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Revision of the genus *Pseudolebinthus* (Orthoptera, Gryllidae, Eneopterinae) with the description of a new species from Southeast Africa

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Abstract

Pseudolebinthus is an intriguing genus of the tribe Xenogryllini with a distribution restricted to southeast Africa and characterized by unique morphological features such as asymmetrical male forewings and harp veins shaped as elongated balloons. It is sister group to the widely distributed genus *Xenogryllus* and has been known by two species, *P. africanus* Robillard, 2006 and *P. whellani* Robillard, 2006. The genus was initially diagnosed based exclusively on male morphological features. In this study, we add a new species to the genus, *P. gorochovi* Robillard sp. nov. and revise the diagnostic features using both male and female characters. We also update identification keys for the species of the genus.

Key words: Xenogryllini, taxonomy, endemic distribution, *Xenogryllus*, Afrotropical region

Introduction

Subfamily Eneopterinae is known for its disjunct distribution (Vicente *et al.* 2017); its members are either endemic to a geographical region or islands (Nattier *et al.* 2012; Dong *et al.* 2018) or widely distributed across continents (Robillard & Ichikawa, 2009; Jaiswara *et al.* in press). Genus *Pseudolebinthus* Robillard, 2006 is one of the endemic taxa, found only from few places in the southeast of Africa.

Pseudolebinthus is an intriguing genus known from very few specimens and characterized by unique morphological features such as asymmetrical male forewings and harp veins shaped as elongated balloons. Phylogenetic studies based on morphological (Robillard 2006) and molecular markers (Vicente *et al.* 2017) revealed that *Pseudolebinthus* is sister to the widely distributed genus *Xenogryllus*. Until now, the genus included two species, *P. africanus* Robillard, 2006 and *P. whellani* Robillard, 2006, known only by males.

In this study, we carry out a taxonomic revision of *Pseudolebinthus* and enrich the species list by describing a new species, *Pseudolebinthus gorochovi* Robillard sp. nov. from southeast Africa. In addition to male characters, female sex is described, including external and genitalic characters to append the diagnostic features of the genus.

Material and methods

Material. The material examined comes from the following natural history collections: Museum national d'Histoire naturelle, Paris, France (MNHN); Natural History Museum, London, United Kingdom (NHMUK); Naturhistorisches Museum, Vienna, Austria (NHMW); Zoological Institute, Russian Academy of Sciences, S. Petersburg, Russia (ZIN).

In lists of materials, 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 and female genitalia were dissected either from dry preserved or freshly killed specimens. 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 & Desutter-Grandcolas (2004). Imaging of male and female genitalia were made using an AmScope MU1000 digital camera (www.Amscope.com) or with a Canon EOS 40D Digital SLR camera. 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; Tarsomere I/II/III-1: basal segment of fore, median and hind leg tarsomere.

Tegminal venation: 1A–4A, first to fourth anal veins; CuA, anterior cubitus; CuA1, CuA2, ... first, second, ... branches of CuA; CuP, posterior cubitus; M, median vein; R, radial vein; Sc, subcostal vein and its branches; c1–3, first to third cells of C alignment; d1 cell (mirror), first cell(s) of D alignment; d2, second cell of D alignment; e1, first cell of E alignment.

Species abbreviations used in figures: Paf, *Pseudolebinthus africanus*; Pwh, *Pseudolebinthus whellani*; Pgo, *Pseudolebinthus gorochovi* sp. nov.

Systematic part

Orthoptera

Gryllidae

Eneopterinae Saussure, 1874

Xenogryllini Robillard, 2004

Genus *Pseudolebinthus* Robillard, 2006

Type species: *Pseudolebinthus africanus* Robillard, 2006

Pseudolebinthus Robillard, 2006: 672—Robillard & Desutter-Grandcolas 2008: 67; Vicente *et al.* 2017: 2202 (historical biogeography); Cigliano *et al.* 2018 (Orthoptera Species File Online).

