

A NEW LOPHOPID GENUS (HEMIPTERA: FULGOROMORPHA) CORROBORATES THE FAMILY PHYLOGENY AND HISTORICAL BIOGEOGRAPHY

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Abstract.— A new genus *Venisiella* and species *V. manifesta* of Lophopidae from the Fiji islands are described. The phylogenetic features of the new taxon were coded and analyzed using parsimony to place it within the previously published phylogeny of the family. Lophopidae remains monophyletic, with the new genus in the Makota⁺ group sister to *Buxtoniella*. The historical biogeography of the Makota⁺ group is discussed and characters are given in order to distinguish this new genus from *Buxtoniella*.



Key words.— Insularity, Auchenorrhyncha, phylogenetic scenario, Planthopper, Fulgoroidea, new genus, new species.

INTRODUCTION

Within the Lophopidae, four main monophyletic lineages have been recognised (Fig. 1): Carriona⁺ group with its only representative *Carriona* Muir, 1931, Makota⁺, Sarebasa⁺ and Bisma⁺ (Soulier-Perkins 2001), to accommodate the 44 genera and 145 species of Lophopidae (Bourgoin 2015). With its five genera, the Makota⁺ group is the only lineage extending east into the Pacific ocean, up to the Samoan islands (Fig. 1). It is distributed from Borneo where *Makota* Distant, 1909 can be found, then the Philippines with the genus *Virgilia* Stål, 1870, followed by the genera *Clonaspe* Fennah, 1955 and *Painella* Muir, 1931 distributed in distinct islands in the Solomon archipelago and extending up to the Samoan islands where the genus *Buxtoniella* Muir, 1927 is located (Soulier-Perkins 2000). In this last genus, two species are described *Buxtoniella hopkinsi* Muir, 1927 found on the Upolu island and *Buxtoniella bryani* Muir, 1927 described

from Savaii island. A new taxon from the Fiji islands (Fig. 2) is here described and gives the opportunity to test the current phylogeny of the family and may bring some support to the historical biogeographic scenario provided in earlier analysis (Soulier-Perkins 2000). Is it going to find its place within the historical biogeography of Makota⁺? The understanding of the historical biogeography of this family, for which most genera are confined to islands, could enlighten how the diversification for some other fulgoromorphan families such as Flatidae (e.g., Świerczewski *et al.* 2014), Ricaniidae (Stroiński 2013) or Tropiduchidae (Wang *et al.* 2014) happened within insular environments.

MATERIALS AND METHODS

Material examined. All specimens of the new taxon were examined from the Bernice Pauahi Bishop Museum, Oahu, Hawaii (BPBM). Labels reported

verbatim with square brackets “[]” indicating individual labels separated by commas.

Preparation and observation. The abdomens of the specimen examined were cut off and cleared for 20 minutes in warm (50°C) 10% KOH with a few drops of chlorazol black (CAS No. 1937-37-7) for dyeing the ectodermic genital ducts based on the method introduced by Carayon (1969). 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 an Olympus microscope (SZH10). The photos of the habitus were taken using a stereomicroscope Leica MZ 16 with IC3D digital camera; final images were produced using Helicon Focus 5.0 software. 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.

Morphological phylogeny. The encoding of the characters for *Venisiella*, and the phylogenetic methodology, used to test the place of this genus within the Lophopidae, followed Soulier-Perkins (2001). The phylogeny is based on 73 morphological characters (described in detail in Soulier-Perkins 2001), for 7 outgroups (2 Eurybrachidae, 3 Ricaniidae, 1 Tettigometridae and *Hesticus* Walker, 1862) with *Venisiella* is added to the 34 ingroup taxa in the matrix (Soulier-Perkins 2001). *Silvanana* Metcalf, 1947, was placed in Ricaniidae by Gnezdilov (2009). The family placement of *Hesticus* remains uncertain. The encoding sequence of *Venisiella*'s 73 characters is the following: 0,0,0,0,1,-,1,1,0,0,1,0,1,0,0,0,0,0,1,1,0,0,0,0,0,0,0,1,0,0,0,0,0,1,2,1,1,1,0,2,0,1,1,1,1,2,-,1,1,1,2,0,?,?,?,1,0,?,0,0,1,1,0,1,1,0,3,1,1.

The cladistic analysis using Parsimony was performed using the same programs as in Soulier-Perkins (2001), PAUP version 3.1.1 (Swofford 1993) and MacClade version 3.07 (Maddison and Maddison 1992). The Bremer support (Bremer 1994) was calculated using the program AutoDecay version 4.0.2 (Eriksson 1999).

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

Total

length – measured (in dorsal view) from the apex of head protrusion to the apex of tegmina,

A/B – width of vertex measured at anterior margin/length of vertex measured at midline,

C/E – width of frons in 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.

Terminology follows Bourgoïn (1988) and Bourgoïn and Huang (1990) for male genitalia, Bourgoïn (1993) for female genitalia and Bourgoïn *et al.* (2015) for forewing venation.

TAXONOMY

Order Hemiptera Linnaeus, 1758

Suborder Fulgoromorpha Evans, 1946

Superfamily Fulgoroidea Latreille, 1807

Family Lophopidae Stål, 1866

Venisiella gen. nov.

(Figs 1–42)

Type species. *Venisiella manifesta* sp. nov., here designated.

Etymology. We used the Latin word “*venis*” (meaning veins) with the last 5 letters of *Buxtoniella*. The gender of this genus is feminine.

Diagnosis. This genus can be quickly recognised from *Buxtoniella* (Figs 43–52) because of its clear venation pattern.

Description. Head. Head with compound eyes distinctly narrower than pronotum. Compound eyes (in dorsal view) large, as long and wide as the vertex, posterior margin of eyes extending the basal margin of vertex (Figs 3, 5, 8–11).

Vertex in midline distinctly shorter than width of head plus compound eyes; in midline longer than wide with all margins carinate; median carina present (Figs 3, 5, 8–11).

Compound eyes touching foramen of antennae. In lateral view, the anterior part of compound eye curving around the foramen. Lateral ocelli absent. Ocellar carinae absent. Genal carinae present (Figs 4, 6, 12–13, 18–19).

Pedicel of antennae elongate but not more than 2 times longer than wide, with 1 type of setae (trichoid sensilla) and plate organs with vertically placed multipetals surrounded by 3–6 massive denticles. Trichoid sensilla present on the whole pedicel, plate organs absent on lateral and $\frac{3}{4}$ of ventral part (Figs 4, 6–7, 18–23).

Frons higher than wide, not longitudinally concave, with lateral margins continuous from the upper margin to the frontoclypeal suture; sub-lateral and median carinae discrete, joined together below the upper margin of frons (Figs 7, 12–14).

Clypeus distinctly narrower than frons. Median and lateral carinae of clypeus present (Figs 7, 12–14). Labium short; not reaching hind trochanters (Figs 14–15).

Thorax. Pronotum at midline distinctly shorter than vertex and mesonotum at midline; disc of pronotum tricarinate, not produced anteriorly, carinae connected anteriorly, dimple present between median and each lateral carinae (Figs 3, 5, 8, 10–11).

Mesonotum with scutellum longer than vertex at midline, with 3 straight and completely separated carinae, median carina single; lateral carinae reaching posterior margin of mesonotum (Figs 3, 5, 8, 10–11, 24).

