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Research article

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The first troglobitic species of *Perigona* Castelnau, 1835 endemic to southeastern Brazil (Carabidae, Perigonini)

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Abstract. We describe the first Neotropical troglobitic species of the genus *Perigona* Castelnau, 1835 from specimens collected in eight caves located in the Arcos-Pains-Dorésópolis speleological province (APD), southeastern Brazil. *Perigona spelunca* sp. nov. is the fourth known microphthalmous species of the genus, and the second of the subgenus *Neoperigona.* Other specialisations to the subterranean environment include brachyptery, elongation of appendages and orangish brown body coloration. The new species has an umbilicate series of punctures on the 8th stria with 15 setae arranged linearly and not divided in three groups. We also provide historic biogeographical remarks on the new species.

Keywords. Subterranean, ground beetle, *Neoperigona*, Brazilian Savannah, Neotropical.

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Introduction

Perigonini Horn, 1881 is a small tribe of Carabidae Latreille, 1802 with only 115 described species (Reichardt 1977; Bousquet 2012). Although *Perigona* Castelnau, 1835 is by far the most speciose genus of the tribe, with 100 species described worldwide (Bousquet 2012), distributed in twelve subgenera, the number of unknown or undescribed species is probably still large (Baehr 2014). In Brazil, there are only five recorded species, all of them belonging to the subgenus *Neoperigona* Perrault 1988. Most of those species are from the Brazilian Amazon forest: *P. laevilateris* (Bates, 1872), *P. ozaenoides* (Bates, 1872), *P. praecisa* (Bates, 1872) and *P. sexstriata* (Bates, 1872). A fifth Brazilian species, *P. vixstriata* (Bates, 1872), is known from the surroundings of Rio de Janeiro (Giachino *et al.* 2008). The lack of studies regarding this group in Brazil is also reflected in checklists of Carabidae species, in which the Perigonini are only listed at the genus level (*Perigona*) (Brito 2017; Araújo-Silva 2018). Some of the individuals listed for this genus were found in a region devoid of described species, the Brazilian Savannah (i.e., Cerrado) (Araújo-Silva 2018) and can comprise new species or at least new records.

Some Perigonini beetles were collected in limestone caves from southeastern Brazil in the Brazilian Savannah. The collected specimens do not fit any of the species of the subgenus *Perigona* Castelnau, 1835 (*Neoperigona*) known from South America, and therefore a new species is described herein. This is the sixth species of the genus *Perigona* recorded in Brazil, and the first troglobitic one.

Material and methods

We obtained the specimens used in this study from the ISLA – Coleção de Invertebrados Subterrâneos de Lavras (Subterranean Invertebrates Collection of Lavras), Minas Gerais, Brazil. The specimens are stored in vials containing 70% ethanol. We visualized general body anatomy through a Stemi 508 (ZEISS) stereomicroscope. We took measurements and images from body morphology under an Axio Zoom V16 (ZEISS) stereo microscope.

We followed Giachino *et al.* (2008) for the general description. All measurements are in millimetres. We dissected and cleaned the male copulatory organ using fine entomological pins. Then we placed the organ in glycerin for examination, taking photographs and measurements. For the female reproductive tract, we modified the procedures from Liebherr (2015). We first removed the entire abdomen from the female using fine entomological pins and this structure was placed in an aqueous solution of cold 10% potassium hydroxide (KOH) overnight. Then, after placing in glycerin, we isolated the copulatory organs from the abdomen by first tearing off the tergites, then removing the entire digestive tract, lipids and tracheae system and finally removing the sternites. We also placed the female genitalia in glycerin for examination and to take photographs. We conducted the ultrastructural analyses using a scanning electron TM4000 Tabletop microscope. The structures were dried out and were not metalized. For observation of head details, especially the more internal structures from the eyespots, we utilized a 15kv electron beam, which penetrates deeper inside the integument enabling the visualization of more internal layers.

The names of structures for the male and female genitalia followed Ball & Shpeley (2013). We used measurement method suggested by Giachino *et al.* (2008) combined with Pellegrini *et al.* (2020) as follows:

AL = Antenna length (from the base of the scape to tip of the antennomer 10th)
EL = Elytra length (linear distance from humerus to apex)
EW = Elytra maximum width (greatest linear transverse distance)
HL = Head length (linear distance from the apex of mandibles to the posterior carina of the head)
HW = Head width (maximum distance across head, including eyes)
HWL = Hind wings length (greatest linear transverse distance)
OBL = Overall body length (the sum of HL, PL, and EL)
PAL = Phallus length greatest (linear transverse distance)
PAW = Phallus width greatest (linear transverse distance)
PL = Pronotum length (linear distance from anterior to posterior margin, measured along the midline)
PW = Pronotum maximum width (greatest linear transverse distance)

Geographical coordinates for localities are given in decimal degrees (DATUM WGS 84).

Depository

ISLA: Coleção de Invertebrados Subterrâneos de Lavras (Subterranean Invertebrates Collection of Lavras), Federal University of Lavras UFLA, Lavras city, Minas Gerais State, Brazil.

Results

Class Insecta Linnaeus, 1758
Order Coleoptera Linnaeus, 1758
Family Carabidae Latreille, 1802
Subfamily Lebiinae Bonelli, 1810
Tribe Perigonini Horn, 1881

Genus ***Perigona*** Castelnau, 1835

Type species

Perigona pallida Castelnau, 1835 (by monotypy).

Diagnosis

Characterized by the *Trechus*-like body shape, but without elongate frontal furrows, by elongate and acute terminal palpomeres, and by the wide, depressed, usually pilose subapical marginal channel of the elytra.

Perigona **(*Neoperigona*)** ***spelunca*** sp. nov.
urn:lsid:zoobank.org:act:7E95F064-CE59-4043-AA2F-EB6DEC2BED47
Figs 1–5

Diagnosis

The new species is a *Perigona* (*Neoperigona*) ranges in size from 3.72 to 4.42 mm, is microphthalmous and brachypterous, with long antennae, also characterized by a smooth and glabrous surface. The pronotum is transverse; its margins sinuate before hind angles. The elytra are coarctate, curved laterally and slightly lengthened, stria almost completely obsolete. Elytra fixed setae represented by one basal seta at the beginning of the second stria, and one preapical discal setae at the end of the junction of the 4th and 5th striae of the elytra, umbilicate series of the 8th stria with 15 setae arranged linearly and not divided in three groups.

