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Title: A new species and new records of *Pseudolebinthus* crickets from Malawi
(Orthoptera, Gryllidae, Eneopterinae)

Running title: *Pseudolebinthus* from Malawi

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Abstract

Recent studies have suggested that the diversity of orthopteran insects in the Eastern African region is largely undersampled and understudied, resulting in numerous new species and genera awaiting discovery, while many species are known from only one or few records, preventing precise assessment of the threat to them. In this paper we describe the new species *Pseudolebinthus ntchisi* **sp. nov.** from Central Malawi and present new records about two other *Pseudolebinthus* species from Malawi, with biological information and illustrations of this genus based on field observations.

Keywords. Xenogryllini, new species, new record, taxonomy, Afrotropical region

Introduction

Recent studies about both katydids and crickets have suggested that many orthopteran insects are unrecorded or understudied in the Eastern African region (e.g., Hemp *et al.*, 2018; Hemp and Heller, 2019; Naskrecki and Guta, 2019). This is particularly true for the crickets of this area, which have received very limited taxonomic attention during the last decades. For example, a single recent field trip in Malawi allowed the re-discovery of two previously described species of the genus *Pseudolebinthus* Robillard, in addition to the discovery of the new species *P. lunipterus* Salazar *et al.* which shows striking new morphological features, such as absence of auditory tympana and stridulatory organs in males (Salazar *et al.* 2020).

In this paper we pursue the taxonomic exploration of the genus *Pseudolebinthus* started in the recent revision of Jaiswara *et al.* (2018a). We present new records about two species from Malawi, original biological information and illustrations of this genus based on field observations, and describe the new species *Pseudolebinthus ntchisi* **sp. nov.** from Central Malawi.

Materials and methods

Material

The new collected material comes from a field expedition in Malawi in September and October 2018 under the collection and export permit number EAD-12-07-087-18-20a and from the personal collection of R.J.M. Specimens are deposited in the collections of Muséum national d'Histoire naturelle, Paris (MNHN). In lists of material, square brackets are used for additional information not mentioned on specimen labels or for translation of key information present on labels in languages other than English.

Taxonomic description

Description of species follows terminologies as proposed by Robillard *et al.* (2014). Observations of external morphological characters and dissection of male and female genitalia were performed using Leica stereomicroscopes MZ16. Terminologies for male FW venation follow Ragge (1995) and Robillard & Desutter-Grandcolas (2004). Male

genitalia were dissected by making a small slit between paraproct and subgenital plate. Female copulatory papilla was dissected by cutting the membrane between ovipositor and subgenital plate. Dissected genitalia were cleared in 10% cold KOH solution and preserved in glass vials containing glycerine. Terminologies for genitalia follow Desutter (1987), modified in Desutter-Grandcolas (2003) and Robillard and Desutter-Grandcolas (2004). Imaging of male and female genitalia were made using an AmScope MU1000 digital camera (www.Amscope.com). To highlight the structural components of male and female genitalia, water solution containing a drop of JBL Punktol was used. To fix orientations and stabilization of genitalia for photography, a clear and viscous Power Plast Hand Sanitizer was used following Su (2016).

Abbreviations used in taxonomic descriptions

General morphology: FI, FII, FIII, fore, median, hind femur; FW, forewing; TI, TII, TIII, fore, median, hind tibia; TaI/II/III-1: basal segment of fore, median and hind leg tarsomere. Tegminal venation: 1A-4A, first to fourth anal veins; CuA, anterior cubitus; CuP, posterior cubitus; M, median vein; R, radial vein; Sc, subcostal vein and its projections.

Measurements: (in mm, except for spine numbers, Table 3) BL, body length in dorsal view, from fastigium to apex of abdomen; FIIL, length of FII; FIILW, width of FII; TIIL, length of TII; FWL, forewing length; FWW, forewing width (at the level of maximal width at about 1/3 of FWL); Ias, inner spines on TIII dorsal side above the spurs; Ibs, inner spines on TIII dorsal side between the spurs; Oas, outer spines on TIII dorsal side above the spurs; Obs, outer spines on TIII dorsal side between the spurs; OL, ovipositor length; PronL, pronotum length; PronW, pronotum width; TaIIIs, spines of third hind tarsomere, not including the apical spines; Ids, inner dorsal spines; Ods, outer dorsal spines; Ols, outer spines on lateral side of TaIII.

Systematic part

Orthoptera

Gryllidae

91 **Eneopterinae** Saussure, 1874

92 **Xenogryllini** Robillard, 2004

93 **Genus *Pseudolebinthus*** Robillard, 2006

94 *Pseudolebinthus* Robillard, 2006: 672 - Robillard and Desutter-Grandcolas, 2008: 67;
95 Vicente *et al.*, 2017: 2202 (historical biogeography); Cigliano *et al.*, 2019 (Orthoptera
96 Species File Online); Jaiswara, *et al.*, 2018: 265; Salazar *et al.*, 2020: 1.

97

98 Type species: *Pseudolebinthus africanus* Robillard, 2006

99

100 ***Pseudolebinthus whellani*** Robillard, 2006

101 (Figs 1-2; 8AC)

102 *Pseudolebinthus whellani* Robillard, 2006: 679 - Cigliano *et al.*, 2019 (Orthoptera Species
103 File Online); Jaiswara, *et al.*, 2018: 265.