Tegmen elongate, coriaceous and weakly convex, whole tegmen covered by stout long setae with granulose base (Figs 3–6, 8, 24–27). Costal margin basally weakly arcuate, costal and claval margins almost sub-parallel, posterior margin weakly arcuate with inflexion point near middle; apex regularly rounded; tip of clavus extending half length of tegmen and placed before the end of costal area, postclaval sutural margin (tornus) present, weakly convex or almost straight. Tegmen membrane shorter than corium (Figs 3–6, 8, 24–27).

Basal cell very narrow about 3 times longer than wide. Costal area present, distinctly narrower than costal cell at middle, with apex distinctly exceeding level of apex of clavus; basally extremely narrow without transverse veinlets alongside costal margin, posteriorly more visible with a few transverse veinlets. Costal cell distinctly wider than costal area, with a few oblique transverse veinlets in distal part (Figs 3–6, 8, 24–27). Vein Sc+RA and RP branching from basal cell by short common stalk; veins Sc+RA and RP forked at nodal line, vein M leaving basal cell and forking at nodal line, Cu bifurcate distinctly before end of clavus; apical cells longer than wide. Tegmen with 2 irregular bands of transverse veinlets between nodal and apical line. Claval veins Pcu and A₁ fused after mid-length of clavus, slightly before CuA fork, and connected with posterior margin; few veinlets present between Pcu+A₁ and claval fold (Figs 3–6, 8, 24–27).

Fore and mid-femora and tibiae flattened (fore stronger than mid) but not foliaceous, femora and tibiae about same length (Figs 4, 12, 15).

Hind tibiae with 3 lateral spines and 9 large, strong spines apically. First hind tarsal segments bearing series of apical spines organised in a triangular area and more than twice longer than cumulative length of second and third. Apical spines on the second segment of hind tarsus absent (Figs 16–17).

Male. From dorsal view, anal tube developed laterally with its largest part at the urite XI level, apically triangular, angles rounded laterally and indented apically (Figs 28–29). Pygofer with a dorsal margin presenting a small medial bump, posterior margin almost straight except for large rounded posterior medial extension and ventral margin longer than dorsal (Figs 28–29). Gonostylus not flattened laterally, on lateral view with the lower margin gently and regularly curved; small tooth dorso-anteriorly orientated, close to the dorsal margin; posterior margin with an indentation less sclerified (Figs 30–32).

Female. Seventh abdominal sternite almost rectangular (Fig. 35). Anal tube bearing two small lobes apically, oriented posteriodorsally; dorsal margin before anus as long as length between anus and apical lobes; small medioventral extension of anal tube present; short thick setae present along ventral margin (Figs 36–38). Gonoplasts unilobate, rounded and bearing few setae internally and externally (Figs 39–40). Gonapophyses VIII rectangular, with few short dorsal setae and long thick setae ventrally with an additional tuft at posterior apex; end of gonocoxal process as long as gonapophysis, distinctly tapering distally, internal surface with long setae (Figs 41–42). *Bursa copulatrix* with a single pouch without sclerified ornamentation. Spermatheca well developed, *ductus receptaculi* longer than *diverticulum ductus*, and basally ribbed on $\frac{2}{3}$ of the length, apically widened and smooth. *Diverticulum ductus* smooth, wider than *ductus receptaculi* and slightly bulbous apically. As for all Lophopidae, gonospiculum absent.

Distribution. Fiji: Levu Island (Figs 1–2).

Venisiella manifesta sp. nov.
(Figs 1–42)

Etymology. Epithet from the Latin word “*manifesto*” meaning to show or make visible, here used in reference to the tegmina venation.

Type locality. Vanua Levu Island, Fiji (Figs 1–2).

Diagnosis. Aedeagus with two simple processes with posterior ventral one bigger than the anterior ventral (Figs 33–34).

Description. Total length: 4 mm (male), 4.64–4.88 mm (females).

Head. Vertex: proportion A/B = 0.68–1.78. Posterior and anterior margin of vertex v shaped and almost parallel to each other; lateral margin slightly rounded posteriorly; median carina well visible reaching margin but can be melted anteriorly. Frons: proportion C/E = 0.36–0.40; proportion D/E = 0.98–1.32. Frons with upper margin distinctly v shaped; frontoclypeal suture clearly visible, arcuate with flattened medially. Medial

area of clypeus flattened. Rostrum short, not reaching the metatrochanter.

Thorax. Pronotum: proportion F/B = 0.47–0.50. Pronotum with median weak median carina with anterior and posterior margins almost parallel. Mesonotum: proportion G/F = 2.30–2.55, proportion G/B+F = 0.79–0.82, proportion G/H = 0.45–0.49. Pro- and mesothoracic carinae with same alignment. Tegmina: proportion I/J = 2.60–2.63.

Male. Periandrium with a small dorsal anterior extension, simply folded with a small tooth apically on each side (Fig. 33). Aedeagus prolonged beyond insertion of processes, rounded apically; anterior ventral process of aedeagus present and simple; posterior ventral process of aedeagus absent (Figs 33–34).

Coloration (Figs 3–7). Yellowish vertex with all females bearing a reddish stripe along the anterior margin. Frons yellow with two broad transverse stripes, antennae reddish with apex and dorsal part blackish. Lateral part of head yellowish. Clypeus with red base and black apex. Pro and mesothoracic legs generally black with some red along the anterior margin. Metathoracic legs with brownish femora and yellowish tibiae. All legs with yellow tarsal segments. Thorax dark brown to black. Abdomen brown for the males and reddish-brownish for the females. Tegmina dark brown, paler toward the apex which is translucent. This translucent area is distinctly wider in males than females. Male pygofer and gonostyles dark brown, anal tube black. Female genitalia brown.

Type materials. **Holotype**, male: [Fiji: Vanua Levu I., Trans-Insular Road, above summit, 500–550 m, 6–9.X.1979], [G.A. & S.L. Samuelson Cools, Bishop museum Acc. No. 1979.387], [7224 forest] – deposited in BPBM.

Paratypes, 3 females: [Fiji: Vanua Levu I., Trans-Insular Road, above summit, 500–550 m, 6–9.X.1979], [S.N. Lal, G.A. & S.L. Samuelson Cools, Bishop museum Acc. No. #1979.387]; [Fiji: Vanua Levu I., Trans-Insular Road, above summit, 500–550 m, 6–9.X.1979], [S.N. Lal, G.A. & S.L. Samuelson Cools, Bishop museum Acc. No. #1979.387], [malaise trap]; [Fiji: Vanua Levu I., Trans-Insular Road, above summit, 500–550 m, 6–9.X.1979], [G.A. & S.L. Samuelson Cools, Bishop museum Acc. No. 1979.387] – 1 deposited in Muséum national d'Histoire naturelle, Paris (MNHN) and 2 in BPBM.

Distribution. Fiji: Vanua Levu Island (Figs 1–2).

RESULTS

After analysis, 17 cladograms were obtained with a length of 165 steps, a consistency index (CI) of 0.55 and a retention index (RI) of 0.78. The strict consensus gives a tree with the same, number of steps, CI and RI. Consequently, the strict consensus is the only

cladogram strictly supported (Nixon and Carpenter 1996). Bremer support values for each node are provided on figure 53. The general topology of the cladogram is unchanged from that of Soulier-Perkins (2001). *Venisiella* is placed within Makota⁺ and appears sister to *Buxtoniella* (Figs 1 and 53).