Emended diagnosis. Genus with species of small size, differing from *Xenogryllus* by shorter FWs, long and slender abdomen, male FWs asymmetrical, venation with unique swollen oblique veins. Eyes larger than in *Xenogryllus*, located laterally. Fastigium forming a wide rectangular rostrum, little prominent on face. Face flat when viewed laterally. Pronotum dorsal disc almost rectangular, its lateral margins not carinated, its posterior margin straight. TII with one inner apical spur. FIII wide basally, shorter and more muscular than in *Xenogryllus*.

Male. Metanotal glandular structures well developed, as in *Xenogryllus*. FWs short, not reaching mid-length of abdomen and not widened basally as in *Xenogryllus*. FW cells smooth, without longitudinal wrinkles on its surface. Left and right FWs asymmetrical, left darker and more sclerotized than right, thin and transparent. File vein with a rounded angle. Harp with characteristic swollen oblique veins (shaped as elongated balloons) and without incomplete oblique vein between diagonal and first complete oblique (incomplete veins present in *Xenogryllus*); harp distal angle flat. CuA vein at the bottom of a deep longitudinal furrow. Mirror small, wider than long, not rounded. Cell d2 not differentiated. Apical field very short, made only of few cells of E alignment. Hind wings present but shorter than FWs. *Male genitalia*. Pseudepiphallic sclerite shorter than rami; lateral membranous lobes present but narrow; basal margin straight and thickened. Pseudepiphallic lophi parallel, well sclerotized dorsally, membranous ventrally; lophi shrunk at mid-length, their basis twice as wide as apical part, their apex usually bilobate, the dorsal lobe ended by a small dorsal expansion. Pseudepiphallic parameres with wide and short conical ornamentation, trilobate, the posterior lobes forming a hook oriented posteriorly. Ectophallic apodemes long, forming wide triangular lamellas. Ectophallic arc faint, slightly sclerotized medially. Ectophallic fold short and triangular, reaching basis of pseudepiphallic parameres; with two lateral sclerites; not fused to endophallic sclerite as in *Xenogryllus*. Endophallic sclerite wide and flat, trifid posteriorly, its median part triangular and short, lateral parts long, reaching basis of ectophallic apodemes. Endophallic apodeme comprising mostly two wide lateral lamellas.

Female. FWs very short, forming lateral triangles not reaching posterior margin of first tergite. Ovipositor apex almost not differentiated, long and lanceolate. Female copulatory papilla triangular, its apex very thin and pointed.

Additional description. In addition to the characters described by Robillard (2006), the female sex is described here for the first time.

Female. General shape similar to male (Fig. 1C–D). FWs very short (Fig. 3B), shorter than in males, forming small lateral sclerotized triangles not reaching posterior margin of first tergite; with strong longitudinal veins and faint transverse ones. Abdomen very long and thin. Subgenital plate with a weak apical indentation (Fig. 6B). Ovipositor flattened laterally, apex

almost not differentiated, long and lanceolate (Fig. 6A).

Female copulatory papilla (Fig. 6C–E). Triangular, its apex very thin and pointed; sclerotization strong except apex, membranous.

Distribution. Eastern Sub-Saharan Africa

Key to known species of *Pseudolebinthus*

1. Dorsal margin of eye with small ommatidia thin. Male FW venation: mirror small, hardly distinct from surrounding cells. Male genitalia: pseudepiphallic lophi long and thin (Fig. 5C) *P. africanus* Robillard, 2006
- Dorsal margin of eye with small ommatidia wider. Male FW venation: mirror larger, wider than long, well differentiated. Male genitalia: pseudepiphallic lophi shorter 2
2. Coloration little contrasted; FIII homogeneously brown on external face. Male FW venation: c1 and c2 cells sub-equal, thin. Vein Sc with four projections along its length. Male genitalia: apex of pseudepiphallic lophi bilobate (Fig. 5B) *P. whellani* Robillard, 2006
- Coloration more contrasted; FIII external face bicolor, dorsal half dark brown, ventral half yellow. Male FW venation: c1 cell wide, c2 twice wider than c1, square and prolonging shape of mirror. Vein Sc with two projections along its length. Male genitalia: apex of pseudepiphallic lophi twisted ventrally, not bilobate (Fig. 5A) *P. gorochovi* Robillard sp. nov.

