natural Monument, named as Peter Lund State Natural Monument in 2005.

Specimen collection and repositories

The material examined is deposited in the Museu de Zoologia da Universidade de São Paulo (MZUSP), Brazil, and in the collection of the Laboratório de Estudos Subterrâneos da Universidade Federal de São Carlos (LES-UFSCar), Brazil.

Specimen preparations

Images of ethanol preserved specimens of *Spaeleoleptes gimli* sp. nov. were captured on a Leica DFC295 camera coupled to a Leica M205C stereo microscope with a Planapo 1.0× lens and produced by mounting multiple images using the LAS software (Leica Application Suite) ver 3.7. (at UFSCar). Pictures of the holotype (MZUSP 28463, male) and paratype (MZUSP 28462, female) of *Spaeleoleptes spaeleus* were taken with a Leica DFC295 digital camera attached to a Leica M205A stereo microscope (at Museo Argentino de Ciencias Naturales – MACN, Buenos Aires, Argentina). Different focal planes of images were combined using Helicon Focus Pro (www.heliconsoft.com). Male genitalia preparation followed Acosta *et al.* 2007, with temporary mounts embedded in glycerol. Line drawings of male genitalia were made using a camera lucida attached to an Olympus BH-2 compound microscope (at MACN) and were digitized using Illustrator 23.1. Figures were edited using Photoshop CS5. For SEM, dissected body parts were dried and mounted on adhesive copper tape (EMS 77802; Electron Microscopy Sciences) affixed to an aluminum stub. Uncoated SEM preparations were examined using an FEI Quanta 250 (at the UFSCar).

Maps

The map was produced with the software QuantumGis Desktop 3.6.0 (QGis Open Source Geospatial Foundation). The coordinates were obtained from field trips to the study location with a global positioning system (GPSGarmin 60CSx).

Results

Taxonomy

Class Arachnida Lamarck, 1801
Order Opiliones Sundevall, 1833
Suborder Laniatores Thorell, 1876
Family Escadabiidae Kury & Pérez-González in Kury, 2003

Genus Spaeleoleptes H. Soares, 1966
Figs 3–14

Spaeleoleptes H. Soares 1966: 111. Type species: *Spaeleoleptes spaeleus* H. Soares, 1966, by original designation.

Spaeleoleptes – Kury 2003: 28.

Spaeloleptes – Kury & Pérez-González 2007: 193, incorrect subsequent spelling.

Etymology

The derivation of the generic name is incorrect; it should be spelled 'Spelaeoleptes' (Kury 2003) from the Greek σπήλαιον (spelaion = cave, cavern) and part of the pre-existing genus *Gonyleptes*. Although incorrect, the original name, *Spaeleoleptes*, has to be kept according to article 32.5.1 of the currently valid ICZN (1999), because it is considered as an incorrect latinization of the Greek σπήλαιον. Gender masculine.

Placement

Spaeleoleptes was originally described in Phalangodidae: Minuinae (= Kimulidae). The genus was considered family uncertain by Kury (2003) and transferred to Escadabiidae by Kury & Pérez-González (2007).

Species included

Spaeleoleptes spaeleus H. Soares, 1966 and *Spaeleoleptes gimli* sp. nov.

Emended diagnosis

Spaeleoleptes clearly differs from the other genera of Escadabiidae by the unique combination of the following characters: legs I and II sexually dimorphic, males with tibia I thickened, with a glandular/sensorial? region with "droplet-like" pegs (sensu Willemart *et al.* 2010) present mainly on the retrolateral surface (Figs 5, 10); glandular/sensorial? region with "droplet-like" pegs ventrally on patella and tibia II in males (Figs 5, 11); post-ocularium region armed with two pointed tubercles, which may be reduced to two granules (Figs 3D, 7B); body hourglass-shaped, covered by setiferous tubercles; coxa and femur IV not thickened; ocularium globose, without apical projection; ocularium and chelicerae not sexually dimorphic. The genital morphology differs from that of other genera of Escadabiidae by the presence of very robust, thickened and folded conductors, totally or partially covering the capsula interna; an capsula interna with two lateral projections; two pairs of reduced ventral setae on the pars distalis and apical lamina very broad (Figs 6, 14).

Distribution

The genus is restricted to two caves in Eastern Brazil. *Spaeleoleptes spaeleus* from Lapa Nova do Maquiné, Cordisburgo municipality, State of Minas Gerais (cave belonging to the Bambui geomorphological group), and *S. gimli* sp. nov. fom Gruta Natal cave, Itaetê municipality, State of Bahia (cave belonging to the Una geomorphological group) (Fig 2).

Spaeleoleptes spaeleus H. Soares, 1966
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Figs 3–6

Spaeleoleptes spaeleus [sic] H. Soares, 1966: 111, figs 7–9.

Spaeleoleptes spaeleus – Gnaspini & Trajano 1994: 582. — Pinto-da-Rocha 1995: 80; 1996: 189. — Kury 2003: 28.

Material examined

Holotype

BRAZIL • ♂; Minas Gerais, Cordisburgo, Lapa Nova de Maquiné cave; 19°07′31″ S, 44°21′07″ W; MZUSP 28463 (ex: MZUSP-OS 3187).

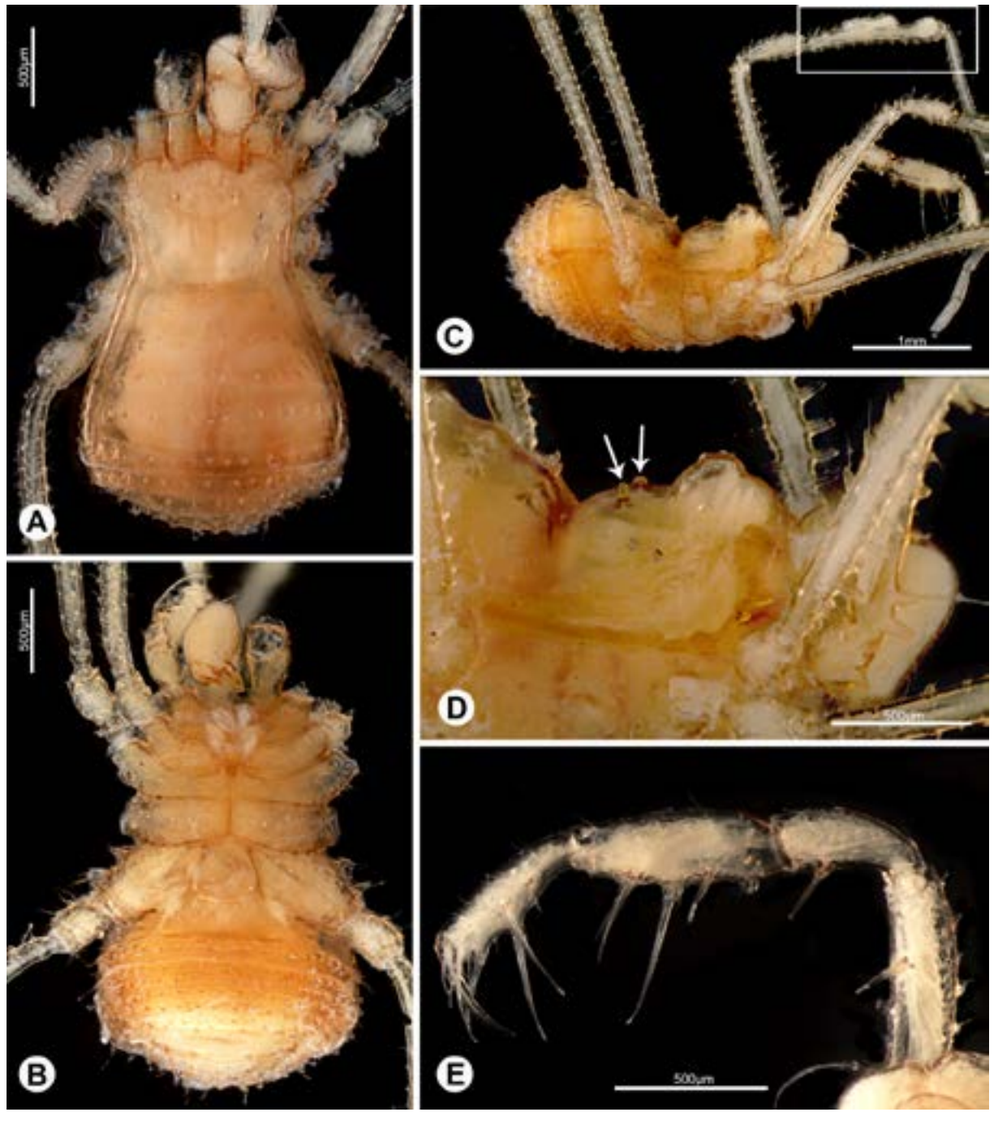

Fig. 3. *Spaeleoleptes spaeleus* H. Soares, 1966, male holotype (MZUSP 28463). **A**. Habitus, dorsal view. **B**. Habitus, ventral view. **C**. Habitus, right lateral view. Square indicatesglandular/sensorial? region of leg I, more detail in Fig. 5. **D**. Carapace, lateral view. Arrows indicate the pointed tubercles on the posterior region of the ocularium. **E**. Male pedipalp, mesal view.

Paratype

BRAZIL • ♀; same collection data as for holotype; MZUSP 28462 (ex: MZUSP-OS 3187).