DISCUSSION

***Venisiella* versus *Buxtoniella*.** At a first look, within the Lophopidae this new genus could be mistaken with *Buxtoniella*, they have a compact and ovoid shape from dorsal view and have their tegmina covered with setae. Both have no ocelli, possess a genal carina, present the same leg structures and similar coloration from dorsal view. The females' anal tube show two small apical lobes (posterodorsally oriented) and the dorsal male periandrium can be characterised as simple, with less than 3 folds. However at closer inspection, the venation of the tegmina is completely different. *Buxtoniella* has reticulated venation, with only the Sc+A identifiable (Figs 43–45, 47, 49–50); for *Venisiella* the venation is clearly recognisable (Figs 3–4, 8, 24–27). The claval margin for *Buxtoniella* is shorter than half the total length of the tegmina, but it is obviously longer for *Venisiella*. Additionally, the claval and post claval margin is straight for *Buxtoniella*, but not for *Venisiella*. Other differences are observable on the antennal pedicel. *Buxtoniella* presents not only the expected small setae covering the entire pedicel but some thicker setae that are absent in *Venisiella*. The plate organs are setae-like in *Buxtoniella* (Figs 51–52), but are multi-petaled for *Venisiella* (Figs 19–23).

Modification of the key to genera of Soulier-Perkins 1998. Modifications start from the point 14:

14. Main veins on tegminae non-recognisable; general aspect of tegminae coarsely reticulate
 *Buxtoniella* Muir, 1927 (Fig. 24)
 –. Main veins on tegminae recognisable 14'
 14'. General shape of habitus compact and ovoid, prothoracic legs flattened *Venisiella* n.g.
 –. General shape of habitus slim and elongated, prothoracic legs not flattened . . . *Painella* Muir, 1931

Phylogenetic placement of *Venisiella*. Because of its distribution in the Fiji islands (Fig. 2), it was expected to find *Venisiella* in Makota⁺. However, this is not why it was placed in this group. It is only after coding this genus accordingly to the characters presented in Soulier-Perkins (2001) and completing the phylogenetic analyses of the resulting matrix that we found this genus belonged to Makota⁺. Based on morphological characters, Sarebasa⁺ present two autapomorphies, a series of small and generally numerous spines on the apex of the metathoracic tibiae and a pad

of microsetae separating two lots of spines on the first metathoracic tarsal segments. Both of those character states are absent in *Venisiella*. *Bisma*⁺ is characterised by the shape of the dorsal periandrium which is complex for this group with more than 3 folds on each side, for all that have been observed, *Venisiella* presents a “simple” structure of the periandrium. The synapomorphy that support *Makota*⁺ is the none flattened laterally gonostyli, which *Venisiella* presents. This new genus presents as well the autapomorphic character of the group *Virgilia*⁺ (*Virgilia*, (*Clonaspe*, (*Painella*, *Buxtoniella*))), which belong to *Makota*⁺, specifically females with small and postero-dorsally oriented anal tube lobes.

Geology of the Fiji region and its surrounding.

The Fiji archipelago is composed of 332 islands (Neall and Trewick 2008). Vanua Levu is one of the two largest islands, mountainous and rising up to 1300 m. It was formed just before 7 Ma, later than Viti Levu which emerged around 25–20 Ma (Whelan *et al.* 1985). Since this island contains the oldest rocks of the archipelago, this age generally serves as the earliest estimate for the Fijian terrestrial lineages (Lucky and Sarnat 2010). The geological history of the Fijian archipelago is closely linked to the Vanuatu and the Solomon islands on the west and the Samoan islands throughout the Tonga-Kermadecs ridge on the east (Soulier-Perkins 2000). Extremely complex, only a few highlights are given here. This archipelago found its origin in the end of Eocene with the subduction of the Pacific plate beneath the Australian plate, along the Vitiaz Arc (Neall and Trewick 2008). At one point the Fiji islands were included in the South west island arc (Ewart 1988), which was still established 12 Ma (Hall 2002). The breakup of this arc was already started 10 Ma, and Fiji started to rotate counter-clockwise and completely separated from the rest of the arc 3 Ma (Ewart 1988). As for the Samoan islands, depending on the hypotheses, their estimated age is variable, from 0.39 Ma to 5.1 Ma. However, a recent study showed that the Savaii submarine flanks are of volcanic origin dating back from 5 Ma, which reinstates the Samoa as a primary hotspot trail associated with a deep mantle plume and a linear age progression (Koppers *et al.* 2008).

Historical biogeographic hypothesis. According to the geological events that shaped the islands where the *Makota*⁺ genera are found, some key dates can be placed on the cladogram of the group. Since the Fiji islands were completely separated from the other islands 3 Ma, and if the genera *Buxtoniella* and *Venisiella* are the result of a vicariant event, their common ancestor must have reached the Fiji and Samoa before this date but could not be established before 5 Ma in Samoa, a time when those islands emerged. *Painella* and *Clonaspe* are both distributed within the Solomon islands and both found on the

remnants of the South-West Pacific island arc like *Buxtoniella* and *Venisiella*. The relationship between all those genera are not completely resolved; however, their ancestor could not reach this island arc before it emerged around 23 Ma (Packham 1973). Those dates and events still perfectly coherent with the rest of the hypothesis proposed by Soulier-Perkins (2000), in which the ancestor of *Makota*⁺ could not established itself before 40 Ma on the West Pacific island arc, from which it dispersed on the South-West island arc when it rises and get in contact with this first arc.

