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Four New Species of Cicadas in the *Yoyetta abdominalis* (Distant) Species Group (Hemiptera: Cicadidae: Cicadettinae) from Southeastern Australia

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Abstract. Four new species are added to the *Yoyetta abdominalis* (Distant) species group: *Y. douglasi* sp. nov., *Y. enigmatica* sp. nov., *Y. loftyensis* sp. nov. and *Y. ngarabal* sp. nov. Calling song descriptions and morphological descriptions are provided for each species. An updated key to male specimens is also provided for the species group.

Introduction

The genus *Yoyetta* was introduced by Moulds (2012) to accommodate nine Australian species, previously allocated to the genus *Cicadetta* Kolenati. The works of Emery *et al.* (2015) and Emery *et al.* (2019) added an additional 12 species, bringing the total to 21. More recently Moulds and Popple (2018) added another and Moulds *et al*. (2020) yet another species, bringing the total to 23.

Emery *et al.* (2015) recognized three informal species groups within the genus. The *Yoyetta abdominalis* (Distant) species group is readily identified with hind wing plagas that are almost entirely white and opaque, and abdominal tergites 2–7 mainly black or dark brown. The *Yoyetta incepta* (Walker) species group have hind wing plagas that are opaque and cream to pale orange-brown along the majority of the jugal fold and outer margin, and abdominal tergites mainly black. The *Yoyetta tristrigata* (Goding & Froggatt) species group possess hind wing plagas that are opaque and cream to light brown or orange-brown along the majority of the jugal fold and outer margin, and abdominal tergites 2–7 that are mainly orange to yellow-brown. This study focuses on the *Yoyetta abdominalis* species group.

Following from the work of Emery *et al.* (2019), the *Yoyetta abdominalis* species group contains 13 described species. This study adds an additional four species to the group from south-eastern Australia, with descriptions based on morphology and calling songs, both of which are established diagnostic features of cicadas (Fleming, 1974; Gogala & Trilar, 2004; Ewart, 2005; Ewart & Marques, 2008).

Methods and terminology

Anatomical terminology follows Moulds (2005, 2012) for body structures and wing characters, Moulds (2005) for genitalia, and Dugdale (1972) and Bennet-Clark (1997) for timbals. The long timbal ribs are referred to as long ribs 1 to 5, with long rib 1 being the most posterior (adjacent to timbal plate). The higher classification adopted in this paper follows Moulds (2012) and Marshall *et al.* (2018). Measurements (in mm) are given as ranges and means (in parentheses) and

Keywords: Australia; behaviour; cicada; Cicadidae; *Yoyetta*; distribution; habitat; taxonomy
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include the largest and smallest specimens. Head width spans across the eyes; pronotum width across the extremities of the lateral margins; abdomen width is measured across the outer edges of the auditory capsules. Measurements were taken using a pair of Toledo manual calipers or Supatool digital calipers (accurate to 0.1 mm).

Abbreviations. Material sourced for this taxonomic work is located in collections abbreviated as follows: AM— Australian Museum, Sydney; ANIC—Australian National Insect Collection, CSIRO, Canberra; DE—private collection of D. L. Emery, Sydney; FD—private collection of F. Douglas, Rainbow, Victoria; LWP—private collection of L. W. Popple, Brisbane; MSM—private collection of M. S. Moulds, Kuranda, Queensland; NMV—National Museum of Victoria, Melbourne; QM— Queensland Museum, Brisbane; SAM—South Australian Museum, Adelaide; UQIC—University of Queensland Insect Collection (now housed at the Queensland Museum), Brisbane. Uninterpreted label-data (i.e. verbatim data) is presented for type material.

Genitalia preparation. Male genitalia were removed using a pair of surgical scissors and placed in a solution of 10% potassium hydroxide. The solution was left overnight at room temperature to clear the soft tissues and provide a clean dissection. Following clearing, the specimens were washed with ethanol and placed into a solution of either 70% ethanol or glycerol. To facilitate close examination of internal structures, the aedeagus was dissected for each genitalia preparation under 10× magnification.

Imaging. Anatomical photographs were taken using an Olympus stereo dissecting microscope mounted with an SC100 camera. Individual or photostacked images were processed with Cells-sens ™ and Adobe Photoshop software.

Calling song analysis. Song terminology is adapted from Ragge & Reynolds (1998), follows Popple (2013) and is comparable with Emery *et al.* (2019). The term "syllable" refers to the shortest duration unit of sound observed to be produced by these cicadas. A higher order grouping of monotonously syllables where there are measurable gaps of silence between each syllable is referred to as a "syllable sequence". A higher order grouping of syllables where the syllables are coalesced is referred to as an "echeme". When a calling song contains multiple echemes or combinations of echemes and syllables that form a repetitive structure, the term "phrase" was adopted to describe each repeated unit.

Calling song analysis was performed using Cool Edit Pro (2.0) software. Two elements of calling song frequency (pitch) were examined: (1) dominant frequency, and (2) high amplitude plateau. The former was measured as the highest single amplitude reading on a Fast Fourier Transform (FFT) spectrum, over a 50–100 ms clip of high quality recording (1024 FFT size, Hamming window representation). The latter was measured by analysing the inclusive sample of the 90th percentile highest amplitude over the same FFT sample. Recordings were checked for potential background interference before running the analysis and any extraneous dominant frequencies were excluded. Information on recordists and audio recording equipment, along with a representative sample of audio files relevant to this study is provided as an online supplement by Popple *et al*. (2020).

Infrageneric relationships within *Yoyetta*

The infrageneric groupings within *Yoyetta* follow Emery *et al.* (2015) and Emery *et al.* (2019), with some slight modifications to accommodate the new species. Accordingly, the *Yoyetta abdominalis* species group is defined by the following characters: (1) hind wing plaga entirely or partly bright to dull white and opaque, and (2) abdominal tergites 2–7 mainly black or dark brown. A list of species included in this group is provided below.

***Yoyetta abdominalis* species group**

Y. aaede (Walker, 1850)
Y. abdominalis (Distant, 1892)
Y. denisoni (Distant, 1893)
Y. douglasi sp. nov.
Y. electrica Emery, Emery & Popple, 2019
Y. enigmatica sp. nov.
Y. grandis Emery, Emery & Popple, 2019
Y. hunterorum (Moulds, 1988)
Y. kershawi (Goding & Froggatt, 1904)
Y. loftyensis sp. nov.
Y. ngarabal sp. nov.
Y. regalis Emery, Emery & Popple, 2019
Y. serrata Emery, Emery & Popple, 2019
Y. spectabilis Emery, Emery & Popple, 2019
Y. subalpina Emery, Emery & Popple, 2019
Y. timothyi Emery, Emery & Popple, 2019
Y. verrens Emery, Emery & Popple, 2019

Systematics

Family Cicadidae Latrielle, 1802

Subfamily Cicadettinae Buckton, 1889

Tribe Cicadettini Buckton, 1889

Genus *Yoyetta* Moulds, 2012

Diagnosis. Diagnosis follows Moulds (2012) with modifications of Emery *et al.* (2015).

Yoyetta douglasi sp. nov.

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Figs 1–3, 4A, 5A, 6A, 7

Holotype ♂, Mt Difficult Rge, Grampians, V. 2600 f[t], 7 Feb 1956, mvl, N. B. Tindale, SAMA Database No. 20-017503, (SAM). **Paratypes**—VICTORIA: 2♂♂, 9 km SSW of Hall's Gap, Jct. Rosea Track & Stoney Ck Rd, Grampians Nat. Park, Vic., 700 m, 37°11'S 142°29'E, 5.ii.1997, D. C. F. Rentz & E. S. Ross, Stop 9, ANIC Database No. 20 010795, 20 010797; 1♀, 11 km SE Halls Gap, 206 m, 37°14'S 142°42'E, 7.ii.1997, D. C. F. Rentz & E. S. Ross, Stop 16 (at light), ANIC Database No. 20 010796 (ANIC); 1♀, Mt. Difficult, Grampians Ra. W. Vic. 2,600' (ft), 2.i.1966, T. Weir (UQIC); 1♂ 1♀, Grampians Nat Pk., Reed lookout, 7 km W Hall's Gap, 2.i.2000, F. Douglas (FD); 2♂♂, 10 km S.

Erratum requested by the authors 20 August 2020. Replace "… 1♂ 1♀, Grampians Nat Pk., Reed lookout, 7 km W Hall's Gap, 2.i.2000, F. Douglas (FD); …" with "1♂, 10 km S. of Visitor's Centre, Grampians National Park, Jnctn. Rd. to Mt Williams, 37°14.631'S 142°32.118'E, 337 m, 1.xii.2006, D. Marshall, K. Hill; 1♀, 0.5 km E Reeds Lookout, Grampians Nat Pk., 37°08'54"S 142°27'11"E, 732 m, 2.ii.2000, F. Douglas (FD); …"

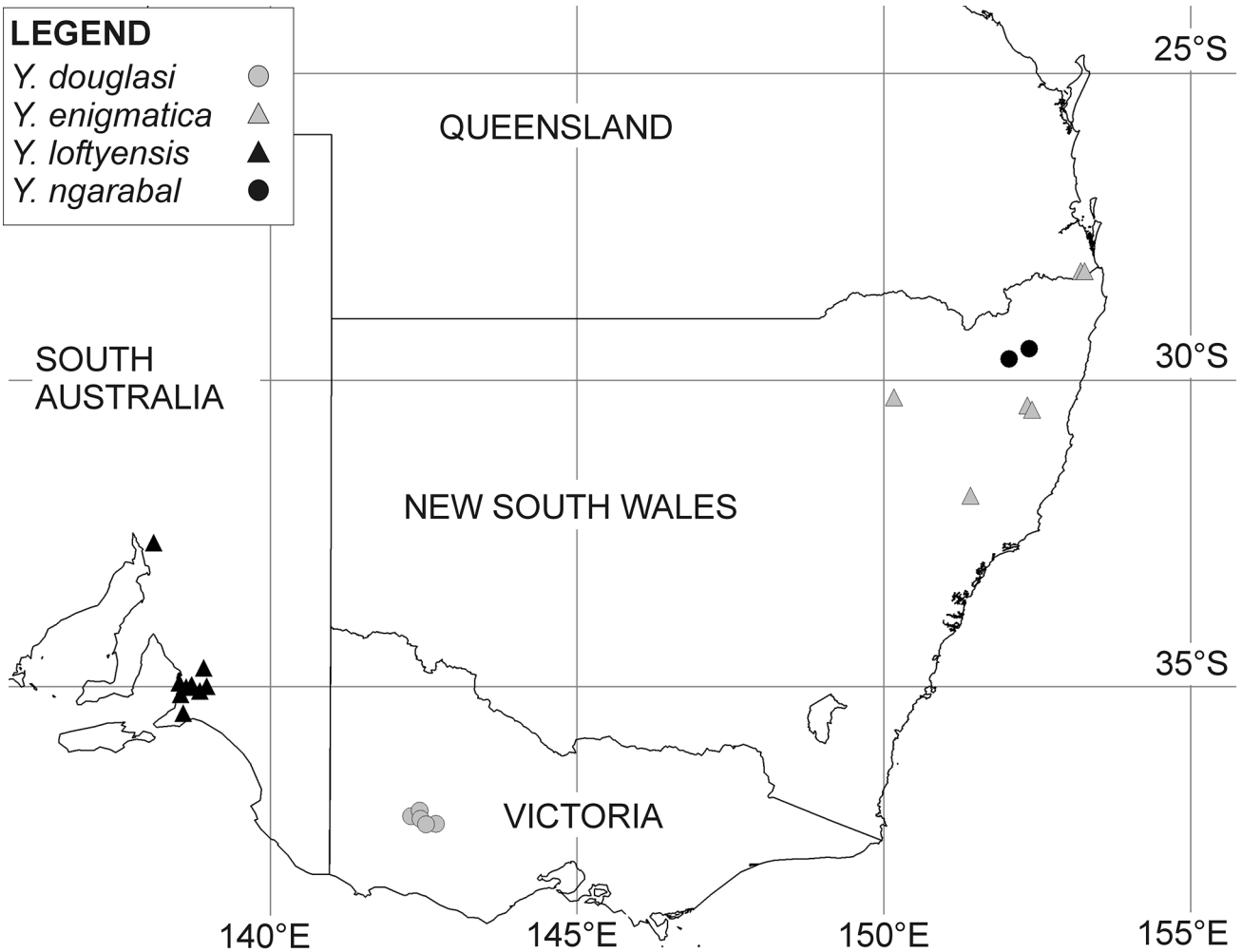

Figure 1. Map of south-eastern mainland Australia showing the geographical distribution of *Yoyetta douglasi* sp. nov. (grey circles), *Y. enigmatica* sp. nov. (grey triangles), *Y. loftyensis* sp. nov. (black triangles) and *Y. ngarabal* sp. nov. (black circles).

of Visitor's Centre, Grampians National Park, 37°14.631'S 142°32.118'E, 337 m, 1 Dec. 2006, D. Marshall, K. Hill, AU.VI.GRB (NMV); 2♂♂, same data as previous (DE); 1♂, same data as previous (LWP); 1♂, same data as previous; 1♂, same data as previous, [MSM genitalia prep.] 74; 1♂, same data as previous, C. Simon lab voucher, legs in ETOH, body pinned, 08.AU.VI.GRB.01, "Yoyetta double-zit", specimen recorded; 1♂, same data as previous, 06.AU.VI.GRB.02; 1♂ 28.8 km S. of Visitor's Ctr, Grampians National Park, 37°23.946'S 142°29.642'E, 319 m, 1 Dec. 2008, D. Marshall, K. Hill, AU.VI.GRC; 1♂, Halls Gap, Grampian Mtns, 11.i.1976, M. S. & B. J. Moulds, [LWP] Genitalia prep. 718-01 (MSM); 1♂ 2♀♀, same data as holotype, SAMA Database No. 20-017504 to 20-017506 (SAM).

Etymology. Named in honour of Fabian Douglas, who has contributed much to the knowledge of cicadas and other insects and their conservation in western Victoria.

Distribution, habitat and seasonality. Known only from the Grampians in central western Victoria (Fig. 1). Adults occur in open forest, mainly on eucalypts (Fig. 2E, F). They have been encountered during January and February.

Calling song. The calling song of *Y. douglasi* sp. nov. is described from a series of recordings made and kindly provided by D. C. Marshall and K. B. R. Hill (C. Simon laboratory, University of Connecticut; n = 11 from one locality), with an example illustrated in Fig. 3. It contains repeated phrases, each comprising an initial series of individual syllables, followed by a long echeme, then a short echeme. The initial syllable sequence typically lasts 0.5–2.0 s. Each syllable is approximately 0.009 s and, for the most part, separated by gaps of 0.5–0.6 s. Prior to commencement of the long echeme, the gaps between syllables reduce successfully (effectively down to c. 0 s at the commencement of the echeme). The long echeme has a duration of 1.0–1.5 s and exhibits a double amplitude modulation at the end, with the penultimate modulation being a subtle increase and the final modulation being much more prominent (Fig. 3B). The long echeme ends abruptly with a brief silence (0.01–0.02 s) before commencement of the short echeme to conclude the phrase. The short echeme lasts 0.06–0.07 s and exhibits a strong amplitude modulation (more extreme than in the long echeme). Each phrase is separated by a gap of 0.2–0.5 s. There may be a longer gap between phrases when a male moves between singing stations. Sometimes, this longer gap is replaced by a longer syllable sequence, some of which may be produced in flight. Otherwise, the calling song is produced from a stationary position.

