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The genus *Terepsalta* Moulds (Insecta: Cicadidae: Cicadettiniae: Cicadettini) in Queensland, including the description of a new species

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ABSTRACT

The new genus *Terepsalta* Moulds, 2012, has recently been described with type species *Cicada infans* Walker. The original types now representing this species are *Cicada infans* Walker 1850 and *C. abbreviata* Walker 1862, the latter a later synonym with *C. infans*, both held in the British Museum of Natural History, and labelled as collected from Adelaide. No further specimens are known from South Australia. Cicadas collected from semi-arid grasslands of southern-central and southwestern Queensland, however, correspond closely to the types and are here identified as *T. infans*. A new species, *T. leichhardti*, is described from Mt Isa, north-western Queensland. The calling songs of both species are documented. ❒ *Cicadas, calling songs, song structures, song analyses, Queensland, taxonomy, semi-arid grasslands.*

This work results from the ongoing systematic collection of cicadas throughout Queensland. Such surveys continue to uncover previously undescribed species, especially smaller species, occurring in a wide range of woodland, heath and grassland habitats (e.g. Ewart & Marques, 2008). An important adjunct of the collection of specimens is the aural recording of their songs, which are valuable taxonomic tools (e.g. Young, 1972; Simmons & Young, 1978; Ewart, 1988, 1989, 1998, 2005; Simões *et al*., 2000; Ewart & Popple, 2001; Sueur, 2002; Popple & Strange, 2002; Popple, 2003; Sueur & Aubin, 2004; Pinto-Juma *et al*., 2005; Quartau & Simões, 2006; Seabra *et al*., 2006). In fact, in the field, calling songs provide an efficient means for identifying known species, and for recognising new species and species complexes.

In this paper, I redescribe *Terepsalta infans* and describe a new species belonging to this genus, including documenting their calling songs.

Abbreviations. *Institutions and collections*. ANIC, Australian National Insect Collection, Canberra; AE, private collection of A. Ewart, Caloundra; BMNH, the Natural History Museum, London; LWP, private collection of L.W. Popple, Brisbane; MSM, private collection of M.S. Moulds, Kuranda; QM, Queensland Museum, Brisbane. *Collectors and general*. NP, National Park; EP, Environmental Park; Rd, Road; H.S., Hstd., Homestead (agricultural property); Hwy., highway; Rec, recorded (= aural/electronic song recording); sp, species; spec, specimen; AE, A. Ewart; I.R., I. Rattray; J.N., Jack Nowland; SWQ, south-western Queensland; NWQ, north-western Queensland; PS refer to Queensland Museum photographic numbers.

MATERIALS AND METHODS

Anatomical terminology follows Moulds (2005, 2012) for general body shape and wing characters, Dugdale (1972) and Moulds (2005, 2012) for genitalia; de Boer (1999) for opercula,

and Simmons and Young (1978), Dugdale (1972) and Bennet-Clark (1997) for timbals. The timbal long ribs are referred to sequentially as ribs numbered 1 to 5, with rib 1 being the most distal (adjacent to timbal plate). The higher classification adopted in this paper follows Moulds (2012).

Measurements (in mm) are given as ranges and means (in parentheses) and include the largest and smallest specimens available. Head width is across the outer margins of the compound eyes; pronotum width across the lateral margins (excluding ampliated lateral angles); abdomen width across the outer edges of the auditory capsules. Abbreviations used are: BL, total body length; FWL and FWB, forewing length and maximum breadth; HW, head width; PW, pronotum width; AW, abdomen width; FWL/BR, forewing length/breadth ratio.

Song Recordings and Analyses. Details of aspects of the methods used for acoustic song recordings, and the accompanying analyses are outlined in Ewart & Marques (2008). Field recordings are generally preferred for detailed analyses of the finer scale syllable structures of the songs and for frequency analyses using amplitude and power spectra. In the case of the *Terepsaltas*, their very small size, the low amplitude and relatively high frequency of their songs necessitates that the recording microphone be placed close to the singing insects, ideally within 1 to 2 m (thus parabolas should not be used). One option used was to use open net cages placed in the field locations of the cicadas. Container recordings, in contrast, allow very low-background noise recordings illustrating subtleties within their temporal characteristics, but commonly distort the finer pulse structures of the songs. Recordings of *T. infans* were made with a Marantz PMD660 Solid State recorder, and for the new species a Sony Walkman cassette recorder WM-D6C (with upper frequency response limited to 18 kHz), both in conjunction with a Sennheiser model K6/ME66 microphone. For the Marantz PMD660, recordings were made in PCM mode at sampling rate of 48 kHz. Although manufacture specifications indicate frequency responses of microphone and recorder to 20.0 kHz (-3.0dB) at 44.1 kHz sampling rate, bat detector comparisons indicate frequency responses to 24 kHz. Processing of recordings was undertaken with Avisoft SAS LabPro software. Amplitude spectra were produced using a 556-point Fast Fourier Transform with Hamming window. As the amplitude spectra of the *Terepsalta* species exhibit broad band frequencies, a "dominant frequency" parameter is used, this being the mean (or inferred mean) frequency of the total amplitude dominant frequency envelope as seen in the amplitude and power spectra. The extents of this envelope are shown in the amplitude spectra presented.