Pseudolebinthus africanus Robillard, 2006 (Fig 5C)

Pseudolebinthus africanus Robillard, 2006: 677—Cigliano *et al.* 2018 (Orthoptera Species File Online)

Material examined. Holotype. ZIMBABWE: ♂, Mt. Melsester 5000 ft [1500 m], Melsester Dist. Dept. Agric. S. Rhodesia. xi.1957, accession no. 11776 (Whellan) identified *Lebinthus africanus* by L. Chopard (NHMUK, Brit Mus 1982–221).

Paratype. ZIMBABWE: 1♂, Chirinda Forest, Melsester Dist. Dept. Agric. S. Rhodesia. x.1948, accession no. 11774 (Whellan) 1# identified *Lebinthus africanus* by L. Chopard (MNHN-EO-ENSIF10684).

Type locality. Zimbabwe, Mount Melsester 5000 ft.

Distribution. Zimbabwe

Diagnosis. (Emended from Robillard 2006). Coloration contrasted; FIII uniformly brown. Dorsal margin of eyes with small ommatidia thin.

Male. Scutellum basal edge sharply raised. FW dorsal field with strong transverse veins. Mirror small, hardly distinct from surrounding cells and crossed by one strong accessory vein; c1 twice as long as c2. Sc with three projections along its length (four in *P. whellani*, two in *P. gorochovi* sp. nov.).



FIGURE 1. (A–D) *Pseudolebinthus gorochovi* sp. nov.: male in dorsal (A) and lateral (B) views, female in dorsal (C) and lateral (D) views. Scale bar: 5 mm.

Male genitalia. Pseudepiphallal lophi (Fig. 5C) longer and thinner than in *P. whellani*, their apical lobes almost completely fused, as in *P. gorochovi* sp. nov. Median part of endophallic sclerite well developed.

Pseudolebinthus whellani Robillard, 2006
(Figs 2D–F; 5B)

Pseudolebinthus whellani Robillard, 2006: 679—Cigliano *et al.* (2018) (Orthoptera Species File Online).

Material examined. Holotype. MALAWI: ♂, Zomba Mountain, 28.ii.1964, Min. Agr. Rhod., ex-Nyas collection, Salisbury, S.R., accession no. 11775 (Whellan), identified *Lebinthus whellani* by L. Chopard (NHMUK).

Type locality. Malawi, Zomba Mountain.

Distribution. Southern Malawi.

Diagnosis. Emended from Robillard (2006). Brown coloration little contrasted; FIII uniformly brown. Dorsal margin of eyes with small ommatidia wide.

Male. Basal edge of scutellum slightly raised. FW dorsal field with faint transverse veins. Mirror larger than in *P. africanus*, well differentiated and crossed by an incomplete accessory vein. c1 cell as long as c2. Vein Sc with four projections along its length (three in *P. africanus*, two in *P. gorochovi*). *Male genitalia.* Pseudepiphallal lophi (Fig. 5B) shorter and wider than in *P. africanus*, with two apical lobes well developed, the dorsal one oriented posteriorly, the ventral one oriented inward.

Pseudolebinthus gorochovi Robillard sp. nov.
(Figs 1A–D; 2A–C; 3A–B; 4A–C; 5A; 6A–E; Table 1)

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

Material examined. 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).

Allotype. TANZANIA: ♀, Tanganyika-Terr., Matengo-Hochland wsw.v. Songea, Ugano 15[00]–1700 m [Mbinga], 20–30.xi.[19]35, Zerny, identified *Lebinthus zernyi* by L. Chopard (NHMW).

Paratype. MALAWI: 5♂, same locality as holotype, 2–4.x.2018, T. Robillard, K. Salazar, R.J. Murphy (MNHN). TANZANIA: 1♀, same information as allotype (MNHN-EO-ENSIF4389).

