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New Species of *Aenetus* from Sumatra, Indonesia (Lepidoptera: Hepialidae) and a 5,000 km biogeographic disjunction

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Abstract

Discovery of *Aenetus sumatraensis* nov.sp. from northern Sumatra expands the distribution range of this genus well into southeastern Asia along the Greater and Lesser Sunda. The species belongs to the *A. tegulatus* clade distributed between northern Australia, New Guinea, islands west of New Guinea and the Lesser Sunda that are separated by over 5,000 km from *A. sumatraensis* nov.sp.. The Sumatran record either represents local differentiation from a formerly widespread ancestor or it is part a larger distribution of the *A. tegulatus* clade in the Greater Sunda that has not yet been discovered. The bursa copulatrix of the Australian species referred to as *A. tegulatus* is different from specimens examined in New Guinea and Ambon Islands (locality for the type) and is therefore referred to here as *A. thermistes* stat.rev.

Zusammenfassung

Die Entdeckung von *Aenetus sumatraensis* nov.sp. in Nord-Sumatra dehnt das Verbreitungsgebiet dieser Gattung aus bis nach Südostasien entlang der Großen und Kleinen Sundainseln. Die Art gehört zur *A. tegulatus*-Gruppe, die auf Nordaustralien, Neuguinea, die Inseln westlich von Neuguinea und die Kleinen Sundainseln verteilt und von *A. sumatraensis* nov.sp. um mehr als 5.000 km getrennt ist. Das Vorkommen in Sumatra stellt entweder eine lokale Differenzierung von einem ehemals weit verbreiteten Vorfahren dar oder es ist Teil einer größeren, noch unentdeckten Verbreitung der *A. tegulatus*-Gruppe auf den Großen Sundainseln. Die Bursa-Kopulatrix der australischen Art von *A. tegulatus* unterscheidet sich von den in Neuguinea und den Ambon-Inseln (Lokalität für den Typus) untersuchten Exemplaren und wird daher hier als *A. thermistes* stat.rev. bezeichnet.

Introduction

Most *Aenetus* species are found in the region broadly described as Australasia with 19 species in Australia (SIMONSEN 2018), eight species in New Guinea, one species each from New Caledonia and New Zealand, and one species from Halmahera just west of New Guinea (ROEPKE 1913). In addition there are reports of *Aenetus* from the islands of the Lesser Sunda as far west as Timor, Flores and Sumba. These specimens have an external appearance similar to that of *A. tegulatus* (PAGENSTECHER, 1888), a species first described for the island of Ambon and attributed to moths in Indonesian Papua and Northern Australia. Recent examination of specimens in Papua, Papua New Guinea, and Ambon (JRG in prep.) indicate that *A. tegulatus* represents more than one species. These species together indicate a fairly contiguous range for *Aenetus* between the Western Pacific and eastern Indonesia, but a number of the western records in the Lesser Sunda are from very recent discoveries (Benny De Groof pers. com.) which raised the question of how much further west the distribution of *Aenetus* may be present. It was anticipated that further records would be found at least in the Lesser Sunda and perhaps the Sulawesi (for which there are no known records of any Hepialidae). It was therefore with some surprise that a new record of *Aenetus* from northern Sumatra was discovered in the Witt Museum collection. This discovery resulted from the suggestion of Benny De Groof that one of the specimens in the collection had a partially visible label suggestive of an Indonesian locality. Upon investigation it was determined that the specimen has been collected from the northern volcano of Seulawah Agam in Banda Aceh Province that was over 5,000 km northwest of any other *Aenetus* records. Here we describe *A. sumatraensis* nov.sp. from Sumatra and discuss some of the systematic and biogeographic issues involved.

Materials & Methods

The abdomen was removed and treated in a cold solution of 5% KOH. The abdominal skin was opened by a right lateral cut from the tergosternal bar to the genitalia which were removed and stained in Chlorazol black. Terminology follows that of MIELKE & CASAGRANDE (2013). Outline diagrams of legs and wings were made by tracing over photographs using InkScape Scalable Vector Graphics (SVG) 1.1 (Second Edition), version <http://www.w3.org/TR/2011/REC-SVG11-20110816/>

Abbreviations

HT (holotype), FW (forewing), HW (hindwing)
MWM..... Museum Witt, München

Systematic Entomology

Order Lepidoptera LINNAEUS, 1758

Suborder Exoporia COMMON, 1975

Superfamily Hepialoidea STEPHENS, 1829

Family Hepialidae STEPHENS, 1829

Taxonomy: *Aenetes sumatraensis* nov.sp.; Figs. 1a, 1b, 3-10.

