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***Griveaudus* gen. nov. (Hemiptera: Fulgoromorpha: Flatidae) from Tsaratanana Massif supports the biodiversity of montane flatids in Madagascar**

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Abstract

The paper describes a new flatid genus, *Griveaudus* **gen. nov.**, comprising two species *G. issidiformis* **sp. nov.** and *G. tsaratananae* **sp. nov.** from Madagascar. Additionally, the illustrations of the female internal genital structures are provided.

Key words: entomology, taxonomy, systematics, endemism, Flatinae, Afrotropical region

Introduction

Madagascar for centuries has inspired naturalists to describe its diverse and unique flora and fauna (Goodman & Benstead 2003). The island is characterized by its extreme biodiversity and high degree of endemism (more than 80% for plants and vertebrates), which at higher taxonomic levels resulted from millions of years of tectonic isolation from Africa and India after the break-up of the Gondwana supercontinent (Storey *et al.* 1995). Additionally, several alternative mechanisms may have generated local endemism, including allopatric speciation driven by isolation, for example, due to rivers or watersheds; parapatric speciation along environmental gradients; or ecologically mediated postspeciation range shifts (Pearson & Raxworthy 2009). Finally, ongoing loss of the original primary vegetation has been constantly reported (Ganzhorn *et al.* 2001), resulting in disappearance of associated with it rich entomofauna.

Despite long history of the research on Madagascan insects, it is evident that the knowledge of Flatidae is still very limited (Świerczewski & Stroiński 2013). It refers especially to relatively unexplored and poorly documented ecosystems, such as those of montane areas, which flatid fauna seems to be quite rich and diverse (Stroiński & Świerczewski 2013, Stroiński & Świerczewski 2014). In this paper we describe new genus *Griveaudus* **gen. nov.** from Tsaratanana Massif—the highest mountain range of Madagascar.

Material and methods

Material. The studied material comes from the entomological collections of the Muséum national d'Histoire naturelle (MNHN), Paris, France.

Methods. The abdomens of the specimens examined were cut off and cleared for 30 min. in a warm (50°C) 10% KOH solution with a few drops of black chlorazol (CAS No. 1937–37–7) for dyeing the ectodermic genital ducts based on the method introduced by Carayon (1969) and Bourgoin (1993). Dissections and cleaning of genital structures were performed in distilled water. Final observations and drawings were made in glycerin using a camera lucida attached to Olympus microscope (SZH10 and BX50). The photos of the habitus, male and female genital structures were taken using a stereoscopic microscope Leica MZ16 with IC3D camera, excluding those of aedeagus, which were taken using a light microscope Leica DM5500B with Leica DFC490 camera. Final images

were created using Helicon 5.0 software and Adobe Photoshop. The SEM photographs of uncoated specimens were taken in the Laboratory of Scanning Microscopy, MIZ PAS (Warsaw), using a scanning microscope HITACHI S-3400N under low vacuum conditions.

Measurements and abbreviations. The following proportions of measurements and abbreviations were made and used in this study:

Total length—measured (in dorsal view) from the apex of head to the apex of tegmina;

A/B—width of vertex measured at anterior margin/length of vertex at midline;

C/E—width of frons at upper margin/length of frons at midline;

D/E—maximum width of frons/length of frons at midline;

F/B—length of pronotum at midline/length of vertex at midline;

G/F—length of mesonotum/length of pronotum at midline;

G/B+F—length of mesonotum/cumulative length of vertex and pronotum at midline;

G/H—length of mesonotum at midline/width of mesonotum between lateral angles;

I/J—length of tegmen measured from the base to the apical margin in median portion/width of tegmen measured from the apex of clavus to the anterior margin.

The nomenclature of the male genitalia follows Bourgoïn & Huang (1990) and for the female genitalia Bourgoïn (1993). Vein nomenclature after the interpretation proposed by Szwedo & Żyła (2009).

Taxonomy

Griveaudus gen. nov.

(Figs 1–70)

Type species: *Griveaudus issidiformis* sp. nov., here designated.

Etymology. The generic name is after Paul Griveaud (1907–1980), a well-known French collector of Madagascan insects. Gender: masculine (Genetivus singularis: *Griveaudus*, 4th declension).

Diagnosis. The newly described genus *Griveaudus* differs from other Madagascar Selizini genera by the combination of the following characters: frons with short median, single carina, mesonotum smooth (frons with Y-shaped carina, mesonotum with gibbositities—*Urana* Melichar, 1902), vertex extremely incised medially (vertex slightly incised medially—*Peyrierasus* Stroiński et Świerczewski, 2013).

Description. Body robust. Head truncate, with compound eyes in dorsal view about as wide as thorax (Figs 2–3, 5).

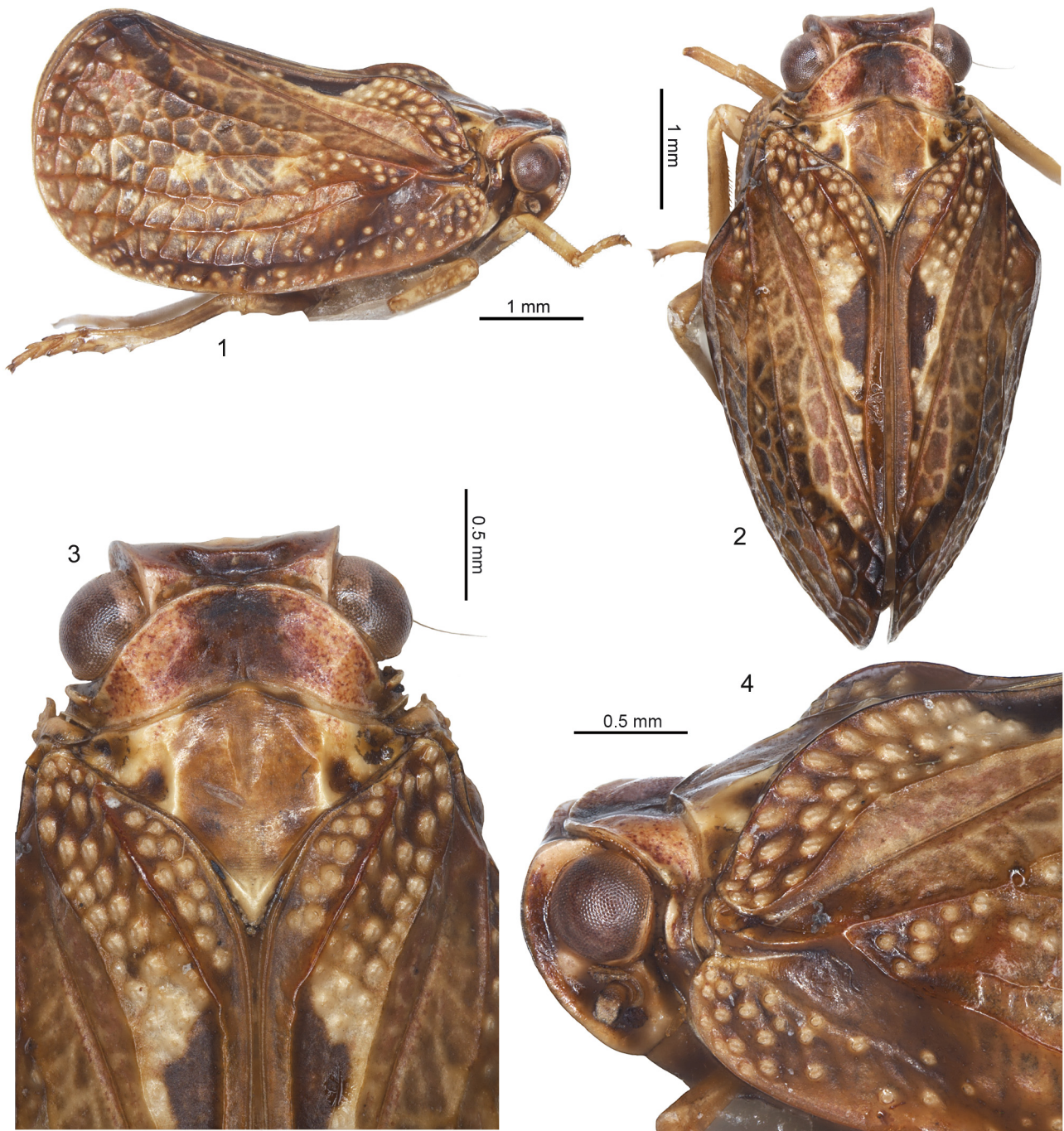
HEAD. Vertex in form of hourglass, extremely narrow medially; posterior margin elevated, anterior margin obliterated laterally, lateral margins subparallel (Figs 7–8), surface with sensory and secretory structures (Fig. 17). Frons (Figs 11–13) as long as wide, the widest at the level of compound eyes; frons with short and wide protrusion in the upper part of head; disc of frons with short median carina; lateral margins of frons carinate and elevated; disc of frons irregularly rugose, with sensory and secretory organs (Fig. 14). Compound eyes oval, with small callus placed at lower-posterior margin. Ocelli absent (Figs 6–7). Antennal pedicel short, widened apically, with setae and plate organs mainly restricted to a hollow area at the top and partly on upper surface (Figs 18–20). Sensilla placodea of the clover-leaf like type (Figs 21–22). Clypeus narrower than frons, without carinae (Fig. 11). Rostrum with apical segment a little shorter than subapical, apex reaching hind coxae.