Differential diagnosis

Perigona (*Neoperigona*) *spelunca* sp. nov. differs from all other *Perigona* in the following set of characters: dorsal surface smooth and glabrous; brachypterous; microphthalmous with depigmented eyes; elytra with only two discal setae, a basal one and a preapical one inserted on the ends of the 4th and 5th striae; median group of umbilicate series of the eighth stria arranged linearly, without an evident separation among the three groups of umbilicate series.

Etymology

The specific epithet refers to the Latin word '*spelunca*' meaning 'cave'.

Type material

Holotype

BRAZIL • 1 ♂; Minas Gerais State, Pains Municipality, Gruta do Éden cave; 20°23′5″ S, 45°39′59″ W; 4 Aug. 2012; P. Ratton *et al.* leg; ISLA 66143.

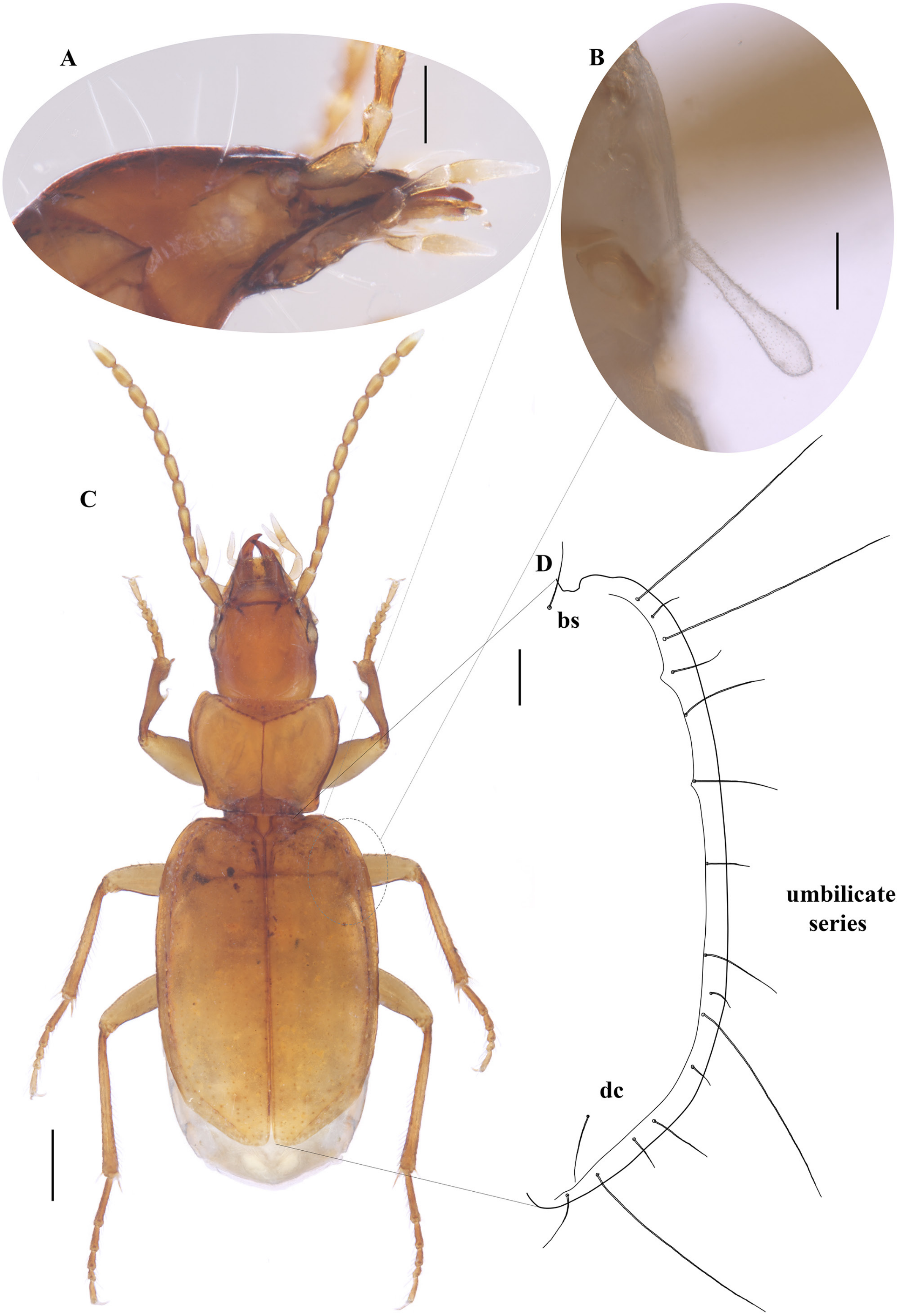

Fig. 1. Illustrations of *Perigona* (*Neoperigona*) *spelunca* sp. nov. (ISLA 66143) **A**. Eye detail, lateral view. **B**. Hindwing detail, dorsal view. **C**. Habitus, dorsal view. **D**. Detailed (bs) elytral basal/scutellar seta, (dc) elytral aplical discal seta of the 4th and 5th striae joint and umbilicate setae series elytral 8th stria. Scale bars: A, D = 0.2 mm; B = 0.1 mm; C = 0.5 mm.