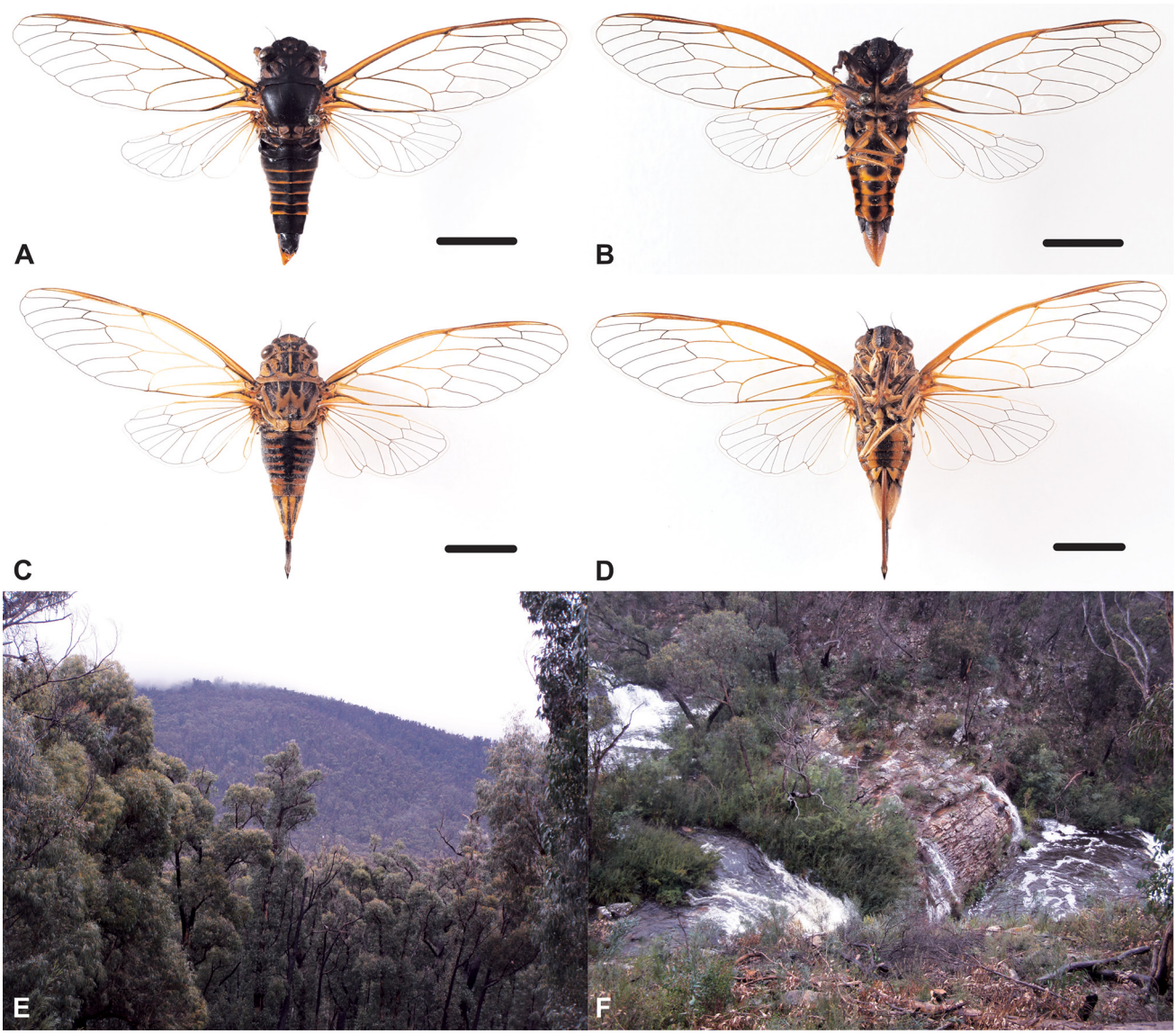

Figure 2. *Yoyetta douglasi* sp. nov.: *(A)* male, Grampians National Park (37°24'S 142°30'E), dorsal habitus; *(B)* male, Grampians National Park, ventral habitus; *(C)* female, Mt Difficult Range, Grampians (37°01'S 142°26'E), dorsal habitus; *(D)* female, Mt Difficult Range, Grampians, ventral habitus; *(E)* typical habitat, Grampians; *(F)* typical habitat, Grampians. Scale bars = 10 mm.

The calling song has a dominant frequency between 8.3 and 11.0 kHz, tending to be higher during amplitude modulations. It has a high amplitude plateau spanning approximately 7.6–11.5 kHz (Fig. 3C). This plateau broadens during amplitude modulations, extending up to 12.5 kHz (Fig. 3D). Males have been observed to be attracted to simulated female wing-flick responses, when these are timed precisely after each echeme (K. Hill and D. Marshall, pers. obs., 1 December 2006).

Morphology. Male (Figs 2A–B, 4A, 5A, 6A, 7). *Head* as wide as mesonotum, a thin yellow-brown triangular fascia on the midline posterior to ocelli, not reaching posterior margin; brown spot between each compound eye and adjacent posterior ocellus; ocelli pink; dorsal side of postclypeus dark brown and black with central yellow-brown triangular marking, apex directed anteriorly; ventral side of postclypeus mainly black, transverse grooves black, lateral borders ochraceous; anteclypeus black, rostrum mainly brown, darkening distally, apex black, reaching posterior margins of mid coxae; lorum black with ochraceous margins; gena black; eyes dark brown or grey-brown; antennae black, supra-antennal plates black, brown at base of pedicel.

Thorax predominantly black. Pronotum variably dark brown to black; pronotal collar brown to dark brown, paranotum dark brown to black. Mesonotum black; cruciform elevation mainly brown, with median area black; wing grooves brown to dark brown. Metanotum black.

Legs. Coxae mainly black, with orange-brown margins; apical joints red; basisterna black; meracantha small, narrow, cream, black at base, pointed, overlapping one-quarter of opercula; trochanters black with central segment orange-red; fore femora pale reddish-brown with black longitudinal stripes; femoral spines erect, black; mid and hind femora black, with reddish-brown apices; fore tibia black, dark brown apically; mid tibia brown; hind tibia pale brown; tarsi reddish-brown (hind tarsi paler); claws dark brown, black at tips.

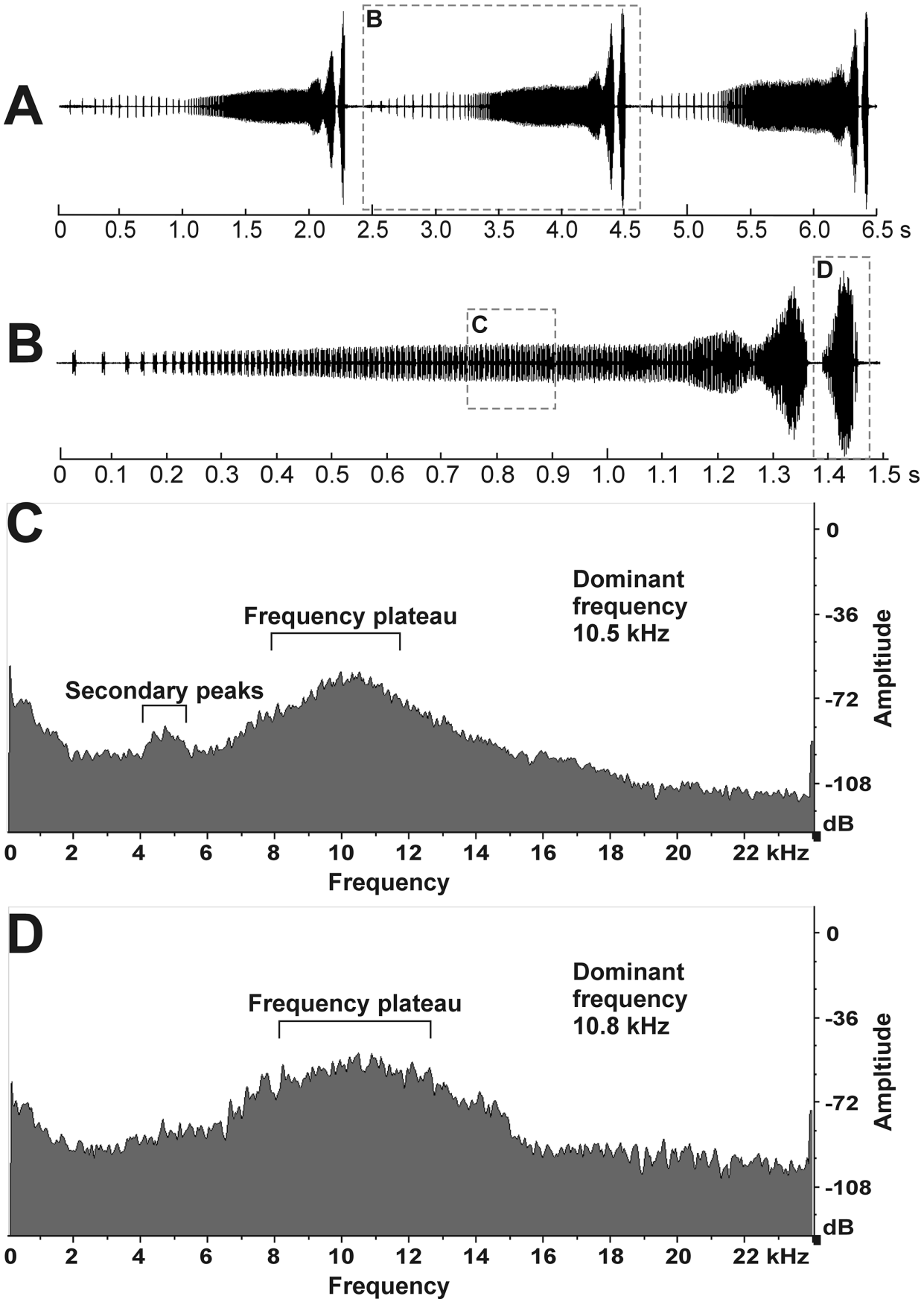

Figure 3. Male calling song structure of *Yoyetta douglasi* sp. nov. illustrated in waveform plots, including: *(A)* three complete phrases; *(B)* expanded section of one phrase from *(A)* showing an initial series of individual syllables, followed by a long echeme (ending with a double amplitude modulation), then a strongly amplitude modulated short echeme; *(C)* spectrogram displaying song frequency in the middle of the long echeme; and *(D)* spectrogram displaying song frequency for the short echeme. This specimen was recorded in the Grampians National Park (37°15'S 142°32'E) by D. Marshall and K. Hill.

Wings with fore wing costal veins brown, CuA pale brown, other veins dark brown to black, pterostigma reddish-brown, other cells hyaline, basal membranes orange, with eight apical cells; hind wing plaga white, including almost all of anal cell 3 (jugum) extending partly onto margins of ac2(v) along vein 3A, vein CuA dark brown, other veins pale brown to brown, with six apical cells.

Opercula (Fig. 4A) covering abdominal cavity, rounded, following body axis ventrolaterally, black over basal area, extensively orange-brown remainder, clearly separated.

Timbals (Fig. 5A) with five distinct long ribs; long ribs 1–4 extending across membrane and fused dorsally along basal spur; long rib 5 independent of basal spur, comparatively shorter, extending ventrally across half of membrane; large ridged dome on posterior timbal plate extending across two-thirds of timbal; apodeme pit oval-shaped and conspicuous.

Abdomen with tergites 1 and 2 black; tergites 3–7 black with orange lateral to dorsolateral posterior margins; tergite 8 black. Epipleurites black with orange posterior margins. Sternite I black; sternite II black with ochraceous ventrolateral posterior margins; sternites III-VI dark orange to orange with black medial areas tapering posteriorly, not reaching posterior margin; sternite VII dark orange-red with broad black along midline, tapering posteriorly; sternite VIII brown, with brown pubescence (Fig. 6A).

Genitalia (Fig. 7). Pygofer dark brown to black; upper lobe prominent, apically acute, with rounded termination; basal lobe gently curved, bulbous. Uncus orange-brown; in lateral view beak-like, with broadly rounded termination; in ventral view narrow; claspers divided, bulbous, with apices tapering ventrolaterally. Aedeagus with pseudoparameres almost extending as far as theca; theca recurved at 180° towards apex, with prominent transparent flange along dorsal margin of distal half of recurvature, smooth and broadening to >3× width of theca and projecting dorsally to terminate above theca; remainder of theca is short, with <20% of theca extending apically beyond margin of recurvature; apical area tapering, with 2–3 spines on ventral surface near base of transparent flange, several small spines on dorsal side at tip.

Female (Fig. 2C–D).

Legs similar to male, otherwise body coloration much paler overall.

Head. Dorsal side brown, with black marking around ocelli and supra-antennal plates, black spot at medial border of eye. Ventral side mainly black; postclypeus black with broad brown or pale reddish-brown lateral margins; gena mainly black; mandibular plates mostly pale brown; anteclypeus pale reddish-brown, black centrally; rostrum pale brown, dark brown apically.

Thorax with a much greater range of pale brown coloration than in males; pronotum pale brown with black markings either side of midline and around paramedian and lateral fissures; pronotal collar brown, with extreme margins of lateral angles black; mesonotum pale brown; submedial and lateral sigilla black; cruciform elevation pale brown, black medially; scutal depressions black, metanotum black with pale brown margins.

Abdomen. Tergites I–VII similar to male, with broader reddish brown coloration on posterior lateral sides; tergite VIII reddish-brown, black medially; sternites I–VII similar to male sternite VIII pale brown; abdominal segment 9 brown with three longitudinal black stripes on midline and either side of midline, darker brown spots on either side in lateral depressions; dorsal beak black; ovipositor dark brown, becoming black at tip, extending approximately 4 mm beyond apex of abdominal segment 9. Anal styles orange-red; ovipositor sheath dark brown to black.

Measurements (in mm; 11 males, 4 females). Body length: male 23.9–27.3 (25.8); female 31.3–32.8 (32.2). Fore wing length: male 28.1–32.5 (30.4); female 32.1–35.6 (34.5). Fore wing width: male 9.9–11.7 (10.5); female 11.0–11.9 (11.5). Head width: male 6.5–7.4 (7.0); female 7.58.3 (7.9). Pronotum width: male 7.1–8.1 (7.6); female 8.0–9.3 (8.6). Abdomen width: male 6.6–8.0 (7.4); female 7.18.7 (7.7). Ovipositor length: female 14.3–14.9 (14.7).

Distinguishing features. The calling song of *Y. douglasi* sp. nov. is similar to that of *Y. subalpina* Emery, Emery & Popple from south-eastern Australia. It differs principally in the longer duration of the long echeme and characteristically by the presence of two amplitude modulations at the end of the long echeme (cf. one in *Y. subalpina*).

Within the *Y. abdominalis* species group, *Y. douglasi* sp. nov. is morphologically closest to *Y. subalpina* Emery, Emery & Popple, *Y. regalis* Emery, Emery & Popple, and *Y. grandis* Emery, Emery & Popple in which the males have black abdominal tergites with conspicuous narrow, orange or yellow posterior margins and both sexes have an extensively opaque, bold, white hind wing plaga and black central markings on sternites III–VII. Males can be easily distinguished from *Y. grandis* by having orange fore wing basal membranes (cf. pale grey or pale orange) and predominantly orange-brown opercula (cf. pale cream). They can be distinguished from *Y. regalis* and *Y. subalpina* by examining the apex of the theca, which tapers apically (cf. club-like or blunt and broad). Females can be easily distinguished from all of the aforementioned species by their long ovipositor, which extends approximately 4 mm beyond the apex of abdominal segment 9.