Etymology: Named for Sumatra where the type specimen was collected.

Holotype: ♂ (with the following labels separated by forward slashes): /SUMATRA (NW-Ache), Mt. Silawa [Seulawah Agam], 600 m, E. Banda-Aceh, 23.,28.,29.3.1993, leg. Dr. R. Breschlin / Holotype, *Aenetes sumatraensis* ♀, Grehan, Witt & Ignatev det 2018/ Dissection No. 34.712. Holotype in the MWM collection.

Diagnosis: The color and pattern of wings is characteristics of females of the *Aenetes* 'tegulatus' group. The species *A. sumatraensis* nov.sp. can be distinguished from other members of this clade by the shape of the bursa copulatrix and the relative size of segments in the labial palps.

Description

Female (Figs. 1-6). Wingspan 46 mm; FW length: 42 mm, width: 20 mm, ratio 2.1: 1; HW length: 33 mm, width: 18 mm, ratio 1.8: 1. Antenna (Fig. 4) filiform, pale yellowish brown, scape and pedicel covered with short piliform scales, scape cylindrical, pedicel rounded and slightly barrel shaped, flagellum with 31 segments, covered with numerous sensilla chaetica, lamellar scales absent, annuli dorso-ventrally tall, narrowing near apex. Interocular-antennal scales absent. Labium (Fig. 5) triangular, labial palp three segmented, covered with pale yellowish brown scales, mid segment slightly longer than basal segment, distal segment half length of mid segment, slightly wider apically with von Rath's organ at apex; clypeus free of scales, projecting anteriorly as a transverse ridge; frons and vertex covered with short, pale green piliform scales.

Thorax: Pro and mesothorax dorsally covered with dark yellowish green scales, scutum III pale yellowish brown, anteriorly free of scales, dorsal posterior scales orange; lateral and ventral thorax orange to yellowish brown; FW triangular, costal margin slightly concave centrally, convex towards apex; outer margin straight, broad curving anal angle merging to an almost straight anal margin; venation 'hepialine' (Fig. 6), Sc1 absent. FW dorsal ground colour yellowish green with darker green transverse lines between veins, width expanding near bordering veins to form a narrow hour glass shape; each row of transverse lines offset from adjacent rows; posterior axillary sclerite of FW with long reddish brown hairs; costal margin with seven central dark brown trapezoidal patches extending to Sc, and 7 smaller and paler trapezoidal brown patches along outer costal margin. Outer margin, anal angle, and distal anal margin edged with dark brown merging with some transverse lines between veins; central region of wing with three transverse rows of diffuse brown patches, central row patches largest; cell between 1A and CuA2 with three

large brown patches, distal patch merging with margin. Ventral FW with costal pocket with concave costal edge; ground colour yellowish to reddish brown, soft piliform scales over much of the basal and central wing surface; costal margin with six rectangular dark brown patches extending to Sc, separated by pale yellowish green patch with central diffuse brown scales; central Sc lined with piliform scales projected posteriorly, cells basal to cross veins and Rs2-3 cell near costa with long, thin hairs merging with lamellar scales over most of the outer wing surface. Dorsal HW ground colour reddish brown basally merging with yellowish brown distally; fringe with pale greyish brown scales. Ventral HW ground colour pale yellowish to reddish brown with darker brown between costal margin and Sc with 1-2 faint rectangular patches of pale yellowish green, soft piliform scales over much of the basal and central wing surface. Legs (Fig. 7) basally yellowish green, tarsi yellowish brown; leg length ratio pro: meso: meta 1: 1.3: 0.73; proleg with well developed, narrow shark fin shaped epiphysis; metaleg femur and first tarsal segment strongly curved; arolium present, distally sclerotized (Fig. 7b).