Notes about the type material

Soares (1966) deposited the type material of *Spaeleoleptes spaeleus* in the "Otto Schubart Collection" with the number 3187. In addition to a holotype male, one female paratype and other male paratype were deposited with the same number (3187) in this same collection. A third male and two female paratypes were deposited in the collection "Coleção H. Soares" with the number 54 and this material was destroyed in the fire at the National Museum of Rio de Janeiro (MNRJ) in 2018, where the "Coleção H. Soares" was deposited. In 2003, Kury referred to the material type with the collection numbers MZUSP-OS 3187. Today, the male holotype and female paratype from the "Otto Schubart Collection" (3187) are

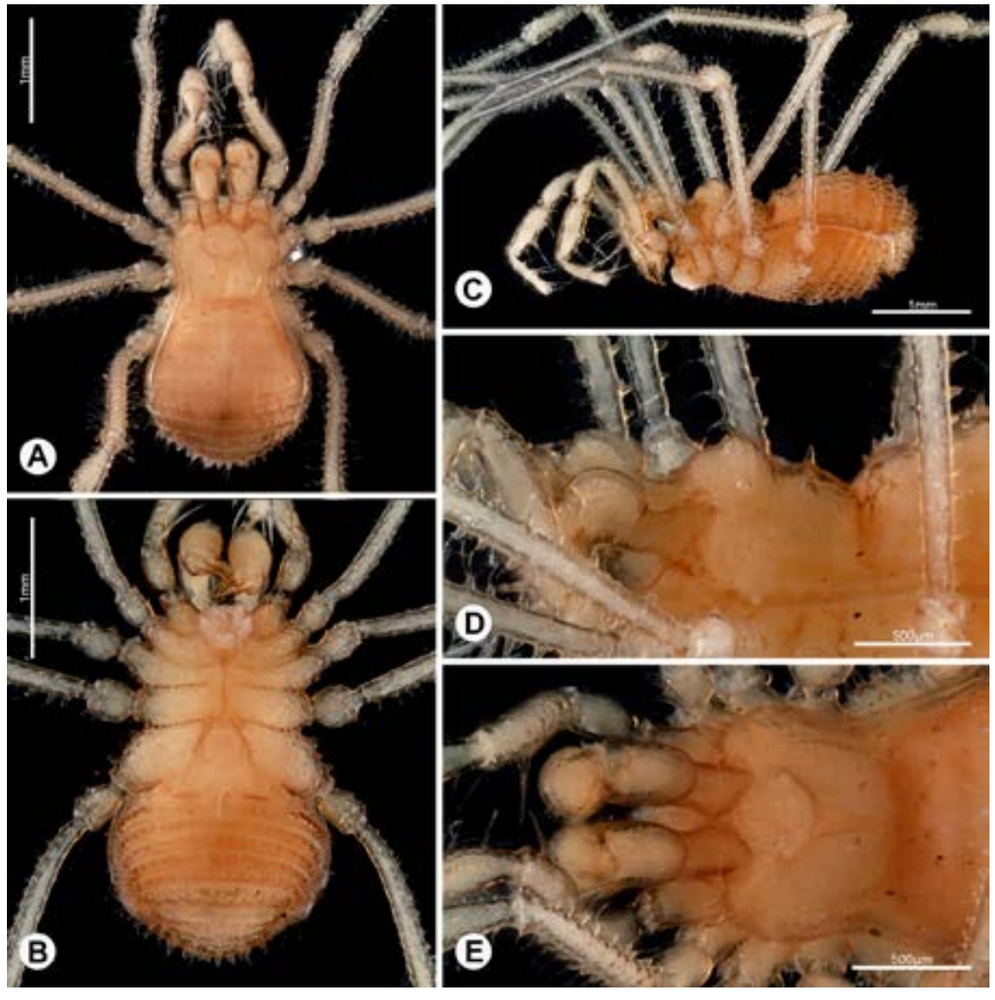

Fig. 4. *Spaeleoleptes spaeleus* H. Soares, 1966, female paratype (MZUSP 28462). **A**. Habitus, dorsal view. **B**. Habitus, ventral view. **C**. Habitus, left lateral view. **D**. Carapace, lateral view. **E**. Carapace, dorsal view.

incorporated into the collection of the University of São Paulo Museum of Zoology (MZUSP) with the collection number: MZUSP 28463 (male holotype) and MZUSP 28462 (one female paratype). These two specimens were analyzed in this work.

Etymology

The original species name is incorrect; it should be spelled 'spelaeus' from Greek σπήλαιον (spelaion = cave, cavern). Although incorrect, the original name, *spaeleus*, can't be emended according to article 32.5.1 of the currently valid ICZN (1999), because it is considered as an incorrect latinization of the Greek σπήλαιον.

Diagnosis

Spaeleoleptes spaeleus differs from *S. gimli* sp. nov. mainly by the following combination of genital characters: apical lamina with a pointed medial projection; the presence of three lateral pairs of reduced setae ventrally on the apical lamina; lateral projections of the capsula interna distally pointed; and by the ventral keel of the pars distalis with a round top in ventral view (Fig. 6). Both species of *Spaeleoleptes* have a very similar external morphology, but *S. spaeleus* can be distinguished by having the tibia I modified, horse saddle-shaped, in retrolateral view (Figs 5A–B); the two large pointed tubercles in the post ocularium region; and by the body being covered by large setiferous tubercles (Fig. 3).

Redescription

Male (holotype, MZUSP 28463) (Figs 3–6)

Measurements (in millimeters). Total body length = 2.2; carapace length = 0.78; scutum magnum length = 1.9; carapace maximum width = 1.0; mesotergal scute maximum width = 1.50.

Body. Entirely covered by setiferous tubercles with the exception of the carapace, chelicerae, and pedipalp (Fig. 3).

Dorsum. Scutum magnum hourglass-shaped with the carapace slightly narrower than the mesotergal shield. Left and right anterior margin of the carapace is armed with two large pointed tubercles close to each other. Mesotergal shield trapezoidal, with areas increasing in width in an anteroposterior direction, with area I being the smallest and area IV the largest (along transversal axis). Areas IV and V with the same width (Fig. 3). Anterior margin of carapace straight, with no pronounced cheliceral sockets. Posterior margin of scutum straight. Each antero-lateral margin of the carapace is armed with two large, pointed tubercles close to each other. Massive ocularium and frontal hump well marked near the anterior margin of the carapace. Ocularium rounded, with several small granules on the surface. Two eyes on the lateral surface of the ocularium with reduced cornea, no visible retina. Carapace in lateral view with a posterior ocularium region slightly convex, armed with two rounded-tipped tubercles. Deep sulcus I. Mesotergal scutum with five distinguishable areas of approximately the same size (along anteroposterior axis). Sulci II–IV shallow (not well marked), especially the sulci III and IV. Sulci II–IV complete, extending from center to edge of mesotergum. Areas I–V and free tergites each with a transversal row of pointed setiferous tubercles. Coxa IV visible in dorsal view, armed with several prominent setiferous tubercles on the retrolateral-dorsal surface.

Venter. Free sternites each with a transverse row of pointed setiferous tubercles. Anal operculum covered by many low, robust setiferous tubercles of the same size as those of the free tergites. Coxa IV longer than wide, with low setiferous tubercles on the ventral surface. Spiracles free, not concealed by coxa IV.

Chelicera. Basichelicerite unarmed, with a well-marked rounded bulla. Cheliceral hand unarmed, normal, neither swollen nor hypertelic, covered with some sensilla.

Pedipalp. Raptorial morphotype (sensu Wolff *et al.* 2016). Coxa short, armed with one large setiferous tubercle ventrally. Trochanter globular, with one setiferous tubercle and two pronounced granules ventrally. Femur armed ventrally with two proximal and two smaller medial major spines (i.e., stiff pointed bristles in highly elevated sockets, sensu Wolff *et al.* 2016); dorsally with a row of small granules and the subdistal-mesal surface with one major spine. Patella armed with one major spine on the mesal surface. Tibia armed ventrally with three ectal and three mesal major spines. Tarsus armed ventrally with three ectal and three mesal major spines. Claw present.

