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NEW GENERA AND SPECIES OF SMALL TICKING AND 'CHIRPING' CICADAS (HEMIPTERA: CICADOIDEA: CICADIDAE) FROM QUEENSLAND, WITH DESCRIPTIONS OF THEIR SONGS

A. EWART

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Five new genera of small cicadas (<15 mm total body length), including nine new species, are described, all assigned to the Cicadidae, Tibicininae, and Tribe Cicadettini. The genera are *Crotopsalta*, *Gagatopsalta, Caliginopsalta, Pipilopsalta* and *Drymopsalta*. The new species are *Crotopsalta plexis, C. fronsecetes, C. strenulum, C. poaecetes, G. auranti, G. obscurus, Caliginopsalta percola, P. ceuthoviridis, and D. crepitum*. Descriptions, distribution, behaviour and songs are provided for each genus and species. The *Crotopsalta* species are characterised by simple ticking songs, differing with respect to their pulse repetition rates and pulse structures between species. Increasingly complex chirping songs, comprising short echemes containing multiple pulses, characterise the *Caliginopsalta* and *Pipilopsalta* songs. Even more complex temporal patterning and structure of the chirp echemes characterise the *Gagatopsalta* and the *D. crepitum* songs, the latter exhibiting a remarkable series of song patterns. □ *Ticking cicadas, chirping cicadas, Queensland, songs, Cicadidae.*

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The Australian cicada fauna is not well documented. There are many known but still undescribed species in museums and private collections and many new species are still being collected. Current taxonomic research is addressing the overdue higher systematics of cicadas in general, and in particular clarifying and extending the generic classification of Australian species (Moulds, in press). Apart from their inherent importance in species recognition, cicada songs are valuable tools taxonomically. In the field, they provide excellent means for identification of known species and recognition of new species and species complexes. Songs are species specific, with many Australian and overseas examples now documented (e.g. Myers, 1929; Alexander & Moore, 1958; Young, 1972; Ewart, 1988, 1989, 1998; Ewart & Popple, 2001; Popple, 2003; Simões *et al*., 2000; Sueur, 2002).

This work stems from the recognition, in Queensland, of small and inconspicuous cicadas emitting soft and apparently simple ticking songs, as well as other small species emitting slightly more complex chirping songs. The field recognition of these songs has been greatly aided by use of a bat detector. Detailed descriptions of these songs are provided, based on field and laboratory sound recordings. Although sharp chirping songs are known in species belonging to several described genera, this work describes five new genera (Table 1) containing nine previously undescribed species.

ABBREVIATIONS. Repositories: ANIC, Australian National Insect Collection, Canberra; AE, private collection of A. Ewart; BMNH, The Natural History Museum, London; LWP, private collection of L.W. Popple, Brisbane; MSM, private collection of M.S. Moulds, Sydney; QM, Queensland Museum, Brisbane; UQIC, The University of Queensland Insect Collection. The following abbreviations apply to the paratype data: Ck, Creek; HS, Homestead; Hwy, Highway; jct, junction; L, Lake; NP, National Park; Pty, property; Ra, Range; Rd, Road; Rec, recorded (= aural/electronic song recording); R, river; SF, state forest; sp, species; spec, specimen; Stn, Station (HS); xing, crossing; CB, C. Burwell; DC, D. Cook; GD, G. Daniels; SE, S. Evans; AE, A. Ewart; RBL, R.B. Lachlan; CL, C. Lambkin; SL, S. Lamond; RM, R. MacSloy; SM, S. McEvey; GBM, G.B. Monteith; GB&SRM, G.B. & S.R Monteith; JM, J. Moss; MSM&BJM, M.S. & B.J. Moulds; JN, J. Nowland; LWP, L.W. Popple; LW&RP, L.W. & R. Popple; IR, I. Rattray; DMR, D.M. Reeves; JS, J. Skevington; MAS, M.A. Schneider; RS, R. Stoodley; AS, A. Strange; AW-H, A. Walford-Huggins; SW, S.

TABLE 1. Summary of selected morphological characters, for males only, distinguishing the five genera described

Genera:	*Crotopsalta*	*Gagatopsalta*	*Caliginopsalta*	*Pipilopsalta*	*Drymopsalta*
Abdomen: shape (in dorsal view):	Evenly tapered distally	Cylindrical, gentle tapered distally	Evenly tapered distally	Tending rounded, bulbous in dorsal and lateral profile	Slender and evenly tapered distally
Rostrum: Extends to:	Mid coxae	Between mid and hind coxae	Hind coxae	Mid coxae	Hind coxae
Fore wing: Lengths of apical cells compared to ulnar cells:	Approximately equal.	Approximately equal.	Approximately equal.	Mostly shorter than ulnar cells.	Approximately equal.
Costal vein; anterior curvature proximal to node:	Gently curved	Gently curved	Gently curved	Minimal curvature	Marked anterior curvature
Hind wing: Apical cells:	6	6	6	6	5 to 6 (rarely 4)
Hindwing: Infuscation:	None	None	Brown infuscation within plaga and anal lobe	None	None
Operculae: shape:	Moderately elongated, rounded along distal margin; marked ridge.	Weakly elongated, rounded along distal to medial margins; marked ridge.	Rounded along distal and medial margins; gently domed and ridged	Broadly rounded along medial-distal margins; gently domed and ridged.	Moderately elongated with oblique, blunt to variably rounded distal margin.
Operculae: Separation of inner margins :	Clearly separated	Clearly separated	Clearly separated	Separated but closely spaced	Clearly separated
Timbals: Long ribs: Ribs fused ventrally: Ribs fused to basal spur:	4; rib 5 shortened in length 1 to 3 (± 4) 1 to 4	5 1 to 2 1 to 3	5; rib 4 discontinuous. 1 to 4 1 to 3	5; ribs 4 and 5 shortened. 1 to 2 1 to 2	4 to 5; ribs 4 ± 5 shortened. 1 to 3 1 to 4
Pygofer: Shape (dorsal view):	Broadly pyriform	Ovoid.	Ovoid.	Ovoid.	Ovoid to roughly rectangular.
Pygofer: Uncal lobes:	Extended orthogonally, thickened and rounded apically	Sharply terminated and extended.	Curved, anteriorly pointing and sharply terminated.	Extended steeply, subacute and curved.	Extended orthogonally, thickened and rounded apically.
Pygofer: Upper lobes:	Triangular, pointing steeply ventrally, rounded apically	Prominent, extended distally and apically rounded.	Prominent, rounded apically	Rounded and not strongly extended	Moderately extended, subacute, rounded apically.
Pygofer: Lower lobes:	Clearly defined and rounded.	Partly hidden (in lateral view)	Small and rounded	Rounded, slightly elongated.	Well developed, rounded apically.
Pygofer: Inner lobes:	Not developed.	Rounded, extended ventrally	Not developed.	Visible, subacute, but not prominent (in lateral view)	Not developed.
Pygofer: Beak:	Inconspicuous to absent.	Prominent and rounded.	Moderately developed, clearly visible.	Prominent and rounded.	Conspicuous, sharply defined in lateral profile.

Wright, FRW, F.R. Wylie; DY, D. Yeates. Other abbreviations used in the main text are: BL, total body length; FWL, fore wing length; HW, head width; PW, pronotum width; AW, abdomen width; FWL/BR, fore wing length/breadth ratio.

MATERIALS AND METHODS

The anatomical terminology follows Moulds (1990; in press) and Duffels (1977) for general body and wing characters; Duffels (1977), Dugdale (1972), and Moulds (2003) for genitalia; de Boer (1999) for operculae, and Simmons & Young (1978), Dugdale (1972) and Bennet-Clark (1997) for timbals. The timbal long ribs are referred to sequentially as ribs numbered 1-4 (±5), with rib 1 being the most posterior rib (i.e. adjacent to the timbal plate).

Measurements (in mm) are given as ranges and means (in parentheses) of a subset of specimens from each species, including the smallest and largest available specimens. The head width is

taken across the outer margins of the compound eyes; pronotum width is the maximum measured width; the abdomen is measured across the auditory capsules. The fore wing length/breadth ratios are based on maximum measured values of each parameter for each fore wing.

SONG RECORDINGS AND ANALYSES

Non-field recorded songs were made, using metal tapes, with a Sony Walkman cassette recorder WM-D6C model, in conjunction with a Sennheiser microphone model K6/ME66. The recorder has a linear response to 15 kHz, and responds to approximately 18 kHz. These recordings were performed with single insects within plastic containers, 16.5x16.5x9.5 cm, in which small quantities of the relevant vegetation were inserted on which the insects were captured. A fine white cloth covering was placed over the top of the boxes, with lighting immediately above, and the microphone placed on the top edge of the box. Reverberation effects have not been observed in the resulting songs recorded, at least within the limits of resolution of the recordings. Near-field effects are a possible complication of using the relatively small recording boxes, and could be significant at frequencies of ≤5kHz. These are, however, lower than the main frequency ranges emitted by the ticking cicadas. For the same reason, possible proximity effects are not considered to be significant. The primary reasons for using the containers are that, for the very small and mostly very wary cicadas, it is usually not feasible to place a microphone close enough, for long enough, to individual insects to directly record their low amplitude songs in the field. The most notable exception is *Pipilopsalta ceuthoviridis* sp. nov. In the containers, they can be readily induced to sing in strong, artificial lighting (not fluorescence), and with minimal background noise. The lighting also provides heat; temperatures in the boxes are consistently 30-35ºC during normal summer recording sessions.

Field recordings were made through bat detectors (Mini-2 and Mini-3 ultra sound Advice models, U.K.), that were also routinely used to detect the ticking songs in the field. The primary aim of these recordings was for determining tick rates, but they have the advantage of being able to confirm the ability of the essential pulse structures to survive propagation in various field environments, the recordings typically made 2-30m from singing insects. Songs of *P. ceuthoviridis* n.sp. were recorded in the field with the WM-D6C cassette recorder, as well as in containers.

Computer analyses were performed by initial digitising through a 16-Bit Terratec sound card at 44.1 kHz sampling frequency, followed by processing with Avisoft SASLab Pro 4 software. These data are stored in a library of mostly Queensland cicada songs held at the Queensland Museum.

A modified terminology of Ragge & Reynolds (1998) is adopted for descriptions and analyses of the songs, with the exception of the *Crotopsalta* ticking cicadas, where the term 'pulse' is considered most appropriate. Although the Ragge & Reynolds terminology was designed for orthopteran insects, there are sufficient similarities in essential song structures to justify extending the terminology to the cicada songs herein. The term ***syllable*** is used for discrete but relatively short (≤20ms) pulse groups that plausibly result from a single buckling movement (in±out) of one or both timbals. The latter may result from alternate buckling of the timbal pairs, or synchronous buckling of both timbals, but implies no significant intervening time gap within the resulting syllable. The term ***echeme*** is applied to the first order assemblage of syllables produced during the continuous buckling of the timbals pairs (i.e. ⩾2 cycles of buckling without significant pause). Time expanded waveform and envelope plots reveal that the syllables are usually resolved into smaller (higher frequency) 'syllable-like' groupings termed ***hemisyllables***, plausibly resulting (at least in part) from the buckling ('clicking') of individual timbal ribs. In most songs of the smaller cicadas, the hemisyllables can be further resolved into shorter (higher frequency) ***pulses***, representing the fundamental frequency carrier waves of songs.

SYSTEMATICS

Family CICADIDAE Leach
Subfamily TIBICININAE Atkinson
Tribe CICADETTINI Buckton

Crotopsalta gen. nov.

TYPE SPECIES. *Crotopsalta plexis* sp. nov.

INCLUDED SPECIES. *C. plexis* sp. nov.; *C. fronsecetes* sp. nov.; *C. strenulum* sp. nov.; *C. poaecetes* sp. nov.

ETYMOLOGY. Greek *croto,* a tick/rattle; -psalta is a generic ending that is sometimes used for the Cicadidae.

DIAGNOSIS. Very small, ~9-15 mm total body length, characterised by sharply defined and

relatively simple ticking songs. Head and thorax of similar width with abdomen relatively narrow and evenly tapered distally (as viewed dorsally); sternites rounded, projecting below tergites in lateral view. Compound eyes clearly separated, along their outer ventral margins, from pronotum; distance between lateral ocelli similar to distance between lateral ocellus and eye. Width of head (including eyes) slightly greater than width of pronotum across lateral margin. Width of pronotum measured from lateral margins similar to width of mesonotum between fore wings; lateral margins of pronotal collar weakly to moderately ampliate and outwardly curved. Rostrum extends to, but not beyond mid coxae. Wings hyaline with no infuscations. Fore wing relatively short and broad with length/breadth ratios in range ~2.3-3.0; red-brown to brown pterostigma; costal vein more or less even in width to node, with only slight thickening at node; costal vein gently curved anteriorly proximal to node; sclerotised area anterior to costal vein very narrow and much thinner than costal vein thickness; intersection of CuA-M veins approximately midway along first vein segment section (proximal to basal cell) of M vein that forms inner margin of radial cell; the distal vein sections along M forming the inner radial cell margin not all of similar length; eight apical cells; apical cells more or less similar in length, overall, to ulnar cells (some shorter, some longer). Hind wing with six apical cells. Operculae moderately elongated parallel to abdomen with weak ridge extending from distal through to basal areas; distal margins broadly rounded; inner margins of operculae widely separated; meracantha located strongly asymmetrically proximal to medial margins of operculae. Timbals with four long ribs and reduced fifth rib, the ribs 1-3 extensively fused ventrally; ribs 1-4 fused dorsally to the distinct basal spur; four (less often three) short ribs; narrow dome on timbal plate; part of the anterior margin of the white resilin area of timbal is markedly deflected outwards into a dome-like outline. Pygofer broadly pear-shaped (pyriform) in dorsal view; uncal lobes steeply ascending as seen in lateral view, thickened and rounded apically; upper lobe roughly triangular, pointing steeply ventrally, terminally rounded to relatively acutely rounded; lower lobe clearly defined and rounded; inner lobes not clearly developed; beak inconspicuous to absent; median process small (relative to uncal lobes); trifid aedeagus with a pair of sclerotised dorsal pseudoparameres longer than sclerotised ventral support, and unsclerotised endotheca.

KEY TO SPECIES OF *CROTOPSALTA*

1. Operculae with brown to black colouration, sometimes patchy and restricted along lateral margins and basal areas; auditory capsules black, dark brown centrally……2

   Operculae uniformly pale sandy brown, with or without minor pale brown around crest on dorso-lateral margins; auditory capsules usually pale brown to sandy brown with or without thin dark brown to black margins (rarely entirely dark brown to black)……3

2. Sternites pale to medium reddish brown (rarely fawn colour); tergites 3- 4 (±5) with or without pale brownish lateral patches; distal margin of opercula does not extend to anterior paramedial margin of sternite II……*plexis*

   Sternites pale to medium brown; tergites 3 - 6 (±7) with well defined black to dark brown patches; distal margins of operculae extend to anterior paramedial margin of sternite II …… ……*fronsecetes*

3. Sternite II with small black patch medially; auditory capsules pale to medium brown with thin black to dark brown margins; dark brown to pale brown irregular patches laterally on tergites 3-7; distal margins of operculae extend to anterior paramedial margin of sternite II; timbal long ribs 1-4 fused ventrally……*strenulum*.

   Sternites without black medial marking; auditory capsules uniformly sandy brown (occasional small brown marking adjacent to central areas); no darker lateral colouration on tergites; distal margins of operculae do not extend to anterior paramedial margin of sternite II; timbal long rib 4 not fused ventrally with ribs 1-3; meracantha very reduced in size and rounded……*poaecetes*

Note: The number of separate characters listed for each step is a reflection of the inherent variability within each species. Single characters, taken alone, may not be diagnostic.

Crotopsalta plexis sp nov..
(Figs 1, 2, 7-11, 36, Table 2)

Notopsalta sp. I: Ewart, 1998: 65, 66, figs 19A, 13B.

MATERIAL. HOLOTYPE ♂, QMT99209, Hubbards Pty. Miles, S.Qld., Large wilga shrubs, 26°09.143'S 150°20.237'E, 28 Sept 1997, AE.

PARATYPES: SOUTH AND CENTRAL QUEENSLAND: 1♂, Brigalow Res. Stn. nr. Theodore, AE; 28.x.2000, 24°49.47'S 149°48.05'E; 1♂, As previously, Rec; 1♂, Brigalow Res. Stn. nr. Theodore, AE, 27.x.2000, 24°49.47'S 149°48.05'E, Rec; 1♂, 1♀, Glebe Weir, 30 km NE Taroom, 2.x.99, AE, 25°27.85'S 150°02.00'E'; 1♂, Glebe Weir, 30 km NE Taroom, 2.x.99, AE, 25°27.85'S 150°02.00'E, Rec; 2♂, 21km N. Wandoan, AE, 3.x.99, mixed brigalow, 25°56.74'S 149°54.14'E; 1♂, As previously, Rec(spec 1); 1♂, As previously, Rec(spec 2); 1?, 1 km W. Morven, 4.x.99, AE, 26°24.68'S 147°06.16'E; 1♂, As previously, Rec; 1?, 16

km E. Roma, AE, wilga, 7.x.99, 26°34.78'S 148°56.95'E; 6♂; 1km W. Morven, AE, 6.x.99, 26°24.68'S 147° 06.16'E; 1♂, As previously, Rec; 1♂, 1km W. Morven, *Casuarina*-brigalow, 2 Sept 2000, AE, 26°24.75'S 147°06.26'E, Rec(spec 1); 1♂, As previously, Rec(spec 2); 1♂, Brigalow Res. Stn., nr. Theodore, N.W. brigalow section, 21.xii.2000, AE, 24°47.92'S 149°45.45'E, Rec; 1♂ 45km N. Roma, myall, 15.xii.2000, AE, IR, 26°11.83'S 148°42.23'E, Rec; 1♂, Muckadilla, nr. School, grass, 16.xii.2000, AE, 26°35.25'S 148°23.19'E; 1♂, 29km E. Goondiwindi, 16.i.2001, AE, brigalow woodland, 28°29.71'S 150°32.82'E; 5♂, 2♀, Hubbards Pty, Chinchilla, 26°09.143'S 150°20.237' 30.i.98; 1♂, 28km S.E. Goondiwindi, 17.i.2001, AE, 28°38.77'S 150°32.98'E, Rec; 2♂, Hubbards Pty. Miles, large wilga shrubs, 26°09.143'S 150°20.237'E, 28.ix.1997; 1♂, Barakula SF, nr. Chinchilla, virgin brigalow, 15.xii.1997, 26°14.42'S 150°48.86'E, AE; 2♀, Mt. Lawnton, 16 km S. Wandoan, on *microcitrus* sp., 23.ix.1990, DMR; 2♂, 12♀, Mt. Lawnton, 16 km S. Wandoan, on *Capparis* sp., 30.ix.1990, DMR; 1♂, 6.1 km E. Kaimkillenbun, AE, 23.xii.2001, 27°04.35'S 151°29.83'E, Rec; 1♂, 16 km E. Roma, 25.xi.1999, AE, *Eremophila mitchellii,* 36°34.80'S 148°56.97'E; 1♂, 44.1 km S. of Theodore, 20.xii.1999, AE, brigalow, 25°14.51'S 149°57.232'E, Rec; 1♂, 41 km WSW Banana, brigalow, AE, 29.xii.2002, 24°37.08'S 149°46.24'E, Rec; 1♂, 14.6 km W. of Drillham, brigalow, 26.x.1998, AE, 26°38.65'S 149°49.94'E; 1♂, 15.6 km N. Taroom/Warrego Rd. jct, N. Miles, AE, brigalow, 17.x.1998, 26°31.64'S 150°07.50'E, Rec; 3♂, Muckadilla, near State School, grass, AE, 2.ii.2000, 26°35.31'S 148°23.19'E; 1♂, As previously, Rec; 1♂, 16 km E. Roma, Blythsdale South Rd., *Eremophila mitchellii*, AE, 2.ii.2000, 26°34.81'S 148°56.98'E; 1♂, brigalow, 1 km E. Brigalow Township, AE, 22.xii.2001, 26°50.94'S 150°47.83'E; 1♂, 31 km W. Mitchell, brigalow, *Cassinia*, *E. mitchellii,* AE, 12.i.2002, 26°28.74'S 147°40.37'E, Rec; 1♀, Glebe Weir, Taroom, 25°27.83'S 150°01.99'E, 29.ix.1997 **(AE)**. 1♂, Brigalow Res. Stat., WNW Theodore, 5-12.xii.1999, JM, LWP, 352-000*; 3♂ 1♀, Coolmunda Dam via Inglewood, 15.xii.2001, LWP, RM, minidisc, 352-0004, 0007 to 0009; 2♂, 2♀, Glebe Weir, nr. Taroom, 4-5.xii.1999, JM, LWP, MV lamp, 352-0002, 0001, 0004, 0003; 1♂, 1♀, Tara Shire, 47 km SW Dalby, 27.xii.2001, LWP, AS, 352-0011, 0010; 1♂, NNW Roma, 26°12'41"S 148°42'02"E, C. Eddie, 20.x.2001, 352-0012;

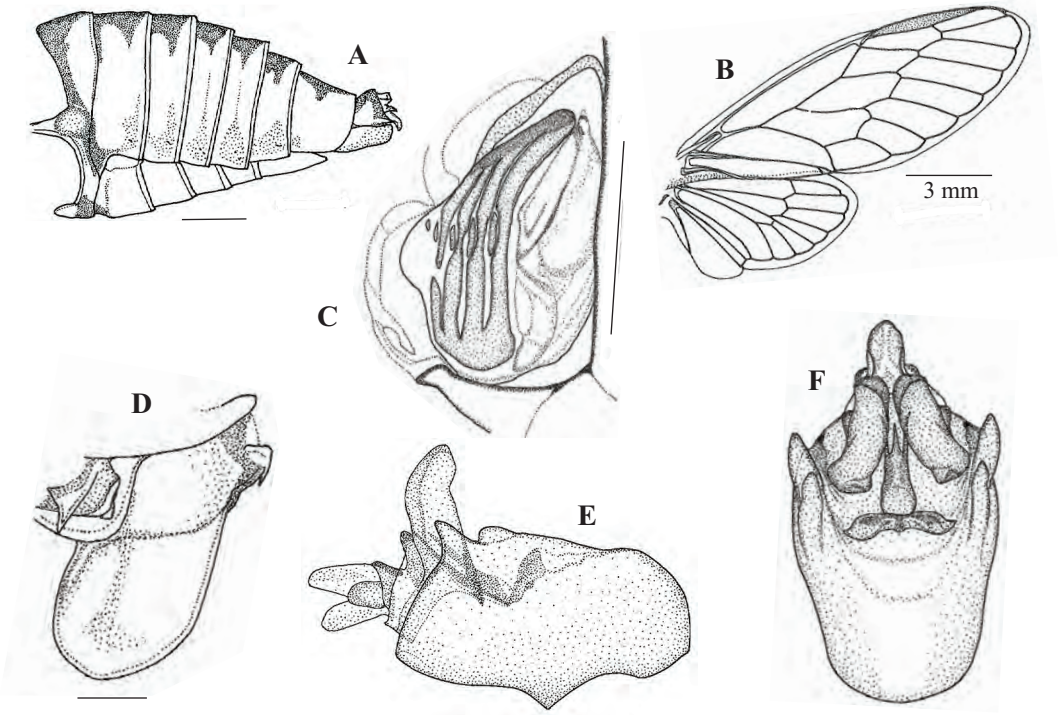

FIG. 1. *Crotopsalta plexis*. A, Lateral abdomen view; B, fore and hind wings; C, timbal; the right-hand edge as shown represents the posterior margin, the top the dorsal edge; D, opercula; E, and F, lateral and ventral views of pygofer.). Length of pygofer 1.7mm. Scale bars =1mm except wings (3mm). Drawings based on specimen from near Chinchilla, SEQ.

1?, as previously, 11.x.2001, 352-0013 **(LWP).** 1♂, 1♀, 25°31'S x 150°03'E, Boggomoss No. 10, via Taroom, 14.xi.1996, DC, at Light. 065 **(QM)**. 1♂, Hubbards Pty, Chinchilla 26°09.143'S 150°20.237', 30.i.98; 1♀, Mt. Lawnton, 16 km S. Wandoan, *microcitrus* sp., 23.ix.1990, DMR **(BMNH)**. 1♂, 44.1 km S. of Theodore, 20.xii.1999, AE, brigalow, 25°14.51'S 149°57.232'E; 1♀, Mt. Lawnton, 16 km S. Wandoan, on *Capparis* sp., 30.ix.1990, DMR **(ANIC)**. 1♂, 1 km W. Morven, *Casuarina*-brigalow, 2.ix.2000, AE, 26°24.75'S 147°06.26'E; 1♀, Mt. Lawnton, 16 km S. Wandoan, on *microcitrus* sp., 23.ix.1990, DMR **(MSM)**.

* These refer to the numerical reference listing of species and specimens used in the private collection of LWP.

DESCRIPTION (Male). Figs 1, 36A. *Head.* Sandy brown to pale brown and black. Supra-antennal plate, gena and mandibular plate dominantly black, with small pale brown spot between ocelli, extending to posterior margin; small pale brown spots along anterior margin of supra-antennal plate extending around base of antennae. Ocelli pink to pale red. Compound eyes brown to dark brown. Postclypeus with pale brown margin; remainder, including transverse ridges, black. Anteclypeus black. Rostrum dark brown, black proximally. Antennae uniform medium brown.

Thorax. Sandy brown, brown and black. Pronotum sandy brown with paler central fascia enclosed by narrow black rim which flares out adjacent to anterior pronotal margin and adjacent to pronotal collar; broken to diffuse black to dark brown areas between the anterior and posterior oblique fissures and between posterior oblique fissure and pronotal collar; pronotal collar pale sandy brown, grading to black at lateral corner; moderately ampliate along lateral margin. Mesonotum with a pair of anterior broad obconical fasciae fused dorsally and extending less than half the length to the cruciform elevation; two very broad lateral fasciae, narrowing towards and just reaching the proximal arms of cruciform elevation; remainder, including cruciform elevation, pale sandy brown with diffuse darker colouration between arms of cruciform elevation; wing grooves pale sandy brown with silver pubescence.

Wings. Fore wing venation pale brown grading to medium brown distally. Costal vein pale sandy-brown to translucent; weakly developed node on costal vein; basal membrane pale pink-brown; dark brown pterostigma. Hind wing plaga opaque white, extending along vein 3A.

Legs. Glossy. Fore coxae pale sandy brown, partially black on anterior and medial inner faces; mid and hind coxae dominantly black on anterior and lateral faces, pale sandy brown along ventral margins. Trochanters and lateral faces of fore femora pale sandy brown, with three black spines; inner faces of femora dominantly dark brown to black. Mid and hind femora pale sandy brown with broad medium to dark brown anterior and lateral margins. Tibiae and tarsi pale sandy brown; claws sandy brown, with dark brown apices.

Operculae. Pale brown, with dark brown patches within basal parts (especially anteriorly), and also proximal to crest around distolateral areas; meracantha elongated to a relatively acute point; distal margin does not extend distally to anterior paramedial margin of sternite II.

Timbals. Ribs 1-4 extensively fused ventrally; a remnant small anterior rib (5).

Abdomen. Tergites brown to reddish-brown with well defined median black areas, each tapering distally, giving the overall appearance of a longitudinal black dorsal fascia; sporadic lateral patches of pale brown colour on tergites 3 (most common)-4 (± 5); auditory capsules black with dark brown central areas, the black extending to adjacent area and along anterior margin to tergite 2; fine silver pubescence paramedially and laterally; posterior margins of tergites and intersegmental membranes yellow. Sternites pale to medium reddish brown, darker distally; medium brown on sternite VII and VIII; small black blotch ventro-medially on sternite II.

Genitalia. Pygofer medium to dark brown. Upper lobe relatively acutely terminated. Otherwise as in generic characters.

FEMALE. Fig. 36B. Generally similar to male. Supra-antennal plate, gena and mandibular plate black, with pale colouration as in male. Postcylpeus with broader outer pale brown margin, transverse ridges black to deep brown. Pronotum dominantly pale sandy brown with thinner dark margin enclosing central fascia. Mesonotum and legs as in male. Tergite colouration, including black dorsal markings as in male. Tergite 9 sandy brown with dark brown paramedial fasciae extending more than three-quarters of the distance to distal margin and also ventro-laterally along anterior margin. Ovipositor sheath extends ≤0.5 mm beyond tergite 9 termination. Sternites uniformly pale sandy brown.

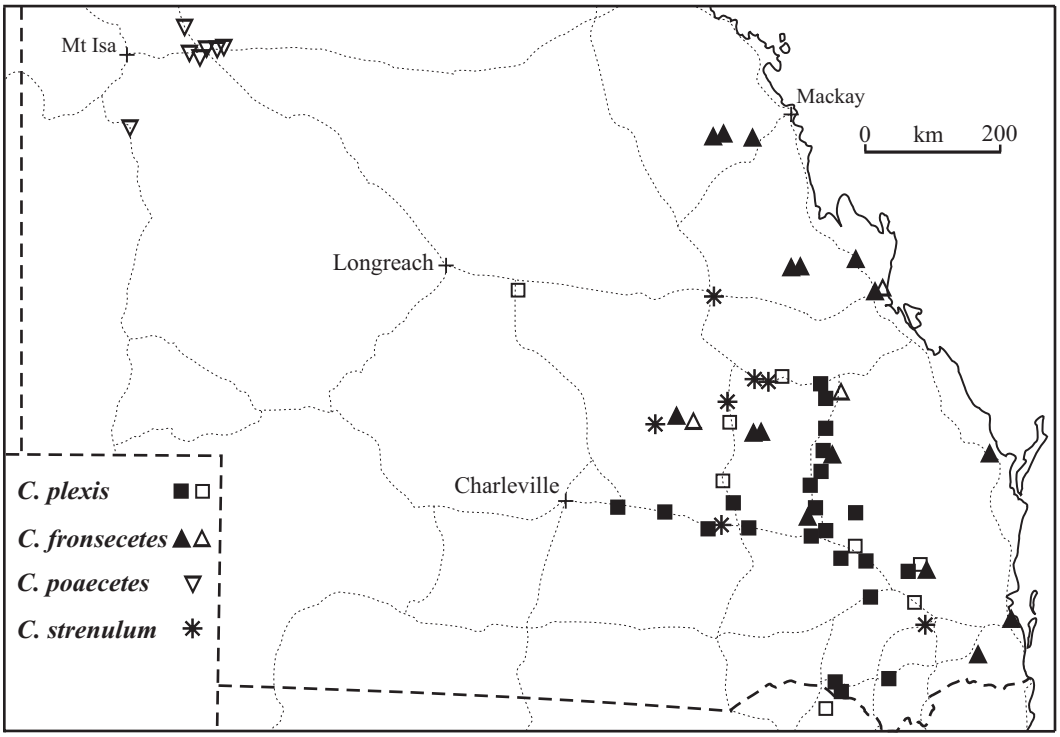

FIG. 2. Distribution records of the four *Crotopsalta* ticking cicadas described, in Queensland and northeastern N.S.W. Data include aural records, indicated by hollow symbols for *C. plexis* and *C. fronsecetes*.

MEASUREMENTS. N = 10♂, 10♀. Ranges and means (in parentheses). *BL:* ♂ 9.7-10.8 (10.2); ♀ 10.8-12.2 (11.7). *FWL:* ♂ 11.2-12.4 (11.7); ♀ 12.4-13.5 (13.2). *HW:* ♂ 2.9-3.4 (3.2); ♀ 3.4-3.6 (3.5). *PW:* ♂ 2.6-3.1 (2.9); ♀ 3.0-3.5 (3.5). *AW:* ♂ 2.8-3.1 (3.0); ♀ 3.0-3.4 (3.2). *FWL/BR*: ♂ 2.53-2.86 (2.72); ♀ 2.60-2.84 (2.73).

DISTRIBUTION, HABITAT & BEHAVIOUR (Fig. 2). Occurs widely through inland southern and central Queensland, from the dividing range west to the Morven and Barcaldine regions. A single aural record exists from near North Star, NNW of Warialda, NSW. Restricted to mixed and disturbed brigalow (*Acacia harpophylla*) - wilga (*Geijera parviflora*) - belah (*Casuarina cristata*) - limebush (*Eremocitrus glauca)* - scrub boonaree *(Heterodendrum diversifolium)* - false sandalwood *(Eremophila mitchelli)* - vegetation communities, and less commonly in Poplar Box *(Eucalyptus populnea)* and silver leaved ironbark *(E. melanophloia)* woodlands. This species has particularly strong affinities with wilga and *E. mitchellii*. It is highly cryptic and mobile, flying quickly and unobtrusively for ≥40 m, although usually much shorter distances. It inhabits outer foliage of shrubs and trees, usually where foliage is dense. Small size, colour, and rapid flight make it a very difficult insect to see. The ticking song is emitted incessantly during the day, even during light rain. Where multiple insects occur in the same tree or shrub, ticking may occur in unison, although sometimes fractionally offset. It occurs from late August/ September to February, based on collected material and aural records.

SONG. (Figs 7-11; Table 2). A soft slow ticking with pulse repetition rate in the range 1.0-3.2 per second. This song is a distinctive field identification character. Further technical and comparative details of the songs follow the taxonomic descriptions of *Crotopsalta species.*

ETYMOLOGY. Greek *plexi(s)*, stroke or sharp percussion; refers to the slow sharp ticking song.

COMPARISON. This species is superficially similar to *Pauropsalta stigmatica* Distant.

Crotopsalta fronsecetes sp. nov.
(Figs 2, 3, 4, 7-11, 37, Table 2)

Notopsalta sp. J: Ewart, 1998: 65, figs 10B, C, 13C.

MATERIAL. HOLOTYPE; ♂, QMT99210, Meadowlands Rec. Reserve, Carina/Belmont, Brisbane, Q., 9543/116587, 23.xii.1997.

