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The first troglobitic *Cryptops* (*Trigonocryptops*) (Chilopoda: Scolopendromorpha) from South America and the description of a non-troglobitic species from Brazil

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Abstract

Cryptops (*Trigonocryptops*) *iporangensis* **n. sp.**, and *C.* (*T.*) *hephaestus* **n. sp.** are described from SE Brazil. *C.* (*T.*) *iporangensis* **n. sp.** presents highly troglomorphic characters and is described from a remarkable cave system located in Sao Paulo State, the Areias cave system, from were other 16 troglobitic species are also known. *C.* (*T.*) *hephaestus* **n. sp.** was described on specimens collected in three caves of the "Quadrilátero Ferrífero" (Iron quadrangle), in Minas Gerais State, but does not presents a clear specialization to subterranean habitat. The new troglobitic species can be separated from other species of *Cryptops* (*T.*) from Brazil and all troglobitc species of the genus *Cryptops* by presenting incomplete paramedian sutures on tergites, antennal article 1 with an inverted Y-shaped suture on its proximal part and distal spinose processes on ultimate leg. *C.* (*T.*) *hephaestus* differs from the other species of *Cryptops* (*Trigonocryptops*) from Brazil by presenting anterior oblique sutures on tergites 2-7 and posterior oblique sutures on tergites 1-3. *Cryptops* (*Cryptops*) *galatheae* Meinert, 1886 is moved here to the subgenus *Trigonocryptops.*

Key words: Neotropics, caves, iron ore, limestone, taxonomy, Cryptopidae

Introduction

The genus *Cryptops* Leach, 1815 is currently divided into four subgenera: *Cryptops* Leach, 1815; *Trigonocryptops* Verhoeff, 1906; *Chromatanops* Verhoeff, 1906 and *Haplocryptops* Verhoeff, 1934 (Bonato *et al*. 2011). Their validity is uncertain (except for *Trigonocryptops*) and the number of valid species of the genus *Cryptops* is probably overestimated (Lewis 2009).

According to the original description of Verhoeff (1906) revised by Attems (1930), the subgenus *Trigonocryptops* is characterized by a transverse ridge on the sternites between the coxae, generally bipartite tarsi, the head overlying tergite 1, a transverse suture on tergite 1, a divided katopleure and mostly yellow or brown colour.

Six species of *Cryptops* have been recorded from Brazil: *C*. (*Trigonocryptops*) *galatheae* Meinert, 1886; *C*. (*T.*) *iheringi* Brölemann, 1902; C. (*Cryptops*) *heathii* Chamberlin, 1914; *C*. (*Cryptops*) *dubiotarsalis* Bücherl, 1946; *C*. (*Cryptops*) *schubarti* Bücherl, 1953; *C*. (*Cryptops*) *goiasus* Chamberlin, 1958 (Bücherl 1940, 1942; Minelli 2006).

Trajano & Bichuette (2010) mentioned erroneously, that only three troglobitic species of *Cryptops* are known to date in the world (two from Australia and one from Cuba). In fact, there are six known troglobitic species of this genus: *C*. (*T.*) *longicornis* Ribaut, 1915, from mainland Spain; *C*. (*T.*) *cavernicolus* Matic, Negrea and Fundora Martinez , 1977, and *C*. (*T.*) *troglobius* Matic, Negrea and Fundora Martinez, 1977, from Cuba; *C*. (*Cryptops*) *vulcanicus* Zapparoli, 1990, from the Canary Is.; *C.* (*T.*) *roeplainsensis* Edgecombe, 2005, and *C.* (*T.*) *camoowealensis* Edgecombe, 2006, from Australia (Ribaut 1915; Matic *et al.*, 1977; Serra, 1981; Zapparoli 1990; Edgecombe 2005, 2006).

In this study, we describe the seventh troglobitic *Cryptops* species in the world, and the seventh and eighth species of this genus from Brazil.

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Material and methods

Specimens were collected by hand and fixed in 70% ethanol. The stereoscopic images were acquired using a Leica M205, with the software Leica Application Suite auto montage to combine the images. The morphological measurements were made using a stereomicroscope (Zeiss Stemi 2000-c) with a millimetric lens.

The specimens have been deposited in the Subterranean Invertebrate Collection of Lavras (ISLA) in the Biology Department/Zoology Division of the Federal University of Lavras, Lavras, Minas Gerais State, Brazil.

We follow the terminology of Lewis *et al*. (2005) and Bonato *et al*. (2010).

Taxonomy

Genus *Cryptops* Leach, 1815

Type species*: Scolopendra hortensis* Donovan, 1810, by monotypy.

Subgenus *Trigonocryptops* Verhoeff, 1906

Type species: *Cryptops gigas* Kraepelin, 1903, by subsequent designation of Attems (1930).

Cryptops (*Trigonocryptops*) *iporangensis* n. sp.

(Figures 1–3)

Type material. Holotype: ISLA 2191 from Ressurgência da Areias Cave, Iporonga, São Paulo, Brazil, 06/IV/2012, *leg*. R.A. Zampaulo

Etymology. The name is given in reference to the municipality in which the cave is located. *Iporanga* is from Tupi origin, a Brazilian Indian language, and means "beautiful water".

Diagnosis. This species is characterized by antennal article 1 with an inverted Y-shaped ventral suture on its proximal part; distal region of first antennal article without setae; incomplete paramedian sutures on tergites; absence of trigonal sutures; legs and antenna elongated; anterior setose area on clypeus pentagonal; a pair of a large distal spinose processes on the ultimate leg tibia (2.5 times as long as processes on prefemur and femur); 10 saw teeth on ultimate leg tibia, and 5 on tarsus 1.

Description. Length (anterior margin of cephalic plate to posterior margin of ultimate tergite) 27.5 mm. Cephalic plate 1.4 mm long, antenna 10.4 mm (Figure 1A).

Head, anterior trunk segments and legs light orange to yellowish; posterior tergites and legs pale yellowish to whitish.

Cephalic plate overlapping tergite 1, slightly longer than wide; posterior corners rounded, sides convex, anterior apex slightly indented; complete paramedian sutures diverging anteriorly. Head homogeneously covered with fine setae.

Antenna composed of 17 articles (Figure 1A); articles 1–9 increasing in length and decreasing in width, quadrangular; article 1 with an inverted Y-shaped suture on its proximal part on ventral side (Figure 1C); articles 2–6 1.5 times as long as wide; articles 10–17 2.5 times as long as wide. Article 1 with a high density of lanceolate setae of varied length, these strong setae progressively less abundant on articles 2–4; distal region of first article without setae, like a ring; from articles 3–4, short, fine setae form a fur-like covering with long setae only encircling the proximal end of each article.

