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Endecous apterus: A new species of cave cricket from northeast Brazil, with comments on the use of subterranean habitats by Luzarinae crickets (Orthoptera: Grylloidea: Phalangopsidae: Luzarinae)

PEDRO G. B. SOUZA-DIAS[1,4], MÁRCIO P. BOLFARINI[2], SILVIO S. NIHEI[1] & FRANCISCO A.G. DE MELLO[3]

[1]*Departamento de Zoologia, Instituto de Biociências, Universidade de São Paulo, rua do Matão, travessa 14, n. 101, 05508-900, Cidade Universitária, São Paulo, SP, Brazil.*

[2]*Laboratório de Estudos Subterrâneos, Departamento de Ecologia e Biologia Evolutiva, Universidade Federal de São Carlos, rod. Washington Luis, km 235, 13565-905, São Carlos, SP, Brazil.*

[3]*Departamento de Zoologia, Instituto de Biociências, Universidade Estadual Paulista, distrito de Rubião Jr., s/n, 18618-000, Botucatu, SP, Brazil.*

[4]Corresponding author: *Pedro G. B. Souza-Dias (pedrogdias@gmail.com)*

Abstract

In this study we describe the first apterous species of *Endecous* Saussure (1878), collected in two caves at Ituaçu, Bahia State, Brazil. In Brazil, *Endecous* is the most widespread cricket in hypogean environments and its species can colonize caves and inhabit the entrance and the aphotic zones; *Endecous* species can also be found in the litter, rock gullies, crevices, burrows, and any natural cavities. The use of subterranean habitat by *Endecous* crickets and its related genera are discussed.

Key words: Grylloidea, Phalangopsidae, Luzarinae, New species, Cave life

Resumo

Neste estudo descrevemos a primeira espécie áptera de *Endecous* Saussure (1878), coletada em duas cavernas em Ituaçu, Bahia, Brasil. No Brasil, *Endecous* é o grilo mais comum em ambientes hipógeos, podendo habitar tanto as zonas de entrada quanto as extremidades mais profundas e zonas afóticas de cavernas, além de habitarem a serapilheira, barrancos/paredões, fendas, tocas e outras cavidades naturais. Discutimos também o uso do habitat subterrâneo por grilos *Endecous* e gêneros próximos.

Palavras-chave: Grylloidea, Phalangopsidae, Luzarinae, Nova espécie, Vida cavernícola

Introduction

The genus *Endecous* was erected by Saussure (1878) for the species *E. arachnopsis*; the type locality of this species, referred to as "Le Brésil, Sierra Gival", is probably "Serra Geral". Brazil has two geologic formations known as Serra Geral: a large rock formation in the southern region, and the second is located on the border of states of Bahia and Minas Gerais. Bruner (1916) mentioned about two adult couples of *E. arachnopsis* collected in a cave in San Matias, Bolivia, and deposited in the Carnegie Museum, but he did not provide additional information. Liebermann (1965–1966) reported the occurrence of the type of *E. arachnopsis* in "Sierra Geral", Minas Gerais state, Brazil, but he did not examine the specimen. Mesa & Garcia-Novo (1997), subsequently, described the male genitalia of *E. arachnopsis* syntypes, and highlighted the lack of precise information regarding the type locality of this species. Thus, the type locality of *E. arachnopsis* remains uncertain.

Since the original description, 10 additional species have been added to the genus. Six of these species—*E.*

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itatibensis Rehn, 1918 (Itatiba, São Paulo state); *E. cavernicolus* Costa-Lima, 1940 (Lagoa Santa, Minas Gerais state); *E. abbreviatus* Piza, 1960 (Piracicaba, São Paulo state); *E. betariensis* de Mello & Pellegatti-Franco, 1998 (Iporanga, São Paulo state); *E. aguassay* Mews, 2008 (Viçosa, Minas Gerais state); and *E. alejomesai* Zefa, 2010 (Vila Propício, Goiás state)—occur in Brazil. The other known species are *E. ferruginosis* Bruner, 1916 (Bolivia, La Paz); *E. lizeri* Rehn, 1918 (Argentina, Córdoba); *E. hubbelli* Liebermann, 1965 (Argentina, Magdalena); and *E. onthophagus* (Berg, 1891) (Uruguay, Arequita) (Eades *et al*., 2013).