THORAX. Pronotum distinctly longer than vertex at midline, with short, median carina placed posteriorly (Figs 3, 7, 10) or in some specimens median carina absent (Fig. 9); disc of pronotum medially depressed, postocular eminences absent. Mesonotum deltoid (Figs 3, 9–10); disc anteriorly with median groove and short obsolete carina; lateral carinae internally arcuate and elevated, reaching posterior margin; lateral parts of mesonotum without gibbositities.

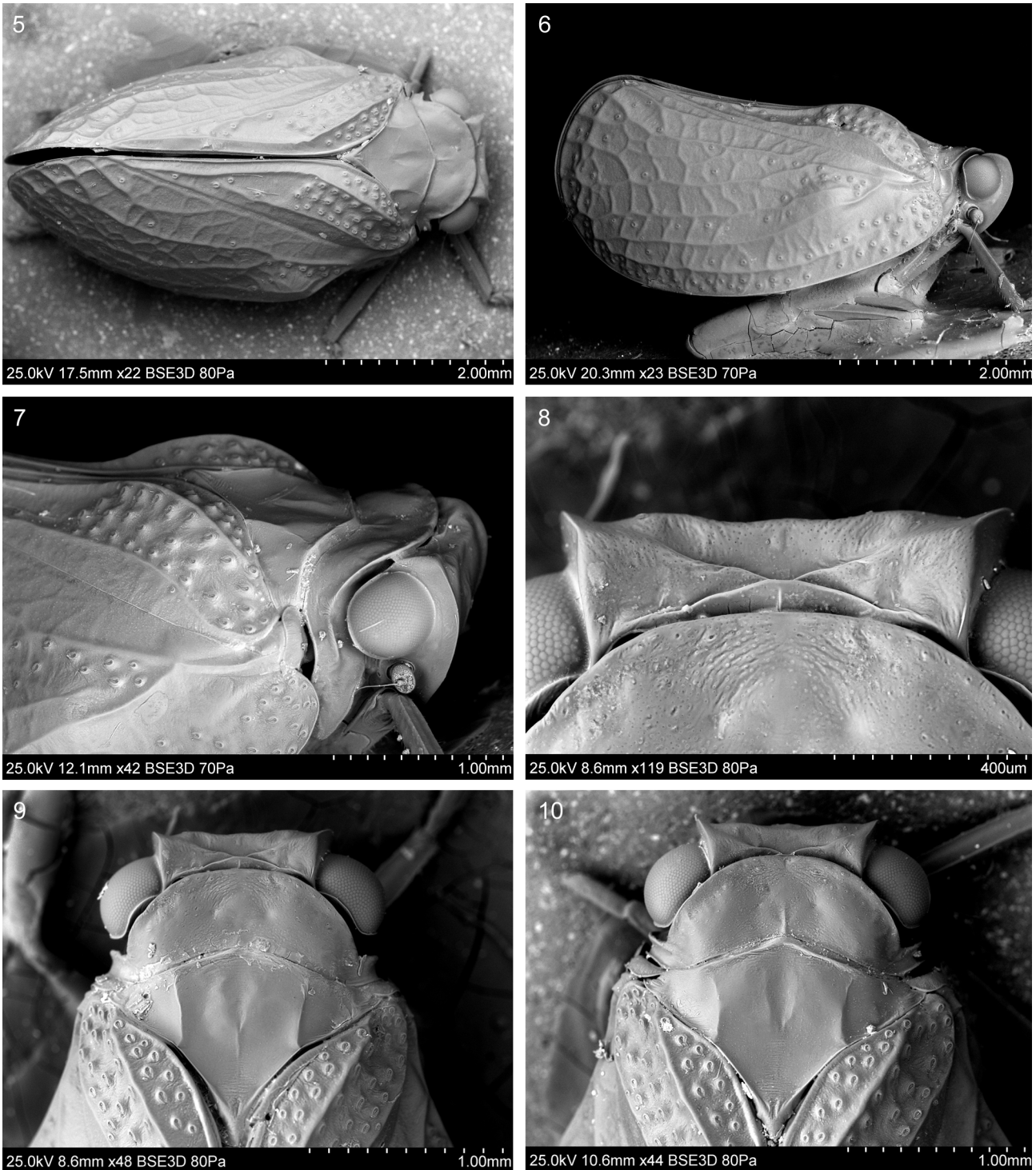
Tegmen (Figs 1, 4, 6, 23–28) coriaceous and convex, with well visible venation and bulla, with apical line only; transverse veinlets forming irregular net on whole tegmen. Costal and posterior margins arcuate, costal and sutural angles bluntly rounded; postclaval sutural margin absent. Costal area narrower than costal cell, with transverse veinlets, terminating at the level of end of clavus. Costal cell with several transverse veinlets. Basal cell

long and narrow. Sc+R forked before bulla and distinctly basad of M forking; ScRA elevated, RP obsolete basally, M fork before half of tegmen; M_{1+2} and M_{3+4} forks at the same level in apical part of tegmen; CuA bifurcated near the midlength of tegmen. Claval veins Pcu and A_1 fused before end of clavus, vein A_1 strongly elevated; transverse veinlets between Pcu and CuP. Terminal forks in subapical part of tegmen. Terminals: CuA—2, M_{1+2} —2, M_{3+4} —2, RP—2, ScRA—2. Sensory and secretory structures present on the whole surface of tegmen. Tubercles with concentration on costal area, alongside apical margin, between basal RP and M veins and in basal part of clavus.

Femora shorter than tibiae; hind tibia arcuate and partly flattened laterally with 2 lateral spines placed after midlength, apically with row of well-developed 7 teeth (Fig. 15); basitarsomere as long as cumulative length of 2nd and 3rd tarsomeres with row of apical spines in formula 2 (longer) + 6–7 (shorter), second tarsomere with 2 lateral spines (Fig. 16).



FIGURES 1–4. *Griveaudus issidiformis* gen. et sp. nov., habitus, female. (1) lateral view; (2) dorsal view; (3) anterior part, dorsal view; (4) anterior part, lateral view.