P r e - g e n i t a l a b d o m e n : Dorsal abdomen reddish brown on segments 1-4 merging to yellowish green on posterior segments with terminal brown scales around genitalia; pleural and ventral surfaces pale yellowish brown. Tergites and sternites weakly sclerotized; tergum II (Fig. 8a) with lateral ridge of extending antero-medially to lateral tuberculate plate, lateral ridge present on tergum III not as strongly developed; tergosternal connection (Fig. 8c) with triangular tergosternal bar, not strongly fused with intermediate zone, ventral sector elongate with acute apex at lateral arm of sternum II, lateral and dorsal brace short, right angled to each other with broad edge, dorsal brace not strongly fused to anterior edge of tergum II; tergal knob absent; sternum II (Fig. 8b) sub-rectangular, wider anteriorly, anterior margin broad v-shape to lateral margin; lateral arms of sternum II short with longitudinal lateral ridge extending posteriorly and angled medially, tergum VII and VIII fused, subsquare, lateral edge slightly convex, posterior margin convex, sternum VII subrectangular, longer than wide, sternum VIII subrectangular, wider than long.

G e n i t a l i a : Internal genitalia (Fig. 9) with ductus bursa narrowing conically at the antrum and further narrowing about two thirds of length, total length about 75% of bursa copulatrix. Bursa distally circular, connected to junction of ductus and cylindrical caecum by a narrow tube. External genitalia (Fig. 9b, c) with moderately sclerotized lamellar anti-vaginalis, dorsally setose and comprising convex central lobe and lateral lobe with rounded medial apex, inner surface of central lobe with pair of low domes with rows of sclerotized ridges extending into antrum (Fig. 9d); dorsal plate narrow, lightly sclerotized, dorsally setose, particularly on the anal papillae bordering the genital region.

Habitat

The specimen was collected at the beginning of a prolonged wet period from March through December (https://www.meteoblue.com/en/weather/forecast/modelclimate/cot-seulawah-agam_indonesia_1213909 last accessed January 19, 2018). Location of the specimen at 600 m places it on the lower slopes of the volcano Seulawah Agam (5,938 m) and at the lower boundary of the present remaining continuous forest cover on the mountain. *Aenetus* is a genus of callus feeding stem borers and therefore requires a forested habitat

to survive. Seulawah Agam is one of three conservation Protected Areas in the Krueng Aceh Watershed and is a high priority area for the Environmental Services Program of the United States Agency for International Development in Indonesia (ESP 2006).

Remarks

The distribution of *Aenetus* comprises a principal range of species diversity across Australasia and eastern Indonesia (Fig. 11a) from which the record of *A. sumatraensis* nov.sp. in northern Sumatra represents a major disjunction. The phylogenetic relationships within *Aenetus* have not yet been subject to comprehensive analysis (GREHAN 2012, SIMONSEN 2018), but the external appearance and genitalia of *A. sumatraensis* nov.sp. is similar to specimens from eastern Indonesia and New Guinea that are referred to here as the *A. tegulatus* clade. This clade has previously been understood to comprise the species *A. tegulatus* (SIMONSEN 2018), distributed across northern Australia, New Guinea, and eastern Indonesian Islands (Fig.11b). The bursa copulatrix of *A. sumatraensis* nov.sp. is distinct from *A. 'tegulatus'* specimens from Ambon and New Guinea (GREHAN et al. in prep). Australian specimens previously regarded as *A. tegulatus* (Fig. 2a) also have a distinct bursa copulatrix which leads to the conclusion they represent a different species (Simonsen pers. comm.) here referred to as *A. thermistis* (LOWER, 1894) stat. rev. in reference to the female type (Fig. 2b) while the male type of *A. cyanochlora* (LOWER, 1894) is designated as a junior synonym (Fig. 2c). At this time the name *A. tegulatus* can only be confidently referred to the type locality of Ambon.