104

105 **Type material.** Male holotype: **Malawi.** Zomba Mountain, 28.ii.1964, Min. Agr. Rhod.,
106 ex-Nyas collection, Salisbury, S.R., accession no. 11775 (Whellan), identified *Lebinthus*
107 *whellani* by L. Chopard (NHMUK). [examined]

108 **Type locality.** Malawi, Zomba Mountain.

109 **New material examined.** **Malawi.** Mount Zomba, summit near recreational center
110 (MAL9), S15°21'11.3" E35°18'1.3", 1480 m, 7-8.x.2018, T. Robillard, K. Salazar & R.J.
111 Murphy: 1♂, plante, molecular sample X35, enregistrement appel F0-♂1, video
112 copulation (MNHN-ENSIF-EO10735); 1♂, adulte en élevage, enregistrement appel F0-
113 ♂2 (MNHN-ENSIF-EO10739); 1♂, adulte en élevage, enregistrement appel F0-♂3,
114 video copulation (MNHN-ENSIF-EO10736); 5♀, 4♂, adultes en élevage F0; 2 juveniles,
115 sur plante [on vegetation], TR131 (MNHN). Mount Zomba, base [**new record**], propriété
116 de John Wilson (MAL10), S15°22'16.0" E35°19'27.4", 1024 m, 8.x.2018, nuit, T.
117 Robillard, K. Salazar & R.J. Murphy: 1♀, TR146, sur plante basse en bord de sentier [on
118 low plant along trail], adulte en élevage [adult in captivity], molecular sample X40
119 (MNHN-ENSIF-EO10737); 1♀, TR147, adulte en élevage [adult in captivity], plante

(MNHN). S. Malawi, Ruo River, Mt. Mulanje, 950 m [new record] 15°58'S 35°39'E, R. Murphy, 18.xi.2019, 1♂, molecular sample X43 (MNHN-ENSIF-EO10748), 1♂, 1♀ (MNHN).

Distribution. Southern Malawi.

Diagnosis. See Jaiswara *et al.* (2018a).

Additional description.

Female. FWs longer than in other members of the genus, short and triangular (Fig. 1B), with 8-11 strong longitudinal veins (n=4), including 3-4 dorsal veins, 3-5 lateral veins, separated by a yellowish band including two whitish veins converging apically. Abdomen dark brown. Ovipositor clearly longer than FIII.

Female copulatory papilla. (Fig. 8AC) Triangular, its apex pointed; sclerotization strong dorsally, lighter ventrally; tip of apex membranous, slightly folded ventrally.

Female measurements (in mm). See Table 1.

Life history traits. *Pseudolebinthus whellani* juveniles and adults were found in high density at night on low vegetation in herbaceous areas near forest hedge or in open areas along trails in forest (Figs 1-2). They have been found active and abundant at night on top of vegetation despite low temperature (less than 10°C at 10-12PM).

***Pseudolebinthus gorochovi* Robillard, 2018**

(Figs 3-4)

Pseudolebinthus sp. – Vicente *et al.* 2017: 2203 (historical biogeography).

Pseudolebinthus gorochovi Robillard, 2018 – Jaiswara *et al.* 2018b: 265; Salazar *et al.* 2020: 4.

Type material. Male holotype: **Malawi.** N. Malawi, 100 km N. Mzuzu, Uzumara Mt. 10°52'18"S 34°07'45"E, 1930 m, 21-22.xii.2010, A. Sochivho leg, molecular sample X17 (ZIN). Female allotype: **Tanzania.** Tanganyika-Terr., Matengo-Hochland wsw.v. Songea, Ugano 15[00]-1700 m [Mbinga], 20-30.xi.[19]35, Zerny, identified *Lebinthus*

148 *zernyi* by L. Chopard (NHMW). Paratype: **Tanzania**. 1♀, same information as allotype
149 (MNHN-EO-ENSIF4389). [examined]

150 **Type locality.** Malawi, Mount Uzumara, 10°52'18"S 34°07'45"E, 1930 m.

151 **New material examined. Malawi.** N. Malawi, Mount Uzumara, S°1052'19.3"
152 E.34°07'44.7"E, 1941 m, 2-4.x.2018, T. Robillard, K. Salazar & R.J. Murphy: 1♂,
153 TR127, nuit, sur plante, molecular sample X27 (MNHN-EO-ENSIF10732); 3♂, adultes
154 en élevage (MNHN); 1♀, adulte en élevage, molecular sample X41 (MNHN-EO-
155 ENSIF10733); 6♀, adultes en élevage (MNHN); 1 juvenile, molecular sample X29
156 (MNHN-EO-ENSIF10734); 2 juveniles (MNHN). N. Malawi, Nikhorongo village [**new**
157 **record**], property of R. J. Murphy, S11°22'58.3" E33°58'57.3" -MAL4), 1353 m, 4-
158 5.x.2018, 1♂, nuit, adulte en élevage, plante, échantillon moléculaire X31, enregistrement
159 appel, T. Robillard, K. Salazar & R.J. Murphy (MNHN-EO-ENSIF10744); N. Malawi,
160 Nikhorongo Mzuzu, 11°23'S 33°59'E, 1♀ 30.i.2013, R.J. Murphy (MNHN).

161 **Distribution.** Northern Malawi.