The morphology of the male genitalia (or phallic complex) and phallic sclerites is very useful in cricket taxonomy. Regarding *Endecous*, the morphology of the male genitalia is considered to be the most important character for species delimitation (Zefa *et al.* 2010). Since the 1960s, published taxonomic descriptions of crickets have included descriptions of male phallic complex. Further, regarding the genus *Endecous*, the male genitalia of eight of its eleven species have been described: *E. hubbelli* Liebermann (*in* Liebermann, 1965–1966); *E. onthophagus* (Berg) and *E. arachnopsis* Saussure (*in* Mesa & Garcia-Novo, 1997); *E. betariensis* de Mello & Pellegatti-Franco and *E. itatibensis* Rehn (*in* de Mello & Pellegatti-Franco, 1998); *E. aguassay* Mews and *E. cavernicolus* Costa Lima (*in* Mews & Sperber, 2008); and *E. alejomesai* Zefa (*in* Zefa *et al*., 2010).

However, there is no consensus regarding the interpretation of phallic sclerites in Grylloidea, and several terminologies have been proposed (*e.g.* Chopard (1961), Randell (1964), Desutter (1987), Gorochov (1995, 2002), and Desutter-Grandcolas (2003)). In Brazil, Mesa & Garcia-Novo (1997) and Mesa *et al*. (1998) proposed a terminology that was employed on the descriptions of the phallic complex of *E. onthophagus* and *E. arachnopsis* (Mesa & Garcia-Novo, 1997), and on the description of *E. alejomesai* by Zefa *et al*. (2010). The other Brazilian species of *Endecous* were described following the terminology proposed by Desutter (1987) and Desutter-Grandcolas (2003).

The taxonomic position of *Endecous* is also controversial. The electronic catalogue Orthoptera Species File (Eades *et al*., 2013) classifies *Endecous* in the genus group Luzarae Hebard, 1928 (Gryllidae, Phalangopsinae group, Luzarinae) together with genera *Amusina* Hebard, *Dyscophogryllus* Rehn, *Luzara* Walker, *Luzarida* Hebard, *Niquirana* Hebard, *Palpigera* Hebard, *Paracophus* Chopard, and *Rehniella* Hebard.

According to Desutter-Grandcolas (1992, 1993a, b, c), *Endecous* is closely related to the genera *Dyscophogryllus* Rehn, *Luzara* Walker, *Luzarida* Hebard, *Acantoluzarida* Desutter-Grandcolas, *Luzaridella* Desutter-Grandcolas, *Melanotes* Desutter-Grandcolas, *Palpigera* Hebard, *Leptopsis* Desutter-Grandcolas, *Allochrates* Desutter-Grandcolas, *Peru* Koçak & Kemal, and *Ochraperites* Desutter-Grandcolas.

Recently, Gorochov (2012) studied certain genera belonging to Luzarae and grouped the genera *Luzara* Walker, *Luzarida* Hebard, *Niquirana* Hebard, *Luzaridella* Desutter-Grandcolas, *Acantoluzarida* Desutter-Grandcolas, *Aracamby* de Mello, *Leptopsis* Desutter-Grandcolas, *Ucayacla* Gorochov, *Peruzara* Gorochov, and *Amazonacla* Gorochov into a new subtribe, Luzarina Gorochov (Gryllidae: Phalangopsinae: Luzarini). However, Gorochov (2012) did not provide information about the taxonomic position of *Endecous.*

Thus, the taxonomic position of *Endecous* within Luzarinae remains unclear, and further detailed studies, including a phylogenetic analysis of *Endecous* and its related genera, are required.

Liebermann (1965) presented an identification key for the known species of *Endecous*. Gorochov (1996) observed two syntypes—designated them as lectotype and paralectotype—of *E. arachnopsis* in the collection of Humboldt University (MNHU, Berlin), and provided a brief description of the lectotype. Mesa & Garcia-Novo (1997) proposed the transfer of the taxon *Dyscophogryllus onthophagus* to *E. onthophagus* (Berg, 1891). The genus has also been studied by tegminal morphology and acoustical communication (Mello & Pellegatti-Franco, 1998; Zefa, 2006; Zefa *et al*., 2010), morphology of the proventricolus (Fontanetti *et al*., 2002), behavioral patterns (Zefa, 2000 unpublished data; Gnaspini & Pellegatti-Franco, 2002) and cytogenetics (Mesa & Garcia-Novo, 1997; Zefa, 2006; Zefa *et al*., 2010).

In the present study, we describe a new species of *Endecous* from the caves of Ituaçu, Bahia, Brazil. For practical reasons, we adopt the taxonomic classification and terminology of male genitalia proposed by Desutter (1987, 1988) and Desutter-Grandcolas (2003). We also discuss the habitat and habits of the new species.

Material and methods

We collected the specimens in two limestone caves near Ituaçu city, state of Bahia (13°49′29″S; 41°20′45″W), on

the southern border of Chapada Diamantina. The native regional vegetation consists of Caatinga (mesophitic and xeromorphic forests) interspersed with Cerrado (Brazilian savannah) (Figs. 1A–C).