Type locality. Malawi, Uzumara Mount, 100 km N. Mzuzu, 10°52'18"S 34°07'45"E, 1930 m.

Distribution. Northern Malawi, Western Tanzania.

Life history traits and calling song. Unknown.

Etymology. The species is dedicated to Dr. Andrej Gorochov.

Diagnosis. Species close to *P. whellani*, from which it differs by contrasted coloration, FIII external face bicolor, male venation and genitalia.

Male. FW dorsal field with faint transverse veins; cell c1 wide; c2 square, twice wider than c1, prolonging shape of mirror (c1 and c2 of similar width and smaller in *P. whellani*). Sc with two projections at one third of its length and near apex (three in *P. africanus*, four in *P. whellani*). Male genitalia with very short pseudepiphallal lophi, twisted ventro-apically as in *P. africanus*; their apex not bilobate (Fig. 5A), as in *P. africanus* (apex bilobate in *P. whellani*).

Description. Species of average size for the genus, coloration contrasted, mostly orange brown with dark brown, black and yellow patterns (Fig. 1A–D). Eyes large, lateral, occupying almost half of head height in lateral view (Fig. 2A & C); dorsal margin of eyes with small ommatidia wide. Vertex with four wide longitudinal dark brown bands fused on dorsum (bands visible basally only); area posterior to eyes yellow, without brown bands. Fastigium as long as wide (Fig. 2B), slightly thinner apically than in *P. africanus* (as in *P. whellani*), dark brown with a yellow transverse stripe apically. Median ocellus surrounded by a black mark posteriorly. Face almost homogeneously brown with faint pale spots; frons with a yellow transverse band below median ocellus, underlined by two back spots (forming a black transverse band in female allotype). Mouthparts yellow, mottled with dark brown; maxillary palpi yellow with dark rings. Lateral part of head dark brown with a median yellow spot;

posterior margin of head and area below eye yellow. Scape yellow brown with black patterns on facial part. Antennae with first article black, remainder orange brown. Pronotum disc mostly dark brown, with a darker spot near posterior margin; lateral lobes black with silver setae, with a yellow spot on ventro-anterior corner; posterior corner yellow mottled with black. Fore and median legs mostly yellow brown; apex of tibiae and tarsomeres black. FIII external face bicolor, its dorsal half dark brown, its ventral half yellow.

Male. FWs brown, with dark brown veins (Fig. 3A). 1A angle forming a wide curve. CuP visible in anterior region of harp. Harp very wide, with two characteristic black swollen oblique veins. Mirror as in *P. whellani*, well differentiated but not rounded, wider than long, crossed by incomplete accessory veins. Cell c1 wide basally, thinner apically; c2 large and square, twice wider than c1, prolonging shape of mirror. Chord cells straight. Apical field with faint transverse veins. M/R area and veins whitish. R/Sc area whitish dorsally (including R), black ventrally (including Sc). Sc with two projections at one third of its length. Lateral field with five longitudinal veins ventral to Sc.

Male genitalia (Fig. 4A–C). Pseudepiphallic sclerite wider than long (not including rami); pseudepiphallic lophi very short (Fig. 5A), divergent basally and slightly convergent apically, their median part twisted ventro-apically; apex with a very small dorsal expansion. Pseudepiphallic parameres typical of the genus, its posterior lobes short. Ectophallic apodemes large and lamellate. Endophallic sclerite with a small median area.

Female. FWs with five strong longitudinal veins (Fig. 3B), the median one whitish. Ovipositor as long as FIII.

Measurements (in mm). See Table 1.

TABLE 1. Measurements of *Pseudolebinthus gorochovi* Robillard sp. nov.