Yoyetta enigmatica sp. nov.

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Figs 1, 4B, 5B, 6B, 8–11

Holotype ♂, "Dawson Springs. 2 km" / "E of Mt Kaputar summit" / "N.S.W. 1400m" / "12 Dec. 1987" / "S. & B. Underwood" (AM K.570298). **Paratypes**—NEW SOUTH WALES: 1♂, N(ew) E(ngland). Nat Pk N.S.W., Pt Lookout, 5200 FT, 6.xii.1964, C. W. Frazier, University of New England coll. Donated 1983; 1♂, Ebor Reserve, 25.xi.1964, E. T. Giles, ex. nymph, University of New England coll. Donated 1983 (ANIC); 1♂, Ebor N.S.W., 10.i.[19]16 [no collector] (QM); 3♂♂, same data as holotype; 1♂, Tubrabucca, Upper Hunter Dist., 18.xii.1975, G. Daniels (MSM). QUEENSLAND: 1♂, Daves Creek, Lamington NP, 28.2226°S 153.2098°E, 12.xii.2017, L. W. Popple, Pop511-0001 (LWP).

Etymology. From Latin, meaning "baffling" or "inexplicable". It refers to this species' habit of spontaneously appearing and calling in flight for a short time before disappearing again as if it was never present. It is a very difficult cicada to observe, let alone capture.

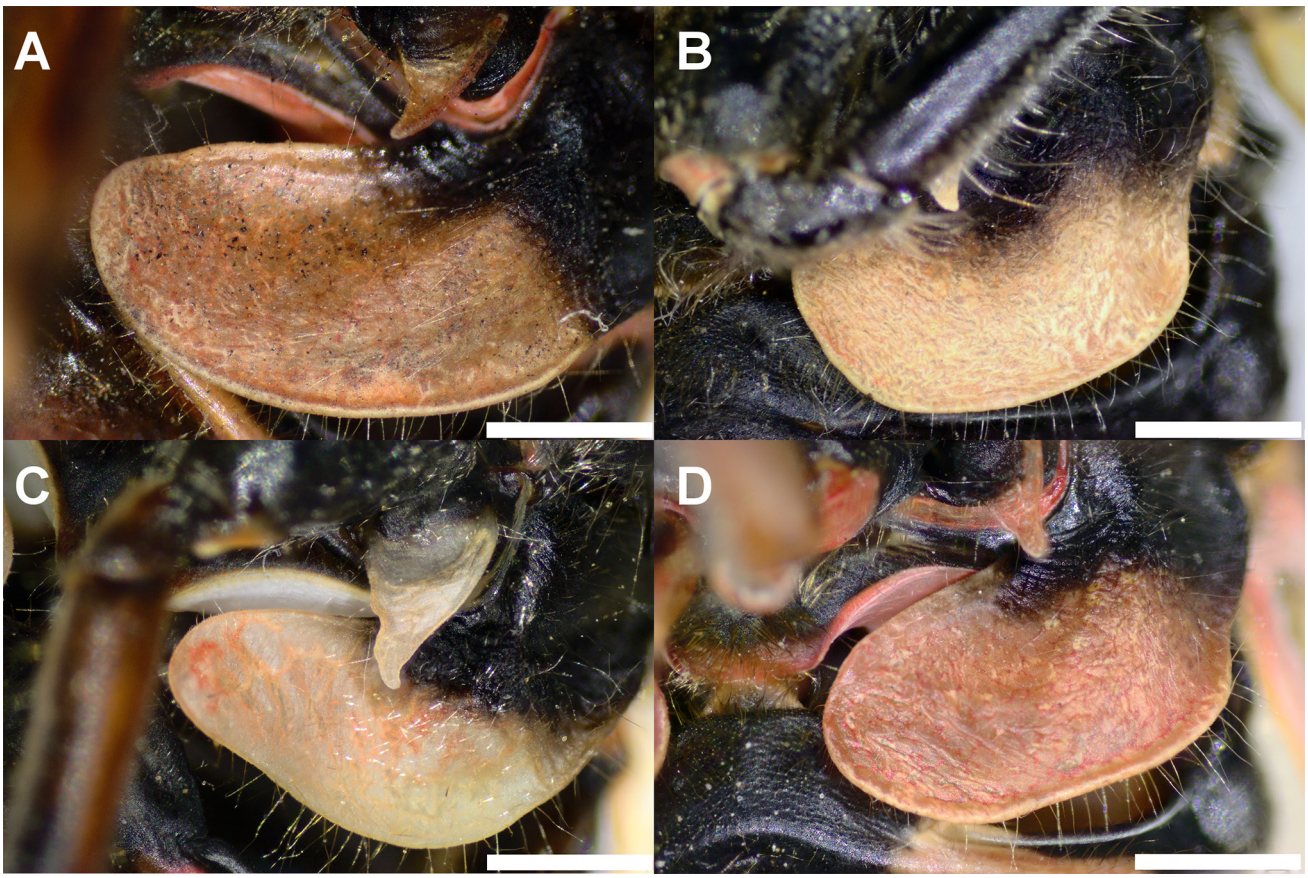

Figure 4. Photos of male left opercula: *(A) Yoyetta douglasi* sp. nov.; *(B) Y. enigmatica* sp. nov.; *(C) Y. loftyensis* sp. nov.; *(D) Y. ngarabal* sp. nov. Scale bars = 1 mm.

Distribution, habitat and seasonality. Known only from mountainous areas above approximately 800 m altitude on the Queensland–New South Wales border at Springbrook and in Lamington National Park in the Daves Creek area. It is also known from Mt Kaputar in inland northern New South Wales, from Dawson Springs (type locality) near the summit. Specimens have also been collected from around Ebor in the New England Tableland east of Armidale and from Tubrabucca in the Upper Hunter district of central New South Wales (Fig. 1). Populations appear to be associated with ash eucalypts *(Eucalyptus* subgenus *Eucalyptus)*. In Queensland, it is associated with *Eucalyptus approximans* subsp. *codonocarpa* at Daves Creek and with *E. oreades* at Springbrook. It occurs in open forest and montane heath (Fig. 8C, D). All specimens have been taken in December or January; however, aural observations and recordings have been made between mid-October and late-January.

Calling song. The calling song of this species consists of repeated echemes emitted both when stationary and in flight (Figs 9, 10). When stationary, the echemes are produced in bouts, with pauses between each bout. When in flight, the echemes are emitted for longer periods and continue until the insect becomes stationary. In average weather conditions, the calling song is produced predominantly in flight. Each echeme has a duration of 0.09–0.15 s and is separated by a silent gap of 0.21–0.31 s (i.e. echemes are produced at a rate of 2 or 3 per second; $n = 13$ recordings from three sites). The calling song has a dominant frequency of 7.6–9.4 kHz and a high amplitude plateau spanning approximately 6.5–13.0 kHz. Males have been observed to be attracted to simulated female wing-flick responses, when these are timed precisely after each echeme (LWP, pers. obs., 12 December 2017).

Morphology. **Male** (Figs 4B, 5B, 6B, 8A–B, 11). *Head* slightly narrower than mesonotum, black, covered with conspicuous dark brown to black pubescence, sometimes with dark brown areas along lateral margins, adjacent to compound eyes; ocelli pink; dorsal side of postclypeus mainly black, dark brown along midline and lateral margins; ventral side of postclypeus black with dark brown lateral and posterior margins; anteclypeus shiny black; rostrum brown at base, becoming dark brown to black at apex, barely extending to proximal margins of hind coxae; lora black with dark reddish brown lateral margins, gena black; eyes dull grey-brown; antennae black, supra-antennal plates black, with base of pedicels ochraceous.

Thorax predominantly dark brown to black, cover in prominent dark brown to black pubescence. Pronotum dark brown with black areas either side of midline and along fissures or entirely black; pronotal collar dark brown to black, lateral angles black. Mesonotum dark brown to black; submedian and lateral sigilla black; cruciform elevation arms black, lateral depressions brown or dark brown. Metanotum shiny black.

Legs. Coxae mainly dark orange-brown or black; fore coxae with black areas on interior outer sides and black longitudinal

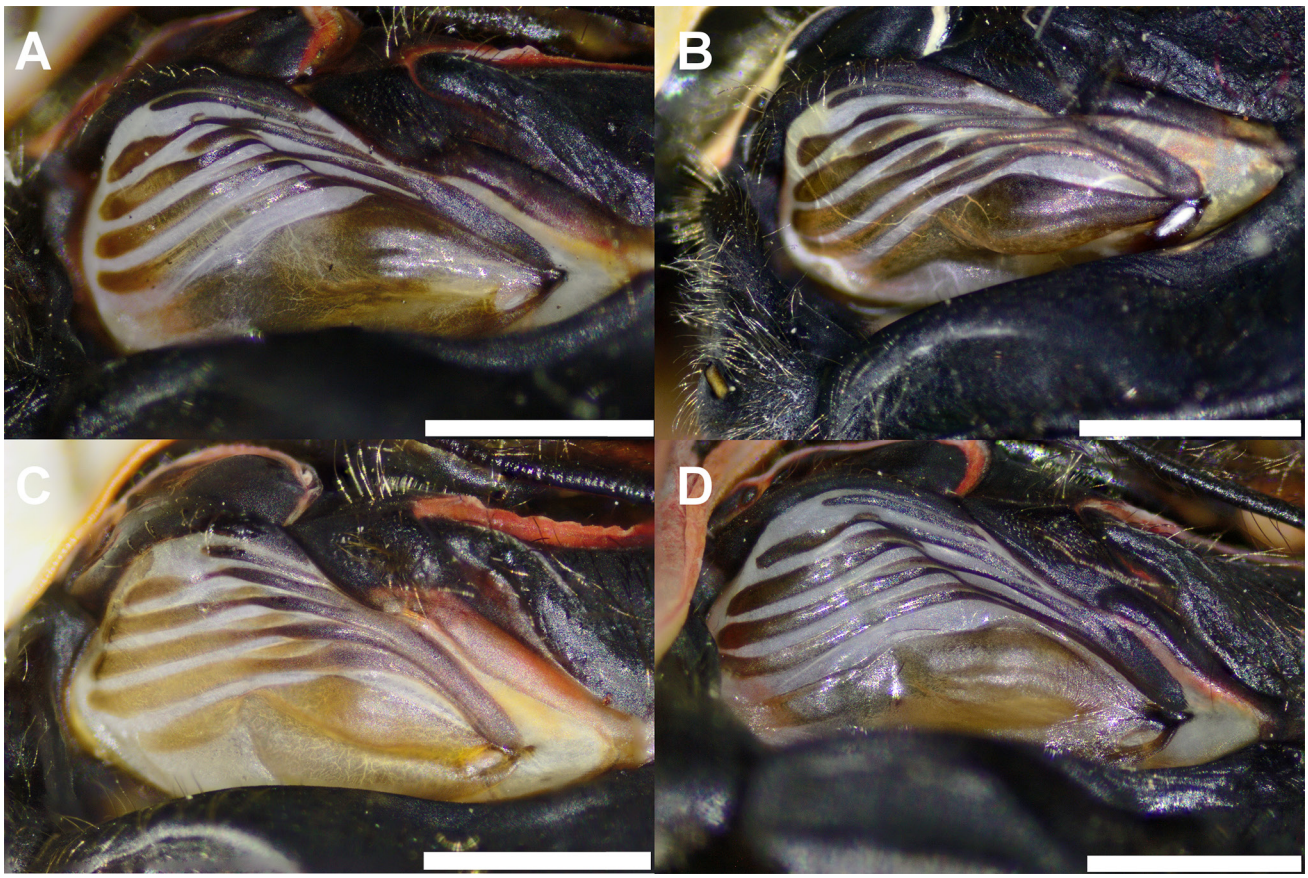

Figure 5. Photos of male left timbals, with dorsal edge at right and posterior margin at bottom: *(A) Yoyetta douglasi* sp. nov.*; (B) Y. enigmatica* sp. nov.; *(C) Y. loftyensis* sp. nov.; *(D) Y. ngarabal* sp. nov. Scale bars = 1 mm.

stripes on inner sides; mid and hind coxae a mixture of dark orange-brown and black or almost entirely black; coxal joints and membranes orange to dull orange-brown; basisterna black; trochanters diffuse orange-brown to black; meracantha small, narrow, orange, black at base, pointed, minimally overlapping opercula; anterior side of fore femora black with an orange longitudinal stripe, posterior side orange with a black longitudinal stripe; femoral spines erect, orange-brown to dark orange-brown, darker apically; mid and hind femora mainly orange-brown or black, always partly black on anterior side; fore tibiae a mixture of black and orange-brown or completely black; mid tibiae orange brown or black; hind tibiae mainly orange-brown or dull brown, sometimes black at base; tarsi orange-brown to dark orange-brown (fore tarsi darkest); claws dark brown to black, black at tips.

Wings with fore wing costal veins dark brown to black, or ochraceous at base, grading to dark reddish-brown distally; pterostigma mottled dark reddish-brown and black; basal cells translucent to transparent, partly pale brown; basal membranes orange; CuP+1A grey-brown; other venation dark brown to black; with eight apical cells; hind wing plagas opaque white; anal lobes transparent; with six apical cells.

Opercula (Fig. 4B) covering abdominal cavity, spatulate, following body axis ventrolaterally, depressed centrally, variably black on basal quarter, otherwise orange-brown, clearly separated.

Timbals (Fig. 5B) with five distinct long ribs; long ribs 1–4 extending across surrounding membrane and fused dorsally along basal spur; long rib 5 independent of basal spur, comparatively shorter, extending ventrally across half of membrane; large ridged dome on posterior timbal plate extending across three-quarters of timbal; apodeme pit oval-shaped and conspicuous.

Abdomen. Tergite 1 black, with orange-red membranes sometimes visible along anterior margin; tergite 2 black; tergites 3–7 black with orange posterior margins that are particularly prominent on lateral sides of tergite 7; tergite 8 black, grading to diffuse dark reddish-brown over posterior half (Fig. 6B). Epipleurites dark orange-brown, orange on posterior margins. Sternite II mainly black, tending orange laterally and along posterior margin; sternite III–VI dull orange, pale and brighter on posterior margin; sternite VIII dull orange, with dark orange-brown pubescence.

Genitalia (Fig. 11). Pygofer shiny black; upper lobes mainly black, apices orange; basal lobes dark orange-brown to black; dorsal beak mainly black, dark brown along posterior margin, anal styles reddish-orange. Uncus reddish-brown; lobes in lateral view beak-like with rounded apex; claspers weakly divided, with apices diverging and directed ventrally. Aedeagus with pseudoparameres extending along approximately 2/3 length of theca; theca recurved ventrally at around 120°, with broken transparent flange shown adjoining a weak hook at strongest point of recurvature, this flange broadest along ventral margin, narrower than width of theca; remainder of theca is long, with >30% of theca extending apically beyond strongest point of recurvature; apex recurved another 90° with tip directed dorsally, terminally acute, with a limited array of short spines.