There are two alternative possible geographic implications for the disjunction between northern Sumatra and the Lesser Sunda. One is that the disjunction represents the absence of intervening localities for *Aenetus* in Sumatra, Java, and the western Lesser Sunda. Such disjunctions are common throughout South East Asia (HEADS 2003). Alternatively it is a collecting artefact and the genus has not been recorded in these intervening localities despite its relatively large size and bright colour. This possibility is suggested by the record of only single or very few specimens from the Lesser Sunda localities as the moths may be geographically or seasonally localized or infrequently attracted to light traps. The Lesser Sunda and the Celebes do not have records of any genera or species of Hepialidae in and Java and Sumatra other records are limited to relatively few localities for the genus *Endoclita*, and even less for *Palpifer*.

Past records of Hepialidae in the region have been suggestive of allopatry between the 'Australasian' and South East Asian Hepialidae, but there is now at least evidence for partial sympatry involving the '*tegulatus*' clade of *Aenetus* (GREHAN & MIELKE 2018). The local differentiation of *Aenetus* species in New Guinea and islands of eastern Indonesia is compatible with a vicariance origin of a widespread *Aenetus* ancestor as proposed for the Southwest Pacific by GREHAN & MIELKE (2018). The origin of *A. sumatraensis* nov.sp. in northern Sumatra would represent a further allopatric component of a widespread '*tegulatus*' group with an ancestral range extending between northern Australia and the Greater Sunda (Sumatra and Java). Whether this range also included the Celebes, Borneo or other adjacent regions is question that may only be resolved by future collecting that confirms the generic and species composition of Hepialidae in those regions.

Acknowledgements

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Figures

(1a)



(1b)



Fig. 1. *Aenetus sumatraensis* nov.sp.: (a) dorsal view, (b) ventral view. Photos Nikolai Ignatev.

(2a)



(2b)



(2c)

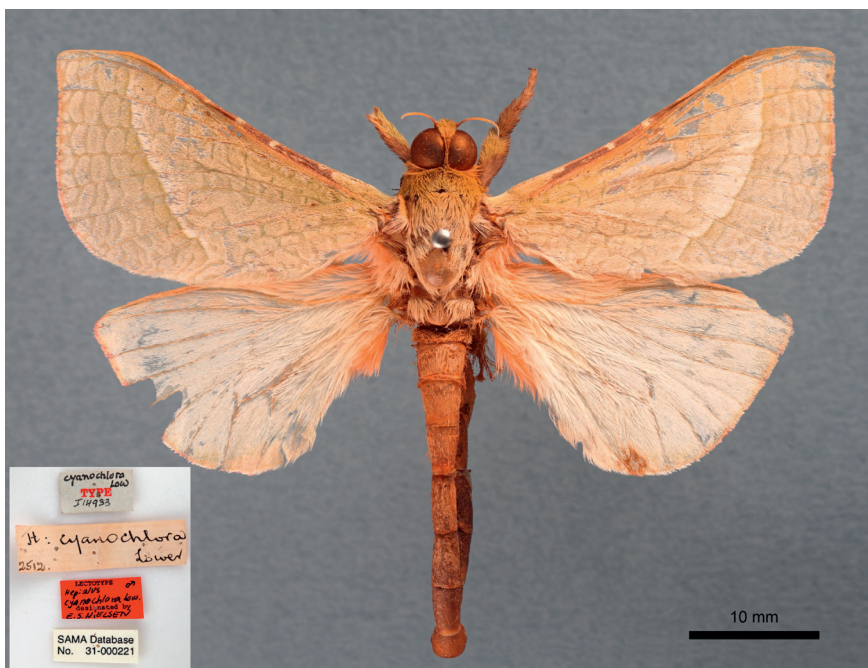


Fig. 2. *Aenetus thermistis* (LOWER, 1894): (a) female, Queensland, Australia. Photo John Nielsen©, (b) female holotype. Photo Matt Golebiowski. ©The Museum Board of South Australia 2011-2012, (c) male *syn.* '*cyanochlora*' type. Photo Alexis Tindall. ©The Museum Board of South Australia 2011-2012.

(3)



Fig. 3. *Aenetes sumatraensis* nov.sp. lateral view. Photo Nikolai Ignatev.

(4)



Fig. 4. *Aenetes sumatraensis* nov.sp. antenna. Photo Nikolai Ignatev.

(5)



Fig. 5. *Aenetes sumatraensis* nov.sp. labial palps. Scale 2 mm. Photo Nikolai Ignatev.