	BL	PronL	PronW	FWL	FWW	FIII L	FIII W		
Holotype male	14.7	2.3	3.5	6.3	3.4	11.7	3.4		
Female allotype	13.4	2.2	3	0.6	-	10.7	2.7		
Female paratype	13.4	2	3.4	0.7	-	10.7	3.2		
	TIII L	TIII s				Tall s			OL
		las	lbs	Oas	Obs	Ids	Ods	Ols	
Holotype male	9.9	11	10	14	11	0	4	4	-
Female allotype	?	?	?	?	?	?	?	?	11.2
Female paratype	9.7	6	9	12	10	0	4	4	11.6

Legends: BL, body length in dorsal view; FIII L, length of FIII; FIII W, width of FIII; TIII L, length of TIII; FWL, forewing length; FWW, forewing width (at the level of maximal width at about 1/3 of FWL); las, inner spines on TIII dorsal side above the spurs; lbs, 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; Tall s, 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 Tall s.

Discussion

Despite extensive studies based on large collections to revise the *Xenogryllini* genera (Jaiswaira *et al.* in press), very little information is available concerning *Pseudolebinthus*. This genus is distributed only in the South Eastern part of Africa, in Malawi, Tanzania and Zimbabwe, and the three documented species show a high endemism. Although no ecological data is available about any of the species, the few localities from where they are reported correspond to low altitude mountains covered with forests. We can thus hypothesise that the species have a forested habitat similar to that of most brachypterous *Lebinthini* (Robillard *et al.* 2016). Such habitats could in turn be responsible for more restricted distributions than for species of *Xenogryllus*, explaining why so few specimens are documented.

Given the morphological and distributional particularities of *Pseudolebinthus*, it is necessary to obtain additional information about the biology, ecology and bioacoustics of these remarkable species. Such information is mandatory to pursue the exploration of the systems of communication and their evolution, investigated at the scale of the subfamily Eneopterinae (e.g., Robillard & Desutter-Grancolas 2004; ter Hofstede *et al.* 2015).

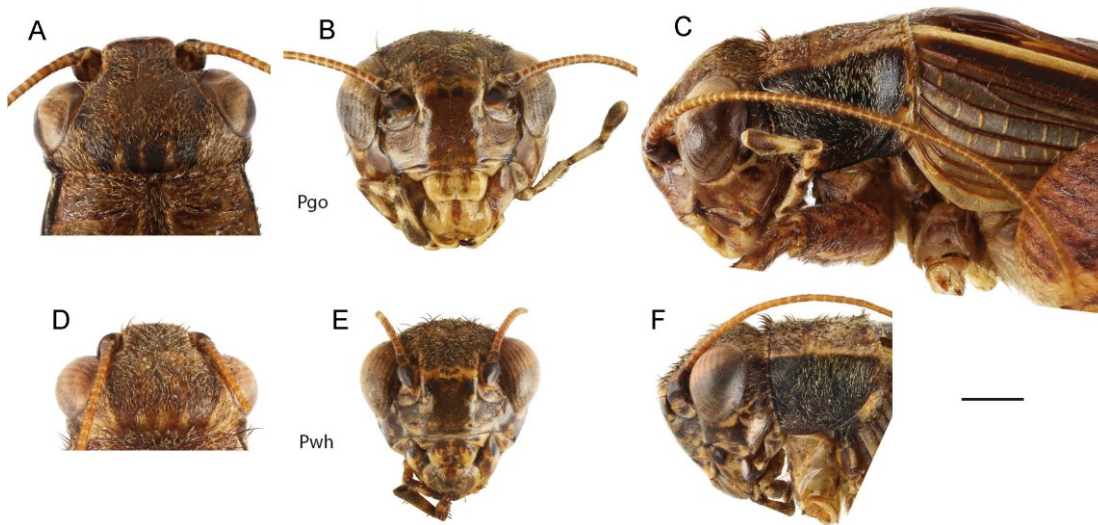


FIGURE 2. Head in dorsal (left), facial (middle) and lateral views (right): (A–C) *Pseudolebinthus gorochovi* sp. nov. (D–F) *Pseudolebinthus whellani*; Scale bar: 1 mm.