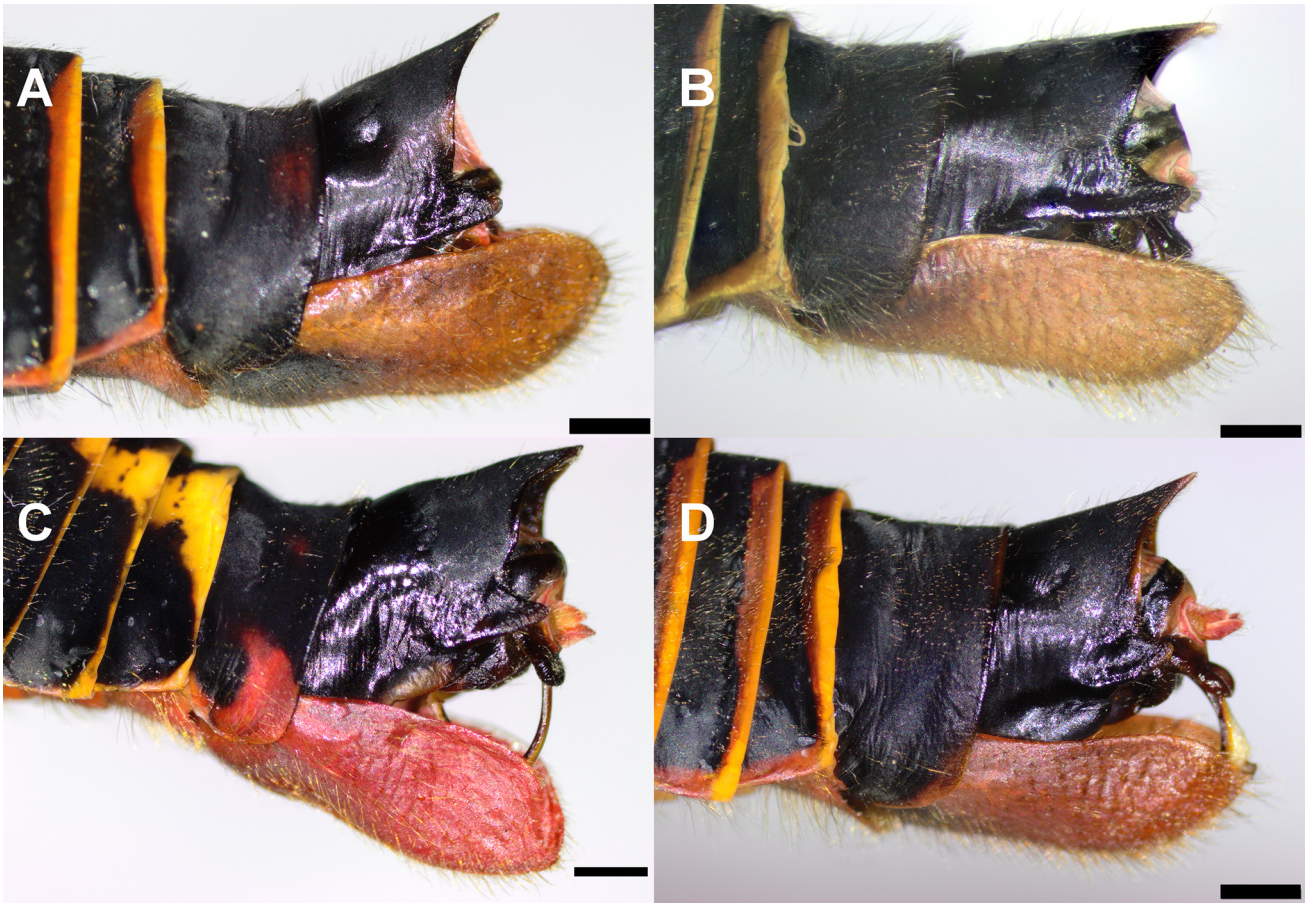

Figure 6. Lateral views of the caudal abdomen of: *(A) Yoyetta douglasi* sp. nov.*; (B) Y. enigmatica* sp. nov.; *(C) Y. loftyensis* sp. nov.; *(D) Y. ngarabal* sp. nov. Scale bars = 1 mm.

Female unknown.

Measurements (in mm; 9 males). Body length: 21.7–25.0 (23.4). Fore wing length: 27.4–30.0 (28.7). Fore wing width: 9.1–10.4 (9.9). Head width: 6.1 (6.3). Pronotum width: 6.5–7.5 (7.0). Abdomen width: 6.5–7.4 (6.9).

Distinguishing features. The calling song of *Y. enigmatica* sp. nov. is unlike any other in the *Yoyetta abdominalis* species group. However, more broadly within the genus *Yoyetta*, the calling song of this species is closely similar to that of *Y. repetens* Emery, Emery & Popple (*Y. tristrigata* species group). Like *Y. enigmatica*, *Y. repetens* produces echemes in bursts when stationary across a broad frequency spectrum (between approx. 6–12 kHz). However, unlike *Y. repetens*, *Y. enigmatica* predominantly calls during prolonged, meandering flights (*Y. repetens* will also call in flight, but only briefly when flying directly between singing stations). The echemes produced by *Y. enigmatica* sp. nov. are also usually longer than those produced by *Y. repetens*. The two species are allopatric in distribution so there would be limited opportunity for confusion.

Within the *Y. abdominalis* species group, *Y. enigmatica* sp. nov. is morphologically closest to *Y. subalpina* Emery, Emery & Popple, *Y. grandis* Emery, Emery & Popple, *Y. regalis* Emery, Emery & Popple and *Y. douglasi* sp. nov. in which both sexes have an extensively opaque, bold, white hind wing plaga and the males have black abdominal tergites with conspicuous narrow, orange or yellow posterior margins. Males can be easily distinguished from *Y. grandis* by having orange fore wing basal membranes (cf. pale grey or pale orange) and predominantly orange-brown opercula (cf. pale cream). They can be distinguished from *Y. regalis* and *Y. douglasi* by the lack of conspicuous bold black central markings on sternites III–VII. Finally, they can be distinguished from *Y. subalpina* by the much longer theca (>30% of theca extending apically beyond strongest point of recurvature, which is distinctly terminally acute (cf. short and blunt).

Yoyetta loftyensis sp. nov.

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Figs 1, 4C, 5C, 6C, 12–15

Holotype ♂, Australia, SA, AU.SA.VHN, 9.8 km NW. of Victor Harbor Rd on Myponga Rd, 229 m, 35°25.733'S 138°34.818'E, 30.xi.2006, Marshall & Hill, SAMA Database No. 20-017507 (SAM). **Paratypes**—SOUTH AUSTRALIA: 1♂, Australia, SA, AU.SA.BIR, 2.3 km S. Birdwood on road to Torrens, 391 m, 34°50.459'S 138°57.687'E, 29.xi.2006, D. Marshall, K. Hill (C. Simon lab voucher specimen 06.AU.SA.BIR.01); 1♀, same location and date as previous (MSM); 1♀, same data as holotype; 1♂, S. of Balhannah on Jones Rd., 1.2 km S Junction Rd., 351 m, 35°00.244'S 138°49.500'E, 8.i.2011, Marshall & Hill (C. Simon lab voucher specimen 11.AU.SA.ADE.01) (DE); 1♂, Collected by G. Rayson, location Stack Jarra Stakes f[ro]m W.A. to

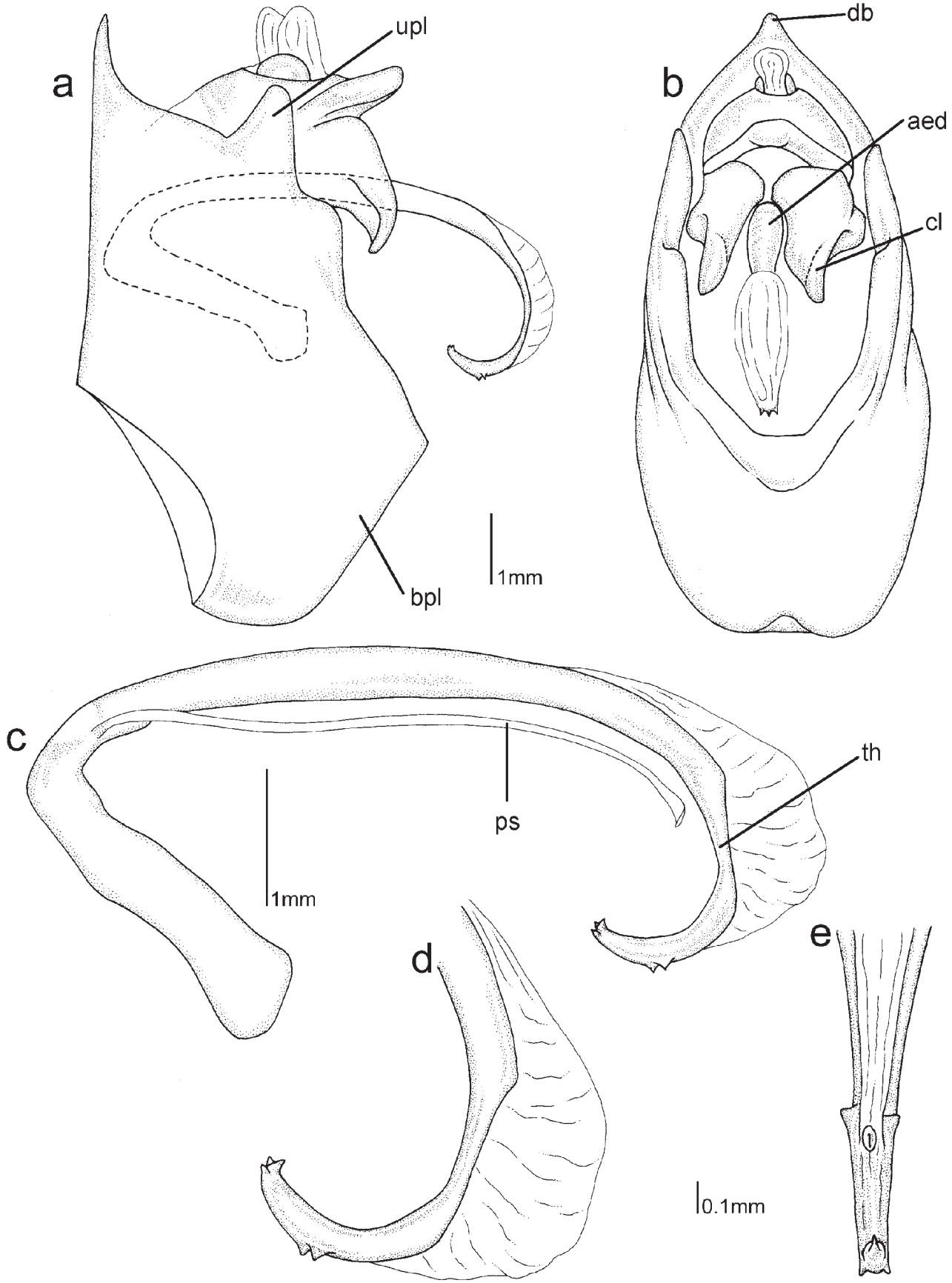

Figure 7. *Yoyetta douglasi* sp. nov.: illustration of male genitalia; *(a)* pygofer, viewed laterally from the left; *(b)* pygofer, viewed ventrally; *(c)* aedeagus, viewed laterally from the left; *(d)* apex of theca, viewed laterally from the left and *(e)* apex of theca, viewed dorsally. Characters include: aed, aedeagus; bpl, basal lobe of pygofer; cl, clasper; db, dorsal beak; ps, pseudoparameres; th, theca; upl, upper lobe of pygofer. Specimen from Halls Gap (37°14'S 142°32'E).

Figure 8. *Yoyetta enigmatica* sp. nov.: *(A)* male, Lamington National Park (28°13'S 153°13'E), dorsal habitus; *(B)* male, Lamington National Park, ventral habitus; *(C)* typical habitat, Lamington National Park; *(D)* typical habitat at Mt Kaputar (30°17'S 150°10'E). Scale bars = 10 mm.

Belair RR, 23-11-77, National Parks & Wildlife Service, SAMA Database No. 20-014465; 1♂, Mt. Barker S.A., 4.Dec. [19]64, N. McFarland, SAMA Database No. 20-014439; 1♂, S. Aust, Mt. Lofty, Jny.[18]85, A. White, SAMA Database No. 20-014440; 1♂, Sth Aus, Reed Beds, Male, 9-Dec-70, W White, SAMA Database No. 20-017497; 1♂ 1♀, Morphett Vale, Dec. 1889, J. W. Mellor; 1♂, 22-11-1958, Belair, S.A., S. Dawson SAMA Database No. 20-017501, 20-017499; 2♀♀, Wilmington, Rev. Burgess, 16.12.86, SAMA Database No. 20-014442, 20-014443; 1♂ 1♀, S. Australia, Rev. A. P. Burgess, SAMA Database No. 20-014444, 20-014445; 2♀♀, Mt Lofty Rge, S. H. Curnow; 1♀, S. Aust, Mt Lofty, Dec-1891, SAMA Database No. 20-017500, 20-017502 (SAM).

Etymology. Named after the Mt Lofty Ranges south-east of Adelaide, South Australia, where this species is most prolific.