162 **Diagnosis and description.** See Jaiswara *et al.* (2018a).

163 **Remark.** Specimens collected in Mount Uzumara show two different colouration
164 patterns already visible in the juvenile late instars: some have uniformly brown bodies,
165 while some specimens have two sub-median yellow dorsal bands (Fig. 3B). Males with a
166 dark band collected as juveniles become similar as others adults, while adult females keep
167 the same colouration pattern as the juveniles, giving dark-bodies females similar to the
168 type specimens described in Jaiswara *et al.* (2018b), and lighter females with the banded
169 pattern.

170 **Life history traits.** *Pseudolebinthus gorochovi* juveniles and adults were found in high
171 density at night on low vegetation in herbaceous areas, near forest hedge or sometimes in
172 open areas along trails in forest (Fig. 4).

173

174 ***Pseudolebinthus lunistrius* Salazar, Murphy, Guillaume, Nattier & Robillard, 2020**

175 *Pseudolebinthus lunistrius* Salazar, Murphy, Guillaume, Nattier & Robillard, 2020: 1.

Type material. Male holotype: **Malawi**. N. Malawi, Mt. Uzumara, 6500 ft. R.J. Murphy col. 2.i.2001 (MNHN-EO-ENSIF10715). Female allotype: **Malawi**. Same information as holotype (MNHN-EO-ENSIF10716). Paratypes (9♂, 6♀): **Malawi**. Same information as holotype, 1♂, #233RJM (MNHN-EO-ENSIF10717). N. Malawi, Mount Uzumara (MAL1), S10°52'19,3"E34°07'44,7", 1941 m (MAL1), 2-4.x.2018, nuit [night], plante, élevage F0 [collected as juveniles on plant, reared to final moult in captivity], T. Robillard, K. Salazar & R. J. Murphy: 3♂, molecular sample X34, X45, X28 (MNHN-EO-ENSIF10718-10720); 2♂, video of mating behaviour (♂3, ♂4) (MNHN-EO-ENSIF10721-10722); 3♂ (MNHN-EO-ENSIF10721-10722); 2♀, video of mating behaviour (♀1, ♀3) (MNHN-EO-ENSIF10723-10724); 4♀ (MNHN-EO-ENSIF10725-10728). [examined]

Type locality. North Malawi, Mount Uzumara, S10°52'19,3" E34°07'44,7", 1941 m.

Distribution. Northern Malawi.

Diagnosis and description. See Salazar *et al.* (2020).

***Pseudolebinthus ntchisi* sp. nov.**

(Figs 5-8D-F)

Type material. Male Holotype: **Malawi**. C.[Central] Malawi, Ntchisi forest, 5000 ft, 24.xi.-2.xii.2000, R.J. Murphy, det. Ref. No.229, molecular sample X32 (MNHN-EO-ENSIF10728). Female allotype: **Malawi**. Same information as HT, det. Ref. No.226. (MNHN-EO-ENSIF10729). Paratypes (3♂, 1♀), **Malawi**. Same information as HT and AT: 3♂ (MNHN-EO-ENSIF10740-10742), 1♀, molecular sample X33 (MNHN-EO-ENSIF10743).

Diagnosis. Species close to *P. gorochovi*, from which it differs by a larger size and stockier shape, male genitalia, details in male and female FW venations and shape of female papilla. Male FW dorsal field rounded apically; cell c1 wide anteriorly, thin posteriorly; c2 rectangular; Sc with one projection at one third of its length (two in *P. gorochovi*, three in *P. africanus*, four in *P. whellani*). Male genitalia with lophi forming an intermediate shape between that of *P. gorochovi* and *P. whellani*: thinner and more elongate than in *P. gorochovi*, but with apex bilobate as in *P. whellani* (not in *P.*

gorochovi). Female FWs longer than in *P. gorochovi*, close to *P. whellani*, with nine strong longitudinal veins (five in *P. gorochovi*). Female with two yellow bands on dorsal part of abdomen; ovipositor rather short, as long as FIII (longer in *P. whellani* and *P. gorochovi*); copulatory papilla rectangular basally (thinner and triangular in *P. whellani* and *P. gorochovi*).

Description. Species of large size for the genus, shape stocky, coloration mostly brown, with dark brown, black and yellow patterns (Fig. 5). Vertex (Fig. 6A) with four faint longitudinal dark brown bands on dorsum, more marked basally; area posterior to eyes yellow with a thin dark brown band. Fastigium as long as wide, slightly thinner apically (as in *P. whellani* and *P. gorochovi*), dark brown with a wide apical yellow transverse stripe. Median ocellus underlined by a black mark posteriorly. Face brown (Fig. 6B) variously mottled with dark brown, always including two large black patterns on frons below yellow apex of fastigium, forming a black transverse band dorsally; two black spots below antennae. Mouthparts yellow, mottled with dark brown; maxillary palpi yellow with dark rings. Posterior margin of head in lateral view more or less densely mottled with black spots; area below eyes yellow. Scapes yellow brown with black patterns on facial part. Antennae first article black, then yellow brown. Pronotum disc mostly golden brown with yellow lateral margins; lateral lobes dark brown, posterior corner yellow mottled with black. Fore and median legs mostly yellow brown, femora with dark spots and tibiae with a faint median brown ring; apex of tibiae and tarsomeres black. FIII external face bicolor, its dorsal half dark brown, its ventral half yellow; TIII dark brown, TaIII-1 black.