Anterior setose area on clypeus pentagonal, bearing four lanceolate setae; a row of 15 prelabal setae; scattered setae between anterior margin of clypeus and prelabal setae (Figure 1D). Labrum with shallow incision against rounded sclerotised bulge (Figure 2B).

Anterior edge of forcipular coxosternite convex on each side, with a row of 7+7 marginal setae (Figure 2B). Surface of coxosternite and trochanteroprefemur with sparse scattered long or short fine setae, with the long setae concentrated on inner margin. Tarsungulum articulated with trochanteroprefemur along wide hinge.

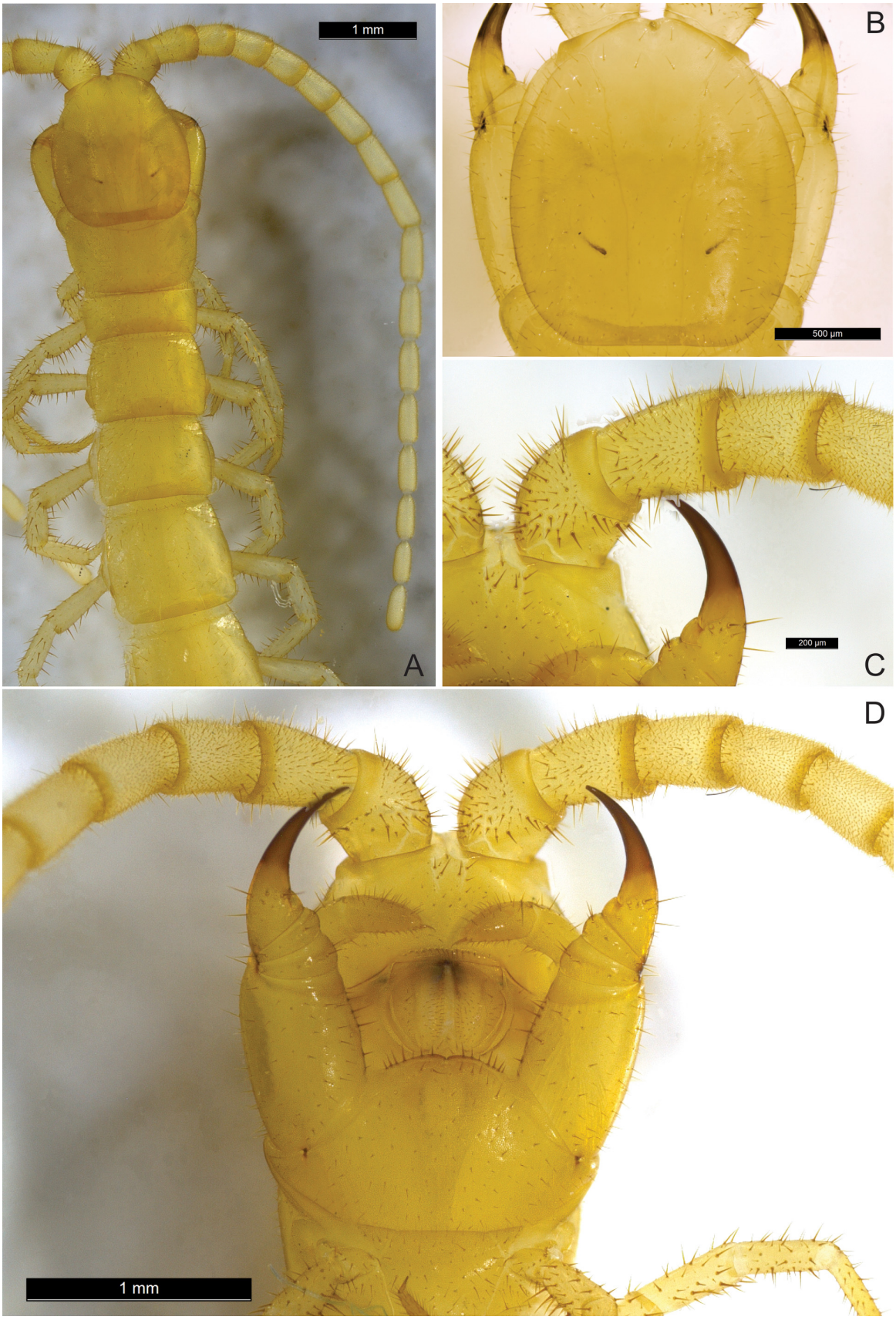

FIGURE 1. ***Cryptops*** (***T.***) ***iporangensis*** **n. sp.** (ISLA 2191): A) Cephalic plate, tergites and antenna; B) cephalic plate; C) proximal part of antenna and clypeus; D) ventral view of head.