Distribution, habitat and seasonality. This species is restricted to the Greater Adelaide region from near Victor Harbour north through the Mt Lofty Ranges to near Williamstown, with a potentially isolated population in the southern Flinders Ranges at Wilmington (Fig. 1). It has also been heard calling in Adelaide Botanic Garden. Populations are found in open eucalypt forest and occasionally in parks

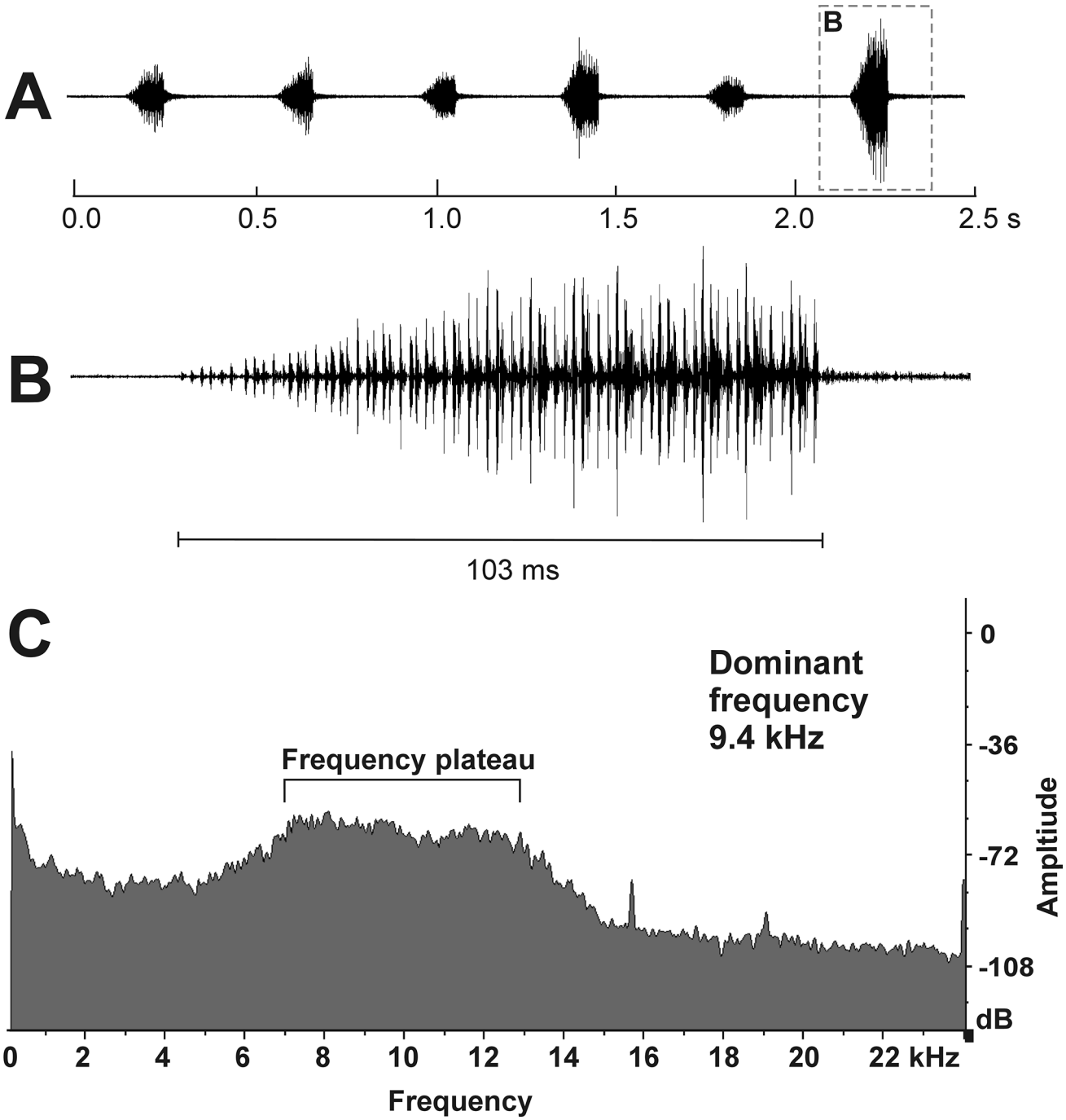

Figure 9. Male calling song structure of *Yoyetta enigmatica* sp. nov. illustrated in waveform plots, including: *(A)* typical repeated echemes (in flight); *(B)* expanded section from *(A)* showing the detailed structure of a single echeme. The final subfigure *(C)* is a spectrogram displaying song frequency. This specimen was recorded in the field at Dawson Springs, Mt Kaputar (30°17'S 150°10'E) by LWP.

with tall eucalypts (Fig. 12E, F). The adults occupy the upper and outer branches where they tend to remain fairly sedentary. Males move singing stations irregularly. Adults have been found during November and December.

Calling song. The calling song of *Y. loftyensis* sp. nov. is moderately high pitched, with a frequency plateau between approximately 10 and 15 kHz and dominant frequency of approximately 12 kHz. It contains repeated patterns of syllables (each 0.008–0.015 s duration) that are grouped in phrases of two subtly different structures: a "normal phrase" and a "cueing phrase". In both cases, each phrase commences with two (rarely one or three) preceding syllables, separated by a gap of 0.04–0.09 s, followed by a shorter gap (0.01–0.07 s), then an echeme (which could equivocally be interpreted as a dense syllable sequence; 0.26–0.71 s duration) and then two (rarely three) subsequent syllables, separated by successively longer gaps (0.03–0.08 s, increasing to 0.07–0.13 s). The cueing phrase is characterized by the longer gap after the final syllable (0.09–0.22 s). In contrast, the normal phrases

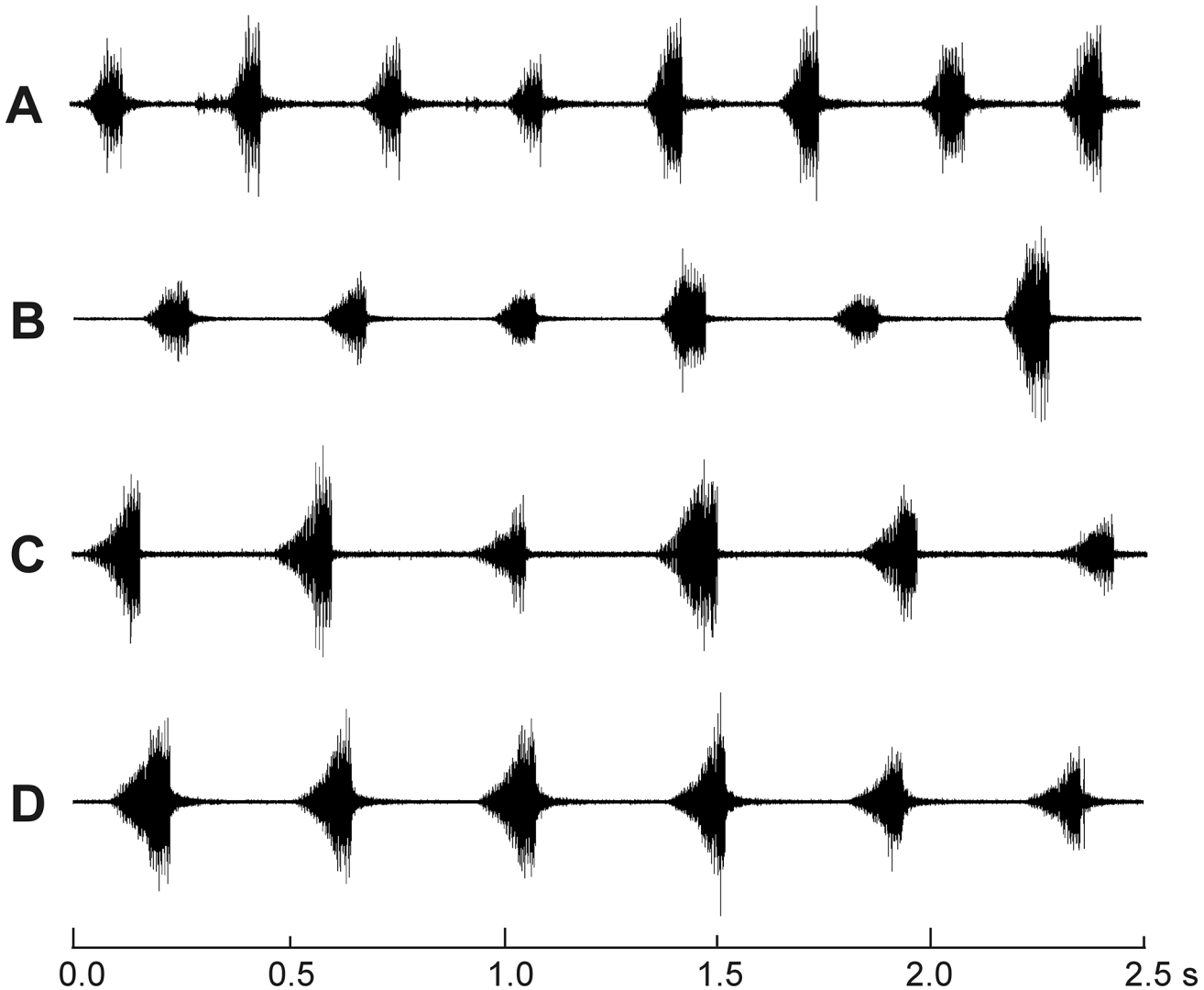

Figure 10. Waveform plots comparing different recordings of the calling song of *Yoyetta enigmatica* sp. nov. from: *(A)* Mt Kaputar (30°17'S 150°10'E); *(B)* Mt Kaputar; *(C)* Lamington National Park (28°13'S 153°13'E); *(D)* Springbrook National Park (28°13'S 153°16'E). All recordings were made in the field by LWP.

lack this longer gap, which makes the beginning and ending of each phrase less conspicuous (Fig. 13). Occasionally, a one-off extended echeme (or dense syllable sequence; 3–19 s duration) is produced within the structure of a normal phrase or cueing phrase (Fig. 13A). The two different phrase types may be produced interchangeably and there is little difference in overall duration between normal and cueing phrases (each lasting approximately 0.5–1.1 s). A comparison of cueing phrase structures recorded from across the geographical distribution of this species is provided in Fig. 14.

Singing occurs almost exclusively when males are stationary. However, a phrase with an extended echeme may also be produced during short flights between singing stations. It is inferred that the female wing-flick response would be timed during these long gaps at the end of each cueing phrase.

Morphology. **Male** (Figs 4C, 5C, 6C, 12A–B, 15). *Head* almost as wide as mesonotum, black; a central triangular yellow-brown fascia on midline posterior to ocelli, base on posterior margin, reducing anteriorly, ocelli pink to pale; dorsal postclypeus black, with a narrow yellow-brown fascia on midline, apex directly anteriorly, ventral surface black, ochraceous spot on anterior midline, with black transverse grooves, lateral margins brown-ochraceous; anteclypeus black, rostrum pale brown at base, black around apical third, brown centrally becoming dark brown to black at apex, reaching anterior of hind coxae; lorum black, gena black; eyes dull black; antennae black, supra-antennal plates black.

Thorax mainly dull black. Pronotum black, with a central yellow-brown fascia extending from behind anterior margin almost to margin of pronotal collar; patchy dark brown markings over raised lateral areas of pronotum; paramedial fissures black, lateral fissures variably dark brown; pronotal collar dark brown to black, central third variably brown, margins of lateral angles brown, lateral areas black. Mesonotum black, parapsidal sutures black, scutal depressions and surrounds black; cruciform elevation arms black, lateral depressions light brown. Metanotum black, midline black, pale brown over central third, becoming black laterally.

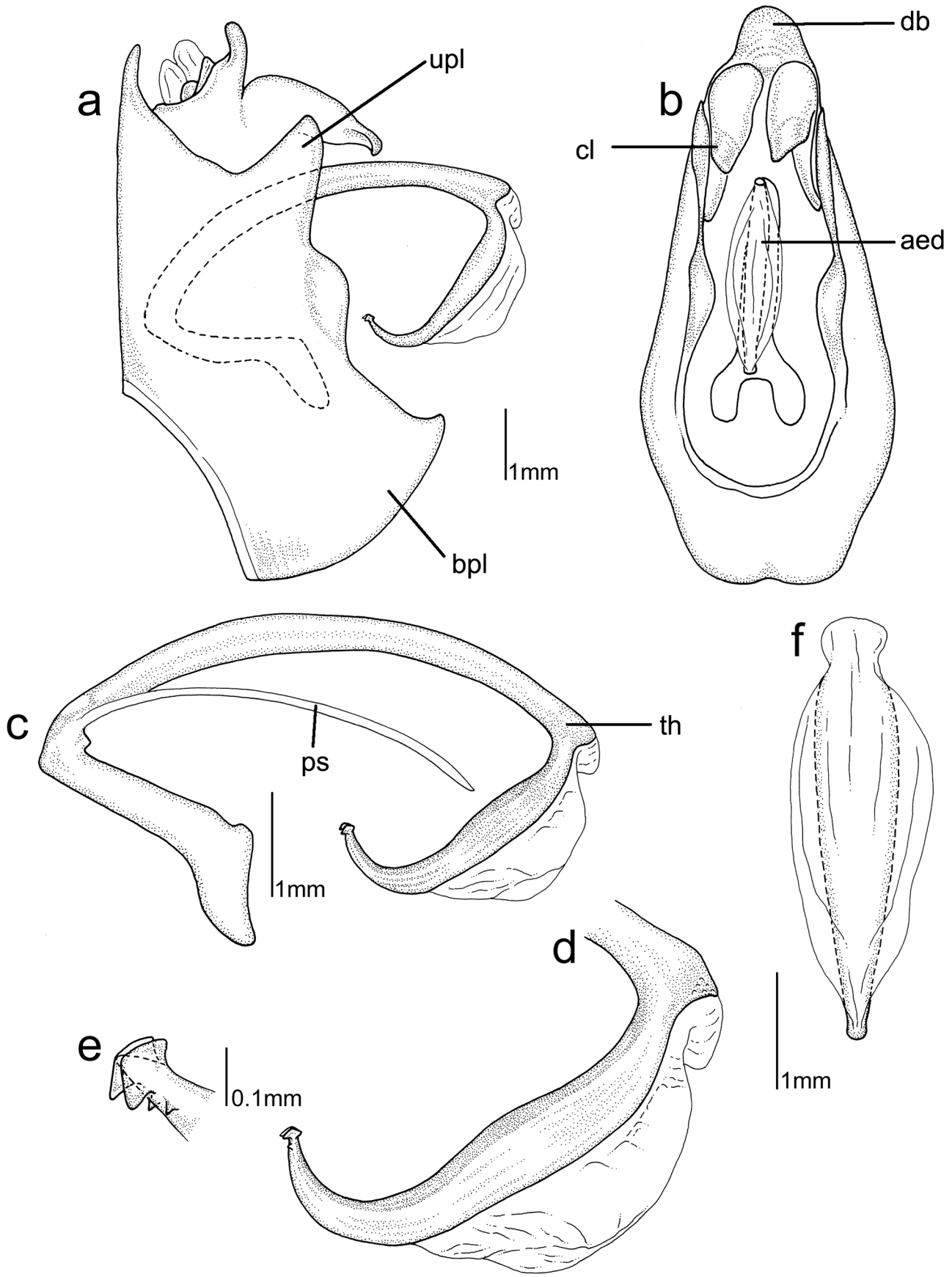

Figure 11. *Yoyetta enigmatica* sp. nov.: illustration of male genitalia; *(a)* pygofer, viewed laterally from the left; *(b)* pygofer, viewed ventrally; *(c)* aedeagus viewed laterally from the left; *(d)* apical portion of theca, viewed laterally from the left; *(e)* terminal apex of theca; *(f)* apical portion of theca, viewed ventrally. Characters depicted as in Fig. 7. Specimen from Dawson Springs, Mt Kaputar (30°17'S 150°10'E).