PARATYPES: SOUTH AND CENTRAL QUEENSLAND: 3♂, 1♀, ~4 km N. from Glendon-Peak Downs Hwy Rd jct, AE, 22.x.2000, 21°37.27'S 148°39.47'E; 1♂, As previously, Rec spec 1; 1♂, As previously, Rec spec 2; 1♂, ~8 km SW Homevale HS, Homevale NP, AE, 23.x.2000, 21º28.67'S 148º27.69'E; 1♂, ~9 km SW Homevale HS, Homevale NP, AE, 23.x.2000, 21º29.48'S 148º27.25'E; 1♂, ~7.5 km WSW Homevale HS, Homevale NP, AE, 23.x.2000, 21º28.01'S 148º27.58'E; 2♂, 1♀, 25º12'S 148º59'E, Expedition Ra NP, 'Amphitheatre' camp, 560m, 17.xii.1997, SE, CB, AE, Mv lamp, open forest; 13♂, 8♀, The Amphitheatre, NW Robinson Gorge N.P., 25º12.07'S 148º59.43'E, Open Forest, 17.xii.1997, AE, CB, SE; 3♂, Fitzroy R xing, 68 km NW Rockhampton, 10.x.1999, AE, 23º10.81'S 149º55.08'E; 1♂, As previously, Rec (spec 1); 1♂, As previously, Rec (spec 2); 1♂, Boomer Ra NP, NW Rockhampton, AE, CB, GBM, SE, 30.ix.1999, 23º12.88'S 149º44.37'E, Rec; 1♂, Amphitheatre, Expedition Range NP, 560m., 18.xii.1997, 25º12'.S 148º59'E, AE, Rec box; 2♂, 41km SE Childers, Bruce Hwy, 30.x.2001, AE, 25º23.22'S 152º36.03'E; 1♂, As previously, Rec spec 1; 1♂, As previously, Rec spec 2; 2♀, 9.0 km NW Yaamba, Bruce Hwy., 8.xi.2001, AE, light, 23º06.22'S 150º17.49'E; 1♂, As previously, Rec spec 1; 1♂, As previously, Rec spec 2; 16♂, 2♀, Gurulmundi, Miles, heath, 26º25.20'S 149º59.50'E, 9.x.1997, AE; 1♂, As previously, Rec; 1♂, Gurulmundi, Miles, heath, 26º25.20'S 149º59.50'E, 25.ix.1997, AE; 5♂, 1♀, Gurulmundi heath, N. of Miles, 22.xi.1997, 26º25.20'S 149º59.50'E, AE; 16♂, 4♀, Meadowlands Reserve, Carina/Belmont, Brisbane, 9543/116587, 23.xii.1997; 1♂, As previously, Rec; 1♂, Gurulmundi heath, N. Miles, 17.x.1998, 26º25.13'S 149º59.48'E, AE; 2♂, As previously, Rec; 1♂, 1♀, 7.2 km N.E. Maclagan, 19.i.2004, AE, 27º03.13'S 151º41.64'E, In Cop; Rec (male) **(AE)**. 3♂, Meadowlands Park, Carindale, 11.xi.2000, LWP, 351-0021, 0022; 11♂, 1♀, Meadowlands Park, Carindale, 22.xi.1998, LW&RP, 351-0003 to 351-0014; 5♂, Meadowlands Park, Carindale, 24.x.1998, LW&RP, 351-0016 to 351-0020; 4♂, 1♀ Meadowlands Park, Carindale, 16.x.2001, LWP, 351-0024 to 351-0028; 5♂, 1♀, Minto Crags (south face), S Boonah, 3.xi.2001, LWP, JM, RS, 351-0030 to 0036; 1♂, Minto Crags (south face), S. Boonah, 3.xi.2001, LWP, JM, RS, minidisc (LWP); 4♂, Gurulmundi SF, 28 km N. Miles, 2-3.xii.1999, JM, LWP, 355-0001 to 0004; 1♂ Meadowlands Park, 6.xii.1998, LWP, *ex Casuarina glauca* 351-0029; 1♂, Meadowlands Park, Carindale, Brisbane, 23.xii.1997, LWP, *Casuarina glauca*, Rec, 351-0015 **(LWP)**. 1♀, 25º26'Sx150º01'E, Boggomoss No. 3, via Taroom, 12.xi.1996-i.1997, DC, GBM, Baited Flight Intercept 041; 1♂, 25º01'S 147º57'E, Rangers HQ, Mt. Moffat NP, 2.xii.1997, SE, CL, JS, mv lamp; 14♂, 11♀, 25º12'S 148º59'E, 'Amphitheatre' campsite, Expedition Ra NP, 560m, 17.xii.1997, CB, SE, AE, mv lamp, open forest; 11♂, 15♀, 24º54' 148º59'E, Expedition Ra NP, 'Amphitheatre' camp, 560 m, 18.xii.1997, AE, CB, SE, mv lamp, open forest; 1♀, 23º12'Sx149º64'E, Boomer Ra, Mongrel Scrub Site 7, vine scrub, 220 m., 16.xii.1999-2.iii.2000, GBM, intercept 9119 **(QM)**. 1♂, Rockhampton, 5.i.1968, FRW **(UQIC)**. 1♂, 1♀, The Amphitheatre, NW Robinson Gorge NP, 25º12.07'S 148º59.43'E, open forest, 17.xii.1997, AE, CB, SE, **(BMNH)**. 1♂, 1♀, The Amphitheatre, NW Robinson Gorge NP, 25º12.07'S 148º59.43'E, open forest, 17.xii.1997, AE, CB, SE, **(ANIC)**. 1♂, 1♀, The Amphitheatre, NW Robinson Gorge NP, 25º12.07'S 148º59.43'E, open forest, 17.xii.1997, AE, CB, SE, **(MSM)**.

DESCRIPTION (Male). Figs 3, 4, 37A. *Head*. Black and pale brown. Supra-antennal plate black with small lanceolate pale to yellow brown area between ocelli, pointing anteriorly, and extending to posterior plate margin; pale brown zone enclosing bases of antennae along anterior rim of plate (not always present). Ocelli red. Compound eyes dark brown. Postclypeus black with pale brown anterior margin. Gena and mandibular plate black with silver pubescence. Anteclypeus black, in some specimens grading pale brown distally. Rostrum dark brown, darker apically. Antennae dark brown.

Thorax. Black to brown. Pronotum with narrow central fascia pale brown enclosed by broad black envelope which flares outwards adjacent to both anterior and posterior pronotal margins; broken black areas between anterior and posterior oblique fissures, and also along and lateral to the posterior oblique fissures; remaining colour medium brown; pronotal collar black anteriorly and at corners, otherwise pale brown; markedly ampliate along lateral margins. Mesonotum with a pair of anterior broad paramedian obconical areas coalescing medially and extending longitudinally to near the cruciform elevation; a pair of broad lateral fasciae tapering distally and extending to, and partially enclosing, the outer arms of the cruciform elevation; cruciform elevation and mesonotum pale to medium brown; arms of cruciform elevation black in some specimens; wing grooves pale brown rimmed by silver pubescence.

Wings. Fore wing venation pale to medium brown, darker distally; pale sandy brown to translucent costal vein; venation proximal to basal cell pale yellow brown; pterostigma deep reddish-brown to dark brown; weakly developed costal node; basal membrane sandy brown. Hind

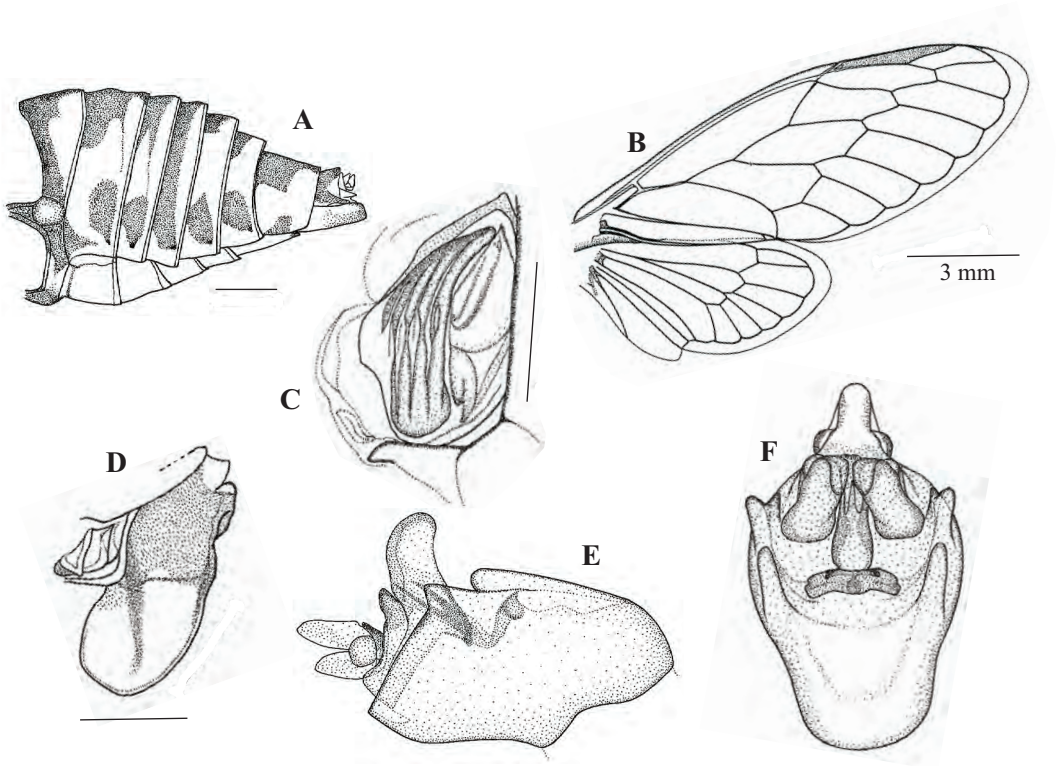

FIG. 3. *Crotopsalta fronsecetes*. A, Lateral abdomen view; B, fore and hind wings; C, timbal; the right-hand edge as shown represents the posterior margin, the top the dorsal edge; D, opercula; E, and F, lateral and ventral views of pygofer. Length of pygofer 1.6mm. Scale bars = 1mm except wings (3mm). Drawings from specimens from the Expedition Range National Park.

wing venation medium to dark brown; plaga opaque off-white colour extending narrowly along the margin of the 3A vein.

Legs. Fore coxae pale brown with extensive deep to medium brown areas on anterior and lateral surfaces; mid and hind coxae black to dark brown on anterio-lateral faces; pale brown on inner (medial) faces. Fore femora and trochanters black to deep brown on anterior faces, with dark to medium brown and pale brown diffuse longitudinal fascia on lateral faces; mid and hind femora and trochanters pale brown with darker brown longitudinal fasciae. Tibiae dark to pale brown, paler on mid to hind legs. Tarsi pale brown, darker distally, with dark brown claws.

Operculae. Rounded distal margins; pale yellow brown between the distal areas to transverse sutures; basal parts varies from mostly brown to black, to only darkly coloured along lateral margins; localised pale brown at crest around dorsolateral basal corners; meracantha yellow-brown, elongated with acute termination apically, extending over medial areas; distal margins of operculae extend to anterior paramedial margin of sternite II.

Timbals. Although ribs 1-3 are always fused ventrally, rib 4 is variable in some specimens; it is either fused or weakly fused to ribs 1-3 (most common), or is not fused to ribs 1-3; it also may be either continuous across timbal or discontinuous in the thinned median region; the anterior rib 5 is also variable in different specimens, varying from a small remnant to a shortened rib extending to median area; three to four short ribs are present, sometimes thin and poorly defined.

Abdomen. Tergites pale brown to reddish brown, usually grading darker in colour on tergites 5-7; each tergite has a black dorsal area, each of which narrows towards posterior margin and becomes progressively smaller towards tergite 7; this

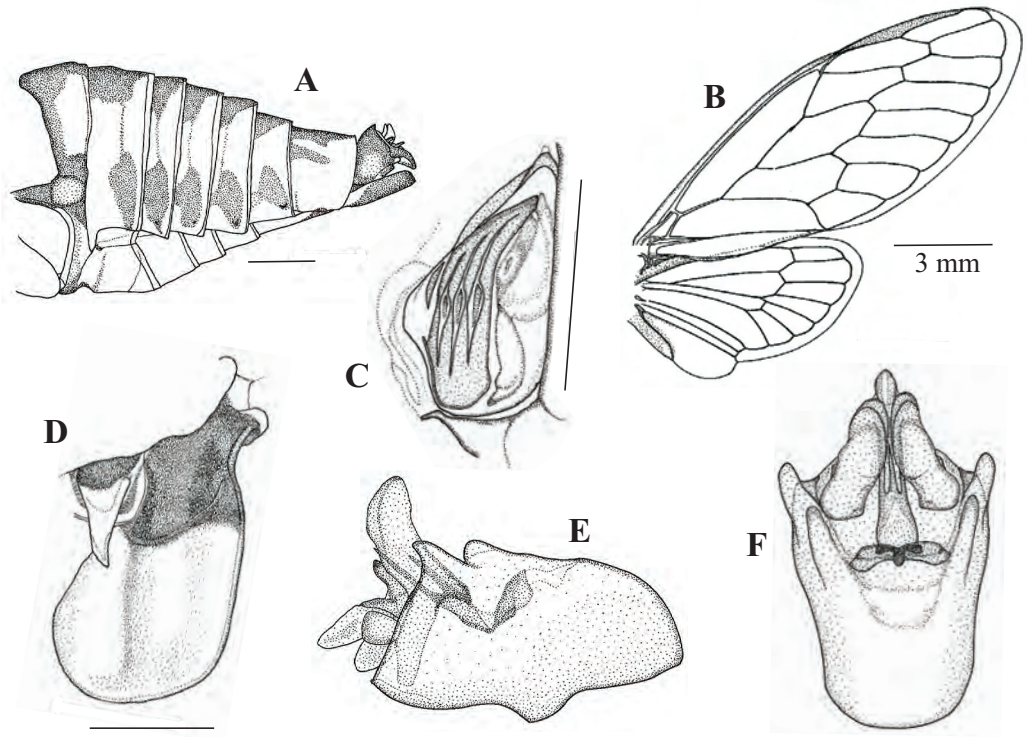

FIG. 4. *Crotopsalta fronsecetes* with slower than normal ticking rate. A, Lateral abdomen view; B, fore and hind wings; C, timbal; the right-hand edge as shown represents the posterior margin, the top the dorsal edge; D, opercula; E, and F, lateral and ventral views of pygofer. Length of pygofer 1.6mm. Scale bars = 1mm except wings (3mm). Drawings from specimens from heath at Gurulmundi, north of Miles.

pattering gives the overall appearance of a black fascia extending dorsally along abdomen; black colouration on tergite 2 extends laterally along anterior margin towards and including the auditory capsules, this being dark brown centrally; tergites 3-6 (±7) have well defined, but relatively localised black areas of colouration developed laterally; distal margins of each tergite, including intersegmental membranes, yellow-brown to pale brown. Sternite II medium to dark brown, black in ventro-medial area; sternites III-VII uniformly pale to medium brown, darker distally; sternite VIII medium to dark brown.

Genitalia. Pygofer colour dark brown grading to black distally. Other details as in generic characters.

FEMALE. Fig. 37B. Head similar to male. Postclypeus with more extensive pale brown colouration and dark brown transverse ridges. Pronotum and pronotal collar similar to male but with black colouration reduced in extent. Mesonotum similar to male, but with broad black fasciae reduced in width, and greater area of brown colouration, including cruciform elevation. Wings as in male, fore wing basal membrane and hind wing plaga pale pinkish-brown. Legs similar to male. Abdomen similar to male, but with generally reduced darker colouration dorso-laterally. The tergite dorsal black areas, in some specimens, continue as thinned streaks dorso-laterally and coalesce with the darker lateral areas; black anterior colouration on tergite 2 is discontinuous paramedially; distal tergite margins pale yellow-brown to brown; tergite 8 with a pair of bluntly terminated paramedial, slightly curved black fasciae, extending approximately three-quarters along the length of the tergite, the dark colouration also extending dorsolaterally along the anterior margin of tergite. Sternites II-

VI pale sandy brown; sternite VII with small black discontinuous area adjacent to distal edge. Ovipositor sheath extends ≤0.5mm beyond tergite 9.

MEASUREMENTS. N=11♂, 10♀. *BL*:♂ 9.1-11.9 (11.0); ♀ 11.2-12.4 (11.7). *FWL*: ♂ 10.7-13.2 (12.4); ♀ 12.7-13.5 (13.1). *HW*: ♂ 2.8-3.6 (3.3); ♀ 3.2-3.7 (3.4). *PW*: ♂ 2.5-3.2 (3.1); ♀ 2.9-3.4 (3.2). *AW* ♂ 2.6-3.3 (3.1); ♀ 2.8-3.6 (3.2). *FWL/BR*: ♂ 2.63-3.04 (2.83); ♀ 2.66-2.88 (2.78).

DISTRIBUTION, HABITAT & BEHAVIOUR (Fig. 2). Occurs widely through Queensland from Mt. Maroon area in the southeastern corner, through Brisbane, northwards including areas north of Maryborough, Emu Park (aural record, east of Rockhampton) to the Homevale National Park region (southwest of Mackay). Inland distributions extend from north of Miles to the Expedition Range National Park (southeast of Rolleston) and the Mt. Moffat and Carnvarvon National Parks (latter an aural record). It appears to be a localised species, but common to abundant where present. It occurs dominantly in eucalypt woodland, including narrow-leaved ironbark (*Eucalyptus crebra*); silver-leaved ironbark (*E. melanophloia*) and mountain coolibah (*E. orgadophila*) and associated lower tree layers, especially acacias (e.g. *A. concurrens*). It is also found in open casuarina woodland (e.g. *C. cristata*), less commonly in surrounding long grass and shrubs (e.g. wild cottonbush, *Gomphocarpus physocarpus*, in disturbed areas), and isolated areas of False Sandlewood (*Eremophila mitchellii*). A distinctive and apparently atypical localised occurrence is in heath near Gurulmundi (north of Miles) where this species occurs abundantly in *Kunzea opposita* and *Melaleuca uncinata*. This occurrence is of further interest as the ticking song is slightly slower than normal (see below). *C. fronsecetes* is highly cryptic, small, very wary and fast flying. It most often inhabits branches within tree foliage, moving frequently between branches and also readily between trees. In warm weather, the rapid ticking song is emitted incessantly from morning to late afternoon. In cooler weather, singing occurs between late morning and mid afternoon. Occurs September-January, most abundant in December.

SONG (Figs 7-11; Table 2). A soft rapid ticking with pulse repetition rate between 5.0-11.5 per second. This is intermediate between *C. plexis* and *C. strenulum* (Fig. 11). The population from the Gurulmundi heath location is notable for its consistently slower pulse repetition rate than observed elsewhere, the respective means and standard deviations (field recordings) being 5.9±0.6 compared to 8.1±1.5 for all data. The individually measured pulse rates do, however, overlap and in view of their close morphological and colour similarities (Figs 3, 4) and the similarity of pulse structures (Fig. 8), there is no justification for defining the Gurulmundi population as a separate species or subspecies.

ETYMOLOGY. Latin *frons* and Greek *ecetes,* meaning foliage dweller.

Crotopsalta strenulum sp. nov.
(Figs 2, 5, 7-11, 38, Table 2)

MATERIAL. HOLOTYPE; ♂, QMT99211, Nogoa R. xing, Emerald, C.Q., Ewart, 25 Oct 2000, 23º31.95'S 148º10.12'E.

PARATYPES: SOUTH AND CENTRAL QUEENSLAND: 3♂, Nogoa R xing, Emerald, AE, 25.x.2000, 23º31.95'S 148º10.12'E; 1♂, As previously, Field Rec; 1♂, As previously, Rec spec 1; 1♂, As previously, Rec spec 2; 16♂, 3.3 km E. of summit Expedition Ra, AE, 26.x.2000, 24º39.13'S 149º02.57'E; 1♂, As previously, Rec spec 1; 1♂, As previously, Rec spec 2; 1♂, As previously, Rec spec 3; 1♂, 5.6 km W. Summit Expedition Ra, (36 km W. Bauhinia), Hwy, 13.ii.1999, AE, grass, 24º37.03'S 148º54.83'E, Rec; 16♂, 16km E Muckadilla, grassland, 16.xii.2000, AE, 26º34.95'S 148º32.74'E; 1♂, As previously, Rec spec 1; 1♂, As previously, Rec spec 2; 12♂, 1 exuviae, Nogoa R, E side Emerald, grass, open shrubland, 14.xii.2000, AE, IR, 23º31.95'S 148º10.16'E; 2♂, 5.7 km W Expedition Ra summit, Rolleston Rd, grass, AE, 29.xii.2002, 24º36.70'S 148º58.46'E; 1♂, As previously, Rec; 2♀, Nogoa R, E side Emerald, grass, open shrubland, 13.xii.2000, AE, IR, 23º31.95'S 148º10.16'E; 8♂, Wyseby-Carnarvon Rd jct, 200m W, CQ, grass, AE, 15.xii.2004. 23º58.24'S 148º31.49'E; 1♂, As previously, Rec; 1♂, 1.2km W Wyseby-Carnarvon Rd jct, CQ, grass, AE, 18.xii.2004, 24º58.39'S 148º31.06'E; 1♂, 3.4km W Wyseby-Carnarvon Rd jct, CQ,, grass, AE, 18.xii.2004, 24º59.00'S 148º29.97'E **(AE)**. 9♂, 4♀, Westbrock Ck, 7 km W Drayton, 29.xi.2001, LWP, JM, 353-0001 to -0004; 1♂, Westbrook Ck, 7 km W Drayton, 29.xi.2001, LWP; 1♂, 24º54'51"S 148º01'31"E, Rotary Shed, Mt Moffat NP, 16.i.2005, LWP, 353-0015 **(LWP)**. 1♂, 25º08.22'S 147º30.37'E, Mt. Moffat NP, W. Branch Maranoa R, 21.xi.1995, 660m Irwin, Gaimari, DY, CB, malaise **(QM)**. 1♂, Nogoa R, E side Emerald, grass, open shrubland, 13.xii.2000, AE, IR, 23º31.95'S 148º10.16'E **(BMNH)**. 1♂, Nogoa R, E side Emerald, grass, open shrubland, 14.xii.2000, AE, IR, 23º31.95'S 148º10.16'E **(ANIC)**. 1♂, Nogoa R, E side Emerald, grass, open shrubland, 13.xii.2000, AE, IR, 23º31.95'S 148º10.16'E **(MSM)**.

DESCRIPTION (Male). Figs 5, 38A. *Head*. Sandy brown and black. Supra-antennal plate

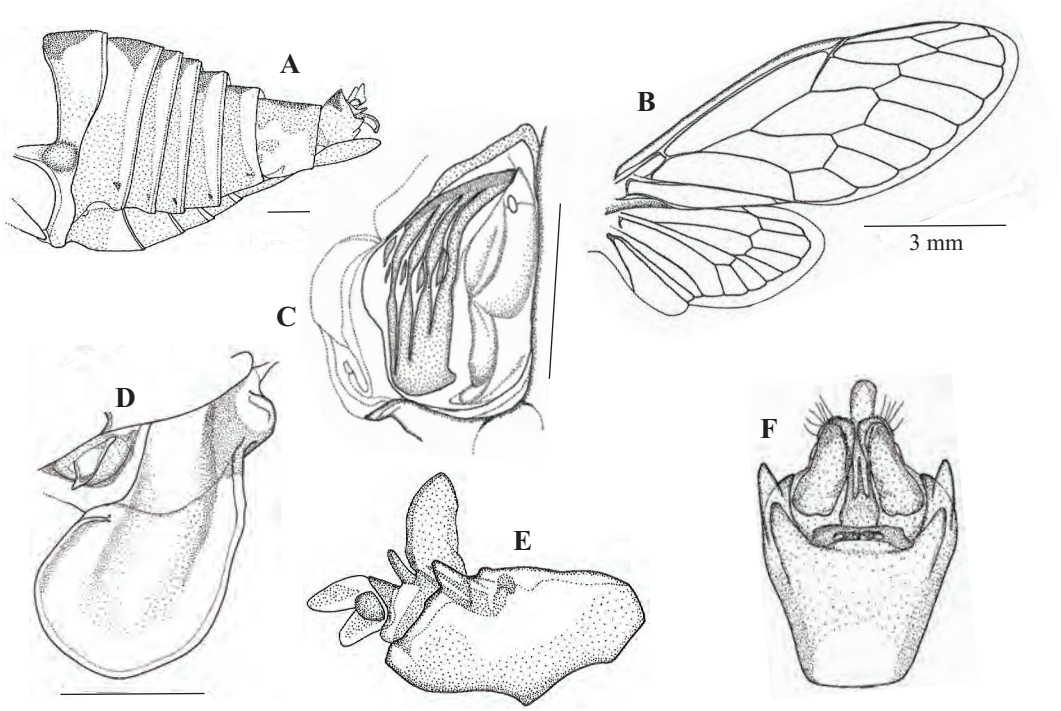

FIG. 5. *Crotopsalta strenulum*. A, Lateral abdomen view; B, fore and hind wings; C, timbal; the right-hand edge as shown represents the posterior margin, the top the dorsal edge; D, opercula; E, and F, lateral and ventral views of pygofer. Pygofer length 1.4mm. Scale bars = 1mm except wings (3mm). Drawings based on specimens from near the summit of the Expedition Range, west of Bauhinia, and Nogoa River at Emerald (abdomen only).

black with small yellow-brown area between ocelli, extending to distal margin; a pair of localised small sandy brown areas enclosing bases of antennae. Postclypeus pale brown with transverse ridges and central area black. Gena and mandibular plate black. Ocelli red. Compound eyes dark brown. Anteclypeus dark brown to black. Rostrum pale brown, darker apically. Antennae dark brown.

Thorax. Sandy brown and black. Pronotum dominantly sandy brown; central fascia yellow-brown enclosed by narrow black envelope which flares outwards along the anterior and especially posterior pronotal margins; small broken irregular black areas between anterior and posterior oblique fissures, and dark brown colouration extending along posterior oblique fissure; pronotal collar yellow- brown, darker at lateral corners; markedly ampliate along lateral margins. Mesonotum sandy brown with a pair of anterior broad, but short black obconical fasciae which coalesce near anterior margin of mesonotum and which extend distally about half way to cruciform elevation; a pair of black broad lateral fasciae tapering distally, extending to anterior arms of cruciform elevation; cruciform elevation pale sandy brown, with diffuse darker brown colouration between anterior arms; wing grooves pale sandy brown with silver pubescence along margins.

Wings. Fore wing venation pale to medium brown, darkening apically; costal vein pale sandy brown to translucent; weakly developed node; pterostigma dark reddish-brown; basal membrane pale brown. Hind wing venation brown, darkening apically; plaga opaque white, extending partially along vein 3A.

Legs. Coxae pale sandy brown, with broad dark brown anterior longitudinal fasciae. Trochanters and femora sandy brown, with variable darker brown longitudinal fasciae along anterio-dorsal edges, broader on fore femora. Tibiae and tarsi pale brown to pale sandy brown, darker on

TABLE 2. Comparative song parameters of the four *Crotopsalta* ticking cicadas. [(1)] Pulse doublets counted as 1 pulse; [(2)]Container data only; [(3)]Specifically the frequency of dominant spectral peaks.

	C.plexis	*C.fronsecetes*	*C.strenulum*	*C.poaecetes*
I Tick repetition rates (s^{-1},±σ)				
- Container recordings	1.81±0.50 (n=52)	7.42±1.36 (n=40)	10.04±1.08 (n=34)	4.43±0.90[(1,2)] (n=23)
- Field recordings (open sunlight)	2.75±0.15 (n=3)	8.14±1.85 (n=25)	15.74±2.97 (n=6)	-
Field (Container) recordings				
- Minimum	2.7(1.0)	5.0(5.0)	11.7(7.4)	(3.5)[(1,2)]
- Maximum	2.9 (3.2)	11.5(9.5)	20.4(12.4)	(6.9)[(1,2)]
II Pulse lengths and separations (ms,±1σ)				
(a) *First and second pulses clearly separate:*				
First pulse	8.1±1.3 (n=29)	8.6±1.7 (n=22)	7.8±0.5 (n=6)	7.9±1.0 (n=17)
Second pulse	5.1±1.2	3.9±1.0	3.8±0.9	-
Inter-pulse duration	18.4±5.3	13.5±3.0	10.2±1.1	32.6±4.2
(b) *First and second pulses without clear separation:*				
First pulse	-	-	9.7±1.6 (n=15)	-
Second pulse	-	-	4.5±1.0	-
(c) *Second and third pulses coalesced into single pulse:*	-	-		7.5±0.7 (n=6)
(d)*Second and third pulses well defined but without separation:*				
Second pulse	-	-	-	3.5±1.3 (n=7)
Third pulse	-	-	-	6.7±1.0
Total length of pulse 2 + pulse 3	-	-	-	10.2±1.4
(e) *Pulse 2 and 3 clearly separated:*				
Pulse 2	-	-	-	4.5±0.3 (n=3)
Pulse 3	-	-	-	5.2±0.6
Total length pulse 2 + pulse 3	-	-	-	9.7±0.9
III Maximum Frequency (kHz)[(3)]	14.7(n=34)	14.8(n=21)	14.9(n=27)	14.9(n=15)
Mean Frequency (kHz)	13.1	13.2	13.9	13.7

forelegs. Claws pale brown, with dark brown tips.

Operculae. Elongated, but with slightly expanded and rounded at distal-medial margins; colour pale yellow-brown; in some specimens, localised darkening of colour occurs adjacent to distolateral crest, on basal areas, and very localised darkening on medial areas of cross suture; meracantha relatively acutely terminated; distal margins extend distally to anterior paramedial margin of sternite II.

Timbals. Ribs 1-4 fused ventrally; rib 4 continuous across timbal, rib 5 shortened; 5short ribs.

Abdomen. Tergites 2 and 3 pale sandy brown, grading to medium brown on tergites 4-8; black areas present dorsally on each tergite, each narrowing distally, giving the overall appearance of a continuous black dorsal fascia extending the length of the abdomen; tergite 2 additionally possesses a thin, discontinuous black anterior margin in some specimens; tergites 3-7 with localised medium to dark brown irregular lateral patches; auditory capsules centrally yellow brown with diffuse, thin black to dark brown margins. Sternites II and III yellow-brown, grading to chestnut brown in sternites IV-VII;

sternite II with a small medium black patch near posterior margin; sternite VIII medium brown.

Genitalia. Pygofer medium to dark brown. Upper lobe extended into small, acutely rounded shape. Other details as in generic description.

FEMALE. Fig. 38B. *Head*: Supra-antennal plate dark brown to black with anterior-pointing triangular yellow-brown spot between ocelli, and small pale areas enclosing bases of antennae. Postclypeus sandy brown with dark brown transverse ridge and central area. Pronotum with pale yellow-brown central fascia enclosed by thin darker brown envelope which only slightly flares outwards along the anterior and posterior pronotal margins; remaining pronotum sandy brown with thin curved slightly darker brown dorso-lateral fascia. Mesonotum sandy brown with a pair of short broad paramedial obconical black fasciae, broken by veinlets of pale colouration, and almost or very weakly fused anteriorly; a pair of broad lateral fasciae extending to anterior arms of cruciform elevation, as in male, but broken by veinlets and lobes of pale brown colouration. Legs similar to male, but generally paler. Abdomen; tergites variably coloured pale to medium brown, with dorsal black areas absent (as seen in male), although local darker brown lateral areas present on tergites 3-5; overall colour of tergites are paler than in male; tergite 9 with pale to medium brown paramedial fasciae extending distally approximately three-quarters of the length of tergite. Sternites uniformly sandy brown. Ovipositor sheath extends ≤1mm beyond tergite 9.

MEASUREMENTS. N = 10♂, 6♀. *BL*: ♂ 8.6-10.4 (9.8); ♀ 10.3-11.9 (11.0). *FWL*: ♂ 10.0-11.4 (10.7); ♀ 11.8-12.1 (11.9). *HW*: ♂ 2.7-3.0 (2.8); ♀ 3.0-3.3 (3.1). *PW*: ♂ 2.5-3.0 (2.7); ♀ 2.8-3.0 (2.9). *AW*: ♂ 2.5-3.1 (2.9); ♀ 3.1-3.4 (3.2). *FWL/BR*: ♂ 2.39-2.72 (2.57); ♀ 2.42-2.58 (2.51).

DISTRIBUTION, HABITAT & BEHAVIOUR (Fig. 2). A very small cicada occurring in open grassland and grassland within open woodland. It is a very cryptic, fast flying and wary species, constantly moving (up to ~5m) when singing. In between singing phases, it will sit quietly on grass stems. Distributed southeastwards from Emerald to over the Expedition Range between Rolleston and Bauhinia. Other occurrences in southern Queensland include the Mt. Moffat National Park; Wyseby; 25km W of Roma (in mitchell grassland); and 7 km west of Drayton. The populations are usually extremely common, but very localised, typically limited to areas less than approximately 300m diameter. An exception was located near Wyseby where the cicada occurred continuously in grassland along the Carnarvon National Park road for 3.4km. A preference for clay-rich alluvial and basalt soils is suggested by available data. Available records are during October to February.

SONG (Figs 7-11; Table 2). An extremely rapid ticking, the fastest of the four *Crotopsalta* species described, providing a diagnostic field criterion. The pulse repetition rate lies in the range 7.4-20.4 per second.

ETYMOLOGY. Latin *strenu,* active and diminutive suffix *-ulum*; referring to its small size and active behaviour.

Crotopsalta poaecetes sp. nov.
(Figs 2, 6, 7-11, 39, Table 2)

MATERIAL. HOLOTYPE; ♂, QMT99212, Cloncurry, E. side, NWQ., 3 Feb 1999, AE., 20º43.27'S 140º31.32'E, Recorded.