Legs. Leg measurements in Table 1. Legs covered with large setiferous tubercles from the coxae to the middle of the metatarsus. Legs I and II sexually dimorphic, males with thickened tibia I and modified distal

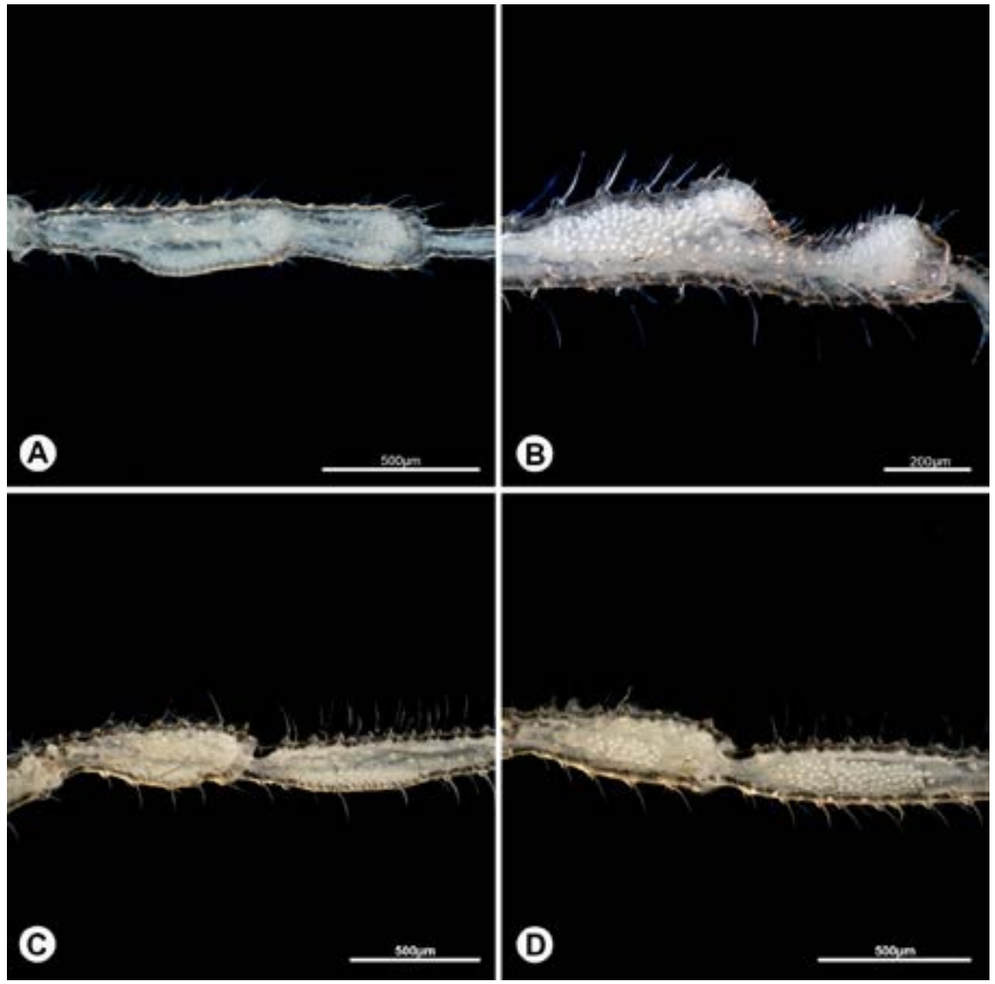

Fig. 5. *Spaeleoleptes spaeleus* H. Soares, 1966, male holotype (MZUSP 28463), glandular/sensorial? region. **A**. Modified region of right tibia I, dorsal view. **B**. Detail of glandular/sensorial? region on right tibia I, retrolateral view. **C**. Modified region of patella and tibia II, lateral view. **D**. Detail of glandular/sensorial? region on patella and tibia II, ventral view.

region horse saddle-shaped in retrolateral view. This modified glandular/sensorial? region has several "droplet-like" pegs present mainly on the retrolateral surface, but they may also be present dorsally and extend from the subproximal region to the subdistal region of the tibia I, occupying the entire medial area (Fig. 5B). Tibia I also expanded retrolaterally in its medial region, in dorsal view (Fig. 5A). Males also have legs II with a glandular/sensorial? region with "droplet-like" pegs on the ventral surface, medially on the patella II and proximally on the tibia II (Fig. 5D). Patella and tibia II slightly expanded ventrally in the glandular/sensorial? region, in lateral view (Fig. 5C). Tarsal formula: 4(2):?:5:5.

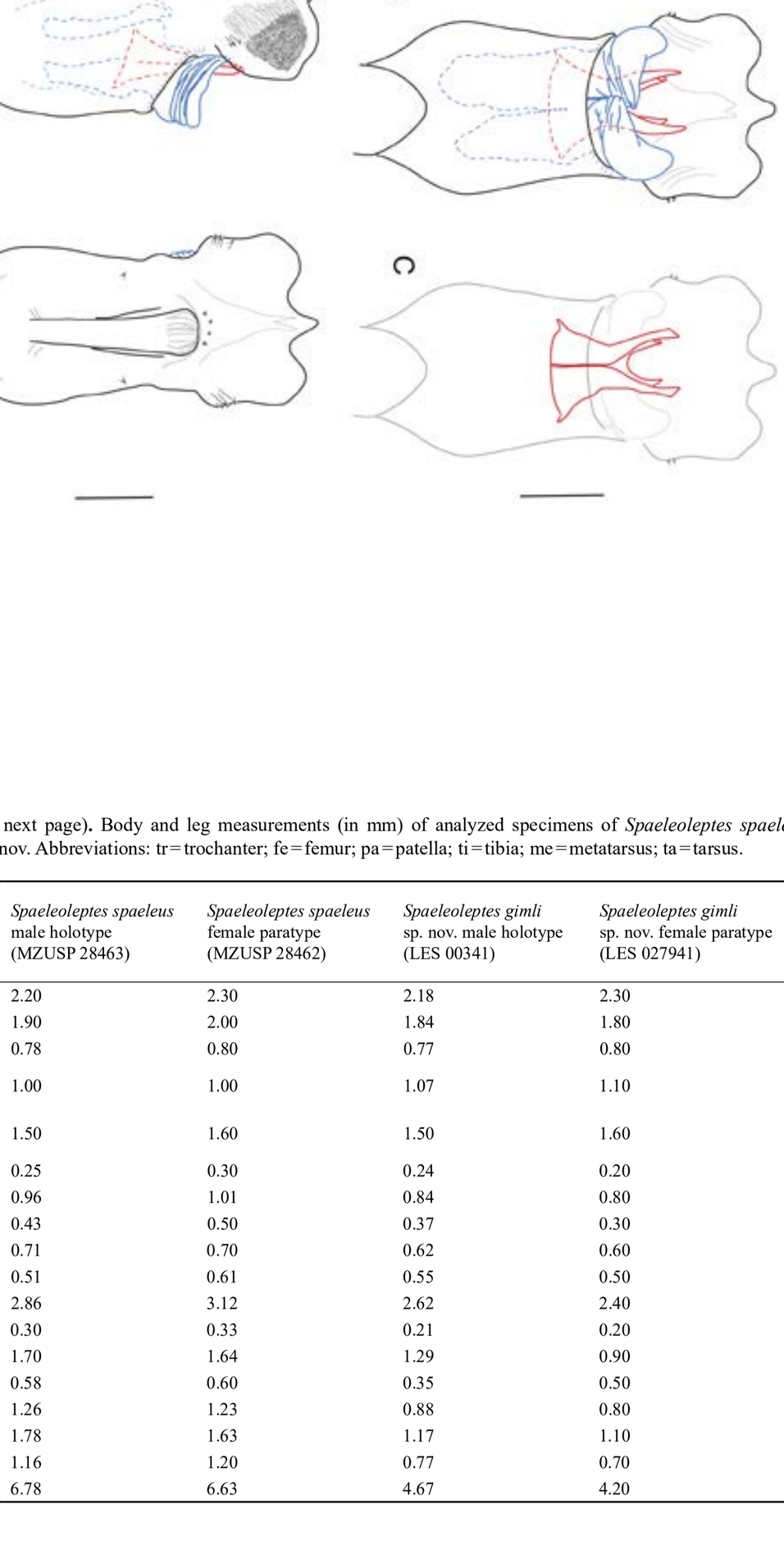

Fig. 6. Line drawings of male genitalia of *Spaeleoleptes spaeleus* H. Soares, 1966, male holotype (MZUSP 28463). **A**. Full genitalia, dorsal view. **B**. Detail of pars distalis, dorsal view. **C**. Detail of capsula interna, dorsal view. **D**. Detail of pars distalis, lateral view. **E**. Same, ventral view. Red lines: capsula interna. Blue lines: conductors. Scale bars: 1 mm.

Table 1 (continued on next page)**.** Body and leg measurements (in mm) of analyzed specimens of *Spaeleoleptes spaeleus* H. Soares, 1966 and *Spaeleoleptes gimli* sp. nov. Abbreviations: tr = trochanter; fe = femur; pa = patella; ti = tibia; me = metatarsus; ta = tarsus.

		Spaeleoleptes spaeleus male holotype (MZUSP 28463)	*Spaeleoleptes spaeleus* female paratype (MZUSP 28462)	*Spaeleoleptes gimli* sp. nov. male holotype (LES 00341)	*Spaeleoleptes gimli* sp. nov. female paratype (LES 027941)	*Spaeleoleptes gimli* sp. nov. male paratype (LES 027941)
total body length		2.20	2.30	2.18	2.30	2.05
scutum magnum length		1.90	2.00	1.84	1.80	1.77
carapace length		0.78	0.80	0.77	0.80	0.73
carapace maximum width		1.00	1.00	1.07	1.10	1.10
mesotergal scute maximum width		1.50	1.60	1.50	1.60	1.51
Pedipalp	tr	0.25	0.30	0.24	0.20	0.25
	fe	0.96	1.01	0.84	0.80	0.83
	pa	0.43	0.50	0.37	0.30	0.40
	ti	0.71	0.70	0.62	0.60	0.69
	ta	0.51	0.61	0.55	0.50	0.51
	Total	2.86	3.12	2.62	2.40	2.68
Leg I	tr	0.30	0.33	0.21	0.20	0.24
	fe	1.70	1.64	1.29	0.90	1.12
	pa	0.58	0.60	0.35	0.50	0.38
	ti	1.26	1.23	0.88	0.80	0.83
	me	1.78	1.63	1.17	1.10	1.05
	ta	1.16	1.20	0.77	0.70	0.75
	Total	6.78	6.63	4.67	4.20	4.37

Table 1 (continued). Body and leg measurements (in mm) of analyzed specimens of *Spaeleoleptes spaeleus* H. Soares, 1966 and *Spaeleoleptes gimli* sp. nov. Abbreviations: tr = trochanter; fe = femur; pa = patella; ti = tibia; me = metatarsus; ta = tarsus.