After collection, the specimens were fixed and immersed in 85% ethanol. The male phallic complexes were removed and treated with an aqueous solution of 10% KOH for 24 h to remove membranes and muscular tissues.

We examined, described and compared the specimens using a Leica MZ-9.5 stereomicroscope. We photographed the specimens (immersed in 85% ethanol) using a Leica MZ-16 stereomicroscope attached with a DFC-420 video camera. We used the digital image processing software Leica Application Suite LAS V4.0 to combine images. The images were subsequently edited in GIMP (GNU Image Manipulation Program) 2.8. The habitus and field photographs were taken with a Sony Cyber-shot DSC-HX1 digital camera.

The holotype, allotype, and paratypes were deposited in the collection of the Museu de Zoologia da Universidade de São Paulo (MZSP). We also sent a couple of paratypes to the collection of the Departamento de Zoologia, Universidade Estadual Paulista, campus Botucatu (UBTU).

Abbreviations. Arc, ectophallic arc; Ect. Ap., ectophallic apodeme; Ect. F., ectophallic fold; End. Sc., endophallic sclerite; End. Cr., endophallic crest; Ps. Arm, pseudepiphallic arm; Ps. Sc., pseudepiphallic sclerite; Ps. P., pseudepiphallic paramere.

Results

Endecous apterus n. sp. Bolfarini & Souza-Dias, 2013

Figures 1 (E–G), 2 (A–L), 3 (A–D), Table 1

Type material: Holotype: 1 male, Brazil, Bahia State, Ituaçu, Cave "*Cavidade 3"*. 13º49'29"S; 41º20'45"W. Bolfarini, M.P. & Souza-Dias, P.G.B.S. *leg*. Allotype: 1 female, same data as the holotype. Paratypes: 6 males, 5 females, same data as the holotype.

Specimens examined: 3 adult males, 4 adult females, 8 juveniles, same data as the type material.

Etimology: specific epithet related to the apterous condition of adult males.

Diagnosis. The most remarkable feature of *Endecous apterus* **n. sp.** is the loss of wings in male adults. This is the only *Endecous* species with apterous male adults known to this moment.

Description. **Male holotype**: general coloration varying from pale yellow to light yellowish brown, almost uniform, without dark maculae or spots (Figs. 1E, 2A). Measurements shown in Table 1. Head: Gena and frons whitish (Figs. 2A, B); clypeus and labrum pale brown, with same size (Fig. 2D). Vertex and occiput yellowish (Figs. 2B, C). Two whitish spots above scape, in the ocelli area (Fig. 2D). Antennal scape yellowish; inter-antennal space shorter than scape (Fig. 2D); pedicel whitish. Distal margin of mandible dark brown. Maxillary palpi whitish, slender, elongate, the fifth joint arcuate, whitish to yellowish, its distal half white (Fig. 2E). Large intra-ocular distance (Fig. 2C, D). Eyes small, with inferior border acuminated and a depigmented area on supero-inner margin as in figures 2B–D. Ocelli absent. Thorax: Pronotum, in dorsal view, with its disk wider than long, slightly inflated, yellowish, darkening towards cephalic and caudal margins (Fig. 2C). Cephalic margin almost straight; caudal margin slightly convex; presence of long bristles on cephalic margin (Fig. 2C). Lateral lobes same color as pronotum (Fig. 2B); ventro-cephalic and caudal angles broadly rounded. Apterous. Absence of glandular structures on metanotum. Legs I and II pale yellow; tibia I with one pair of ventral apical spurs (on inner and outer face); tibia II with four spurs, two internals (ventral and dorsal) and two externals, the dorsal one is the smaller. Auditory tympana absent. Legs III pubescent, general coloration pale yellow; tibia III pale yellow, serrulated; subapical spurs: three subapical spurs on inner face and four on outer, the distal one the smaller; apical spurs: the median the longest on inner face and the upper the longest on outer face (Fig. 2L). Abdomen: Abdominal tergites yellowish. Sternites pale yellow. Supra anal plate simple, lateral margins slightly constricted, with translucid aspect, and the distal margin rounded, as in figure 2G. Subgenital plate small, translucid, elongated, the posterior border rounded as in figure 2H. Cerci pale brown with distal portion whitish.

Female: slightly larger and darker than male. Apterous. Supra anal plate short as in figure 2F. Subgenital plate dark brown, small, bilobate, as in figure 2I. Ovipositor dark yellow in basis and dark brown towards the apex, as in figures 2J, K.

Phallic complex: Male phallic complex as in figure 3. Pseudepiphalic sclerite simple, the distal portion of

pseudepiphallic arm dorsally curved; ectophallic apodeme short, above the median part of the pseudepiphallic sclerite; endophallic sclerite and endophallic crest well developed.