PARATYPES: NORTHWESTERN QUEENSLAND: 4♂, 2♀, Cloncurry, E side, 3.ii.1999, AE, 20º43.27'S 140º31.32'E; 9♂, 1♀, 11 km E Cloncurry Hwy, 4.ii.1999, AE, 20º43.41'S 140º37.47'E; 1♂, Cloncurry R bridge, 1.2 km W. Cloncurry, 4.ii.1999, AE, 20º42.24'S 140º29.88'E; 6♂,~2 km SE Cloncurry, grass, AE, 23.i.2000, 20º43.52'S 140º31.10'E; 5♂, 4♀, ~2 km SE Cloncurry, grass, AE, 25.i.2000, 20º43.52'S 140º31.10'E; 1♂, As previously, Rec; 2♂, 2♀, ~2 km SE Cloncurry, grass, AE, 24.i.2000, 20º43.52'S 140º31.10'E; 1♂, As previously, Rec; 2♂, 29 km W Cloncurry, grass, AE, 24.i.2002, 20º44.27'S 140º15.01'E; 1♂, As previously, Rec, 1♂, Quamby, 44 km N. Cloncurry, AE, grass and forbs, 25.i.2002, 20º22.48'S 140º17.19'E, Rec; 1♂; Dajarra township, grass, AE, 20.i.2002, 21º41.76'S 139º31.05'E, Rec spec 1; 1♂, As previously, Rec spec 2; 2♂, 34 km E Cloncurry, grass, AE, 26.i.2002, 20º41.59'S 140º48.86'E; 1♂, As previously, Rec **(AE)**. 1♂, 29 km W Cloncurry, grass, AE, 24.i.2002, 20º44.27'S 140º15.01'E **(BMNH)**. 1♂, 34 km E Cloncurry, grass, AE, 26.i.2002, 20º41.59'S 140º48.86'E **(ANIC).** 1♂, ~2 km SE Cloncurry, grass, AE, 25.i.2000, 20º43.52'S 140º31.10'E **(MSM)**.

DESCRIPTION (Male). Figs 6, 39A. *Head*. Pale sandy brown and black. Supra-antennal plate partially black, with the following: a pair of lozenge-shaped pale sandy brown areas, joined adjacent to the distal margin of head, and splaying outwards anteriorly, thereby partially enclosing the two posterior ocelli and terminating adjacent to, but not enclosing, the anterior ocelli; a pair of inward pointing pale sandy brown to brown areas adjacent to inner margins of compound eyes; a small pale area between the anterior ocelli and postclypeus; sandy brown colouration along dorso-anterior

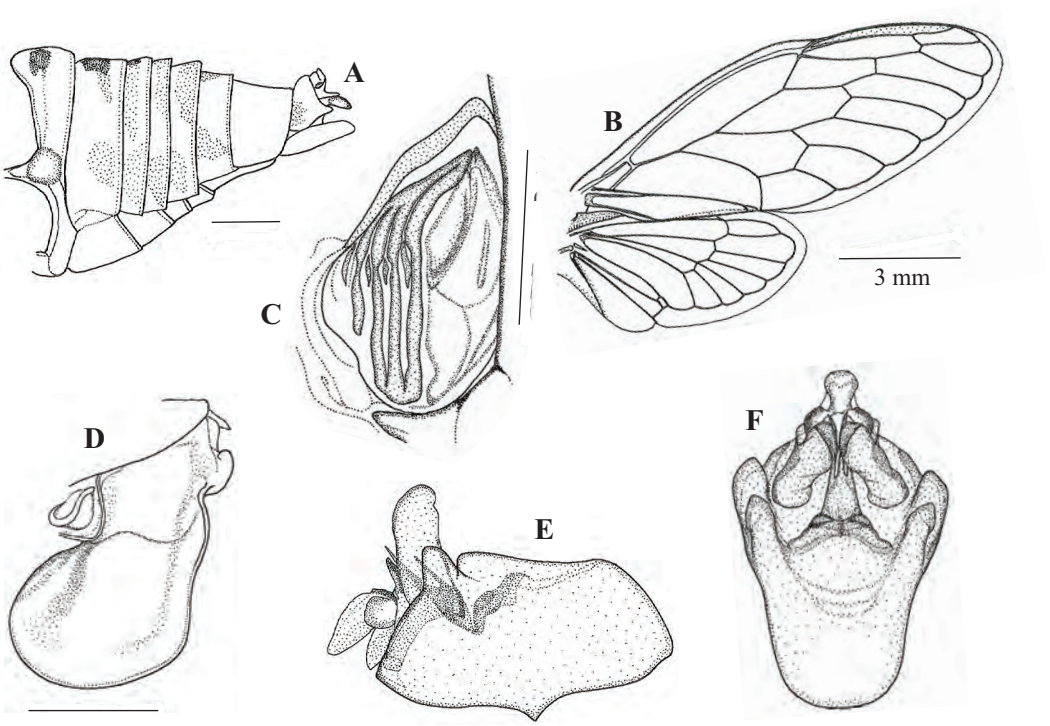

FIG. 6. *Crotopsalta poaecetes*. A, Lateral abdomen view; B, fore and hind wings; C, timbal; the right-hand edge as shown represents the posterior margin, the top the dorsal edge; D, opercula; E, and F, lateral and ventral views of pygofer. Pygofer length 1.4mm. Scale bars represent 1mm except wings (3mm). Drawings from specimens from Cloncurry, northwestern Queensland.

margin of plate, extending around bases of antennae. Ocelli red. Compound eyes dark brown. Gena and mandibular plate pale sandy brown, with narrow black margin adjacent to anteclypeus; silver pubescence conspicuous. Postclypeus with anterior central area entirely pale yellow-brown, enclosed by a narrow and discontinuous dark brown to black marginal zone; black to dark brown transverse ridges; remaining area pale sandy brown. Anteclypeus pale sandy brown with small central brown area. Rostrum sandy brown grading to darker brown apically and along central suture. Antennae dark brown, paler apically.

Thorax. Pale sandy brown and dark brown. Pronotum and pronotal collar entirely pale sandy brown; pronotal collar along lateral margin weakly ampliate. Mesonotum with a pair of anterior obconical, short, brown and broad paramedial fasciae, fused medially, with diffuse distal terminations which extend distally approximately one-third of the length of the mesonotum; a pair of broad, oblique lateral brown fasciae, diffusively terminated anteriorly, inward pointing distally; a pair of thin brown oblique fasciae between the two sets of broad fasciae (i.e. lateral and paramedial); a black, irregular central spot anterior to the cruciform elevation; remaining areas pale sandy brown, including the cruciform elevation and the wing grooves, the latter with marginal silver pubescence.

Wings. Fore wing venation very pale yellow-brown to translucent; clearly developed node on costal vein; costal vein exhibits gentle but quite distinct anterior curvature; pterostigma pale yellow brown, translucent; basal membrane pale sandy brown. Hind wing colouration as in fore wing; plaga opaque white, extending adjacent to 3A vein.

Legs. Dominantly pale sandy brown. Foreleg tarsi tending darker brown. Thin pale to medium brown longitudinal fasciae are present along the anterio-dorsal margins of the fore and mid

femora; three dark brown spines on fore femora. Claws dark brown apically.

Operculae. Elongated but slightly expanded and rounded at distal-medial margins; entirely pale sandy brown except for a small pale brown area adjacent to crest around distolateral margins; meracantha rounded and poorly developed.

Timbals. Ribs 1-3 extend across timbal; anterior rib 5 very short; rib 4 intermediate in length, not fused to ribs 1-3 ventrally; four short ridges.

Abdomen. Tergites dominantly sandy brown, grading to pale brown distally; diffuse black to brown medio-dorsal areas, which are most extensive on tergite 2, becoming progressively smaller and paler towards tergite 7; these darker areas do not extend to distal tergite margins; auditory capsules pale sandy brown, rarely with small brown marking adjacent to central areas; brown diffuse lateral patches on tergites 3 to 4, becoming more weakly developed distally. Sternites II and III pale sandy brown, grading to pale brown towards sternites VII and VIII.

Genitalia. Pygofer variable pale to medium brown. Otherwise as in generic description.

FEMALE. Fig. 39B. Similar to male but with reduced areas of darker colouration. Supra-antennal plate as in male, with decreased black colouration along distal and lateral margins. Postclypeus as in male but with the areas of brown colouration paler and reduced in extent. Pronotum as in male. Mesonotum similar to male with reduction in size of anterior obconical fasciae which are not fused medially, and are paler brown; the lateral oblique fasciae are paler brown and fragmented in extent; two small brown spots adjacent to anterior arms of cruciform elevation. Legs pale sandy brown with apices of claws brown. Tergites pale sandy brown, with paramedial darker brown areas on tergites 2-4, which are paler and greatly reduced on tergite 4, and absent on tergites 5-9; dorsal surface of tergites with well defined pale sandy brown, with fine silver pubescence, giving overall appearance of weak dorsal fascia; diffuse pale brownish ventrolateral patches on tergites 3-7. Sternites pale sandy brown. Ovipositor sheath extends ~0.5 mm beyond tergite 9.

MEASUREMENTS. N = 10♂, 9♀. *BL*: ♂ 8.7-10.8 (10.0); ♀ 10.4-10.9 (10.7). *FWL*: ♂ 9.9-11.4 (10.7); ♀ 11.4-12.2 (11.8). *HW*: ♂ 2.5-3.0 (2.8); ♀ 2.7-3.0 (2.9). *PW*: ♂ 2.4-2.8 (2.7); ♀ 2.8-3.1 (2.9). *AW*: ♂ 2.8-3.3 (3.1); ♀ 2.9-3.3 (3.1). *FWL/BR*: ♂ 2.33-2.87 (2.57); ♀ 2.42-2.83 (2.63).

DISTRIBUTION, HABITAT & BEHAVIOUR (Fig. 2). A species restricted to open grassland and grassland in open forest, occurring in northwest Queensland. It occurs in a variety of grass species including buffel grass (*Cenchrus ciliaris*), Queensland bluegrass (*Dichanthium sericeum*), and silky browntop (*Eulalia aurea*). This cicada is wary, highly cryptic and readily flies, singing whilst sitting on grass stems and in associated forbs. The species is most widespread in the Cloncurry region, extending to Dajarra and Quamby, but is not recorded from Mt. Isa.

ETYMOLOGY. Greek *poa* and *ecetes*, grass dweller.

SONG (Figs 7-11; Table 2). A relatively slow ticking song, generally intermediate between the *C. plexis* and *C. fronsecetes* tick rates, ranging between 3.5-6.9 per second(s^{-1}). The ticks aurally sound to be single ticks, but when examined at higher resolution, comprise distinct double pulses of nearly equal amplitude.

ANALYSIS OF THE TICKING SONGS OF *CROTOPSALTA* CICADAS

The genus is characterised by relatively simple ticking songs. Although a number of other Queensland species have tick-like songs (e.g. *Pauropsalta dubia* Goding & Froggatt; *P. emma* Goding & Froggatt; *Urabunana marshalli* Distant; *U. segmentaria* Distant; and others decribed below), detailed analyses of most of these songs reveals their tick-like structure to be more complex than those described in *Crotopsalta*, and are more appropriately termed chirps (Ewart, 1998). The four *Crotopsalta* species described occur within relatively diverse habitats and regions, and their ticking songs cannot be correlated with specific habitat types. The cicadas are, however, all very small and highly mobile in their behaviour patterns, but these attributes are common in other small Australian cicadas, some of which have significantly more complex songs (e.g. *U. verna* Distant; *Cicadetta murrayensis* Distant; Ewart & Popple, 2001). Such ticking songs are significant in the context of their apparent simplicity and therefore apparently limited potential for evolution of inter-specific song variations. Two variables that seem to have been exploited, however, are the pulse repetition rates and the detailed pulse structures.

Waveform and envelope plots of the songs are shown in Figs 7-9, and amplitude spectra of the songs in Fig. 10. Comparative details of the ticking songs (Table 2), indicate the following:

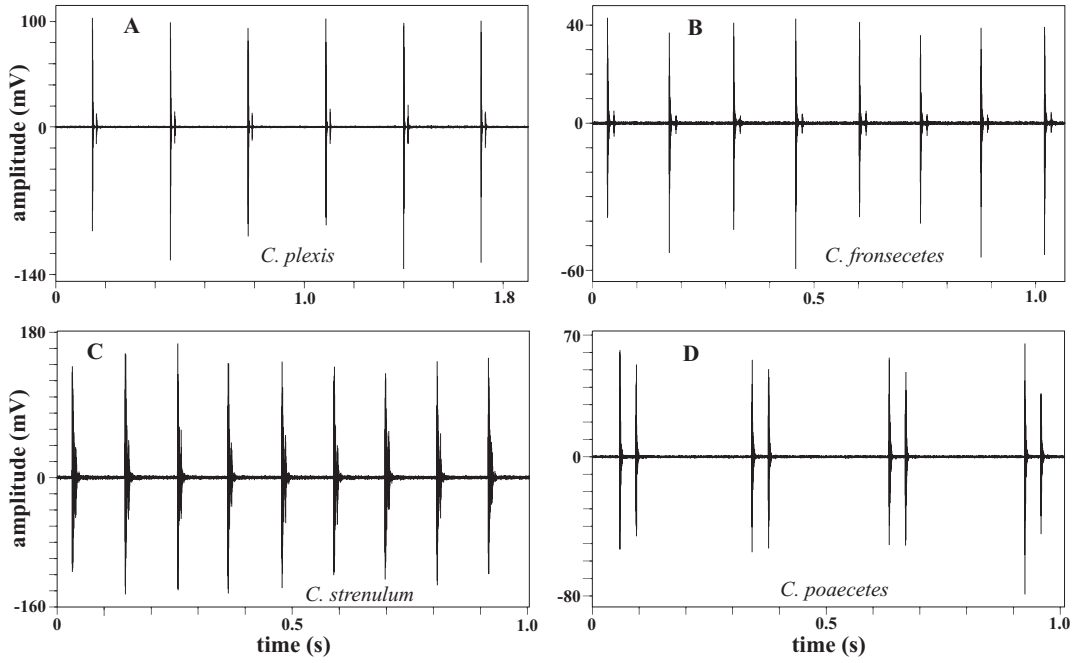

FIG. 7. Waveform plots, comparing the broader pulse structures of the four *Crotopsalta* ticking cicadas: (a) *C. plexis*, from 31km W. of Mitchell. (b) *C. fronsecetes*, 41km southeast of Childers. (c) *C. strenulum*, 5.7km east of summit of Expedition Range, west of Bauhinia, central Queensland. (d) *C. poaecetes*. Dajarra, northwestern Queensland. Each figure represents a recording made of insects within a container. The data have each been filtered (FIR) to 1kHz.

(a) In all species, each tick structure comprises two (or sometimes three in *C. poaecetes*) distinct pulses which in Fig. 9 are numbered 1 and 2 (and 3 in the *C. poaecetes* plot). With the exception of some of *C. poaecetes* songs, the second pulse has a reduced amplitude (weakest in *C. fronsecetes*), resembling the simple 'hand operated' timbal 'in-out' movements illustrated by Josephson & Young (1985). In *C. strenulum*, the two pulses may partially coalesce or be separated (less common). In *C. poaecetes*, the amplitudes of pulses 1, 2 and 3 are variable. If pulses 2 and 3 have coalesced, their combined amplitude is similar to pulse 1. If pulses 2 and 3 are separated, their amplitudes are reduced relative to pulse 1 (Fig. 9E). Attention is drawn to the differences in detailed timbal structures of *C. poaecetes* compared to the other three species, notably the rib 4 that is clearly separate from ribs 1-3. This suggests that the independent role of rib 4 could be significant in the generation of pulses 2 or 3. In contrast, the ventral fusion (or near fusion) of ribs 1-4 in the other three species (see above) suggests that these act in unison during the initial 'in' movement of the timbal in producing pulse 1, and similarly for the fused ribs 1-3 in *C. poaecetes*.

(b) Pulse repetition rates vary between all four species, with some overlap occurring between *C. fronsecetes* and *C. strenulum* songs. It is clear, however, that temperature does affect the pulse rates. Temperatures within the recording boxes fall into a relatively narrow range (30-35ºC) as previously noted. Field recordings cannot be constrained in terms of the insect temperatures as these were made of insects singing in open sunlight and in partial and constantly varying shade conditions (e.g. in moving tree foliage), typically at shade temperatures in excess of 30ºC. Comparison of container and field recordings (Table 2; Fig. 11) indicate that the pulse rates are higher in field recordings, although they do not greatly differ for *C. plexis* and *C. fronsecetes*, but are more significant for *C. strenulum*. Reasons for these differences are attributed to the microhabitats of the respective species, with *C.*

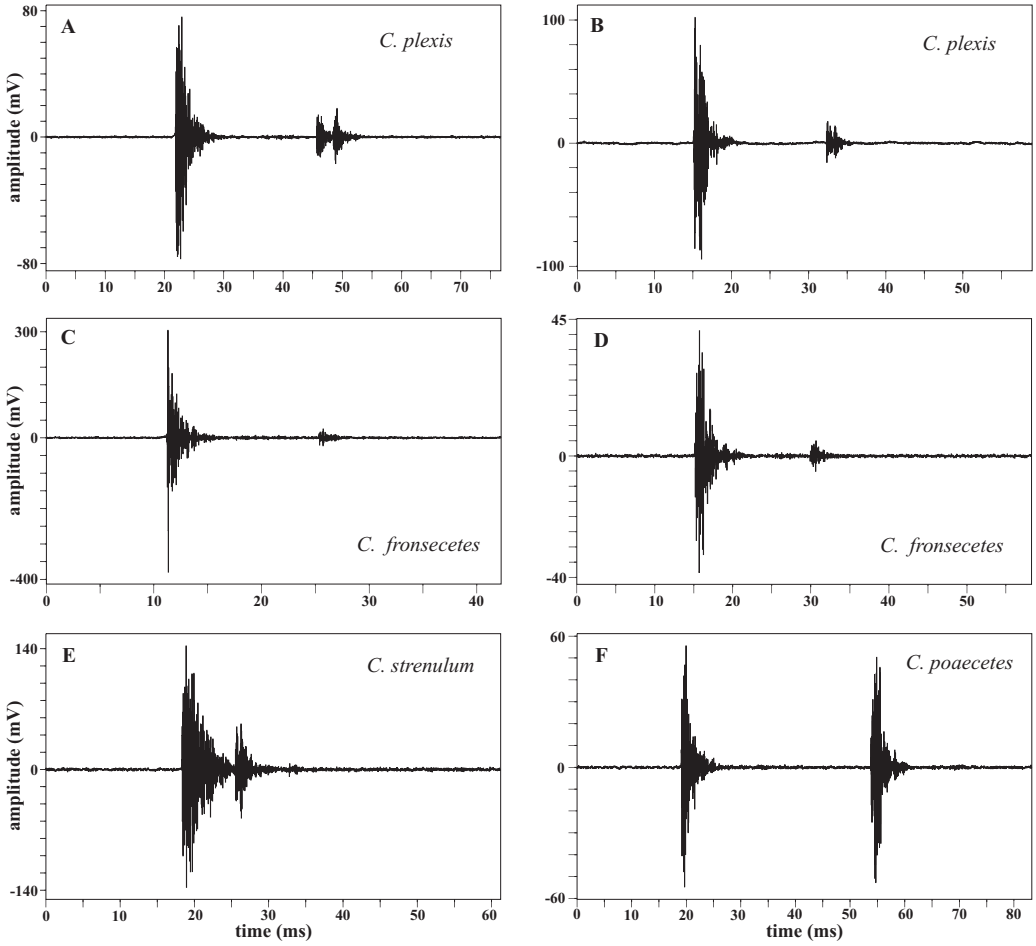

FIG. 8. Expanded waveform plots comparing further detail of individual pulse structures of the four *Crotopsalta* ticking cicadas. (a) and (b), *C. plexis*, from Kaimkillenbun, near Dalby, and 31km west of Mitchell, respectively. (c) and (d), *C. fronsecetes* from Gurulmundi, near Miles, and 41km southeast of Childers, respectively. (d) *C. strenulum*, location as in Fig. 7C. (d) *C. poaecetes*, location as in Fig. 7D. Each based on container recordings, each filtered (FIR) to 1kHz.

strenulum, a grassland species, frequently singing in open sunlight. In contrast, *C. plexis* and *C. fronsecetes* sing within foliage under variable shaded conditions. The tick rates provide important field criteria for species identification.

(c) Length of pulses 1 and 2 are very similar (Table 2) in each species, consistent with a similar mechanism of generation. Pulse 3 in *C. poaecetes* is slightly longer than the pulse 2 length. The inter-pulse intervals (time duration between start of pulses 1 and 2; Fig. 11; Table 2) exhibit differences between species, noting the overlap between *C. plexis* and *C. fronsecetes*. The partial differences in pulse repetition rates and inter-pulse intervals suggests that the combination of these two variables can be used to separate the four species. In Fig. 11 the data are subdivided according to container versus field recordings, and the data fields indicate systematic differences, and variability, between and within species, especially when considering the field and container data separately. Importantly, differences between tick rates and pulse structures are discernible and are therefore presumably utilised in species recognition.

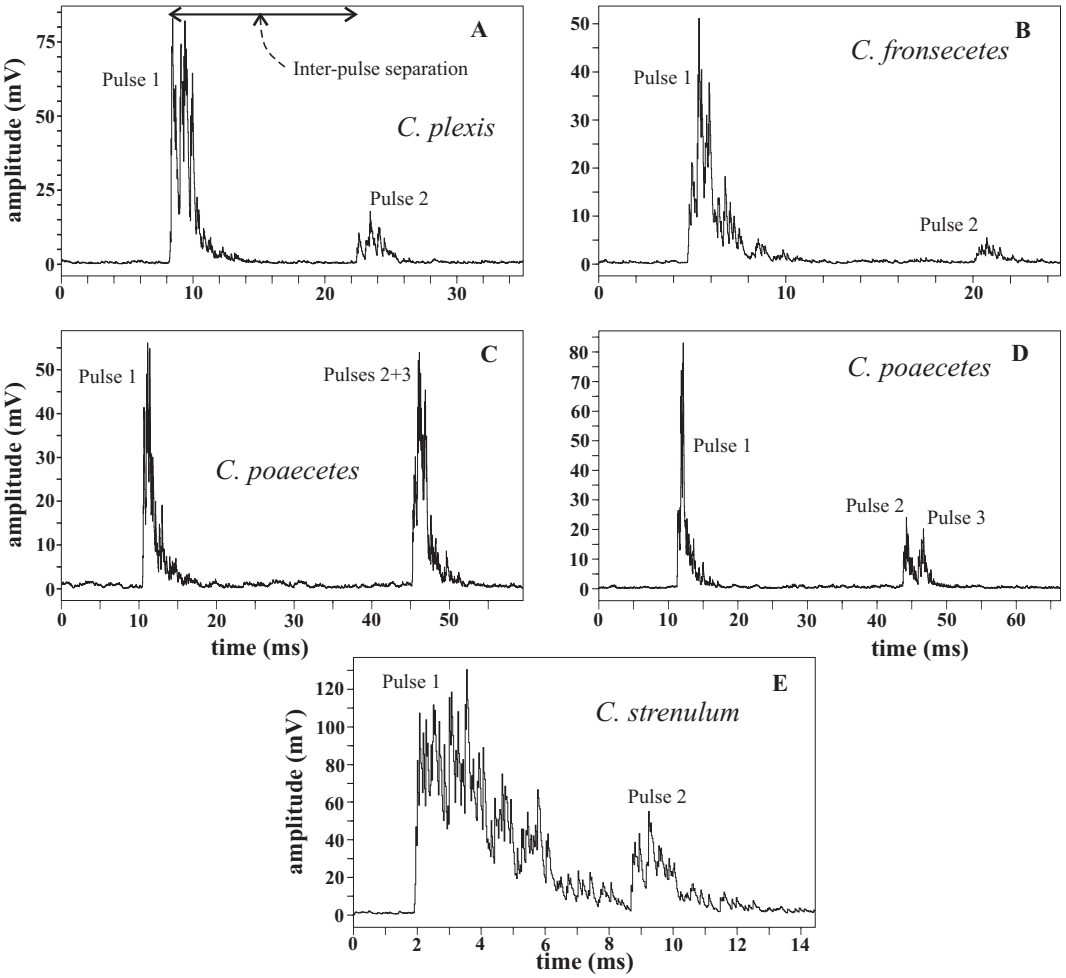

FIG. 9. Expanded envelope curves showing higher resolution structures of the ticking pulses, and the definitions used in the text for the inter-pulse separation intervals, and pulse numbering. (a) *C. plexis*, location as in Fig. 7A. (b) *C. fronsecetes*, location as in Fig. 7B. (c) and (d) *C. poaecetes*, from Dajarra and 34km east of Cloncurry, respectively. In (c), the coalescence of pulses 2 and 3 produce a higher amplitude second pulse, compared to (d), in which pulses 2 and 3 are separated, each with lower amplitudes. (e) *C. strenulum*, location as in Fig. 7C. Each plot based on container recordings, each filtered (FIR) to 1kHz.

These differences are emphasised by other variations in pulse structures in their respective envelope curves (Fig. 9A-E), especially notable in *C. strenulum* and *C. poaecetes*.

(d) Time expanded envelope curves (Fig. 9) indicate very abrupt initiation to the first pulses of the ticks, with the possible exception of *C. fronsecetes,* with the second pulse generally also exhibiting relatively sharp initiations. The structures of individual pulses illustrate further complexities. Pulse 1 of *C. plexis*, for example, exhibits at least four distinct 'carrier pulse' phases. The damping of the individual pulses seems to approximate logarithmic decay curves, with the exception of *C. strenulum* in which pulse 1 follows a more linear damping.

(e) Amplitude spectra (Fig. 10) are complex, showing a series of broad frequency peaks occurring between approximately 4 to near 18kHz (the latter the limit of recording

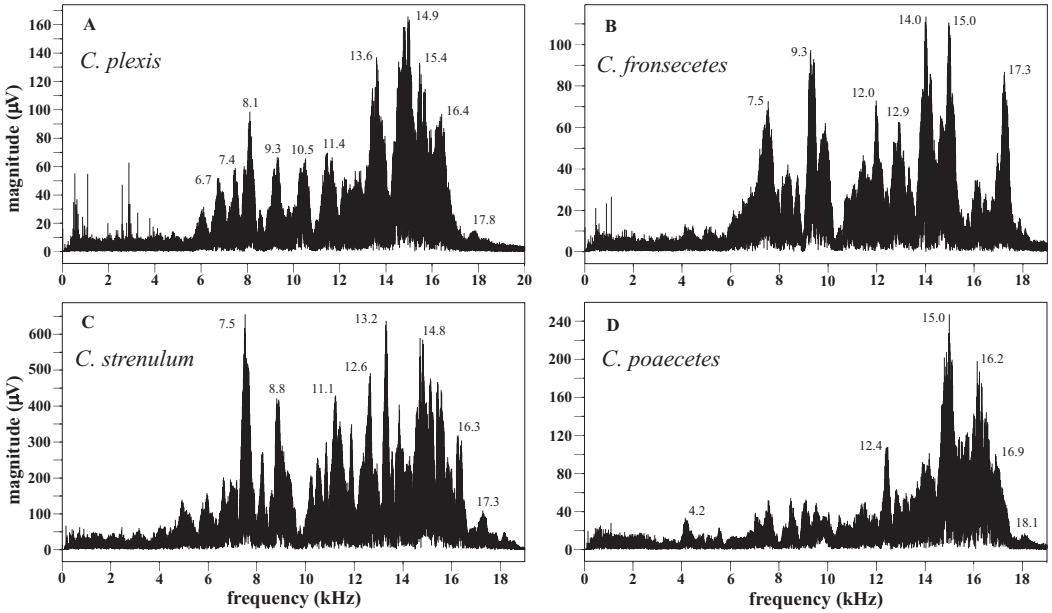

FIG. 10. Amplitude spectra of the songs of the four *Crotopsalta* ticking cicadas. (a) *C. plexis*; (b) *C. fronsecetes*; (c) *C. strenulum*; (d) *C. poaecetes*. Locations and other details as in Fig. 7A-D, respectively. Frequencies of the main peaks are labelled (kHz). Recordings filtered (FIR) to 0.5kHz.

capability). Carrier frequencies of ⩾ 14kHz are verified by counts of resolvable carrier pulses in the amplitude envelope curves. The width of the spectral peaks is attributable to the short duration of the constituent sinusoidal pulses. The spectra indicate no regular sequence of harmonic or side band peak sets, but there is nevertheless a crude periodicity in the modulation and grouping of the peaks in each species, averaging approximately 1kHz. Specifically for *C. plexis*, *C. fronsecetes*, *C., strenulum* and *C. poaecetes*, the means and ranges of the observed periodicities are, respectively (kHz): 1.066 (0.74-1.34); 1.09 (0.84-1.29); 1.07 (0.78-1.24); and 1.10 (0.58-1.47). The detailed irregularities suggest frequency overtones. It is important to note that the various frequency peaks are not present in the background spectra, and are characteristics only of the ticking songs, which clearly represent complex periodic waves.

(f) The modulation frequencies defined by the pulse repetition rates, the inter-pulse intervals and the pulse lengths lie in the range of approximately 2-300Hz. These are very low frequencies compared to the carrier frequencies and are strongly developed in the amplitude spectra as line spectra that decrease irregularly in amplitude with increasing frequency. They are generally weakly developed above 1kHz and for clarity are filtered out in the spectra shown (Fig. 10).

(g) The amplitude differences between pulses 1 and 2 have been noted above. These differences extend to the separate amplitude spectra prepared separately for each of the pulses. Comparison between pulse 1 and the composite amplitude spectra made of multiple pulses (Fig. 10) reveals good correspondence between the main peaks, as expected by the higher amplitude of pulse 1. Comparison of the spectra between pulses 1 and 2, however, reveals many detailed discrepancies in the frequencies of the main peaks. For example, in *C. plexis*, *C. fronsecetes*, *C. strenulum* and *C. poaecetes*, respectively, only 9 close coincidences are observed out of the total of 22 combined peaks; 9 out of 17 peaks; 6 out of 22 peaks; and 9 out of 17 peaks. These point to a variation in their mechanisms of generation and/or radiation. One plausible explanation for pulse 2 is by the 'clicking back' of the timbal, representing changed stress conditions (Bennet-Clark, 1997; Fonseca & Popov, 1994). In this scenario, the maximum amplitude of vibration of the timbals during their outward buckle is not as close, relative to pulse 1, to the natural resonance frequency of the relevant parts

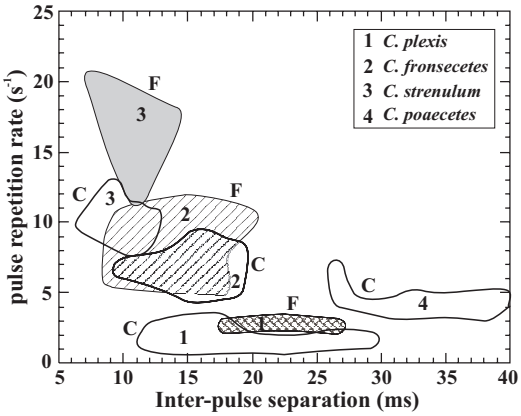

FIG. 11. Plots of pulse repetition rate versus inter-pulse separation of the songs of the four *Crotopsalta* ticking cicadas. Data subdivided into field recordings (F; enclosed fields with fill) and container recordings (C; enclosed fields without fill).

of the body (e.g. timbals, abdominal cavity, and tympana) responsible for radiating the sounds (Bennet-Clark, 1997; Fonseca & Popov, 1994), i.e. the impedance of the sound radiating structures is higher and the forced amplitude of the body systems correspondingly reduced.

(h)The mean maximum and mean frequencies measured are >13kHz for each species (Table 1), but as shown above, the ticking songs are very broadband, with distinct lower frequency peaks. It needs to be noted that the frequency ranges (Fig. 10) underestimate the higher frequency range of the emitted ticks, as bat detector field observations indicate that at close range, frequencies extend (albeit weakly) to 45-60kHz. The lower frequency peaks in the spectra of such small cicadas are significant in view of the correlation between decreasing body size and increasing song frequencies (e.g. Bennet-Clark & Young, 1994; Bradbury & Vehrencamp, 1998). Broadening of frequencies are, however, characteristic of short and very sharp signals (e.g. Bradbury & Vehrencamp, 1998). Fonseca & Popov (1994), in their detailed study of the similarly small Portugese cicada, *Tympanistalna gastrica* Stål, showed that several separate structures contribute differently to the radiation of clicks and soft pulses. The timbals are the main radiators of the dominant spectral peaks at 10-11kHz (clicks) and 12-13kHz (soft pulses), the tympana are important in radiation of frequencies both below and above the timbal peaks, while the abdomen is more important in click generation at lower frequencies of approximately 5kHz. The overall song of *T. gastrica* is more complex than the ticking cicadas described here, but the occurrence of the wide range of frequency peaks of the clicking pulses has close similarities.

POSSIBLE SIGNIFICANCE OF TICKING SONGS

Ticking songs represent the most cryptic and simplest of periodic patterns, characterised by low amplitudes (at least below 18kHz), a very high degree of redundancy and broad frequency spectra, the latter producing marked ventriloquial effects in the field. These attributes, when coupled to the highly mobile behaviour of the cicadas, negates the need for long distance sound transmission (e.g. Römer & Lewald, 1992). The simple patterns are thought relatively robust to temporal degradation during sound transmission (based on bat detector field recordings), and may also minimise predation, the latter further aided by the small size, soft calls, cryptic nature and mobility of the *Crotopsalta* cicadas. As noted above, field observations with a bat detector indicate that at close range, frequencies extend (albeit weakly) to 45-60 kHz. The wide frequency range of the songs should, however, facilitate more efficient survival of the essential form of the signal due to loss and degradation by absorption, scattering, boundary reflections and refraction during propagation, all of which are frequency dependant. Bat detector observations confirm their strongly reflective properties from the ground and surrounding vegetation without obvious distortion. The wide frequency range also provides an effective way to minimise induced amplitude modulations due to wind movement and turbulence within tree foliage, together with frequency filtering of sound propagating through foliage (e.g. Michelsen, 1992, Römer, 1992, 1993; Stephen & Hartley, 1991; Richards & Wiley, 1980; Michelsen & Larsen, 1983; Römer & Lewald, 1992). In their study of the propagation of pure tone bursts of 15 kHz frequency with variable duration (0.5-2 ms, at 100 ms inter-burst intervals), comparable to the ticking songs considered here, Stephen & Hartley (1991) showed that pulses of increased duration propagated better, i.e. the relative amplitudes of the lower frequency segment of the envelope spectrum were increased. At constant duration (1ms), increasing distance results in shrinking of the signal coherence until at $\geqslant 4$ m, only the

15kHz carrier frequency remained coherent. In the case of the *Crotopsalta* ticking songs, the broadband frequencies will presumably offset the predicted degradation effects. A further potential value of the highest frequency components of the ticking pulses is in sound localisation (Gerhardt & Huber, 2002).

