



New species, locality records and calling songs of crickets of the subfamily Phaloriinae (Orthoptera: Grylloidea: Phalangopsidae) from Malaysia

MING KAI TAN^{1,2*}, AMIRA AQILAH MUHAMMAD³, NURUL ASHIKIN ABDULLAH³, RAZY JAPIR⁴, ARTHUR Y.C. CHUNG⁴ & TONY ROBILLARD²

¹Block 207A, Woodleigh Link, Singapore 361207, Republic of Singapore

✉ orthoptera.mingkai@gmail.com; <https://orcid.org/0000-0002-4324-6305>

²Institut de Systématique, Evolution, Biodiversité (ISYEB), Muséum national d'Histoire naturelle, CNRS, SU, EPHE-PSL, UA, 57 rue Cuvier, CP 50, 75231 Paris Cedex 05, France

✉ tony.robillard@mnhn.fr; <https://orcid.org/0000-0002-2177-9549>

³Institute of Biological Sciences, Faculty of Science, Universiti Malaya, Kuala Lumpur 50603, Malaysia

✉ miamedulla@gmail.com; <https://orcid.org/0000-0001-5772-1149>

✉ shikin84@um.edu.my; <https://orcid.org/0000-0002-1111-2732>

⁴Forest Research Centre (Sepilok), Sabah Forestry Department, PO Box 1407, 90715 Sandakan, Sabah, Malaysia

✉ razy.japir@sabah.gov.my; <https://orcid.org/0009-0004-1879-6550>

✉ arthur.chung@sabah.gov.my; <https://orcid.org/0000-0002-9529-4114>

*Corresponding author

Abstract

Specimens representing three genera of Phaloriinae—*Borneloria* Gorochov, 2018, *Phaloria* (*Papuloria*) Gorochov, 1996 and *Trellius* (*Zatrellius*) Gorochov, 1999—were collected from Peninsular and East Malaysia and examined here. We report a new locality record for *Borneloria moorei* (Chopard, 1940) in Johor, Peninsular Malaysia, the first record of this genus in Malay Peninsula. From Sandakan, East Malaysia, we discovered a new species of *Trellius* (*Zatrellius*) and describe here: *Trellius* (*Zatrellius*) *puntung* **sp. nov.** We also recorded the previously unknown calling songs of *Phaloria* (*Papuloria*) *tristis* Gorochov, 2014 and *Trellius* (*Zatrellius*) *puntung* **sp. nov.** and describe them here.

Key words: Borneo, Peninsular Malaysia, *Borneloria*, *Phaloria*, *Trellius*

Introduction

Crickets from the subfamily Phaloriinae Gorochov, 1985 (Grylloidea, Phalangopsidae) are species-rich in Southeast Asia, where different morphological-similar congeners can exhibit vast inter-specific variability in their male genitalia (e.g., Gorochov, 1999, 2014, 2018). As many as 17 new species were discovered recently when more material was examined (e.g., Tan *et al.*, 2021; Gorochov, 2022). Similar to other groups of crickets, the male genitalia are typically used to delimit species (Gorochov, 2015). However, other useful characters such as the parameters of the male calling songs are rarely described and used in taxonomy (but see Gorochov & Tan, 2012; Ma & Jing, 2018; Tan *et al.*, 2021). This may be attributed to the considerable effort needed to obtain these sound recordings. Phaloriinae crickets are very sensitive to disturbance when they call while staying cryptic among foliage in the understory trees at night. In captivity, they may not necessarily call readily. At present, there are insufficient data to effectively use calling songs as a means to validate morphological hypotheses.

Here, we obtained new material belonging to three genera of Phaloriinae from recent fieldwork in Peninsular Malaysia and East Malaysia: *Borneloria* Gorochov, 2018, *Phaloria* (*Papuloria*) Gorochov, 1996 and *Trellius* (*Zatrellius*) Gorochov, 1999. These have led to the discovery of a new species of *Trellius* (*Zatrellius*): *Trellius* (*Zatrellius*) *puntung* **sp. nov.** Previously known to occur only in Borneo and Sumatra, we found a species of *Borneloria* in Malay Peninsula, i.e., *Borneloria moorei* (Chopard, 1940), therefore expanding our understanding of the generic distribution. We also recorded the calling songs of *Phaloria* (*Papuloria*) *tristis* Gorochov, 2014 and *Trellius* (*Zatrellius*) *puntung* **sp. nov.**

Materials and methods

Sampling

Material examined here was collected during orthopteran samplings by M.K. Tan and T. Robillard in Kabili Sepilok Forest Reserve in Sabah State, East Malaysia between 11 and 19 May 2022; as well as by M.K. Tan and A.A. Muhammad in Panti Forest Reserve in Johor State, Peninsular Malaysia between 27 April and 1 May 2024. Whenever possible, live specimens were photographed using a Canon EOS 500D digital SLR camera with a compact-macro lens EF 100 mm f/2.8 Macro USM, and Canon Macro Twin Lite MT-24EX was used for lighting and flash.

Acoustic recording and analyses

Male adult crickets were recorded in the field using the following recording equipment: Zoom H1n with Stereo X/Y 90° microphones (sampling frequency of 96 kHz-samples/s and handle up to 120 dB SPL) with the recordings saved in 24-bit BWF-compliant WAV format and SONY Handycam FDR-AX53 4K 16.6 megapixels. A temperature logger, HOBO 8K Pendant® Temperature logger (model: UA-001-08, Onset, Bourne, MA), was used to record the ambient temperature.

Acoustic analysis generally follows Tan *et al.* (2022, 2023). The basic cricket song terminology generally follows Baker & Chesmore (2020):

Calling song = spontaneous song produced by an isolated male to attract a female

Dominant frequency = frequency with highest energy from the mean spectrum

Echeme = a first-order assemblage of syllables

Echeme-sequence = a first-order assemblage of echemes

Interval = silent interval between calls and/or pulses, or down-time

Syllable = single complete stridulatory movement (i.e., opening and closing of wings)

Parameters of the temporal domain (e.g., durations and intervals) were measured manually using Raven Lite 2.0.0. The dominant frequency was obtained using the ‘spectro_analysis’ function from the R package warbleR version 1.1.27 (Araya-Salas & Smith-Vidaurre, 2017) in the R software version 4.1.3.