Male. FWs cells and veins dark brown (Fig. 5A). 1A angle forming a wide curve. CuP visible in anterior region of harp. Harp very wide, with two characteristic dark brown swollen oblique veins. Mirror as in *P. whellani*, well differentiated but not rounded, wider than long, crossed by an incomplete accessory veins. Cell c1 wide basally, thinner apically; c2 large and rectangular, twice wider than c1, prolonging shape of mirror. Chord cells curved. Apical field short and rounded apically, with faint transverse veins. Base of 1A and CuA with a yellow sclerotization; M/R area and veins yellow dorsally, then dark brown; R/Sc area dark brown (including R and Sc). Sc with one projection at one third of its length. Lateral field with five longitudinal veins ventral to Sc.

Male genitalia (Fig. 7). Pseudephiphallic sclerite slightly wider than long (not including rami); pseudephiphallic lophi of average length, twisted ventro-apically, wide and divergent basally, thinner and slightly convergent apically; their apex clearly bilobate, with a wide ventral lobe and a small dorsal expansion on dorsal lobe. Pseudephiphallic parameres typical of the genus. Ectophallic fold wide basally. Ectophallic apodemes large and lamellate.

Female. FWs short and triangular, with nine strong longitudinal veins, three dorsal, four lateral, separated by a yellowish band including two whitish veins converging apically. Abdomen dark brown, with two parallel sub-median yellow bands (Fig. 5CD). Ovipositor short and wide, as long as FIII, its apex little differentiated.

Female copulatory papilla (Fig. 8D-F). Rectangular basally, its apex pointed. Basal region very sclerotized ventrally; apex sclerotized ventrally, its dorsal side with lateral folds coming from ventral sclerotization; tip membranous, folded ventrally.

Measurements (in mm). See Table 2.

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Table Legends

Table 1. Measurements of *Pseudolebinthus whellani*. Male holotype measurements from Robillard (2006). Legends: see Materials and methods section.

Table 1. Measurements of *Pseudolebinthus whellani*

	BL	PronL	PronW	FWL	FWW	FIII L	FIII W	
Holotype male	?	2.4	4	6.8	3.4	10.9	3.2	
Females (n=5)	14.9-18.5	2.5-2.8	3.5-4.4	1.2-1.9	-	12.5-15	3.7-3.8	
(Female mean)	(16.4)	(2.7)	(3.9)	(1.5)	-	(13.8)	(3.7)	
	TIII L	TIII s				TaIII s		OL
		Ias	Ibs	Oas	Obs	Ods	Ols	
Holotype male	10.3	?	?	?	?	5	4	-
Females (n=5)	11.4-12.7	5-9	8-11	10-16	10-12	4-5	2-4	14.4-17.2
(Female mean)	(12.1)	(7)	(9)	(13)	(11)	(5)	(3)	(15.9)

Table 2. Measurements of *Pseudolebinthus ntchisi* Robillard sp. nov.

Legends: see Materials and methods section.

Table 2. Measurements of *Pseudolebinthus ntchisi* sp. nov.

	BL	PronL	PronW	FWL	FWW	FIII L	FIII W	
Holotype male	17.2	2.3	3.2	6.5	3.7	11.8	3.2	
Males (n=4)	14.2-17.2	2.1-2.3	3.2-3.6	5.7-6.5	3.5-3.7	11.1-12.2	3.2-3.6	
(Male mean)	(15.4)	(2.2)	(3.4)	(6.2)	(3.6)	(11.7)	(3.4)	
Female allotype	14.2	2.2	3.9	1	-	12.2	3.5	
Female paratype	14.5	2.2	3.5	1.3	-	12.2	3	
(Female mean)	(14.4)	(2.2)	(3.4)	(1.2)	-	(12.2)	(3.3)	
	THIL	THIs				TaIIs		OL
		Ias	Ibs	Oas	Obs	Ods	Ols	
Holotype male	11.5	7	9	11	11	4	3	-
Males (n=4)	9.5-11.5	7-8	8-11	11-12	9-11	3-4	2-3	-
(Male mean)	(10.7)	(8)	(9)	(11)	(10)	(4)	(2)	-
Female allotype	11	6	9	8	11	4	2	12.6
Female paratype	11.2	6	8	11	9	3	3	12.2
(Female mean)	(11.1)	(6)	(9)	(10)	(10)	(4)	(3)	(12.4)

Figure legends

Figure 1. (A-B). *Pseudolebinthus whellani*; male (A) and female (B) habitus on vegetation in Mount Zomba (Malawi).

Figure 2. (A-C). *Pseudolebinthus whellani*; (A) herbaceous secondary habitat near summit of Mount Zomba (Malawi); (B) illustration of dense population, showing 3 juveniles on the same plant, on low vegetation at night in Mount Zomba; (C) juvenile on flower at night.

Figure 3. (A-B). *Pseudolebinthus gorochovi*; male (A) and female light variant (B) habitus on vegetation in Mount Uzumara (Malawi).

Figure 4. (A-D). *Pseudolebinthus gorochovi*; herbaceous habitat near forest hedge on Mount Uzumara (Malawi); (B) late juvenile instar on plant at night; (C-D) males on leaf little or low vegetation at night.