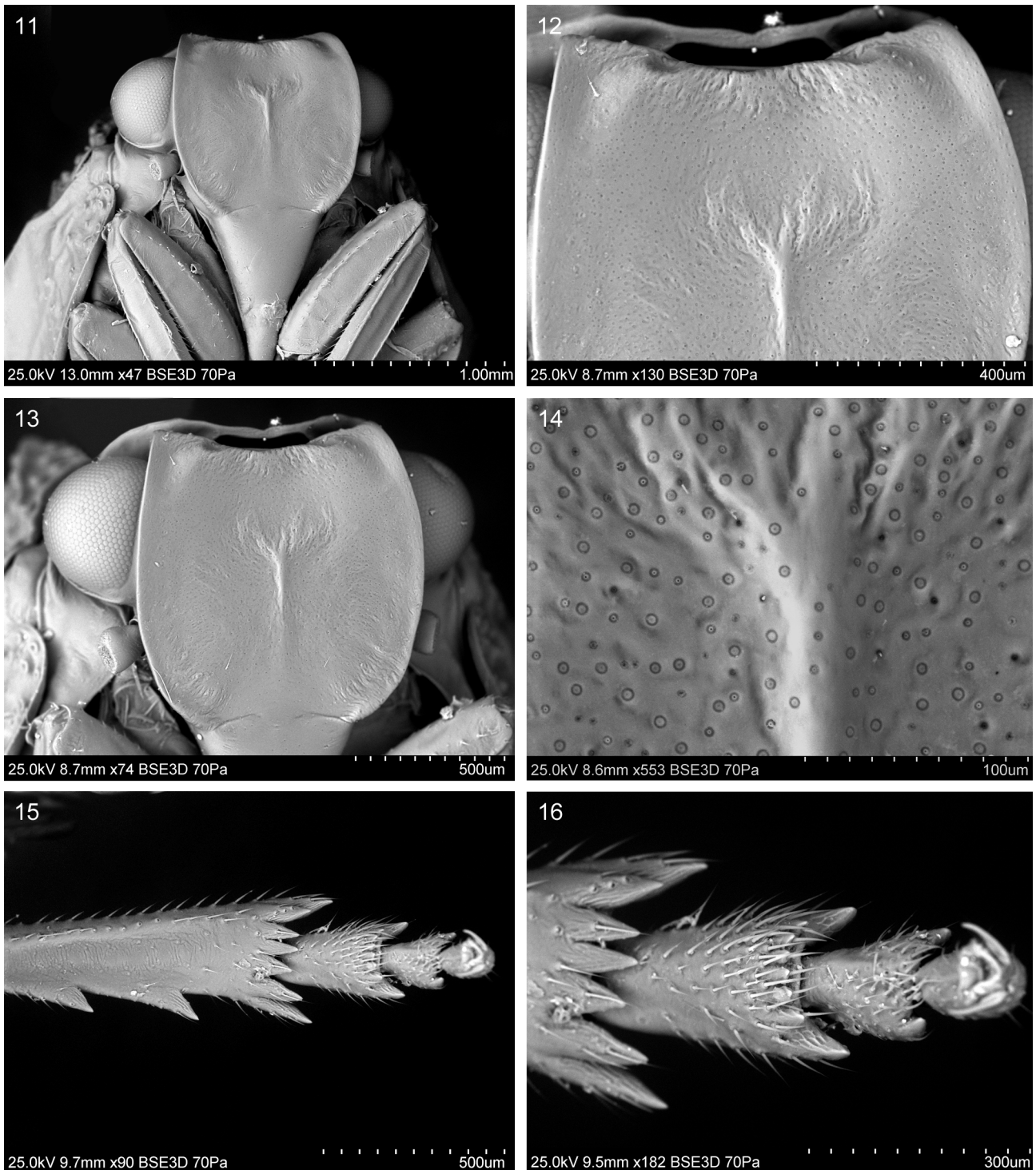


FIGURES 5–10. *Griveaudus issidiformis* gen. et sp. nov. (5) habitus, dorsal view; (6) habitus, lateral view; (7) anterior part, dorso-lateral view; (8) vertex, dorsal view; (9–10) anterior part, dorsal view. (8–9) male, (5–7, 10) female.

MALE. Anal tube (in lateral view, Figs 29–30, 37) elongate, distinctly tapering apicad; anus placed about midlength. Anal tube (in dorsal view, Fig. 31, 39) elongate, basal part distinctly narrower than median part; apical margin with shallow incision; anus placed about midlength.

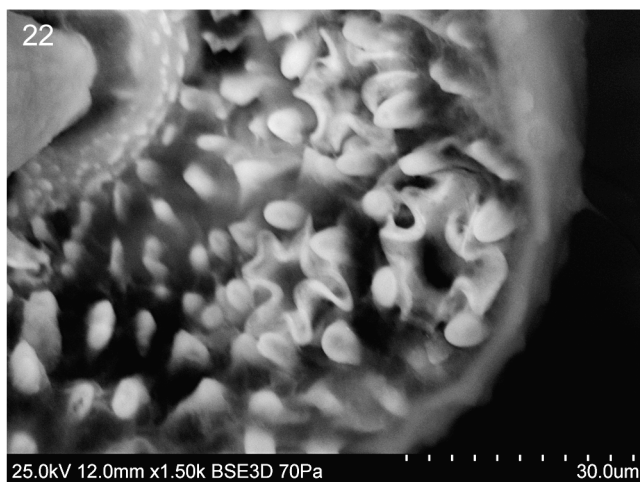
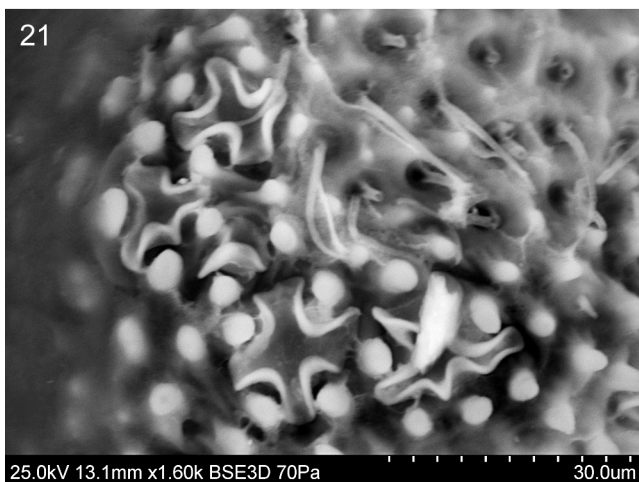
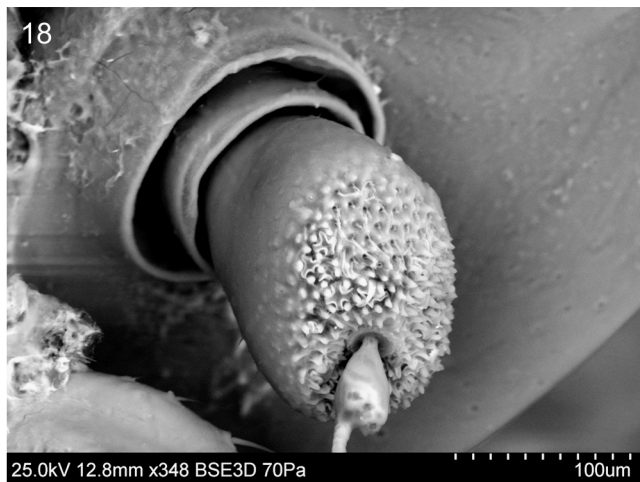
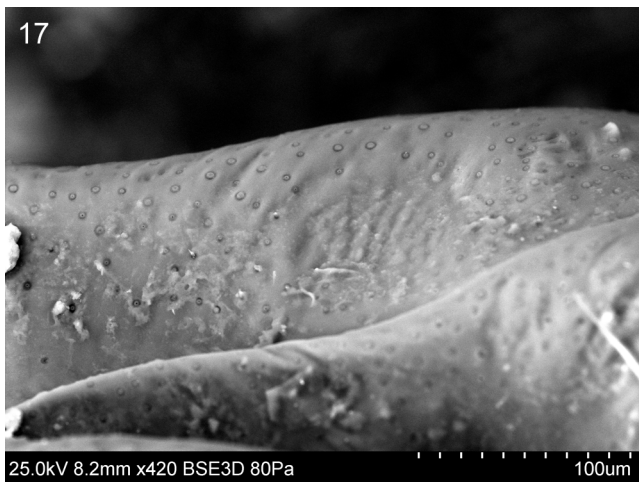
Pygofer (in lateral view) distinctly higher than wide, narrowing dorsally (Figs 29–30, 36); dorso-posterior angle almost right; anterior margin sinuate, posterior margin weakly arcuate.

Genital styles (in ventral view, Fig. 32; in lateral view, Fig. 38) longer than wide and bearing distinct, long and sharp capitulum; upper margin near base of capitulum strongly convex; ventro-posterior angle widely rounded.