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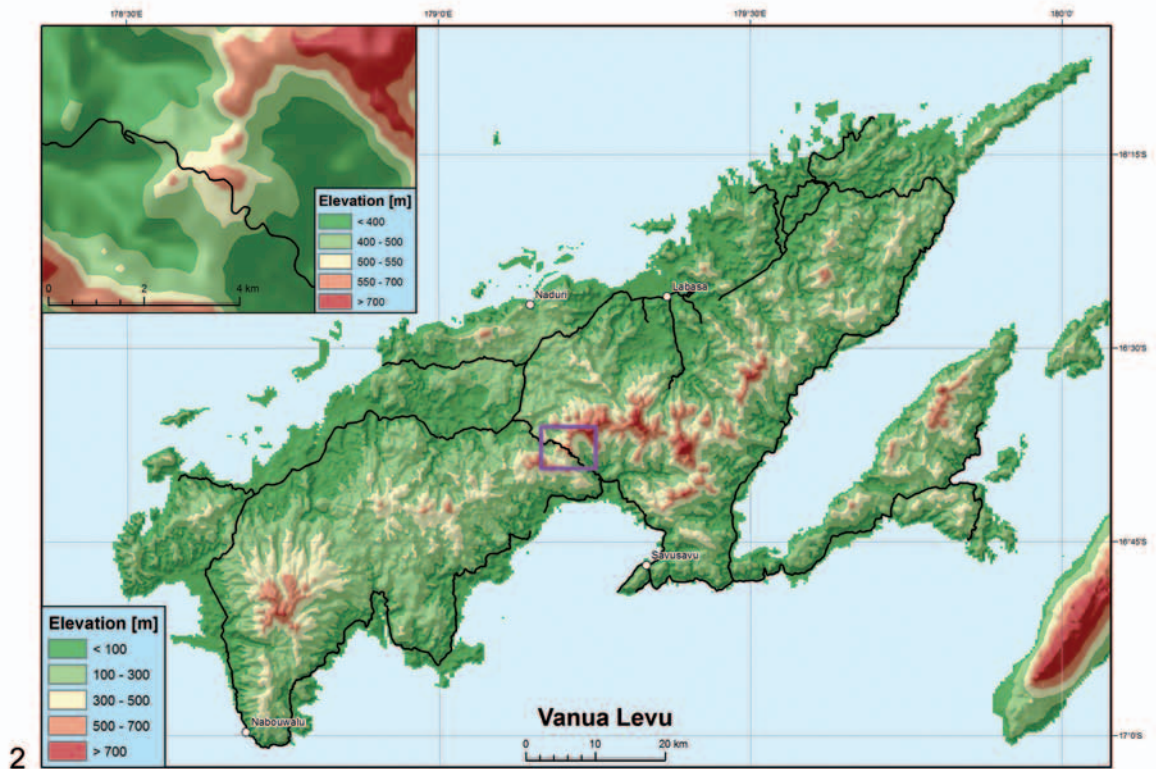
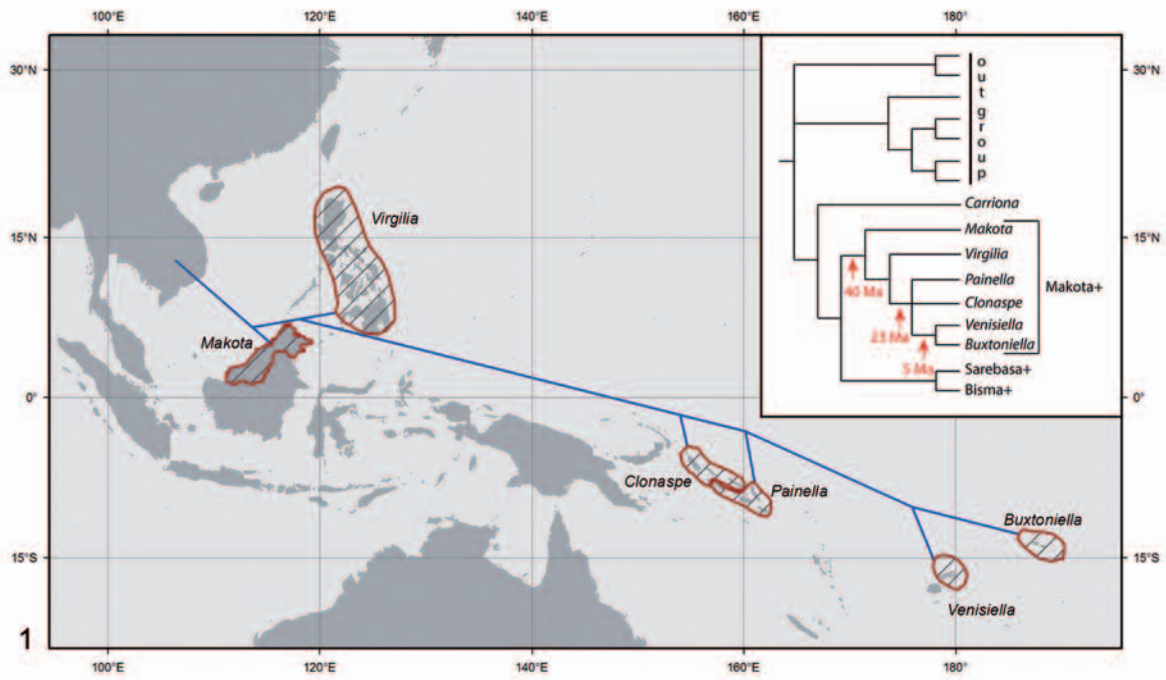
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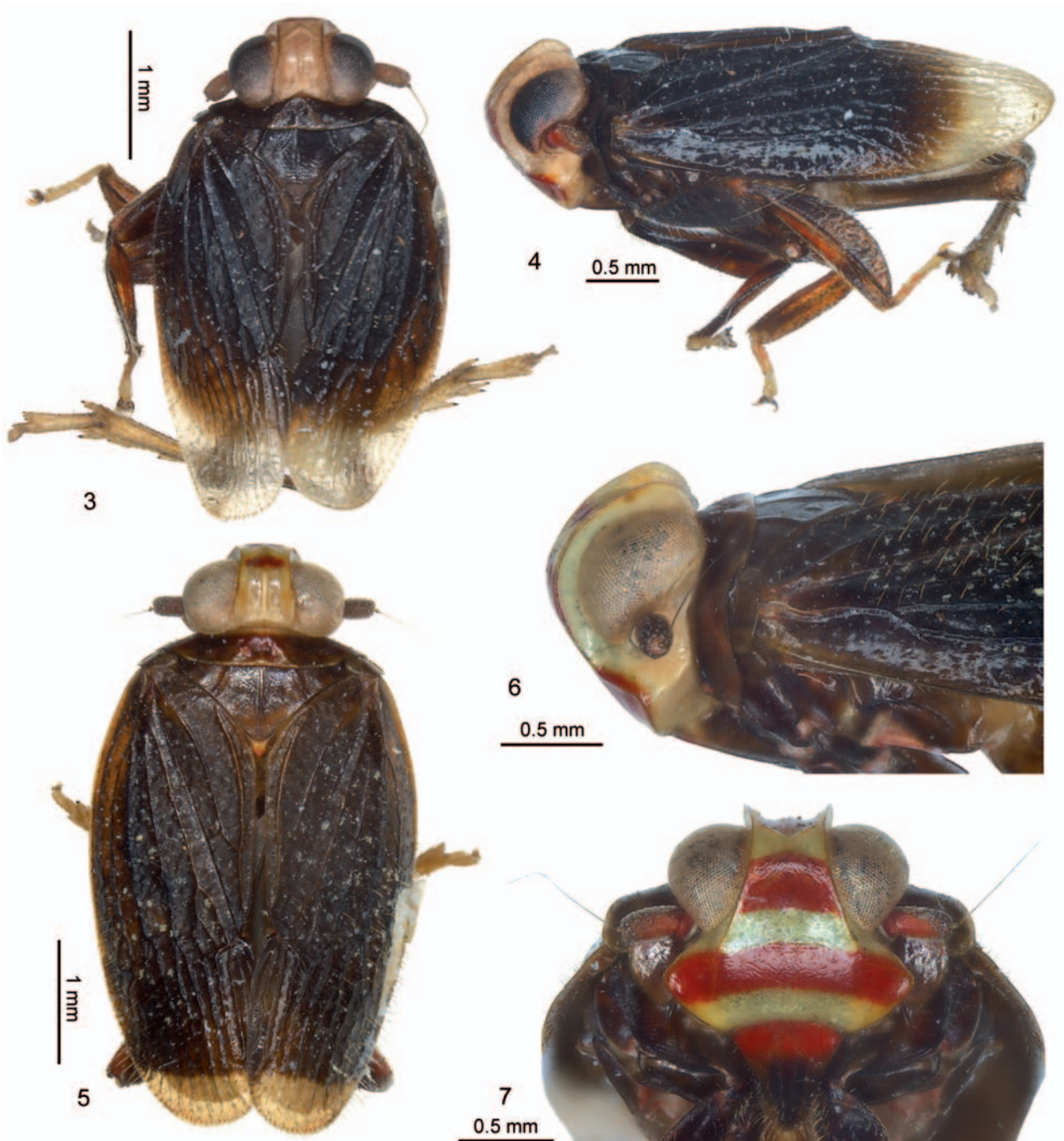
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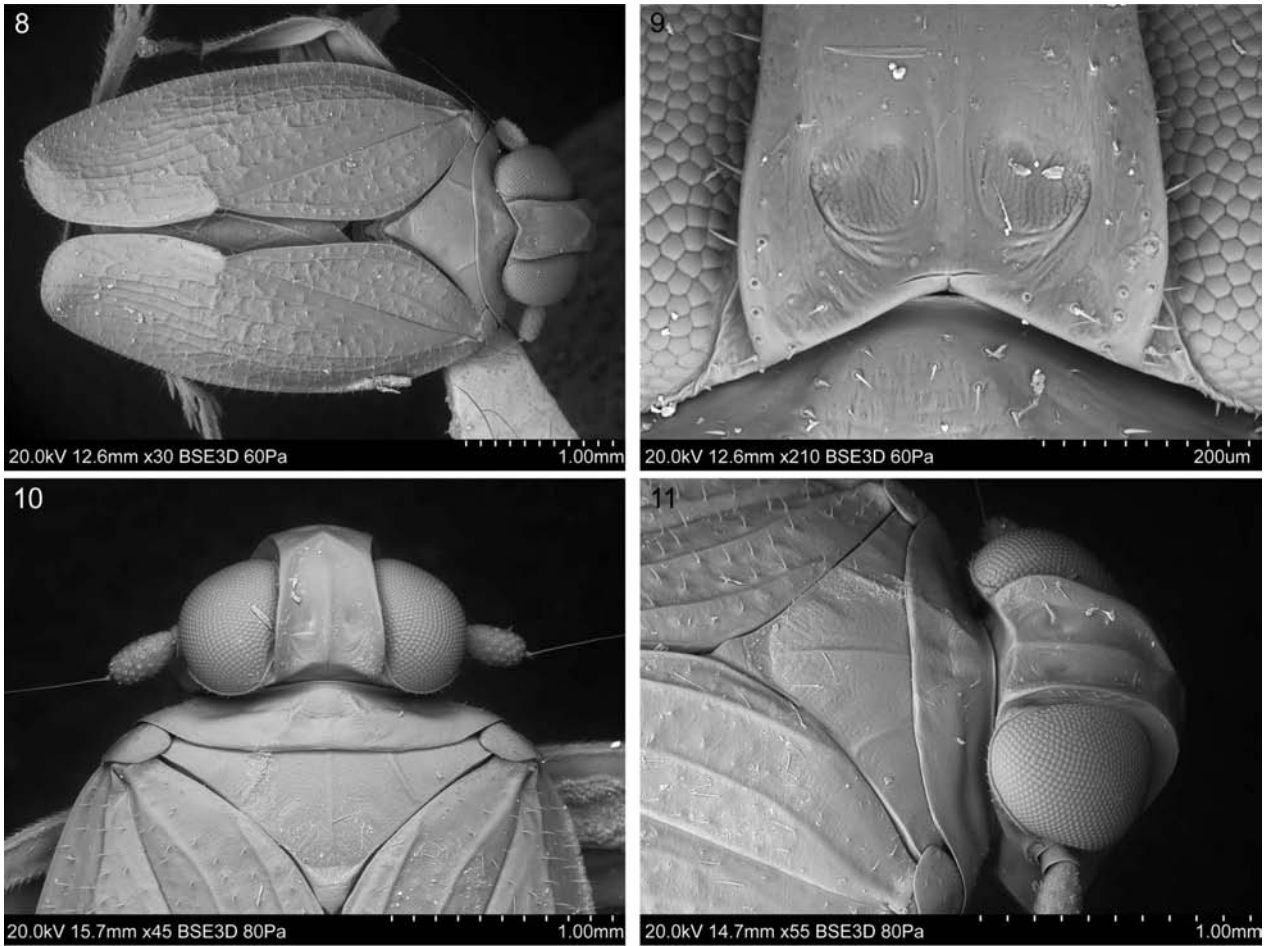
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Figures 1–2. *Venisiella manifesta* gen. et sp. nov. (1) geographical distribution of Makota+ group and phylogenetic relationship between genera of the group; (2) Fiji Island – distribution map.