Curation and examination of material

The specimens were preserved in absolute analytical-grade ethanol and later pinned and dry-preserved. Typically, a single leg (not standardised) from each specimen was kept in absolute analytical-grade ethanol for future molecular work. Male genitalia were dissected from softened specimens and removed, then cleaned using aqueous KOH. The male genitalia were imaged using a binocular microscope Leica MZ16 with AMScope Microscope Eyepiece Camera (MU1000, 10 MP Aptina Colour, CMO50) attached via an AmScope FMA050 fixed microscope adaptor and the software ToupView. Subsequently, the genitalia were preserved in glycerine or hand sanitiser. Terminology used to describe the male genitalia follows Desutter-Grandcolas (2003) and Gorochov (2015) [in square brackets]:

Pseudepiphallus (ps) [epiphallus]

Pseudepiphallic lophi (ps l) [posterolateral epiphallic lobe]

Pseudepiphallic paramere (ps p) [ectoparamere]

Ectophallic fold (ec f) [rachis (= guiding rod)]

Ectophallic apodeme (ec ap) [endoparameral apodeme]

Endophallic sclerite (en s) [formula (= mold of spermatophore attachment plate)]

Rami (ra)

Morphological features were imaged using a macro photo lens MP-E 65 mm 1:2.8 USM (1–5×). Canon Macro Twin Lite MT24EX was used for lighting and flash. Image editing was accomplished using Adobe Photoshop CC 2014 (Adobe Systems Incorporated, San Jose, CA, USA). Measurements of dried-pinned specimen were made from images using ImageJ 1.51j8 (Wayne Rasband, Research Services Branch, National Institute of Mental Health, Bethesda, MD, USA). Terminology used to describe the male forewing (FW) follows Josse *et al.* (2023).

For the general morphology, the following abbreviations are used: I, II, III = anterior (fore), median, posterior (hind); F = femur; FW = forewing; T = tibia. In the measurements, the following abbreviations are used: HL = head length; PronL = pronotum length; PronW = pronotum width (at posterior margin); FWL = forewing length; FWW = forewing width; HWT = hindwing surpassing forewing length; FIIL = hind femur length; TIIL = hind tibia length.

The specimens were eventually deposited in:

FRC	Forest Research Centre (Sepilok), Sabah Forestry Department, East Malaysia
MNHN	Muséum national d'Histoire naturelle, Paris, France
ZRC	Zoological Reference Collection, Lee Kong Chian Natural History Museum, Singapore

Taxonomic part

Subfamily Phaloriinae Gorochov, 1985

Tribe Phaloriini Gorochov, 1985

Genus *Borneloria* Gorochov, 2018

Borneloria Gorochov, 2018: 55—Tan *et al.*, 2020: 245; Gorochov, 2022: 244.

Type species. *Borneloria spinosa* Gorochov, 2018, by original designation.

Remarks. This genus consists of three species (one of which having two subspecies) from Borneo [*Borneloria spinosa* Gorochov, 2018 and *Borneloria moorei* (Chopard, 1940)] and Sumatra (*Borneloria sumatrana* Gorochov, 2022) (Gorochov, 2022; Cigliano *et al.*, 2024). Below, we report a new locality record of this genus from Johor in Peninsular Malaysia, extending the generic distribution to the biogeographic region of Malay Peninsula.

Borneloria moorei (Chopard, 1940)

(Figs 1, 2, 3A–C)

Heterotrypus moorei Chopard, 1940: 201

Phaloria moorei (Chopard, 1940)—Chopard, 1968: 361

Vescelia moorei (Chopard, 1940)—Gorochov, 1999: 35

Borneloria moorei (Chopard, 1940)—Gorochov, 2018: 56

Material examined. PENINSULAR MALAYSIA • 1♂; Johor State, Panti Forest Reserve, Bunker Trail; N1.86250, E103.89675, 37.1±7.1 m.a.s.l.; 30 April 2024, 22h31; on foliage near ground; coll. M.K. Tan and Amira A. Muhammad; PANTI.24.46 (ZRC).

Remarks. *Borneloria moorei moorei* (Chopard, 1940) was described from Mount Dulit (Sarawak, and not Kalimantan as stated in Gorochov [1999]), whereas *Borneloria moorei occidentalis* Gorochov, 2018 was described from Mount Matang (Sarawak). Our male specimen from Panti Forest Reserve represents the first record of this species outside Sarawak.

Our male specimen resembles *Borneloria moorei moorei* more than *Borneloria moorei occidentalis* in the male FW dorsal field having the apical area longer than the mirror area (instead of shorter in the latter subspecies) (Fig. 1), the pseudepiphallal lophi [epiphallal distal lobe] curving less dorsad and ectophallal fold [rachis] with its apex slightly bifurcated (Figs 3A–C). However, it differs slightly from both subspecies in the pseudepiphallal lophi having a more rounded apex (rather than truncated) (Fig. 3C). Our male specimen differs from *Borneloria spinosa* and *Borneloria sumatrana* by the pseudepiphallal lophi [posterolateral epiphallal lobes] lacking both the posteroventral projections and apical notches (Figs 3A, 3B).



FIGURE 1. *Borneloria moorei* (Chopard, 1940) ♂ in its natural environment in Pantí Forest Reserve.



FIGURE 2. *Borneloria moorei* (Chopard, 1940) ♀ in its natural environment in Pantí Forest Reserve.