The inferred properties of the ticking songs are therefore suggested to represent very flexible recognition signals. Combined with the mobility and small size of the cicadas, these attributes should minimise predation. In fact, field observations suggest that capture in spider webs is perhaps the major predation threat. The pulse repetition rates and pulse structures appear to provide the differential characteristics that are utilised for inter-specific song recognition.

Gagatopsalta gen. nov.

TYPE SPECIES. *Gagatopsalta auranti* sp. nov.

INCLUDED SPECIES. *G. auranti* sp. nov.; *G. obscurus* sp. nov.

ETYMOLOGY. Greek *gagat,* referring to the prominent shiny/jet black appearance of extensive areas of the bodies of the two described species.

DIAGNOSIS. Small cicadas, 10-13.5 mm total body length. Head and thorax broadly 'cylindrical' in form; distance between lateral ocelli similar to distance between lateral ocellus and eye; head width (across eyes) slightly greater than width of pronotum across lateral margins; abdomen cylindrical, gently curving into pygofer in dorsal view; pronotal collar markedly ampliate along lateral margins and outwardly curved; width of pronotum measured from lateral margins similar to width of mesonotum measured between fore wings. Head, thorax and tergites predominantly a distinctive shiny (jet) black, with subordinate orange-brown and/or yellow-orange markings. Rostrum extends to between mid and hind coxae. Wings hyaline, without infuscation; fore wing costal vein even in width to node, with gentle anterior curvature proximal to node; sclerotised anterior area of costal vein narrow, less than costa thickness; intersection of CuA with M veins occurs approximately one third to midway along length of the first vein section (proximal to basal cell) of the M vein (that lies along inner margin of radial cell); the three distal vein sections that make up the inner margins of the radial cell are all of unequal length; 8 apical cells, which are, overall, similar in length to the ulnar cells (some shorter, some longer). Hind wing with 6 apical cells. Operculae weakly elongated with a marked ridge extending longitudinally along anterio-lateral half of each opercula to, and terminating in distal area; rounded along distal to medial margins; meracantha prominent, relatively acutely terminated, extending over distal area of opercula, and located asymmetrically towards midline, near or at the inner margins of operculae; inner margins of opposite operculae widely separated. Abdomen with sternites rounded and mostly projecting below the level of tergites in lateral view. Timbals with five long ribs, ribs 1 to 2 fused ventrally; four short ribs; dome on timbal plate lozenge-shaped, somewhat elongated; distinct basal spur into which ribs 1 to 3 are fused dorsally. Pygofer broadly ovoid when viewed dorsally; upper lobe prominent, extended distally, with rounded termination; lower lobe partially hidden behind upper lobe in lateral view; inner lobe prominent, somewhat rounded and extended ventrally; uncal lobes sharply terminated and extended anteriorly; prominent and rounded median process; beak relatively short and obtusely terminated. Aedeagus trifid with prominent sclerotised pseudoparameres, sharply terminated apically; sclerotised shorter ventral support and poorly sclerotised endotheca.

Gagatopsalta auranti sp. nov.
(Figs 12, 13, 15, 17, 19, 20, 40, Table 3)

Notopsalta sp. H: Ewart, 1998: 64, 65, figs.9A, 14C.

MATERIAL. HOLOTYPE; ♂, QMT99213, Barakula S.F., nr. Chinchilla, S.Q., Virgin brigalow, 15 Dec 1997, 26°14.42'S 150°48.86'E, Ewart, Recorded.

PARATYPES: SOUTHEAST QUEENSLAND: 31♂, 30♀, Brigalow, 1km E Brigalow Township, AE, 22.xii.2001, 26°50.94'S 150°47.83'E; 2♂, 14♀, Brigalow-belah, 'Lakeview', nr. L Broadwater, via Dalby, AE, 20.xii.2001, 27°81'S 151°04.98'E; 27♂, 51♀, Brigalow, L Broadwater, via Dalby, AE, 19.xii.2001, 27°20.42'S 151°05.65'E; 1♂, As previously, Rec spec 1; 1♂, As previously, Rec spec 2; 1♀, 'Allinga' pty, N. Chinchilla, brigalow, AE, 9.i.2002, 26°39.79'S 150°38.06'E; 29♂, 24♀, 'Allinga', Lithgow Rd., Chinchilla, 8.i.1994; 1?, Brigalow Res. Stn., nr. Theodore, NW Brigalow section, 18.xii.2000, AE, 24°47.93'S 149°45.45'E, Rec; 1♂, 5♀, Barakula SF, nr. Chinchilla, virgin brigalow, 15.xii.1997, 26°14.42'S 150°48.86'E, AE; 1♂, As previously, Rec spec 1; 1♂, As previously, Rec spec 2; 3♀, Brigalow Res. Stn., nr. Theodore, E brigalow section, 19.xii.2000, AE, 24°48.85'S 149°47.48'E; 1♂, As previously, Rec **(AE).** 1♀, Kalbar, 17.xii.1998, JM, LWP, MV lamp. 367-0001 **(LWP)**. 1♀, 26°13'S, 150°35'E, Barakula, 23 km NNE, 18.xii.2001, GBM, DC, SW, brigalow, 400m, 10313; 1♂, 25°10'S, 150°01'E, Isla Gorge

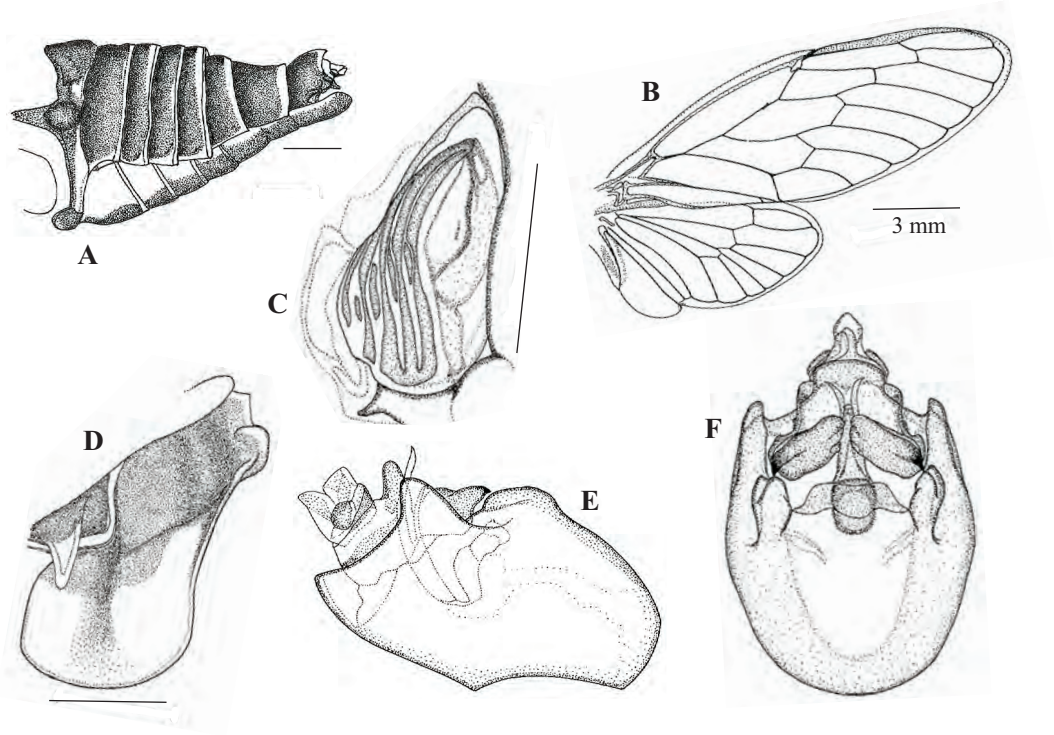

FIG. 12. *G. auranti*. A, Lateral abdomen view; B, fore and hind wings; C, timbal; the right-hand edge as shown represents the posterior margin, the top the dorsal edge; D, opercula; E, and F, lateral and ventral views of pygofer. Pygofer length 2.1mm. Scale bars = 1mm except wings (3mm). Drawings based on specimens from the northern Barakula State Forest, north of Chinchilla, and near Chinchilla (genitalia only).

NP, NE corner, 240m., 3.iii.1998, Mv lamp, CB, SE **(QM)**. 1♂, 1♀, brigalow, L Broadwater, via Dalby, AE 19.xii.2001, 27°20.42'S 151°05.65'E **(BMNH)**. 1♂, 1♀, brigalow, L Broadwater, via Dalby, AE, 19.xii.2001, 27°20.42'S 151°05.65'E **(ANIC)**. 1♂, 1♀, brigalow-belah, 'Lakeview', nr. L Broadwater, via Dalby, AE, 20.xii.2001, 27°81'S 151°04.98'E **(MSM)**.

DIAGNOSIS**.** Given under *G. obscurus* sp. nov.

DESCRIPTION (Male). Figs 12, 40A. *Head.* Supra-antennal plate shiny black with small lanceolate medial, sandy brown fascia, anteriorly pointing, extending from distal margin of plate (between the lateral ocelli), terminating proximally to the anterior ocellus; small discontinuous sandy brown spots extend along the anterior dorsal margin of the plate, adjacent to the postclypeus, but not reaching to the bases of the antennae. Ocelli pink to pale red. Gena and mandibular plate shiny black with conspicuous silver pubescence. Postclypeus dominantly shiny black including transverse ridges, with a very small and short pale sandy brown fascia in medial anterior area, extending in some specimens to the dorsal postclypeal surface as a triangular pale brown area, a narrow but well defined pale sandy brown margin encloses the frons. Anteclypeus shiny black with small dark brown dorso-medial area. Compound eyes dark brown, their outer distal margins clearly separated from pronotum. Rostrum medium brown grading to black apically. Antennae dark brown to black.

Thorax. Pronotum shiny black with small orange-brown central fascia which extends from anterior to approximately one half (or less) the distance to the posterior margin; pronotal collar entirely shiny black. Mesonotum with a pair of anterior short, broad obconical, shiny black paramedial fasciae, completely fused medially, extending from the pronotal collar distally for approximately one quarter of the length towards

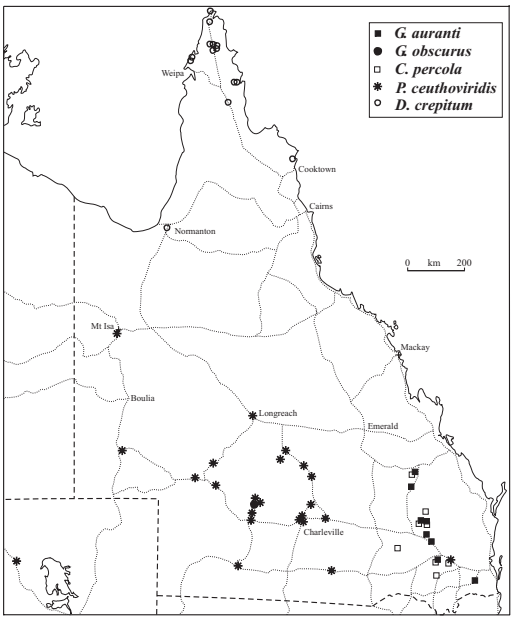

FIG. 13. Distribution records of the five new species of 'chirping' cicadas belonging to the genera *Gagatopsalta, Pipilopsalta, Caliginopsalta,* and *Drymopsalt*a, through Queensland and northeastern South Australia.

the distal margin; extending distally from these fused fasciae is a broad medial black fascia which extends to, and abruptly expands into, the anterior margin of the cruciform elevation; this fascia continues as a dark brown triangular marking across the cruciform elevation, narrowing and terminating at the distal mesonotum margin; a pair of black spots occur between the anterior arms of the cruciform elevation; a pair of broad shiny black lateral fasciae extend distally from the pronotal collar, tapering and subacutely terminated distally, to near but not reaching the anterior cruciform elevation arms; the margins of these fasciae are sharp but crenulated, especially along medial margins; remainder of mesonotum and wing grooves bright orange.

Wings. Fore wings with costa and R+Sc veins bright orange grading to pale brown distally along the R+Sc vein; remaining venation orange-brown proximal to wing bases grading to dark brown apically; basal membrane bright orange; costal vein gently curved; pterostigma with dark reddish-brown infuscation, extending weakly along anterior wing margin towards apex. Hind wing with veins pale orange-brown proximally, grading to medium brown distally; plaga orange which extends along 3A vein; central area of plaga with brown infuscation.

Legs. Coxae shiny black along anterior and lateral edges, changing to orange on and proximal to the trochanters, with additional orange along corners of fore coxae. Fore femora orange with three black spines, and black around and joining the bases of the spines; mid femora orange with broad diffuse brown longitudinal fasciae along lateral margin; hind femora orange. Tibiae and tarsi of fore legs dominantly orange to orange-brown. Pretarsal claws orange to orange-brown with dark brown to black tips.

Operculae. Distal areas orange-brown becoming shiny black proximal to and along medial sutures, and extending across most of the basal part except for the small pale brown crest at the dorsolateral corners; shapes broadly rounded along distal margins, becoming initially relatively linear and then relatively sharply rounded towards and around the medial margins; operculae do not extend to paramedial anterior margin of sternite II, when viewed laterally.

Timbals. Ribs 4 and 5 not fused ventrally to ribs 1-3; rib 4 extends across timbal, while rib 5 extends only partially across timbal.

Pygofer. Refer to generic characters.

Abdomen. Sternites visible in lateral view. Tergites dominantly shiny black with short sparse silver pubescence; tergite 2 with slightly diffuse narrow orange-brown distal margin extending completely across tergite; tergites 3-7 with sharply defined, relatively narrow orange-brown to pale brown distal margins extending completely across each tergite; tergite 8 black, grading to pale brown along paramedial and lateral margins; auditory capsules mainly black with small pale brown ventro-medial areas. Sternite II orange-brown along lateral and paramedial margins, shiny black along anterior margin and medially; sternites III-VII orange-brown laterally, with broad black medial area, each brown along distal edge; the general appearance is of a broad, clearly defined black longitudinal median fascia along abdominal ventral surface; sternite VIII black, grading to pale brown along lateral edges.

FEMALE. Fig. 40B. Colour shiny black and orange, similar to male. Pronotum, mesonotum, wings and leg markings very similar to male. Tergites 3-7 similar to male; tergite 2 shiny black with narrow diffuse orange-brown distal margin,

becoming broader laterally; tergite 8 shiny black with orange-brown distal margin, narrow medially but broadening irregularly laterally; tergite 9 orange-with shiny black medial and anterio-lateral area, narrow black ventral edges, and a prominent black spot disto-laterally; junctions between the black and orange colourations very irregular. Sternites II-VII orange-brown laterally, each with a well defined black medial area which rapidly narrows, and becomes paler proximal to the distal margins; these give the general appearance of a broad black longitudinal fascia extending along the sternites. Ovipositor sheath extends approximately 0.5 mm beyond the distal edge of tergite 9.

MEASUREMENTS. N = 10♂, 10♀. *BL*: ♂ 9.8-12.3 (10.8); ♀ 10.7-12.8 (11.6). *FWL*: ♂ 13.2-15.2 (14.1); ♀ 14.2-16.4 (15.6). *HW*: ♂ 3.6-4.3 (3.9); ♀ 3.9-4.4 (4.2). *PW*: ♂ 3.0-3.7 (3.3); ♀ 3.4-4.0 (3.6). *AW*: ♂ 3.3-4.0 (3.6); ♀ 3.2-4.2 (3.7). *FWL/BR*: ♂ 2.62-2.80 (2.71); ♀ 2.64-2.88 (2.75).

DISTRIBUTION & HABITAT (Fig. 13). Restricted to brigalow (*Acacia harpophylla*) in southeast Queensland. Known locations extend southwards from Isla Gorge National Park to Theodore (Brigalow Research Station) to the Chinchilla-Dalby region, including the Barakula State Forest, and to Kalbar. It is anticipated that its occurrence will extend more widely through the brigalow regions. Emergences most commonly coincide with summer rains during mid December to mid January, with one specimen taken in early March (Isla Gorge). It is an inconspicuous species inhabiting brigalow foliage, normally caught only at light.

ETYMOLOGY. Latin *auranti*, referring to the bright orange colouration, in conjunction with the jet/shiny black, of the body.

Gagatopsalta obscurus sp. nov.
(Figs 13,14,16,18-20, 41, Table 3)

Species B: Ewart & Popple, 2001, 57, 60, 61, figs 3B, 8B.

MATERIAL. HOLOTYPE; ♂, QMT99214, 1km NW Milroy Hstd. ~70 km N. Quilpie, SWQ, Light, Gidyea area, A.E(wart)., I.R(atray)., 13 Jan 2000, 26º02.28'S 144º20.43'E.

PARATYPES: SOUTHWEST QUEENSLAND: 16♂, 20♀, Dam, Milroy Hstd, ~70 km N Quilpie, gidyea, AE, IR, JN, 15.i.2000, 26º02.85'S 144º20.81'S; 4♂, 1♀, Dam, Milroy Hstd, ~70 km N Quilpie, gidyea, AE, IR, JN, 10.i.2000, 26º02.85'S 144º20.81'S; 1♂ As previously, Rec; 17♂, 7♀, Dam, Milroy Hstd, ~70 km N Quilpie, gidyea, AE, IR, JN, 11.i.2000, 26º02.85'S 144º20.81'S; 1♂, As previously, Rec; 7♂,13♀, 1 km NW Milroy Hstd, ~70 km N Quilpie, Light, gidyea area, AE, IR, 13.i.2000, 26º02.28'S 144º20.43'E; 1♂, 1♀, Milroy Hstd, ~70 km N Quilpie, Light, AE, IR, 12.i.2000, 26º02.85'S 144º20.81'E **(AE)**. 1♂, Dam, Milroy Hstd, ~70 km N Quilpie, gidyea, AE, IR, JN, 15.i.2000, 26º02.85'S 144º20.81'S; 1♀, Dam, Milroy Hstd, ~70 km N Quilpie, gidyea, AE, IR, JN, 11.i.2000, 26º02.85'S 144º20.81'S **(BMNH)**. 1♂, Dam, Milroy Hstd, ~70 km N Quilpie, gidyea, AE, IR, JN, 10.i.2000, 26º02.85'S 144º20.81'S; 1♀, Dam, Milroy Hstd, ~70 km N Quilpie, gidyea, AE, IR, JN, 15.i.2000, 26º02.85'S 144º20.81'S **(ANIC)**. 1♂, Dam, Milroy Hstd, ~70 km N Quilpie, gidyea, AE, IR, JN, 15.i.2000, 26º02.85'S 144º20.81'S; 1♀, Dam, Milroy Hstd, ~70 km N. Quilpie, gidyea, AE, IR, JN, 11.i.2000, 26º02.85'S 144º20.81'S **(MSM)**.

DIAGNOSIS. This species is very similar in appearance to *G. auranti*, the two representing sibling species. The following distinguishing characters are considered most significant: (a) The darker and more clearly defined dark median fascia present longitudinally along the abdominal sternites of *G. auranti*. (b) The more prominent broader, orange-coloured distal margin to tergite 2 in *G. obscurus*. (c) Song characteristics (see below). (d) Distribution and habitat. *G. obscurus* occurs in gidyea (*Acacia cambagei)* in southwestern Queensland, while *G. auranti* is currently known only in southeastern Queensland within brigalow and associated woodland communities.

DESCRIPTION (Male). Figs 14, 41A. *Head.* Supra-antennal plate shiny black with small median sandy-brown triangular fascia, anteriorly pointing, extending from the distal margin anteriorly to near, but not in contact with, the anterior ocellus; anterior paramedial margin adjacent to and dorsal to the bases of the antennae sandy-brown. Ocelli pink to pale red. Gena and mandibular plate shiny black with conspicuous silver pubescence. Postclypeus dominantly shiny black with minor pale brown areas between transverse ridges adjacent to dorso-lateral margin; transverse ridges shiny black. Anteclypeus shiny black with small dark brown anterior area. Compound eyes dark brown, with outer distal margin clearly separated from pronotum. Rostrum dark brown, grading to black apically. Antennae black.

Thorax. Pronotum shiny black with pale sandy brown central fascia not quite reaching distal or anterior pronotal margins; a pair of small paramedial pale yellow-brown reniform-like spots adjacent to the anterior margin of the pronotal collar; pronotal collar shiny black

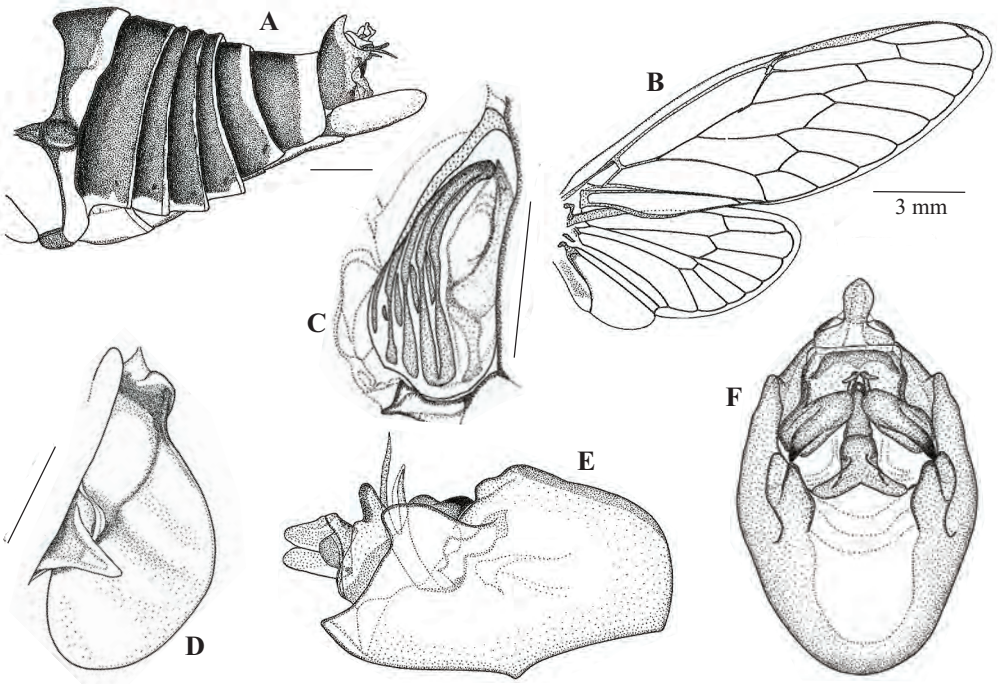

FIG. 14. *G. obscura*. A, Lateral abdomen view; B, fore and hind wings; C, timbal; the right-hand edge as shown represents the posterior margin, the top the dorsal edge; D, opercula; E, and F, lateral and ventral views of pygofer. Pygofer length 2.0mm. Scale bars = 1mm except wings (3mm). Drawings based on specimens from "Milroy" H.S., approximately 70km north of Quilpie.

grading to brown at lateral corners. Mesonotum; a pair of anterior paramedial short obconical shiny black fasciae, fused medially, extending distally from pronotal collar to approximately one quarter of the mesonotum length; extending distally from these fasciae is a broad median shiny black fascia, slightly broadening distally, and terminating near the anterior area of the cruciform elevation where it coalesces with a pair of conspicuous black spots; a pair of broad black lateral fasciae extend distally from the pronotal collar, tapering and rounded distally, terminating near (but not reaching) the cruciform elevation arms; their outline is sharp, but locally crenulated; anterior margin of cruciform elevation dark brown; remaining colouration of mesonotum, including wing grooves and areas between the fasciae, is pale orange.

Wings. Fore wings: Costa and R+Sc veins pale orange-brown to sandy brown colour, grading to orange proximal to mesonotum; CuP vein pale orange-brown; remaining venation shiny medium to dark brown, darker apically; basal membrane orange; pterostigma with reddish infuscation, grading to brown apically and extending as a narrow marginal infuscation towards the apex of the fore wing. Hind wing with 3A vein orange, and 2A, 1A and CuP veins pale brown, remaining venation pale to dark brown, darker distally; plaga opaque white which extends along 3A vein; pale brown infuscation between plaga and adjacent anal cell.

Legs. Coxae shiny black on anterior and lateral edges, changing to orange on and adjacent to the trochanter and along the anterio-lateral margin of the fore coxae. Fore femora orange with three black shiny black spines, the black colour extending around and between bases of spines; mid femora with extensive lateral black to deep brown colour, elsewhere orange; hind femora dominantly orange with thin longitudinal brown fascia anteriorly. Tibiae and tarsi dominantly orange to yellow-orange, darker apically on fore legs. Claws yellow-orange with dark brown to black tips.

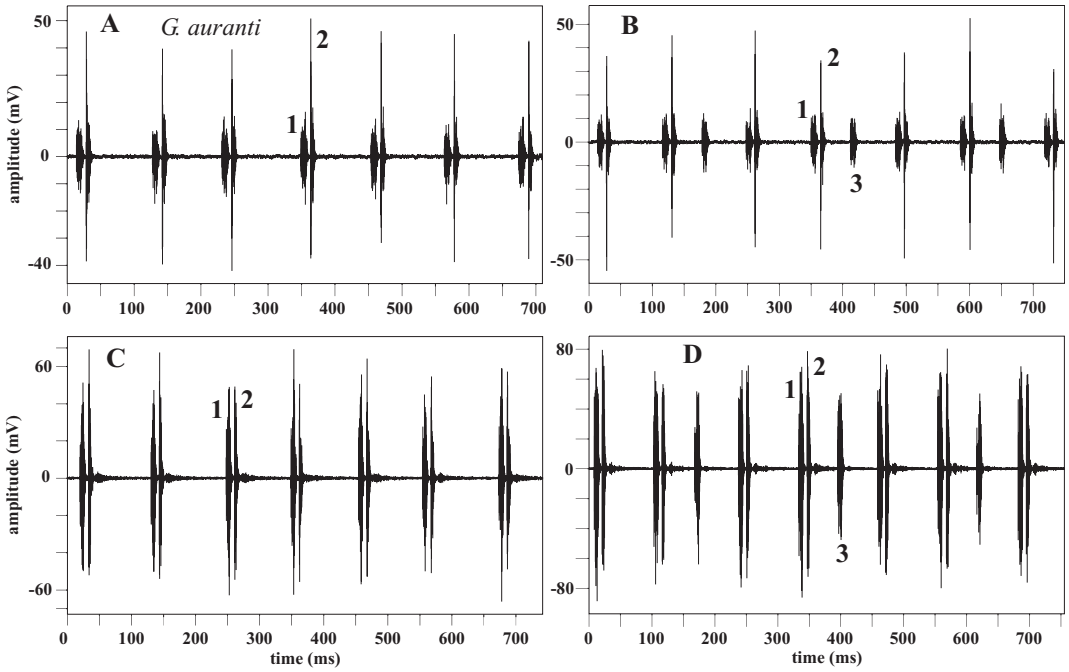

FIG. 15. Waveform plots of songs of *G. auranti* showing: (a) Regular syllable doublets (termed twin syllables; numbered 1 and 2) with no intermediate syllables; (b) the presence of regular twin syllables with alternating intermediate syllables (numbered 3); recording from specimen from Brigalow Research Station, near Theodore. In these records, the second syllable of the twin syllables has higher amplitude than syllable 1. (c) and (d) a similar sequence of twin syllables with no intermediate peak, and twin syllables with alternating intermediate syllables; recorded from Lake Broadwater, near Dalby. In these recordings, the syllables 1 and 2 are of similar amplitude. Each are unfiltered container recordings.

Operculae. Distal areas, extending from medial suture, pale brown; basal parts, including crest around dorso-lateral corners, vary from medium brown to black, the latter especially along the adjacent lateral margins; shapes elongated, domed and ridged, gently rounded outline extending from the lateral, through the distal to the medial margins; operculae just reach the anterior paramedial termination of sternite II, in lateral view.

Timbals. Ribs 3 and 4 not fused ventrally to ribs 1 and 2, but are continuous across timbal; long rib 5 extends only partially across timbal.

Pygofer. Refer to generic characters.

Abdomen. Tergites dominantly shiny black with short-sparse silver pubescence; tergite 2 with a prominent, broad orange distal margin extending completely across tergite; tergite 3 with a narrow, less conspicuous, but continuous orange distal margin; tergites 4-5 have narrow orange-brown to brown distal margins; tergites 6-7 with relatively broader pale orange-brown to medium brown distal margin; tergite 8 grades to a broad orange-brown to brown distal margin which widens laterally; ventro-lateral margins of tergites 3-7 are orange; auditory capsules predominantly shiny black, grading to dark brown centrally. Sternite II pale orange-brown, black medially; sternites III-VII orange-brown, each grading to brown distally; each exhibits the development of a diffuse, dark brown medial area, giving the overall appearance of a narrow but diffuse fascia extending longitudinally along the sternites; sternite VIII black to deep brown ventrally grading to pale brown along lateral margins.

FEMALE. Fig. 41B. General colouration shiny black and orange to orange-brown. Pronotum similar to male, but with narrow orange-brown anterior margin, and central fascia extending anteriorly to anterior margin. Mesonotum similar to male, with the black medial fascia (which

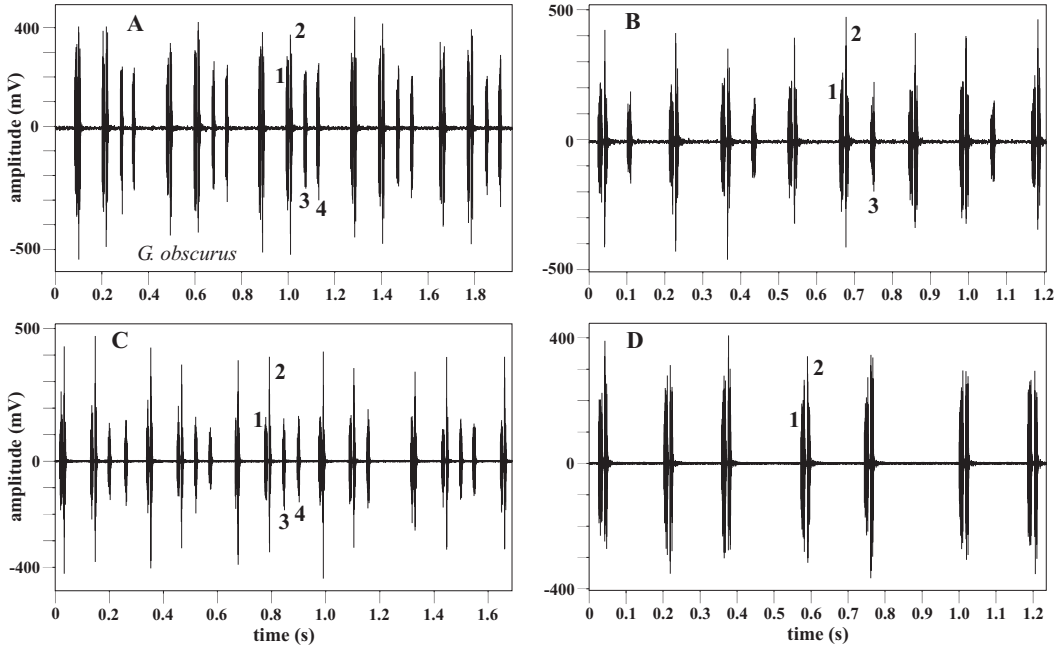

FIG. 16. Waveform plots of songs of *G. obscurus* showing: (a) twin syllables (numbered 1 and 2) with the 'normal' pair of alternating intermediate syllables (numbered 3 and 4); (b) as previously with only a single intermediate syllable (number 3); (c) twin syllables (1 and 2) with two alternating intermediate syllables (3 and 4), and in one instance, a single intermediate syllable; (d) twin syllables with no intermediate syllables. Note the relative differences in amplitudes between the syllables 1 and 2 in (a) to (d), and the relative timing of the intermediate syllables (3 and 4) in (a) and (c). Plots (b) and (d) superficially resemble the *G. auranti* song patterns shown in Fig. 15. Recordings from "Milroy" H.S., approximately 70km north of Quilpie, south-west Queensland, of two separate specimens. Each are container recordings, filtered (FIR) to 1kHz.

extends distally from the paramedial obconical fasciae) broadening abruptly and sharply terminating adjacent to anterior margin of cruciform elevation, which also exhibits a small narrow transverse black fascia. Wings and legs as in male. Tergites 3-7 similar to male, dominantly shiny black grading to deep brown laterally; tergite 2 with relatively broad continuous orange-brown distal margin, becoming progressively broader laterally; tergite 8 orange to orange-brown with narrow shiny black colouration along anterior margin only, broadening slightly medially and laterally; tergite 9 shiny black medially, this extending as a narrow zone anterio-laterally, with a prominent black spot disto-laterally and remaining area orange to orange-brown, slightly darker along ventral margins. Sternites II-VII orange-brown grading darker brown medially, giving overall impression of a weak longitudinal fascia extending along sternites. Ovipositor sheath extends <0.5mm beyond distal margin of tergite 9.