FIGURES 11–16. *Griveaudus tsaratananae* **gen. et sp. nov.**, male. (11) anterior part, frontal view; (12–13) frons, general view; (14) frons, sensory and secretory structures; (15) hind tibia, apical part; (16) hind tarsomeres, ventral view.

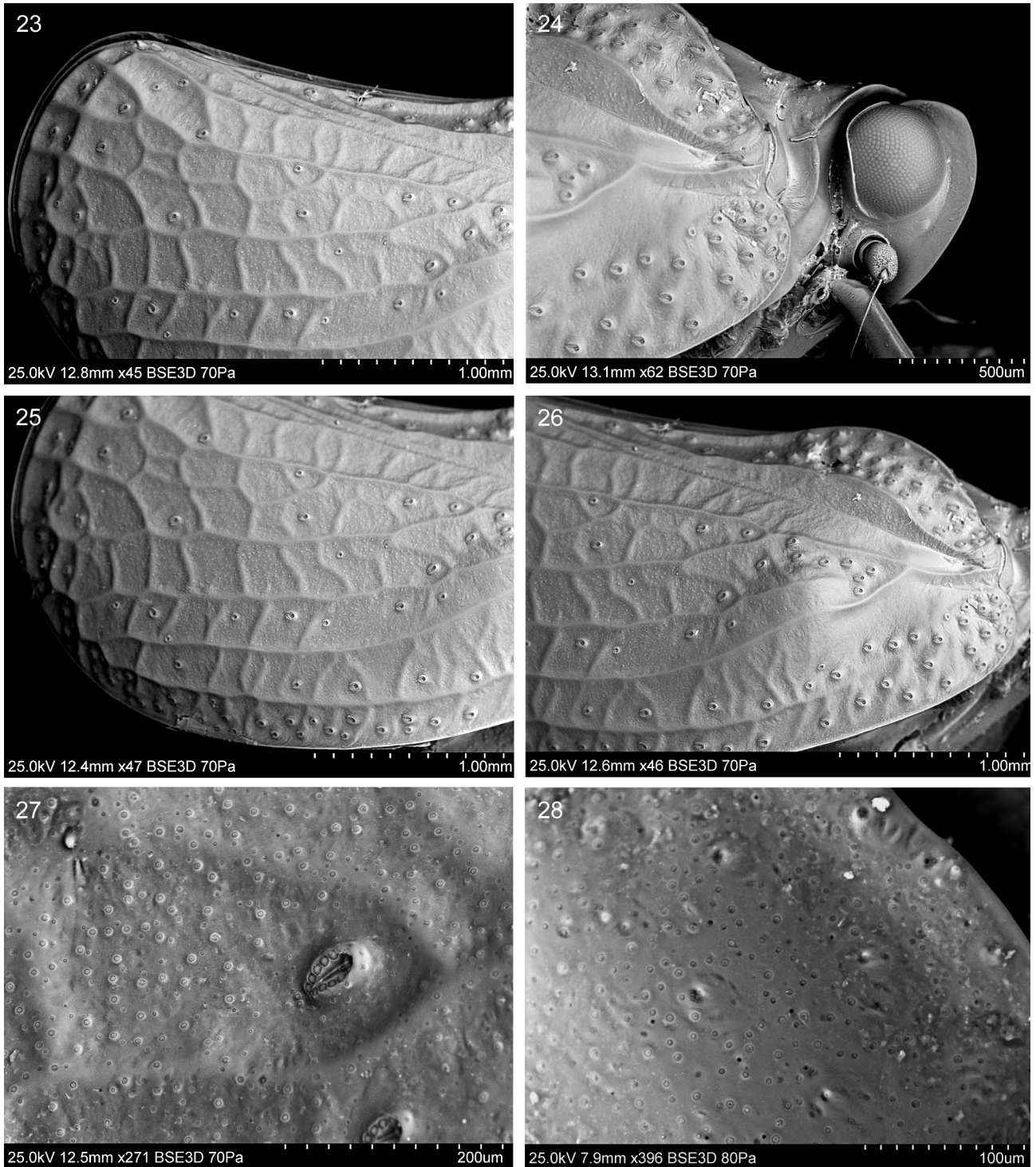
Phallic complex. Periandrium closed basally, open dorsally with long lateral split (Figs 40–43, 65–68). Ventral part apically tripartite with median sharp process and lateral folds; vertical keel and ventrally pointed tooth present; apical lateral folds with several teeth. Dorsal part trilobate; median part very short with vertical, bifurcate process oriented dorso-basad; lateral lobes as long as ventral part, with two groups of lateral teeth, median and apical processes; median process huge and multiforked apically, oriented basad; apical process long and narrow, well sclerotised basally with short tooth and bifurcate apically, with or without median short process. Aedeagus divided into dorsal and ventral parts (Figs 69–70), lateral split extending midlength. Dorsal part about as long as ventral part, medially with lateral lobe, apically distinctly bilobate.



FIGURES 17–22. *Griveaudus issidiformis* gen. et sp. nov., female. (17) vertex, sensory and secretory structures; (18–20) antenna, general view; (21–22) antennal plate organs.

FEMALE. Pregenital sternite massive, lateral lobes weakly separated (Figs 44–47, 56); anterior margin weakly concave, medially with sclerotized lobe; posterior margin medially with two bluntly triangular lobes separated by shallow concavity, sometimes shifted. Abdominal sternites with scattered sensory pits (Figs 48–49).

Anal tube (in lateral view, Figs 50–51) flattened, elongate and narrow, reaching end of gonoplac; anus placed about midlength; ventral surface with long setae. Anal tube (in dorsal view, Fig. 57) oval or ovoid; anus placed about midlength.



FIGURES 23–28. *Griveaudus issidiformis* gen. et sp. nov., tegmen, female. (23) upper posterior part; (24) anterior part; (25) lower posterior part; (26) basal part; (27–28) sensory and secretory structures: (27) tegmen; (28) pronotum.