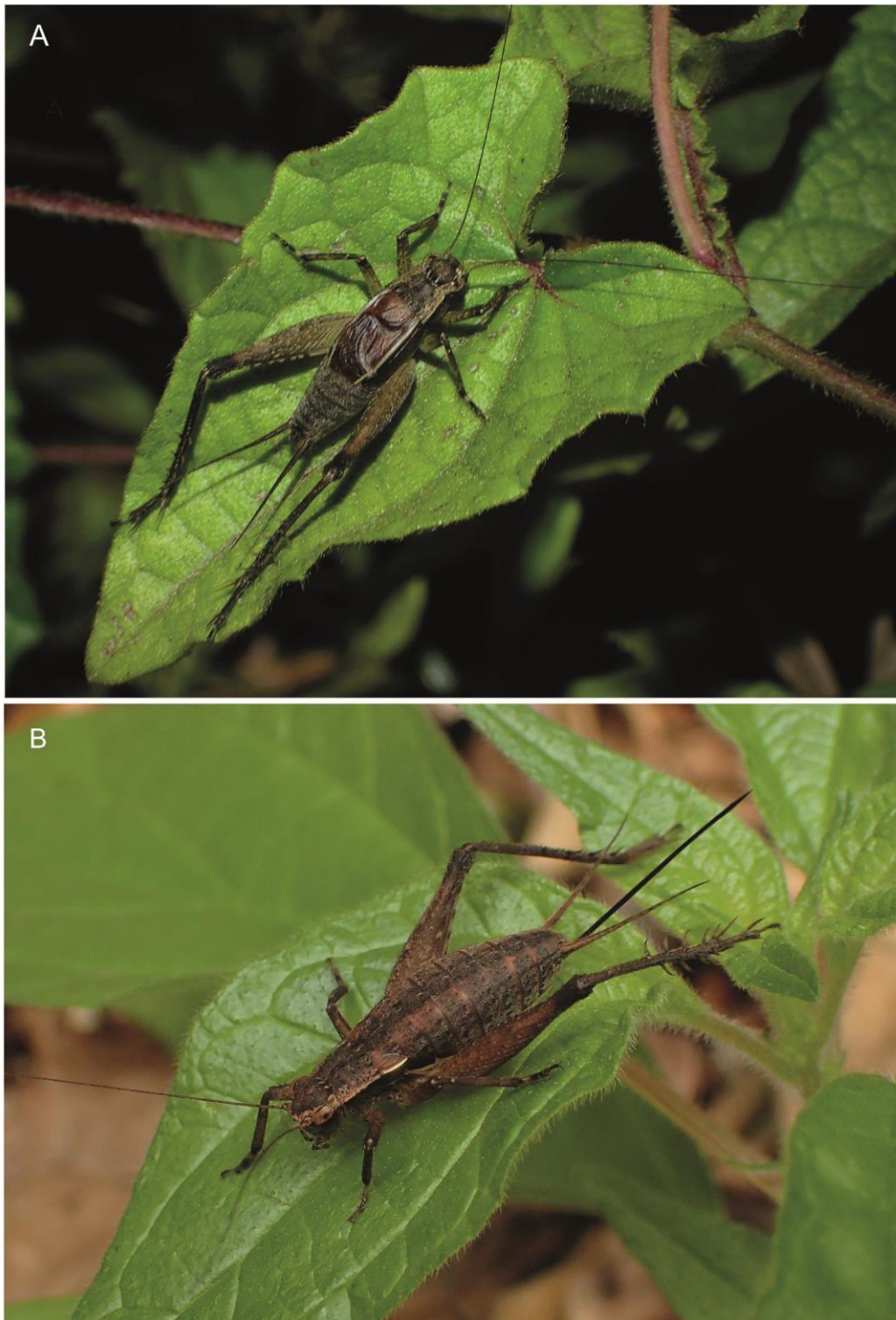
Figure 5. (A-D) *Pseudolebinthus ntchisi* sp. nov.: male in dorsal (A) and lateral (B) views, female in dorsal (C) and lateral (D) views. Scale bar: 5 mm.

Figure 6. (A-B) *Pseudolebinthus ntchisi* sp. nov.: head in dorsal (A) and facial (B) views. Scale bar: 1 mm.

Figure 7. (A-D) *Pseudolebinthus ntchisi* sp. nov.: male genitalia in dorsal (A) and ventral (B) views; details of pseudepiphallus lophi in dorsal (C) and lateral (D) views. Scale bars: A-B, 1 mm; C-D, 0.5 mm.