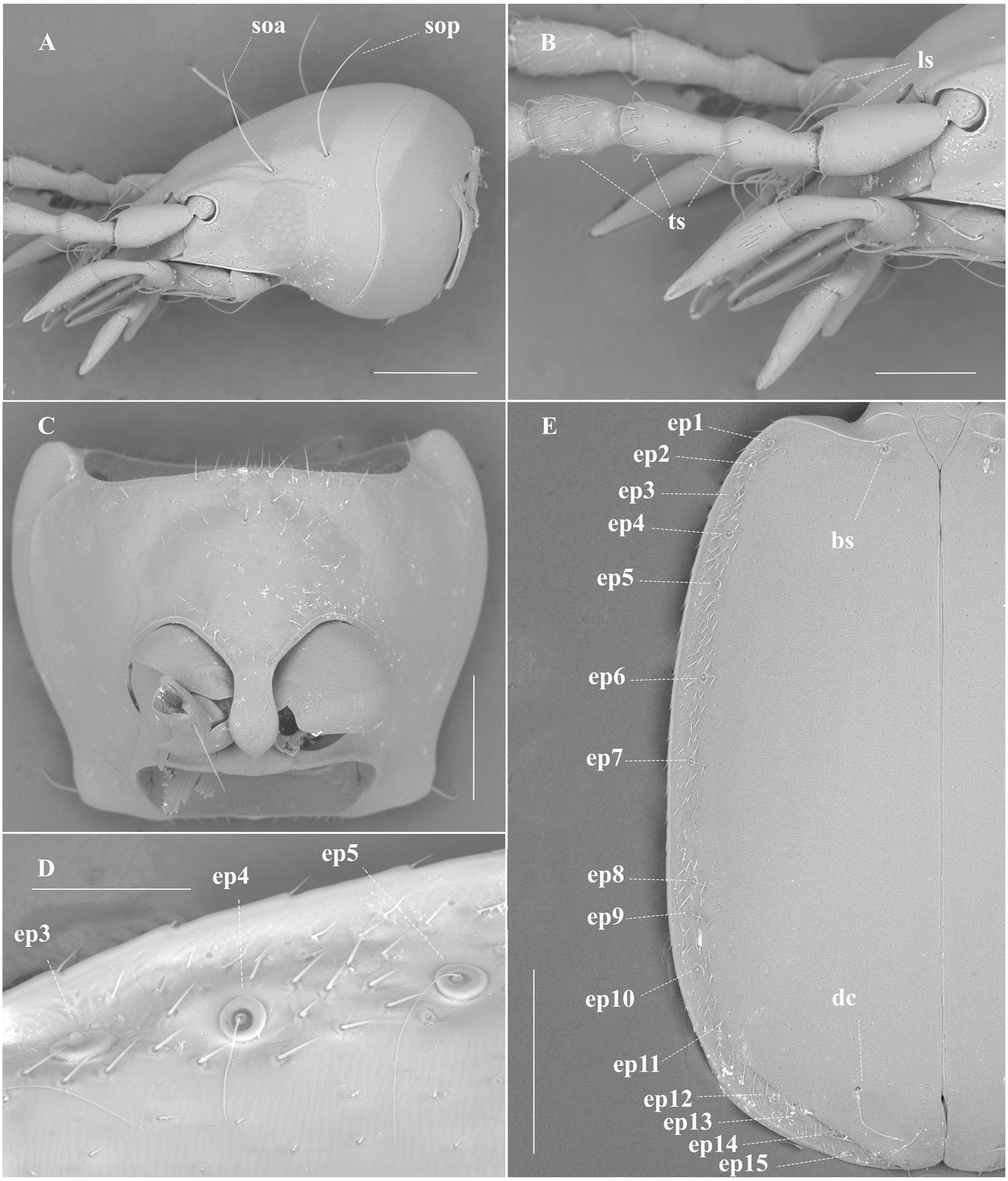

Fig. 2. *Perigona* (*Neoperigona*) *spelunca* sp. nov. (ISLA 66142). **A**. Head, lateral view. **B**. Antennae, detail. **C**. Prosternum. **D**. Elytral pores 3–5, detail. **E**. Elytra, dorsal view. Abbreviations: bs = elytral basal/scutellar seta; dc = elytral aplical discal seta; ep1–15 = elytral pores of setae 1–15 from the umbilical series; ls = antennal scape long setae; soa = supraorbital setae anterior; sop = supraorbital setae posterior; ts = antennal trichoid sensilla. Scale bars: A, C = 250 μm; B = 150 μm; D = 100 μm; E = 500 μm.

Paratypes

BRAZIL • 1 ♀, entire abdomen was removed for genitalia dissection; same collection data as for holotype; 27 Aug. 2009; R.A. Zampaulo *et al.* leg.; ISLA 363 • 1 ♂; same collection data as for holotype; 27 Aug. 2009; R.A. Zampaulo *et al.* leg.; ISLA 360 • 1 ♂, left proleg is broken; same collection data as for holotype; 4 Aug. 2012; P. Ratton *et al.* leg.; ISLA 66142 • 1 ♂; same collection data as for holotype; 27 Aug. 2009; R.A. Zampaulo *et al.* leg.; ISLA 73707 • 1 ♂; same collection data as for holotype; 22 Apr. 2012; P. Ratton *et al.* leg.; ISLA 75679.

Additional material

BRAZIL • 1 ♀; Minas Gerais State, Pains Municipality, Gruta do Zezinho Beraldo cave; 20°21′25.04″ S, 45°50′4.68″ W; 21 Jan. 2009; R.A. Zampaulo *et al.* leg.; ISLA 359 • 1 ♀; Minas Gerais State, Pains Municipality, Gruta Santuário cave; 20°25′11.61″ S, 45°46′27.25″ W; 20 May 2006; T.O. do Carmo *et al.* leg.; ISLA 65792 • 1 ♂; Minas Gerais State, Pains Municipality, Gruta Cinderela cave; 20°26′44″ S, 45°36′22″ W; 18 Sep. 2009; R.A. Zampaulo *et al.* leg.; ISLA 354 • 1 ♂; Minas Gerais State, Pains Municipality, Gruta da Fazenda Amargoso Cave 20°23′53.63″ S, 45°35′38.34″ W; 29 Jan. 2009; R.A. Zampaulo *et al.* leg.; ISLA 353 • 1 ♂; Minas Gerais State, Pains Municipality, Gruta Serro Azul Cave; 20°22′31.97″ S, 45°38′48.35″ W; 30 Jun. 2009; R.A. Zampaulo *et al.* leg.; ISLA 361 • 1 ♂; Minas Gerais State, Pains Municipality, Gruta do Brega cave; 20°25′4.37″ S, 45°46′20.16″ W; 5 Jul. 2012; R.L. Ferreira *et al.* leg.; ISLA 65795 • 3 ♂♂, 1 ♀; Minas Gerais State, Pains Municipality, Gruta do Santuário cave; 26 Aug. 2015; R.L. Ferreira *et al.* leg.; ISLA 65792 • 2 ♂♂; Minas Gerais State, Pains Municipality, S1-GEC-035 Cave; 20°23′26.1″ S, 45°35′54.6″ W; 18 Aug. 2017; L.G.S. Soares leg., ISLA 47701 • 2 ♀♀; same locality data as for preceding; 23 Jan. 2018; L.G.S. Soares leg.; ISLA 47702.