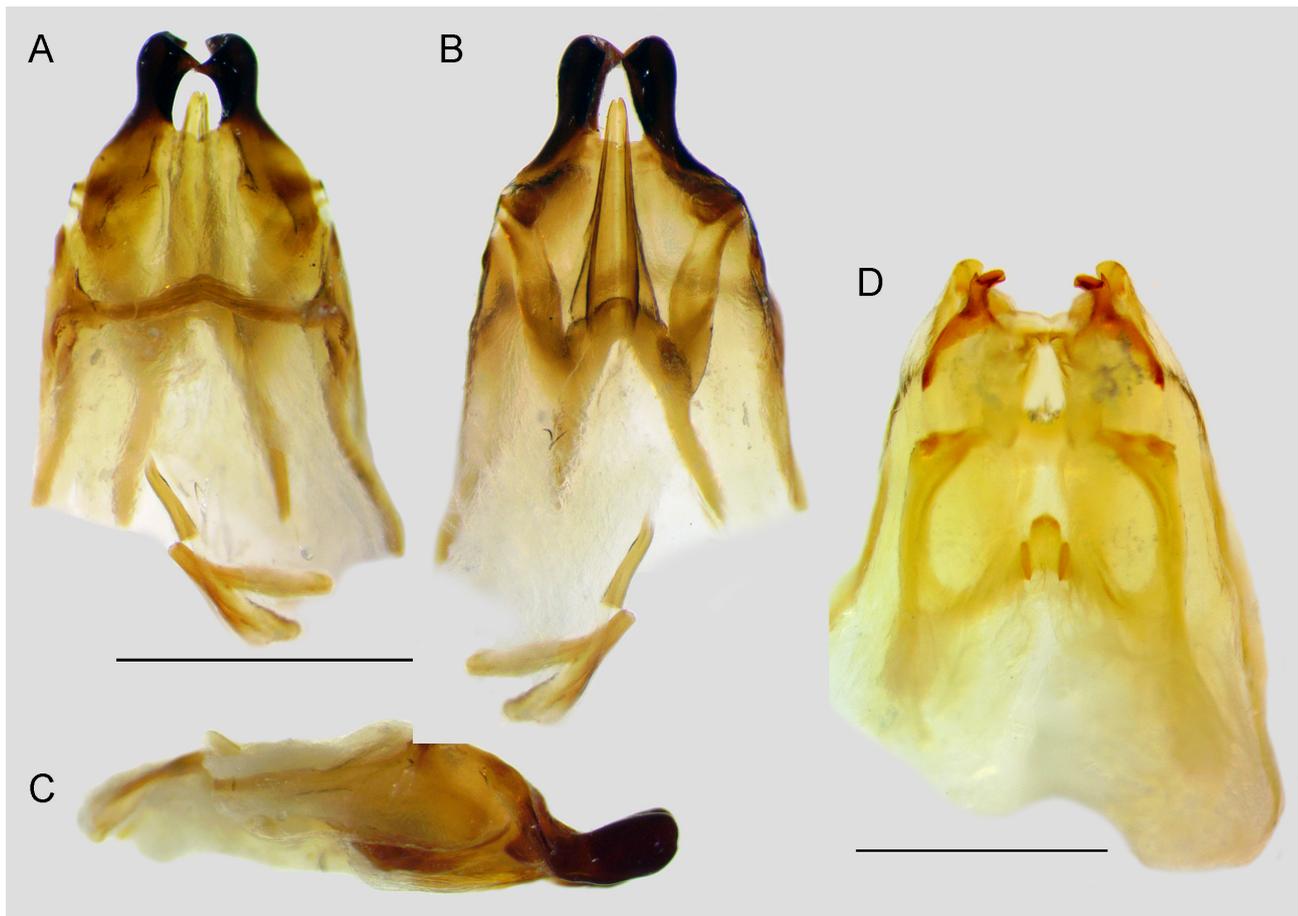


FIGURE 3. *Borneloria moorei* (Chopard, 1940) (A–C) and *Phaloria (Papuloria) tristis* Gorochov, 2014 (D) ♂ genitalia in dorsal (A), ventral (B, D) and lateral (C) views. Scale bars: 1 mm.

Ecology. Found near forest stream.

Distribution. Borneo (Sarawak), Peninsular Malaysia (Johor) [new locality record].

Calling song. Unknown.

Subgenus *Phaloria (Papuloria)* Gorochov, 1996

Phaloria (Papuloria) Gorochov, 1996: 66—Hugel *et al.*, 2021: 239; Tan *et al.*, 2021: 515.

Type species. *Phaloria solomonica solomonica* Gorochov, 1996, by original designation.

Remarks. This is a speciose and widely-distributed subgenus consisting of 49 species ranging from Sumatra, Borneo, Sulawesi to east of New Guinea (Cigliano *et al.*, 2024). In East Malaysia (Borneo), three species are currently known: *Phaloria (Papuloria) latiuscula* Gorochov, 2014 from Kubah National Park (Sarawak); *Phaloria (Papuloria) paratristis* Gorochov, 2014 from Lambir Hills, Mulu National Park, Kubah National Park and Gunung Gading (all Sarawak); *Phaloria (Papuloria) tristis* Gorochov, 2014 from numerous parts of East Malaysia and Borneo (see below) (Gorochov, 2014, 2018).

Phaloria (Papuloria) tristis Gorochov, 2014 (Figs 3D, 4, 5)

Phaloria (Papuloria) tristis Gorochov, 2014: 75—Tan & Wahab, 2018: 132 (new locality record in Brunei Darussalam); Gorochov, 2018: 60 (new locality record in Tawau Hills)

Material examined. EAST MALAYSIA • 1♂; Sabah State, Sandakan, Sepilok, Rainforest Discovery Centre; N5.87435, E117.94205, 49.9±5.7 m.a.s.l.; 17 May 2022, 19h30; calling on foliage of shrub; video recording of call TR0057; coll. M.K. Tan & T. Robillard; TR22-22 (MNHN-EO-ENSIF11149) • 1♂; Sabah State, Sandakan, Sepilok, Rainforest Discovery Centre; N5.87435, E117.94205, 49.9±5.7 m.a.s.l.; 17 May 2022, 19h30; calling on low tree foliage; video recording of call TR0059 (Fig. 4); coll. M.K. Tan & T. Robillard; TR22-22 (MNHN-EO-ENSIF11150).



FIGURE 4. *Phaloria (Papuloria) tristis* Gorochov, 2014 ♂ singing in its natural environment in Rainforest Discovery Centre, Sepilok.

Remarks. The male genitalia resembles that described by Gorochov (2014) (Fig. 3D).

Ecology. Found near forest stream, singing from hidden locations in low tree foliage.

Distribution. Sarawak (Mulu National Park, Lambir Hills), Sabah (Sandakan, Tawau Hills), Brunei Darussalam.

Calling song (1♂, in the field, 26.6°C) (Fig. 5). The calling song consists of echeme-sequences. Each echeme-sequence consists of variable number of echemes, ranging from 3 to 8. The average echeme-sequence duration is 0.57 ± 0.26 s (0.29–1.04 s) and the down-time interval between consecutive echeme-sequences is 0.84 ± 0.41 s (0.38–1.36 s). Each echeme is made up of three very closely-spaced syllables (on rare occasion, four syllables) and has an average duration of 37.3 ± 0.5 ms (36.4–38.0 ms). The average down-time interval between consecutive echemes is 106.5 ± 8.7 ms (92.5–118.4 ms). Each syllable has an average duration of 7.7 ± 0.9 ms (6.7–9.6 ms) and the average down-time interval between consecutive syllables is 6.9 ± 0.7 ms (5.8–8.1 ms). The frequency spectrum is pure-tonal and forms a harmonic, with the energy peaking at the fundamental frequency of 5.03 ± 0.09 kHz (4.97–5.16 kHz).