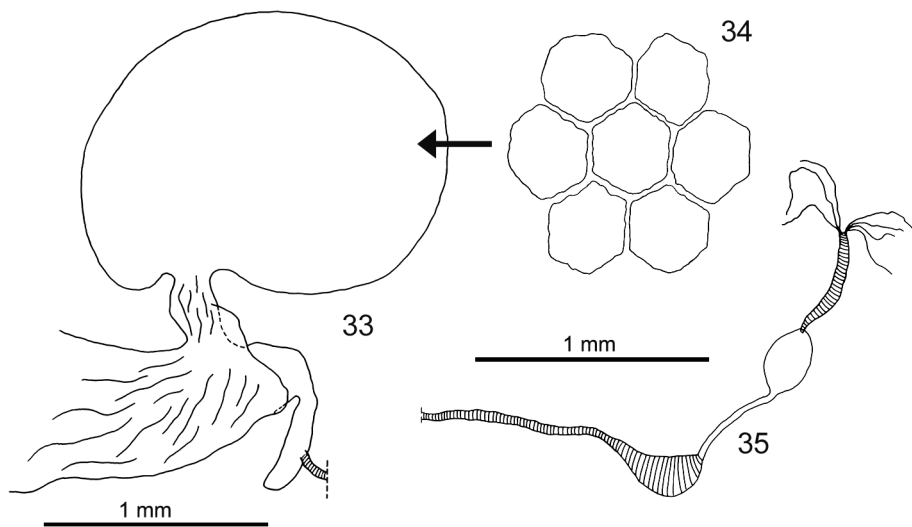
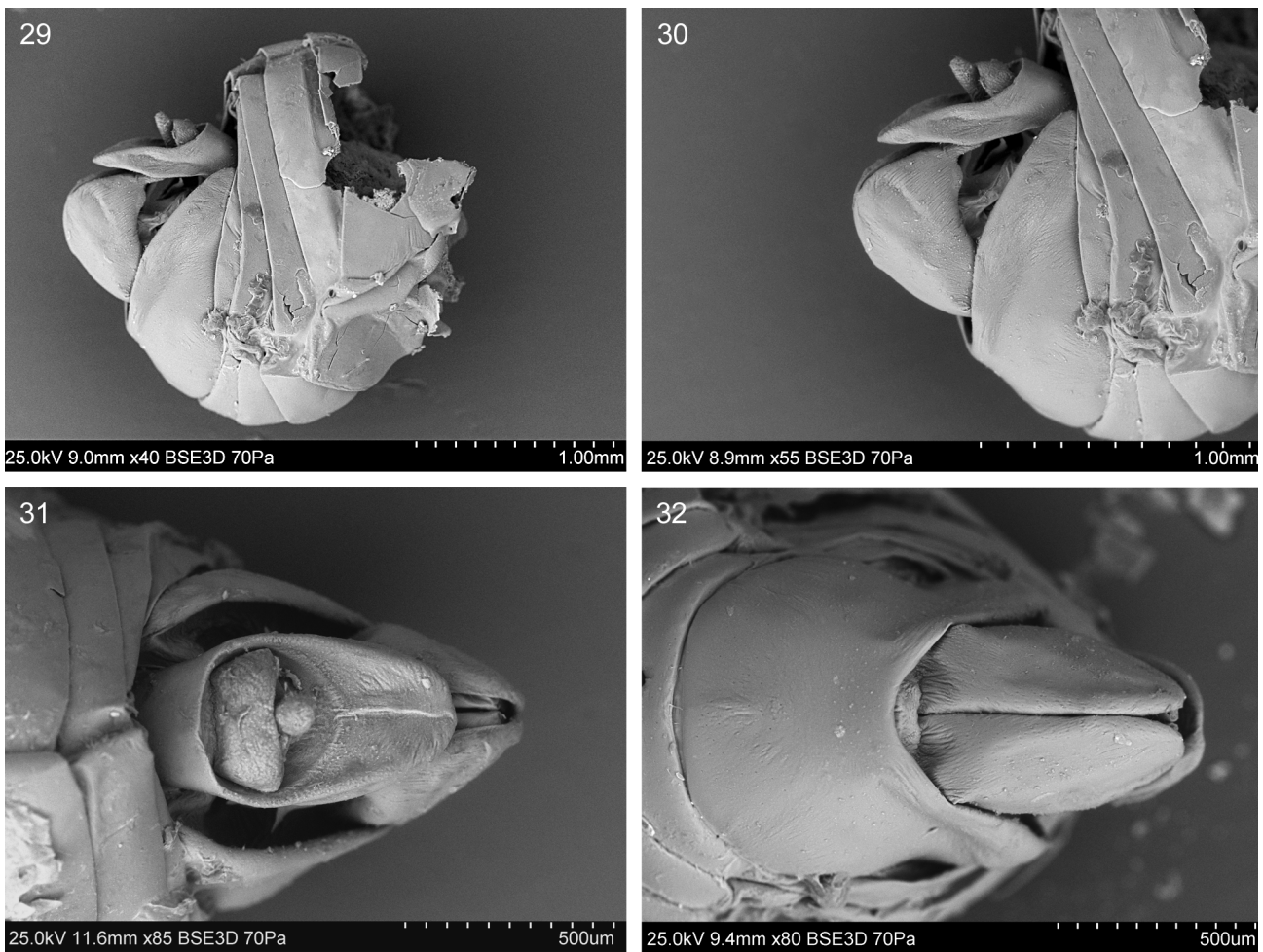
Gonoplac unilobate, laterally flattened, elongate (Figs 58–59); posterior margin rounded with single row of 5–6 well-developed teeth (Figs 52–53, 60); narrow, membranous part placed alongside ventral margin, extending half of gonoplac.

Gonapophysis VIII sabre-shaped and laterally flattened, tapering apicad (Figs 61–62); apical part of ventral margin folded externally, apical part of dorsal margin with 4 teeth. Endogonocoxal process shorter than gonapophysis VIII, sabre-shaped with spiniferous microsculpture (Figs 54–55).

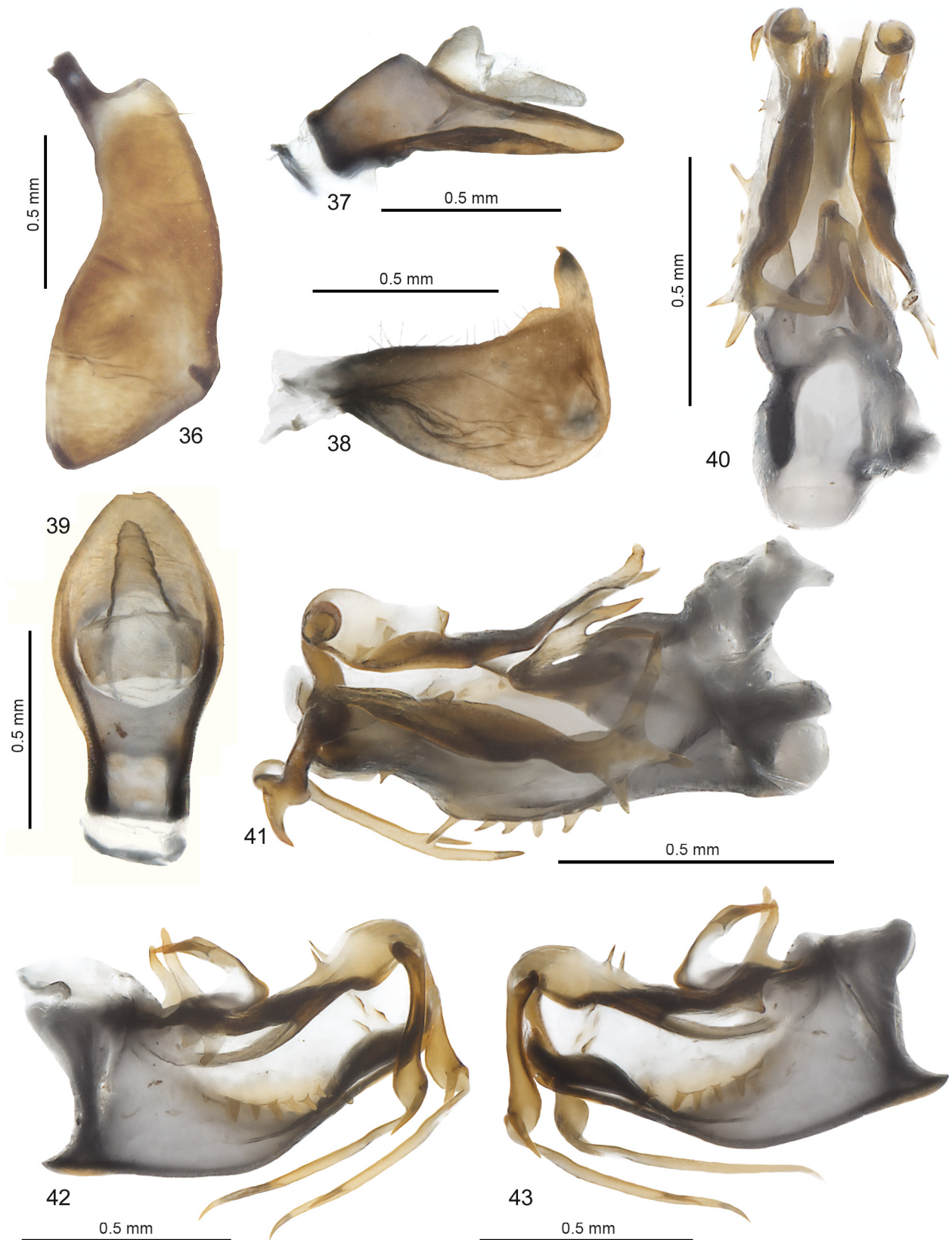
Gonapophyses IX and gonospiculum bridge as in Figs 63–64.

Bursa copulatrix of single, elongately oval, huge pouch and narrow basis (Fig. 33); cells well visible, without ornamentation (Fig. 34). Spermatheca well developed; *ductus receptaculi* ribbed and widened apically, *diverticulum ductus* smooth and narrow with bulba (Fig. 35).