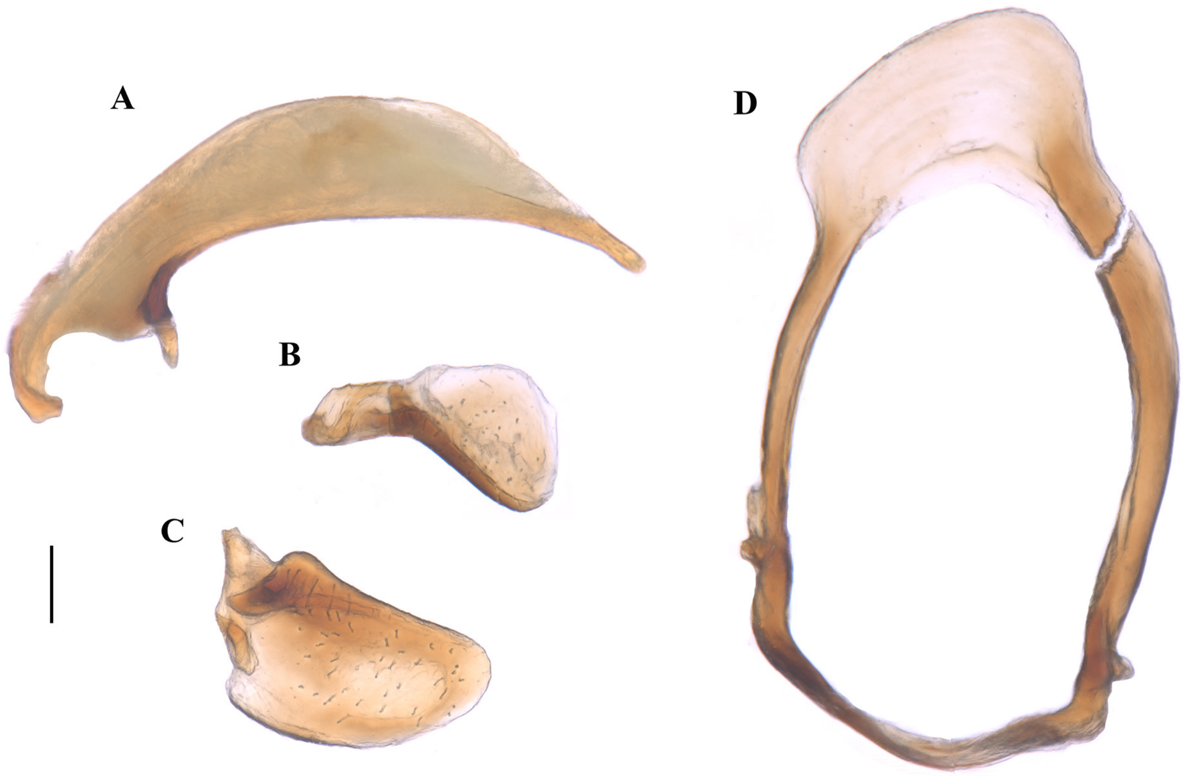

Fig. 3. Male genitalia, *Perigona* (*Neoperigona*) *spelunca* sp. nov. (ISLA 361). **A**. Median lobe of the aedeagus in lateral view. **B**. Right paramere. **C**. Left paramere. **D**. Male gonosomite. Scale bar = 0.1 mm.