The calling song of *Phaloria (Papuloria) tristis* has a similar frequency spectrum as those of other congeners, having a dominant frequency of around 5 kHz (although that of *Phaloria? jereylnae* Gorochov & Tan, 2012 from Singapore peaks slightly lower at 4.5 kHz). The call structure, however, can be quite variable among congeners. *Phaloria (Papuloria) tristis* has a similar call structure as *Phaloria (Papuloria) berbeda* Tan & Robillard, 2021 from West Papua, but differs by the number of syllables within each echeme. In contrast, the calling song of *Phaloria (Papuloria) paradischidia* Tan & Robillard, 2021 from West Papua is made up of echemes with two syllables each. The calling song of *Phaloria? jereylnae* consists of echemes occurring in pairs with 7–8 syllables each (instead of a sequence made up of a variable number of three-syllabic echemes).

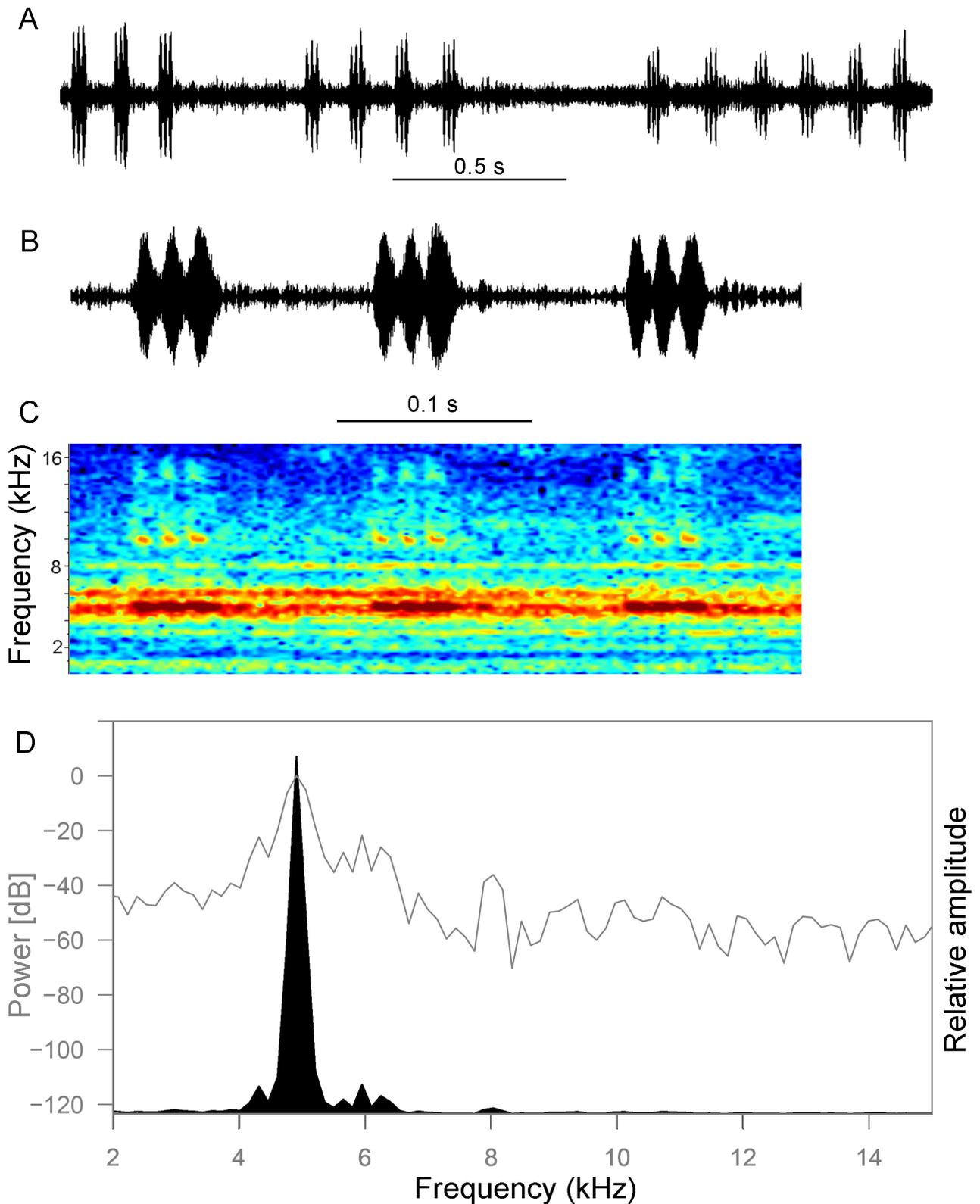


FIGURE 5. *Phaloria (Papuloria) tristis* Gorochov, 2014 ♂ calling song: oscillograms showing three echeme-sequences with three, four and six echemes, respectively; (A) and one echeme-sequence showing three echemes, each with three syllables (B); spectrogram of the same echeme-sequence (C); power spectra of a syllable (D) where the grey line represents the power [dB] (axis name and scale in grey) and the black solid peak represents the relative amplitude (axis name in black).

Genus *Trellius* Gorochov, 1988

Subgenus *Zatrellius* Gorochov, 1999

Trellius (*Zatrellius*) Gorochov, 1999: 31—Gorochov, 2003: 88 (note that the ‘1992’ years for the subgenus and type species are incorrect)

Type species. *Trellius communis* Gorochov, 1999, by original designation.

Remarks. This subgenus consists of five species from Borneo [*Trellius* (*Zatrellius*) *crocker* Gorochov, 2018; *Trellius* (*Zatrellius*) *kinabalu* Gorochov, 2018; *Trellius* (*Zatrellius*) *tawau* Gorochov, 2018], Nicobar Islands [*Trellius* (*Zatrellius*) *andamanensis* Gorochov, 2003] and Thai Peninsula [*Trellius* (*Zatrellius*) *communis* Gorochov, 1999] (Cigliano *et al.*, 2024). It can be distinguished from the other subgenera by its pseudepiphallus [epiphallus] broadly separated into lateral halves with the lateral parts more sclerotized, its characteristic ectophallic fold [rachis] with a pair of long, curved processes at the apex (Gorochov, 1999).

Trellius (*Zatrellius*) *puntung* sp. nov.

(Figs 6–8)

Material examined. Holotype: EAST MALAYSIA • ♂; Sabah State, Sandakan, Sepilok, Rainforest Discovery Centre; N5.87532, E117.94241, 45.0±7.9 m.a.s.l.; 11 May 2022, 20h00; on foliage of small tree, calling near stream; coll. M.K. Tan & T. Robillard; SBH.22.13 (FRC).

Paratype: EAST MALAYSIA • 1♂; Sabah State, Sandakan, Sepilok, Rainforest Discovery Centre; N5.87435, E117.94205, 49.9±5.7 m.a.s.l.; 17 May 2022, 20h17; calling on foliage of tree above stream; coll. M.K. Tan & T. Robillard; SBH.22.128 (ZRC).