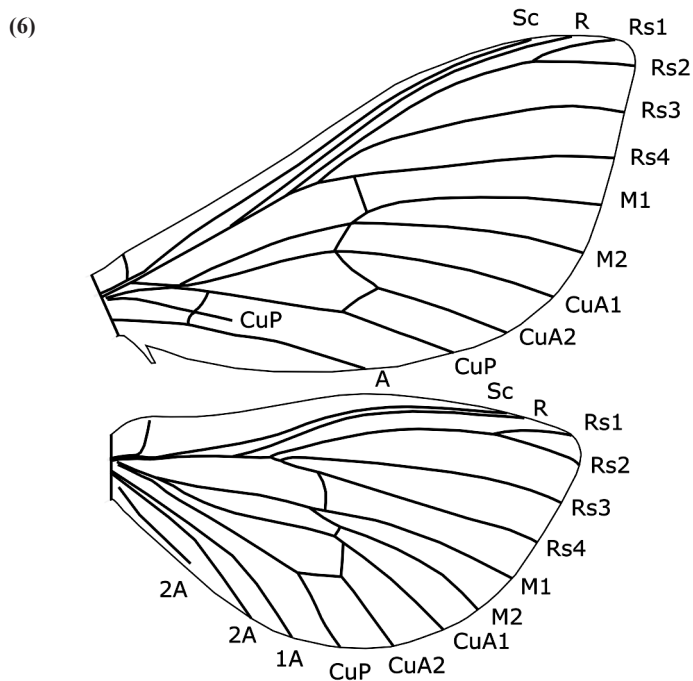


Fig. 6. *Aenetus sumatraensis* nov.sp. wing venation.

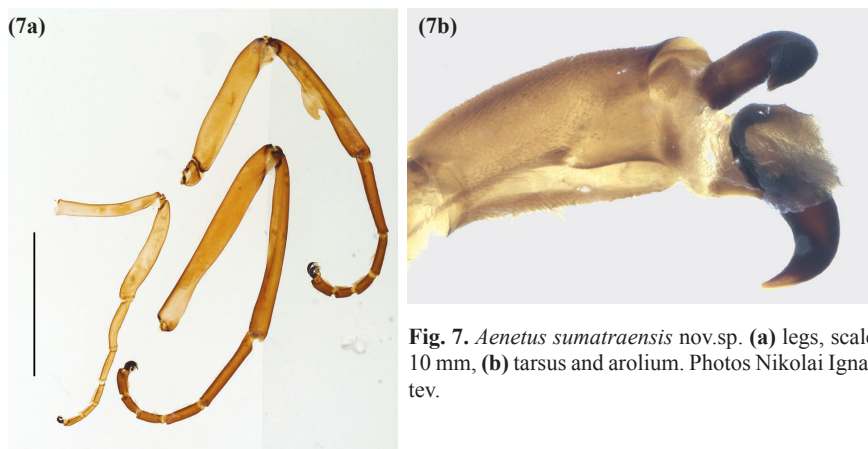
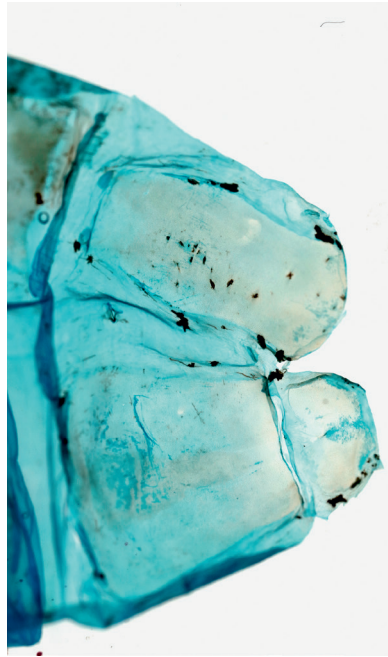


Fig. 7. *Aenetus sumatraensis* nov.sp. (a) legs, scale 10 mm, (b) tarsus and arolium. Photos Nikolai Ignatov.