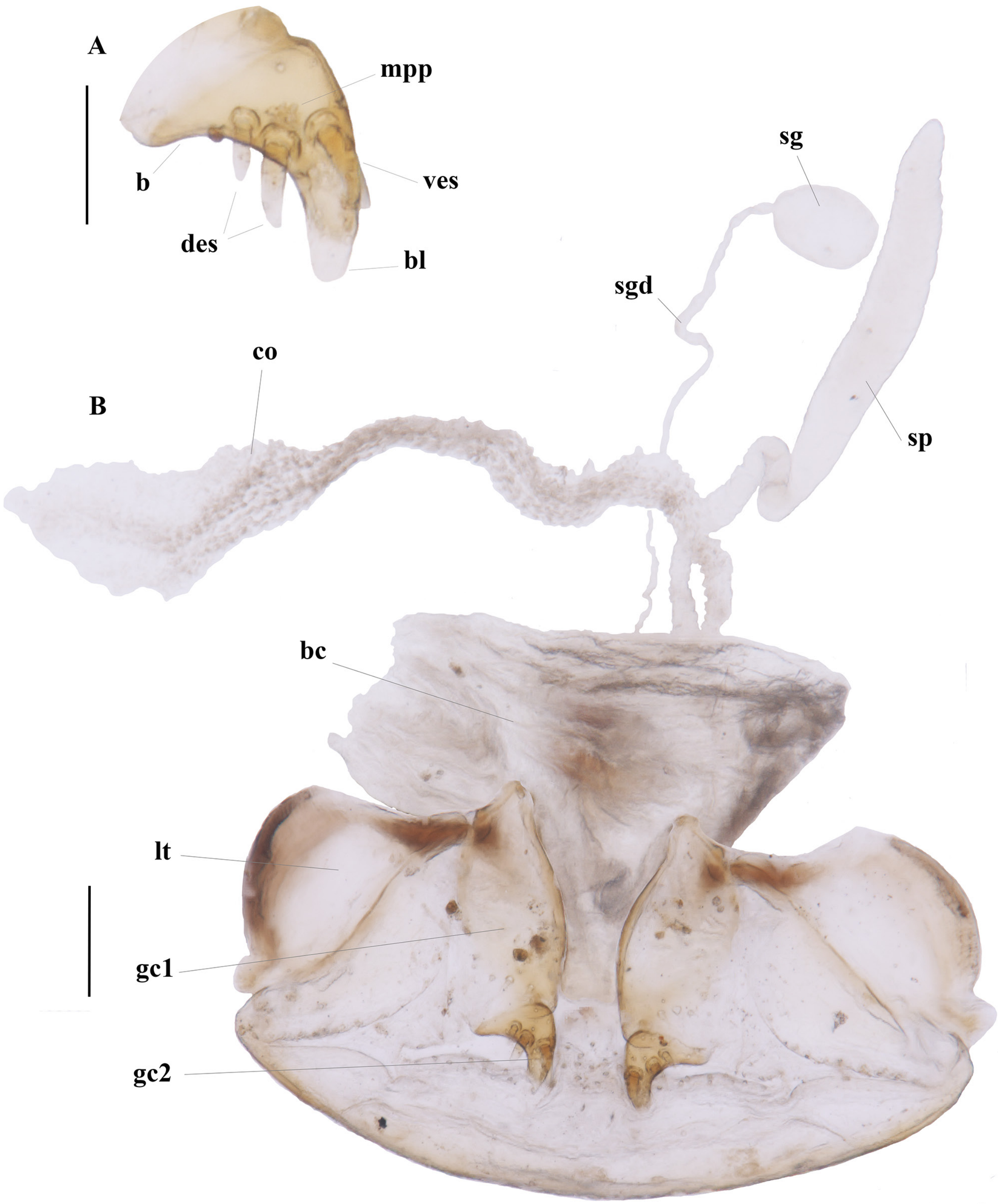

Fig. 4. Female genitalia, *Perigona* (*Neoperigona*) *spelunca* sp. nov., paratype (ISLA 363). **A**. Gonocoxite 2, dorsal aspect. **B**. Female reproductive tract in dorsal aspect. Abbreviations: b = base of gonocoxite 2; bc = bursa copulatrix; bl = blade of gonocoxite 2; co = common oviduct; des = dorsal ensiform seta; gc1 = gonocoxite 1; gc2 = gonocoxite 2; lt = laterotergite; sg = spermathecal gland; sgd = spermathecal gland duct; sp = spermatheca; ves = ventral ensiform setae; mpp = marginal pit pegs Scale bars: A = 0.05 mm; B = 0.1 mm.

Type locality

The holotype was collected in the Gruta do Éden cave (20°23′5″ S, 45°39′59″ W), located in Pains municipality in Minas Gerais state, Brazil (Fig. 5).

Description

Holotype male (Fig. 1). OBL: 4.20 mm; EW: 1.53 mm; HW/PW: 0.72. Body coloration orangish brown (Fig. 1C). Dorsal integument glabrous, with vanished microsculpture transversally on pronotum and vertically on the elytra.

HEAD. Head relatively large (Figs 1–2), HL/HW: 1.44; HL: 1.10 mm, and narrower than pronotum. Eyes reduced, flattened and depigmented, with vestigial eyes scars, situated laterally at the end of the genal sulcus (Fig. 1A), with two supraorbital setae on each side (Fig. 2A). Frons slightly depressed. Anterior margin of the clypeus subrectilinear, with two setae on the anterior angles. Labrum with a subrectilinear front margin and with 6 setae, with the larger ones on the side edges becoming smaller inward. Antennae stocky, relatively long and exceeding the base of the elytra (Fig. 1C) AL: 2.01 mm, AL/OBL: 0.48. First antennomere (scape) with a long seta distally close to the apical portion, and a row of several semi-erect trichoid setae; 2nd short; 2nd and 3rd with semi-erect trichoid setae (Fig. 2B). Segments 4th–11th subequal, pubescent with semi-erect setae distally, and almost round in cross-section (Fig. 2B).

PRONOTUM. Shape trapezoidal and slightly transverse, it sinuates before hind angles, PW/PL: 1.31 (PL: 0.79) (Fig. 1C). Maximum width approximately in the anterior third and wider than the head. Anterior angle rounded; posterior angle also rounded, narrowed towards base, which is slightly narrowed than the anterior edge. Dorsal surface with two pairs of lateral marginal erect setae: one longer at the anterior third and the other shorter, close to the posterior-lateral angles. Ventral surface with a fine pubescence distributed in the middle portion of the prosternum (Fig. 2C).

ELYTRA (Figs 1C–D, 2D–E). Elytra coarctate, curved laterally and slightly lengthened EL/EW: 1.51 (EL: 2.31). Maximum width in the middle. Presence of an entire basal groove from the humeri to the scutellum. Humeri indicated but not rounded; post-humeral margin with a fine and delicate pubescence restricted to the 8th stria interval; apex of elytra is slightly angular, presenting a small break that coincides with the height of the discal setae, giving a small closure to the angle towards the junction of the apex of the elytra. (Fig. 1C–D). Marginal groove wide and distinct until the apical border. Elytral chaetotaxy: one basal seta at the beginning of the second stria; and one preapical discal inserted at the end of the 5th stria interval; Umbilicate series of the 8th stria with 15 setae arranged linearly and not divided in three groups, of these 4 setae (1st and 3rd humeral, 10th lateral and 14th distal) are quite long (0.86 mm long), going beyond the end of the femur (Figs 1D, 2D–E)

HIND WINGS. Brachypterous, HWL: 0.271, EL/HWL: 8.16 (Fig. 1B).

LEGS. Long and slender, protarsi with 2nd, 3rd and 4th segments dilated in the male (Fig. 1C).

ABDOMEN. Abdominal tergites with a very short and fine pubescence; 3nd, 4th and 5th tergites with one pair ventral of setae at its posterior margin; male sixth sternite with two pairs of ventral setae at its posterior margin and female sixth sternite with four pairs of ventral setae at its posterior margin.