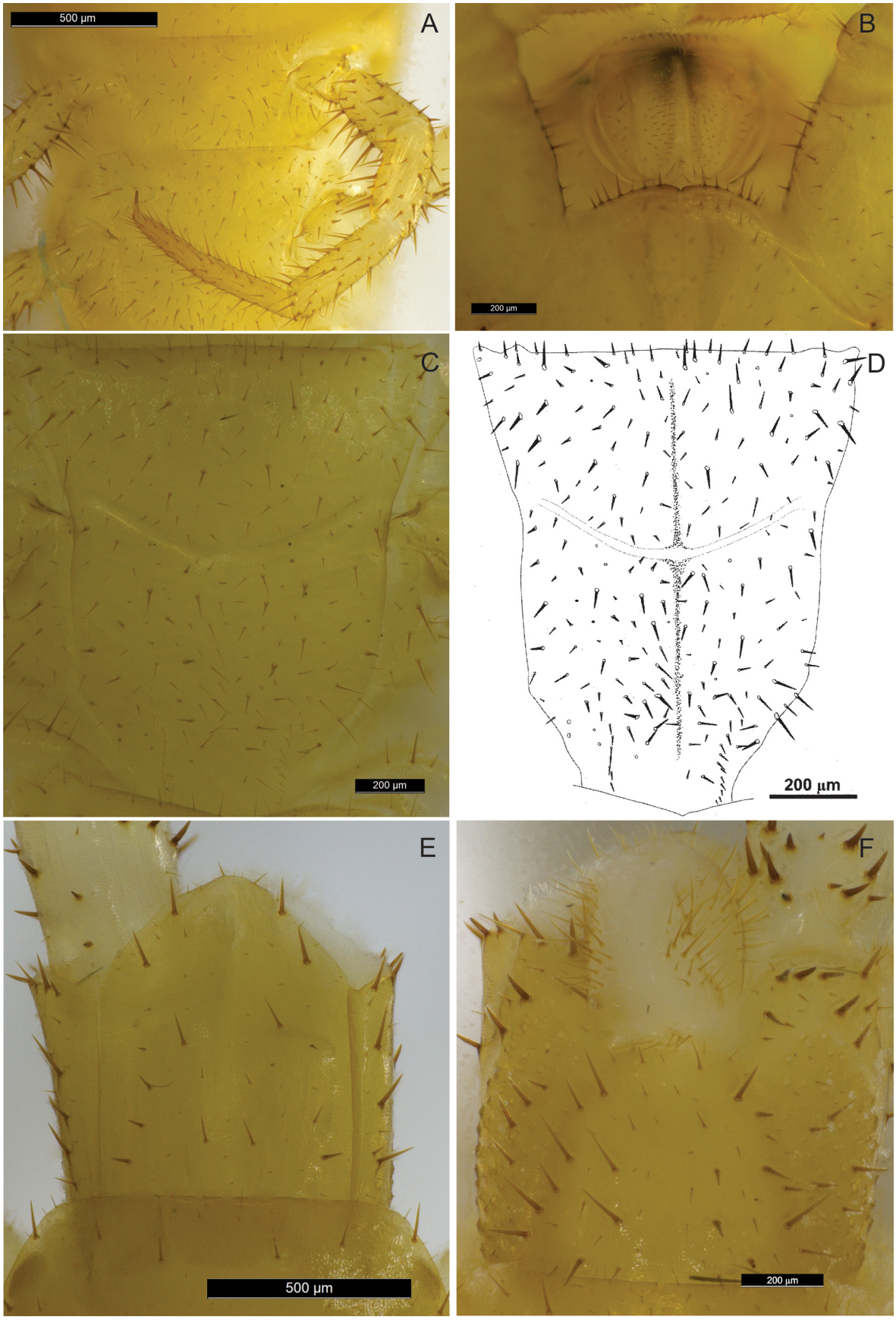

FIGURE 2. ***C.*** **(*T.*)** ***iporangensis*** **n. sp.** (ISLA 2191): A) Tergite 1 and leg 1; B) anterior margin of the forcipular coxosternite; C–D) sternite 4; E) dorsal view of ultimate leg-bearing segment; F) ventral view of ultimate tergite.

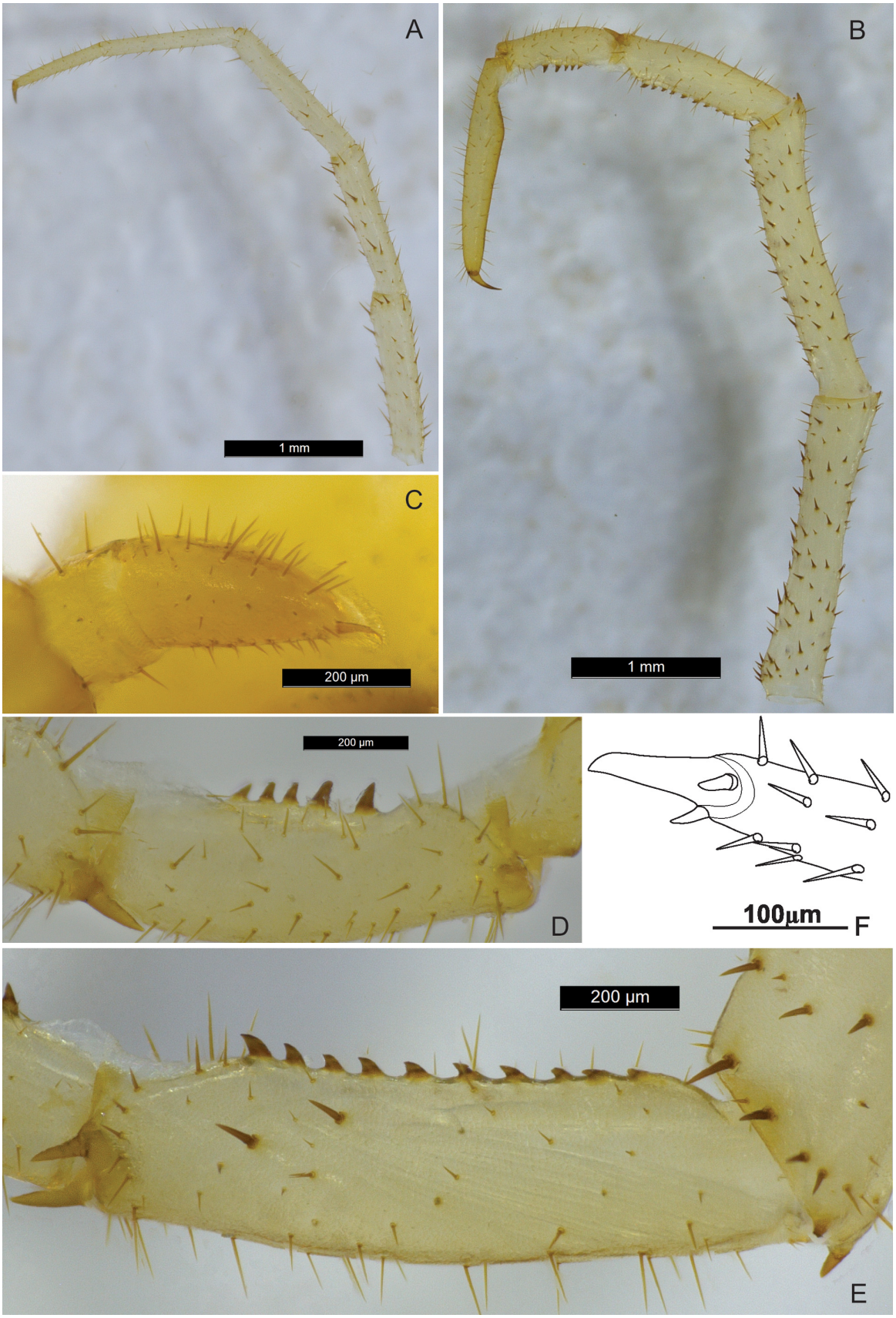

FIGURE 3. ***C.*** **(*T.*)** ***iporangensis*** **n. sp.** (ISLA 2191): A) Lateral view of leg 20; B) lateral view of leg 21; C) telopodite of second maxilla; D) saw-teeth on tarsus 1 of ultimate leg, lateral view; E) saw-teeth on tibia of ultimate leg, lateral view; F) pretarsus of leg 10.