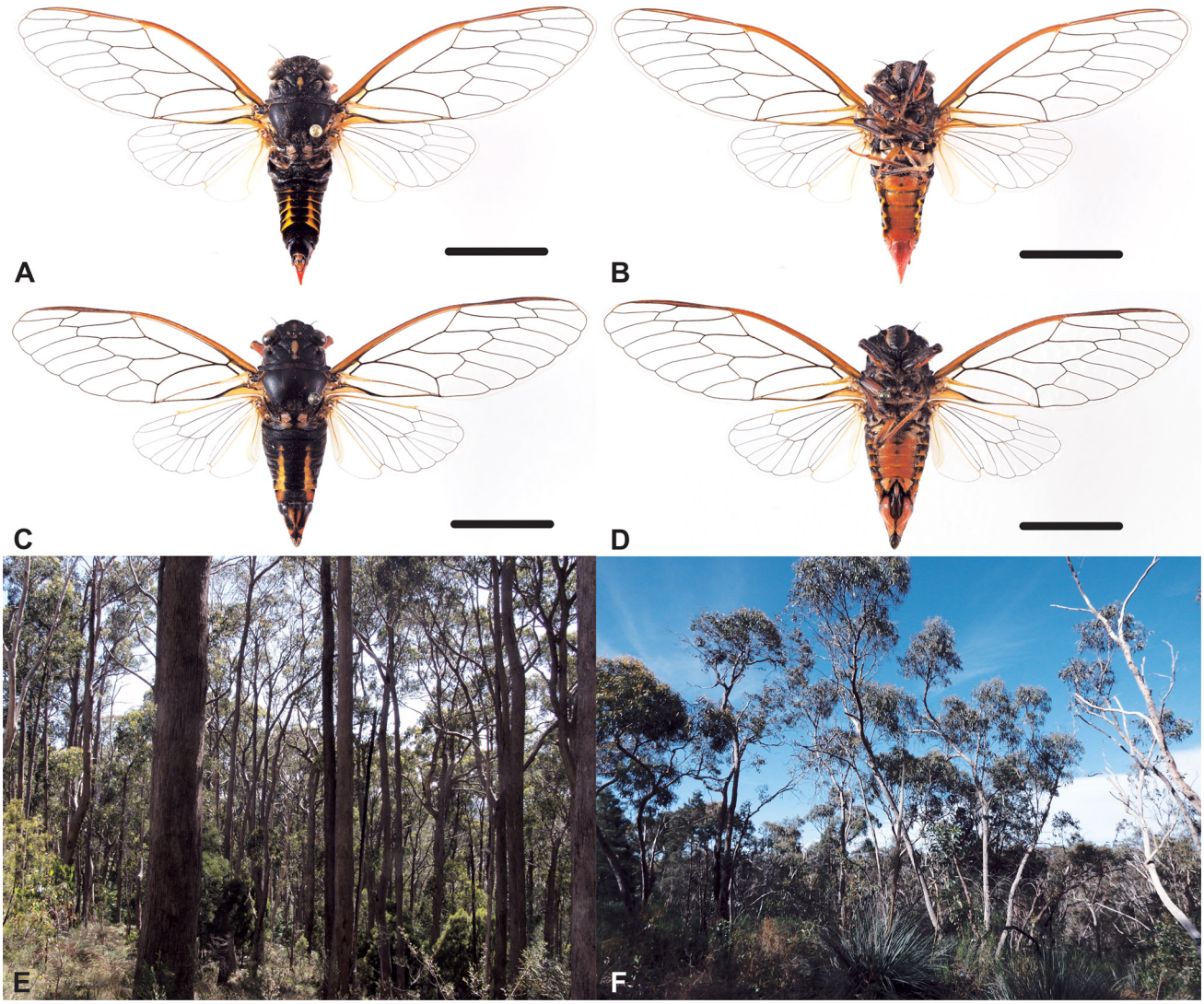

Figure 12. *Yoyetta loftyensis* sp. nov.: *(A)* holotype male, 9.8 km NW. of Victor Harbour Road (35°26'S 138°35'E), dorsal habitus; *(B)* holotype male, ventral habitus; *(C)* female, 2.3 km S. of Birdwood (34°50'S 138°58'E) dorsal habitus; *(D)* female, 2.3 km S. of Birdwood, ventral habitus; *(E)* typical habitat, Adelaide; *(F)* typical habitat, Adelaide. Scale bars = 10 mm.

Legs. Coxae black, joints orange-red; basisterna black, bordered orange-red; trochanter black with diffuse brown areas; meracantha small, narrow, pale cream, black at base, pointed, marginally overlapping opercula; fore femora mainly orange-red, with black longitudinal markings on inner ventral sides and around base of femoral spines; femoral spines erect, black; mid femora black mainly orange red, with diffuse black areas on anterior sides, hind femora orange-brown with black markings on anterior apices, joints orange-red; fore tibia mainly black, dark reddish-brown on inner sides; mid tibia black, tending dark reddish-brown towards anterior apices; hind tibia dark reddish-brown with diffuse black areas; fore and mid tarsi dark reddish brown, tending black on outer sides; hind tarsi pale orange-brown, becoming dark brown towards claws; spines orange-brown; claws dark brown, black at tips.

Wings with fore wing costal veins black anteriorly, orange-brown central rib, becoming brown distally, pterostigma mottled red, basal cell pale yellow, translucent, black anterior border, arculus black, basal membranes orange, other veins dark brown to black, proximal segment of vein CuA pale, becoming brown distally with eight apical cells; hind wing plaga white to whitish-cream over jugum and vein 3A, thin along vein 2A, subcostal vein pale, other veins brown, with six apical cells.

Opercula (Fig. 4C) covering abdominal cavity, spatulate, following body axis ventrolaterally, depressed centrally, variably black at base, pale cream across remainder, tinged orange in some specimens, clearly separated.

Timbals (Fig. 4D) with five distinct long ribs; long ribs 1–4 extending across surrounding membrane and fused dorsally along basal spur; long rib 5 independent of basal spur, comparatively shorter, extending ventrally across half of membrane; large ridged dome on posterior timbal plate extending across two-thirds of timbal; apodeme pit oval shaped, inconspicuous.

Abdomen with tergite 1 black, membrane anterior to timbals orange-red, tergite 2 black, tergites 3–7 black with

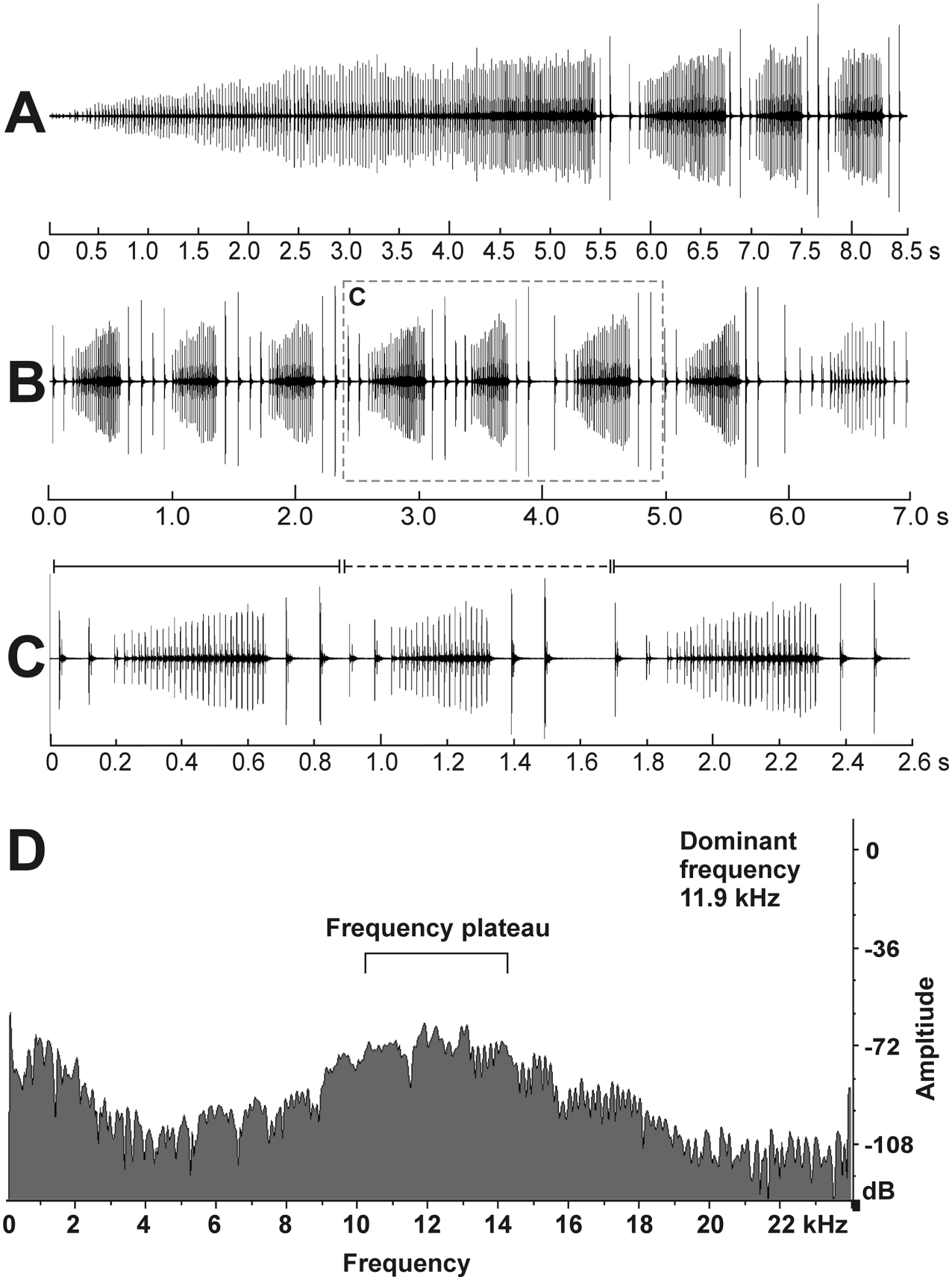

Figure 13. Male calling song structure of *Yoyetta loftyensis* sp. nov. illustrated in waveform plots, including: *(A)* a single cueing phrase commencing with an extended dense syllable sequence/long echeme, followed by three normal phrases; *(B)* a series of four normal phrases, followed by a cueing phrase, then two sets of alternating normal and cueing phrases; *(C)* expanded section from *(B)* showing two normal phrases (demarcated by solid black bar above) and one cueing phrase (demarcated by dashed line above). The final subfigure *(D)* is a spectrogram displaying song frequency. This specimen was recorded in the field at 9.8 km NW. of Victor Harbour Road (35°26'S 138°35'E) by D. Marshall and K. Hill.

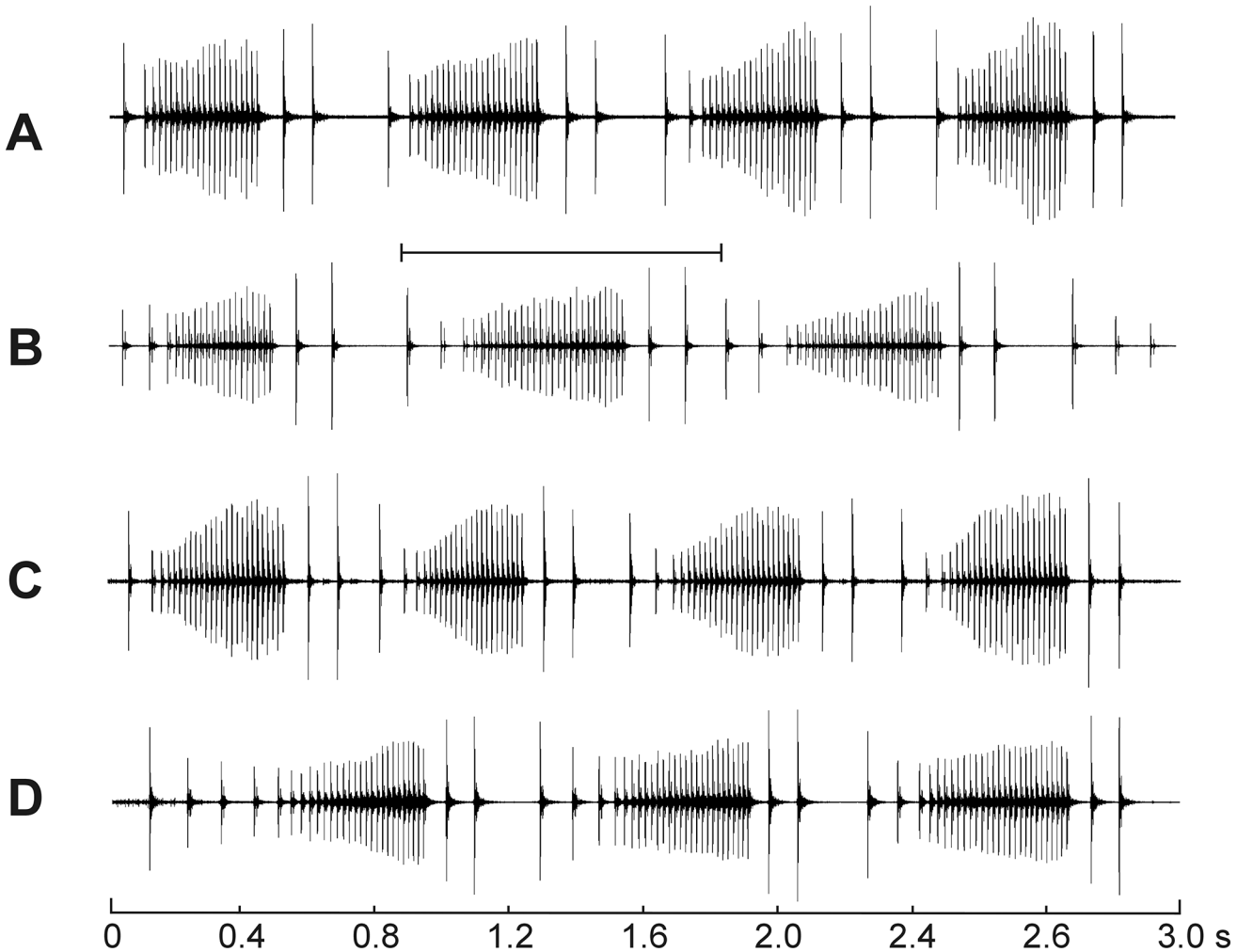

Figure 14. Male calling song structure of *Yoyetta loftyensis* sp. nov. A comparison of phrase structures recorded from multiple sites, including: *(A)* Mt Lofty (34°59'S 138°43'E); *(B)* Hale Conservation Park (34°41'S 138°55'E); *(C)* 9.8 km NW. of Victor Harbour Road (35°26'S 138°35'E); and *(D)* 2.3 km S. of Birdwood (34°50'S 138°58'E). All examples are cueing phrases, apart from the one in *(B)* with a black scale bar above, which is a normal phrase. Recordings *(A)* and *(B)* were made in the field by LWP. Recordings *(C)* and *(D)* were made by D. Marshall and K. Hill.

orange posterior margins, extending laterally to epipleurites, progressively increasing on either side of midline to reach anterior borders of tergites 4–7, posterior margins yellow; tergite 8 black, with red markings on lateral margins (Fig. 6C). Epipleurites 1–3 black anteriorly, orange red posteriorly, epipleurites 4–6 mainly orange. Sternite I black, sternite II black medially, orange-red over central third posterior to timbal cavity, black laterally, sternite III orange-red with central black spots on anterior and posterior margins, sternites IV–VI orange, sternite VII mainly orange, red posteriorly, sternite VIII fiery red, with pale brown pubescence.

Genitalia (Fig. 15). Pygofer shiny black upper lobe mainly black with red posterior margin; basal lobe ochraceous; dorsal beak black, dark brown posterior margin, anal styles orange, red at tip. Uncus orange-brown; in lateral view beak-like and stumpy; lobes in ventral view bulbous, with rounded lateral termination; claspers clearly divided, triangular with apices gradually tapering laterally. Aedeagus with pseudoparameres extending around one third the length of theca; theca recurved ventrally at 180° towards apex, with transparent flange along outer margin of recurvature, broadly smooth, around 2× width of theca, terminating adjacent to apex of theca; apex short, tapered, sclerotized, angled 30° ventrally, with two lateral rows of prominent cornuti at base, numerous cornuti over apex.

Female (Fig. 12C–D).

Head and *thorax* similar to male, with darker brown markings along parapsidal sutures.

Abdomen. Tergites similar to male. Sternite I–II black, posterior margins ochraceous, sternites III–VI orange-red with midline black marking decreasing to sternite IV, sternite VII pale brown with anterior black spot either side of midline. Abdominal segment 9 with central black triangular marking, base at anterior margin, reducing over middle third, expanding over dorsal beak, flanked laterally by orange stripe and lateral black area, extending laterally over anterior third, remainder reddish-orange laterally with posterior black spot. Dorsal beak black, ovipositor dark brown, becoming black at tip, not extending beyond apex of abdominal segment 9. Anal styles orange-red; ovipositor sheath black, becoming paler brown ventrally, gonocoxites black laterally, ochraceous along midline.