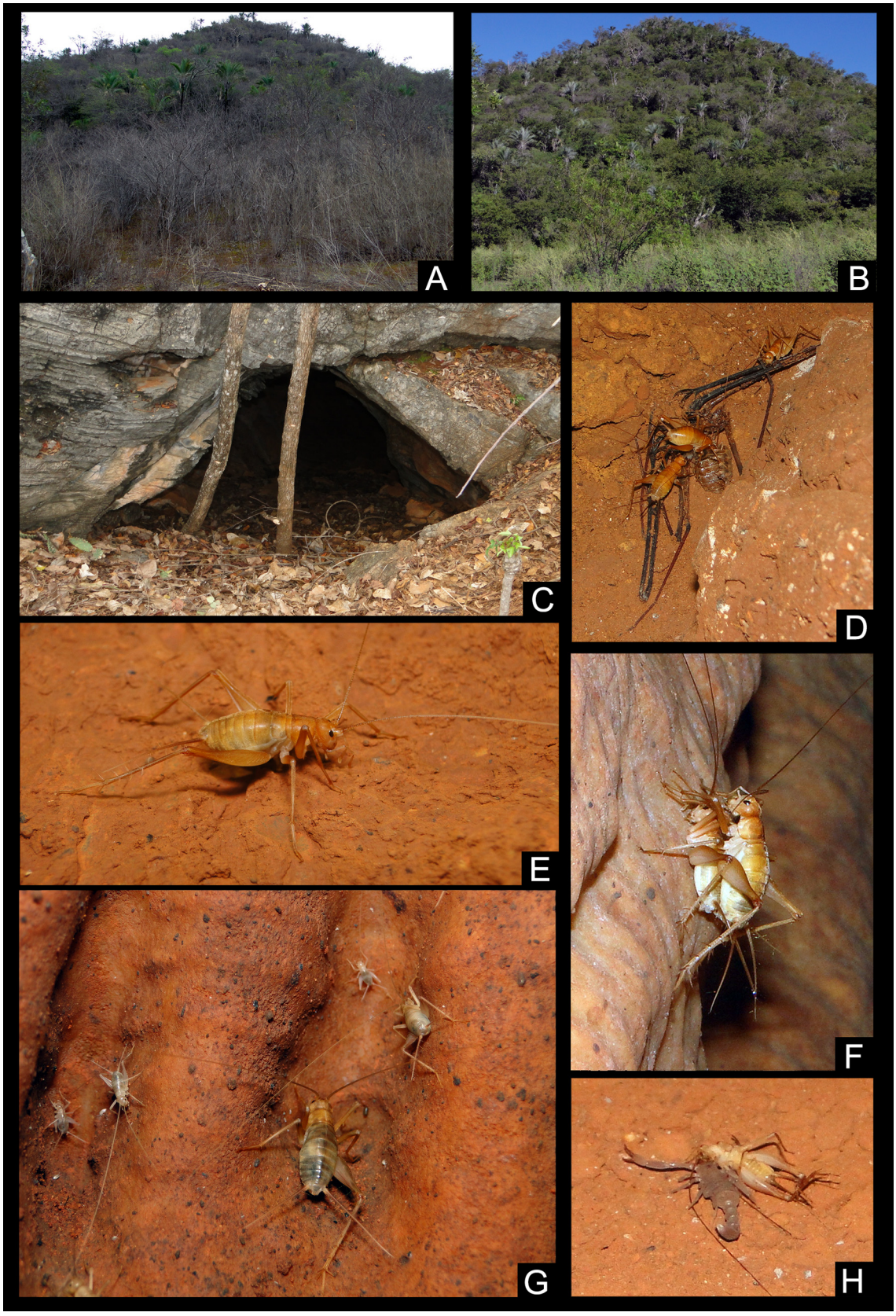

FIGURE 1. Habitat and habits of *Endecous apterus* **n. sp.** A—surroundings of the cave "Cavidade 3" in dry season; B—the same, in wet season; C—entrance of the cave "Cavidade 3"; D—individuals feeding; E—Male adult; F—Individuals copulating; G—individuals adults and nymphs; H—individual of *E. apterus* preyed by a scorpion.