Apical claw of second maxilla with slender hook distally, lacking a flange along its inner edge. Dorsal brush dense, running along distal fourth of article 3 (Figure 3C).

Tergite 1 with complete anterior transverse suture; incomplete paramedian sutures on tergites 2–19, occupying roughly one fifth of the length of the posterior part of the tergite; lateral crescentic sulcus on tergites 4–19. Tergite 1–4 with homogeneous short and long setae; remaining tergites with sparse, short and long setae. Tergite 21 slightly longer than wide, posterior margin with rounded apex (Figure 2E); shallow longitudinal median depression along its posterior two-thirds; pretergites 1–20 with a transverse row of fine setae.

Spiracles elongated, elliptical.

Legs long and thin, e.g., leg 10 with prefemur 0.9 mm long, femur 0.8 mm, tibia 0.9 mm, tarsus 1 0.7 mm, tarsus 2 0.4 mm compared to tergal width of 1.2 mm. All tarsi strongly bipartite. Leg 1 with strong spiniform setae combined with short, fine setae on prefemur and femur, and tibia, pretarsus and tarsus with fine spiniform setae (Figure 2A); setae on legs 2 to 20 similar but less dense. Leg 20 prefemur and femur about equally long; tarsus 2 0.5 times as long as tarsus 1 (Figure 3A). Ultimate leg: prefemur 1.9 mm long, femur 1.8 mm, tibia 1.1 mm, tarsus 1 0.7 mm, tarsus 2 1.2 mm; prefemur and femur 4.5 times as long as than their maximal width at the distal end (Figure 3B). A pair of distal spinose processes on anterior side of prefemur, femur and tibia; spinose processes of tibia 2.5 times as long as spinose processes of prefemur and femur; numerous spiniform setae on ventral side of prefemur and femur; tibia, tarsus 1 and tarsus 2 with fine setae, concentrated on dorsal region; 10 saw-teeth on tibia (Figure 3E), 5 on tarsus 1 (Figure 3D); inner margin of tarsus 2 a ridge. Pair of accessory spines of pretarsus on legs 1–20 divergent, one third the length of pretarsus (Figure 3F); accessory spines lacking on ultimate leg.

Sternites 2–19 with median longitudinal and curved transverse sulci, their intersection forming a depression, without trigonal sutures in front of the endosternites (Figure 2C, 2D); sternite of ultimate leg-bearing segment with sides gently convex and converging posteriorly (Figure 2F); posterior corners rounded. Sternites 1–18 with sparse, short and long setae varying in density on each sternite. Coxopleural pore field elliptical, with about 70 pores. Short and moderately spiniform setae in pore field, less numerous than pores; posterior margin of coxopleuron with spiniform and fine setae.

Cryptops (*Trigonocryptops*) *hephaestus* n. sp.

(Figures 4–6)

Type material. Holotype: ISLA 3998 from SPA – 74, Mariana, Minas Gerais State, Brazil, 21/III/2012, *leg*. T.G. Pellegrini; paratypes: ISLA 3997 from Mina do Pico 7, Itabirito, Minas Gerais State, Brazil, 28/III/2012, *leg*. Carste; ISLA 3699 from Mina do Pico 4, Itabirito, Minas Gerais State, Brazil, 6.X.2013, *leg*. M.P.A. Oliveira.

Etymology. The epithet is given in reference to Hephaestus, God of blacksmiths, metarllugy and fire in Greek mythology.

Diagnosis. This species is characterized by tergite 1 bearing a complete anterior transverse suture hidden under the cephalic plate; tergites 1–3 with complete posterior oblique sutures and tergites 2–7 with complete anterior oblique sutures; antennal article 1 with an irregular ventral suture in its proximal part; trigonal sutures present; ultimate legs lacking spinose processes.

Description. Length (anterior margin of cephalic plate to posterior margin of ultimate tergite) 20–24.5 mm. Cephalic plate 1.5–1.6 mm long, antenna 3.75–4.3 mm (Figure 4A).

Head, trunk segments and legs dark orange.

Cephalic plate overlaps tergite 1; cephalic plate slightly longer than wide, posterior corners rounded, sides convex outward, anterior apex indented; paramedian sutures complete, diverging anteriorly on head plate; head covered with fine, long setae, with a greater density at the margins (Figure 4B).

Antenna of 17 articles (Figure 4A); articles 1–17 almost the same length, decreasing in width distally; article 1 with an reticulate suture on its proximal part on ventral side and forming a transverse suture on proximal part on dorsal side. Article 1 with a high density of lanceolate setae progressively less abundant on articles 2–4; distal region of first article with a dark coloured setose ring (Figure 4C); from article 3–4, with short, fine setae forming a fur-like covering with long setae only around the proximal end of each article.

Anterior setose area on clypeus diamond-shaped; four lanceolate setae on anterior part and one on posterior part of clypeus; a row of 12 prelabal setae; scattered setae between anterior margin of clypeus and prelabal setae. Labrum with shallow incision against rounded sclerotised bulge in sidepiece.