MEASUREMENTS. N = 10♂, 10♀. *BL*: ♂ 11.2-13.4 (12.5); ♀ 11.2-13.0 (12.3). *FWL*: ♂ 14.7-16.0 (15.3); ♀ 14.7-17.0 (16.2). *HW*: ♂ 3.8-4.6 (4.2); ♀ 4.1-4.7 (4.4). *PW*: ♂ 3.5-4.1 (3.7); ♀ 3.7-4.3 (3.9). *FWL/BR*: ♂ 2.69-2.90 (2.81); ♀ 2.78-2.91 (2.83).

DISTRIBUTION & HABITAT (Fig. 13). Known so far only from the area approximately 70km north of Quilpie, southwest Queensland. In this region, it is restricted to gidyea *(Acacia cambagei)* within the flood plain communities, occurring as an inconspicuous, foliage inhabiting species. This species is encountered in small numbers from November to December (aural records), but emerges in relatively large numbers following summer rains, typically during January. The distribution of the species is expected to be much more extensive through south-western Queensland, in flood plain gidyea communities, than is currently known. It is readily captured at light.

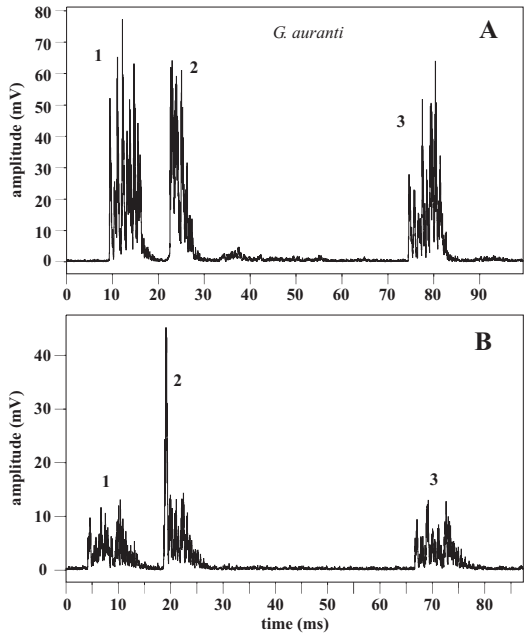

FIG. 17. Expanded time scale envelope curves of *G. auranti* songs showing detail of the twin syllables (1 and 2) and intermediate syllable (3). (a) from Lake Broadwater; (b) from Brigalow Research Station. Note the relative differences in syllable amplitudes. Other details as in Fig. 15.

ETYMOLOGY. Latin *obscurus,* inconspicuous; refers to the general habit and behaviour.

SONG. *G. auranti.* The basic song structure consists of a pair of closely spaced, but quite separate syllables (labelled 1 and 2 in Figs 15, 17) which are here together termed **twin syllables**. These repeat at intervals of 94-161ms (Table 3), the intervals slightly variable between adjacent twin syllable pairs. The intervals between syllables 1 and 2 range between 13-20ms, while the syllable lengths are 9.6-13.5ms (syllable 1), and 7.3-10.4ms (syllable 2). Relative amplitudes of the twin syllable pairs are variable (Figs 15, 17).

The major variation is the insertion of a third (labelled 3, Figs 15, 17) intermediate syllable alternately between the sets of twin syllables (1 + 2). This exerts a strong control on the intervals between each twin syllable (1 + 2), which vary between 94-128ms (no syllable 3 present) and 122-161ms (syllable 3 present). Syllable 3 has a structure and duration identical to syllable 1. The spacing of syllable 3 is asymmetric, as shown by the inter-syllable intervals of 46-69ms (i.e. between syllables 2 and 3) compared to 122-161ms between successive twin syllable pairs. Expanded envelope curves of syllables 1 and 3 (Figs 17, 19) resolve six to nine distinct hemisyllables, each with mean lengths between 0.50-0.66ms. The initial hemisyllable commonly exhibits a small but distinct separation from the immediately following hemisyllables. Syllable 2 has a structure distinct from syllables 1 and 3, comprising four to six hemisyllables, some of markedly reduced amplitude. Hemisyllable lengths range between 0.78-1.0ms, the first typically exhibiting greatest amplitude, the following syllables generally decreasing in amplitude.

Amplitude spectra (Fig. 20A) exhibit a complex series of relatively broad peaks, the maximum frequency lying between 14.8-15.0kHz, but with associated peaks at ~15.8 and 14.0-14.2kHz, and clearly defined lower frequency peaks at ~13.5, 13.0, 12.1, 10.7 and 7.7kHz. The width of the peaks, together with the concentration of dominant peaks between ~14 to 17kHz reflects the contrasting scales and

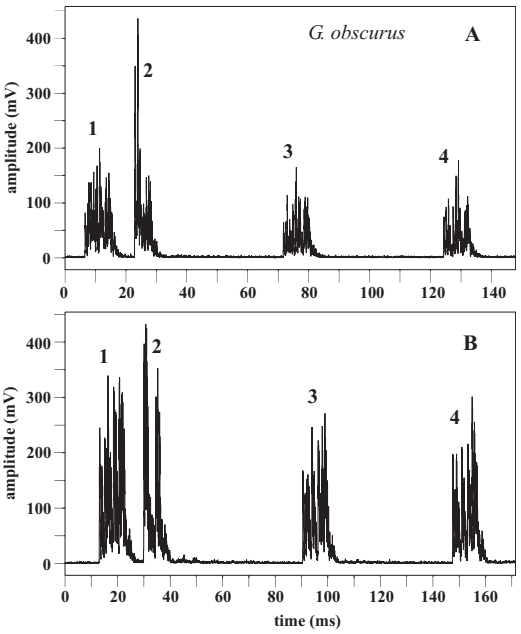

FIG. 18. Expanded time scale envelope curves of *G. obscurus* songs showing detail of the twin syllables (1 and 2) and the two intermediate syllables (3 and 4). Note the relative amplitude differences between the two separate songs. Other details as in Fig. 16.

TABLE 3. Comparison of song parameters between *G. auranti* and *G. obscurus*. [(1)]Based on data from three localities; Brigalow Research Station, near Theodore; Lake Broadwater, near Dalby; Barakula State Forest, north of Chinchilla. (2) Shown as ranges and means (in parentheses)

	G. auranti[(1)]	*G. obscurus*
Intervals between twin syllable sets (ms):		
(a) No intermediate syllables (4 and/or 3) present:	97-139 (117)[(2)]	135-281 (182)[(2)]
(b) Alternating intervals with intermediate syllables:		
(i) Interval without intermediate syllables	94-128 (105)	109-143 (121)
(ii) Interval with syllable 3 (only) present	122-161 (137)	172-256 (197)
(iii) Interval with syllables 3 and 4 present	-	189-284 (231)
Inter-syllable intervals (ms):		
(a) Syllables 1 to 2	12.9-20.4 (16.0)	16.6-17.4 (16.9)
(b) Syllables 2 to 3	46.3-69.1 (55.1)	46.5-60.4 (54.0)
(c) Syllables 3 to 4	-	49.3-58.9 (53.5)
Syllable lengths (ms):		
(a) Syllables 1	9.6-12.0 (11.2)	12.5-13.5 (3.2)
(b) Syllables 2	7.3-10.4 (8.2)	8.9-10.3 (9.8)
(c) Syllables 3	9.7-12.1 (11.1)	11.8-15.6 (13.6)
(d) Syllables 4	-	12.1-15.1 (13.4)
Inter-hemisyllable durations (syllables 1, 3 ± 4):	0.37-2.19 (1.18)	0.82-2.31 (1.46)
Hemisyllable lengths (excluding tails) within syllables 1, 3 ± 4 (ms):	0.25-0.97 (0.56)	0.40-1.35 (0.86)
Mean twin syllable (1, 2) repetition rates (s^{-1}):		
(a) No intermediate syllables (4 and/or 3) present	8.5	5.5
(b) Alternating intervals with intermediate syllables:		
(i) Intervals without intermediate syllables	9.5	8.3
(ii) Intervals with syllable 3 (only)	7.3	5.1
(iii) Intervals with syllables 3 and 4	-	4.3
Mean frequency of dominant spectral peak (kHz):	14.8	16.6

variability of the component syllable and hemisyllable structures, together with the complexity of the fundamental carrier waves. The existence of the multiple spectral peaks is thought to reflect the relative importance and configuration the main sound radiation structures, as noted for the *Crotopsalta* cicadas, namely timbals, tympana and abdomen (Fonseca & Popov, 1994; Fonseca & Bennet-Clark, 1998). The complex peaks broadly centred at ~14.2-15.8kHz could represent side bands centred on the main carrier frequency at ~15kHz, i.e. amplitude modulations (~0.8kHz) with lengths of ~1.25ms. This is similar to the observed mean inter-hemisyllable lengths (syllables 1, 3) of 1.18ms (Table 3). Comparison of the spectra of individual syllables 1 and 3 indicates very similar frequency peak distributions as in the overall combined spectra (Fig. 20A), whereas individual syllable 2 spectra, although showing the similar grouping of peaks in the same maximum frequency ranges, indicate stronger development (i.e. higher amplitudes) of the lower frequency peaks between 7.5-213kHz.

G. obscurus. The basic song structure is close to *G. auranti*. The critical difference is the insertion of a second intermediate syllable (labelled 4, Figs 16, 18) between the twin syllable (1+2) sequences. The syllables 3 and 4 again are only inserted alternately between the twin syllable (1 + 2) sequences, which is reflected in differing intervals between the twin syllable pairs (Table 3). Aurally, the resulting song sounds remarkably similar to the 'clip-clop' of a galloping horse.

Nevertheless, during the initial stages of singing, the song commonly lacks both intermediate syllables (3 and 4), then followed by the insertion of a single intermediate syllable (3) asym- metrically and alternately between the twin syllable (1+2) pairs (Fig. 16B,D). These initial songs look superficially identical to the *G. auranti* song, but in detail, the intervals between the twin syllable pairs differ (Table 3). Nevertheless, inter-syllable intervals between

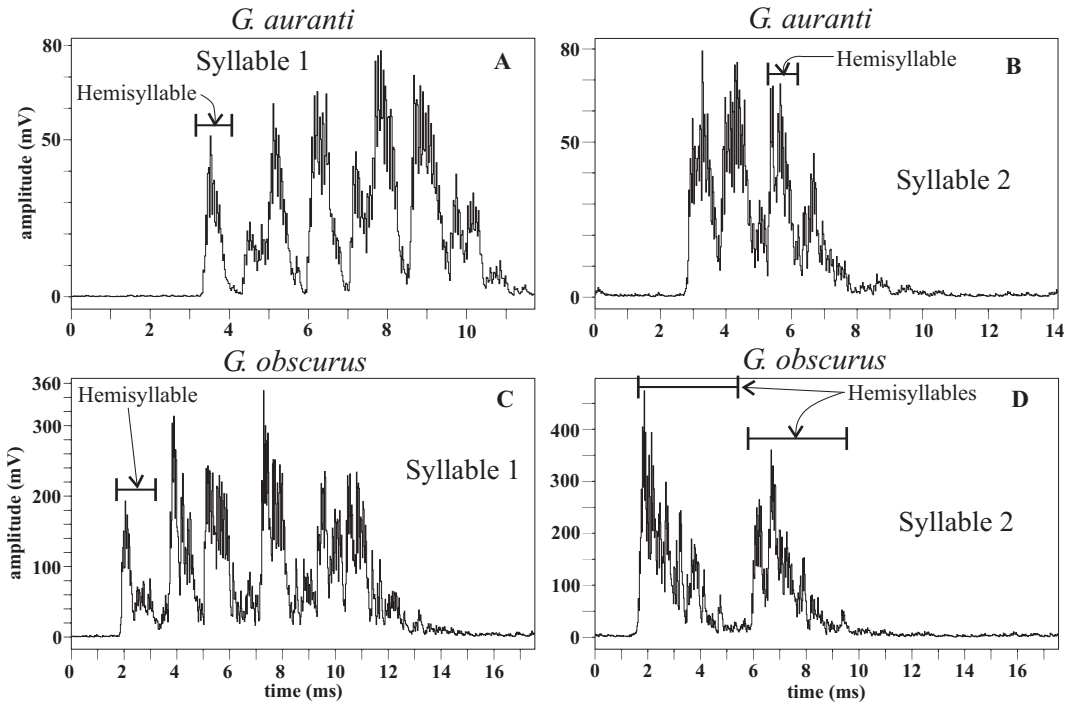

FIG. 19. Further expanded envelope curves of (a), (b), the twin syllables 1 and 2 of the *G. auranti* song showing detailed hemisyllable structures, from Lake Broadwater; (c), (d) hemisyllable structures within the twin syllables 1 and 2 of the *G. obscurus* song; recorded from "Milroy" H.S., southwest Queensland. In plots (a) to (c), only selected hemisyllables are labelled.

1-2, and 2- 3, of *G. auranti* and *G. obscurus* songs completely overlap, as do the intervals between syllables 1-3. The relative amplitudes of syllables 1 and 2 are variable in *G. obscurus*, as in *G. auranti*. In *G. obscurus*, the structures and lengths of syllables 1, 3 and 4 are equivalent, but differ from syllable 2 (as in *G. auranti*).

Higher resolution expanded envelope curves of syllable 1 (Figs 18, 19; also relevant to syllables 3 and 4), reveal 5-9 distinct hemisyllables whose mean lengths range between 0.4-1.35ms. Syllable 2 is shorter than syllables 1, 3 and 4 (Table 3), consistent with *G. auranti* data, and comprises 2 clearly defined hemisyllables each ranging in total duration (including tail) of 2.5-4.3ms. In some data sets, the hemisyllable doublets of syllable 2 are complicated by superimposed shorter (higher frequency) hemisyllables ranging in length 0.8-1.7ms, comparable to those within syllables 1, 3 and 4. Amplitude spectra (Fig. 20B) are dominated by a series of complex peaks between ~15.8-17.2kHz, with broad, lower frequency peaks at ~14.9, 14.2, 13.6, 11.4-12.7, and 7.5kHz. The complexity and width of the peaks is again attributed to the variable and complex structures and lengths of the syllables and the hemisyllables. The frequency maxima feasibly incorporates two side bands centred near 16.6kHz, representing modulation rates of approximately 0.6-0.8kHz, corresponding to ~1.3-1.7ms, similar to the observed inter-hemisyllable intervals of 0.8-2.3ms. Compared to the *G. auranti* spectra, that of *G. obscurus* differs mainly in respect to the higher frequency maxima (although the potential effect of temperature differentials cannot be excluded).

Comparison of the amplitude spectra of the individual syllables 1, 3 and 4 indicate frequency peaks that are closely comparable to the spectra of the broader song pattern (Fig. 20B). Individual syllable 2 spectra exhibit similar frequency peaks, but differ in the relatively higher amplitudes of peaks in the 13.6-14.7kHz range.

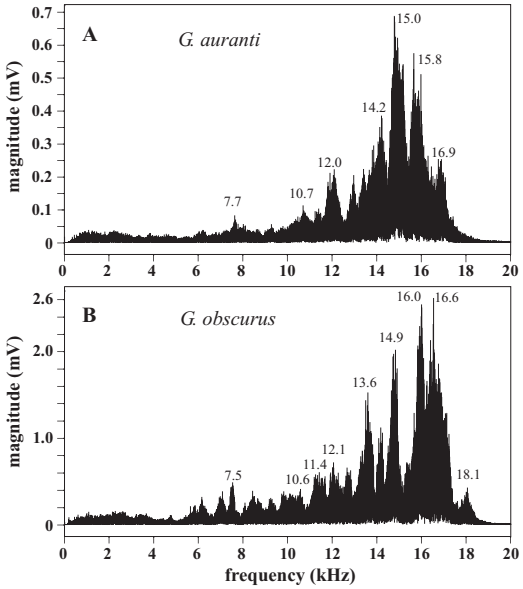

FIG. 20. Comparison of amplitude spectra of : (a) *G. auranti* song from Lake Broadwater, and (b) *G. obscurus* song from "Milroy" H.S., southwest Queensland. The frequencies of the main peaks are labelled (kHz). Both spectra based on 1.65s of song. Recordings filtered (FIR) to 0.5kHz.

The wide range of frequency seen in the spectra is similar to that of *G. auranti*, and again is thought to reflect the relative importance, efficiency and configuration of the sound radiating structures responsible for the multiplicity of frequency emission (Fonseca & Popov, 1994; Fonseca & Bennet-Clark, 1998).

Given the many similarities between the songs (and morphology) of *G. auranti and G. obscurus*, similarity between their respective timbal structures is expected (Figs 12C, 14C). The only obvious difference concerns the ventral fusion of ribs 1-3 in *G. auranti* compared to only ribs 1 and 2 in *G. obscurus*. It seems possible that the additional syllable (4) in the latter species might correlate with the difference in long rib 3 configuration, but this can only be evaluated by physiological studies.

Caliginopsalta gen. nov.

TYPE SPECIES. *Caliginopsalta percola* sp. nov.

INCLUDED SPECIES. *C. percola* sp. nov.

ETYMOLOGY. Latin *caligin,*dark and/or obscure, a reference to the obscure habitat and habits of the type species.

DIAGNOSIS. Small cicada, 10.5-13 mm total body length (type species). Head width including eyes greater than pronotum width across lateral margins; distance between lateral ocelli similar to distance between lateral ocellus and eyes; width of pronotum measured from lateral margins similar to width of mesonotum between fore wings; pronotal collar moderately ampliate along lateral margins and outwardly curved; abdomen tapered evenly to pygofer in dorsal view; sternites strongly rounded and clearly visible in lateral view. General colour of body pale sandy brown, brown to chestnut brown and black. Rostrum extends to anterior margins of hind coxae. Wings hyaline; fore wing with eight apical cells which are, overall, similar in length to ulnar cells (some shorter, some longer); costal vein equal in width to node with very gentle anterior curvature proximal to node; sclerotised anterior margin of costal vein narrow and less than vein width; intersection of CuA with M veins veins occurs approximately one third of distance along first vein section (proximal to basal cell) of M that makes up the inner radial cell margin;. length of the three distal vein sections that make up the inner margin of the radial cell are unequal, but not strongly so. Hind wing with six apical cells; distinctive brown infuscation fills the central area of the plaga and occurs within the anal lobe adjacent to the 3A and the 2A veins, extending to, and widening towards the distal wing margin of the 2A vein. Operculae rounded along distal and medial margins; gently domed and ridged; meracantha normal and located strongly asymmetrically within operculae towards midline; inner margins of operculae widely separated. Timbals somewhat extended anteriorly in shape; 5 long ribs, with ribs 1-4 fused ventrally; 3 prominent short ribs, plus 2 very small remnant(?) ribs between long ribs 2 and 4; dome on timbal plate narrow and laterally tapering; basal spur prominent and fused to long ribs 1-3. Pygofer: ovoid in general shape in dorsal view, but unusually broad in lateral view; upper lobe prominent with rounded termination, lower lobe small with rounded termination and no clearly defined inner lobe; prominent median process, uncal lobes curved, anteriorly pointing and sharply terminated at apices; well defined and gently curved beak; aedeagus trifid with a pair of dorsal, sclerotised

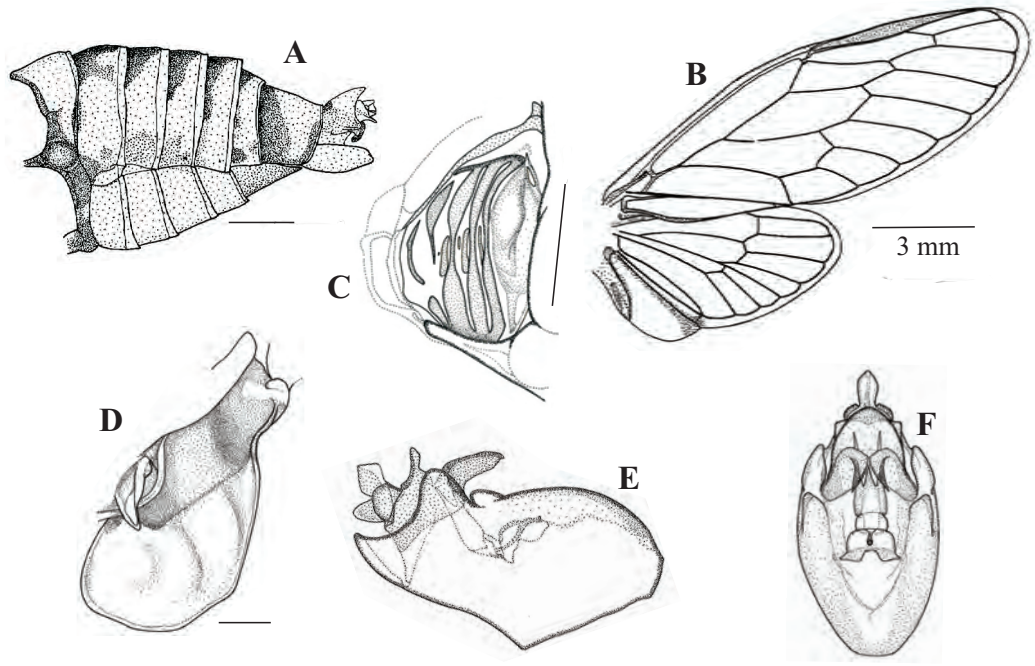

FIG. 21. *Caliginopsalta percola*. A, Lateral abdomen view; B, fore and hind wings; C, timbal; the right-hand edge as shown represents the posterior margin, the top the dorsal edge; D, opercula; E, and F, lateral and ventral views of pygofer. Pygofer length 1.8mm. Scale bars represent 1mm except wings (3mm). Drawings based on specimens from the northern Barakula State Forest, north of Chinchilla.

pseudoparamers of similar length to ventral support; poorly sclerotised endotheca.

Caliginopsalta percola sp. nov.
(Figs 21-24, 42, Table 4)

Notopsalta Species D: Ewart, 1988, 183, 184, 191, 195, plate 4F; 1998, 64, 69, figs 9B, 13A.

MATERIAL. HOLOTYPE; ♂, QMT99215, Barakula S.F., nr. Chinchilla, S.Q., virgin brigalow, 15 Dec 1997, 26º14.42'S 150º48.86'E, Ewart.

PARATYPES: SOUTHEAST QUEENSLAND: 1♂, 1♀, Brigalow Res. Stn., nr. Theodore, E brigalow section, belah, 21.xii.2000, AE, 24º48.54'S 149º47.54'E; 1♂, Brigalow Res. Stn., nr. Theodore, E brigalow section, belah, 20.xii.2000, AE, 24º48.54'S 149º47.54'E, Rec spec 1; 1♂, As previously, Rec spec 2; 4♀, Brigalow Res. Stn., nr. Theodore, E brigalow section, belah, 20.xii.2000, AE, 24º48.54'S 149º47.54'E; 11♂, 10♀, Brigalow-belah, "Lakeview', nr. L Broadwater, via Dalby, AE, 20.xii.2001, 27º20.81'S 151º04.98'E; 7♂, 8♀, Barakula SF, nr. Chinchilla, virgin brigalow, 15.xii.1997, 26º14.42'S 150º48.86'E, AE; 1♂, As previously, Rec spec 3; 1♂, As previously, Rec spec 2; 1♂, 2♀, L Broadwater, ~30 km SW Dalby, brigalow, 20.xii.1987, JM; 2♂, L Broadwater, ~30 km SW Dalby, brigalow, 20.xii.1987, JM, (*Notopsalta* species D, Ewart 1988); 3♂, 2♀, Brigalow, L Broadwater, via Dalby, AE, 19.xii.2001, 27º20.42'S 151º05.45'E; 1♂, As previously, Rec **(AE).** 3♂, Myall Park, 8 km N. Glenmorgan, 27-28.xii.2001, Mv lamp, LWP, AS, 359-0003-006; 1♂, Myall Park, 8 km N. Glenmorgan, 27-28.xii.2001, Mv lamp, LWP, AS, On minidisc, LWP, 359-0003,-0006; 1♂, 1♀, L Broadwater, via Dalby, 21.xii.1987, JM,. MV lamp, 359-0001-0002; 1♂, 27º45'S 151º13'E, 5km W Milmerran, 10.i.2004, LWP, RM; 3♂, 27º23'10"S 151º36'43"E, Jondaryan district, 5.ii.2005, *Casuarina cristata*, LWP, 359-00008 to 0010 **(LWP).** 1♀, 26º13'S, 150º35'E, Barakula, 23 km NNE, 18.xii.2001, GBM, DC, SW, brigalow, 400m, 10313; 8♂, 9♀, 26º04'S, 150º49'E Wonga Hills, site 3, 520m, 11.xii.2001, 10257 GBM, DC, SW, MV light, vine scrub **(QM)**. 1♂, 1♀, Brigalow, L Broadwater, via Dalby, AE, 19.xii.2001, 27º20.42'S, 151º05.45'E **(BMNH)**. 1♂, 1♀, Brigalow-belah, "Lakeview', nr. L Broadwater, via Dalby, AE, 20.xii.2001, 27º20.81'S, 151º04.98'E **(ANIC)**. 1♂, 1♀, Brigalow-belah, "Lakeview', nr. L Broadwater, via Dalby, AE, 20.xii.2001, 27º20.81'S, 151º04.98'E **(MSM)**.

DESCRIPTION (Male). Figs 21, 42A. *Head.* Supra-antennal plate pale sandy brown with irregular but continuous black colouration covering much of the central dorsal area, also enclosing each ocellus, and extending as narrow

fingers towards the anterior margin of the eyes and around the anterior postclypeal surface; a pale sandy brown, short, lanceolate fascia lies between the two posterior ocelli, extending and narrowing anteriorly towards, but not reaching the anterior ocellus; it extends distally to the pronotal margin and continues as the pronotal central fascia; a pair of small elongated ovoid castaneous areas extend obliquely from near the inner margin of the posterior ocelli towards the lateral dorsal postclypeus margin. Ocelli pink. Gena pale sandy brown with oblique black fascia lying between the eyes and mandibula plate; mandibula plate dominantly black. Postclypeus with pale brown dorso-medial area which continues to the dorsal surface, and with the pale brown anterior marginal zone of the frons; the transverse ridges and central region of frons black, the transverse ridges grading to pale sandy brown laterally. Anteclypeus pale sandy brown dorsally, black on ventral segment. Compound eyes dark brown to black. Rostrum pale sandy brown adjacent to anteclypeus, grading dark brown to black apically. Antennae dark brown.

Thorax. Pronotum dominantly castaneous with pale sandy brown central fascia which tapers irregularly towards, but not reaching the pronotal collar; the fascia is enclosed laterally and distally by a thin black envelope which flares outwards distally, the medial part just reaching the pronotal collar; a broadly triangular pale sandy brown area extends outwards from near the distal termination of the central fascia adjacent to the pronotal collar, narrowing and terminating paramedially; very irregular and broken black colouration occurs along, adjacent to, and between the anterior and posterior oblique fissures, further extending around the lateral pronotal margin between the posterior oblique and ambient fissures; pronotal collar, and the narrow anterior pronotal margin, are pale sandy brown. Mesonotum with a pair of black paramedial obconical fasciae, not fused medially, extending distally from anterior margin approximately a quarter of the mesonotum length; a pair of broad lateral black fasciae, very irregular and broken in form and outline, tapering distally, terminally rounded which terminate adjacent to the outer anterior margins of the anterior cruciform elevation arms; a pair of conspicuous black spots lie adjacent to the inner margins of the anterior arms of the cruciform elevation; the latter is pale yellow brown; remaining mesonotum colour and wing grooves pale sandy brown, grading to pale brown medially.

Wings. Costa and R+Sc veins pale sandy brown, tending translucent in costa; venation grades from pale sandy brown adjacent to basal cell to brown and dark brown apically; pterostigma with pale brown infuscation, extending slightly towards wing apex; basal membrane off-white to pale brown. Hind wing; venation pale brown grading to darker brown distally; plaga opaque offwhite, extending along both margins of 3A vein.

Legs. Coxae and trochanters pale sandy brown with well defined deep brown to black areas on their anterior and lateral edges. Fore femora pale sandy brown with broad longitudinal brown fasciae on outer lateral edges; three deep brown to black spines, the dark colouration extending between the bases of the spines; inner margins with more extensive brown colouration except for pale sandy brown central and dorsal areas; mid and hind femora pale sandy brown with longitudinal brown fasciae along margins. Tibiae pale sandy brown grading distally to dark brown. Tarsi and tarsal claws medium to pale brown.

Operculae. Relatively linear lateral margins, gently curving around distal margins, more sharply curved along medial margins; colour dominantly pale sandy brown with localised black areas adjacent to mercantha and adjacent to, but not including the crest in the distolateral corners of basal areas; gentle ridge extending distally from basal parts of operculae and narrowing towards, and terminating near distal margins. Meracantha prominent, subacutely terminated, extending above the disto-medial areas.

Timbals. Rib 4 discontinuous medially and rib 5 not extending completely across timbal.

Pygofer. Pale brown with small anterior paramedial black triangular marking, adjacent to tergite 8. See generic characters for detail.

Abdomen. Tergite 2 pale sandy brown to pale brown, with narrow black anterior margin extending to, and around the auditory capsules; tergites 3-7 pale sandy brown laterally, grading to pale reddish brown medially; black areas occur dorso-medially, each extended paramedially along anterior margins, tapering (somewhat irregularly) distally, and terminating at distal margins (excluding intersegmental membranes); poorly defined pale brown to brown markings occur ventro-laterally, darker on the more distal tergites, but variable between specimens; tergite 8 with black to dark brown area extending as a

narrow dorsal fascia, widening across the lateral and ventro-lateral area, the remaining area pale brown to pale reddish brown; auditory capsules black, grading to deep brown centrally. Sternite II black to deep brown; sternites III-V uniformly pale sandy brown, becoming paler brown on sternite VI; sternites VII and VIII medium to dark brown.

FEMALE. Fig. 42B. Similar markings to male with general reduction in extent of areas of black colouration. Supra-antennal plate dominantly pale sandy brown with diffuse and broken black areas around ocelli extending to lateral margin of dorsal surface of postclypeus. Postclypeus pale sandy brown; frons with central region mostly black, becoming paler dorsally; transverse ridges black medially. Gena and mandibular plate with reduced areas of black. Pronotum similar to male, but with smaller patterns of black colouration associated with the oblique fissures and lateral margin; broad central fascia pale sandy brown enclosed by brown envelope, otherwise similar to male; remaining pronotum pale brown. Mesonotum with medium to dark brown lateral fasciae, each grading black distally; their outlines similar to male, but the paramedial fasciae much reduced in size medially; the pair of spots adjacent to inner margin of anterior arms of cruciform elevation deep brown; remaining mesonotum pale sandy brown. *Wings* as in male. *Legs.* Coxae pale sandy brown each with broad wedge-shaped, deep brown to black anterior longitudinal fasciae, and narrow dark lateral dorsal edge. Femora pale sandy brown with diffuse brown longitudinal fasciae along anterior and distal edges; fore femora with three deep brown to black spines. Tibiae pale brown to pale sandy brown, darkening distally. Tarsi pale to medium brown, darker distally; claws dark brown. Tergites 2 to 9 chestnut brown medially, grading to pale brown paramedially and laterally; anterior medial areas of tergites 4-7 dark brown, grading distally to chestnut brown; distal edges and intersegmental membranes of tergites 3-7 dull yellow-brown; tergite 8 with prominent and relatively broad paramedial and lateral deep brown to black transverse fasciae, lying adjacent to tergite anterior margin; tergites 4 to 7 with very diffuse, slightly darker brown areas lying ventro-laterally; tergite 9 with a pair of broad paramedial deep brown to black fasciae extending approximately two-thirds towards distal margin of tergite, and a prominent dark spot at each disto-lateral margin. Sternites II to VI uniformly pale sandy brown; sternite VII with short dark oblique paramedial fasciae either side of ovipositor sheath entry. Ovipositor sheath extends ≤0.5 mm beyond tergite 9.

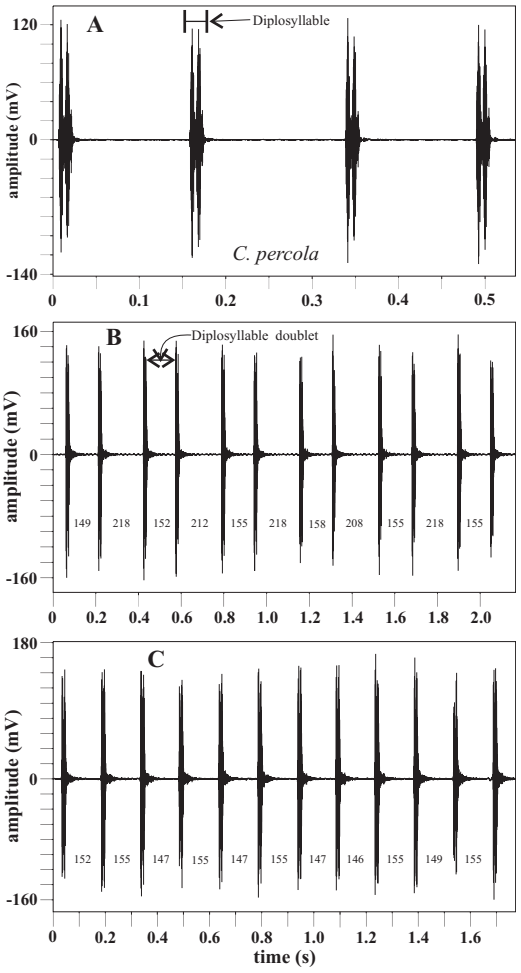

FIG. 22. Waveform plots of the *C. percola* songs. (a) Four sets of diplosyllables showing the double syllable structures; (b) the 'uneven' diplosyllable spacings with alternating short and longer inter-diplosyllable intervals, observed most commonly late in song sequences; (c) the 'even' diplosyllable spacing, in which subtle alternations of fractionally shorter and longer inter-diplosyllable intervals are still evident. The timing of the intervals is indicated in ms. Recording (a) from Brigalow Research Station, near Theodore; recordings (b) and (c) from Lake Broadwater, near Dalby. Unfiltered container recordings.