		Spaeleoleptes spaeleus male holotype (MZUSP 28463)	*Spaeleoleptes spaeleus* female paratype (MZUSP 28462)	*Spaeleoleptes gimli* sp. nov. male holotype (LES 00341)	*Spaeleoleptes gimli* sp. nov. female paratype (LES 027941)	*Spaeleoleptes gimli* sp. nov. male paratype (LES 027941)
Leg II	tr	0.38	0.40	0.25	0.30	0.24
	fe	2.40	2.43	1.68	1.50	1.57
	pa	0.76	0.82	0.59	0.60	0.48
	ti	-	2.04	1.39	1.30	1.32
	me	-	2.11	1.57	1.50	1.40
	ta	-	2.98	1.57	1.30	1.48
	Total	-	10.78	7.05	6.50	6.49
Leg III	tr	0.37	0.36	0.28	0.20	0.27
	fe	1.76	1.85	1.24	0.80	1.12
	pa	0.62	0.59	0.33	0.50	0.37
	ti	1.44	1.41	0.95	0.90	0.86
	me	1.83	1.77	1.16	1.10	1.15
	ta	1.92	1.89	1.11	1.10	0.98
	Total	7.94	7.87	5.07	4.60	4.75
Leg IV	tr	0.37	0.44	0.32	0.40	0.27
	fe	2.36	2.39	1.58	1.70	1.39
	pa	0.69	0.73	0.60	0.40	1.48
	ti	2.06	1.93	1.30	1.30	1.24
	me	2.34	2.32	1.59	1.60	1.59
	ta	2.45	2.42	1.28	1.30	1.16
	Total	10.27	10.23	6.67	6.70	7.13

Male genitalia (Fig. 6). Pars distalis swollen, separated from the pars basalis by a constriction. The apical region of pars basalis extends over the pars distalis dorsally, forming a structure similar to a small round-tipped plate in the region of constriction that separates pars basalis and pars distalis. Pars distalis with a ventral keel with round top in ventral view. Pars distalis with abroad apical lamina partially surrounding the glans ventrolaterally. Apical lamina with three lateral pairs of reduced setae ventrally. Apical lamina with a pointed medial projection. Four ventral setae reduced on the pars distalis. Glans with a pair of very robust, thickened, and folded conductors, partially covering the capsula interna. Capsula interna with lateral projections pointed.

Female (paratype, MZUSP 28462) (Fig. 4)
Measurements (in millimeters). Total body length = 2.3; carapace length = 0.8; scutum magnum length = 2.0; carapace maximum width = 1.0; mesotergal scute maximum width = 1.60. Leg measurements in Table 1.

Body. Similar in appearance to the males but without the modified region on the tibia I, II and patella II. Ocularium with no small granules on the surface. Left antero-lateral margin of the carapace is armed with two large pointed tubercles close to each other, and the right antero-lateral margin of the carapace is armed with three large pointed tubercles close to each other (Fig. 4E). Tarsal formula: 4(2):5(3):5:5.

Distribution

Known only from the type locality.

Spaeleoleptes gimli sp. nov.

urn:lsid:zoobank.org:act:F2FDBB7A-8465-488C-A216-97A812D210E6
Figs 7–14

Material examined

Holotype

BRAZIL • ♂; Bahia, Itaetê, Gruta Natal cave; 12°59′48″ S, 41°05′27″ W; 4 Jul. 2004; M.E. Bichuette leg.; LES 00341.

Paratype

BRAZIL • 1 ♂, 1 ♀; same collection data as for holotype; LES 027941 • 1 ♂; same collection data as for holotype; LES 027942 (SEM voucher).

Etymology

The species epithet is used as a noun in apposition. It refers to the dwarf Gimli, one of the main characters from J.R.R. Tolkien's famous novel "The Lord of the Rings". This name was chosen because in Tolkien's novel the dwarves are a race associated with mining and have a strong admiration for caves. Particularly, Gimli explicitly expresses his fascination for the Glittering Caves of Aglarond with their extensive series of spectacular speleothems, and after the defeat of Sauron he was given the lordship over this marvelous cave. The intention of the specific name is to make a metaphorical association with the close relationship of this species with its subterranean habitat.

Diagnosis

Spaeleoleptes gimli sp. nov. differs from *S. spaeleus* mainly by the following combination of genital characters: apical lamina with a narrower base and medial projection absent; the presence of four lateral pairs of reduced setae ventrally on the apical lamina; by the lateral projections of the capsula interna being distally flattened; and by the ventral keel of the pars distalis having straight top in

ventral view (Fig. 14). The external morphology of *S. gimli* also presents many convergences, but it can be distinguished by the slight depression on the retrolateral surface of tibia I (Fig. 10A); the two-pointed tubercles on the post-ocularium that are reduced to two small granules; and by the absence of large setiferous tubercles covering the body (Figs 7, 14).

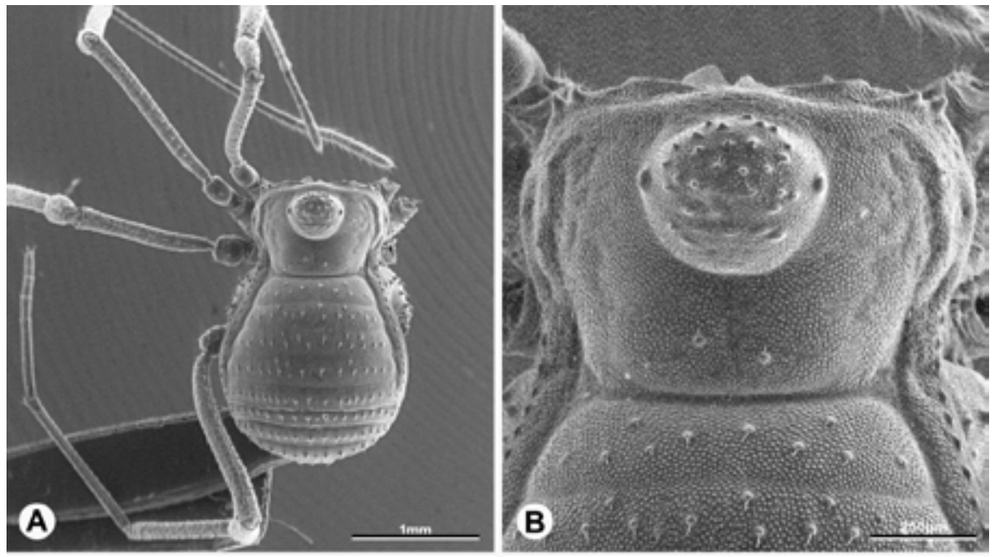

Fig. 7. *Spaeleoleptes gimli* sp. nov., male paratype (LES 027942), dorsal view. **A**. Habitus. **B**. Detail of carapace. **C**. Detail of antero-lateral margin of carapace. Arrows indicating the two projections. **D**. Detail of right coxa IV.

Description

Male (holotype LES 00341) (Figs 7–14)

Measurements (in millimeters). Total body length = 2.18; carapace length = 0.77; scutum magnum length = 1.84; carapace maximum width = 1.07; mesotergal scute maximum width = 1.5. Leg measurements in Table 1.

Body. Entirely finely granulated.

Dorsum (Figs 7, 13). Scutum magnum hourglass-shaped with the carapace slightly narrower than the mesotergal shield. Mesotergal shield trapezoidal, with areas increasing in width in an anteroposterior direction, with area I being the smallest and area IV the largest (along transversal axis). Areas IV and V with the same width. Anterior margin of carapace straight, with no pronounced cheliceral sockets. Posterior margin of scutum straight. Each antero-lateral margin of the carapace is armed with two small, round-tipped tubercles close to each other. Massive ocularium. Ocularium rounded, with several small granules on the surface. Two reduced eyes on the lateral surface of the ocularium, with cornea and retina. Carapace in lateral view with the posterior ocularium region slightly convex, armed with two thickened granules. Deep sulci I. Mesotergal scutum with five distinguishable areas of approximately the same size (along anteroposterior axis). Sulci II–IV shallow (not well marked), especially the sulci III and IV. Sulci II–IV complete, extending from center to edge of mesotergum. Areas I–IV with several setiferous tubercles. Area V and free tergites each with a transversal row of setiferous tubercles. Coxa IV visible in dorsal view, armed with several small setiferous tubercles on the retrolateral-dorsal surface.

Venter (Fig. 7). Free sternites each with a transverse row of small and rounded setiferous tubercles. Anal operculum covered by many low, robust setiferous tubercles of the same size as those of the free tergites. Coxa IV slightly rounded, longer than wide, with no setiferous tubercles on the ventral surface. Coxa IV with a cylinder-shaped projection on the ventro-distal portion, next to sternites. Spiracles somewhat concealed by coxa IV. Epistome with sulcus well marked. Post-sulcal epistome wider than tall, with a medial groove dividing the post-sulcal epistome into two convex domes. Basal pre-sulcal epistome wide and long, almost triangular. Pre-sulcal epistome process long and somewhat cylindrical, without median constriction (Fig. 8D).