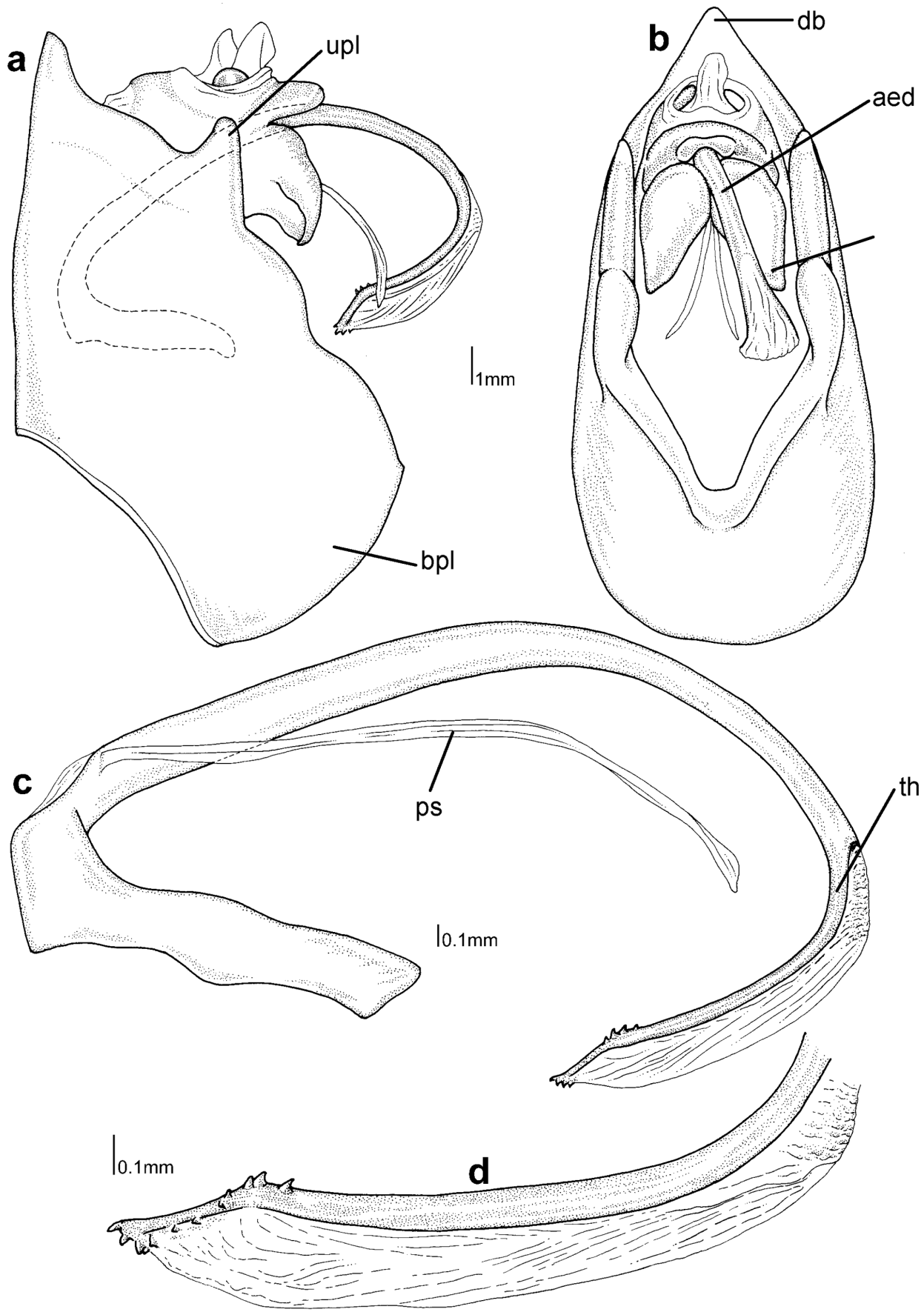

Figure 15. *Yoyetta loftyensis* sp. nov.: illustration of male genitalia; *(a)* pygofer, viewed laterally from the left; *(b)* pygofer, viewed ventrally; *(c)* aedeagus, viewed laterally from the left; *(d)* apex of theca. Characters depicted as in Fig. 7. Specimen from 9.8 km NW. of Victor Harbour Road (35°26'S 138°35'E).

Measurements (in mm; 10 males, 8 females). Body length: male 20.9–24.7 (22.7); female 22.3–24.0 (28.5). Fore wing length: male 25.5–28.7 (26.9); female 28.3–31.2 (29.4). Fore wing width: male 9.2–10.6 (9.8); female 9.7–11.3 (10.5). Head width: male 6.0–7.0 (6.6); female 6.6–7.1 (6.9). Pronotum width: male 5.9–7.7 (6.9); female 6.4–8.0 (7.5). Abdomen width: male 6.1–7.2 (6.5); female 6.4–7.5 (7.0). Ovipositor length: female 6.0–8.4 (7.7).

Distinguishing features. Within the *Y. abdominalis* species group, the calling song of *Y. loftyensis* is most similar to the call of *Y. serrata* Emery, Emery & Popple from south-eastern Australia. The longer minimum gaps between syllables (>0.16 s; Emery *et al.* 2019) distinguishes *Y. serrata* from *Y. loftyensis*. The former also lacks the characteristic structure of the cueing phrases produced by *Y. loftyensis* (see Figs 13, 14).

Morphologically, *Y. loftyensis* sp. nov. is closest to *Y. abdominalis* (Distant), which also occurs in south-eastern South Australia, and *Y. serrata*. It can be distinguished easily from *Y. serrata* by the colour of the fore wing basal membranes, which are orange (cf. pale whitish-grey). Males can be distinguished from *Y. abdominalis* by examining the apex of the theca, which is tapered and angled 30° ventrally (cf. short and club-like). Both sexes can be distinguished from fresh specimens of by *Y. abdominalis* by the lack of conspicuous golden hairs on the head and thorax. Otherwise, females cannot be distinguished reliably from *Y. abdominalis*.

Yoyetta ngarabal sp. nov.

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Figs 1, 4D, 5D, 6D, 16–18

Holotype ♂, Old Grafton Road, Glen Elgin, 29.65546°S 152.04396°E, 7.i.2016, L. W. Popple, open forest, SL100704, 515-0007 (recorded) (AM K.570297). **Paratypes**—NEW SOUTH WALES: 1♂, same data as holotype, Pop515-0010 (QM); 1♂, same data as holotype, Pop515-0008 [genitalia prep] (DE); 1♂, same data as holotype, Pop515-0011 (MSM); 1♂, same data as holotype, Pop515-0009 (LWP).

Etymology. Named in honour of the Ngarabal people, the traditional Aboriginal owners of the Glen Innes area and surrounds, including the site where this cicada has been found. The specific epithet is a noun in apposition.

Distribution, habitat and seasonality. This species is known only from a single locality at Glen Elgin east of Glen Innes in northern New South Wales (Fig. 1). It occurs in moist open forest, dominated by eucalypts and she-oaks, with a grassy understorey (Fig. 16E–F). Adults have been observed only during January.

Calling song. Males of *Y. ngarabal* sp. nov. typically commence calling whilst stationary and continue to call in flight. Based upon high quality recordings from the type locality ($n = 5$), the calling song comprises repeated phrases, containing a syllable sequence (14–27 syllables with each syllable 0.010–0.013 s duration and separated by silent gaps of 0.02–0.03 s) and an echeme (0.06–0.31 s), followed by a longer silent gap (0.11–0.31 s) (Fig. 17). The echemes at the end of each phrase show a sharp amplitude modulation, which is much louder than the preceding syllable sequence. In flight, the syllable sequence is often dropped, with long silent gaps of 1.3–1.6 s occupying the intervals between each echeme.

The calling song has a dominant frequency of 8.9–9.6 kHz and a high amplitude plateau between approximately 6.8 and 11.1 kHz (Fig. 17D). Males were found to be responsive to simulated female wing-flick responses when these were timed precisely to occur at the end of each echeme (LWP, pers. obs., 7 January 2016).

Morphology. **Male** (Figs 4D, 5D, 6D, 16A–16B, 18). *Head* almost as wide as mesonotum, black, with a central dark brown fascia posterior to ocelli; ocelli pink; dorsal side of postclypeus black anteriorly, dark brown over remainder; ventral side of postclypeus black with black transverse grooves, with brown lateral margins; anteclypeus black, rostrum mainly brown, dark brown at apex, reaching anterior edge of hind coxae; lora black; gena black; eyes dull reddish-brown; antennae and supra-antennal plates black.

Thorax mainly black with variable dark brown patterning. Pronotum mainly black, a thin central dark brown line on anterior half, dark brown on lateral angles; fissures mainly black; pronotal collar black. Mesonotum mainly black, area between submedian and lateral sigilla dark brown, cruciform elevation arms black, lateral depressions dark brown. Metanotum black.

Legs. Fore coxae black with brown to pale brown lateral margins; mid and hind coxae black; coxal membranes red; basisterna black, kapepisterna brown posteriorly; meracantha small, narrow, pale orange-red, black at base, pointed, minimally overlapping opercula; femora mainly black, with brown areas on outer sides; femoral spines erect, brown at base, becoming black at tips; fore tibiae dark brown to black; mid tibiae black anteriorly, brown to orange-brown over remainder; hind-tibiae orange brown; tarsi orange-brown becoming black towards claws; claws dark brown, black at tips.

Wings with fore wing costal veins dark brown, darker central rib; pterostigma pinkish-brown; basal cell translucent pale yellow-brown with black anterior border; basal membranes orange, becoming darker distally; other veins dark brown to black, with eight apical cells, each hyaline with a slightly smoky appearance; hind wing plagas dull white with pink intrusions along margins of anal cell 3 and vein 2A, central area and posterior of jugum hyaline, with six apical cells.

Opercula (Fig. 4D) covering abdominal cavity, spatulate, following body axis ventrolaterally, depressed centrally, black over basal area, pale reddish-brown over remainder, clearly separated.

Timbals (Fig. 5D) with five distinct long ribs; long ribs 1–4 extending across surrounding membrane and fused dorsally along basal spur; long rib 5 independent of basal spur, slightly shorter, extending ventrally three quarters of membrane; intercalary ribs present, most prominent between long ribs 3 and 4, inconspicuous between long ribs 4 and 5; large ridged dome on posterior timbal plate extending across half of timbal; apodeme pit oval-shaped and conspicuous.

Abdomen with tergite 1–2 black; tergites 3–7 black with orange posterior margins; tergite 8 black (Fig. 6D). Epipleurites brown with orange posterior margins. Sternite II black centrally, orange-brown laterally; sternites III–VII

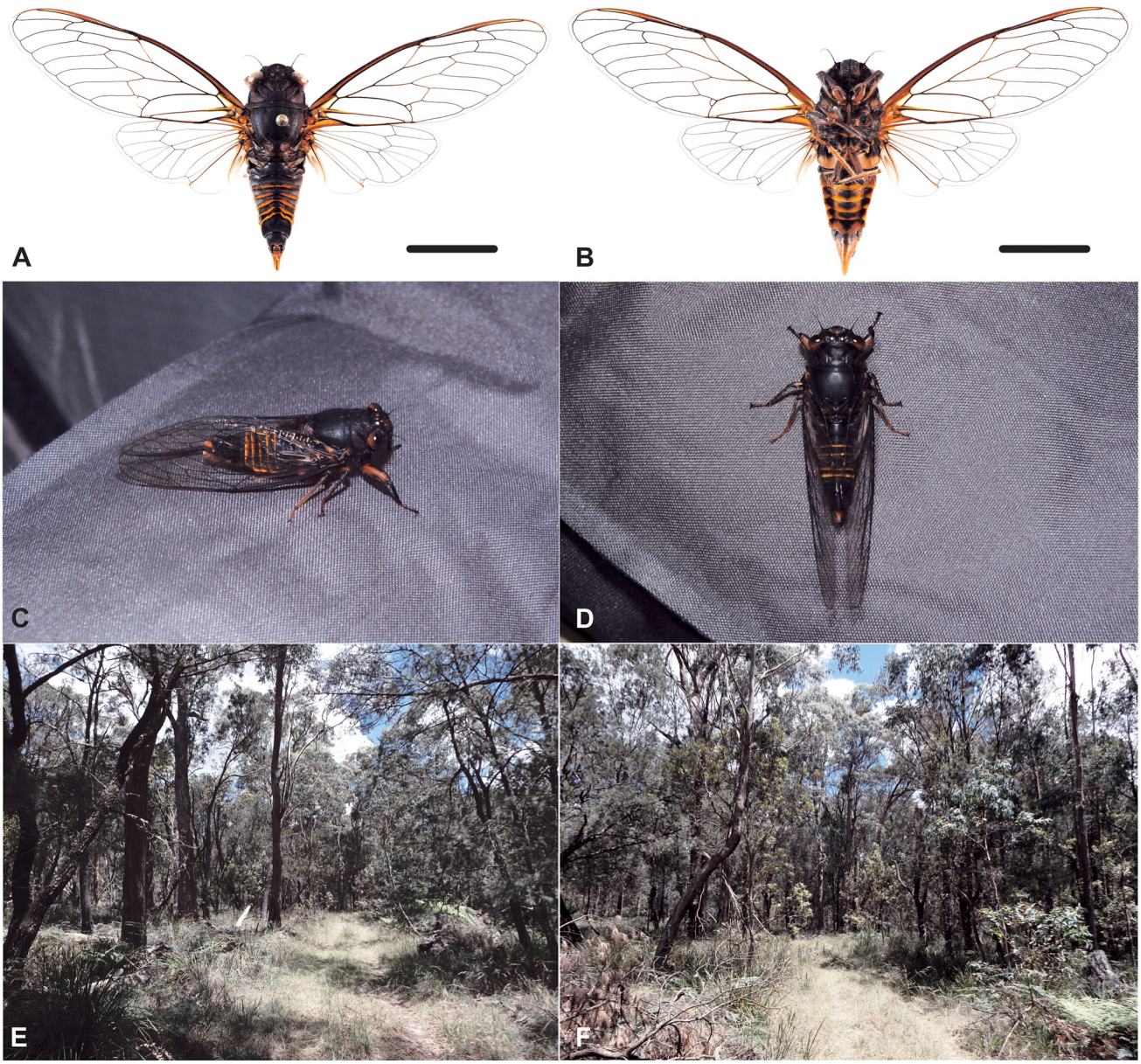

Figure 16. *Yoyetta ngarabal* sp. nov. *(A)* holotype male, Glen Elgin (29°39'S 152°03'E), dorsal habitus; *(B)* holotype male, ventral habitus; *(C)* live male, Glen Elgin, lateral view; *(D)* live male, Glen Elgin, dorsal view; *(E)* typical habitat, Glen Elgin *(F)* typical habitat, Glen Elgin. Scale bars = 10 mm.

orange-brown with prominent black central areas and orange posterior margins; sternite VIII dark brown to black anteriorly, becoming brown to orange-brown posteriorly, with brownish pubescence.