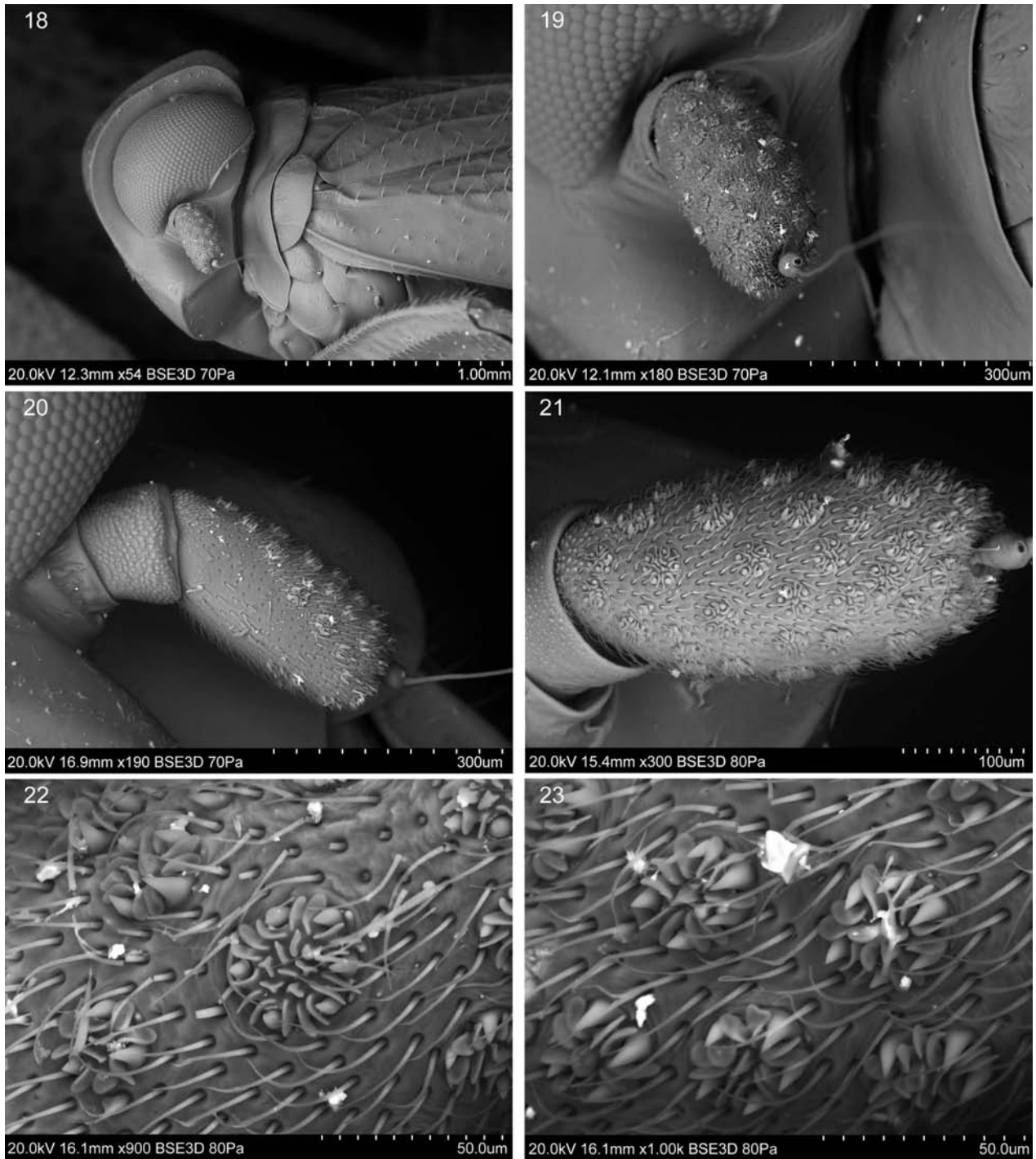
Figures 3–7. *Venisiella manifesta* gen. et sp. nov. (3, 5) Habitus, dorsal view; (4) habitus, lateral view; (6) anterior part of body, lateral view; (7) anterior part of body, frontal view. (3–4) male, (5–7) female.