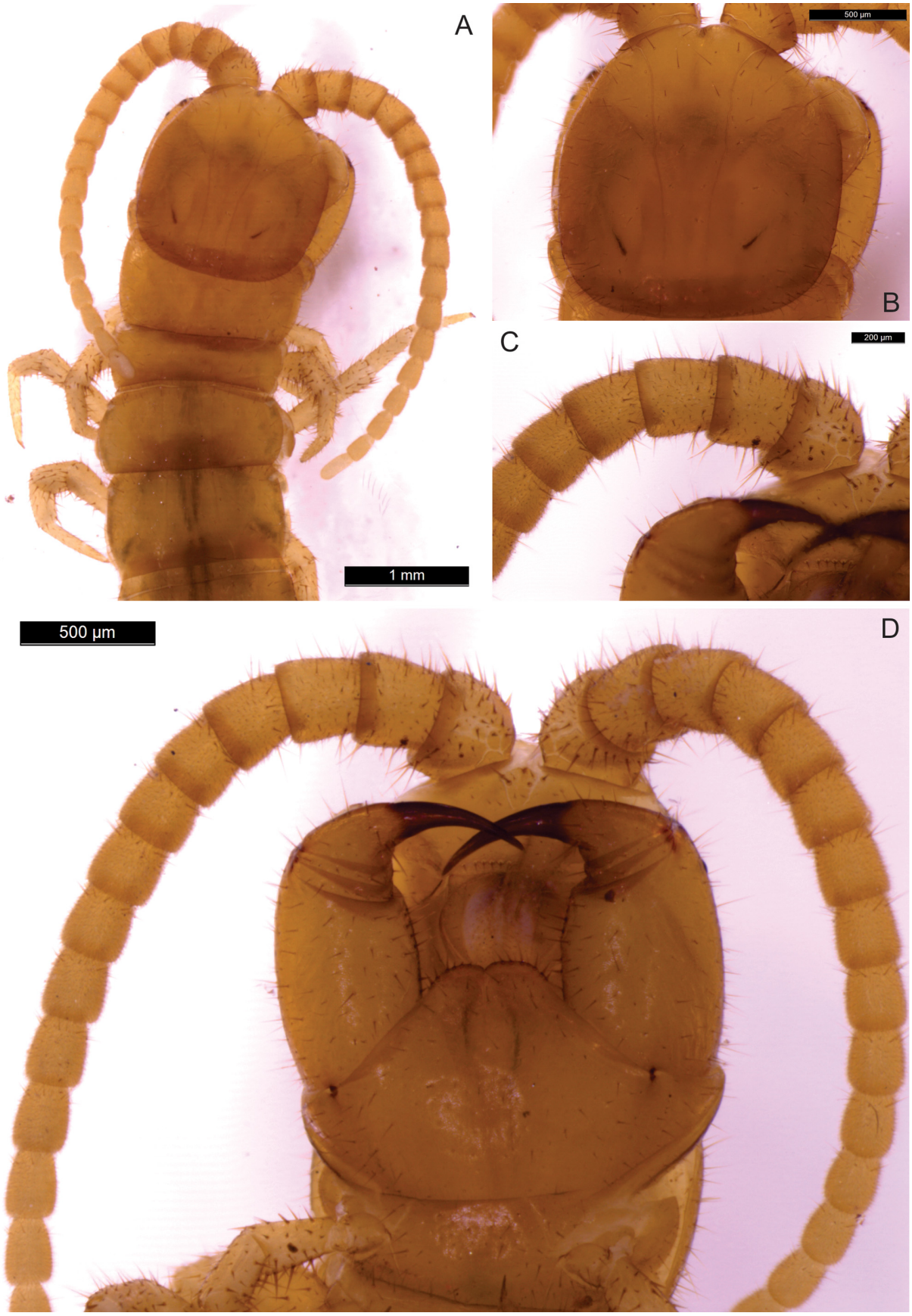

FIGURE 4. ***Cryptops*** **(*T.*)** ***hephaestus*** **n. sp.** (ISLA 3998): A) Cephalic plate, tergites and antenna; B) cephalic plate; C) proximal part of antenna and clypeus; D) ventral view of head.

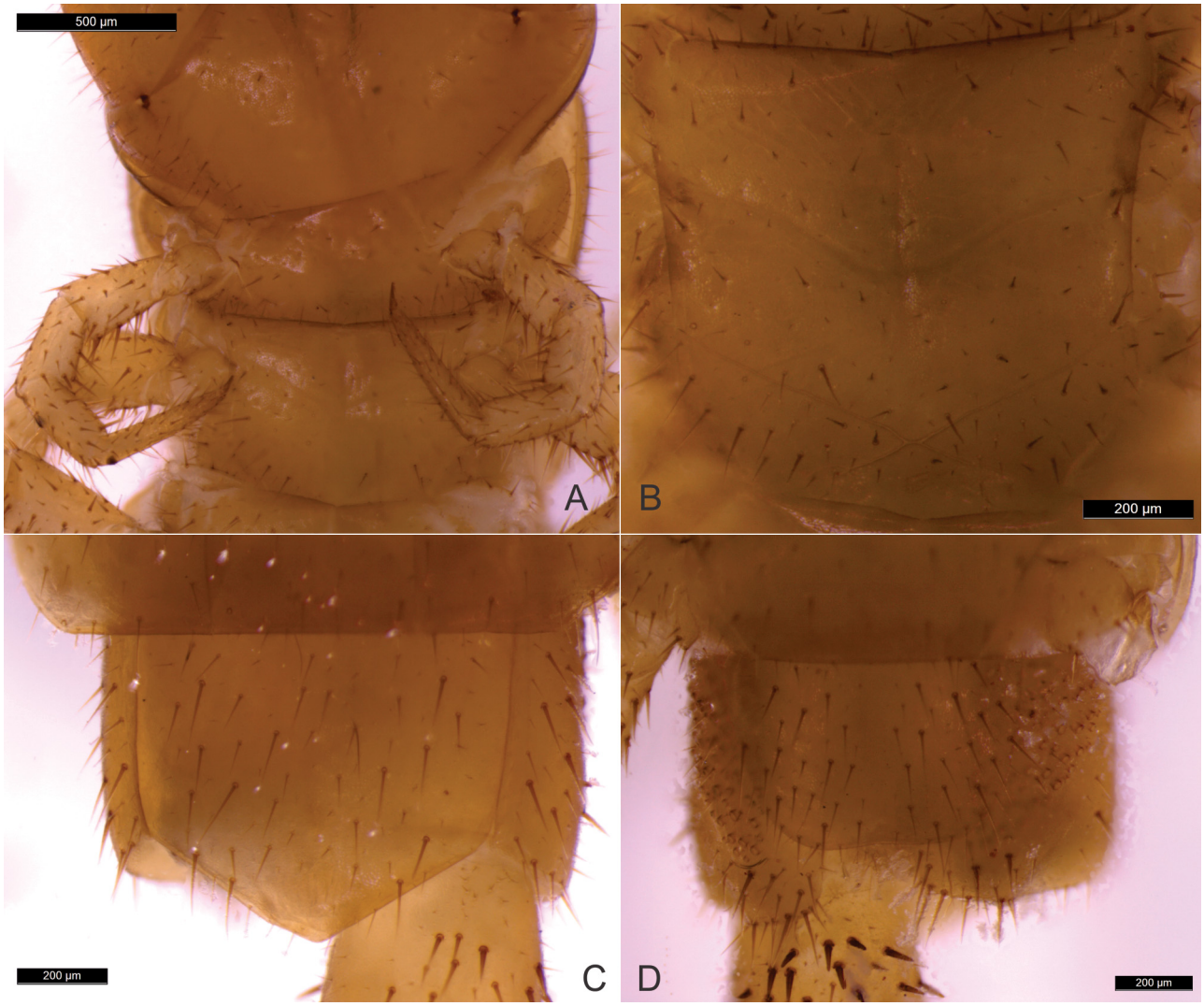

FIGURE 5. ***C***. (***T***.) ***hephaestus*** **n. sp.** (ISLA 3998): A) Tergite 1–2 and leg 1; B) sternite 4; C) dorsal view of ultimate tergite; D) ventral view of ultimate leg-bearing segment.