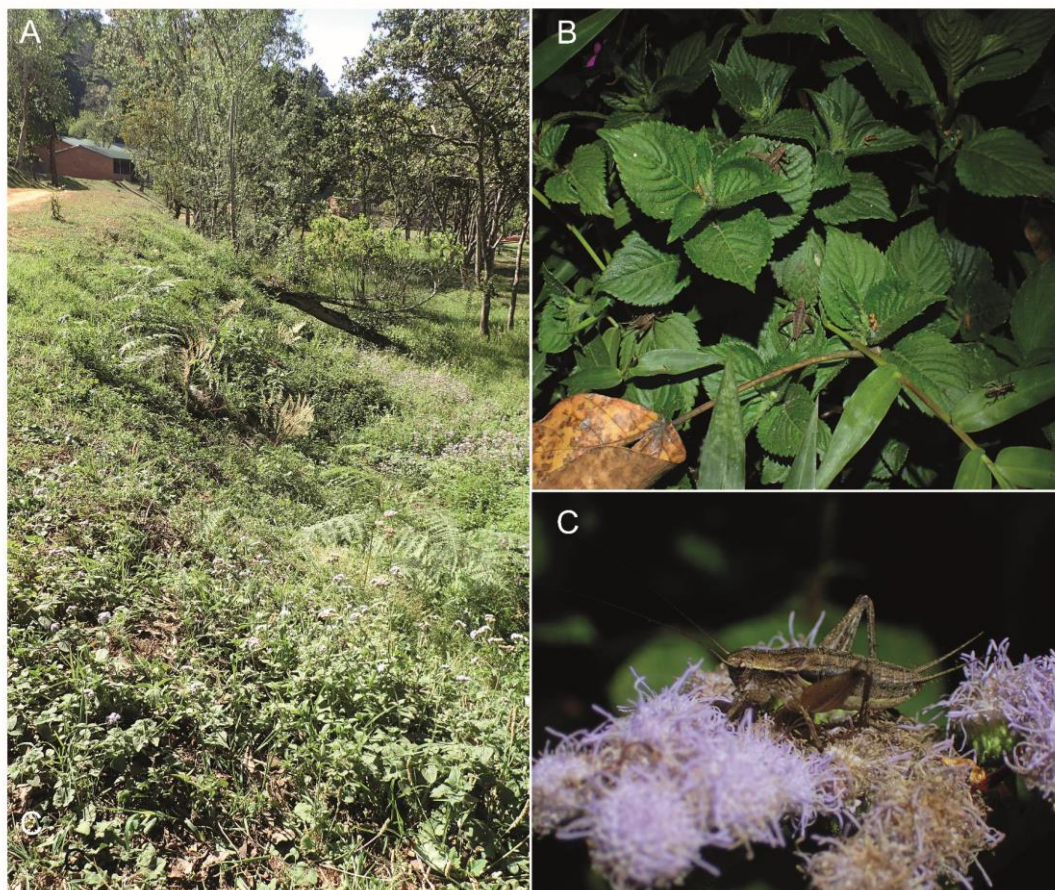
Figure 8. (A-F). Female genitalia of *Pseudolebinthus whellani* (A-C) and *Pseudolebinthus ntchisi* sp. nov. (D-F) in dorsal (A, D), ventral (B, E) and lateral (C, F) views. Scale bar: 0.5 mm.