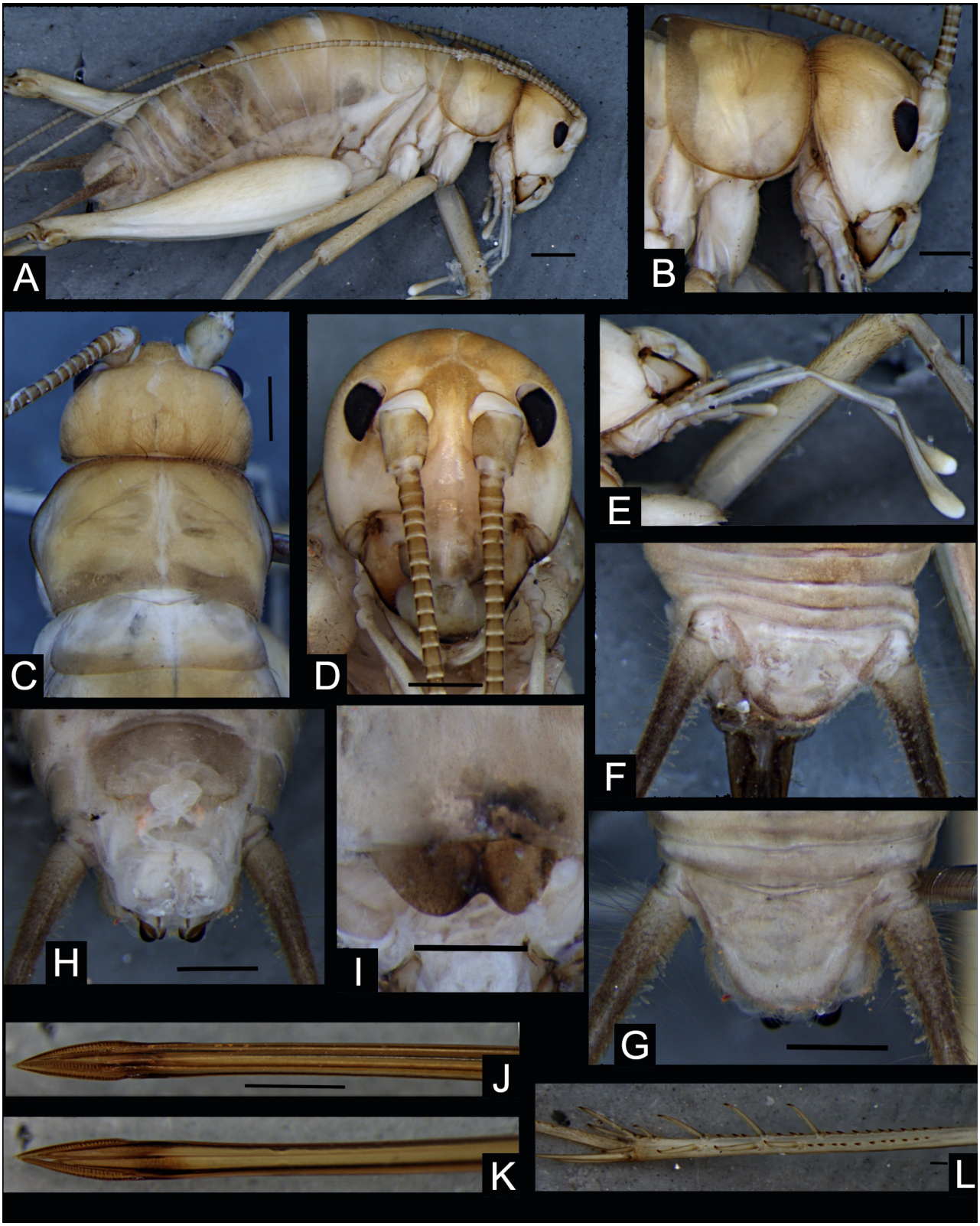

FIGURE 2. *Endecous apterus* **sp. n.**, general morphology. A—male habitus, lateral; B—Lateral view of male head and pronotum; C—Male head and pronotum in dorsal view; D—Male head in frontal view; E—Maxillary palpi; F—Supra anal-plate (female); G—Supra-anal plate (male); H—subgenital plate (male); I—subgenital plate (female); J—ovipositor in dorsal view; K—ovipositor, ventral view; L—male hind tibia. Scale bar: 1mm