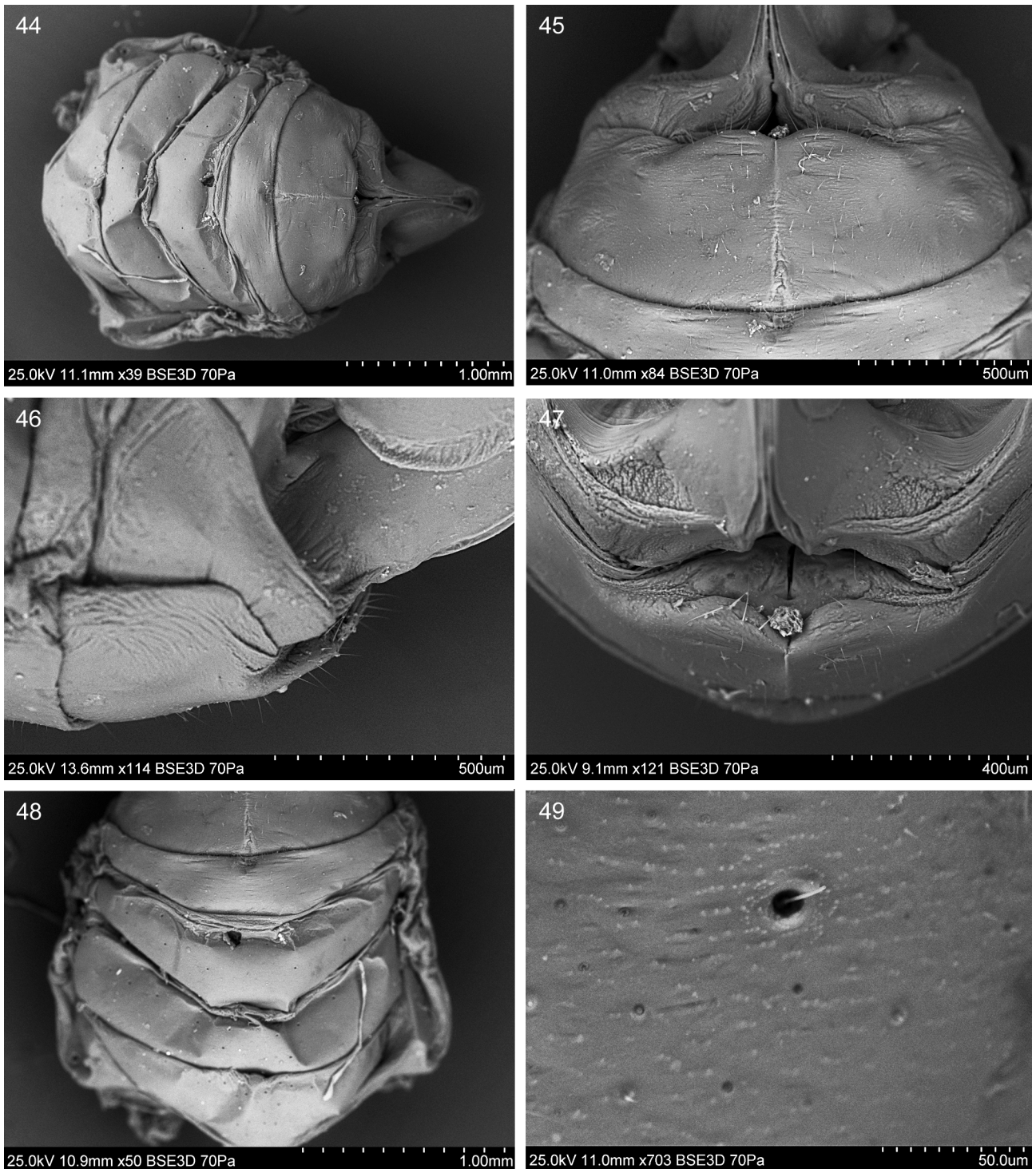
Distribution. Madagascar.



FIGURES 29–35. *Griveaudus issidiformis* gen. et sp. nov. (29) male, abdomen, lateral view; (30) male, genital capsule, lateral view; (31) male, genital capsule, dorsal view; (32) male, genital capsule, ventral view; (33) female, bursa copulatrix; (34) female, bursa copulatrix, cells; (35) female, spermatheca.



FIGURES 36–43. *Griveaudus issidiformis* **gen. et sp. nov.**, male. (36) pygofer, lateral view; (37) anal tube, lateral view; (38) genital style, lateral view; (39) anal tube, dorsal view; (40) periandrium, dorsal view; (41) periandrium, dorso-lateral view; (42) periandrium, lateral view, right side; (43) periandrium, lateral view, left side.



FIGURES 44–49. *Griveaudus issidiformis* **gen. et sp. nov.**, female. (44) abdomen, ventral view; (45–47) pregenital sternite: (45) ventral view, (46) lateral view, (47) posterior view; (46–47) pregenital sternite, ventral view, gonoplacs, frontal view; (48–49) sternites with sensory structures.

***Griveaudus issidiformis* sp. nov.**

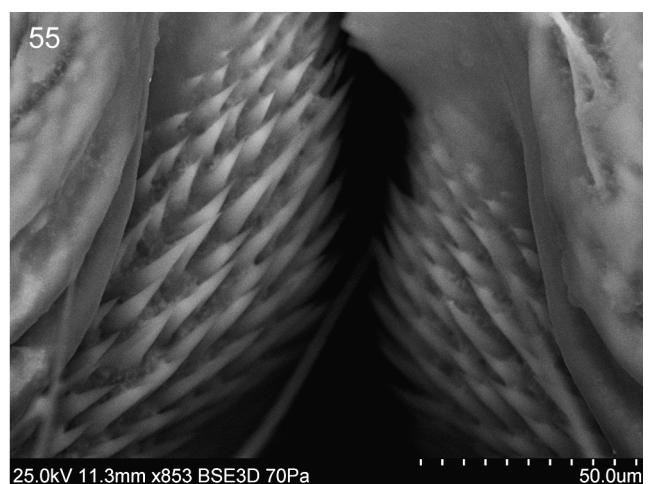
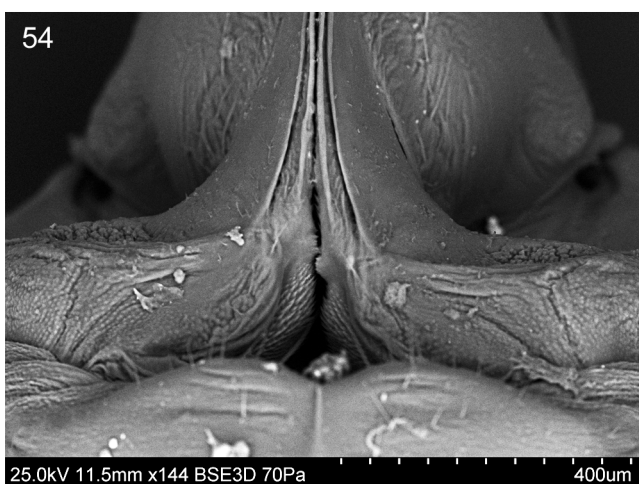
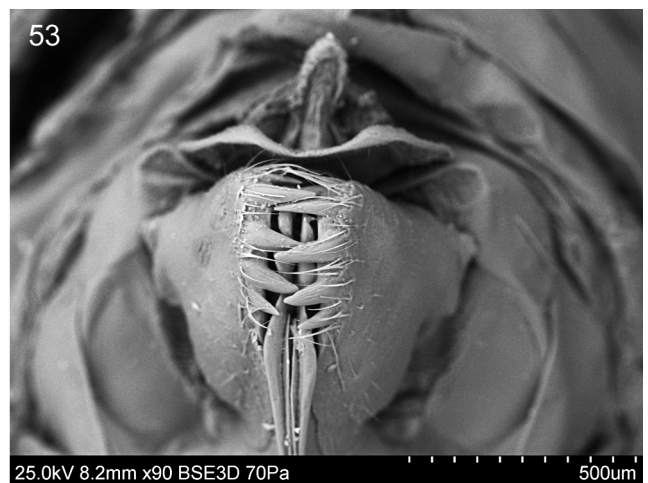
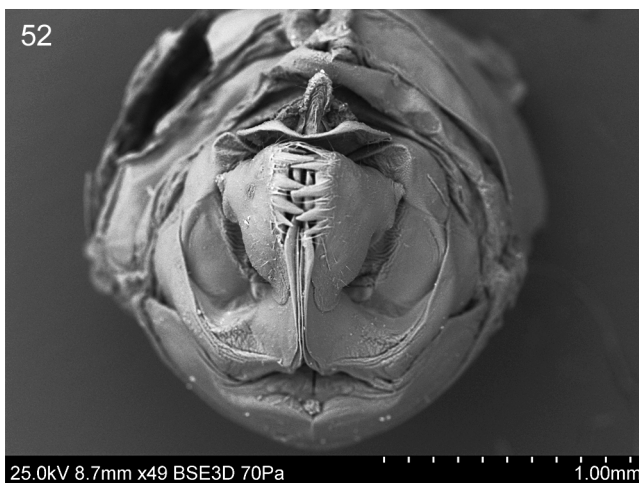
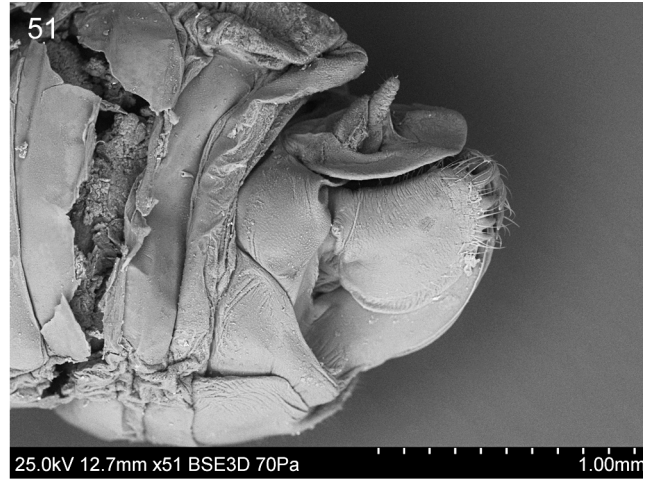
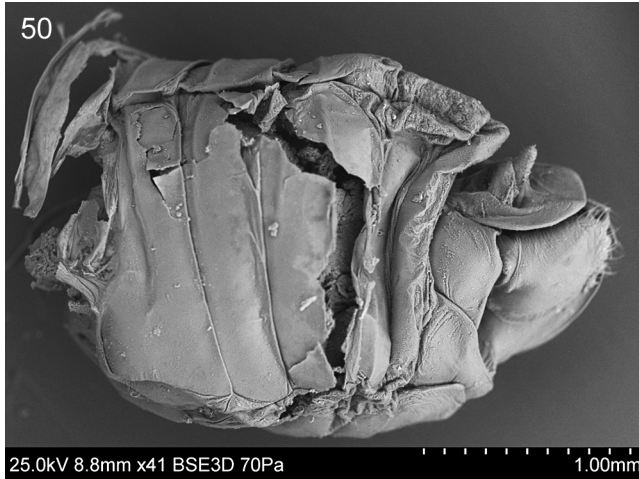
(Figs 1–10, 17–64)