Diagnosis. The new species differs from congeners by the combination of these characters: the pseudepiphallic lophi [epiphallic distal lobe] with truncated apices, the ectophallic fold [rachis] with subacute apex. It is most similar to *Trellius* (*Zatrellius*) *crocker* Gorochov, 2018 from Crocker Range National Park and *Trellius* (*Zatrellius*) *tawau* Gorochov, 2018 from Tawau Hills National Park in the shape of the genitalia. The new species differs from *T. crocker* by the pseudepiphallic lophi [epiphallic distal lobe] more straight and at apex in dorsal view truncated (more like *T. tawau* and not arcuate and tapering to an acute apex), the ectophallic fold [rachis] with distal process having a subacute apex (instead of acute apex). It also differs from *T. tawau* by the pseudepiphallic lophi, and the ectophallic fold [rachis] slender, not widened in the middle and with notch between the proximal parts of these processes narrow (more like *T. crocker*).

Etymology. The species is named after Puntung, one of Malaysia’s last Sumatran Rhinoceros; noun in apposition. “Puntung”, in Dusun language, means stub. It also refers to the more truncated or less acute apices of the pseudepiphallus and ectophallic fold as compared to those of *T. crocker* and *T. tawau*.

Description. Habitus very typical of the genus, medium sized, mostly brown. Head with dorsum slightly flattened, finely pubescent. Rostrum dark coloured, about 1.2 times as wide as scape, with apex somewhat truncated (in dorsal view) (Fig. 6A). Eyes projected anteriorly in dorsal view (Fig. 6A). Median ocellus transversely oval; lateral ocelli oval, located near eyes (Fig. 6B). Face in anterior view 1.1 times as tall as wide (Fig. 6B). Gena yellow brown (Fig. 6B). Maxillary palpi with apical segment longest, distinctly enlarged and rounded apically; with subapical segment cylindrical and shorter; third segment about as long as apical segment (Fig. 6C). Pronotal disc brown, darker anteriorly; about 1.7 times as wide as long, widening posteriorly (posterior margin 1.5 times as wide as anterior margin); finely and densely pubescent; anterior margin of disc broadly concave; posterior margin of disc angularly convex (Fig. 6A). Pronotal lateral lobe about as long as high; brown with dark margins; ventral margin rising posteriorly (Fig. 6C). Metanotal gland absent (Fig. 6D). TI slightly swollen; with inner and outer tympana open and having oval tympanal membrane; inner tympanum larger than outer (Fig. 6E). Legs generally pale brown; FI and FII with pale ring followed by dark ring before apex; TI and TII generally darker in colouration with two pale rings each; FIII with pale ring near knee (Fig. 6F); TIII with pale rings alternate with dark ones near base of spines (Fig. 6F). TIII with 4 inner and 4 outer long spines; with 2–4 denticles between spines; 4 denticles before most proximal spines; and with inner spurs (apical spines) longer than corresponding outer ones (Fig. 6F). Thoracic and abdominal segments yellow brown to brown.

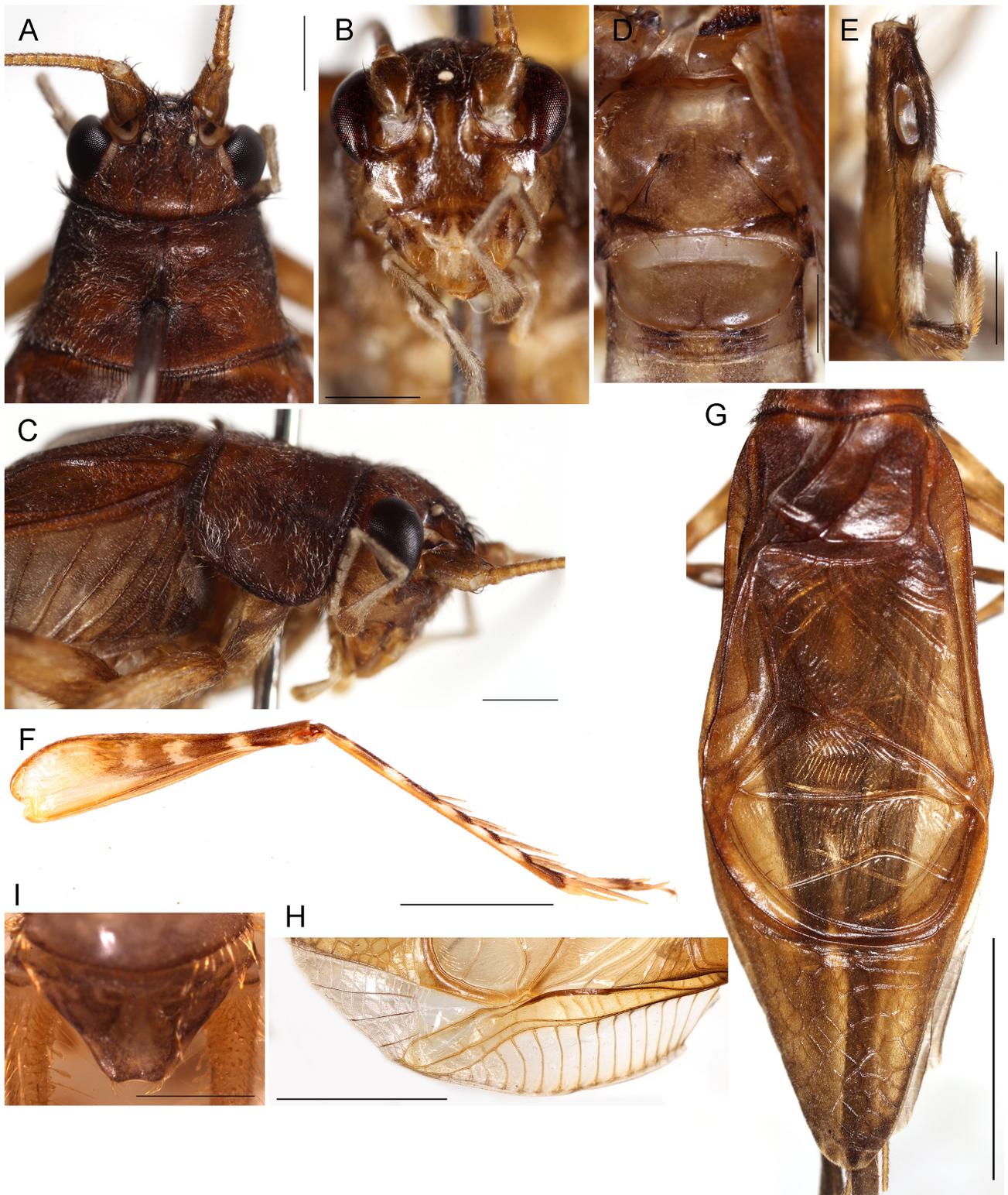


FIGURE 6. *Trellius (Zatrellius) puntung* sp. nov. ♂: head and pronotum in dorsal view (A); face in anterior view (B); anterior half of body in lateral view (C); metanotal gland in dorsal view (D); inner tympanum on TI (E); leg III in lateral view (F); FW in dorsal (G) and lateral view (H); anal plate in dorsal view (I). Scale bars: 5 mm (F–H); 1 mm (rest).