334 Fig1.
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336

337 Fig.2
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340 Fig.3
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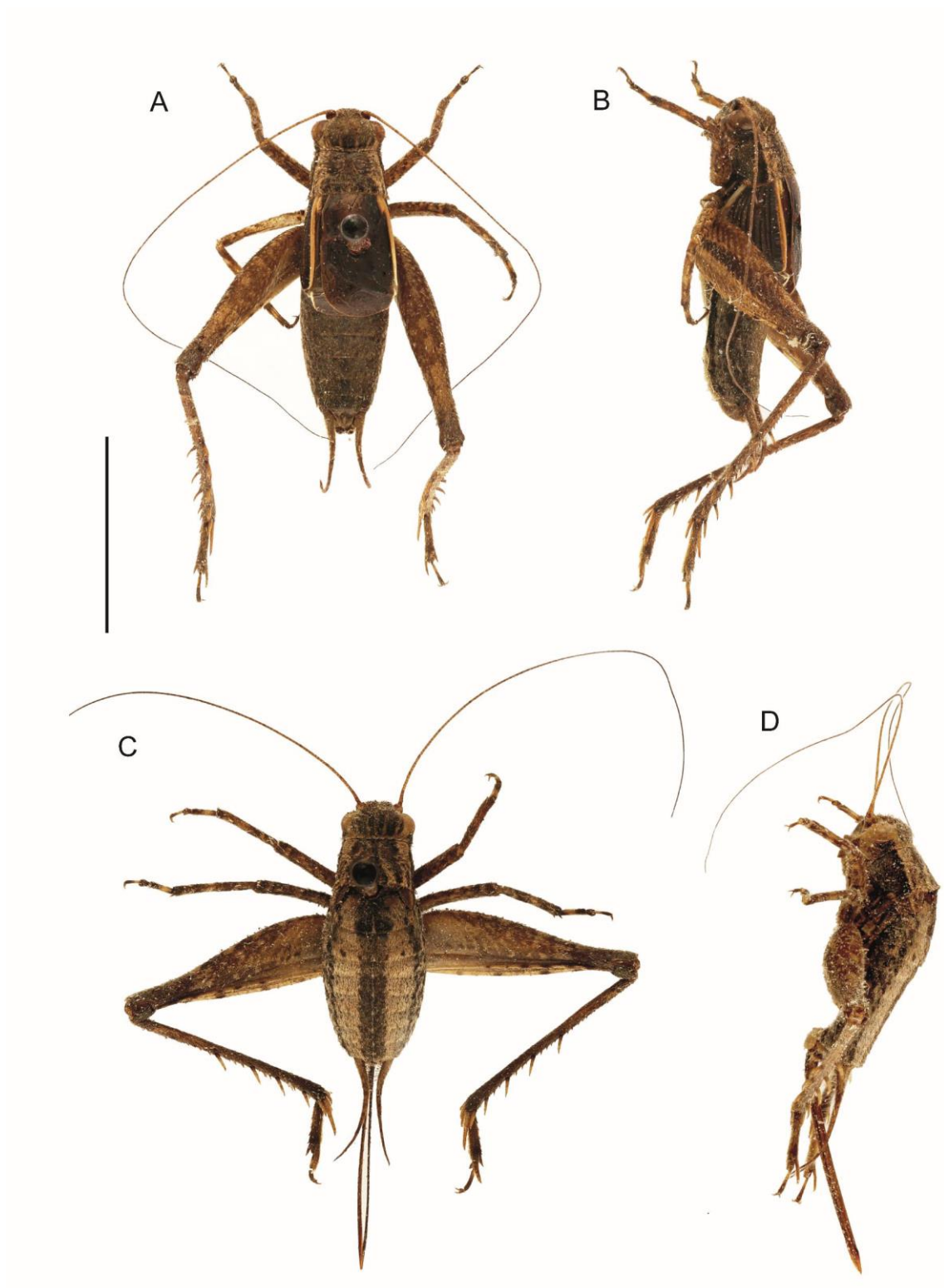
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343 Fig. 4
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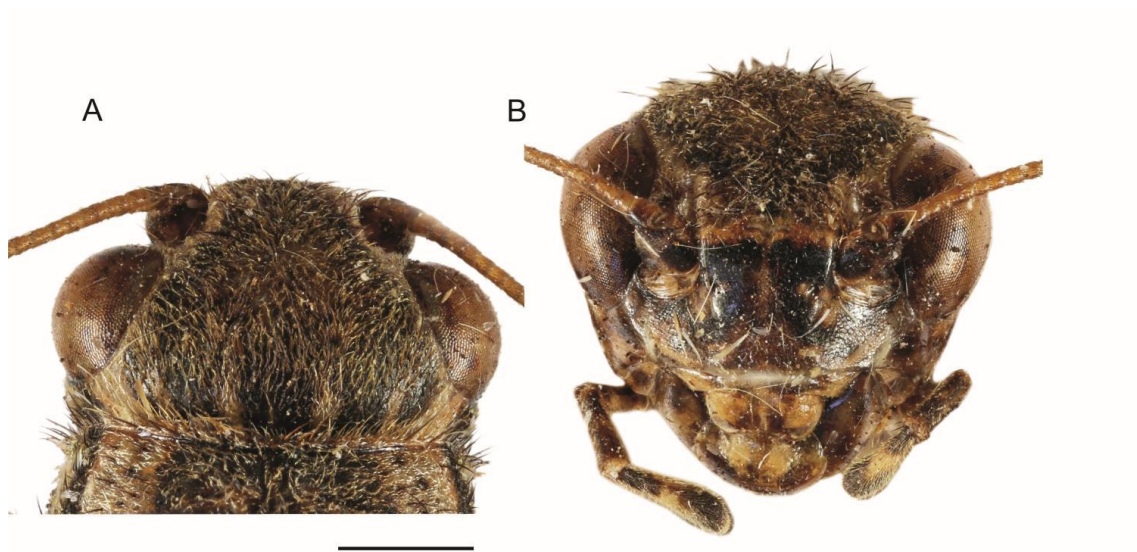
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346 Fig. 5.