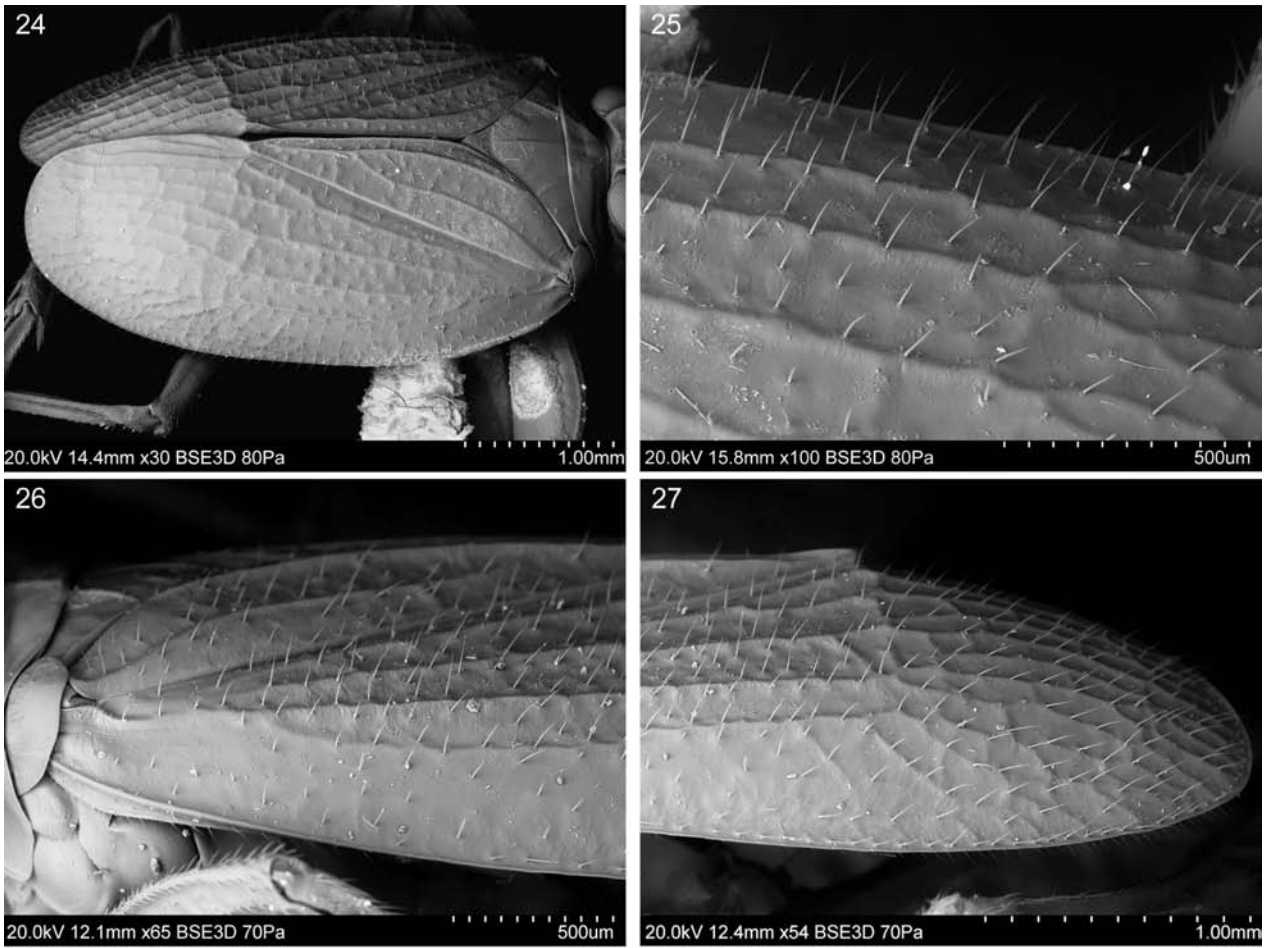
Figures 8–11. *Venisiella manifesta* gen. et sp. nov., SEM photographs. (8) Habitus, dorsal view; (9) basal part of vertex, dorsal view; (10–11) anterior part of body: (10) dorsal view, (11) dorso-lateral view. (8–9) Male, (10–11) female.



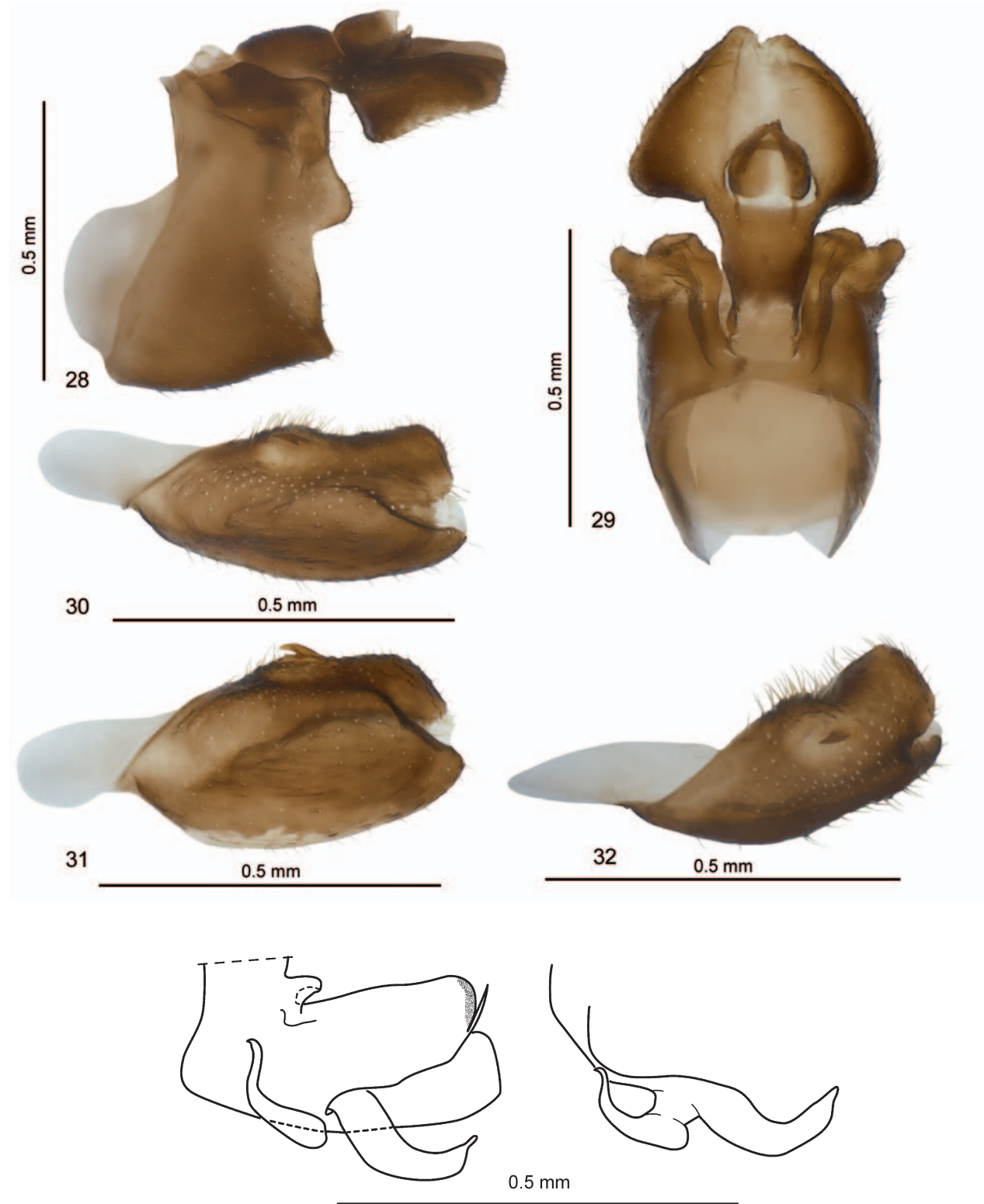
Figures 12–17. *Venisiella manifesta* gen. et sp. nov., female. SEM photographs. (12–14) Anterior part of body: (12) frontal view, (13) lateral view, (14) ventral view; (15–17) legs: (15) prothoracic leg, (16) hind leg, ventral view, (17) distal part of hind tibia and tarsomeres, ventral view.