Anterior edge of forcipular coxosternite convex on each side, with a row of 9+9 marginal setae. Surface of coxosternite and trochanteroprefemur with sparse, long or short, fine setae, with the long setae concentrated on inner margin. Single band of setae of various length on femur and tibia. Tarsungulum articulated with trochanteroprefemur along a wide hinge (Figure 4D).

Apical claw of second maxilla with slender hook distally, lacking a flange along its inner edge. Dorsal brush dense, running along the distal half of article 3 (Figure 6C).

Tergite 1 with complete anterior transverse suture hidden under cephalic plate. Tergites 3–20 with complete paramedian sutures. Lateral crescentic sulci on tergites 11–17; tergites 5 to 7 with a posterior transverse suture and a small depression between the paramedian sutures. Tergites 2–7 with complete anterior oblique sutures; tergites 1–3 with complete posterior oblique sutures. All tergites with homogeneous short and long setae; pretergites 2–20 with a transverse row of long setae. Tergite 21 1.5 times as wide as long, posterior margin with rounded apex; shallow longitudinal median depression along its posterior two-thirds (Figure 5C).

Spiracles elongate, elliptical.

Legs short and thin, e.g., leg 10 with prefemur 0.6 mm long, femur 0.4 mm, tibia 0.3 mm, tarsus 1 0.3–0.3 mm, tarsus 2 0.2–0.3 mm, compared to tergal width of 1.5–1.7 mm. Tarsi 1–19 slightly bipartite, 20–21 strongly bipartite. Leg 1 with strong to weak lanceolate setae on prefemur, femur and tibia, and tarsus with long fine setae (Figure 5A); from leg 2, following the same pattern, but with strong lanceolate setae concentrated on the ventral region of prefemur to tibia. Leg 20 prefemur and femur about equally long; tarsus 2 0.6 times as long as tarsus 1

(Figure 6A). Ultimate leg: prefemur 1.3–1.4 mm long, femur 1.3–1.4 mm, tibia 0.9 mm, tarsus 1 0.6–0.7 mm, tarsus 2 0.9 mm; prefemur and femur 2 and 2.5 times as long, respectively, as their maximum widths at distal end; femur, prefemur, and tibia lacking distal spinose processes; prefemur and femur with spiniform setae on ventral region; prefemur to tarsus 2 with short, long and fine setae on all surfaces (Figure 6B); 8–9 saw teeth on tibia, 3–4 on tarsus 1; inner margin of tarsus 2 a ridge (Figure 6E). Pair of accessory spines of pretarsus on legs 1–20 diverging, one third the length of pretarsus (Figure 6D); accessory spines lacking on ultimate leg.

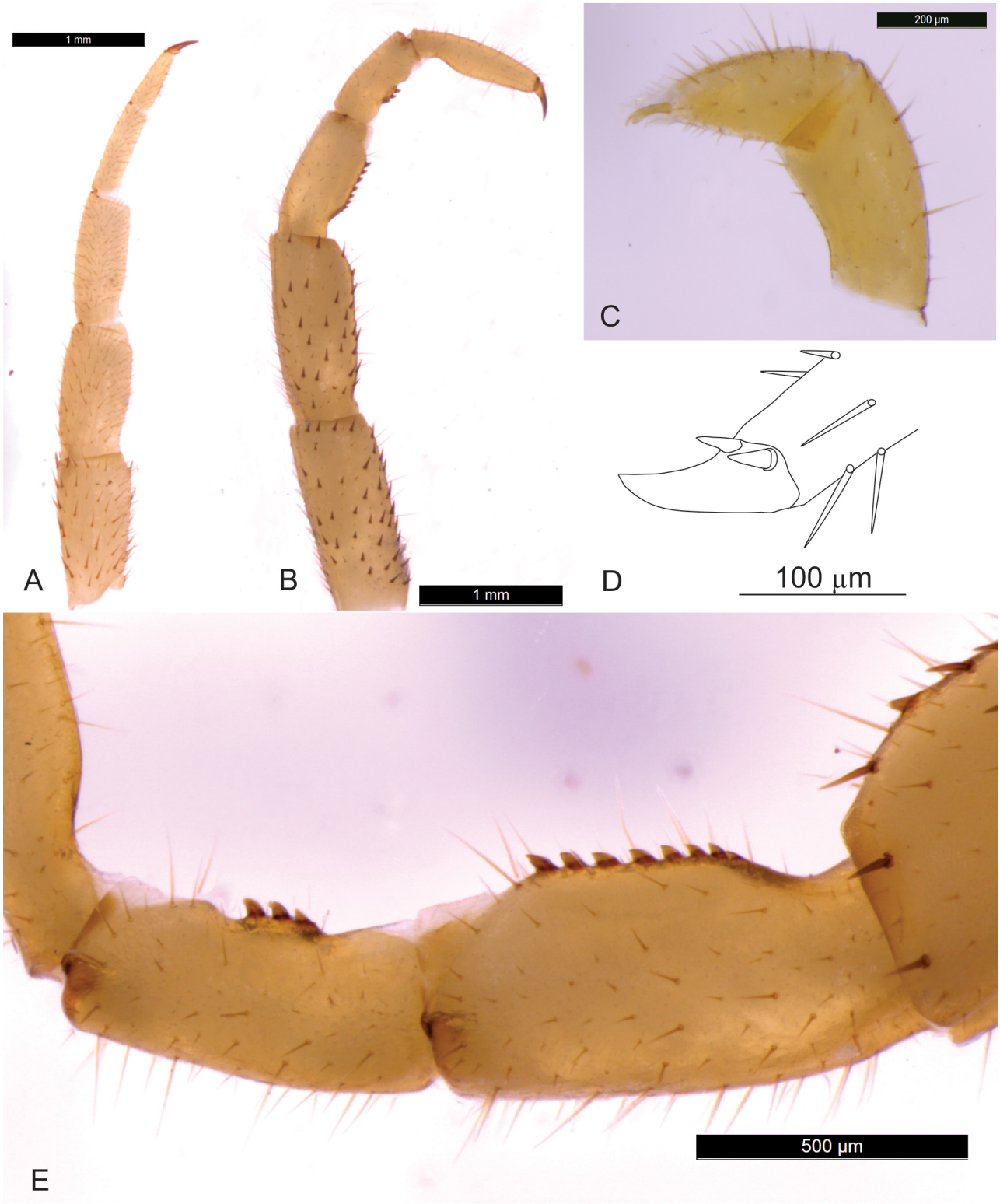

FIGURE 6. ***C.*** **(*T.*)** ***hephaestus*** **n. sp.** (ISLA 3998): A) Lateral view of leg 20; B) lateral view of leg 21; C) telopodite of second maxilla; D) pretarsus of leg 10; E) saw-teeth on tibia and tarsus 1 of ultimate leg, lateral view.