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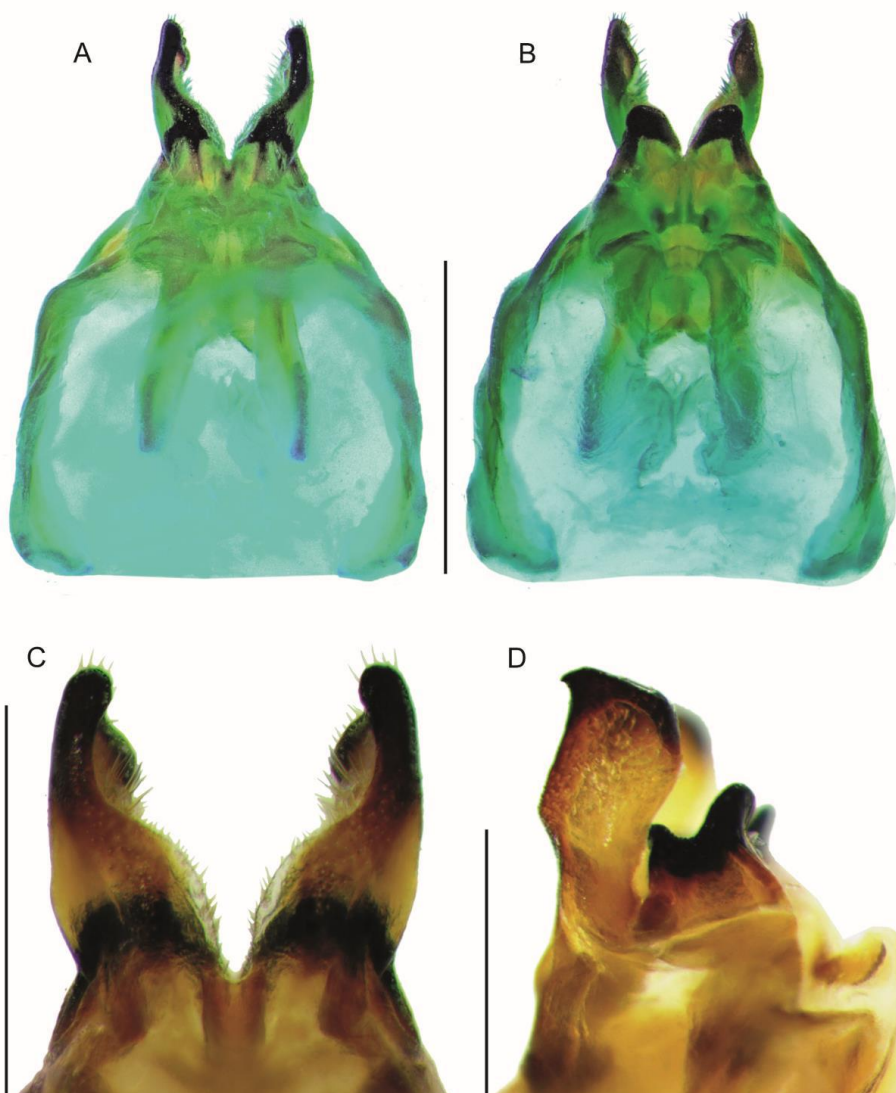
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349 Fig. 6
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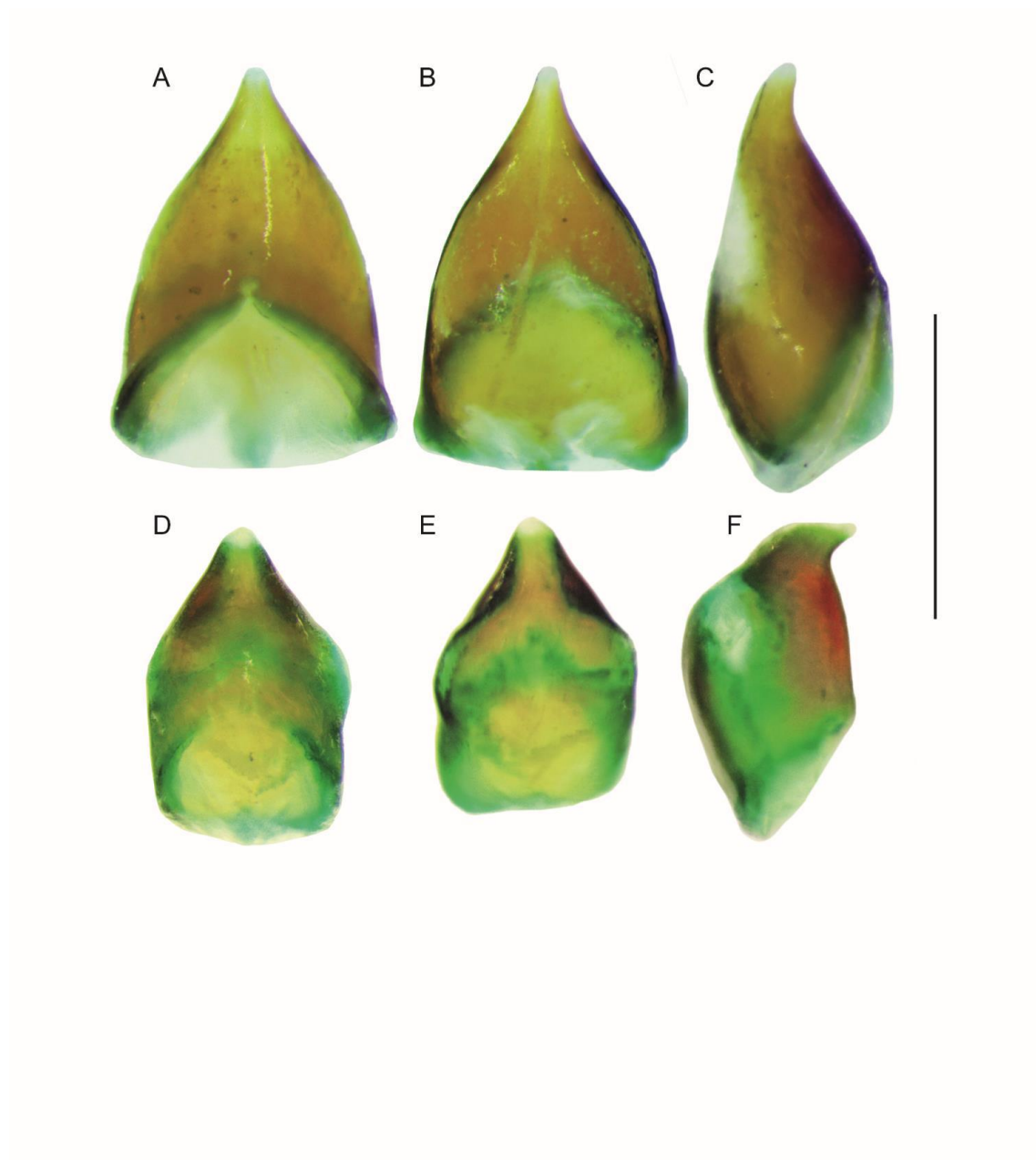
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352 Fig. 7
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355 Fig. 8.
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