Chelicera (Figs 9A–C). Basichelicerite unarmed, with a well-marked rounded bulla. Cheliceral hand unarmed, normal, neither swollen nor hypertelic, covered with several sensilla on the anterior surface.

Pedipalp (Figs 9D–H). Raptorial morphotype (sensu Wolff *et al.* 2016). Coxa short, unarmed, finely granulated and with a row of three small granules on the mesal surface. Trochanter globular, with one small setiferous tubercle dorsally and two pronounced setiferous tubercles disto-ventrally, with two other pronounced granules baso-ventrally. Femur armed ventrally with two proximal and two smaller medial major spines (i.e., stiff pointed bristles in highly elevated sockets, sensu Wolff *et al.* 2016); dorsally with a row of small granules and two subdistal-mesal major spines. Patella cylindrical, armed with one ventro-medial major spine on the mesal surface. Tibia armed ventrally with four ectal and four mesal major spines. Tarsus armed ventrally with three ectal and three mesal major spines. All major spines possess very small and sparse microtrichia covering the distal half. Claw present.

Legs (Figs 10–12). Cuticle of legs is scale-like and granulated except on calcaneus and tarsus. Calcaneus restricted to the distal portion of legs. Legs I and II sexually dimorphic, males with thickened tibia I. The glandular/sensorial? region is present on the retrolateral surface and extends from the subproximal region to the subdistal region of tibia I, occupying the entire medial area (Fig. 10). Males also have glandular/sensorial? openings with “droplet-like” pegs on the patella and tibia II ventrally, but different from what is observed in *S. spaeleu*s. In *S. gimli* sp. nov. the glandular/sensorial? openings are not

concentrated in one region but are dispersed throughout the ventral region of the patela and tibia II (Fig. 11). Patella and tibia II are not expanded ventrally. Tarsal formula: 4(2):6(3):5:5.

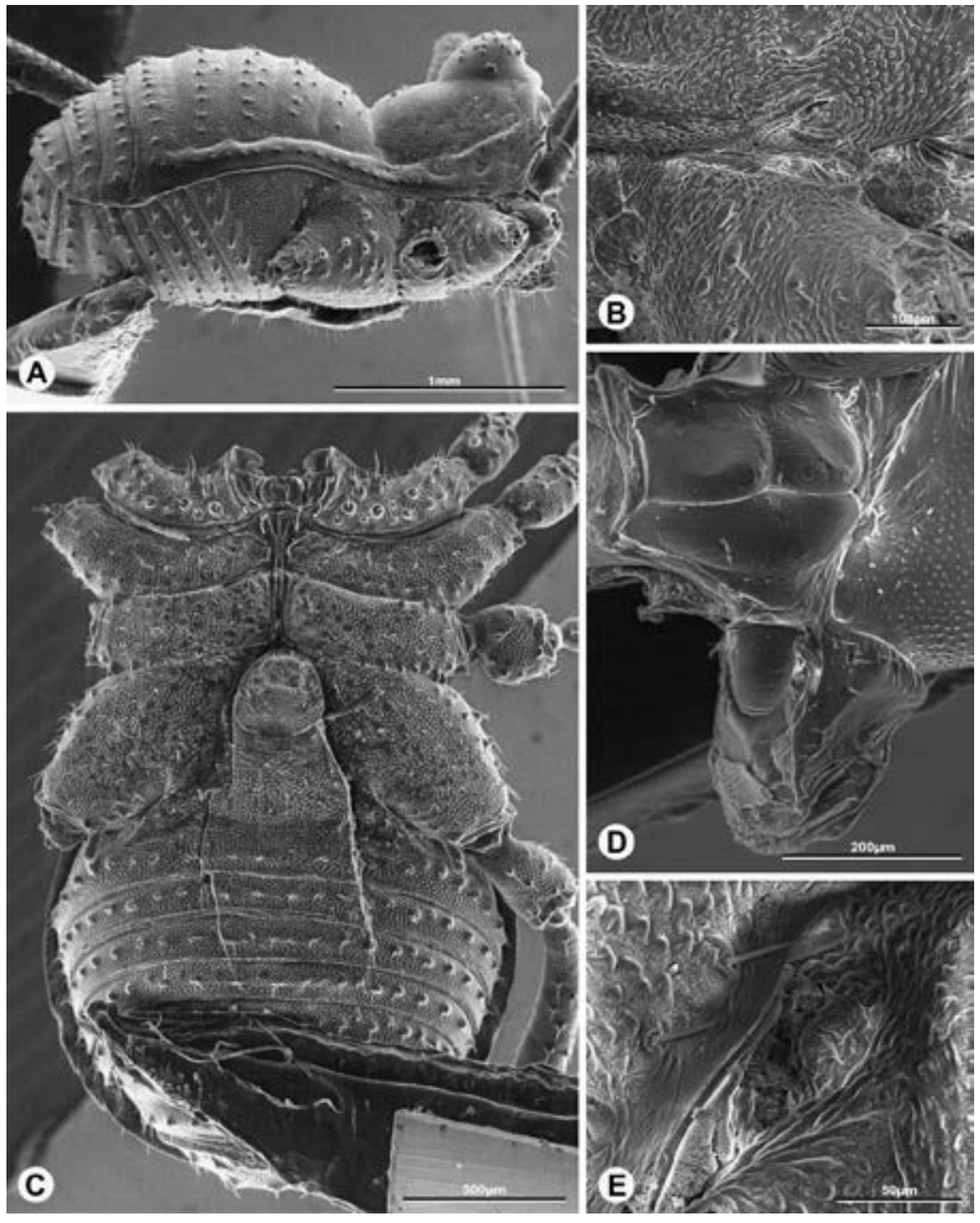

Fig. 8. *Spaeleoleptes gimli* sp. nov., male paratype (LES 027942). **A**. Habitus, lateral view. **B**. Lateral carapace showing the ozopore region. **C**. Habitus, ventral view. **D**. Epistome, anterolateral view. **E**. Detail of spiracle area.

Male genitalia (Fig.14). Pars distalis swollen, separated from the pars basalis by a slight constriction. Pars distalis with a ventral keel with straight top in ventral view. Pars distalis with a broad apical lamina with narrow base that does not surround the glans ventrolaterally. Apical lamina with two very small setae located in a depression in the mid-apical region. Apical lamina with four lateral pairs of

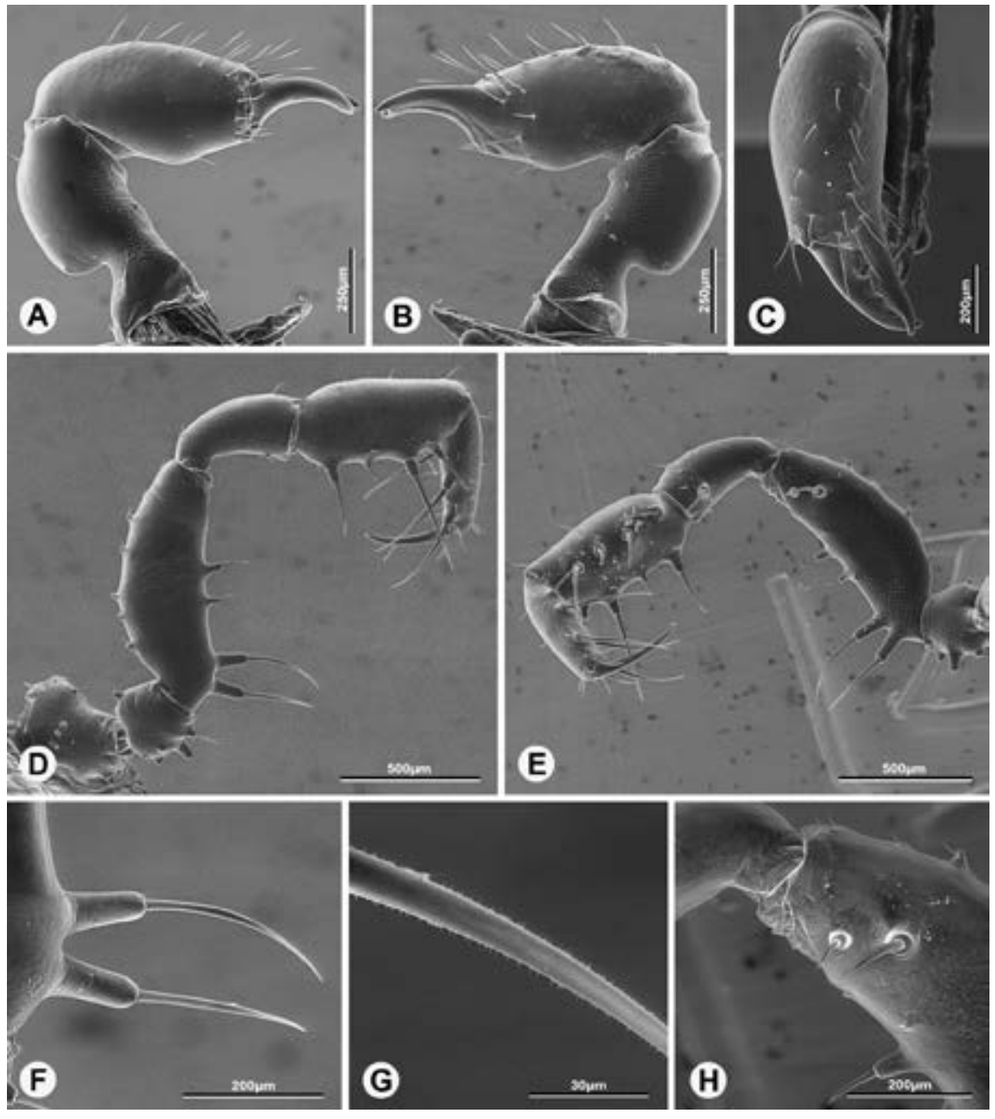

Fig. 9. *Spaeleoleptes gimli* sp. nov., male paratype (LES 027942). **A**. Right chelicera, ectal view. **B**. Right chelicera, mesal view. **C**. Right chelicera, frontal view. **D**. Right pedipalp, ectal view. **E**. Right pedipalp, mesal view. **F**. Detail of the two basal major spines on ventral femur of right pedipalp, ectal view. **G**. Detail of major spine on right pedipalp with very small and sparse microtrichia , ectal view. **H**. Detail of spines on mesal distal femur of right pedipalp, mesal view.