Male. FW covering abdomen and well-surpassing abdominal apex (Fig. 6G). Colouration: mostly yellow brown, median fold and lateral field transparent (Fig. 6G). Venation: diagonal angularly bent in the middle, with 6 or 7 oblique veins in harp area; mirror 1.1 times as long as wide; mirror with two dividing veins, anterior one

substraight to slightly sinuous, posterior one angularly bent near middle (Fig. 6G). FW dorsal field with apical area long, 0.9 times as long as mirror length (Fig. 6G). FW lateral field with R and M widely spaced with faint transverse veins, with around 15 parallel branches on Sc (Fig. 6H). Hind wings clearly surpassing FWs (Fig. 6G).

Anal plate triangular, with anterior half broad, lateral margins taper and diverge into a narrow apex; apex emarginated (Fig. 6I). Subgenital plate typical of subgenus. Male genitalia as shown in Fig. 7: Pseudepiphallos [epiphallus] typical of subgenus, broadly separated into lateral halves with lateral parts more sclerotized. Pseudepiphallic lophi [posterolateral epiphallic lobe] slender and elongated (sometimes stouter); lobe in dorsal view sinuous at the basal third, faintly curved pointing slightly outwards thereafter; apex truncated, inner end with minute tooth; in lateral view with a distinct broad dorsal lobe in the middle. Pseudepiphallic paramere [ectoparamere] tooth-like with posterior apex subacute. Ectophallic fold [rachis] with a pair of strongly curved processes at the apex, having distinctly subacute apex; notch between proximal parts of processes very narrow. Endophallic sclerite [formula] forming bean-shaped lateral parts. Rami weakly sclerotized, straight and converging basally, nearly but not touching or fused together.

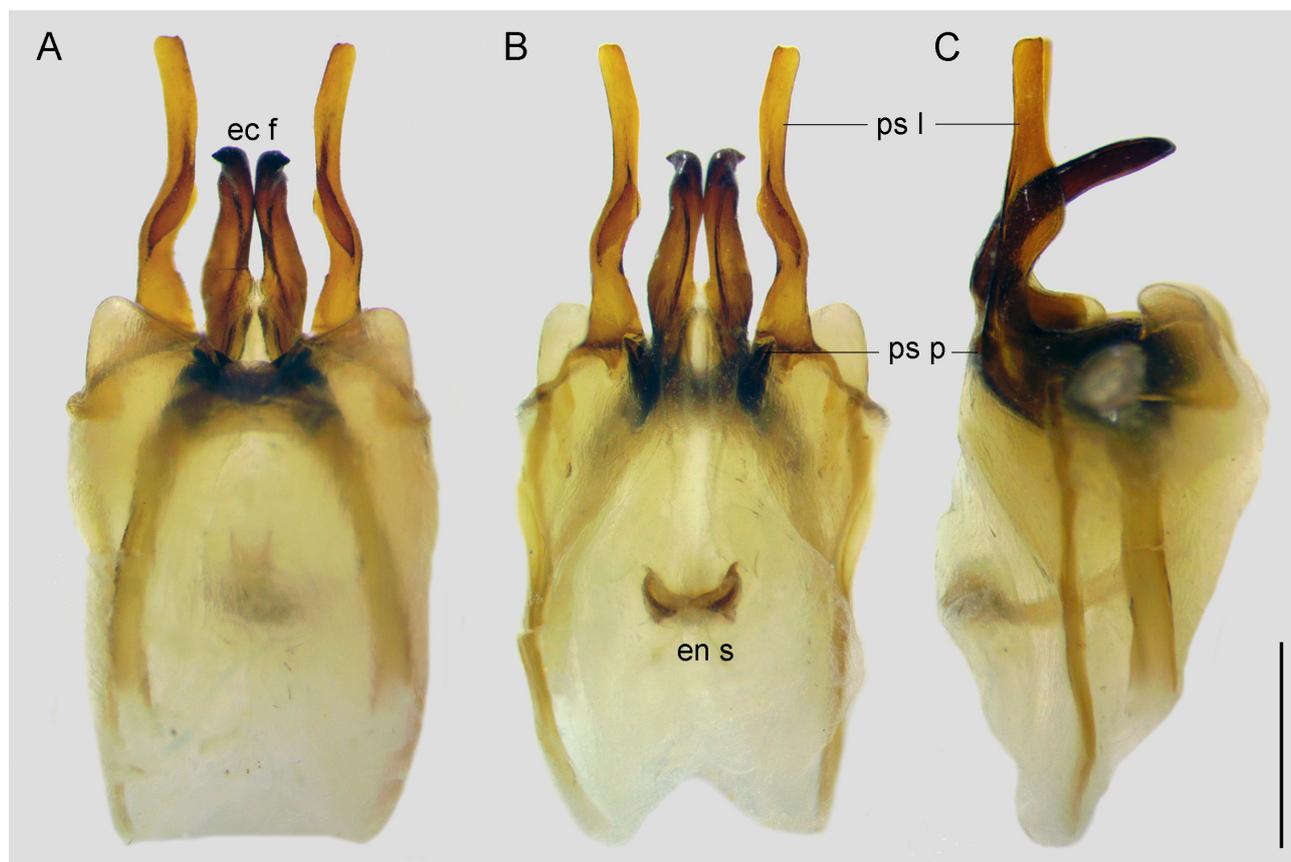


FIGURE 7. *Trellius (Zatrellius) puntung* sp. nov. ♂ genitalia in dorsal (A), ventral (B) and lateral (C) views. Scale bar: 1 mm.

Female. Unknown.

Measurements (2♂, in mm). HL = 1.4–1.5 (1.5); PronL = 2.2–2.3 (2.2); PronW = 3.4–3.7 (3.6); FWL = 14.3–15.1 (14.7); FWW = 5.6–5.9 (5.8); HWT = 2.5; FIIL = 9.8–9.9 (9.9); TIIL = 9.6–9.7 (9.7).