MALE GENITALIA (Fig. 3). Phallus (i.e., median lobe of the aedeagus) elongate and narrow (PAL: 0.89; PAW/PAL: 0.22), slightly curved ventrally, tip narrowed and rounded (Fig. 3A). Parameres short and robust (Fig. 3B–C), the left is oval and widened in the basal third; the right is smaller, with a thinner base and a convex apex in the shape of a spoon. Male gonosomite ovoid and elongated, two apophyses in the distal part in the form of small hooks (Fig. 3D).

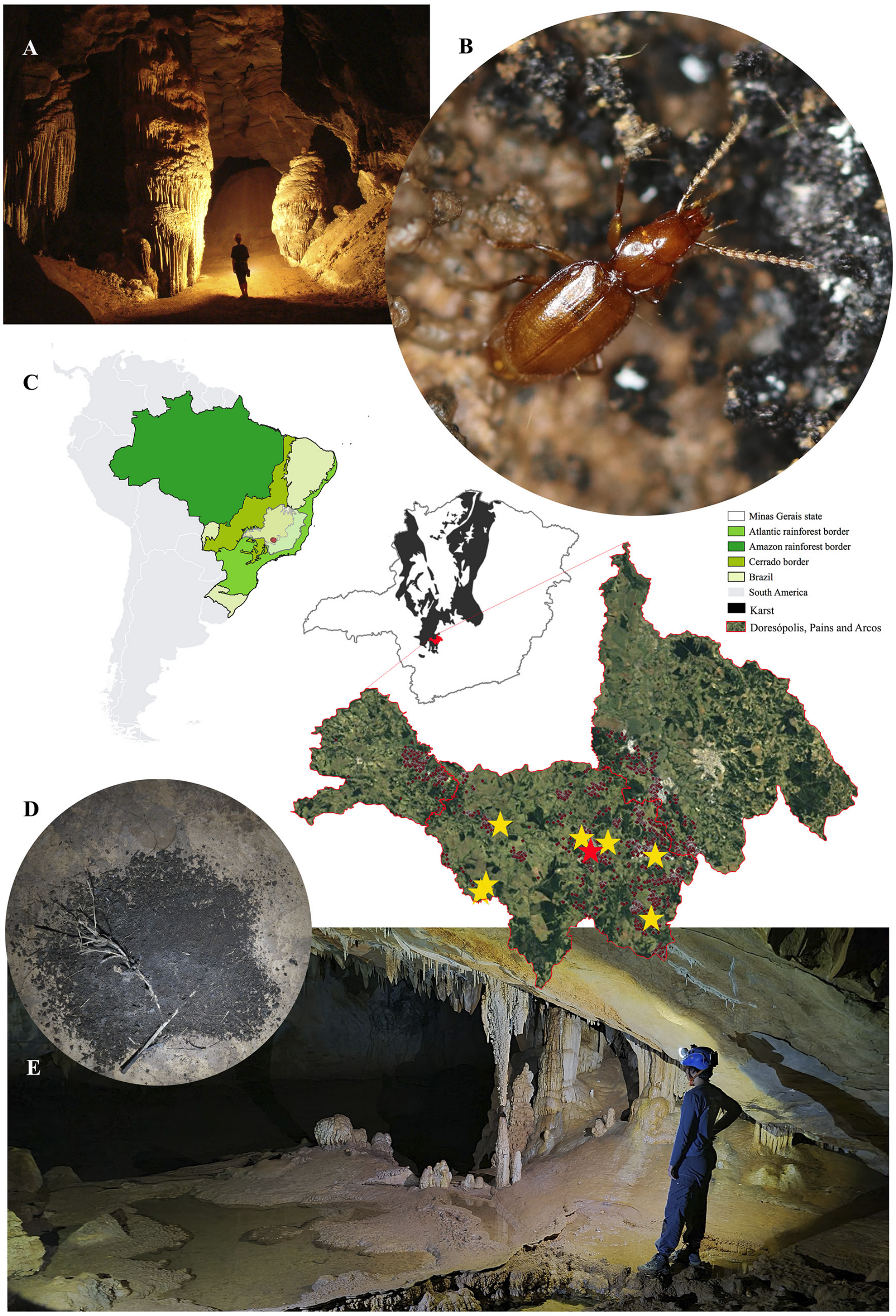

Fig. 5. Geographic localization of *P.* (*Neoperigona*) *spelunca* sp. nov. **A**. Éden cave, type locality. **B**. *Perigona spelunca* sp. nov. living specimen. **C**. Map of South America highlighting Brazil, Amazon rainforest, Atlantic rainforest and Cerrado Biomes, Minas Gerais state and the municipalities of Arcos, Pains and Doresópolis; the black areas correspond to the limestone groups in South America; the red dots represent all caves registered in the highlighted municipalities; the red star corresponds to Éden cave type locality and the yellow stars correspond to the others caves where *P. spelunca* sp. nov. was found. **D**. A small guano pile at Santuário cave. **E**. Santuário cave. (Photographs A and D are by Robson de Almeida Zampaulo; B and E are by Rodrigo L. Ferreira).

Female genitalia. Ovipositor (Fig. 4) with broad laterotergite (lt), basal gonocoxite 1 (gc1) longer than apical gonocoxite 2 (gc2); gonocoxite 1 apico-laterally bearing short and sturdy setae; gonocoxite 2 short, curved, in lateral aspect falciform, base (b) medium-size, narrow, blade (bl) rounded on the tip, with two dorsal ensiform setae (des), and one ventral ensiform seta (ves), all ensiform setae moderately long and robust; surface with many marginal pit pegs (mpp) (Fig. 4A). Female reproductive tract (Fig. 4B) proximally with short, broad bursa copulatrix (bc), continuous at its distal end with common oviduct (co) and long robust spermatheca (sp), latter slightly narrowed distally; spermathecal gland (sg) bulbous; spermathecal gland duct (sgd) long, slender, attachment not evident.