Etymology. The specific epithet comes from the Issidae-like shape of the body.

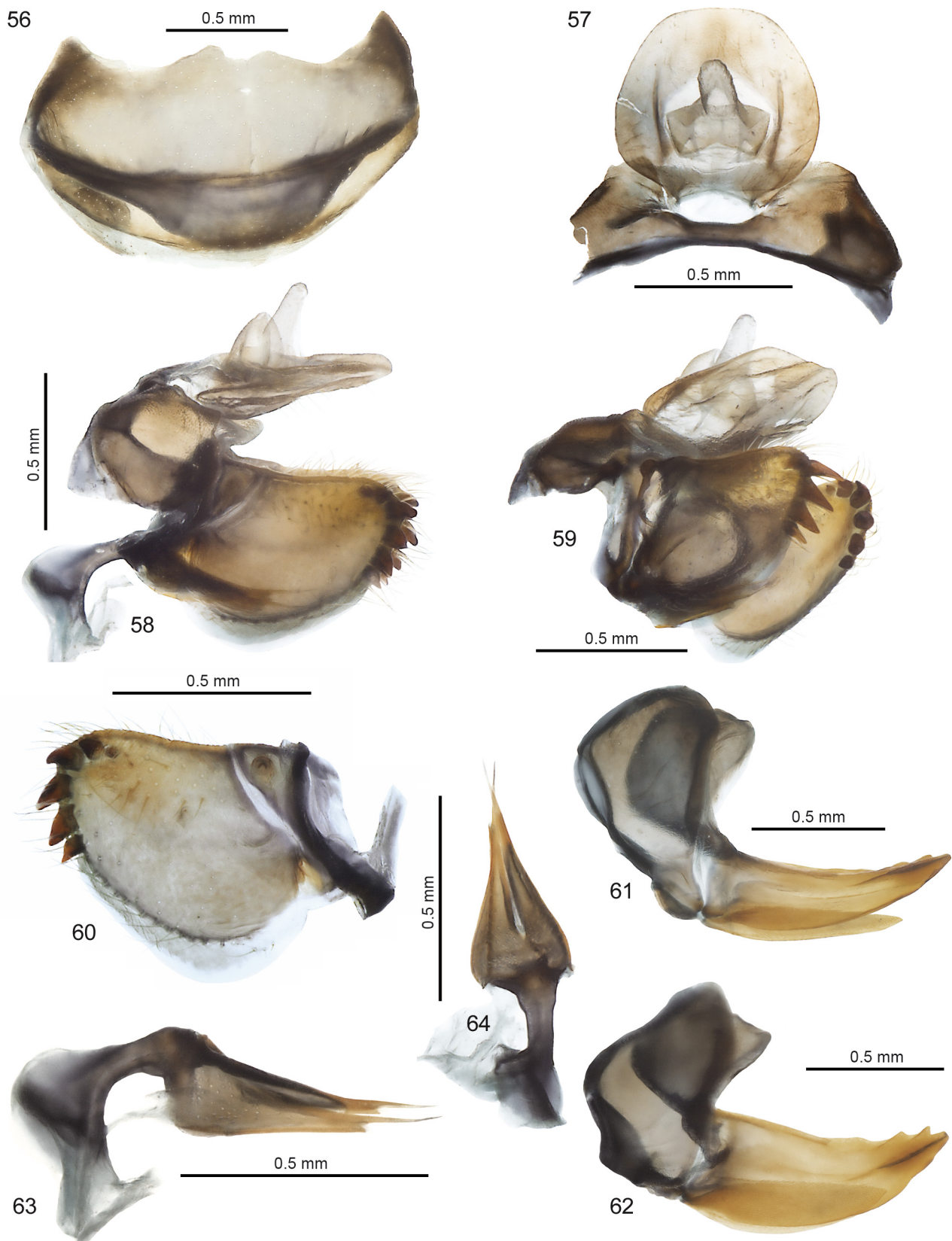
Diagnosis. The species differs from *G. tsaratananae* by the combination of the following characters: male—lower part of perianthium with longer and shorter processes (Figs 41–43), female—anal tube oval,

gonapophysis VIII with 3 weakly developed and blunt teeth, *ductus receptaculi* longer than *diverticulum ductus*, bulba of *diverticulum ductus* huge and oval (Figs 57, 62, 35).

Description. Total length 0.46–0.54 cm. Head. Vertex: proportion A/B = 17.33–26.00; Frons: proportion C/E = 0.92–0.98; proportion D/E = 1.06–1.18. Thorax. Pronotum: proportion F/B = 6.00–12.00. Mesonotum: proportion G/F = 2.58–3.78, proportion G/B+F = 2.38–3.24, proportion G/H = 0.74–0.78. Tegmina: proportion I/J = 1.86–1.90.



FIGURES 50–55. *Griveaudus issidiformis* gen. et sp. nov., female. (50) abdomen, lateral view; (51) genital terminalia, lateral view; (52) genital terminalia, posterior view; (53) posterior margin of the gonoplac, posterior view; (54) posterior margin of pregenital sternite and gonapophysis VIII and endogonocoxal process, basal part, ventral view; (55) endogonocoxal process, microsculpture.



FIGURES 56–64. *Griveaudus issidiformis* gen. et sp. nov., female. (56) pregenital sternite; (57) anal tube, dorsal view; (58) terminalia, lateral view; (59) terminalia, latero-ventral view; (60) gonoplac, ventral view; (61) gonapophysis VIII, lateral view; (62) gonapophysis VIII, latero-dorsal view; (63–64) gonapophyses IX and gonospiculum bridge: (63) lateral view, (64) dorsal view.