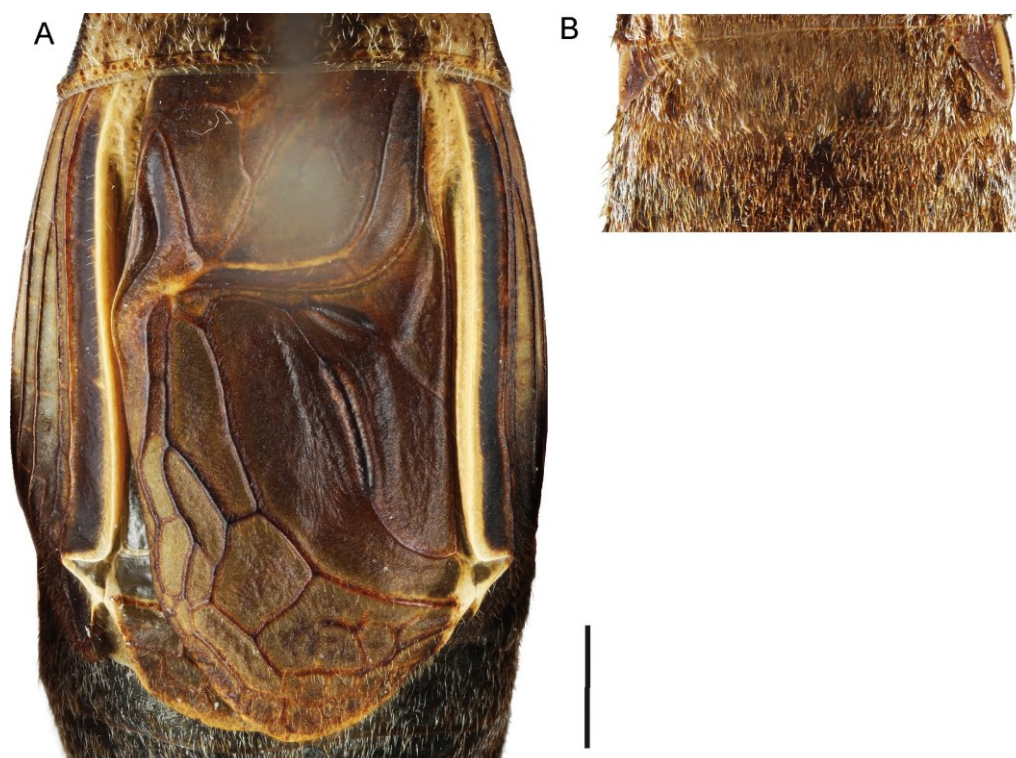


FIGURE 3. *Pseudolebinthus gorochovi* sp. nov. forewings in dorsal view: (A) male; (B) female. Scale bar: 1mm.