Terepsalta Moulds, 2012

Type species: *Terepsalta infans* (Walker, 1850)

Included species. *infans* (Walker, 1850), comb.n. Moulds, 2012: *leichhardti* sp. nov.

Diagnosis (slightly modified after Moulds, 2012)**.** Small cicadas, total body lengths <13 mm. Head width, including compound eyes slightly wider than thorax, but not as wide as abdomen across auditory capsules; supra-antennal plate meeting eye; compound eyes separated from pronotum along outer ventral margin; distance between lateral ocelli slightly less than between lateral ocelli and eyes; rostrum clearly reaching mid coxae but not beyond. Postclypeus rounded transversely across ventral midline, also as seen in anterior and dorsal view; lateral margins of pronotum in dorsal view approximately parallel sided; pronotal collar width less than diameter of eyes; paranota confluent with adjoining pronotal sclerites; no mid lateral tooth; cruciform elevation wider than longer; metanotum clearly visible at dorsal midline. Abdomen broadly cylindrical between tergites 1 to 5, tapering posteriorly on tergite 6, more strongly tapered on tergites 7 and 8; widest part of abdomen across auditory capsules; epipleurites not reflexed to ventral surface; tergite 1 narrowed across dorsal midline; tergite 2 usually wider than tergite 3 along dorsal midline; sternites III to VII in cross-section weakly convex laterally, often somewhat flattened ventrally, not unusually swollen.

Fore wings hyaline, relatively short and broad (length/breadth ratios 2.3-2.6), similar in length to body; 8 apical cells; no subapical cells; ulnar cell 3 angled to radial cell; basal cell long and narrow; costal veins translucent and slightly higher than the R+Sc; costa parallel-sided to node, uncurved to gently curved (male); vein CuA weakly bowed so that the cubital cell of similar width to medial cell; veins M and CuA not touching or fused at basal cell; vein RA_1 not closely aligned with Sc, but vein RA is aligned with Sc; vein CuA_1 divided by cross vein m-cu such that the proximal portion may be shorter or nearly equal to distal segment; veins CuP and 1A fused in part; distance between cross veins r and r-m similar to distance between r-m and m; apical cells 3-6 approximately equal to ulnar cells (some longer, some shorter); radial cell clearly shorter than distance from its apex to wing tip; 3 distal vein sections of M that form inner margin of radial cell are of unequal length; basal cell slightly translucent, hyaline; infuscation absent; wing outer margin developed for its whole length, never reduced to be contiguous with ambient vein. Hind wings hyaline; most commonly with 5, but varying from 3 to 6 apical cells; no infuscation; width of 1st cubital cell at distal end about twice that of 2nd cubital cell; anal lobe moderately broad with 3A vein curved, long and separated from wing margin; veins RP and M fused basally. Fore legs with 3 erect spines. Male operculae reaching margin of tympanal cavity, directed towards disto-medial margin of tympanal cavity; broadly rounded along distal and lateral margins, more linear along medial margin; gently domed across dist-medial area; operculae not meeting medially; clearly raised above tympanal cavity along its outer margin; developed asymmetrically around meracanthae, these located towards midline; meracantha spikes well developed, just overlapping operculae. Timbals with 5 long ribs, rib 5 shortest, rib 4 not continuous medially, ribs 1 to 3 fused ventrally, and also dorsally with basal spur; basal dome on timbal plate elongated, relatively prominent; anterior part of timbal plate mostly occupied by ribs; posterior margin of timbal cavity ridged on lower half; timbals not extended below wing bases; 2 to 3 small inter-rib sclerites; timbal covers absent.

Male genitalia; pygofer in ventral view sub-ovoid to ovoid in shape; distal portion of upper pygofer lobes not widest point; pygofer with distal shoulders not developed; upper lobes flat, moderately developed, set well away from dorsal beak, moderately acutely terminated distally; basal lobes undivided, moderately developed, broadly rounded in lateral view, abutted against pygofer margin, slightly indented at distal terminations; dorsal beak present, relatively sharp apex, part of chitinized pygofer; uncas relatively small, flattened, more or less duck-billed shape; claspers well developed, dominant, restraining aedeagus, slightly flattened, outer face with an overhanging lip along margin, unfused, lacking an inward facing swelling on proximal half of inner margins and diverging gently towards distal ends, their apices not widely separated; aedeagus with basal plate in lateral view undulated, weakly depressed on dorsal midline, in dorsal view as long or longer than broad, apically broadened with 'ears'; basal portion directed forwards away from thecal shaft; junction with theca and basal plate with a functional 'hinge' that posses a chitinous back; thecal shaft relatively straight; pseudoparameres present, dorsal of theca and originating distal of thecal base, unfused throughout their length, in dorsal view slightly undulated and diverging apically, in lateral view aligned with thecal shaft; endotheca exposed, soft, entirely fleshy; endothecal ventral support present, shorter than pseudoparameres; thecal apex chitinized.