Genitalia (Fig. 18). Pygofer shiny black; dorsal beak dark brown to black; anal styles orange; upper lobes shiny black; basal lobes black. Uncus dark brown, rounded, in lateral view extending as far posteriorly as anal styles, in ventral view bulbous; claspers black, apposed at base, clearly divided anteriorly, short, with apices rounded, gradually tapering laterally. Aedeagus with pseudoparameres extending around two-thirds the length of theca; theca recurved ventrally at 120° towards apex, with prominent transparent flange along the outer margin of recurvature, this broadly smooth along theca with substantial lateral ornamentations, together >5 times width of theca, terminating at apex; apex bifurcate in ventral view, terminals blunt, each with beak-like angulation ventrally, dual cornuti dorsally.

Female. Unknown.

Measurements (in mm; 5 males). Body length: 24.2–26.3 (25.4). Fore wing length: 29.5–30.4 (30.0). Fore wing width: 9.8–10.4 (10.1). Head width: 6.7–7.1 (7.0). Pronotum width: 7.0–7.6 (7.4). Abdomen width: male 6.6–7.9 (7.6).

Distinguishing features. Within the *Y. abdominalis* group, in both calling song and morphology, *Y. ngarabal* sp. nov. is most similar to *Y. verrens* Emery, Emery & Popple, which also occurs in northern New South Wales. Notably, *Y. verrens* has two modes of calling ("cascade mode" and "ratchet mode"; see Emery *et al.* 2019), whereas

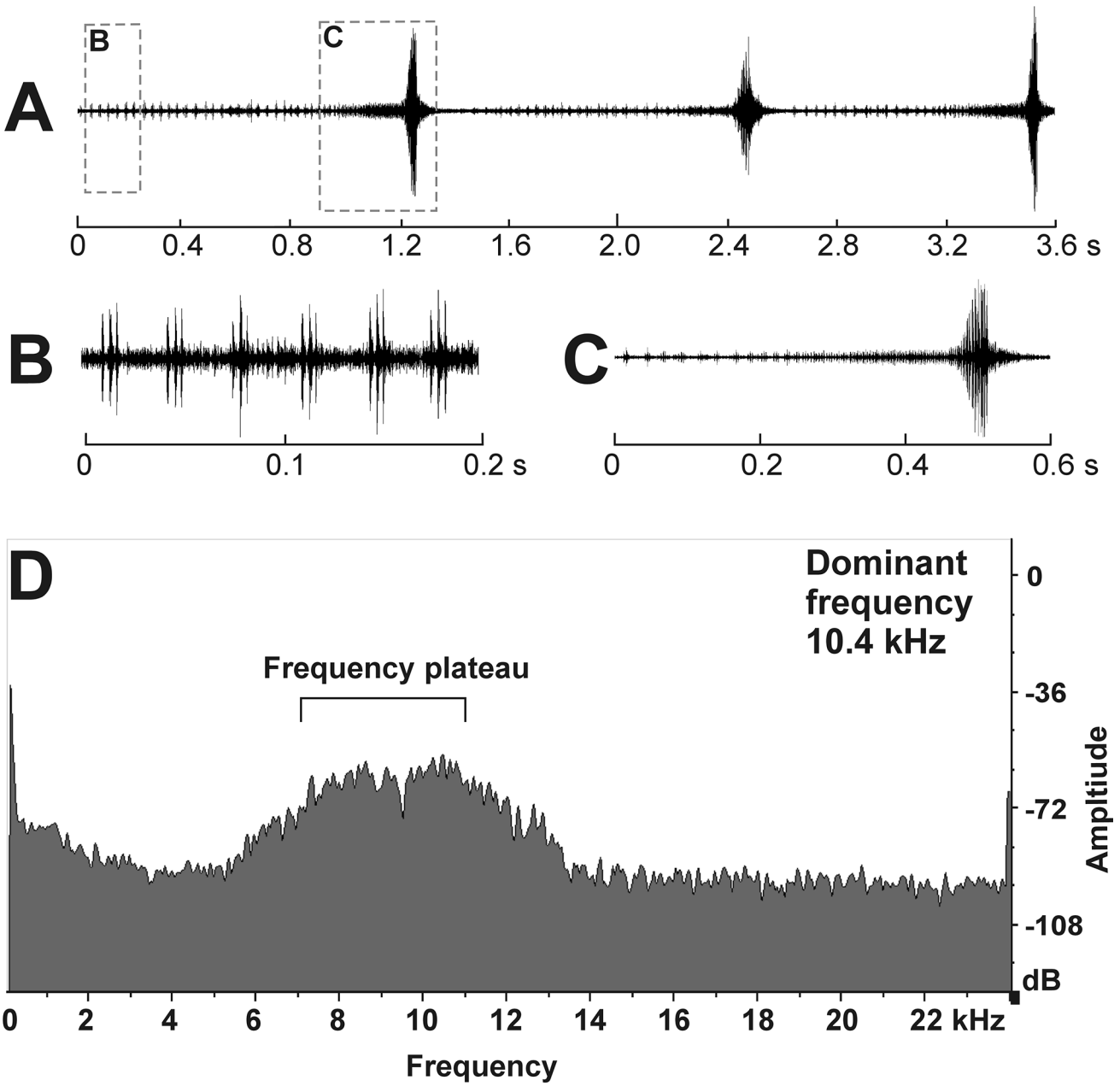

Figure 17. Male calling song structure of *Yoyetta ngarabal* sp. nov. illustrated in waveform plots, including: *(A)* three complete phrases, each comprising a syllable sequence followed by an echeme; *(B)* expanded section from A showing the detailed structure of the syllable sequence; *(C)* expanded from *(A)* showing the detailed structure of a normal phrase followed by a cueing phrase and another normal phrase. The final subfigure *(D)* is a spectrogram displaying song frequency. This specimen was recorded in the field at Glen Elgin (29°39'S 152°03'E) by LWP.

Y. ngarabal sp. nov. only has one. The calling song of *Y. ngarabal* sp. nov. is most comparable with the ratchet mode of *Y. verrens*. The most notable difference is in the abbreviated gap between syllables in the syllable sequence (0.021–0.031 s, c.f. 0.07–0.14 s for *Y. verrens*), which gives the call a more rattle-like quality. The amplitude modulation in the echeme is also more prominent in *Y. ngarabal* sp. nov. than in *Y. verrens*.

Both *Y. ngarabal* sp. nov. and *Y. verrens* share a characteristic trait that distinguishes both species from other species in the *Y. abdominalis* species group: the colouration of the hind wing plaga. In both species, it is dull white and restricted along the margins of anal cell 3 and vein 2A. In other species within the same species group, the opaque colouration is bold white and more extensive. Males of *Y. ngarabal* sp. nov. can be distinguished from males of *Y. verrens* by their larger size (head width ≥6.7 mm) and by the presence of bold black central markings on sternites III–VII (inconspicuous or absent in *Y. verrens*). A single female was observed at Glen Elgin; however, it evaded capture. Observations indicate that the female has a conspicuously longer ovipositor than that reported for *Y. verrens* by Emery *et al.* (2019) (i.e. 2 mm). However, this observation requires a specimen for confirmation.

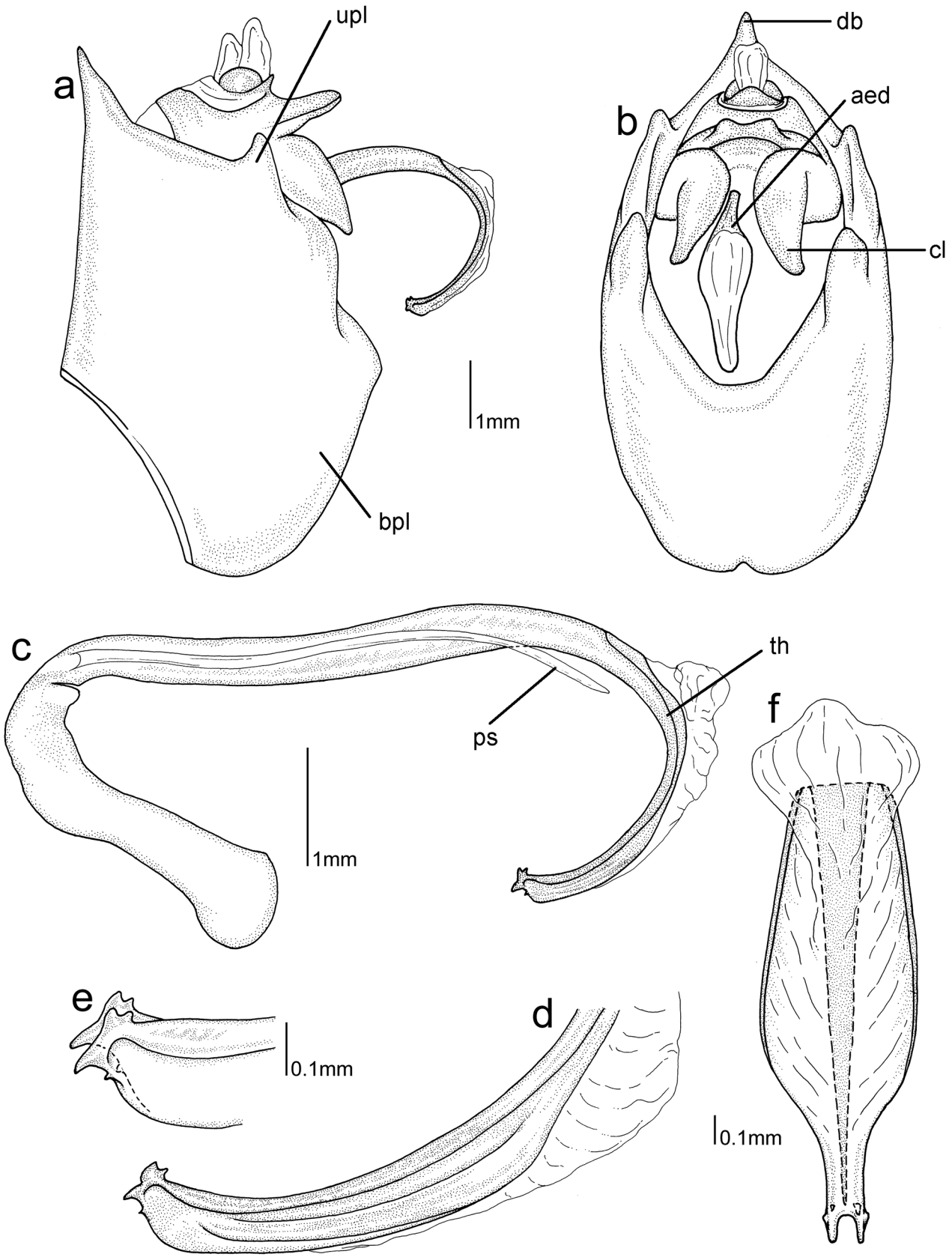

Figure 18. *Yoyetta ngarabal* sp. nov.: illustration of male genitalia; *(a)* pygofer, viewed laterally from the left; *(b)* pygofer, viewed ventrally; *(c)* aedeagus viewed laterally from the left; *(d)* apical portion of theca, viewed laterally from the left; *(e)* terminal apex of theca; *(f)* apical portion of theca, viewed ventrally. Characters depicted as in Fig. 7. Specimen from Glen Elgin, (29°39'S 152°03'E).

Key to species in the *Yoyetta abdominalis* species group based on male specimens

The key is slightly modified and expanded from Emery *et al.* (2019). Specimens must be set with wings spread to begin using this key. For males, in some cases, the genitalia will need to be exposed (or dissected) to allow examination of the aedeagus. A vernier caliper is required to check measurements. Male specimens must often be examined microscopically and may require dissection in some instances.

1	Abdominal tergites 2–8 and sternites II–VII uniformly black or brown without orange- or yellow-brown markings; intersegmental membranes dark and inconspicuous	2
——	Abdominal tergites 2–8 mainly black with contrasting orange- or yellow-brown markings, or contrasting intersegmental membranes; sternites II–VII mainly yellow-brown or orange	4
2	Fore wing basal membranes orange or pale orange-white	*Y. timothyi*
——	Fore wing basal membranes red	3
3	When viewed from ventral side, tip of aedeagus strongly bifurcate, with apical arms splayed laterally, sometimes in a weak "v" shape, at an angle of 150–180 degrees	*Y. denisoni*
——	When viewed from ventral side, tip of aedeagus undivided or weakly divided, without distinct lateral arms	*Y. kershawi*
4	Tergites 5–7 partly black with contrasting, orange or yellow markings	5
——	Tergites 5–7 entirely dark brown to black with yellow or orange coloration restricted to the intersegmental membranes	10
5	Opercula mainly pale grey to dark grey-brown	6
——	Opercula mainly red or orange	9
6	Dorsal surface of head, pronotum and mesonotum typically covered with dense gold pubescence; fore wing basal membranes orange or pink	7
——	Head, pronotum and mesonotum not covered in conspicuous pubescence; fore wing basal membranes pale grey	8
7	Hind wing plagas narrow on ac2(v) (along vein 3); apex of theca blunt and club-like	*Y. abdominalis*
——	Hind wing plagas broad on ac2 (along vein 3), though not quite as broad as on jugum; apex of theca tapered and angled 30° ventrally	*Y. loftyensis*
8	Lateral sides of tergites 3–7 mainly orange; tergite 8 with orange markings on anterodorsal side	*Y. aaede*
——	Lateral sides of tergites 3–7 mainly black (with yellow dorsolateral markings); anterodorsal side of tergite 8 black	*Y. serrata*
9	Body length < 23 mm; sternites III–VII bright reddish-orange without a continuous dark brown to black central marking	*Y. spectabilis*
——	Body length > 23 mm; sternites II–VII yellowish-orange or reddish-brown with a continuous dark brown to black central marking	*Y. regalis*
10	Fore wing length < 26 mm	11
——	Fore wing length > 26 mm	12

11 Pronotum dark brown to black with contrasting yellow-brown central marking ..... *Y. electrica*

—— Pronotum dark brown to black without contrasting yellow-brown central marking ..... *Y. hunterorum*

12 Dorsal surface of head, pronotum and mesonotum with an inconspicuous, sparse covering of pubescence; lateral depressions adjacent to cruciform elevation conspicuous, brown to pale brown ..... *Y. grandis*

—— Dorsal surface of head, pronotum and mesonotum typically with dense, black pubescence; lateral depressions adjacent to cruciform elevation inconspicuous, typically dark brown to black 13

13 Hind wing plagas broad; with opaque white area expressed equally in cells ac3 and ac2(v) (either side of the jugal fold) ..... *Y. subalpina*

—— Hind wing plagas narrow or predominantly expressed in ac3, with a narrow extent on ac2(v) (along vein 3a) 14

14 Tergite 8 black with a brown, reddish-brown or dark reddish-brown posterior lateral marking on each side; apex of theca distinctly club-shaped; transparent flange along margin of recurvature not quite as broad as thecal shaft ..... *Y. regalis*

—— Tergite 8 entirely dark brown to black without posterior lateral markings; apex of theca not club-shaped but narrow with ornamentation; transparent flange along margin of recurvature much broader than thecal shaft 15

15 Hind wing plagas opaque bold and occupying the jugum ..... *Y. douglasi*

—— Hind wing plagas dull and narrow with jugum mainly hyaline 16

16 Sternites III–VII yellow-brown to orange-brown without a dark brown to black central marking ..... *Y. verrens*

—— Sternites II–VII mainly yellow-brown to orange-brown with a broken, dark brown to black central marking ..... *Y. ngarabal*

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