Habitat and ecological remarks

Caves are usually oligotrophic hypogean systems, with a nearly stable environment given the total absence of light and the humid atmosphere, reaching saturation (Howarth 1980). Such features make the deep cave a unique environment. The environment that has characteristics most similar to the subterranean, is epigean leaf litter and edaphic soil in the cooler moist forests (Howarth 1980) that maintain continually saturated atmospheres (Bursell 1974). As a result, the arthropod fauna occurring in such habitats shares some of the features of hypogean fauna (e.g., brachyptery, lack of eyes and depigmentation) (Poulson & White 1969), facilitating the colonization of the subterranean environment. The subterranean realm comprises the entire fissure network, the shallow subterranean habitats (i.e., MSS) and the human accessible macro-caves, making it an uninterrupted habitat, which is used by much of the specialized hypogean fauna (Giachino & Vailati 2010). Still, specific subterranean microhabitats can also result in different morphologies for a highly specialized fauna, with specific characteristics related to the cave habitat, such as antenna length (Trontelj *et al.* 2012).

Despite the common occurrence of species of *Perigona* in deep leaf piles during dry seasons, in forests (Reichardt 1977; Baehr 2017), and associated with endogean compartments (e.g., *P. gerardi* Perrault, 1985 from French Guiana), the occurrence of the genus in the cave environment has not been documented. The only species registered close to a cave, *P. nigriceps* (Dejean, 1831), was found in the MSS (subterranean superficial medium) in the surroundings of Movile Cave in Romania (Nitzu 2001). This is a nearly cosmopolitan species (Darlington 1953), with an edaphic habitat preference, which can be also found 6 m deep in the MSS (Nitzu 2001). Although *P. spelunca* sp. nov. does not have remarkably elongated appendages, usually linked to cave habitat (Trontelj *et al.* 2012), it does have elongated antennae that extend half the length of the body. Such elongation does not occur in its close microphthalmous relative, *P. Neoperigona belloi*.

Specimens of *P. spelunca* sp. nov. were observed in eight caves from the Arcos-Pains-Doresópolis speleological province (APD), in southeastern Brazil (Fig. 5). This area has the highest density of caves in South America, with more than 2500 limestone caves registered. Despite the fact that more than 500 caves have been inventoried in the area (Ferreira R.L. pers. comm.), *P. spelunca* sp. nov. was only observed in eight caves, although some of those caves are located far from each other (18.65 km in a straight line in the case of the most distant pair of caves) (Table 1). It is important to mention that all the known caves in the province are located within a polygon of about 900 square kilometres. Thus, the species can be considered widely distributed in the area. It is important to note that the wide distribution of a given subterranean species is possible by dispersal through small cracks in the karst and through the MSS. However, traps installed in the MSS between Brega and Santuário caves in a five-year long study never collected *P. spelunca* sp. nov. Furthermore, other traps installed at additional locations within the area also failed in capturing *P. spelunca* sp. nov in the last two years. This finding indicates that the species has caves as its preferred habitat, and that dispersion seems to occur occasionally, though this can be better assessed in more specific future studies. Hence, we prefer to consider the new species as a troglobitic, instead of generally subterranean or hypogean. Additionally, although such terms are to some

Table 1. Occurrences and body measurements of the new species *Perigona spelunca* sp. nov. individuals. Measurements are given in millimetres.

Individual ID	Cave	Coordinates		HL	HW	AL	PL	PW	EL	EW	OBL
		Latitude	Longitude								
P. spelunca ♂ Holotype ISLA 66143	Gruta do Éden	−20.3847889	−45.6671278	1.101	0.756	2.092	0.795	1.044	2.314	1.528	4.210
P. spelunca ♀ Paratype ISLA 363	Gruta do Éden	−20.3847889	−45.6671278	1.023	0.735	2.003	0.792	1.065	2.297	1.607	4.112
P. spelunca ♂ Paratype ISLA 360	Gruta do Éden	−20.3847889	−45.6671278	0.942	0.691	1.892	0.745	0.937	2.054	1.384	3.741
P. spelunca ♂ Paratype ISLA66142	Gruta do Éden	−20.3847889	−45.6671278	1.046	0.696	1.861	0.569	0.984	2.106	1.447	3.721
P. spelunca ♂ Paratype IV ISLA_73707	Gruta do Éden	−20.3847889	−45.6671278	0.969	0.729	1.763	0.742	1.010	2.144	1.494	3.855
P. spelunca ♀ other material ISLA 65792	Gruta Santuário	−20.4198917	−45.7742361	1.198	0.761	2.156	0.782	1.009	2.283	1.490	4.263
P. spelunca ♀ other material ISLA 359	Gruta do Zezinho Beraldo	−20.3569556	−45.8346333	1.247	0.790	2.065	0.834	1.070	2.346	1.580	4.427
P. spelunca ♂ other material ISLA 354	Gruta Cinderela	−20.445556	−45.606111	1.167	0.765	2.158	0.805	1.054	2.264	1.504	4.236
P. spelunca ♂ other material ISLA 361	Gruta Serro Azul	−20.3755472	−45.6467639	1.091	0.758	1.942	0.768	0.990	2.138	1.454	3.997
P. spelunca ♂ other material ISLA 65795	Gruta do Brega	−20.4178806	−45.7722667	1.071	0.776	2.051	0.804	1.026	2.244	1.542	4.119

extent equivalent, for practical purposes, the use of the term troglobitic may directly influence the species' status, ensuring its protection according to the current Brazilian speleological legislation.

Most of the caves in the region are rather dry and may not provide a suitable habitat. All the caves in which specimens have been observed have water for at least part of the year, from percolating water, and from streams or phreatic levels. It is interesting to note that in most of the caves only a single individual was sampled (e.g., Serra Azul, Fazenda Amargoso, Cinderela and Brega caves), and in all cases they were males. The largest populations were found in Santuário, Éden and S1-GEC-035 caves, in which specimens are quite common.

In Santuário cave (Fig. 5E), specimens were generally observed near (or within) bat guano piles (Fig. 5D), apparently searching for prey (such as springtails). They did not show any reaction to light, indicating a potential absence of phototaxy. On some occasions (especially during rainy periods), up to three specimens were observed in the same guano pile. On the other hand, specimens from the Éden cave

(Fig. 5A) were most frequently found close to decomposing plant material deposited along the stream banks, although some specimens were also observed near guano piles in the upper conduits of this cave. Unfortunately, no such data were provided for specimens from the S1-GEC-035 cave.