Sternites 3–19 with median longitudinal and curved transverse sulci, their intersection forming a depression; complete trigonal sutures on tergites 4–9 (Figure 5B); sternite of ultimate leg-bearing segment with sides gently convex and converging posteriorly; posterior corners rounded. Sternites 1–20 with sparse, short and long setae varying in density on each sternite; sternite 21 with more long setae than the others (Figure 5D). Coxopleural pore field elliptical with about 60 pores and with sparse short setae between the pores; posterior margin of coxopleuron with spiniform and fine setae.

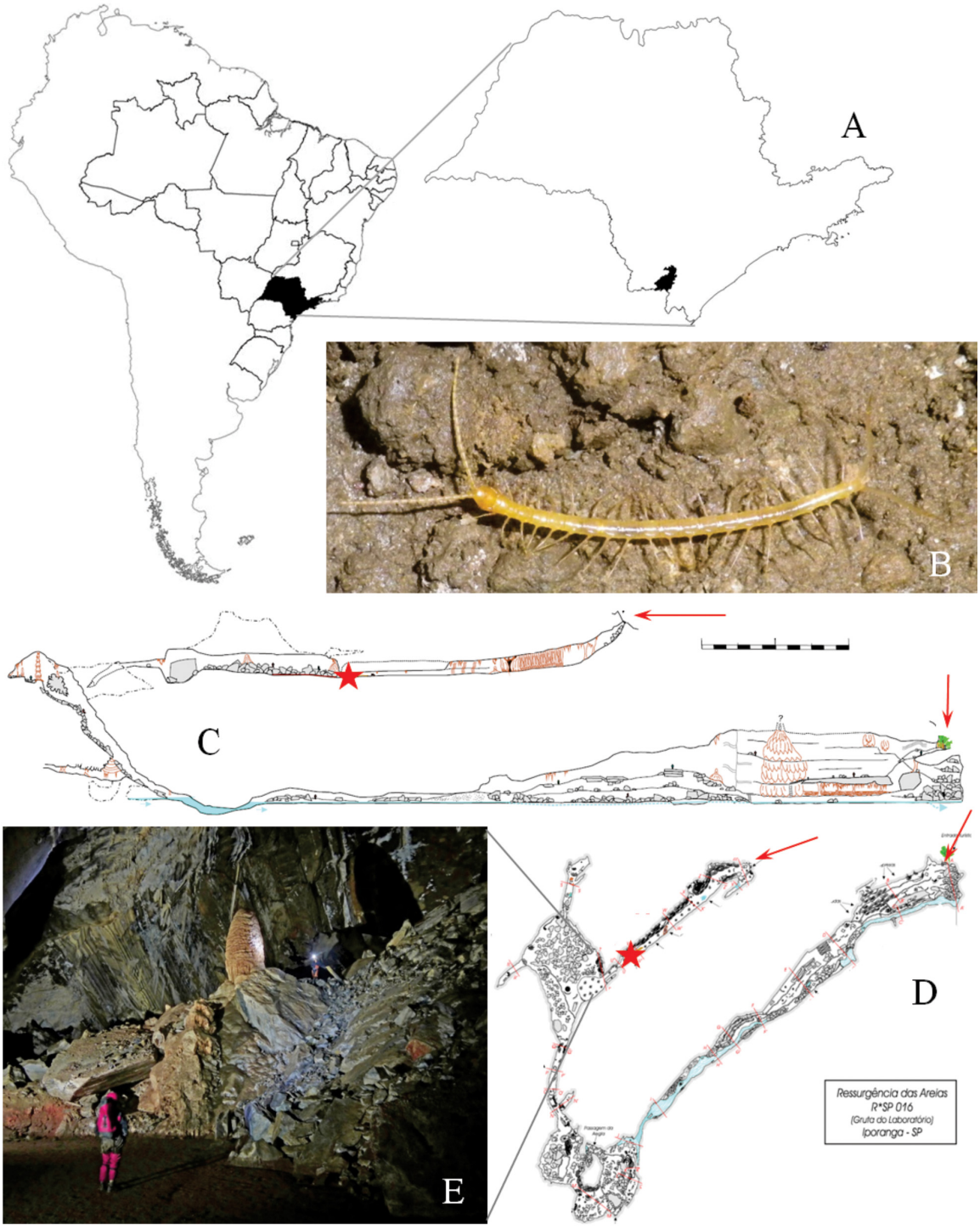

FIGURE 7. A) Map of Brazil and São Paulo State, showing the region of the municipality of Iporanga; B) ***C.*** (***T.***) ***iporangensis* n. sp.**, living specimen inside the cave; C) cave profile and D) cave map of the Ressurgência das Areias cave; in both figures, the arrows indicates the entrances and the red star represent the exact location in which the holotype specimen was found; E) a large hall present in this cave.

Discussion

The Brazilian species *C. (Cryptops) galatheae* was erroneously assigned to the subgenus *Cryptops*. It possesses complete paramedian sutures on the cephalic plate, an anterior setose area on the clypeus delimited by sutures, and trigonal sutures on anterior sternites, characters indicative of membership in *C.* (*Trigonocryptops*), and analyses of molecular sequence data group it with *C.* (*Trigonocryptops*) (G. D. Edgecombe, pers, comm., 2013). Accordingly, it is classified here formally as *C.* (*Trigonocryptops*) *galatheae* Meinert, 1886.

The two new species here described could not be properly compared with other Brazilian species of *Cryptops*, especially due to the lack of detailed morphological information on the very old descriptions of these species. However, some morphological characters could be briefly compared with the other two species of *Cryptops* (*Trigonocryptops*) known from Brazil (Table 1).

TABLE 1. Comparative morphological characters of the species of *Cryptops* (*Trigonocryptops*) from Brazil. Characters of *Cryptops* (*T.*) *galatheae* according to Coscarón (1959), those of *Cryptops* (*T.*) *iheringi* according to Bücherl (1942).