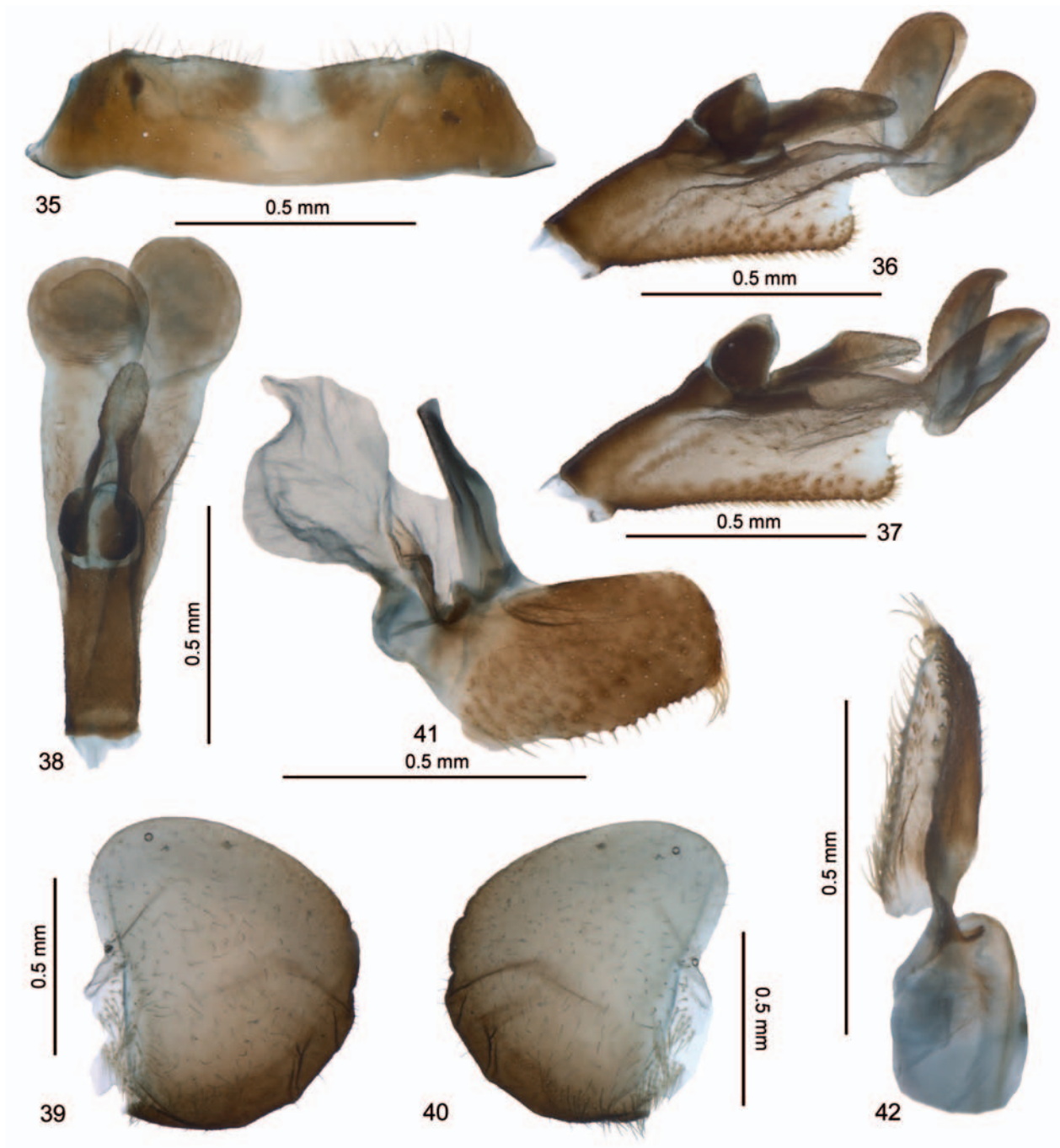
Figures 18–23. *Venisiella manifesta* gen. et sp. nov., female. SEM photographs. (18) Anterior part of body, lateral view; (19–21) antenna: (19) latero-dorsal view, (20) frontal view, (21) dorsal view; (22–23) antennal plate organs.