It is important to mention that even in caves with larger populations, specimens may not be encountered on every visit, especially during dry periods. Therefore, it is plausible that specimens migrate vertically, searching for suitably moist microhabitats during such periods. It is interesting to note that epigean species of *Perigona* usually occur in litter in dense forests, usually only being collected by specialized sampling methods, such as Berlese extraction or sifting ground litter (Baehr 2017). For the endogean species *P. gerardi*, soil washing was the best method for collecting the specimens (Perrault 1985). The caves lack typical external soils and also lack litter deposits, only having cave sediments, so specimens of *P. spelunca* sp. nov. are easier to find, especially due to their apparent lack of cryptic behavior. Furthermore, while most species of *Perigona* are capable of flight, being also encountered in flight intercept traps and at light (Baehr 2017), *P. spelunca* sp. nov. has extremely reduced hind wings (which is considered to be an adaptation to life in caves) (Fig. 1B), being incapable of flight. However, according to Baehr (2017), little is known about the habits and ecology of almost all species of the genus.

Discussion

All characteristics of *Perigona spelunca* sp. nov. are consistent with the description of the genus *Perigona*, which is characterized by a *Trechus*-like body shape, by the lack of elongate frontal furrows, by the elongate and acute terminal palpomeres, and by the wide depressed, usually pilose subapical marginal elytral channel (Baehr 2004). The new species is also consistent with the subgenus *Neoperigona,* which is characterized by the arrangement of the three lateral marginal elytra pores in a straight line, dorsal surface smooth and glabrous and by the absence of other discal setae besides the basal and an apical setae (Giachino *et al.* 2008).

There are three subgenera reported in South America, *Perigona* (s.str.), *Neoperigona* and *Cryptoperigona* (Bousquet 2012). As mentioned above, of these subgenus only *Neoperigona* has records in Brazil, with five described species associated with Brazilian Amazon and Atlantic rainforests (Giachino *et al.* 2008). Three other microphthalmous *Perigona* species are known for South America; one is from Ecuador, *P. belloi* Giachino, Moret & Picciau, 2008, also belonging to the subgenus *Neoperigona*. *Perigona spelunca* sp. nov. differs from *P. belloi* by the presence of a discal apical seta in the third interval, in *P. belloi* this seta is in the apex of the 5th interval. They differ also by the pronotum shape; the pronotum has more rounded edges in *P. belloi,* and the appendages are more elongated in *P. spelunca* sp. nov. The two other species are from the subgenus *Cryptoperigona*: *P. microphthalma* Jeannel, 1950 (from Venezuela) and *P. gerardi* Perrault 1985 (from French Guiana) and this subgenus differ from *P. spelunca* sp. nov. by the triangular arrangement of the median group of the umbilicate series of punctures (Perrault 1985).

Perigona spelunca sp. nov. represents the first troglobitic species of the tribe Perigonini in the world. The specimens were found within an area of about 119 square kilometres in the Brazilian cerrado (i.e., Savannah). Although *P. spelunca* sp. nov. can be considered widespread in the APD speleological province, this region is severely altered, bringing some concern for the species' conservation. In the last decades, this province has been the target of intense mining activities to produce cement, lime and soil correctives. The region has also experienced strong impacts on its natural vegetation, which has been replaced, in most areas, by pastures or crops. It is important to highlight that caves depend on external organic resources, which are primarily produced by the surrounding forests and later carried (by physical or biological agents) into caves. Furthermore, the dispersal of species may ultimately depend on continuous areas with moist conditions, and the deforestation allied to mining activities may eventually alter dispersion routes, by both drying out some superficial subterranean habitats (in the case of forest removal) or by the direct destruction of mesocaverns (by mining activities). From the eight caves in which *P. spelunca* sp. nov. occurs, five are in areas considered requiring conservation, because of cave features such as the troglobitic richness and threats to subterranean ecosystems by human activities (Zampaulo 2010; Souza-Silva *et al*. 2017). In Brazil, the current speleological legislation (Decree nº 6.640/ 2008) only protects those caves defined as showing maximum relevance. The presence of troglobitic species can raise the cave to this status, if the rarity of the species concerned is verified. Thus, the description of *P. spelunca* sp. nov. increases the relevance of the caves where it was recorded, thus helping the conservation of at least their main known habitats (and their external surroundings).

Another interesting aspect of *P. spelunca* sp. nov. is that it may represent a relictual species confined to the cave environment. The other *Perigona* species in Brazil are all found in tropical rainforests. Four of them are found in the Amazon rainforest, in northwestern Brazil, and there is a fifth species associated with the Atlantic rainforest, in Rio de Janeiro State, in southeastern Brazil (Giachino *et al.* 2008). *Perigona spelunca* sp. nov. is observed in caves inserted in the Cerrado biome (Brazilian Savannah), which in turn, is located between the two tropical rainforests in Brazil (Amazon and Atlantic rainforest). Its distributional area was covered by a dense rainforest during the mid Holocene (Ledo & Colli 2017). During the last glacial maximum, the Neotropical rainforests experienced intense distributional dynamics, which allowed connections between both forests during some periods (Sobral-Souza *et al.* 2015). Species associated with such environments followed the forest's retraction and fragmentation during glacial periods. This dynamic process engendered regions with a high biodiversity, which were mainly those associated with historically stable areas (Leite *et al.* 2016). On the other hand, the caves where *P. spelunca* sp. nov. occur are in a transitional zone between the Cerrado and the Atlantic forest, which experienced pronounced changes in the last glacial cycle. Since caves are stable environments, frequently presenting a saturated atmosphere and stable temperatures, such environments certainly represent shelters for pre-adapted invertebrates (Howarth 1980) during external landscape changes. The isolation of troglophilic populations in caves resulting from their extinction on the surface by climate change, in turn, promotes evolution and speciation, giving rise to troglobitic species (Howarth 1980). This geographic relict hypothesis has already been proposed for other troglobitic species in Brazil, as the harvestman *Spinopilar moria* (Kury & Pérez-González 2008) and the hydrometrid hemipterans *Cephalometra* and *Spelaeometra* (Polhemus & Ferreira 2018).

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