	Cryptops (*T.*) *galatheae*	*Cryptops* (*T.*) *iheringi*	*Cryptops* (*T.*) *hephaestus* **n. sp.**	*Cryptops* (*T.*) *iporangensis* **n. sp.**
Paramedian sutures	Complete on tergites 3–21	Complete on tergites 2–20	Complete on tergites 3–20	Incomplete on tergites 2–19
Anterior oblique sutures	Absent	Absent	Complete on tergites 2–7	Absent
Posterior oblique sutures	Absent	Absent	Complete on tergites 1–3	Absent
Trigonal sutures on anterior part of sternites	Present	Present	Present	Absent
Distal spinose processes on ultimate legs	Absent	Absent	Absent	Presents on prefemur, femur and tibia
Number of saw-teeth of ultimate legs	7–8 on tibia and 3–4 on tarsus 1	13–21 on tibia and 5–7 on tarsus 1	8–9 on tibia and 3–4 on tarsus 1	10 on tibia and 5 on tarsus 1

Cryptops (*T.*) *iporangensis* can be separated from all other Brazilian species of the subgenus *Trigonocryptops*, including *C.* (*T.*) *hephaestus*, for the lack complete paramedian sutures on tergites 2–20 and the number of saw-teeth, of which *C.* (*T.*) *iheringi* presents 13–21 on the tibia and 5–7 on tarsus 1, the highest number observed in a non-troglobitic species from Brazil; *Cryptops* (*T.*) *galatheae* presents 7–8 teeth on tibia and 3–4 on tarsus 1, while the new troglobitic species has 10 on the tibia and 5 on tarsus 1. *Cryptops* (*T.*) *hephaestus* can also be separated from other Brazilian species of the subgenus *Trigonocryptops* in that tergites 2–7 have complete anterior oblique sutures and tergites 1–3 have complete posterior oblique sutures.

Cryptops (*T.*) *iporangensis* presents highly troglomorphic characters, including very long trunk, antennae and legs and a high setal density on the cephalic plate and the trunk segments. Such traits also occur, in different degrees, in all described troglobitic species within the genus. *C.* (*T.*) *iporangensis* does not present trigonal sutures on the posterior part of sternites, an absence shared with *C.* (*T.*) *quadrisulcatus uncinulus* Demange, 1963 and *C.* (*T.*) *royi crucisulcatus* Demange, 1963, both described from Guinea and originally included in the subgenus *Paratrigonocryptops* Demange, 1963, which is now regarded as a junior synonym of *Trigonocryptops* (Lewis 2005). However, the new species presents bipartite tarsi, a transverse suture on tergite 1, an anterior setose area on the clypeus delimited by sutures (although it is not completely delimited posteriorly), distal spinose processes on the femur and tibia of ultimate leg, indicating that this species is a member of *Trigonocryptops*.

Cryptops (*T.*) *iporangensis* **n. sp.** differs from all other troglobitic species of *Cryptops*, according to their original description, by not presenting complete paramedian sutures on tergites 2–20, instead having sutures that occupy only the equivalent of one fifth the length of tergite. The new troglobitic species has elongated antennae, 7 times the length of the cephalic plate. The highest antennal elongation in the genus is observed in *C.* (*T.*) *roeplainsensis*, according to the original description, with 8.9 times the length of the cephalic plate. Thus the antennae of *C.* (*T*) *iporangensis* **n. sp.** are relatively long, even when compared with other troglobitic species.

Regarding the saw-teeth on the tibia and tarsus 1 of the ultimate pair of legs, the new troglobitic species presents 10 teeth on the tibia and 5 on tarsus 1, differing from *C*. (*T.*) *roeplainsensis* which presents, according to the original description, the highest number of saw-teeth, 20–25 on the tibia and 11–24 on tarsus 1, and also the lowest *C*. (*T.*) *cavernicolus*, according to the original description, with 11 teeth on the tibia and 1 on the tarsus, has the lowest number of teeth. It also differs from other species in having large distal spinose processes on the tibia (2.5 times as long as the processes on the prefemur and femur), while the other species have, according to their original description, processes of about the same size on the prefemur, femur and tibia.

Ecological remarks. Until recently, caves in ferruginous rocks were not included in biospeleological studies due to their reduced dimensions, which lead to the erroneous assumption that they could only have low biological diversity. However, such caves have revealed extremely complex communities living under peculiar conditions (Ferreira 2005). The caves where the specimens of *C*. (*T.*) *hephaestus* were collected are located in a complex iron ore outcrop regionally known as the "Quadrilátero Ferrífero" (Iron Quadrangle). There are distinct lithotypes in the area, with caves associated with the superficial ferruginous breccia (canga formation), and with the iron ore formations (hematite and itabirite) (Simmons 1963). More than 300 caves are known in the entire area and at least a third of them were investigated in biospeleological surveys (Hoch & Ferreira 2012). However, *C.* (*T.*) *hephaestus* lacks troglomorphic traits and was found in three caves, of which the Mina do Pico 4 and Mina do Pico 7 occurs next to each other and both distant from the cave SPA approximately 50 kilometers, which suggests that eventually the main habitats of the species are not the caves.

The single specimen of *C.* (*T.*) *iporangensis* was collected in the Ressurgência das Areias Cave, Iporanga, São Paulo, Brazil (Figure 7A, C, D). This cave is part of the Areias System, which is divided into three caves connected by the Areias stream. The Ressurgência das Areias cave is the last (downstream) cave in the system, possessing around 1 km of linear projection and a depth of 70 meters, being divided in two conduits, one at the stream level and an upper conduit, where the specimen was found (Figure 7E). The karst of Iporanga is associated to carbonate rocks of the Formation Bairro da Serra, belonging to the Açungui Group, which was formed between the Mesoproterozoic and Neoproterozoic (approximately 1,45 billion and 540 million years ago) corresponding to essentially marine deposits of an ancient continental margin (Campanha & Sadowski 1999, Campanha *et al*., 2008, 2010). The karst system (the caves and associated features) developed during the Quaternary Period (between 1.8 million years and the present) and is still active, although its origin is related to the geomorphological evolution (relief), since the separation of the continents, which began in the Cretaceous (approximately 120 million years ago) (Karmann 1994). To date, 16 troglobitic species (15 invertebrates and 1 vertebrate) have been described for the whole system (Trajano 2007), which is considered the richest system for troglobitic fauna in Brazil. This cave system has been studied for over 100 years and only in recent samplings a single specimen of this new species was found (Figure 7B), which strongly suggests its extreme rarity.

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