(8a)



(8b)



(8c)

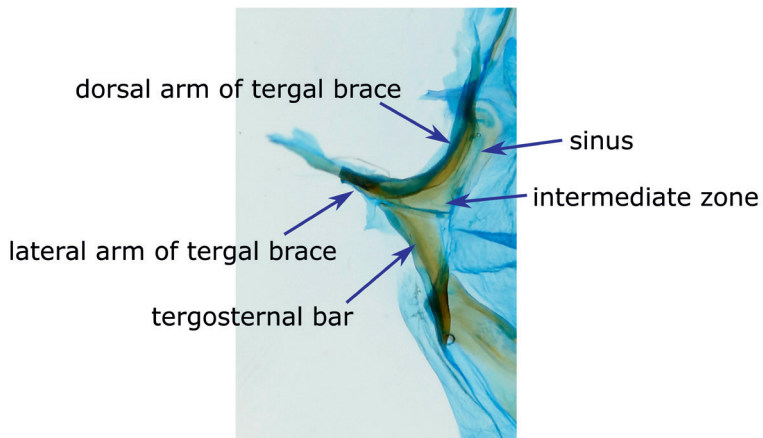


Fig. 8a *Aenetes sumatraensis* nov.sp. abdomen: **(a)** anterior, **(b)** posterior, **(c)** tergo-sternal connection. Photos Nikolai Ignatev.