Ecology. This new species shares similar habitat with another similar-looking Phaloriinae *Vescelia sepilokensis* Tan, Gorochoy, Japir & Chung, 2019 (see Tan *et al.*, 2019) and was found to occur in the same forest patch as the latter species. Curiously, we did not find *Vescelia sepilokensis* during the recent field trip in May 2022. Likewise, in the previous field trip in January during which *Vescelia sepilokensis* was collected, *Trellius (Zatrellius) puntung* sp. nov. was not encountered. The males call at night, while hiding within tree foliage. They are often found and heard near forest streams.

Distribution. Known only from type locality, Sepilok (Borneo, Sabah State).

Calling song (1♂, in the field, 26.6°C) (Fig. 8). The calling song consists of a trill made up of a long sequence of echemes. Each echeme consists of four (very rarely three or five) very closely-spaced syllables and has an average

duration of 82.1 ± 8.3 ms (76.4–98.4 ms). The down-time interval between consecutive echemes is 101.5 ± 12.4 ms (75.7–123.6 ms). Each syllable has an average duration of 15.4 ± 0.3 ms (15.0–16.1 ms) and the down-time interval between consecutive syllables is 4.3 ± 0.4 ms (3.8–5.0 ms). The frequency spectrum is pure-tonal and forms a harmonic, with the energy peaking at the fundamental frequency of 4.59 kHz.

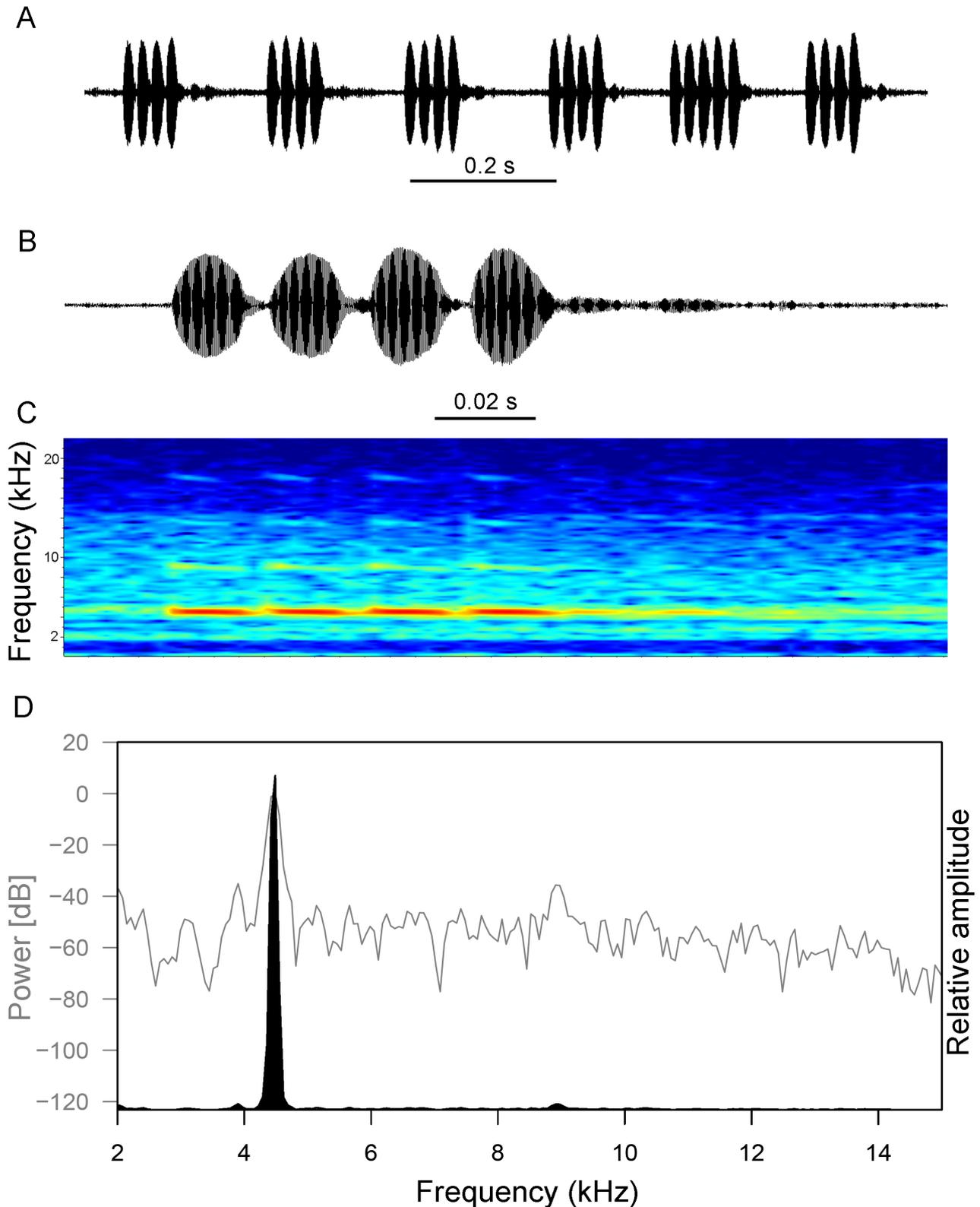


FIGURE 8. *Trellius (Zatrellius) puntung* sp. nov. ♂ calling song: oscillograms showing six echemes (A) and one echeme showing four syllables (B); spectrogram of the same echeme (C); power spectra of a syllable (D) where the grey line represents the power [dB] (axis name and scale in grey) and the black solid peak represents the relative amplitude (axis name in black).

Acknowledgements

We thank Husin bin Abdullah and Khaiidil bin Tahir (in Panty Forest Reserve) and Mohamad Azizan Bin Asidi (in Sabah) for field assistance. Permission for collection of material in Panty Forest Reserve was granted by the Johor State Economic Planning Division (SUKJ.BPEN.700-3/2/2 (1) (25)) and the Johor Forestry Department. The permission for research in Sabah was granted by the Sabah Biodiversity Centre (JKM/MBS.1000-2/2 JLD.10 (179)). The work of MKT was supported by the Orthoptera Species File Grants 2019 and 2023 and the Percy Sladen Memorial Fund 2024.