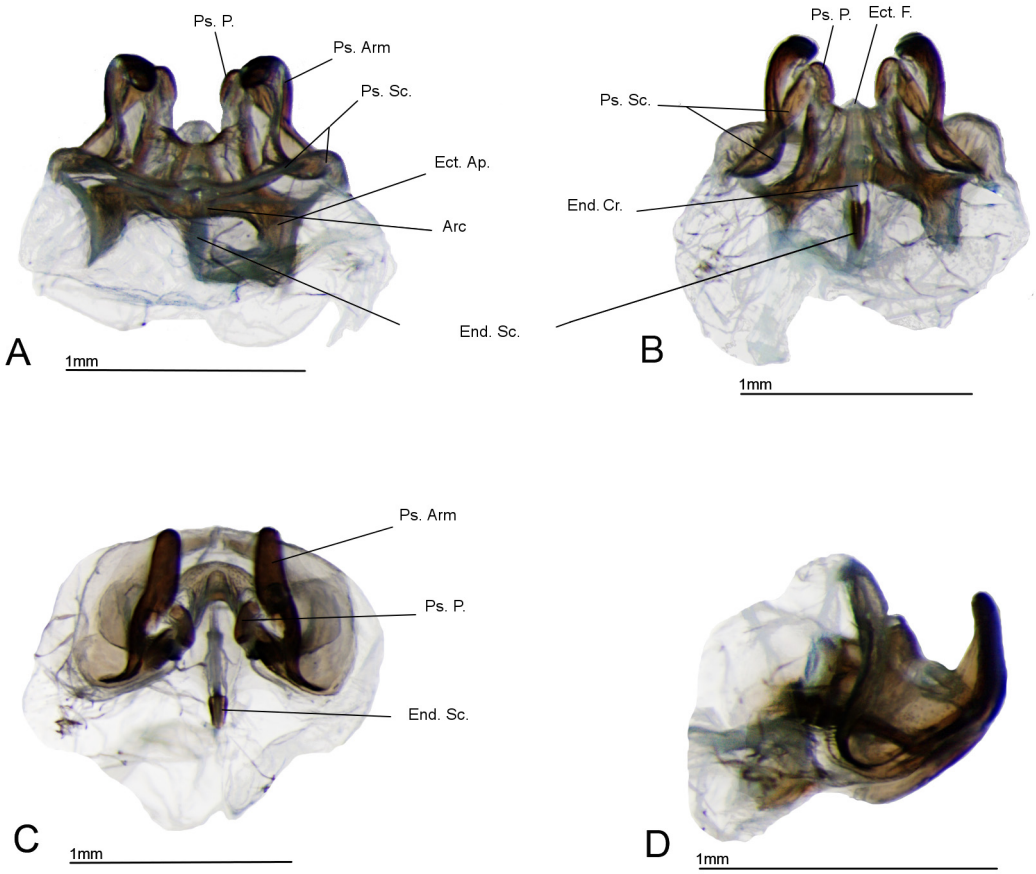

FIGURE 3. Male phallic complex of *Endecous apterus* **n. sp.** in dorsal view (A), ventral (B), posterior (C) and lateral (D).