setae ventrally reduced. The other four ventral setae reduced on the pars distalis. Glans with a pair of very robust, thickened, and folded conductors, almost completely covering the capsula interna. Capsula interna with lateral projections distally flattened.

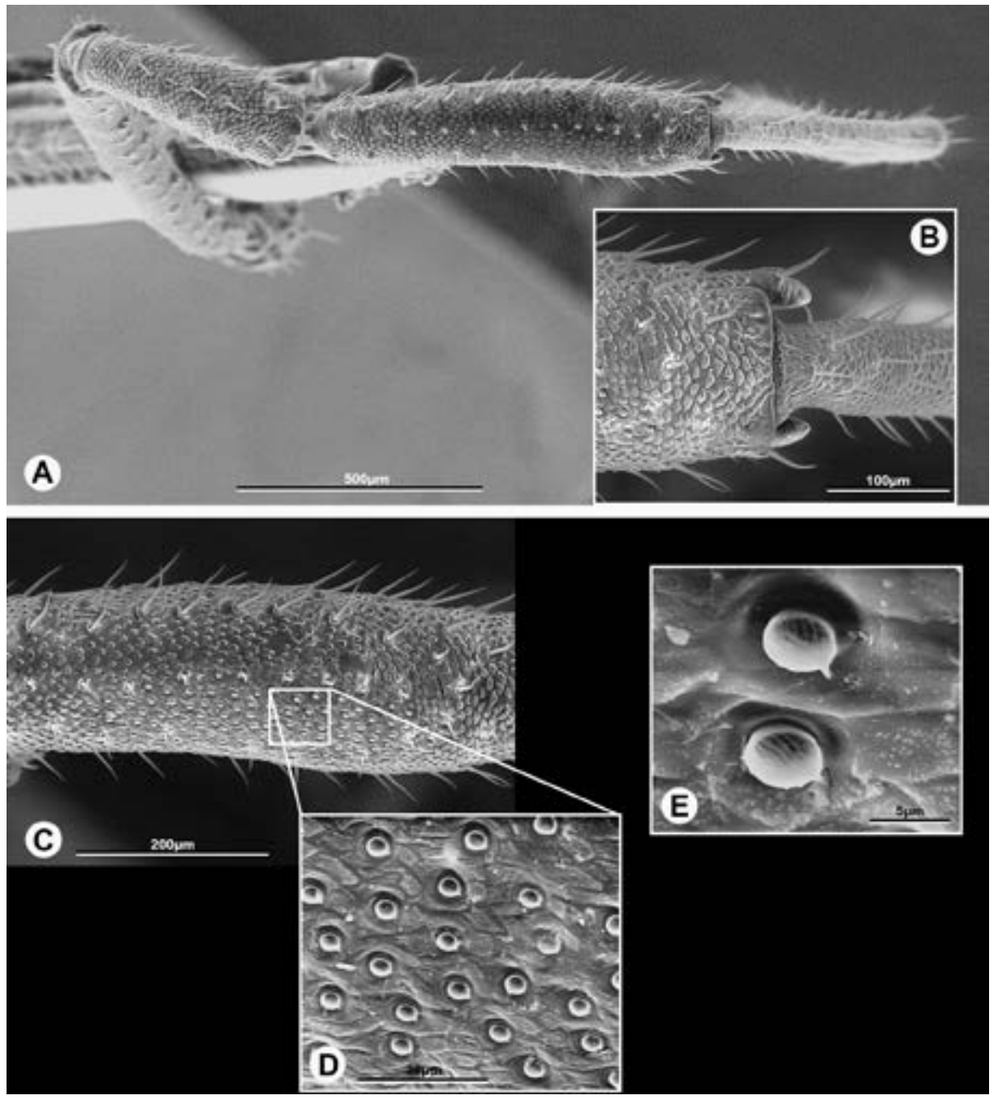

Fig. 10. *Spaeleoleptes gimli* sp. nov., male paratype (LES 027942), leg I. **A**. Right leg I, dorsal view. **B**. Detail of distal area of tíbia I, dorsal view. **C**. Detail of glandular/sensorial? region on tibia I, dorsal view. **D**. Detail of glandular/sensorial? openings, dorsal view. **E**. Detail of glandular/sensorial? openings with "droplet-like" pegs.

Female (paratype, LES 027941)

Measurements (in millimeters). Total body length = 2.3; carapace length = 0.8; scutum magnum length = 1.8; carapace maximum width = 1.1; mesotergal scute maximum width = 1.6. Leg measurements in Table 1.

Body. Similar in appearance to the males but without the modified region on the tibia I, II and patella II. Tarsal formula: 4(2):6(3):5:5.

Natural history

The specimens were found in the aphotic zone near the water body inside the Gruta Natal cave (phreatic water); they were under rocks in highly moist susbtrate. They were not grouped and did not show gregarious habit. It is noteworthy that *S. gimli* sp. nov. exhibits thanatosis as a defensive behavior.

Distribution

Known only from the type locality, Gruta Natal cave.

Discussion

Escadabiidae is one of the hardest Zalmoxoidea families to diagnose. This is in part due to the scarce morphological information available for its component species, which prevents us from having a reliable

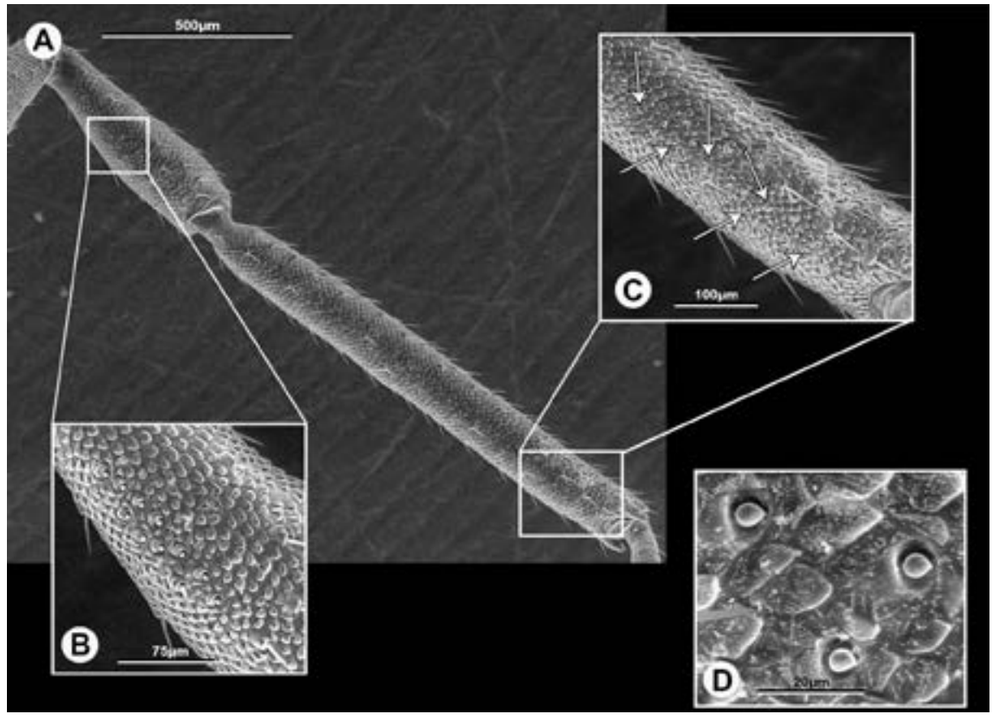

Fig. 11. *Spaeleoleptes gimli* sp. nov., male paratype (LES 027942), leg II. **A**. Right leg II, ventral view. **B**. Detail of patella II, ventral view. **C**. Detail of tibia II, ventral view. Arrows point to some of the glandular/sensorial? openings. **D**. Detail of glandular/sensorial? openings with "droplet-like" pegs, ventral view.

diagnosis applicable to all the genera and species. Before this work, none of the escadabiid species have ever been redescribed under modern taxonomic criteria, including external and genital characteristics. Regarding male genital characteristics, their importance in the taxonomy and systematics of harvestmen has been demonstrated for decades and there is already a consensus among harvestman taxonomists (e.g., Martens 1976; 1986; 1988; Pinto-da-Rocha 1997; Kury & Pérez 2002; Kury & Villarreal 2015, Pérez-González *et al*. 2016). Genital characters are of extreme importance in the delimitation of genera and species as well as in higher taxonomic categories. This is particularly important in groups where a large number of species exhibit highly conserved morphology (stasis) and also where some external features appear convergently in more than one lineage (e.g., Gainett *et al.* 2020). This is the case in many Zalmoxoidea and it needs to be investigated whether this is the case with Escadabiidae. The detailed study of the male genitalia of the two species of *Spaeleoleptes* is the first step in this direction.