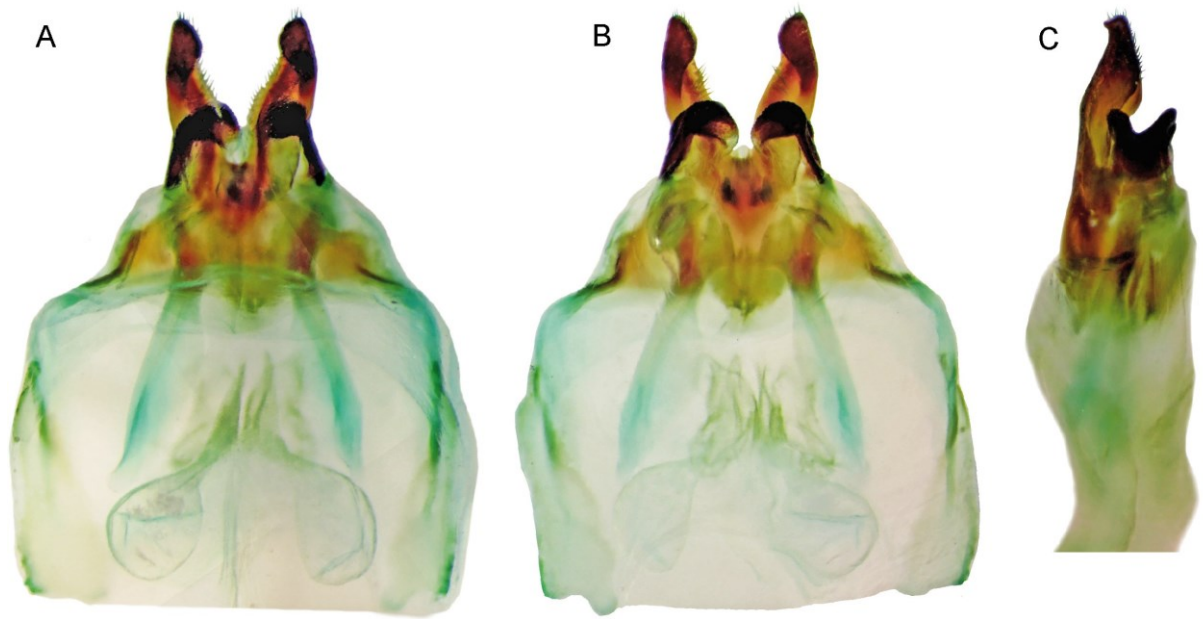


FIGURE 4. Male genitalia of *Pseudolebinthus gorochovi* sp. nov. in dorsal (A), ventral (B) and (C) lateral views.