References

- Araya-Salas, M. & Smith-Vidaurre, G. (2017) warbleR: an R package to streamline analysis of animal acoustic signals. *Methods in Ecology and Evolution*, 8, 184–191.
<https://doi.org/10.1111/2041-210X.12624>
- Baker, E. & Chesmore, D. (2020) Standardisation of bioacoustic terminology for insects. *Biodiversity Data Journal*, 8, e54222.
<https://doi.org/10.3897/BDJ.8.e54222>
- Chopard, L. (1940) Results of the Oxford University expedition to Sarawak (Borneo), 1932. Gryllacridae and Gryllidae (Orthoptera). *The Entomologist's Monthly Magazine*, 76 (8–9), 189–192 + 193–204.
- Chopard, L. (1968) Fam. Gryllidae: Subfam. Mogoplistinae, Myrmecophilinae, Scleropterinae, Cachoplistinae, Pteroplistinae, Pentacentrinae, Phalangopsinae, Trigonidiinae, Eneopterinae; Fam. Oecanthidae, Gryllotalpidae. In: Beier, M. (Ed.), *Orthopterorum Catalogus. Vol. 12*. Junk, 's-Gravenhage [The Hague], pp. 213–500.
- Cigliano, M.M., Braun, H., Eades, D.C. & Otte, D. (2024) Orthoptera species file online. Version 5 (5.0). Available from: <http://orthoptera.speciesfile.org/HomePage/Orthoptera/HomePage.aspx> (accessed 2 June 2024)
- Desutter-Grandcolas, L. (2003) Phylogeny and the evolution of acoustic communication in extant Ensifera (Insecta, Orthoptera). *Zoologica Scripta*, 32, 525–561.
<https://doi.org/10.1046/j.1463-6409.2003.00142.x>
- Gorochov, A.V. (1999) New and little known Phaloriinae (Orthoptera: Gryllidae). *Zoosystematica Rossica*, 8 (1), 27–60.
- Gorochov, A.V. (2003) New and little-known Cachoplistinae and Phaloriinae (Orthoptera: Gryllidae). *Zoosystematica Rossica*, 12 (1), 79–92.
<https://doi.org/10.31610/zsr/2003.12.1.79>
- Gorochov, A.V. (2014) Classification of the Phalangopsinae subfamily group, and new taxa from the subfamilies Phalangopsinae and Phaloriinae (Orthoptera: Gryllidae). *Zoosystematica Rossica*, 23 (1), 7–88.
<https://doi.org/10.31610/zsr/2014.23.1.7>
- Gorochov, A.V. (2015) Evolution and taxonomic significance of the copulatory apparatus in Ensifera (Orthoptera). Part 2: Male genitalia in Grylloidea (Orthoptera: Ensifera). *Zoosystematica Rossica*, 24 (1), 31–41.
<https://doi.org/10.31610/zsr/2015.24.1.31>
- Gorochov, A.V. (2018) Taxonomic studies on the cricket subfamilies Pteroplistinae, Phaloriinae and Cacoplistinae (Orthoptera: Gryllidae) from the Old World. *Zoosystematica Rossica*, 27 (1), 40–76.
<https://doi.org/10.31610/zsr/2018.27.1.40>
- Gorochov, A.V. (2022) New and little-known taxa of the subfamily Phaloriinae (Orthoptera: Gryllidae) from the Old World. *Euroasian Entomological Journal*, 21 (5), 243–257.
<https://doi.org/10.15298/euroasentj.21.5.01>
- Gorochov A.V. & Tan, M.K. (2012) New crickets of the subfamilies Phaloriinae and Pteroplistinae (Orthoptera: Gryllidae) from Singapore. *Zootaxa*, 3525 (1), 18–34.
<https://doi.org/10.11646/zootaxa.3525.1.2>
- Hugel, S., Warren, B.H. & Desutter-Grandcolas, L. (2021) The Phalangopsidae crickets (Orthoptera, Grylloidea) of the Seychelles Archipelago: Taxonomy of an ecological radiation. *Zootaxa*, 5047 (3), 201–246.
<https://doi.org/10.11646/zootaxa.5047.3.1>
- Josse, H., Faberon, L., Schubnel, T., Nel, A. & Desutter-Grandcolas, L. (2023) Reconciliation between neontology and paleontology in the Gryllidea (Orthoptera, Ensifera): reinterpreting the venation of the stridulatory apparatus in crickets. *Zoosystema*, 45 (24), 769–801.
<https://doi.org/10.5252/zoosystema2023v45a24>
- Ma, L. & Jing, X. (2018) Revision of the Phaloriini crickets (Orthoptera: Phalangopsidae: Phaloriinae) from China. *The Canadian Entomologist*, 150, 578–593.
<https://doi.org/10.4039/tce.2018.40>
- Tan, M.K., Gorochov, A.V., Japir, R., Chung, A.Y.C. & Wahab, R.A. (2019) New taxa of crickets (Orthoptera: Grylloidea: Gryllinae, Phaloriinae and Pteroplistinae) from northern Borneo (Belait and Sandakan). *Zootaxa*, 4661 (1), 101–117.

<https://doi.org/10.11646/zootaxa.4661.1.4>

Tan, M.K., Japir, R., Chung, A.Y.C. & Wahab, R.A. (2020) New taxa of crickets (Orthoptera: Grylloidea: Phaloriinae, Phalangopsinae, Itarinae and Podoscirtinae) from Borneo (Brunei Darussalam and Sandakan). *Zootaxa*, 4810 (2), 244–270.

<https://doi.org/10.11646/zootaxa.4810.2.2>

Tan, M.K., Japir, R., Chung, A.Y.C. & Robillard, T. (2022) New taxa and notes on bark and bush crickets (Orthoptera, Grylloidea, Gryllidae, Landrevinae and Podoscirtinae) from Sabah. *Zootaxa*, 5178 (3), 201–228.

<https://doi.org/10.11646/zootaxa.5178.3.1>

Tan, M.K., Rahmadi, C. & Robillard, T. (2021) New species of *Phaloria* (Orthoptera: Phalangopsidae: Phaloriinae) from West Papua (Indonesia). *Zootaxa*, 4985 (4), 513–530.

<https://doi.org/10.11646/zootaxa.4985.4.5>

Tan, M.K., Salvador, J.A.G., Sabang, A.M.M., Bahoy, D.C.M., Nuñez, O.M. & Robillard, T. (2023) Taxonomy and bioacoustics of little-known Grylloidea crickets (Orthoptera, Ensifera) from Mindanao, Philippines. *Zootaxa*, 5323 (3), 301–348.

<https://doi.org/10.11646/zootaxa.5323.3.1>

Tan, M.K. & Wahab, R.A. (2018) Preliminary study on the diversity of Orthoptera from Kuala Belalong Field Studies Centre, Brunei Darussalam, Borneo. *Journal of Orthoptera Research*, 27 (2), 119–142.

<https://doi.org/10.3897/jor.27.24152>