TABLE 4. *Caliginopsalta percola* -summary of song parameters from three locations. [(1)]Poorly defined in records from this locality. [(2)]These figures represent selected segments from recordings illustrating 'even' and 'uneven' intervals. The two sets of figures in each data set represent the averaged lengths of adjacent inter-diplosyllable intervals.

	All data	Barakula State Forest	Brigalow Research Stn.	Lake Broadwater
Mean diplosyllable repetition rates (s^{-1}, ± ó);				
Mean	6.4±0.7(n=19)	6.4±1.2 (n=6)	6.5±0.4(n=8)	6.2±0.5(n=4)
Minimum	4.1	4.1	6.0	5.4
Maximum	7.7	7.7	7.1	6.6
Diplosyllable lengths (excluding pre-diplosyllable 'disturbance') -(ms)	17.0±0.85(n=8)	-	15.9-16.6(n=4)	17.2-18.4(n=4)
First syllable length (including tail) -(ms)	8.2±0.60(n=8)	-	7.4-7.7(n=4)	8.5-9.0(n=4)
First syllable length (excluding tail) -(ms)	4.4±0.34(n=8)	-	4.3-4.8(n=4)	3.8-5.0(n=4)
First syllable -				
(i) First hemisyllable length -(ms)	2.5±0.79(n=5)		2.1-2.8(n=4)	2.0[(1)] (n=1)
(ii) Second hemisyllable length -ms	2.0±0.75(n=5)	-	0.65-2.4(n=4)	2.2[(1)] (n=1)
Second syllable length (including tail) -(ms)	8.7±0.44(n=8)	-	8.1-8.9(n=4)	8.3-9.3(n=4)
Second syllable length (excluding tail) -(ms)	4.6±0.54(n=8)	-	4.2-5.0(n=4)	3.4-5.2(n=4)
Second syllable -				
(i) First hemisyllable length - (ms)	2.3±0.30(n=5)	-	2.3-2.6(n=4)	1.9[(1)] (n=1)
(ii) Second hemisyllable length -(ms)	2.3±0.23(n=5)	-	1.6-2.8(n=4)	2.7[(1)] (n=1)
Preliminary pre-diplosyllable 'disturbance'-(ms)	0.87±0.30(n=8)	-	0.59-0.94(n=4)	0.64-1.5(n=4)
Inter-diplosyllable intervals -(ms)				
(i) 'Even' intervals (earlierin songs)[(2)]	- -	137±3/132±1 254±11/249±14	162±6/157±2 155±1/155±1	148±2/155±3 155±3/160±2 147±1/152±3
(ii) 'Uneven' intervals (later in songs)[(2)]	-	129±2/165±6 129±3/177±3	155±2/172±2	154±3/215±5

MEASUREMENTS. N = 10♂, 10♀. *BL*: ♂ 10.5-11.7 (11.1); ♀ 10.9-13.0 (12.0). *FWL*: ♂ 12.7-14.2 (13.5); ♀ 14.1-15.5 (15.0). *HW*: ♂ 3.5-3.7 (3.6); ♀ 3.7-4.1 (3.9). *PW*: ♂ 3.0-3.3 (3.2); ♀ 3.3-3.6 (3.4). *AW*: ♂ 3.2-3.4 (3.3); ♀ 3.2-3.6 (3.4). *FWL/BR*: ♂ 2.75-2.99 (2.86); ♀ 2.86-3.06 (2.94).

DISTRIBUTION & HABITAT (Fig. 13). An inconspicuous cicada restricted to both disturbed and undisturbed brigalow forest communities. It has a preference for belah (*Casuarina cristata*) within these communities, inhabiting the inner branches and foliage environments. Known locations are all in southeastern Queensland, including Jondaryan, Lake Broadwater near Dalby; the Barakula State Forest north of Chinchilla; Myall Park near Glenmorgan; near Millmerran; and the more northern area of Isla Gorge National Park and extending northwest of Theodore. The distribution is expected to occur more widely within the southern-central Queensland brigalow belt. All records are for mid to late December.

ETYMOLOGY. Latin *percol(a),* dusky, a reference to the appearance of this species in its natural habitat.

SONG (Figs 22-24). Aurally, this consists of monotonously repeated ticks (Fig. 22A-C). In time expanded waveform plots (Fig. 22A), the 'ticks' are each resolved into discrete complex double syllables, each doublet here termed a **diplosyllable**. This term is applied as each is believed to represent an unbroken single cycle of 'in-out' buckling movements of the timbals. Diplosyllable mean repetition rates (Table 4) are similar for the three localities studied, ranging between approximately 4-8s^{-1}. In detail,

however, significant variability is evident. The repetition rates in fact vary from nearly even diplosyllable-diplosyllable intervals to clearly uneven intervals, the latter nevertheless exhibiting regular alternations of what are effectively 'diplosyllable doublets' (Fig. 22B; Table 4). These sequences of uneven intervals seem to occur most often towards the end of an extended song phase. The diplosyllable sequences with relatively 'even' inter-echeme intervals, however, frequently also have small, but regular variations in their alternating inter-diplosyllable intervals (Fig. 22C). Lengths of the individual diplosyllables range between 15.9 - 18.4ms.

Higher resolution envelope curves (Fig. 23A,B) reveal that each syllable comprising the diplosyllable doublets have lengths of 7.4-9.3ms (including peak tails). Each syllable is further resolved into two complex hemisyllables, best developed in the Brigalow Research Station songs (Fig. 23B), although less clearly defined in the Lake Broadwater data. The hemisyllable lengths (excluding tails) range between 1.5-2.8ms, averaging between 2.0-2.5ms (equivalent to approximately 400-500Hz). Both the syllables and hemisyllables have sharply defined initiations as well as cessations, although typically followed by a low amplitude tail. The hemisyllables comprise clearly recognisable smaller (higher frequency) pulses, considered to represent the carrier waves (Fig. 23A,B).

An unusual feature present within the diplosyllable structures is the presence of a short, low amplitude, subdued 'pre-diplosyllable disturbance' with a length of 0.59-1.5ms (equivalent to approximately 667-1695Hz). In some records (Fig.23A,B), the 'pre-diplosyllable disturbances' are themselves preceded by a very weak but distinct disturbance of the background waveform which have durations of approximately 1-1.5ms. Equivalent disturbances are not recognised preceding the second syllable within each diplosyllable. It is suggested that they may represent an initial response of the buckling of the 2 'extra' short ribs between ribs 2-3 and 3-4, noted below. The occurrence of comparable 'pre-syllable disturbances' has not been observed in the songs of any other small Queensland cicada species.

The timbals of this species (Fig.21C) exhibit the fusion of ribs 1-3 both dorsally (to basal spur) and ventrally (suggesting that they buckle in unison), while rib 4 (discontinuous medially) is fused only ventrally to ribs 1-3. Two additional

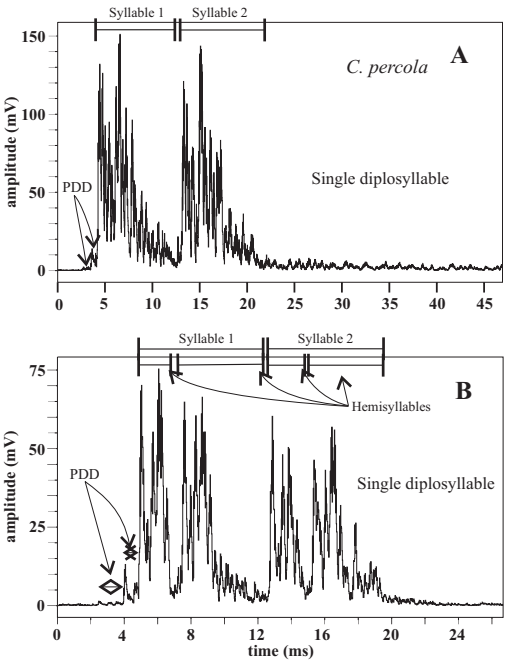

FIG. 23. Expanded time scale envelope curves showing the detailed diplosyllable and shorter hemisyllable structures, and the pre-diplosyllable 'disturbances' (PDD; arrowed) characteristics of the *C. percola* song. The higher frequency carrier pulses are clearly visible within the syllables and hemisyllables. Recording (a) from Lake Broadwater; (b) from Brigalow Research Station.

features of possible significance are the marked increase in rib width of rib 3, and the presence of a second (?relict) short rib between ribs 2-3 and 3-4 (see above). Two possible explanations for the diplosyllables seem appropriate. One is that they represent the initial inward buckling of one timbal (or both synchronously) producing syllable 1, followed by the outward buckling accompanying timbal relaxation producing syllable 2. An alternative explanation is that each syllable represents a single cycle of 'in-out' buckling of each timbal, there being a small gap in timing between the firing of the two timbals (equivalent to the inter-syllable durations, i.e. 7.4-8.9ms). This explanation implies that within each syllable, the first hemisyllable results from the inward bucking, and the second hemisyllable from the accompanying outward buckling during timbal relaxation. It is noted that within each song, there is a strong similarity of detailed structures between the two syllables comprising each diplosyllable.

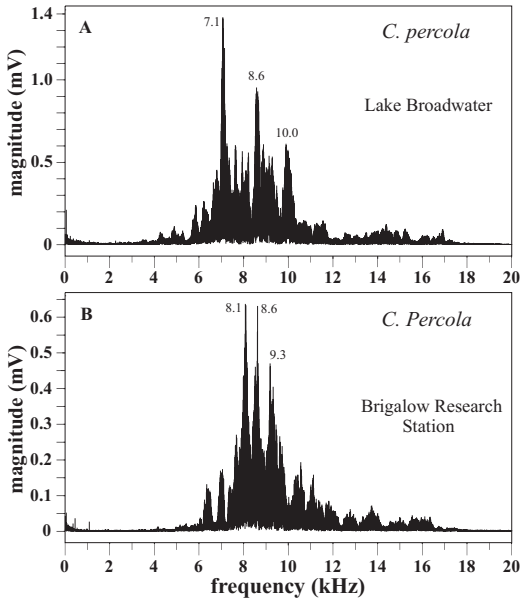

FIG. 24. Amplitude spectra of *C. percola* songs from; (a) Lake Broadwater, with bimodal (uneven) inter-diplosyllable intervals, and (b) Brigalow Research Station, with relatively even inter-diplosyllable intervals. Both spectra based on analyses of a sequence of twelve diplosyllables. The frequencies of the main peaks are labelled (kHz). Unfiltered recordings.

Amplitude spectra (Fig. 24) show the presence of broad and complex peaks centred at or near 8.6kHz, but extending between approximately 5.9 to 11.5kHz. Strongest peaks occur at 7.1, 8.6 and 10.0kHz, suggesting side bands around a 8.6kHz carrier frequency, and modulation rates of 1.4-1.5kHz, equivalent to ~0.7ms. These rates are not clearly equated to the measured syllable and hemisyllable lengths (Table 4), although they may correspond to the 'pre-diplosyllable disturbance' durations. The numerous peaks extending either side of the 8.6kHz peak suggest further side bands at approximately 0.6kHz (equivalent to a 1.7ms modulation frequency) which is similar to the lengths of the hemisyllables. The width and wide range of the frequency peaks is assumed to reflect the various diplosyllable and syllable/hemisyllable modulation rates, together with the relative roles and efficiencies of the main sound radiation structures (Fonseca & Popov 1994; Fonseca & Bennet-Clark, 1998).

Pipilopsalta gen. nov.

TYPE SPECIES. *Pipilopsalta ceuthoviridis* sp. nov.

INCLUDED SPECIES. *P. ceuthoviridis* sp. nov.

ETYMOLOGY. Latin *pipil(o)*, chirp or peep; a reference to the characteristic, although soft, sharp chirping song.

DIAGNOSIS. Small cicada, 9.4-13.5 mm total body length (type species). Width of head (including eyes) only slightly greater than width of pronotum across lateral margins, but less than abdomen width (across auditory capsules); width of pronotum measured from lateral margins similar to width of mesonotum measured between fore wings; pronotal collar ampliate along lateral margins and outwardly curved; distance between lateral ocelli similar to distance between lateral ocellus and eye. Abdomen rounded to bulbous in dorsal and lateral profile, with sternites projecting well below level of tergites. Rostrum extends to midway along mid coxae. Wings hyaline without infuscations; costal vein even in width to node, with minimal curvature; sclerotised anterior costa margin weakly developed and much narrower than width of vein; fore wing with eight apical cells which are mostly shorter than length of ulnar cells; CuA-M vein intersection occurs approximately halfway along the first vein section (proximal to basal cell) of the M vein that makes up inner margin of radial cell; lengths of the three distal vein sections that comprise the inner radial cell margin are clearly of unequal length. Hind wings with six apical cells. Operculae slightly elongated, gently rounded along lateral, distal and medial margins; meracantha normal and located strongly asymmetrically (towards midline) with respect to operculae; inner margins of operculae separated but closely spaced. Timbals with five long ribs; ribs 1 and 2 fused ventrally and also anteriorly to the basal spur; three short ribs. Pygofer roughly ovate in dorsal view; upper lobe rounded and not strongly extended; lower lobe rounded and slightly enlarged; inner lobe visible, subacute; uncal lobes extend steeply from pygofer, subacutely terminated and curved anteriorly; prominent and rounded median process; beak defined but short. Aedeagus trifid, with dorsal pseudoparameres significantly longer than endotheca, and splayed outwards apically; sclerotised ventral support and partially sclerotised endotheca.

Pipilopsalta ceuthoviridis sp. nov.
(Figs 25-28, 43, Table 5)

Species E: Ewart & Popple, 2001, 64, 66, 71, figs 6A, 9A.

MATERIAL. HOLOTYPE; ♂, QMT99216, Cluny Lagoon, SW.Qld., 25/8/78, 24º31'S 139º37'E, A.Ewart.

PARATYPES: WEST AND SOUTHWEST QUEENSLAND: 1♂, Dam, Milroy Hstd, ~70 km N Quilpie, grass, AE, IR, JN, 13.i.2000, 26º02.85'S 144º20.81'E; 1♂, Near "Arawee", Milroy, ~70 km N Quilpie, grass, AE, 13.i.2000, 25º58.88'S 144º20.43'E; 3♂, Blackwater Ck xing, Adavale, grass, AE, IR, 15 Jan 2000, 25º54.88'S 144º36.99'E; 1♂, 3♀, Thompson R xing, 4 km W Jundah, 1.ii.1999, AE, 24º49.36'S 143º01.14'E; 1♂, Dam, Milroy Hstd,~70 km N Quilpie, grass, AE, IR, JN, 12.i.2000, 26º02.85'S 144º20.81'E, Rec; 8♂, 1♀, E segment 'Moothandella' pty, 2.1 km E Jundah Rd, 31.i.1999, AE, 25º33.85'S 143º04.24'E; 2♂, As previously, Rec; 2♂, 1♀, Warrego R xing, Charleville, 13.i.1999, AE, 26º24.04'S 146º14.05'E; 1♂, NE corner Blackall, 28.xi.1999, AE, grassland, 24º25.03'S 145º27.33'E; 1♂, NE corner Blackall, 30.xi.1999, AE, grassland, 24º25.03'S 145º27.33'E; 1♂, 10 km SW Charleville, In *Eremophila bignoniiflora*, AE, 19.x.1999, 26º26.37'S 146º09.64'E; 2♂, Warrego R. crossing, Charleville, AE, 26º24.04'S 146º14.05'E, 19.x.1999; 3♂, 1 km W Morven, 26.xi.1999, AE, 26º24.68'S 147º06.16'E; 2♂, 30.6 km S Augathella, AE, grassland, 27.xi.1999, 25º59.58'S 146º27.67'E; 2♂, 14 km NW of Tambo, grassland, AE, 27.xi.1999, 24º48.79'S 146º09.91'E, Rec; 1♂, 10 km SW Charleville, grass, AE, IR, 8.i.2000, 26º26.37'S 146º09.64'E; 1♂, ~30 km N Quilpie, grass, AE, IR, 8.i.2000, 26º22.50'S 144º18.68'E; 2♂, 5.8 km W Bollon, grassland, 12.xii.2001, AE, 28º01.49'S 147º25.42'E; 1♂, 12 km S Charleville, sand plain, 8.xii.2000, AE, IR, 26º30.22'S 146º12.96'E; 1♂, Bulloo R flats, Quilpie, grassland, 11.ix.2000, AE, 26º36.77'S 144º16.78'E; 1♂, 55 km W Windorah, dune, 5.ix.2000, AE, 25º21.54'S 142º03.76'E; 1♂, As previously, Rec; 1♂, 3 km S Thargomindah, 12.ix.2000, AE, grassland, 28º00.94'S 143º50.92'E; 10♂, 1♀, Bulloo R, Milroy Hstd, nr. Adavale, 10.xii.2000, AE, IR, 26º03.42'S 144º21.23'E; 4♀, 16.5 km W Barcaldine, grassland, 12.xii.2000, AE, IR, 23º32.48'S 145º07.38'E; 7♀, 41 km SW Blackall, grass, 11.xii.2000, AE, IR, 24º41.74'S 145º17.66'E; 1♂, 0.5 km N along Muttaburra Rd., W side Thompson R, nr. Longreach, grass, AE, 16.i.2002, 23º23.67'S 144º13.21'E; 10♂, 1♀, 1 exuviae, Warrego R xing, Charleville, grass, 19.x.1998, AE, 26º24.04'S 146º14.05'E; 1♂, As previously, Rec; 1♂, 44 km SE Tambo, grass, AE, 14.i.2002, 25º10.48'S 146º29.78'E; 12♂, 1♀, Cluny Lagoon, 25.viii.1978, 24º31'S 139º37'E, AE **(AE).** 3♂, 26º31'S, 146º04'E, Charleville, 21km SW, 4-5.iii.2003, 270m, GM, CB; 1♀, 20º49'S, 139º27'E, Mica Creek, Mt. Isa, 9-12.iii,2000, mvlamp, SE, 50277 **(QM).** 6♂, 1♀, Red Sand hill, 55km W Windorah, 5.ix.2000, LWP, AE, 260-0001 to 0007; 1♂, Lake Houdraman, via Quilpie, 6.ix.2000, LWP, 260-0008 **(LWP)**. 1♂, Warrego R xing, Charleville, 13.i.1999, AE, 26º24.04'S 146º14.05'E; 1♂, Warrego R xing, Charleville, grass, 19.x.1998, AE, 26º24.04'S 146º14.05'E **(BMNH)**. 1♀, 41 km SW Blackall, grass, 11.xii.2000, AE, IR, 24º41.74'S 145º17.66'E **(ANIC)**. 1♂, Warrego R xing, Charleville, 13.i.1999, AE, 26º24.04'S 146º14.05'E; 1♀, 16.5 km W Barcaldine, grassland, 12.xii.2000, AE, IR, 23º32.48'S 145º07.38'E **(MSM)**. SOUTHEAST QUEENSLAND: 1♂, Jct Warrego Hwy with Jondaryan-Mt Tyson Rd, Jondaryan, grass, AE, 9.ii.2005, 27º22.88'S 151º36.75'E, field rec **(AE).** 3♂, 27º22'34"S 151º36'00"E, Jondaryan district, grass, 5.ii.2005, LWP, 360-0009 to 0011 **(LWP)**. SOUTH AUSTRALIA: 1♂, 27.54'S 135.49'E, Neales R, 22viii.1989, I. Bunic **(ANIC)**.

DESCRIPTION (Male). Figs 25, 43A. General colouration most commonly bright apple green; rarer pale brown, pale yellow-brown, pale mauve and yellow-green specimens occur. The following description is based on the normal green form.

Head. Supra-antennal plate, postclypeus and transverse ridges, gena, mandibular plate and anteclypeus all bright apple green. Ocelli pink to pale red. Compound eyes medium to red-brown. Antennae fawn to pale brown. Rostrum pale sandy brown, grading darker apically.

Thorax. Pronotum bright apple green, including anterior margin, pronotal collar and central fascia area; variation in intensity of colour, tending towards a more translucent appearance between and along the oblique fissures. Mesonotum with a pair of wide pale grey-brown obconical paramedial fasciae which extend and taper distally from anterior margin about one quarter of the distance along mesonotum, but not quite fused anteriorly; a pair of pale grey-brown broad lateral fasciae, irregular and broken in outline, extend and taper distally from anterior margin to near anterior arms of cruciform elevation; remaining colour apple green to pale yellow-green, with pale sandy colour along wing grooves.

Wings. Fore wing venation pale green, basal membrane pale sandy yellow. Hind wing with pale green venation; plaga pale sandy yellow which extends along both margins of 3A vein.

Legs. Dominantly pale green with diffuse pale sandy yellow areas (possibly due to fading in storage) on anterior margins of coxae and trochanters, and as weakly developed longitudinal fasciae on femora. Tibiae tending pale brown distally. Tarsi pale greenish brown, with apices of claws brown.

Operculae. Pale green; distal margins gently curved, but becoming more sharply curved along medial margins; gentle short doming developed

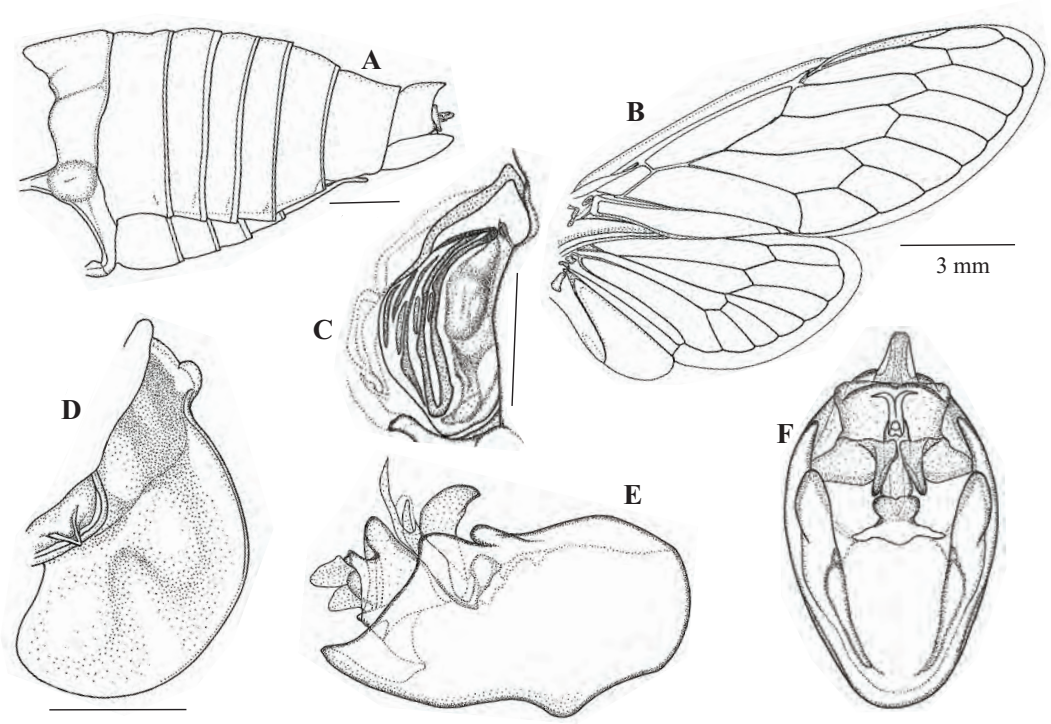

FIG. 25. *Pipilopsalta ceuthoviridis.* A, Lateral abdomen view; B, fore and hind wings; C, timbal; the right-hand edge as shown represents the posterior margin, the top the dorsal edge; D, opercula; E, and F, lateral and ventral views of pygofer. Pygofer length 1.7mm. Scale bars represent 1mm except wings (3mm). Drawings based on specimens from Cluny H.S. lagoon, near Bedourie, and "Milroy" H.S. north of Quilpie (pygofer only).

from distolateral areas extending to basal areas; meracantha small, subacutely terminated

Timbals. Rib 3 extends across timbal, while ribs 4 and 5 are relatively short; in some specimens, rib 5 apparently exhibits a remnant small discontinuous extension ventrally; ribs 3 to 5 not fused to basal spur; well developed, but relatively small central dome on timbal plate.

Abdomen. Tergites bright apple green, without any clearly defined fasciae. Sternites apple green, tending towards yellow-green distally.

Pygofer. Apple green, becoming darker towards beak. Details as in generic characters.

FEMALE. Fig. 43B. Dominantly uniform apple green, similar overall to male. Antennae dark brown apically. Ocelli pale pink. Compound eyes dark brown to red-brown. Postclypeus with medial segments between the transverse ridges dark brown to black, these coalescing dorsally; in some specimens, there is minor black mottling dorsally on postclypeus and supra-antennal plate. Legs usually as in male, but sparse thin dark brown fasciae are seen on the fore tibiae, mid and hind femora, and fore trochanters of some specimens. Ovipositor black on apex; ovipositor sheath extends approximately 1 to 1.3 mm beyond tergite 9.

MEASUREMENTS. N = 11♂, 11♀. *BL*: ♂ 9.4-13.5 (12.0); ♀ 10.7-13.0 (11.9). *FWL*: ♂ 9.7-13.0 (12.2); ♀ 12.2-13.7 (12.8). *HW*: ♂ 2.6-3.8 (3.2); ♀ 2.8-3.3 (3.0). *PW*: ♂ 2.5-4.0 (3.4); ♀ 3.0-3.6 (3.3). *AW*: ♂ 3.0-4.4 (4.0); ♀ 3.3-3.7 (3.5). *FWL/BR*: ♂ 2.50-2.88 (2.64); ♀ 2.48-2.81 (2.63).

DISTRIBUTION & HABITAT (Fig.13). A relatively localised, highly cryptic and static species inhabiting the low grasslands of predominantly inland Queensland, including the Mitchell grass plains. It sits in short to moderately short grass, typically singing in full sunshine. The known distribution extends to

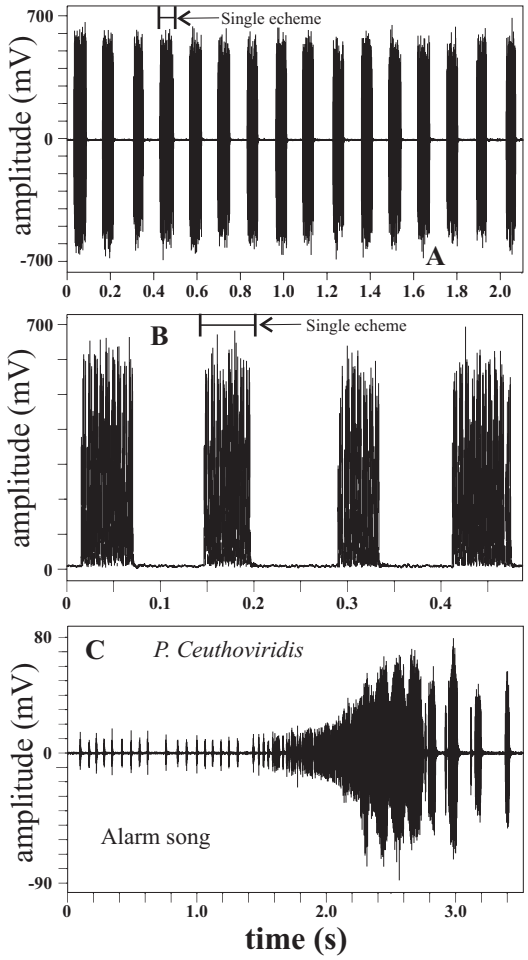

FIG. 26. *P. ceuthoviridis*. Waveform plots of; (a), (b) normal chirping song comprising repetitive, sharply defined echemes, and (c), alarm song when under stress. In (b), a time expanded envelope plot shows the multiple syllables comprising each echeme. Data in (a) and (b) based on field recordings, unfiltered, from 55km west of Windorah; (c) represents a container recording, unfiltered, from 44km southeast of Tambo.

northern South Australia, but it is almost certainly a widespread species throughout the inland regions of Australia. Known Queensland localities extend west and southwest of Bollon and Morven, including Charleville, Thargomindah and westwards to Quilpie, Adavale, Windorah, Jundah and Cluny H.S. (near Bedourie). Northern inland locations include Augathella, Tambo, Blackall, Barcaldine and the Longreach region, plus a single more northern record from Mica Creek at Mt. Isa. An isolated record exists from southeastern Queensland at Jondaryan. The South Australian record is from Neales River (Creek).

ETYMOLOGY. Greek *ceutho,* and Latin *viridi(s);* referring to the hidden/concealed habits and behaviour and to the bright apple green colouration typical of this species, respectively.

SONG (Figs 26-28). Data are based on recordings from six southwestern Queensland locations, namely: 55 km W. of Windorah; Moothandella H.S. (nr. Windorah); Cluny H.S. (near Bedourie); Charleville; Tambo; and Milroy H.S. (70 km N.Quilpie), plus a recording from Jondaryan in southeastern Queensland. Four data sets are presented in detail (Table 5).

The song consists of monotonously repeated sequences of nearly identical (within a given song cycle) short echemes ('chirps'), ranging

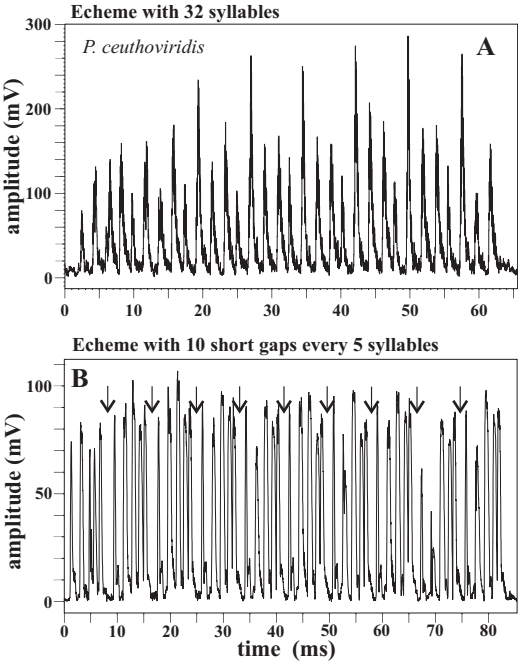

FIG. 27. Expanded time scale envelope plots of single echemes in *P. ceuthoviridis* songs showing the individual syllables; (a) from the Warrego River at Charleville, southwest Queensland; (b) Jondaryan, southeast Queensland. In (b), small short time gaps between the sets of five syllables are arrowed. Unfiltered field recordings.

TABLE 5. *Pipilopsalta ceuthoviridis* - summary of song parameters, based on field recordings from four locations. [(1)]Based on separate wave form plots from seven separate locations. [(2)]Figures represent mean values,±σ, number of measurements (n), and measured ranges of data (in brackets). [(3)]Figures represent mean values, equivalent inter-echeme intervals in ms [in brackets], and measured ranges of data (in brackets). [(4)] Based on mean frequencies of dominant spectral peaks of each recording, and mean value of the measured mean frequencies.

	All data	Cluny	Charleville	W. Windorah	Jondaryan
Inter-echeme intervals - ms	141[(1)]	160±5(n=11) (150-165)[(2)]	117±4(n=15) (110-124)[(2)]	137±11 (n=30) (122-153)[(2)]	148±4(n=55) (137-156)[(2)]
Echeme lengths - ms	68.1[(1)]	74.0±8.0(n=14) (60.2-85.0)[(2)]	64.9±4.5(n=19) (55.5-71.2)[(2)]	49.3±9.7 (n=20) (27.4-63.7)[(2)]	84.1±6.0(n=60) (68.0-95.0)[(2)]
No. of syllables per echeme	40.1[(1)]	44.4±4.8(n=14) (36-51)[(2)]	34.4±2.5(n=19) (30-66)[(2)]	31.2±6.1 (n=20) (17-40)[(2)]	50.4±4.3(n=60) (40-58)[(2)]
Syllable lengths (including. tail) - ms	1.68	1.64±0.54(n=60) (0.56-2.68)	1.88±0.18(n=39) (1.52-2.28)	1.58±0.31 (n=79) (1.06-2.85)	1.63±0.47(n=122) (0.52-2.85)
Hemisyllable lengths - ms	0.53	0.50±0.18(n=27)	0.68±0.02(n=2)	0.54±0.08 (n=8)	0.41±0.11
Echeme repetition rates (s^{-1}); measured from multiple echeme counts					
(i) Field	7.34±0.89 (n=13)	6.29[159] (6.19-6.39)[(3)]	8.62[116] (8.57-8.68)[(3)]	7.71[130] (7.44-8.11)[(3)]	6.76[148] (6.72-6.83)[(3)]
(ii) Container	6.85±0.90 (n=8)				
Maximum frequency - Mean (kHz)[(4)]	15.4	15.1	15.5	14.8	15.4
Mean frequency - (kHz)[(4)]	15.1	15.0	15.2	14.6	15.2

between 27-95ms in length. The term echeme is used on the basis of the presence of trains of multiple syllables without significant gaps, which are thought to represent more than a single cycle of the buckling of the timbal pairs. Inter-echeme intervals range between 110-165ms (Fig. 26), equating to repetition rates of approximately 6 to 9s^{-1}. Comparison of these rates between field and container recordings indicate little significant difference (Table 5), although container recordings tend to be slightly slower. Each echeme consists of coalescing syllables (Figs 26b, 27) 17- 66 in number, their overall structures being similar throughout each echeme, i.e. there being no systematic temporal or peak amplitude variations. In some recordings from N.W. Windorah, Cluny and Jondaryan, there exists an indication of regular groupings or sets of five syllables within the echemes, each group separated by slightly increased inter-syllable gaps (Fig. 27b). It seems possible that each syllable grouping represent a single contraction (and relaxation?) cycle of one timbal. The sequential alternation of the timbal pairs would, in this explanation, provide the unbroken trains of syllables seen in each echeme.

Higher resolution envelope curves of the syllables (two separate records shown in Fig. 28A, B) show each to have a sharply defined initiation and decay to and from their maximum amplitudes, followed by either a low amplitude tail, or commonly by low amplitude secondary peaks (termed hemisyllables). Mean measured syllable lengths (including tails, i.e. peak to peak) range 1.58-1.88ms (equivalent to modulation rates of 532-633Hz). The mean lengths of the individual hemisyllables range between 0.41-0.68ms (Table 5). The hemisyllables vary in their exact temporal relationships to the syllables. A possible explanation for their production is that they represent the clicks emitted during relaxation of the timbal ribs following primary syllable production.