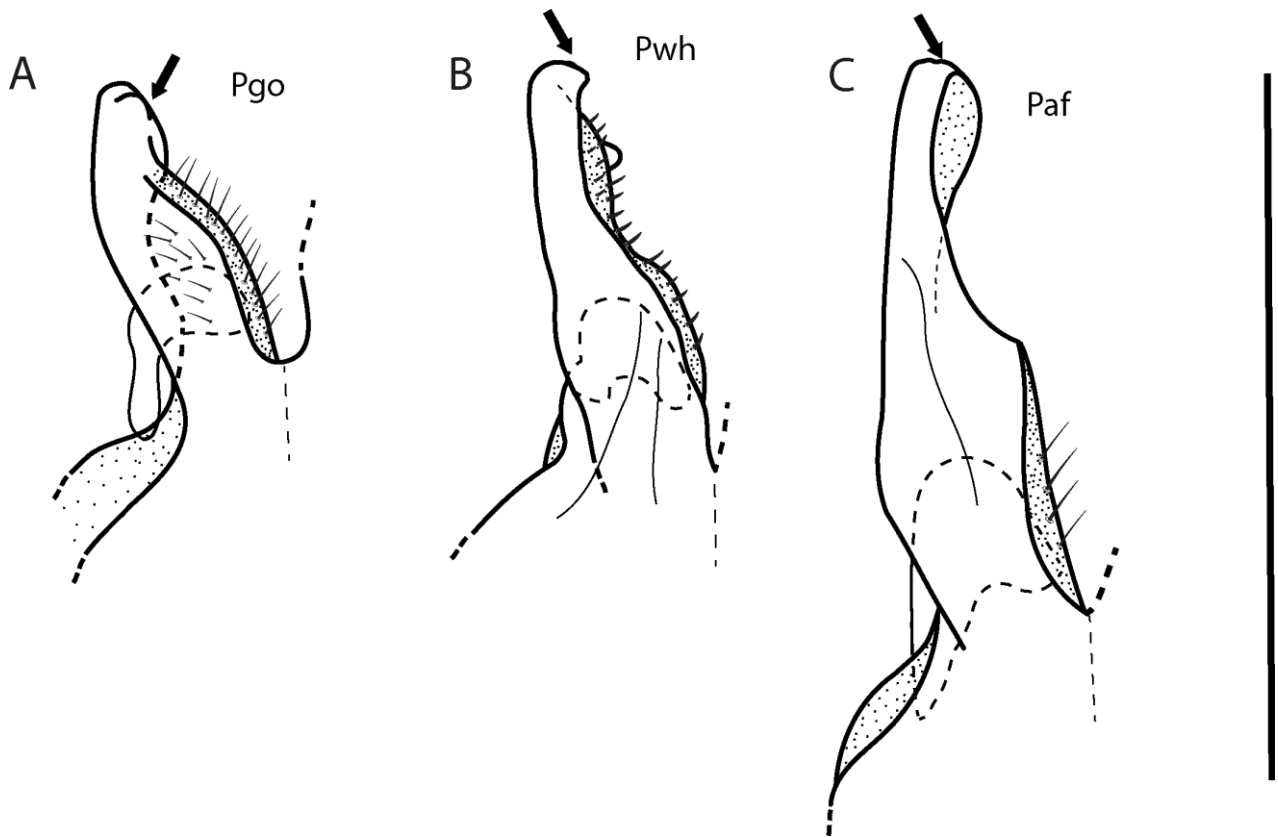


FIGURE 5. Right pseudepiphallal lophi of male genitalia in dorsal view: (A) *Pseudolebinthus gorochovi* sp. nov.; (B) *Pseudolebinthus whellani*; (C) *Pseudolebinthus africanus*. Scale bar: 1 mm.

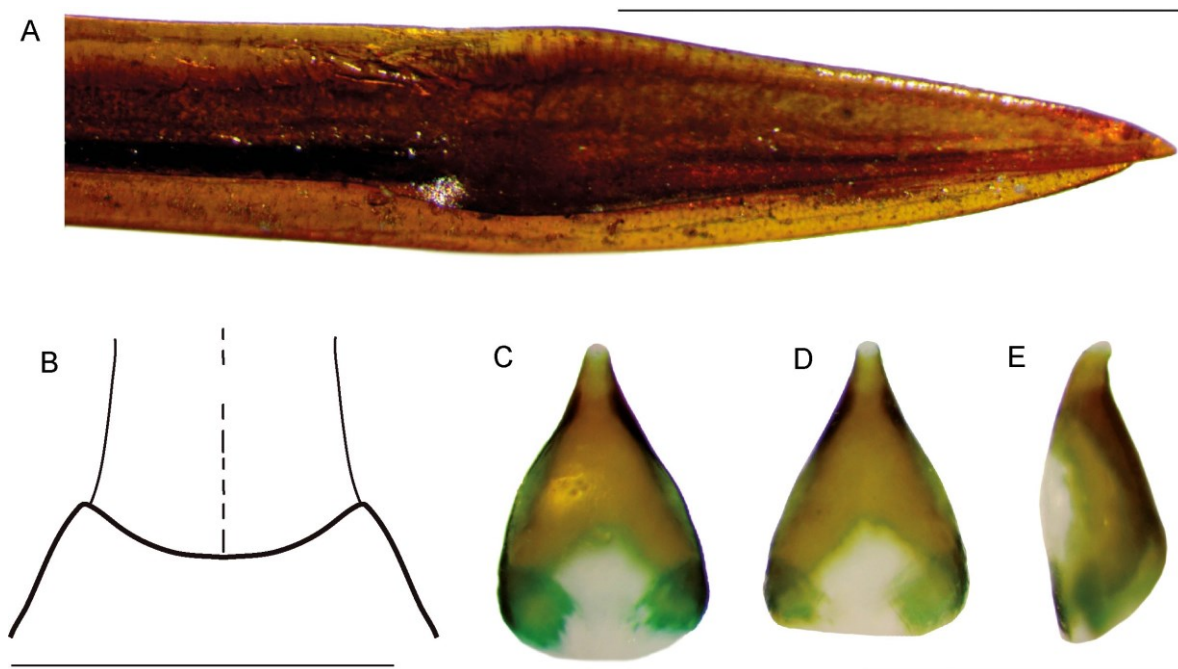


FIGURE 6. Female genitalia of *Pseudolebinthus gorochovi* sp. nov.: (A) apex of ovipositor; (B) apex of subgenital plate; copulatory papilla in dorsal (C), ventral (D) and lateral (E) views. Scale bars: 1mm.

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