For Escadabiidae, this is the first time that the genitalia of the species of *Spaeleoleptes* is described and illustrated, and only the third time that images or illustrations of the genitalia of the family's species are

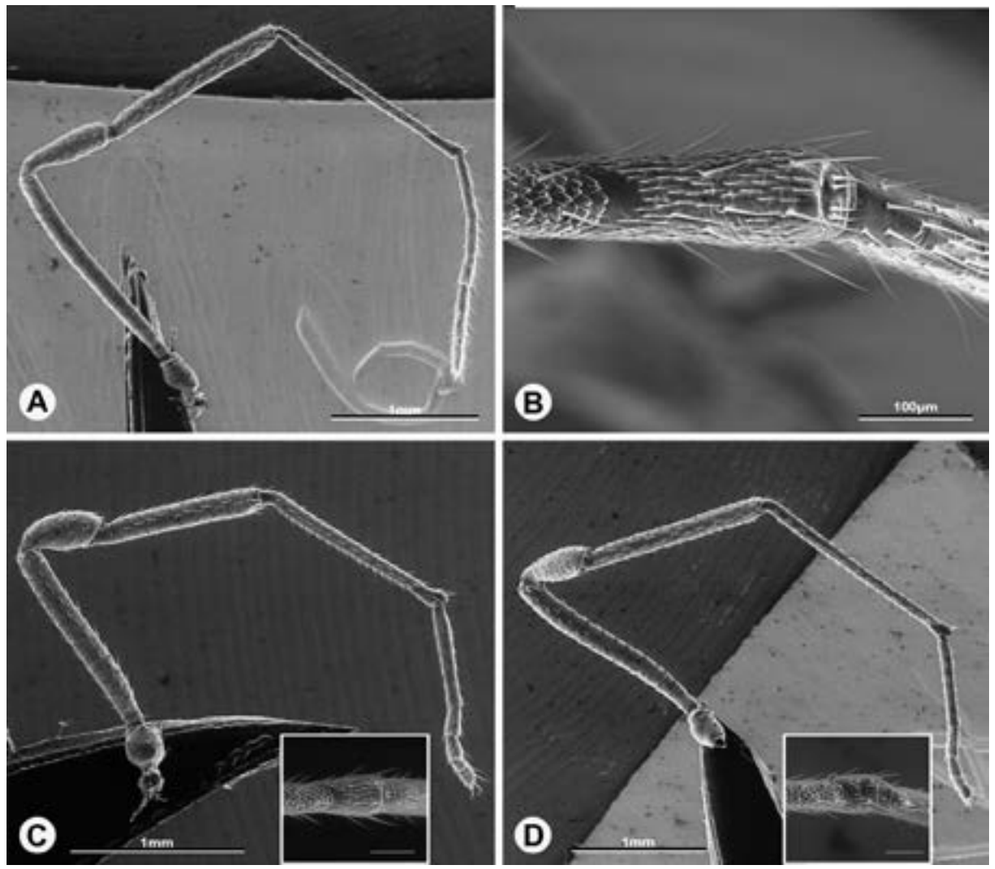

Fig. 12. *Spaeleoleptes gimli* sp. nov., male paratype (LES 027942), right legs. **A**. Leg II, retrolateral view. **B**. Detail of distal region of metatarsus II, dorsal view. **C**. Leg III, retrolateral view. Inset shows detail of distal region of metatarsus III, dorsal view, scale 100 µm. **D**. Leg IV, retrolateral view. Inset shows detail of distal region of metatarsus IV, dorsal view, scale 100 µm.

published. The first species to have the male genitalia illustrated was *Recifesius pernambucanus* H. Soares (1978, figs 6–7); however, the author did not offer any description or interpretation of what was illustrated, and the morphology of the glans is difficult to interpret. We suspect that the penis was damaged during

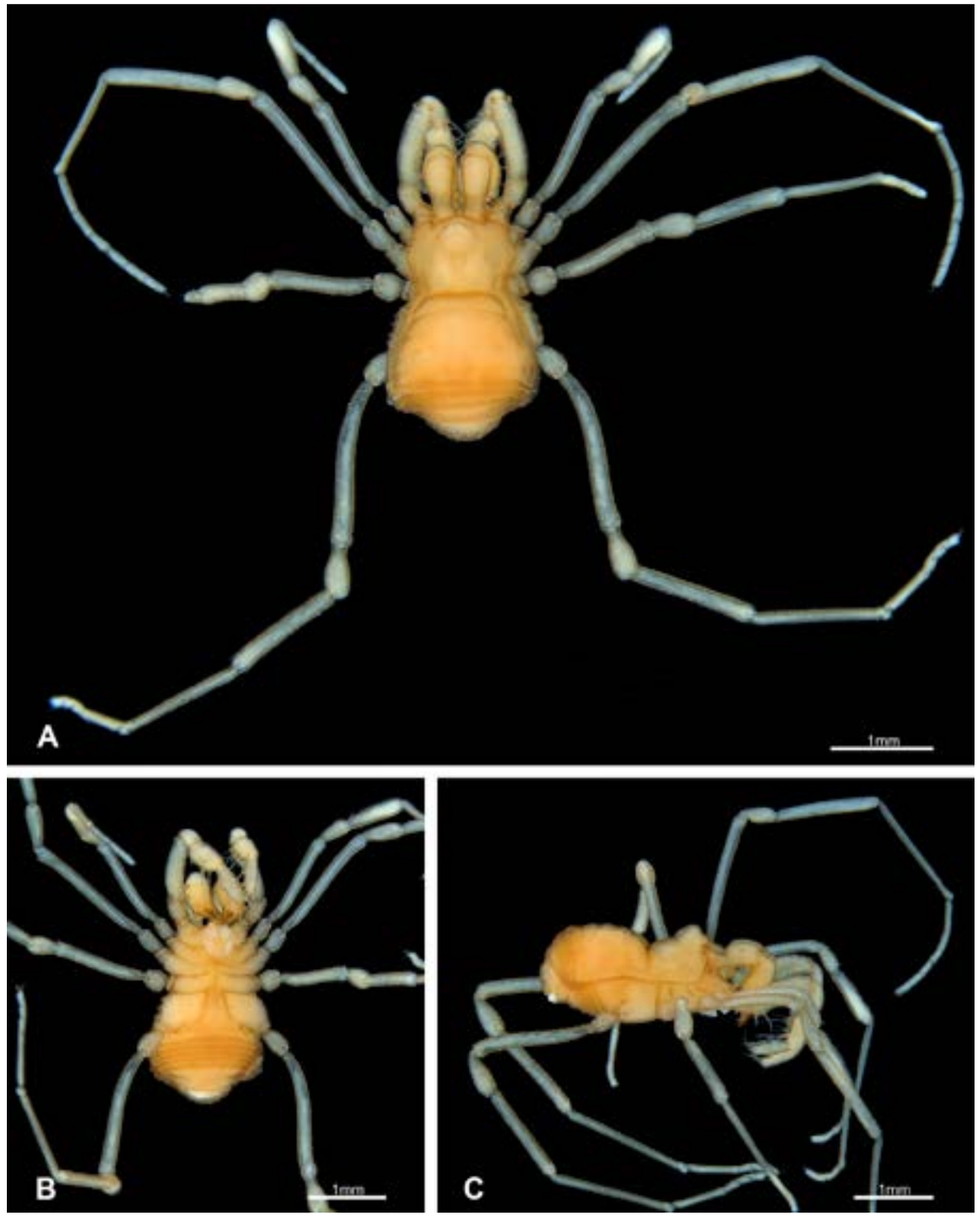

Fig. 13. *Spaeleoleptes gimli* sp. nov., male holotype (LES 00341), habitus. **A**. Dorsal view. **B**. Ventral view. **C**. Lateral view.