Coloration. General coloration dark brown; upper part of frons dark brown, lower part light brown; upper part of head, pronotum and mesonotum yellowish with median, dark brown-reddish band; tegmina light brown or stramineous with darker basal part and margins, clavus with dark brown or black semicircle; abdomen—sternites stramineous, tergites dark brown with yellowish margins; legs brownish-yellow (Figs 1–4).

Type material. Holotype: ♂, [Madagascar Nord, massif du Tsaratanana (versant Sud), 2030m, Andohanambatoafo, 16/18-XII-1966, P. Soga], [Museum Paris]—(MNHN). Paratypes: 2♀, [Madagascar Nord, massif du Tsaratanana (versant Sud), 2030m, Andohanambatoafo, 16/18-XII-1966, P. Soga], [Museum Paris]—(MNHN).

Distribution. Madagascar, Antsiranana Province.

***Griveaudus tsaratananae* sp. nov.**

(Figs 11–16, 65–70)

Etymology. The specific epithet comes from the name of the Tsaratanana massif—*locus typicus* of newly described species.

Diagnosis. The species differs from *G. issidiformis* by the combination of the following characters: male—lower part of periandrium with longer process only (Figs 67–68); female—anal tube (in dorsal view) ovoid, gonapophysis VIII with 4 well developed and sharp teeth, *ductus receptaculi* shorter than *diverticulum ductus*.

Description. Total length 0.47–0.54 cm. Head. Vertex: proportion A/B = 24.00–28.00; Frons: proportion C/E = 0.90–1.00; proportion D/E = 1.07–1.15. Thorax. Pronotum: proportion F/B = 12.00–13.00. Mesonotum: proportion G/F = 2.31–2.50, proportion G/B+F = 2.14–2.31, proportion G/H = 0.69–0.73. Tegmina: proportion I/J = 1.00–2.32.

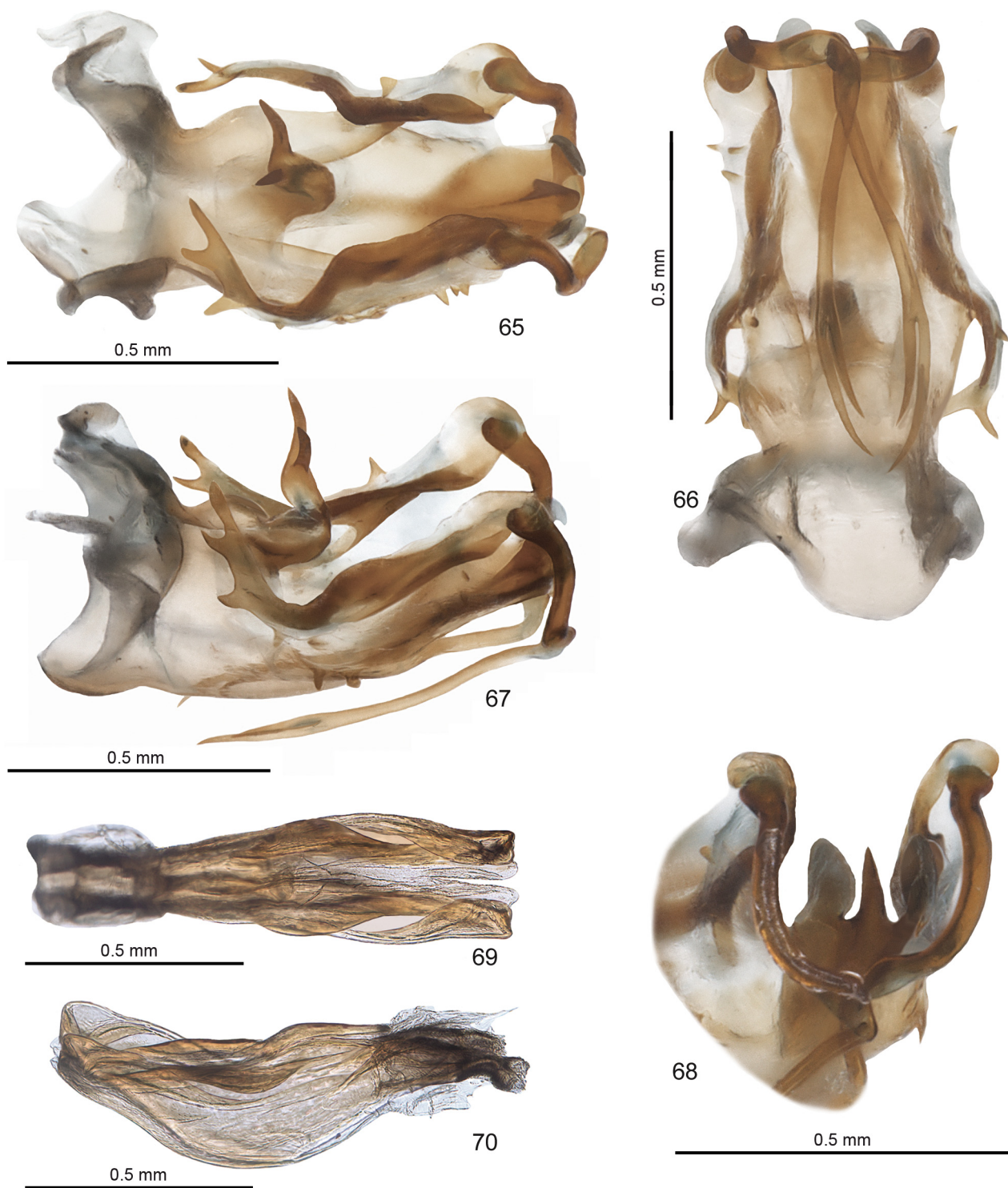
Coloration. Coloration pattern similar to that of *G. issidiformis* but specimens are much lighter.

Type material. Holotype: ♂, [Madagascar Nord/massif du Tsaratanana/piste de Mangindrano/ au Maromokotra, au N./du piton coté 2362m/9/12-XI-1966, 2310m], [mission au Tsaratanana/XI-1966 Camp n°2/P. Griveaud, P. Soga/P. Viette et D. Wintrebert], [Museum Paris]—(MNHN). Paratypes: 1♂, 2♀, locality labels the same as the holotype.

Distribution. Madagascar, Antsiranana Province.

Discussion

Flatidae constitute one of the largest families within planthoppers (Fulgoromorpha, Hemiptera) with 1446 species described in 299 genera and 12 tribes distributed worldwide (Bourgoin 2014). Flatidae fauna of Madagascar presently consists of 17 genera with 39 species of Flatinae and 11 genera with 37 species of Flatoidinae and is briefly reviewed in the paper by Świerczewski and Stroiński (2013). Regarding the Madagascar Flatidae fauna, the relatively poorly investigated ecosystems are those occurring in mountainous areas, although they seem to be quite rich and diverse, with endemic species and genera restricted to particular mountain massifs. Several examples can be given here. *Madoxychara unicornis* Stroiński et Świerczewski, 2013 is confined to western part of Madagascar and comprises lowland and mountain populations. The representatives of the genus *Urana* Melichar, 1902—*Urana paradoxa* Melichar, 1902 and *Urana unica* Stroiński et Świerczewski, 2012 are distributed across north-south mountain ranges and related to the ecotone habitats of high altitude montane forest (humid forest) and wooded grassland-bushland vegetation. *Peyrierasus philippiae* Stroiński et Świerczewski, 2013 is associated with *Philippia* scrubland of Anosyan mountain ranges in southeastern Madagascar. Both *Sogalabana ochracea* Stroiński et Świerczewski, 2014 and newly described *Griveaudus* Stroiński et Świerczewski, 2014 are recoded from Tsaratanana Massif in the northern part of the island.



FIGURES 65–70. *Griveaudus tsaratanae* gen. et sp. nov., male. (65) periandrium, dorsal view; (66) periandrium, ventral view; (67) periandrium, dorso-lateral view; (68) periandrium, frontal view; (69) aedeagus, dorsal view; (70) aedeagus, lateral view.

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