Comparison of the song parameters between the songs of the two most geographically separated recordings (Table 5) shows the essential similarity and stability of the song

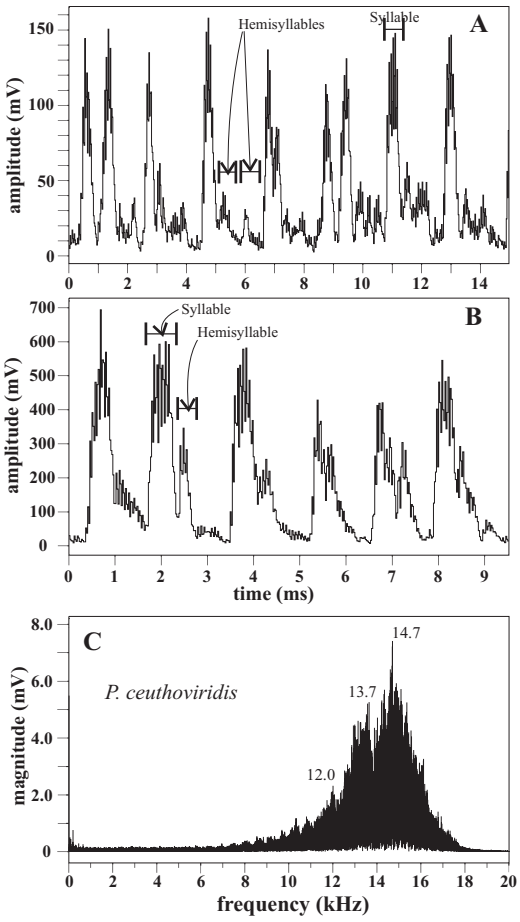

FIG. 28. (a) Detailed syllable and lower amplitude hemisyllable structures within a short time segment of an echeme, showing uneven inter-syllable intervals; recorded from Cluny H.S. lagoon; (b) as previously, based on recorded specimen from 55km west of Windorah. In these two plots, only selected syllables and hemisyllables are labelled; (c) amplitude spectrum of *P. ceuthoviridis* song from 55km west of Windorah. Main frequency peaks are labelled (kHz). All are unfiltered field recordings.

structures, even though separated by a linear distance of about 1240km.

Amplitude spectra (Fig. 28C) show the spectra to possess a complex broad peak centred at 14.7kHz, but extending between ~12 to 17kHz. There are very subdued peripheral peaks at ~10.4, 12, 12.5 and 16.2kHz. No significant sidebands peaks can be clearly identified. The width and complexity of the dominant peaks are nevertheless attributed, at least in part, to the complex, overlapping ranges of lower frequency side band peaks which reflect the range of amplitude modulation structures seen within the echemes, syllables and hemisyllables. The carrier frequency is inferred to correspond to the main peak maxima at 14.7kHz. The absence of peaks extending to lower frequencies, as seen in the other species described in this paper, suggest either that sound radiation was concentrated in a smaller number of body structures, or that these structures are perhaps more coherently tuned. It is therefore perhaps significant to recall that *P. ceuthoviridis* is a localised and relatively static species.

Timbal structure has five long ribs and three short ribs. Only ribs 1 and 2 are fused ventrally and dorsally (to basal spur), the remaining long ribs lying 'suspended' on the timbal resilin. It is possible that ribs 1 and 2 are partially or even completely coupled, and react independently from ribs 3-5, giving rise to the complexities seen in the detailed syllable structures. The groupings of 5 syllables seen within some echemes, noted above, may correlate with the buckling of each long rib within a single timbal buckling cycle.

The stress call (Fig. 26C) of this species is very different from the calling song, and contains significantly more complex temporal and amplitude modulations. The maximum frequency however, is 14.9kHz, close to the calling song maximum.

Drymopsalta gen. nov.

TYPE SPECIES. *Drymopsalta crepitum* sp. nov.

INCLUDED SPECIES. *D. daemeli* (Distant, 1905), n.comb.; *D. crepitum* sp. nov.

ETYMOLOGY. Greek *drymo,* wood/woodland; a reference to the habitat preference.

DIAGNOSIS. Small cicadas, <15 mm total body length. Width of head (including eyes) greater than width of pronotum across lateral margin, the latter similar to the abdomen width across the auditory capsules; width of pronotum measured from lateral margins similar to, or slightly greater than mesonotum width measured between fore wings; pronotal collar moderately to strongly ampliate along lateral margin and outwardly curved; distance between lateral ocelli similar to distance between lateral ocellus and eye. Abdomen slender and evenly tapered distally; sternites rounded and visible when viewed

laterally, although sternites VI and VII may only just be visible. Rostrum extends beyond the hind coxae. Wings hyaline and relatively elongated; forewings with costal vein more or less equal in length to node and exhibits a marked anterior curvature proximal to node; sclerotised area along anterior margin of costal vein very narrow; fore wing with eight apical cells which are similar, overall, to length of ulnar cells (some longer, some shorter); intersection of M and CuA veins occurs approximately one half of distance along first vein section (proximal to basal cell) of M vein that makes up inner margin of radial cell; lengths of the three distal vein sections that make up inner margin of radial cell are clearly of unequal length. Hind wing with normally 5 to 6 apical cells, rarely 4; these vary not only between species, but sometimes are variable within a single specimen. Operculae elongated with somewhat blunt, oblique and variably rounded distal margins; meracantha normal and located strongly asymmetrically, towards midline, relative to operculae; inner margins of each opercula widely separated. Timbal with four to five long ridges, ribs 1-3 always fused ventrally; ribs 1-4 fused anteriorly with the clearly developed basal spur; three short ribs, sometimes very weakly developed. Pygofer ovoid to roughly rectangular-shaped in dorsal view; upper lobes moderately extended, subacute, but apically rounded; lower lobes well developed, apically rounded; inner lobes not developed; uncal lobes erect, extending almost orthogonally, and thickened and rounded apically; conspicuous beak; median process small and narrow in lateral view; aedeagus trifid with dorsal pseudo

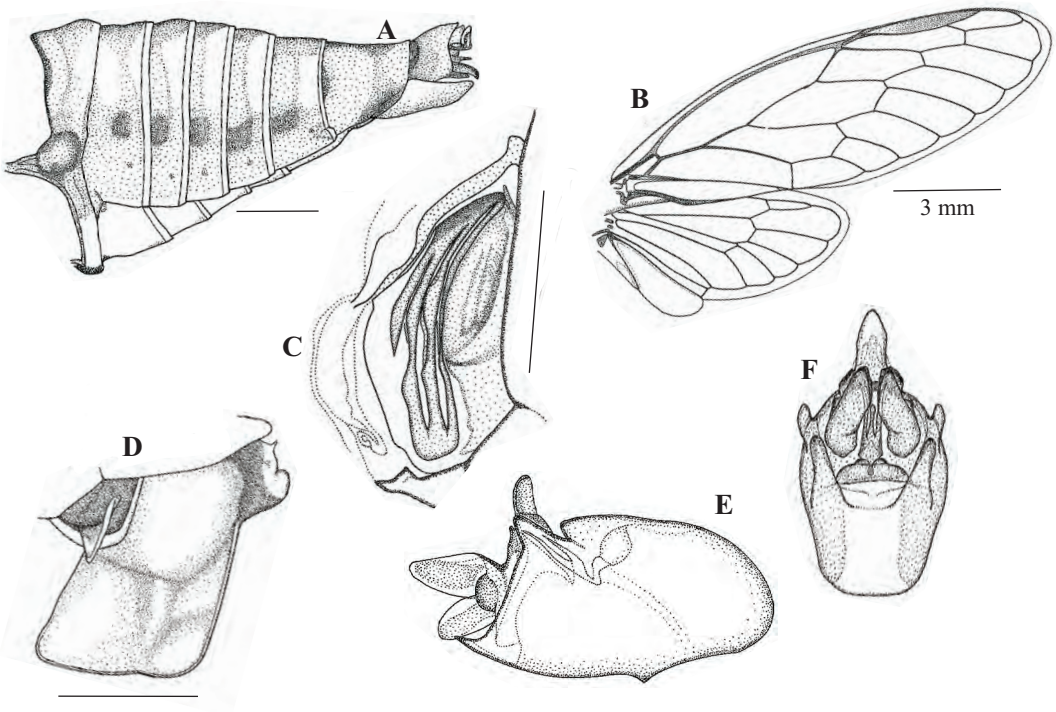

FIG. 29. *Drymopsalta crepitum*. A, Lateral abdomen view; B, fore and hind wings; C, timbal; the right-hand edge as shown represents the posterior margin, the top the dorsal edge; D, opercula; E, and F, lateral and ventral views of pygofer. Pygofer length 1.5mm. Scale bars represent 1mm except wings (3mm). Drawings based on specimens from Heathlands H.S., and Cockatoo Creek, near Heathlands Resource Reserve (pygofer only), northern Cape York Peninsula.

parameres longer than endotheca, sclerotised ventral support, and unsclerotised endotheca.

Drymopsalta crepitum sp. nov.
(Figs 29-35, 44)

Species F: Ewart, 1993, pp. 139, 147, fig. 14 (not fig. 12 as labelled); Heathlands species F: Ewart, 2005, p.172, fig 5.

MATERIAL. HOLOTYPE; ♂, QMT99217, Pumphouse, Heathlands Stn., Cape York Peninsula, N.Q., 1 Feb 1992, A. Ewart, 11º45.35'S 142º35.38'E.

PARATYPES: CAPE YORK PENINSULAR, QUEENSLAND: 2♂, 4♀, Pumphouse, Heathlands Stn, 16.i.1992, AE, 11º45.35'S 142º35.38'E; 4♂, As previously, 21.i.1992; 6♂, 4♀, As previously, 25.i.1992; 7♂, 5♀, As previously, 1.ii.1992; 2♂, 1♀, Open Forest, nr. Heathlands Stn, 26.i.1992, AE, 11º45.24'S 142º34.62'E; 4♂, 4♀, Nr. Cockatoo Ck xing, ~18 km NW Heathlands Stn, 20.i.1992, AE, 11º39.19'S 142º27.36'E; 2♂, 2♀, Nr. Bertie Ck xing, ~12 km SW Heathlands Stn, 19.i.1992, AE, 11º49.70'S 142º29.89'E; 1♂, 3♀, Heathlands Stn, 24.i.1992, AE, 11º45.11'S 142º34.34'E; 1♂, Nr. Cockatoo Ck xing, ~18 km NW Heathlands Stn, 31.i.1992, 11º39.19'S 142º27.36'E; 1♂, Tall heath, N side Pennefather R, 2.xi.2002, AE, 12º13.45'S 141º45.41'E, Rec spec 1; 1♂, As previously, Rec spec 2; 2♂, Tall heath, N side Pennefather R, 3.xi.2002, AE, 12º13.45'S 141º45.41'E; 1♂, As previously, Rec spec 3; 1♂, 1♀, Tall heath, N side Pennefather R, 5.xi.2002, AE, 12º13.45'S 141º45.41'E; 1♂, As previously, anomalous song type; 1♂, ~0.7km S of Base Camp, Pennefather R, S side of entrance, heath, 7.xi.2002, AE, 12º14.60'S 141º42.89'E; 34♂, 10♀, 10.8 km N of Norman R, Normanton, mixed *melaleuca* woodland, AE, 14.i.2003, 17º37.10'S 141º09.17'E; 1♂, As previously, Rec spec 1; 1♂, As previously, Rec spec 2 **(AE).** 1♀, Cape Flattery heath, 45km N Cooktown 13-14 July 1976, GB&SRM **(QM).** 1♂, Browns Ck, W of Tozer Gap, 9.i.1988, AW-H; 12♂?, 7♀, Tozer Gap, Iron Range, 27.xii.1983, MS&BJM; 1♀?, Jardine R xing, 11º09'S 142º22'E, 11.x.1979, MS&BJM; 3♂, 1♀?, Jardine R xing, 11º09'S 142º22'E, 29.x.1979, MS&BJM; 3♂?, 2♀, Dalhunty R xing, N of Coen, 2.xii.1983, AW-H; 1♂?, 1♀, Gunshot Ck, 11º43'S 142º29'E, 21.iii.1992, GD, SM; 1♂, Punsand Bay, 16.i.1987, RBL; 1♂, 1♀, Archer R., April 1988, SL **(MSM).** 13♂, 4♀, Gunshot Ck., 13 km NW Heathlands HS, 11º43'S 141º28'E, 21.iii.1992, mv lamp, GD, MAS; 1♂, Iron Ra, West Claudie R, open forest, 3.xii.1985, DY **(UQIC)**. 1♂, Nr. Cockatoo Ck xing, ~18 km NW Heathlands Stn, 20.i.1992, AE, 11º39.19'S 142º27.36'E; 1♀, Pumphouse, Heathlands Stn, 16.i.1992, AE, 11º45.35'S 142º35.38'E **(BMNH)**. 1♂, 1♀, Pumphouse, Heathlands Stn, 1.ii.1992, AE, 11º45.35'S 142º35.38'E **(ANIC)**.

DESCRIPTION (Male). Figs 29, 44A. General colouration pale to medium brown and black.

Head. Brown to black with fine silver pubescence. Supra-antennal plate medium brown with short yellow fascia extending along medial suture from distal margin to between the two posterior ocelli; irregular black patches enclosing ocelli. Gena brown; mandibular plate brown with narrow black margin adjacent to anteclypeus; prominent silver pubescence. Postclypeus dominantly black to dark brown dorsally with median pale yellow-brown fascia extending anteriorly to dorsal anterior margin; frons pale sandy colour with black transverse ridges which become paler laterally. Anteclypeus pale brown with small median darker spot. Compound eyes pale brown. Ocelli pink to pale red. Rostrum pale sandy brown, darker brown apically. Antennae dark brown, grading pale brown apically.

Thorax. General colour pale brown to black. Pronotum with black central fascia, slightly broadened adjacent to both the distal and proximal margins, appearing somewhat 'dumbell'-shaped, and enclosed by a medium brown envelope without pubescence; between the anterior and posterior oblique fissures occur areas of both broken and continuous black colouration; the posterior oblique fissure is also marked by broken black colouration; short thin irregular black fasciae lie proximally to the lateral margin; anterior pronotal margin and pronotal collar are pale sandy-yellow except for localised black colouration at outer corners of collar. Mesonotum with a pair of anterior, paramedial, short broad black obconical fasciae, tapered distally, just coalescing adjacent to pronotal collar, and extending distally approximately one quarter of the distance along the mesonotum; a pair of broad lateral fasciae, brown to black colour, tapered distally and enclosed by medium brown colouration; two small elliptical black spots located anteriorly to the anterior arms of cruciform elevation; remainder of mesonotum colour medially is pale-medium brown, paramedially sandy brown, and laterally pale brown; cruciform elevation pale sandy brown on anterior arms and in lateral area between arms, remainder deep brown to black; wing grooves pale sandy brown; scattered silver pubescence.

Wings. Fore wing venation medium brown, with costal vein colourless to translucent; pterostigma infuscated reddish to dark brown; basal membrane opaque white. Hind wing venation pale brown; 5 apical cells, very rarely 4; plaga opaque white which extends along both sides of 3A vein.

Legs. Coxae pale sandy brown; fore coxae dark brown on distal lateral margins; mid and hind

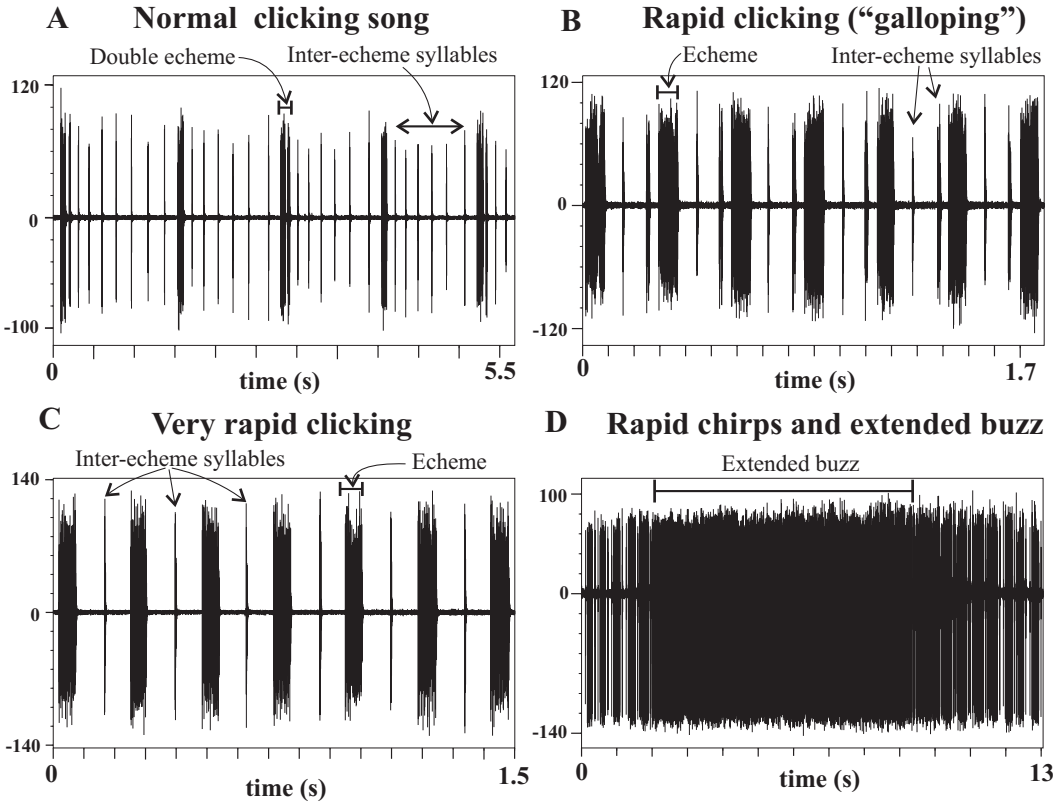

FIG. 30. Waveform plots of four described phases of the *D. crepitum* songs. The change from the normal song (a), through to the buzzing phase (d) is gradational. Plots (a) and (d) recorded from the northern shores of the Pennefather River, northwestern Cape York Peninsula. Only selected echemes, double echeme, and inter-echeme syllables are labelled. Plots (b) and (c) recorded from 11km north of Normanton, northern Queensland. Recordings (a) to (c) were made in a container, filtered (FIR) to 1kHz, while (d) represents a bat detector field recording.

coxae with broad dark brown fasciae along anterior margins. Fore femora with alternate pale sandy brown and medium brown longitudinal fasciae, and three dark brown spines; mid and hind femora dominantly medium brown but with pale brown longitudinal fasciae. Tibiae of fore legs medium brown along lateral margins, pale sandy colour on anterior margins. Mid and hind tibiae predominantly pale sandy brown. Tarsi pale to medium brown, with claws dark brown.

Operculae. Roughly rectangular in form with distal margin obliquely terminated and relatively uncurved; meracantha prominent and relatively acutely terminated; broad ridge extends the length of each opercula from distal to basal area; colour off-white except for small area of brown adjacent to crest around distolateral corners; prominent silver pubescence.

Timbals. Four long ribs; rib 4 extends approximately half way across timbal, and is fused dorsally to basal spur; prominent and relatively elongated and ovate grooved dome on timbal plate.

Abdomen. General colour pale to darker brown with pale sandy distal margins and inter-segmental membranes. Conspicuous narrow medial concentration of silver pubescence dorsally on all tergites and pygofer, giving appearance of a conspicuous silver dorsal fascia; tergite 2 dominantly medium brown, slightly darker paramedially, with narrow deep brown anterior edge extending to, and partially covering and enclosing the auditory capsules; central area of capsules pale brown; tergites 3 to 8 darker brown in medial and paramedial areas, and sporadically laterally, remaining areas paler

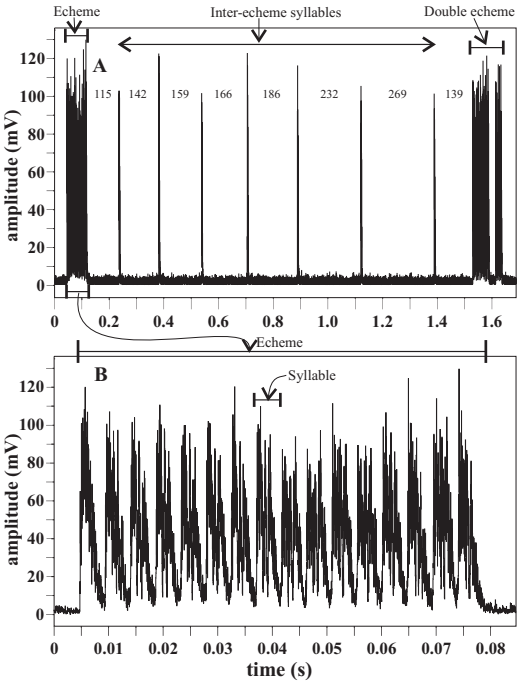

FIG. 31. Time expanded envelope plots of *D. crepitum* songs showing: (a) Two echemes with a series of single inter-echeme syllables. The inter-syllable time intervals are labelled in ms, showing the progressive increase in the intervals. The second echeme represents a double echeme. (b) Expanded time scale envelope plot of the initial echeme in plot (a) showing the sequence of 16 component syllables. Container recording from north side of Pennefather River, filtered (FIR) to 2kHz.

sandy brown with silver pubescence; distal margins and intersegmental membranes of tergites 3-7 conspicuously pale sandy yellow. Sternites pale to medium brown, tending darker in medial areas; sternite II with small black medial area which extends in part to area below auditory capsule; sternite VIII medium brown.

Pygofer. Irregularly coloured medium to dark brown. Details as in generic characters.

FEMALE. Fig. 44B. Supra-antennal plate medium brown with short black irregular thin streaks extending laterally from eyes, and a thin black fascia extending inwards from inner eye margins; a medial black fascia extends from between ocelli, through the anterior ocellus and widens adjacent to postclypeus. Remainder of head markings as in male. Pronotum with a central brown fascia which is more diffuse in outline and slightly enlarged at its distal and proximal margins; the markings between and adjacent to oblique fissures are medium brown (not black as in male). Mesonotum with brown paramedial obconical anterior fasciae which coalesce towards anterior margin; the lateral fasciae are relatively indistinct; a pair of small, dark, elliptical paramedial spots lie anterior to each anterior arm of cruciform elevation; the dominant mesonotum colouration is pale-medium brown, with cruciform elevation medium to dark brown along distal and proximal margins, joining anteriorly with a small median fascia. Legs, wings and tergites similar to male, except tergite 2 which lacks any black colouration. Tergite 9 with a pair of paramedial dark brown fasciae extending distally approximately 80-90% of distance towards distal margin. Sternites similar to male, with generally slightly paler colouration. Ovipositor sheath extends approximately 1.5 mm beyond tergite 9.

MEASUREMENTS. N = 14♂, 12♀. *BL*: ♂ 9.1-11.2 (10.4); ♀ 11.2-14.7 (13.4). *FWL*: ♂ 11.2-13.5 (12.6); ♀ 12.2-15.0 (13.8). *HW*: ♂ 3.1-3.7 (3.5); ♀ 3.1-4.0 (3.6). *PW*: ♂ 2.7-3.2 (3.0); ♀ 2.8-3.6 (3.2). *AW*: ♂ 2.9-3.5 (3.2); ♀ 2.5-3.6 (3.1). *FWL/BR*: ♂ 3.07-3.31 (3.20); ♀ 3.18-3.60 (3.39).

DISTRIBUTION & HABITAT (Fig. 13). A very small inconspicuous cicada occurring widely through the Cape York Peninsula, in dense shrub/heath and woodland environments, especially in proximity to water courses. It has also been found in low melaleuca woodland near Normanton. It inhabits the foliage, inner branches and less commonly open trunks of the shrubs and trees, its colouration, its soft and high pitched song, and small size ensuring its very cryptic nature. It is nevertheless locally abundant during the summer (November – March). Specific localities extend from Punsand Bay and the Jardine River in the north; extensively in the Heathlands region (including the Gunshot, Dulhunty, Bertie and Cockatoo rivers and creeks); the Archer River crossing; Pennefather River, north of Weipa; Tozer Gap and the West Claudie River near Iron Range; near Cape Flattery; and to the north of Normanton (southeastern Gulf).

ETYMOLOGY. Latin *crepitum,* a crackle/rattle noise; in reference to the various song forms of this species.

SONG (Figs 30-35). For a very small cicada, this species emits a remarkable range of song patterns

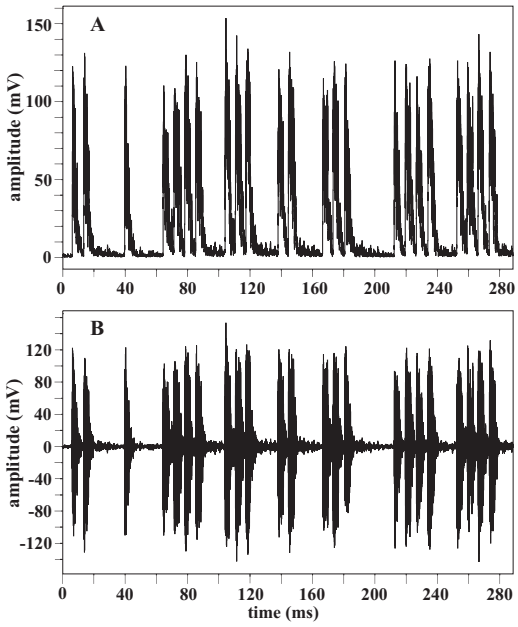

FIG. 32. *D. crepitum*. Envelope curve (a) and waveform plot (b) of the initial stage of syllable coalescence, following the very rapid clicking phase, which leads, with increasing rapidity of song emission, to the continuous buzzing song phase. Recorded from 11km north of Normanton. Container recordings, filtered (FIR) to 1kHz,

(Fig. 30). The simplest pattern, referred to as the *normal clicking song* (Fig. 30A), consists of a series of short, repetitive chirps, referred to as echemes, each ranging between approximately 16 to 86ms in length, comprising between 3 to 16 syllables without clearly defined gaps. The term echeme is used as their lengths and syllable numbers seem to mostly require more than a single cycle of buckling of the timbal pairs. This term, is however, somewhat complicated by the occurrence of the echemes not only singly (most common), but sometimes as sets of double (Figs 30A, 31A) or even triple echemes. For the purposes of the following descriptions, these multiple echeme sets are treated as single echemes unless specified otherwise.

Inter-echeme intervals within the normal clicking song range in length between 0.94-2.26s (Table 6). Within these intervals occur a series of single syllables, 4-11 in number, with inter-syllable intervals of approximately 100-270ms. In detail, these inter-syllable intervals are variable in length, with the most common pattern being one of progressively increasing intervals during song emission, with the exception of the final syllable interval (Fig. 31A).

Under appropriate conditions (e.g. singing in full sunshine; rapidly rising morning temperatures), a significant speeding up of song emission occurs, producing the *rapid clicking song* (sounding to the ear as a distinct 'galloping' song), followed with further increasing rapidity of echeme emission, by the *very rapid clicking song* (Fig. 30B, C). The changes through these song phases involve the reduction in the number of inter-echeme syllables emitted, together with the contraction of the inter-echeme intervals (Table 6). The echemes in these faster song phases mostly occur singly, but in some records, also as double echemes. The song phases further develop, by the progressive coalescence of echemes and syllables (Figs 30D, 32), into the *continuous buzzing song*, with sporadic interspersed very rapid clicking phases. Mean syllable lengths range between 4.6-7.3ms in the normal clicking songs, and 6.1-6.9ms in the faster songs types.

TABLE 6. *Drymopsalta crepitum* - summary of song parameters from three locations. [(1)] Single and doublet echemes overlap in their respective inter-echeme intervals [(2)]Figures represent means, ±σ, number of measurements (n) and ranges of data (in brackets).

	Heathlands	Pennefather River	Normanton
A. Echemes			
Inter-echeme intervals -(s) [(1)]			
(i) Normal clicking song	1.50±0.30 (n=28) (1.01-2.26)[(2)]	1.13±0.18 (n=14) (0.94-1.44)[(2)]	-
(ii) Rapid clicking song	-	-	0.30±0.05 (n=14) (0.20-0.37)[(2)]
(iii) Very rapid clicking song	-	-	0.25±0.02 (n=16) (0.22-0.28)

TABLE 6. *(Continued)*

	Heathlands	Pennefather River	Normanton
Inter-syllable intervals (ms) between adjacent echemes [(1)]**;** [number of inter-echeme syllables in square brackets].			
(i) Normal clicking song	187±22 (n=40) (102-234) [4-11]	175±42 (n=30) (107-269) [6-8]	-
(ii) Rapid clicking song	-	-	70±21 (n=6) (46-97) [2]
(iii) Very rapid clicking song	-	-	93±9 (n=32) (73-109) [1]
B Echeme structures			
Individual echeme lengths (ms); [number of syllables in square brackets]			
Single echemes:			
(i) Normal song	38.7 [5] to 60.4 [8]	74.2 [16] to 86.2 [16]	-
(ii) Rapid clicking song	-	112 [19] to 137 [23]	65.3 [11] to 79.4[13]
(iii) Most rapid clicking song	-	-	57.2 [11] to 64.9[12]
Double echemes sets:			
(i) Normal clicking song	-	15.8 [3] to 58.8 [14]	-
(ii) Rapid clicking song	-	-	18.6 [3] to 59.0 [10]
Triple echemes sets:			
(i) Normal clicking song	-	19.4 [4] to 34.0 [7]	-
Syllable lengths within echemes (ms);			
(i) Normal clicking song	6.76±0.41 (n=7) (5.9-7.1)	4.86±0.26 (n=32) (4.4-5.4)	-
(ii) Rapid clicking song	-	5.98±0.09 (n=5) (5.9-6.1)	5.09±0.10 (n=12) (5.0-5.2)
(iii) Very rapid clicking song	-	-	5.17±0.17 (n=12) (5.0-5.6)
(iv) Syllable coalescence (buzzing) phase	-	-	7.08±0.28 (n=4) (6.7-7.4)
Syllable structures within echemes;			
Individual hemisyllables – mean lengths (ms)	Not clearly resolvable	1.4-1.8 (normal song)	(a) 1.07±0.35 (0.66-1.52) (very rapid clicking)
C Inter-echeme single syllable structures:			
(i) Mean total lengths - (ms)	7.26±0.79(n=17) (6.0-9.1) (normal song)	4.62±0.39(n=16) (4.1-5.8) (normal song)	(a) 6.38± 0.58(n=18) (5.7-7.8) (rapid clicking)
			(b) 6.12±0.54 (5.7-7.8) (very rapid clicking)
			(c) 6.85±0.27(n=22) (6.16-7.38) (coalescence phase)
(ii) Hemisyllable mean lengths -(ms)	3.28±0.40(n=17) (2.8-3.4) (normal song)	2.13±0.11(n=16) (2.0-2.4) (normal song)	(a) 0.47±0.19(n=48) (0.17-0.90) (rapid clicking)
			(b) 0.44±0.11(n=43) (0.27-0.71) (very rapid clicking)
			(c) 0.85±0.43(n=52) (0.28-1.71) (coalescence phase)

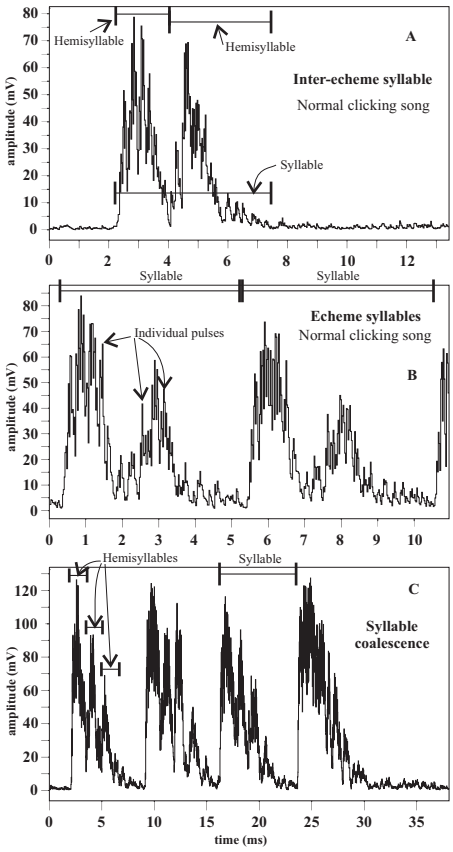

FIG. 33. *D. crepitum*. Expanded time scale envelope curves showing; (a) details of an inter-echeme syllable structure of the normal clicking song showing two hemisyllables; (b) two syllables within an echeme of the normal clicking song, each with two hemisyllables; and (c) four syllables from the pulse coalescence phase leading to the continuous buzzing song (see Fig. 32), each syllable showing three or more hemisyllables. Within the hemisyllables shown within the three plots, the complex higher frequency carrier pulses are visible; selected pulses labelled in (b) and selected hemisyllables labelled in (c). (a) and (b) represent container recordings from the northern shore of Pennefather River; (c) is a container recording from 11km north of Normanton. Each record is filtered (FIR) to 1kHz.

In time expanded plots, the majority (but not all) of the inter-echeme syllables of the normal clicking song display two well defined component hemisyllables (Fig. 33A), with lengths between 2-4ms (250-500Hz). In the rapid clicking ('galloping') song, the inter-echeme syllables vary between one to two in number (most common), and rarely three (Fig. 30B). Single inter-echeme syllables characterise the very rapid clicking songs (Fig. 30C). In the coalescence phase leading to buzzing, the progressive coalescence of the syllables (Figs 32, 33D) becomes evident. Within these more rapidly emitted song phases, the internal syllable structures move away from the double hemisyllables of the normal clicking song to more complex multiple hemisyllable structures (Figs 33C, 34) whose lengths range between 0.17-1.7ms (0.59-5.9kHz). The hemisyllables themselves comprise finer scale (higher frequency) pulses, representing the various carrier wave pulses (Figs 33, 34) whose wavelengths lie between approximately 0.06-0.25ms (~4-16.7kHz). The important aspect is that with increasing song emission rates, there is a recognisable change in pulse structures, consistent with the amplitude spectral data discussed below.