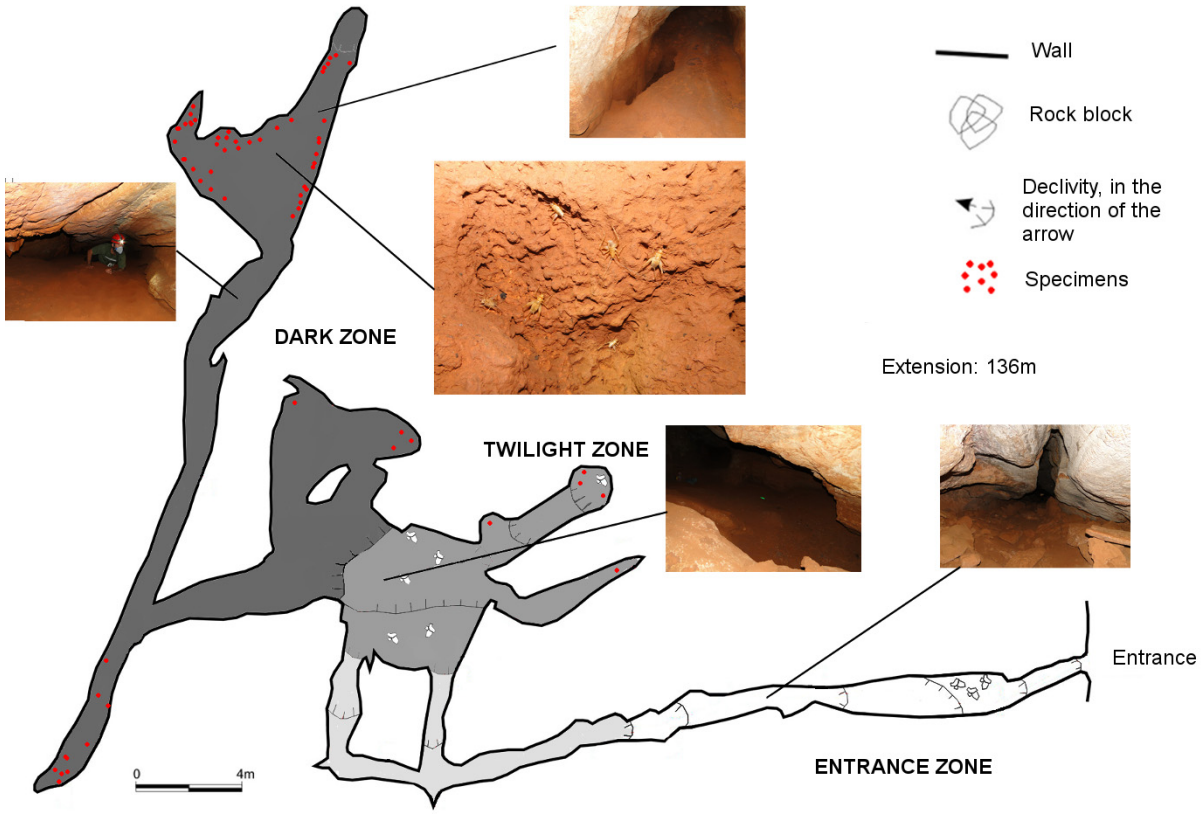

FIGURE 4. Map of the cave "Cavidade 3". The cave zones are demonstrated by gray color and the red spots refer to the places inside the cave where we found specimens.

TABLE 1. Measurements of *Endecous apterus* **n. sp.** BL = body length; HW = head width; IOD = intra-ocular distance; PL = pronotum length; PW = pronotum width; HFL = hind femur length; HTL = hind tibia length; OL = ovipositor length.

	BL	HW	IOD	PL
Males (n=6)				
Range	9,89–14,45	2,45–2,93	1,19–1,80	1,75–2,16
Mean	12.65	2.70	1.41	1.94
	PW	HFL	HTL	OL
Range	3,18–3,62	7,17–9,10	8,15–10,30	//
Mean	3.45	8.35	8.95	//
	BL	HW	IOD	PL
Females (n=5)				
Range	13,32–17,21	2,84–3,62	1,44–1,70	2,04–2,59
Mean	15.23	3.18	1.56	2.42
	PW	HFL	HTL	OL
Range	3,65–4,51	9,02–10,86	9,30–11,03	6,50–11,22
Mean	4.12	9.93	10.02	8.14

Discussion

Endecous is a widely distributed genus, with species recorded from Brazil, Argentina, Bolivia and Uruguay. In Brazil, it occurs in all biomes and is the most conspicuous and widespread genus of cricket in hypogean environments. *Endecous* populations have been reported to occur in many cavities, in almost all of the main Brazilian karst areas, particularly in the southern, southeastern, and central states, and also in some northern and northeastern states, such as Pará, Maranhão, Ceará, Rio Grande do Norte, and Bahia (Trajano, 1987; Trajano & Gnaspini-Netto, 1991; Pinto da Rocha, 1993; Pinto da Rocha, 1995; Trajano, 2000; Zeppelini-Filho *et al*., 2003; Ferreira *et al*., 2010; Trajano & Bichuette, 2010; Silva *et al*., 2011; Cajaiba, 2012).

To date, however, only four species have been described from cave populations: *E. alejomesai* Zefa, 2010; *E. betariensis* de Mello & Pellegatti-Franco, 1998; *E. cavernicolus* Costa Lima, 1940; and *E. onthophagus* (Berg, 1891).

Desutter-Grandcolas (1995) classified the neotropical phalangopsid crickets according to the diversity of habitats, and defined *Endecous* as a troglobitic genus—i.e., living only inside caves. Studies on cave fauna and the evolution of troglobitic life have been extensively reported and a number of definitions and classifications for cavernicolous taxa have been proposed (Racovitza, 1907; Barr, 1968; Howarth, 1983, 1987; Desutter-Grandcolas, 1993a, 1997, 1997 (1999); Heads, 2010).Traditionally, these taxa are categorized as troglobites, troglophiles, and trogloxenes. Troglobites are defined as organisms that are able to survive only in cave environments; troglophiles, organisms that are able to live and reproduce in caves, and also in environments with similar dark, humid conditions; and trogloxenes are the organisms that may colonize caves, but must return to the surface.

Several authors have suggested that troglobitic taxa frequently show troglobiomorphosis, i.e., share some distinct modifications (Howarth, 1983; Desutter-Grandcolas, 1997; Marques & Gnaspini, 2001). In arthropods, this phenotypic syndrome is characterized by pale coloration, increased appendage size (mainly legs and antennae), reduction/loss of eyes, and loss of wings (Desutter-Grandcolas, 1997 (1999); Aden, 2005; Christiansen, 2005; Heads, 2010). However, as demonstrated in previous studies (Desutter-Grandcolas, 1997 (1999); Desutter-Grandcolas *et al*., 2003; Heads, 2010), there is no connection between troglobiomorphosis and troglobitic habit in neotropical phalangopsid crickets—i.e., not all troglobites are troglobiomorphics, and some species that show characters considered as troglobiomorphies have surface populations.