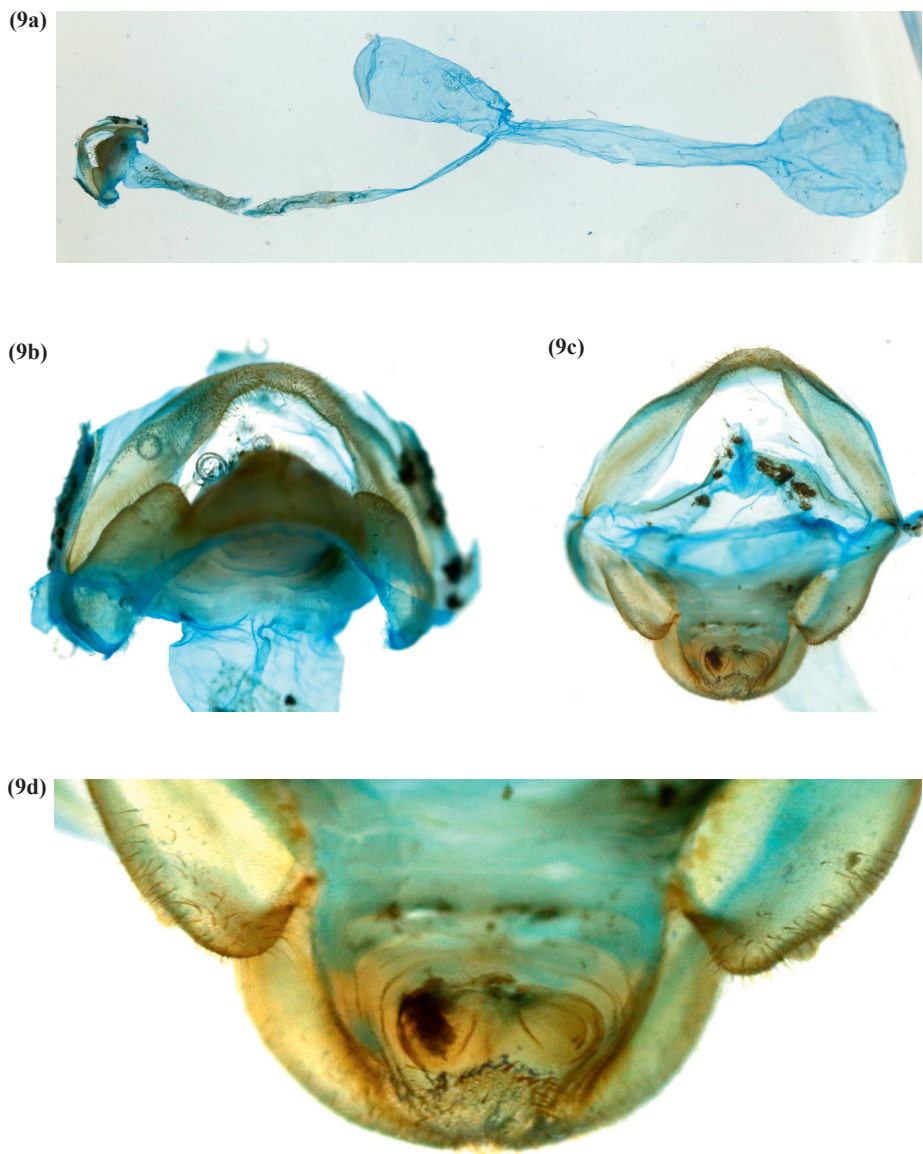


Fig. 9. *Aenetus sumatraensis* nov.sp. genitalia: **(a)** ductus bursa and bursa copulatrix, **(b)** external genitalia, postero-ventral view, **(c)** External genitalia, posterior view, **(d)** lamellar antivaginalis, dorsal view. Photos Nikolai Ignatev.

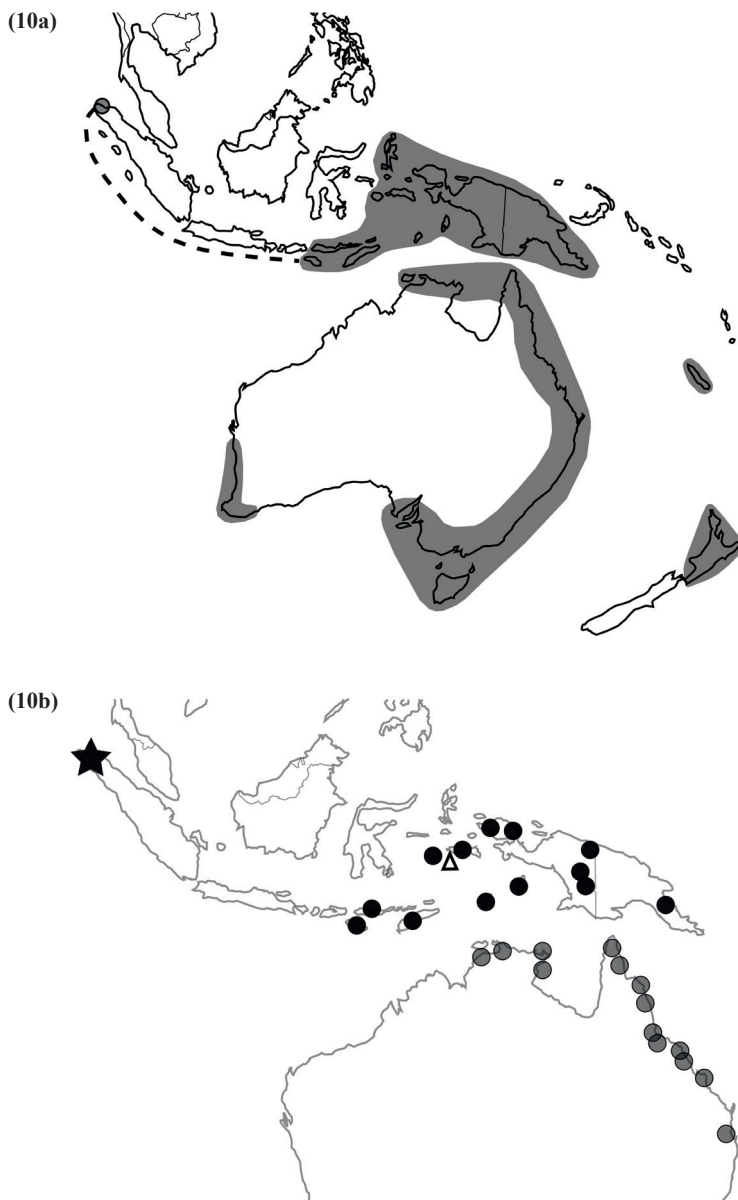


Fig. 10. *Aenetus* distribution: **(a)** *Aenetus* distribution range (shaded) with dashed line marking disjunction of *A. sumatraensis*, **(b)** '*Aenetus tegulatus*' clade distribution; star – *A. sumatraensis* nov.sp., pale circles – *A. thermistis* (LOWER, 1894), dark circles – status undetermined, triangle – type locality of *A. tegulatus* (PAGENSTECHER, 1888).

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