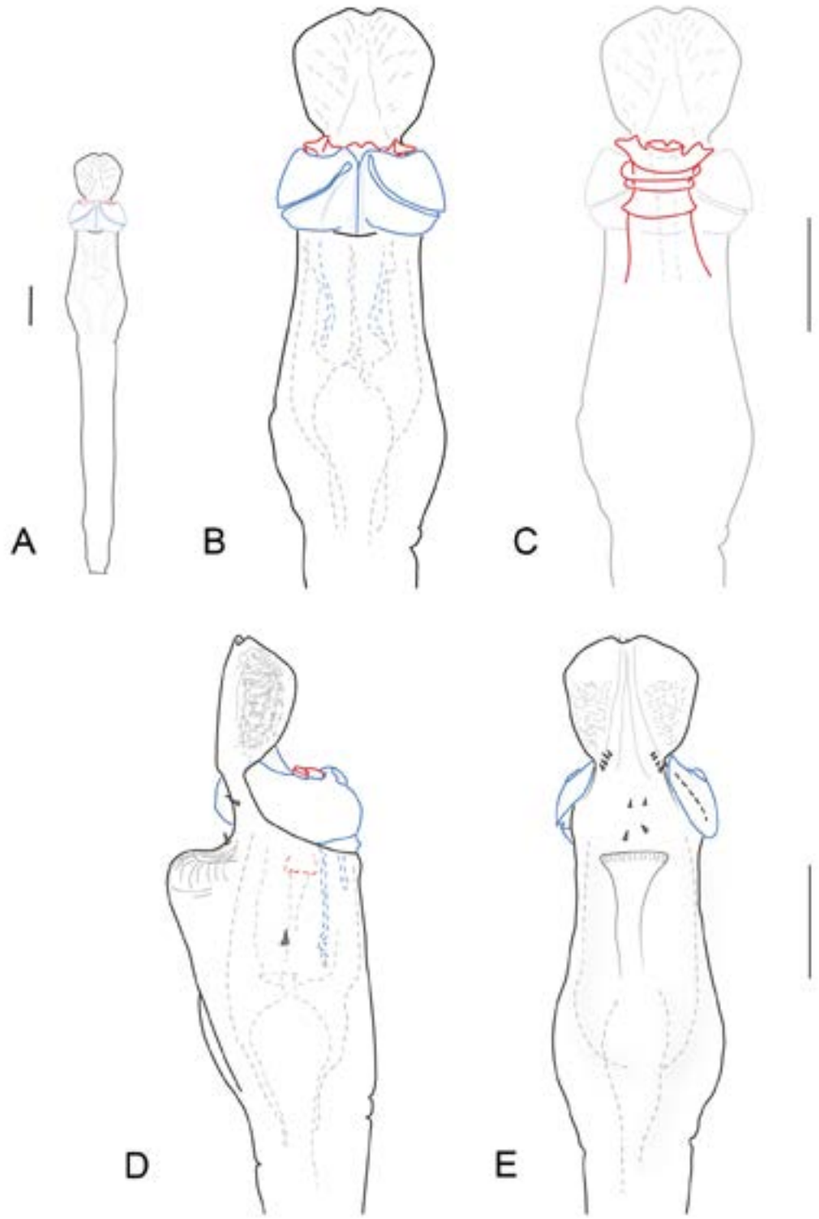

Fig. 14. Line drawings of male genitalia of *Spaeleoleptes gimli* sp. nov. male holotype (LES 00341). **A**. Full genitalia, dorsal view. **B**. Detail of pars distalis, dorsal view. **C**. Detail of capsula interna, dorsal view. **D**. Detail of pars distalis, lateral view. **E**. Same, ventral view. Red lines: capsula interna. Blue lines: conductors. Scale bars: 1 mm.

the preparation process, since Soares often used aggressive KOH for this purpose (A.B. Kury comm. pers.). The second escadabiid with documented male genital morphology was an indeterminate species assigned to the genus *Baculigerus* H. Soares by Kury & Pérez-González (2007: figs 4.27f–h). The figure of these genitalia is composed of three micrographs (one apical, one ventral, and one lateral) of the penis pars distalis. These micrographs were taken with a scanning electron microscope (SEM) and illustrated the external morphology in great detail. However, when using SEM, it is not possible to examine the morphological characteristics of the capsula interna that can only be observed through transparency. The present work shows for the first time a detailed study, compatible with modern standards, of Escadabiidae genitalia, including drawings made from preparations observed under the compound microscope. With this, the knowledge about male genitalia of Escadabiidae increases considerably, allowing, in addition to a good identification of the species of *Spaeleoleptes* and possibly related species, the identification of a series of characteristics that should be compared with species of other genera to verify their diagnostic value, as well as putative synapomorphies to be tested in a phylogenetic framework.

Kury & Pérez-González (2007) proposed two primary species groups under Escadabiidae. The first group, also known as the "*Escadabius* group", which includes all species of the genus *Escadabius*, is primarily identified by the presence of free sternites with long falciform projections in males; penis without setae and with very small conductors; pars distalis not separated from pars basalis by a groove; and poorly developed apical lamina of the pars distalis. The second group includes all the other genera of Escadabiidae and was called by the authors the "*Baculigerus* group" and is characterized by having poorly armed sternites or without projections but having tibia I or II modified in a warty or saddle-shaped mound; penis with small setae; large and well-developed conductors; pars distalis separated from pars basalis by a groove; and well-developed apical lamina of the pars distalis. However, these groups were proposed based on the scarce information available (Pérez-González pers. obs.) and still need to be tested in a broader context of morphological sampling. Even so, if we consider the scheme proposed by Kury & Pérez-González, the *Spaeleoleptes* species are part of the "*Baculigerus* group" because they have all the characteristics originally proposed, although two of them are present in *Spaeleoleptes* species in a slightly different way from those described previously: 1) in *S. gimli* sp. nov. the tibia I are not modified into a wart or saddle shape as in *S. spaeleus* (and other "*Baculigerus* group members"), but rather into a slight depression on the retrolateral surface and 2) the region of the sulcus that separates the pars basalis from the pars distalis in *S. spaeleus* forms a kind of dorsal plate by extending the distal region of the pars basalis over the pars distalis.

In this work, we also provide the first documentation of the modified areas found on the legs I and II of *Spaeleoleptes* species. Soares (1966) had already observed these regions on tibia I and II (but not on the patella) of *S. spaeleus*, referring to them as regions of swelling, more pronounced in tibia I than in II. Here we recorded the arrangement of these regions in *S. spaeleus* using high-quality digital photos, and we captured the format and arrangement of these openings in *S. gimli* sp. nov. using SEM images of the tibiae I and II in even greater detail. Willemart *et al.* (2010) published a pioneering study on the format and distribution of glandular openings on the legs of harvestmen of the suborder Laniatores and mentioned in that work three Zalmoxoidea species with pores that resembled those seen in *Spaeleoleptes* species. Two of the species studied by the authors belong to the escadabiid genus *Brotasus* (species not identified) and for these species, the authors recorded the presence of swelling with pores on tibiae I, II, and III and on patella III. According to Willemart *et al.* (2010), these openings could be glandular or have a sensory function, as they differ from common glandular openings by the presence of "droplet-like" pegs. In the only specimen of *S. gimli* used for SEM images, we did not find any type of glandular secretion near the modified regions of the tibiae and patellae I and II. However, it is possible to see, through transparency, a dense and whitish internal area associated with the pore region in *S. spaeleus*, which may lead us to believe that it could be a glandular region (Fig. 5). Even though the objective of this work is not to propose functions for this type of modification, we believe that the images registered here can provide data that have great potential to be

used in future works on functional morphology and also help in understanding the behavioral ecology of these animals, aspects that until now have been remarkably little explored for harvestmen.

Despite extensive collections in the epigean environment of the Itaetê region, *S. gimli* sp. nov. was not recorded outside the Gruta Natal cave. This, allied to the troglomorphic characteristics (cuticle depigmentation and eye reduction), categorize the species as troglobitic (obligatory cave-dwelling organisms, sensu Schiner-Racovtiza, 1907). With the description of *S. gimli* for the state of Bahia in northeastern Brazil, the distribution of the genus increases in amplitude, occurring in the Cerrado (Bambuí Group cave) and in Caatinga interspersed by Atlantic Forest (Una Group cave) Brazilian biomes. The gap between the location of the two species is occupied by several subterranean environments and new species of cave harvestmen are increasingly described for these regions (Pérez-González & Kury 2002; Kury 2008; Kury & Pérez-González 2008; Hara & Pinto-da-Rocha 2008; Pinto-da-Rocha *et al* 2015; Pérez *et al* 2017). In particular, caves from the Una Group (specifically in the Una-Utinga metasedimentary basins) and surroundings present high troglobitic diversity and they are considered spots of subterranean biodiversity and also examples of unique evolutionary history (Bichuette *et al.* 2015; Gallão & Bichuette 2015; Trajano *et al.* 2016; Gallão & Bichuette 2018). For example, geological and hydrological barriers explain the differences among the aquatic subterranean populations, specifically the cave catfish *Rhamdiopsis krugi* Bockmann & Castro, 2010, suggesting a possible parapatric model (see: Bichuette *et al.* 2015). The high degree of morphological specialization of *Rhamdiopsis krugi* and also of *Spaeleoleptes gimli*, characterized by an elevated number of morphological autapomorphies, could be associated with a long period of evolution in the subterranean habitat, but in the case of *Spaeleoleptes gimli* this fact should be tested in a further molecular chrono-phylogenetic approach. These factors together suggest that there are still many species of *Spaeleoleptes* to be described for the Brazilian savannah and semi-arid regions.

Conservation Remarks

Spaeleoleptes gimli sp. nov. is a troglobitic species with a very small distributional range, known from only one cave located outside the protected area of the Chapada Diamantina National Park; its population is not protected by law. Therefore, they are subject to local environmental impacts, including habitat conversion due mainly to the uncontrolled exploitation of the subterranean waters in that region and pollution of the aquifers by pesticides and deforestation in the surroundings of Gruta Natal cave. We recommend special attention for monitoring this highly specialized and endemic population whose protection should be prioritized. Troglobites are fragile and threatened species, most of them included in regional and global IUCN Red-Lists (Gallão & Bichuette 2018), which reinforces the necessity of further studies to effectively protect *S. gimli*.

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