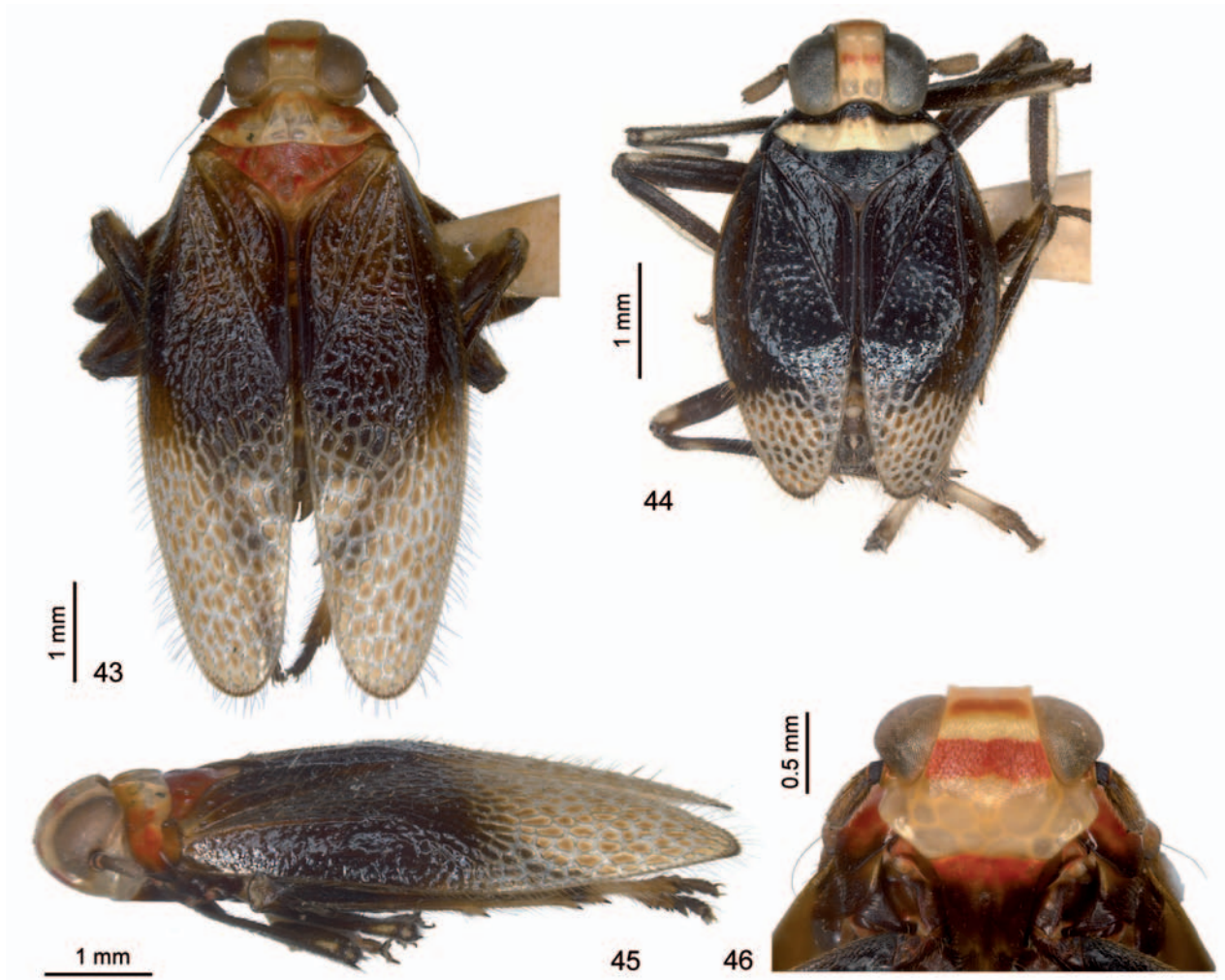
Figures 24–27. *Venisiella manifesta* gen. et sp. nov., female. SEM photographs. (24) Habitus, dorsal-lateral view; (25) surface of tegmen; (26–27) tegmen, dorso-lateral view: (26) basal part, (27) posterior part.



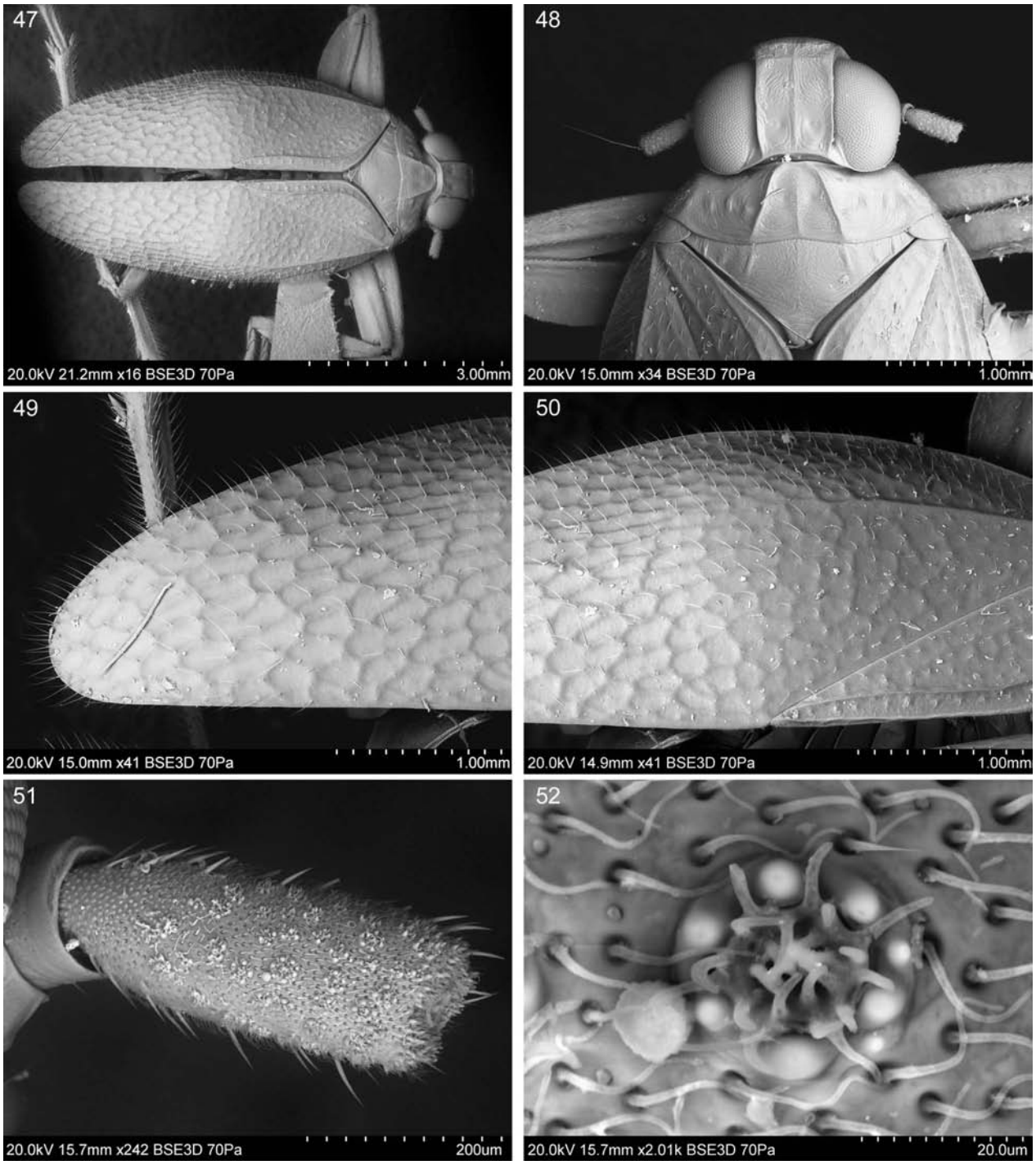
Figures 28–34. *Venisiella manifesta* gen. et sp. nov., male. (28–29) Male terminalia: (28) lateral view, (29) dorsal view; (30–32) genital style: (30) lateral view, (31) ventral view, (32) dorsal view; (33) phallic complex, lateral view; (34) aedeagus, lateral view.



Figures 35–42. *Venisiella manifesta* gen. et sp. nov., female. (35) Pregenital sternite; (36–38) anal tube: (36–37) lateral view, (38) dorsal view; (39–40) gonoplac, lateral view: (39) external part, (40) internal part; (41–42) gonapophysis VIII: (41) lateral view, (42) dorsal view.



Figures 43–46. *Buxtoniella hopkinsi* Muir, 1927. (43–45) Habitus: (43–44) dorsal view, (45) lateral view; (46) anterior part of body frontal view. (44) male, (43, 45–46) female.



Figures 47–52. *Buxtoniella hopkinsi* Muir, 1927, female, SEM photographs. (47) Habitus, dorsal view; (48) anterior part of body dorsal view; (49–50) tegmen, dorso-lateral view: (49) basal part, (50) posterior part; (51) antenna, frontal view; (52) antennal plate organs.