De Mello & Pellegatti-Franco (1998) noted that *Endecous* species live inside caves, but can also spend the day hidden in caves, rock gullies, crevices, burrows, and other natural cavities (even in man-made constructions as

bridges and wells). The species emerge at night to feed on litter and reproduce, which characterizes a cavicolous habit. Cavicoly is frequent among Brazilian Luzarinae, and some taxa referred as troglobitic are, in fact, cavicolous with troglophilic populations—i.e., the population is able to live and reproduce inside the cave (with some individuals never leaving the cave); however, eventually, a contact occurs between the cave and surface populations (e.g., migration of outside individuals into the cavity), with subsequent gene flow. Thus, most of the *Endecous* species are cavicolous or cavicolous species with troglophilic populations (Table 2)..

TABLE 2. Known species of *Endecous* and its habits. The presented data were obtained from field observations carried out by the authors and colleagues and previous works (Costa-Lima, 1938; Liebermann, 1965; Mesa & Garcia-Novo, 1997; de Mello & Pellegatti-Franco, 1998; Zefa, 2000 unpublished data; Mews & Sperber, 2008; Zefa *et al*., 2010).

Taxon	Habit
E. abbreviatus Piza	prob. cavicolous (no data)
E. aguassay Mews	cavicolous – straminicolous
E. alejomesai Zefa	cavicolous, troglophilic populations
E. arachnopsis Saussure	prob.cavicolous (no data)
E. betariensis de Mello & Pellegatti-Franco	cavicolous, troglophilic populations
E. cavernicolus Costa-Lima	cavicolous, troglophilic populations*
E. ferruginosus Bruner	cavicolous
E. hubbelli Liebermann	cavicolous
E. itatibensis Rehn	cavicolous, troglophilic populations straminicolous
E. lizeri Rehn	cavicolous
E. onthophagus (Berg)	cavicolous, troglophilic populations
E. apterus Bolfarini & Souza-Dias	troglobitic

* *E. cavernicolus* was referred as troglobitic by Mews & Sperber (1998). In fact, this species is cavicolous with troglophilic population since individuals were observed out of the caves, mainly males stridulating (Zefa, 2000 unpublished data).

E. apterus **n. sp.** presents some morphological features that can be considered as troglobiomorphosis, namely, pale coloration, loss of auditory tympana, and loss of wings. The loss of wings is the most remarkable feature of this species. In the genus group Amphiacustae (Grylloidea, Phalangopsidae, Luzarinae), which comprises hypogean and epigean species, the pale coloration is present in troglobitic taxa (the epigeans are darker), indicating that alterations in body coloration follow the habitat change (Desutter-Grandcolas, 1997 (1999)). Otherwise, although *E. apterus* **n. sp.** does not present tegmina and auditory tympana, which are typical characters of troglobites, some studies have shown a lack of correlation between cave colonization and wing modification, with subsequent loss of acoustical communication (Desutter-Grandcolas, 1995, 1997).

Trajano & Moreira (1991) discovered a large population of *Endecous* feeding on guano and the carcasses of small dying arthropods, in sandstone caves in the speleological province of Altamira-Itaituba, Pará State, northern Brazil. The authors also observed crickets at different stages of maturity, including adult males stridulating inside the caves.

In Ituaçu (Bahia State), we observed a population of *E. apterus* **n. sp.** in two cavities (a cave and a doline) at a distance of *ca*. 400 m from each other. In the cave "Cavidade 3" (Figs. 1C; 4) we observed a large population, composed of nymphs and adults (Fig. 1G), as well as individuals feeding on dead arthropods (Amblypygi, *Trichodamon* sp., Fig. 1D) and reproducing (Fig. 1F), concentrated mainly in the dark/aphotic zone (Fig. 4). The natural predators of this population were amblypygids (*Trichodamon* sp.), scorpions (*Tityus* sp. (Buthidae), Fig. 1H) and spiders (*Loxosceles* sp. (Sicariidae)).

During three nights of collection, we found no specimen in the surroundings of the cave or at entrance zone. Considering the dynamics of the population inside the cavity and the absence of individuals at entrance zone and outside even during the night, we can assume that the individuals do not leave the cave. Thus, we propose that the

new species should be classified as a troglobitic species and, to this moment, the first troglobitic species of *Endecous* described.

The taxonomy of *Endecous* is not fully understood due to its large number of undescribed species— several of which have specimens deposited in Brazilian collections. Therefore, further taxonomic studies with species descriptions are very important. Additionally, systematic studies with phylogenetic analysis are required, in order to understand the taxonomic position of *Endecous* and the relationships of its species. Moreover, because of its wide distribution, and its taxonomic and habitats diversity, *Endecous* comprises a valuable subject for natural history and evolutionary biology studies, particularly those focused on the evolution of cave life.

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