The echemes represent the coalescence of syllables (Fig. 31B), each normally with two hemisyllables in the normal clicking song (Fig. 33B), similar in structure to the inter-echeme syllables. In the rapid and very rapid clicking songs, however, the double hemisyllable structures tend to change towards multiple, shorter hemisyllables as seen in the associated inter-echeme syllables (see above). Syllable lengths vary between 4.4-7.4ms (Table 6), there being overlap of the data between the normal clicking and the faster song types, and also with the inter-echeme syllable lengths. The syllable structures comprising the echemes and inter-echeme syllables are clearly very similar.

Amplitude spectra (Fig. 35A) are especially complex in the normal clicking song, with two dominant peak groupings between ~12-13.5 and ~14-16 kHz. Further broad multiple peaks occur at ~16.5-17.5, 11-11.5, 8-8.5, and 7.5 kHz. Some of the observed complexity may represent multiple side band peaks originating from the complex hemisyllable through to echeme structures and amplitude modulation rates. Nevertheless, the range of frequencies presumably represents sound radiation from multiple sound radiation structures (Fonseca & Popov, 1994; Fonseca & Bennet-Clark, 1998). Comparison of the spectra of the normal song with those of the continuous buzzing phase (syllable coalescence phase; Fig. 35C) shows a marked amplitude increase of a broad peak centred at 15.2 kHz, but a notable amplitude reduction of all the other peaks. Nevertheless,

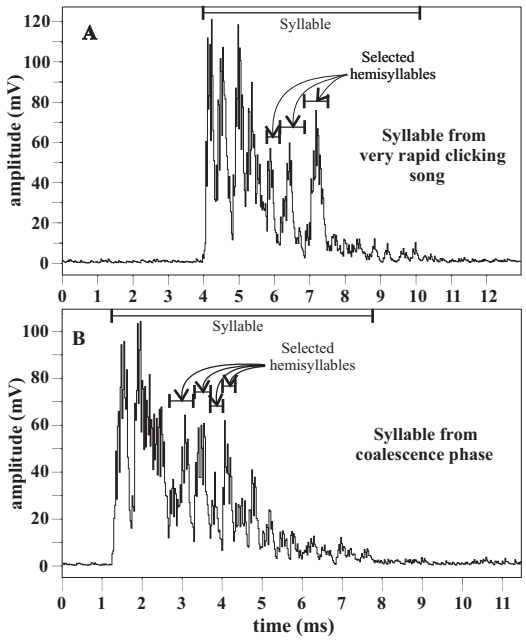

FIG. 34. *D. crepitum*. Expanded time scale envelope curves showing detailed structures of: (a) an inter-echeme syllable from the very rapid chirping song phase, and (b) single syllable from the syllable coalescence phase leading to the continuous buzzing song. In both plots, the syllables are characterised by multiple hemisyllables of variable lengths (cf. Figs 33A, B). Selected hemisyllables labelled. Container recordings from 11km. north of Normanton, filtered (FIR) to lkHz.

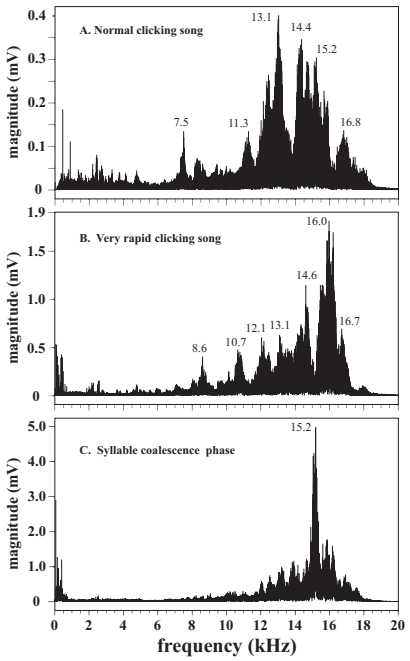

FIG. 35. Amplitude spectra of *D. crepitum* songs, showing the shifting emission frequency patterns in the changing song phases; (a) normal clicking song, filtered (FIR) to 0.5kHz; (b) very rapid clicking song, unfiltered; (c) syllable coalescence phase leading to buzzing song, unfiltered. Container recordings from (a) northern shore of Pennefather River, and (b, c), 11km north of Normanton. The frequencies of the main peaks are labelled (kHz).

weak peaks centred at 12, 12.5, 13.2, 13.9, 14.7, 15.9 and 16.9 are evident.

The major peak at 15.2 kHz is inferred to represent the fundamental frequency. Although a complex of peaks coincides with this frequency in the normal clicking song, the maximum frequency amplitude of the latter lies at ~13 kHz. It therefore seems possible that with increasing speed of song production, there is a change in the relative importance of the various sound radiating structures, with or without a change in the fundamental frequency. Amplitude spectra of the rapid chirping and most rapid chirping phases exhibit intermediate stages in the relative reduction of the frequency peaks less than ~15 kHz, as shown in Fig. 35B by the very rapid chirping phase. This clearly exhibits the reduction of the 13 and 14-14.8 kHz peaks, and the enhancement of the 15-16 kHz peaks (the latter inferred to represent the carrier frequency). Thus, the amplitude spectra, when considered through the sequence of increasing syllable emission rates, suggest a general increase in the carrier frequencies and corresponding reduction of the lower frequency components, consistent with changing patterns of sound radiating centres, and apparently correlated to the greater importance of timbal radiation.

It is noted that the timbal rib structure of this species is relatively simple with four long ribs and three poorly developed short ribs (Fig. 29C). Ribs 1-3 are fused ventrally and dorsally, whereas rib 4 is fused only dorsally to the basal spur. It is therefore suggested that the fused posterior long ribs act, in unison, as the dominant sound producing mechanism.

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Field work carried out over a number of years

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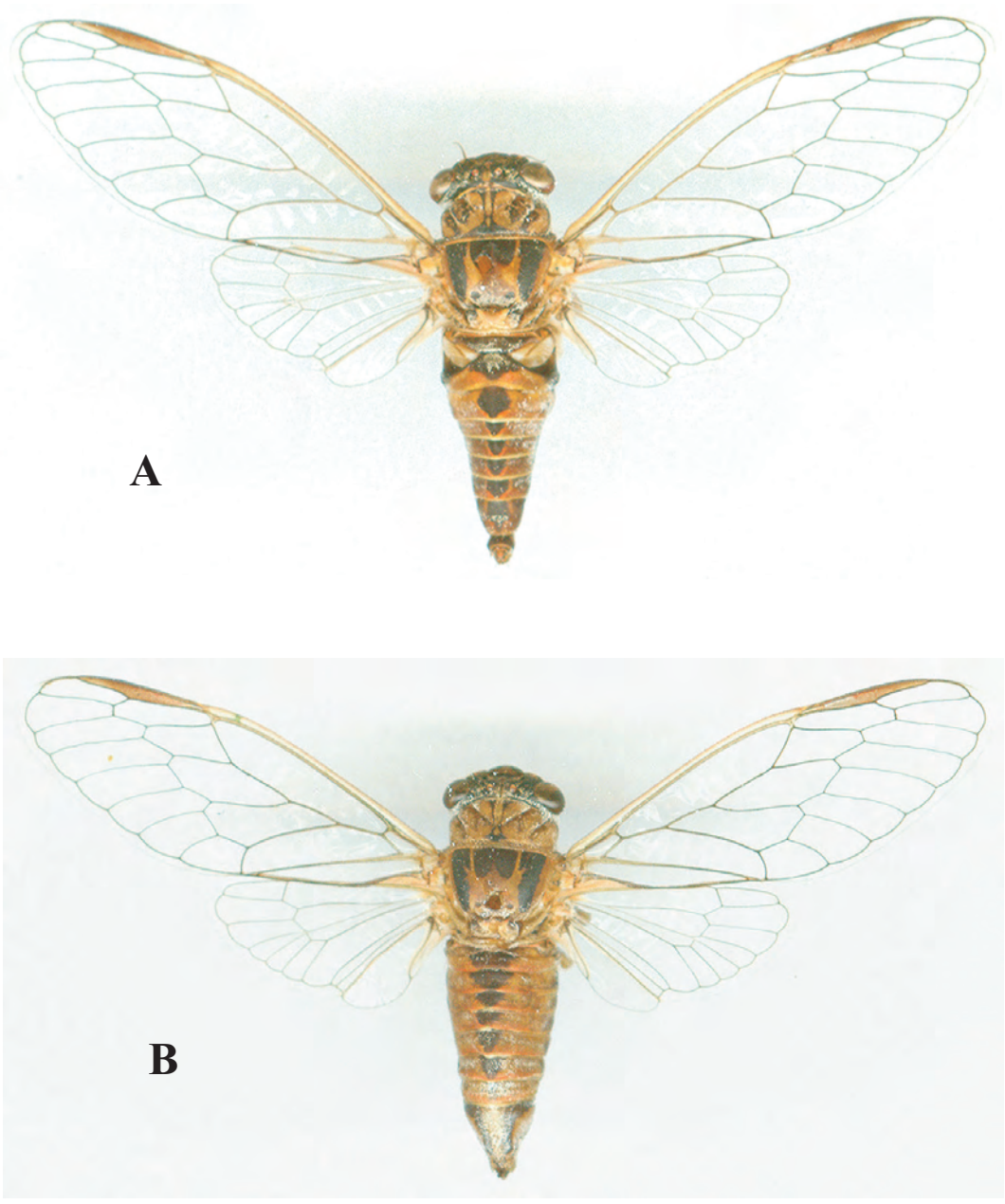

FIG. 36. *Crotopsalta plexis*. A, male, from near Chinchilla, 10.5mm long; B, female, Glebe Weir near Taroom, 11.8mm long.

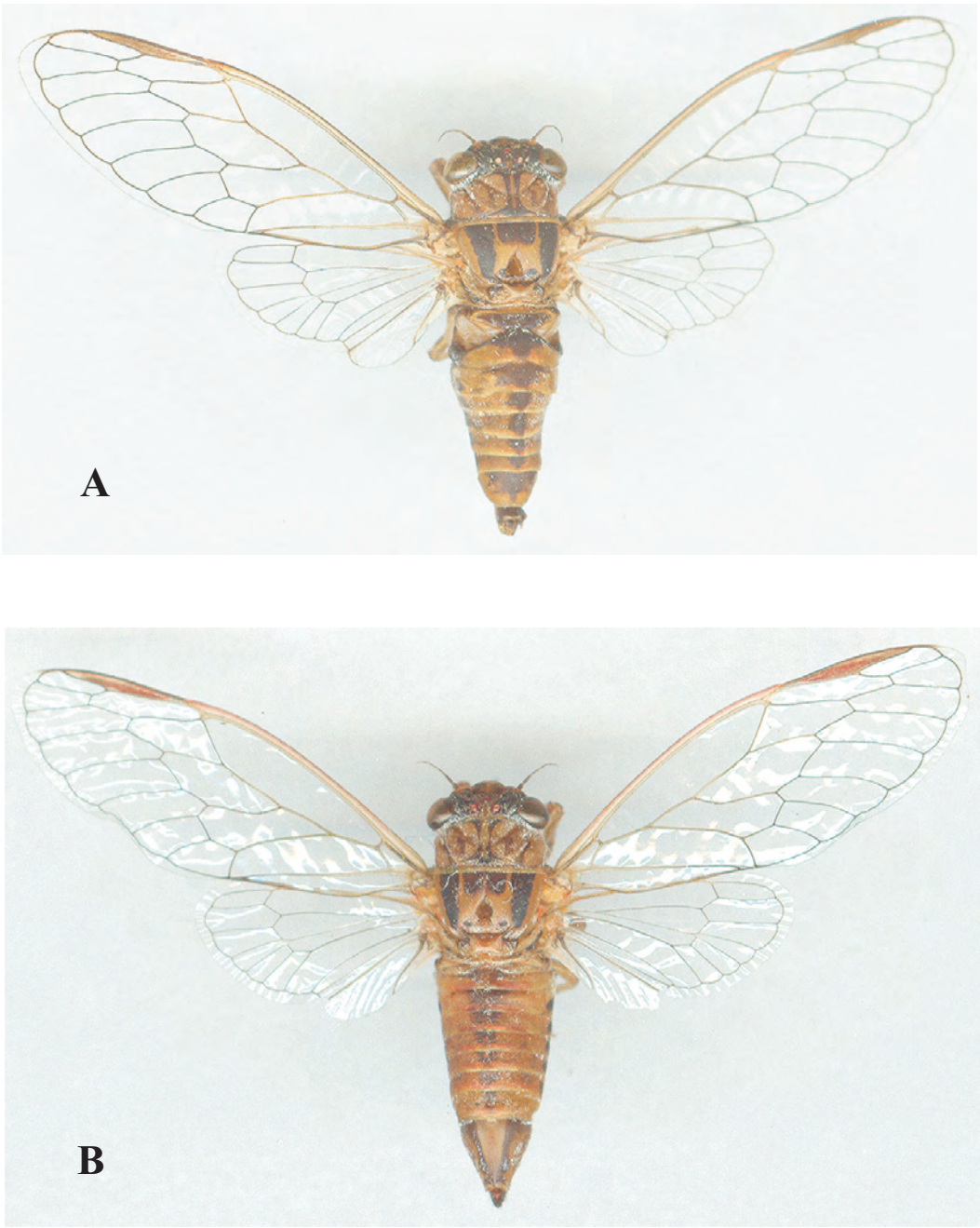

FIG. 37. *Crotopsalta fronsecetes*. A, male, from Gurulmundi, north of Miles, 11.7mm long; B, female from 9 km northwest of Yaamba, 12.0mm long.

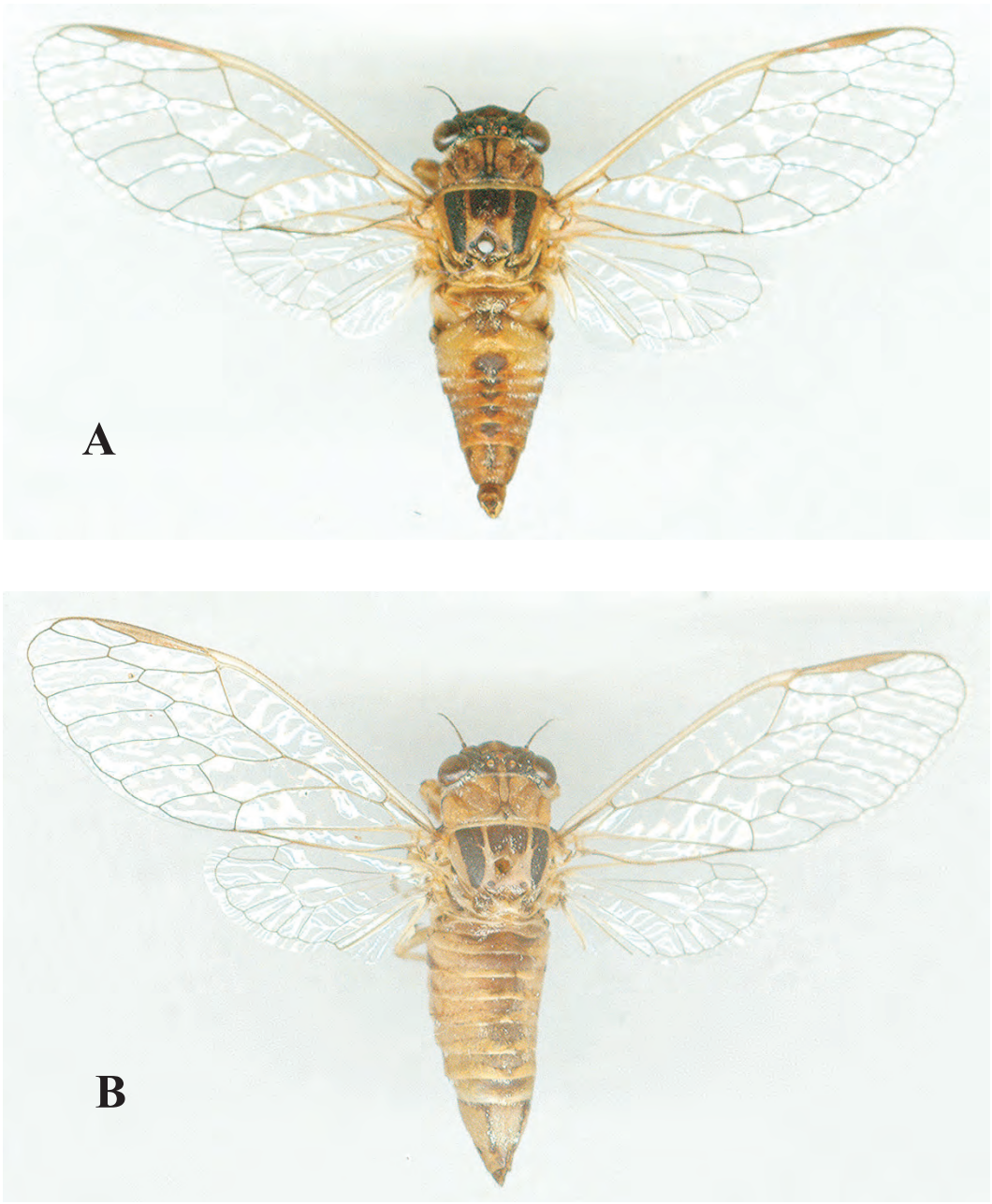

FIG. 38. *Crotopsalta strenulum*. A, male; B, female, from Nogoa River, Emerald, central Queensland. Total body lengths 10.3 and 11.2mm, respectively.

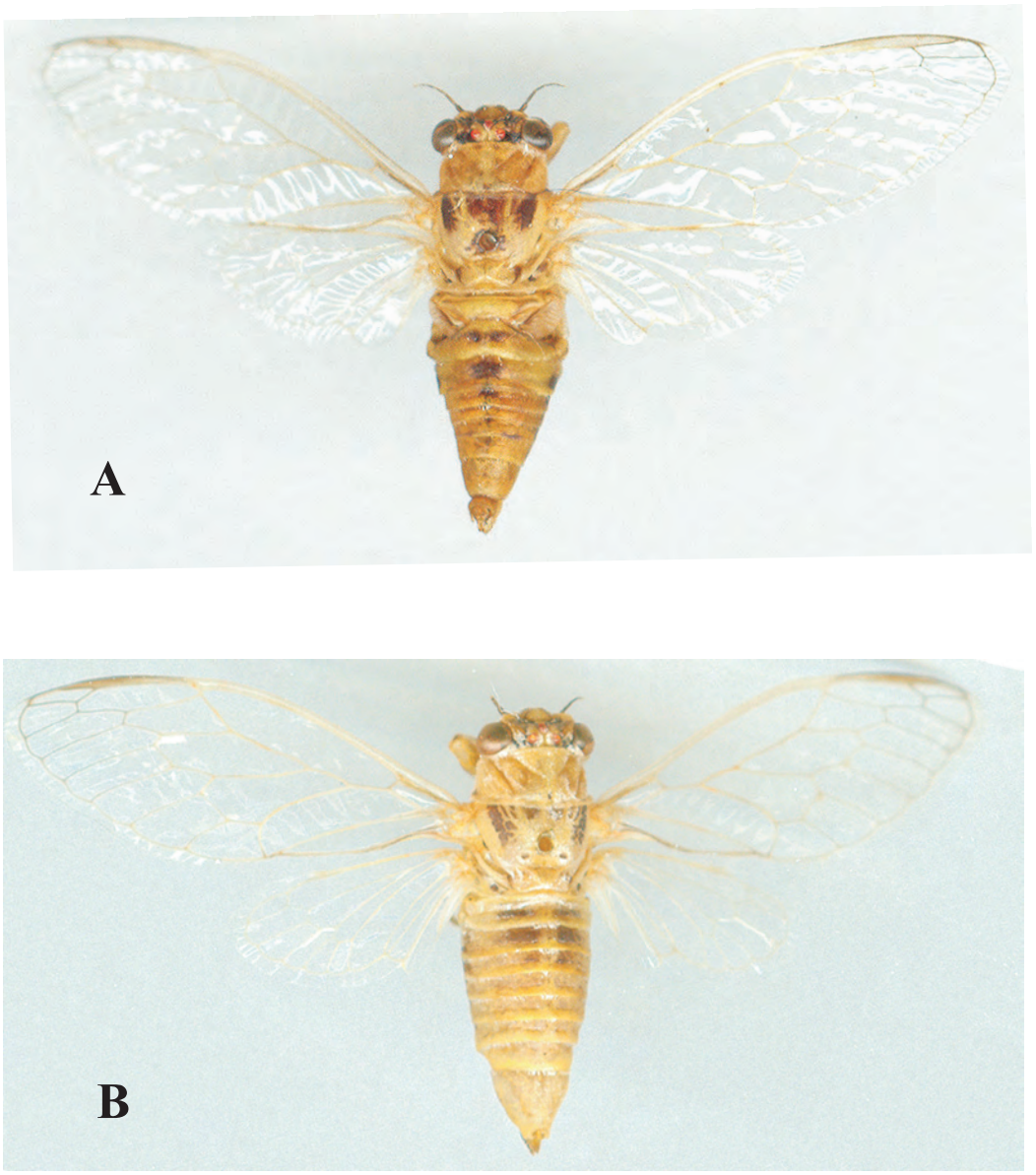

FIG. 39. *Crotopsalta poaecetes*. A, male; B, female, from Cloncurry, northwestern Queensland. Total body lengths 10.0 and 10.9mm, respectively.

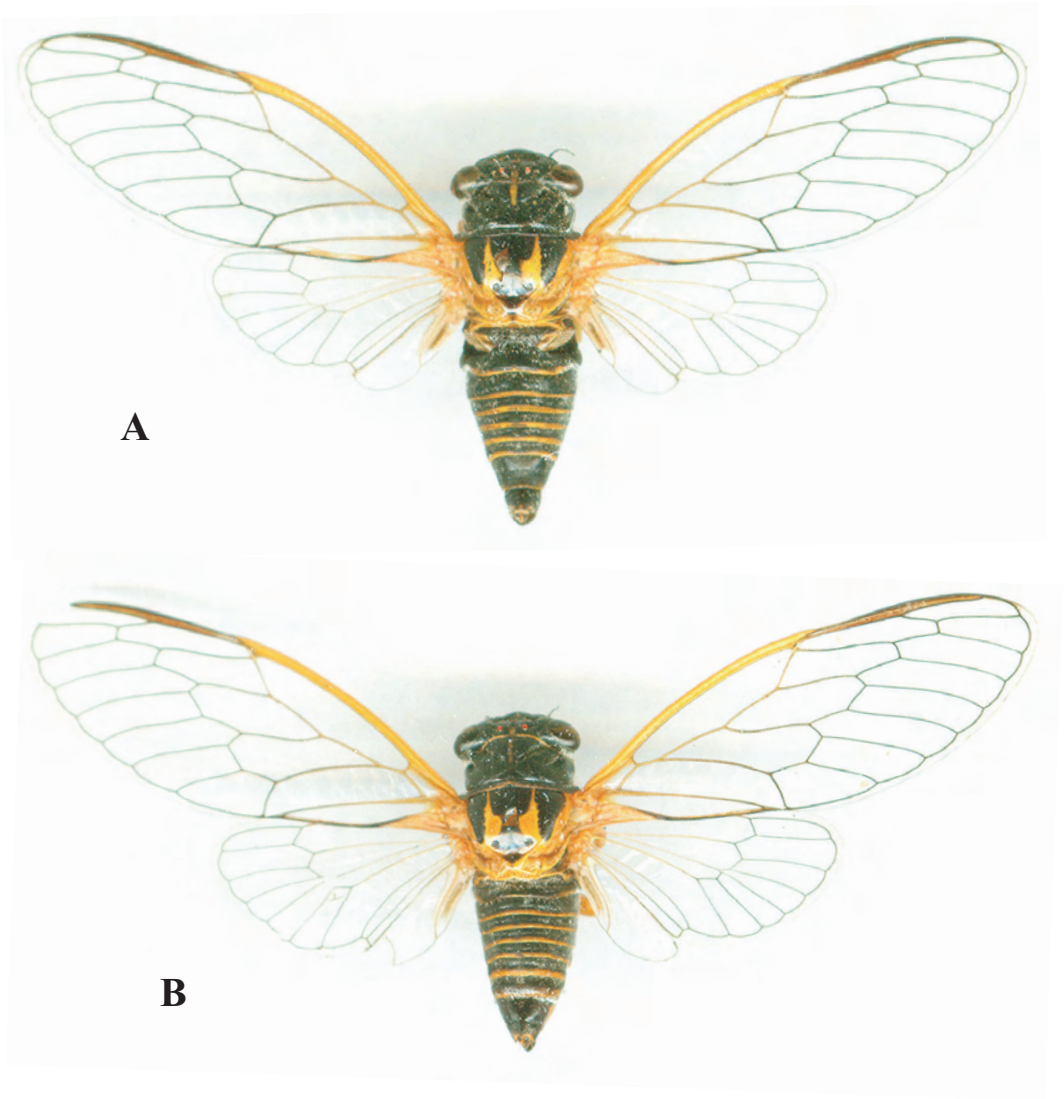

FIG. 40. *Gagatopsalta auranti*. A, male; B, female. From northern Barakula State Forest, north of Chinchilla, southeast Queensland. Total body lengths 10.6 and 11.1mm, respectively.

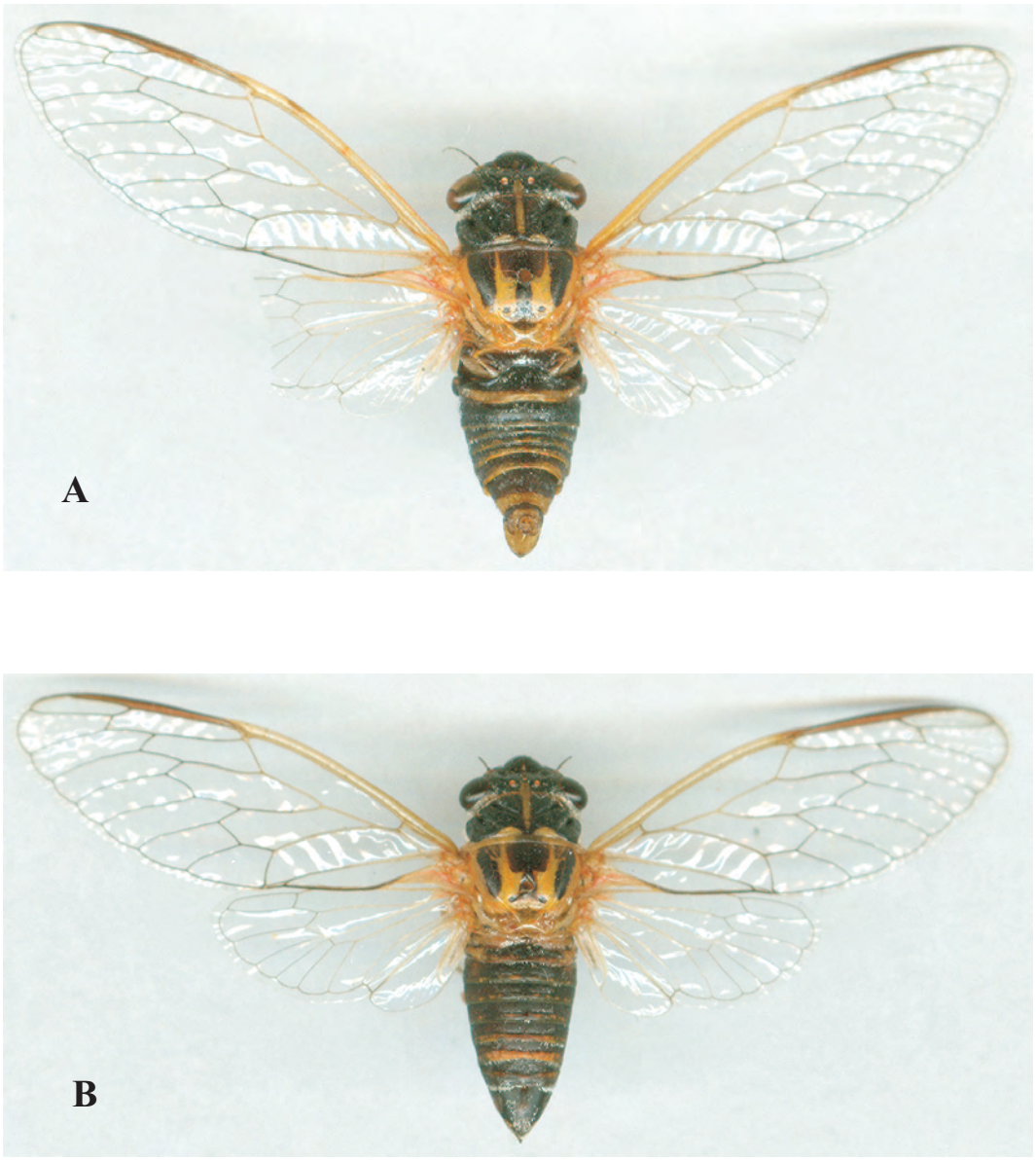

FIG. 41. *Gagatopsalta obscurus.* A, male; B, female. From Milroy H.S., approximately 70km north of Quilpie, southwest Queensland. Total body lengths 12.3 and 13.4mm, respectively.

FIG. 42. *Caliginopsalta percola*. A, male, from northern Barakula State Forest, north of Chinchilla, 11.6mm long; B, female, from Lake Broadwater, near Dalby, 12.3mm, long.

FIG. 43. *Pipilopsalta ceuthoviridis*. A, male, from Cluny lagoon, near Bedourie, 12.6mm long; B, female, from the Thompson River, near Jundah, 12.9mm long.

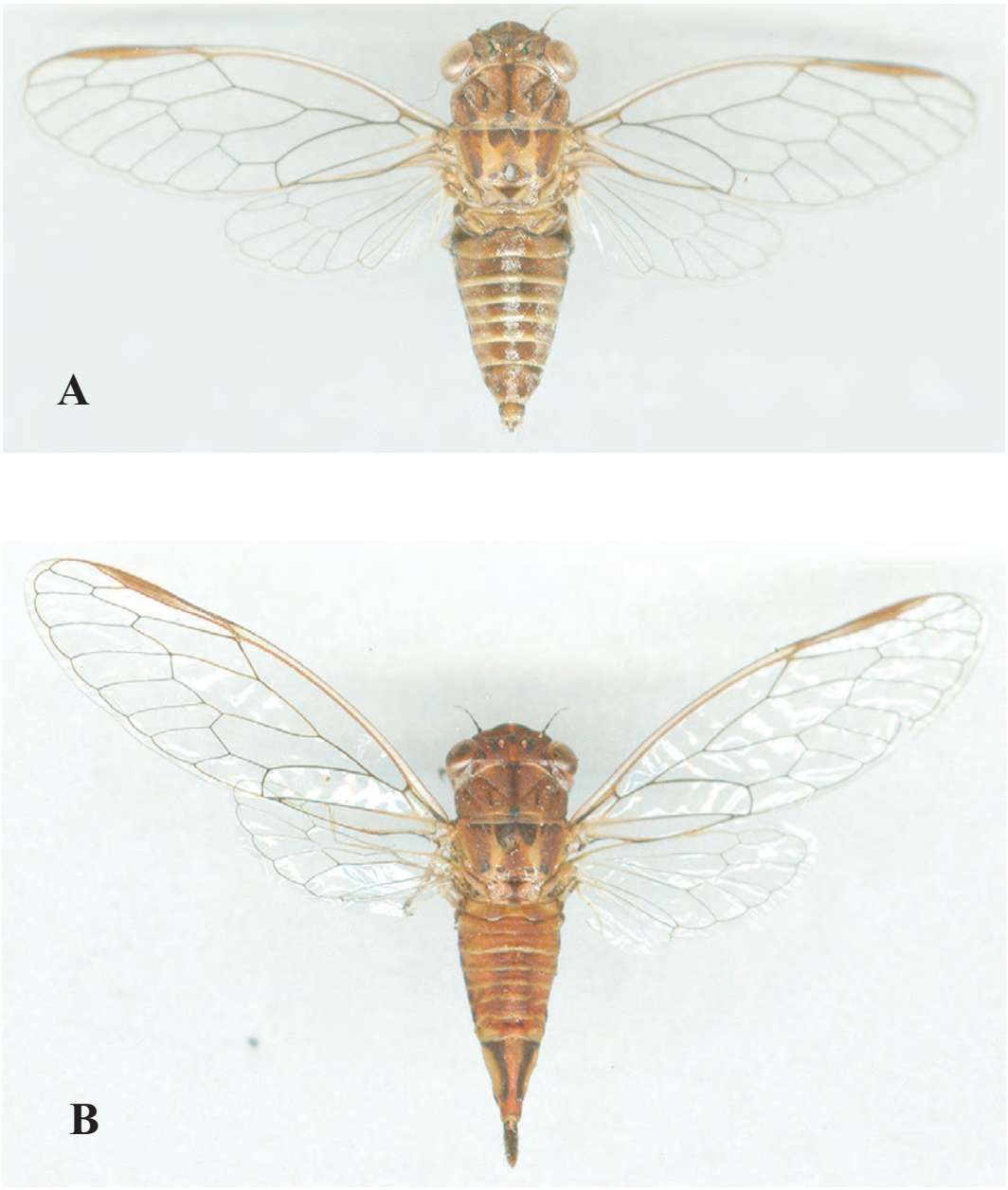

FIG. 44. *Drymopsalta crepitum*. A, male, from Heathlands H.S., 10.6mm long; B, female, from the northern side of Pennefather River, northern Cape York Peninsular, 12.2mm long.