Terepsalta infans (Walker, 1850
(Figs 1-5, 8, Plates 1A-D, 2A-B, Table 1)

Cicada infans Walker, 1850: 201 (*nec* Walker 1862:304)
Tibicen infans (Walker): Stål, 1862: 485
Cicada abbreviata Walker 1862: 303-304
Melampsalta abbreviata (Walker): Goding and Froggatt, 1904: 649-650
Quintilia infans (Walker): Distant, 1906: 144 (*nec* Froggatt, 1907:352)
Terepsalta infans (Walker): Moulds, 2012: 216-219

Distant (1906) synonymised *C. infans* (type is a female held in BMNH) and *C. abbreviata* (Walker), type is a male also held in the BMNH.

Moulds (2012) has accepted this synonymy, and this is followed here. Plate 1 illustrates these two type specimens. As documented in Moulds (2012), both the type specimen locations are labelled as 'Adelaide'. No further specimens of this species are known from Adelaide, or indeed from South Australia.

Collecting in central and south-western Queensland has, however, revealed the presence at multiple locations of small dark grass cicadas which very closely match the characters of the types of *T. infans* and are here specifically identified as *T. infans*. The following descriptions are based on representative specimens from central and south-western Queensland, together with analyses of their calling songs. Until such time when further specimens of *T. infans* are captured in South Australia, and their calling songs documented, there could remain some doubt about the true identity of this species, but the overall similarities with the type specimens are noteworthy. Nevertheless, comparison of Plates 1, 2 and 4 indicates that the type specimens have more extensive darker pigmentation of the tergites than the Queensland specimens. The semi-arid grassland habitats in which the Queensland specimens occur suggests that the types may actually have come from dryer grassland areas north or northeast of Adelaide, rather than Adelaide City.

Material. Queensland: 14♂, 35 km W. Barcaldine, C.Q., grass, A.E., 15.i.2002, 23°31.94'S 144°56.51'E; 10♂, 2♀, ~8.2 km E Longreach, C.Q.,grass, A.E., 16.i.2002, 23°26.67'S 144°19.19'E; 1♂, "Big Hole", Vergemont Cks, Tonkoro Rd,W. of Noonbah H.S., SWQ, A.E., 30.i.2009, 24°05'14.8"S 143°07'45.2"E; 2♂, 3♀, Dam, Milroy Hst, ~70 km N. Quilpie, SWQ, grass, A.E., I.R., J.N., 13.i.2000; 26°02.85'S 144°20.81'E; 2♂, 6.7 km E. Longreach airport, along Hwy, C.Q., grassland, A.E. 10.i.2008, flood plain, 23°26.73'S 144°20.18'E; 1♂, 2♀, Buffel grass, Blackall, C.Q., early.ii.1979, after rains, Qld. Dept. of Primary Industries; 10♂, 7.7 km N. Milroy Hstd, ~70 km N Quilpie, SWQ, grass, A.E., I.R., 9.i.2000; 25°59.98'S 144°24.37'E; 1♂, 10 km ESE Blackall, W.Q., grassland, 25.ii.2007, A.E., 24°27.56'S 145°33.27'E; 1♂, 51 km NNW Blackall, C.Q., grass, A.E., 15.i.2002, 24°04.27'S 145°19.94'E; 1♂, 42 km NNW Blackall, SWQ, grass, A.E., 15.i.2002, 24°08.38'S 145°20.72'E; 2♂, 23 km NW Longreach, CQ., grass, A.E., 17.i.2002, 23°14.54'S 144°06.39'E; 2♂, Bulloo R. crossing, Milroy/Bulls Gully Hstds., ~70 km N. Quilpie, SWQ, A.E., I.R., 9.i.2000, 25°59.38'S 144°25.79'E; 1♂, 11.7 km E. Noonbah H.S., Tonkoro Rd, Lochern N.P., SWQ, Mitchell grassland, A.E., 19.ii.2009, 24°06.46'S 143°18.11'E (**AE**). 1♂, 7.7 km N. Milroy Hstd, ~70 km N Quilpie, SWQ, grass, A.E., I.R., 9.i.2000; 25°59.98'S 144°24.37'E (LWP). 1♂, (molecular voucher 09.AU.QL.VER.01), Vergemont R. channels, Noonbah Stn, 24° 05.327'S 143° 08.773'E, 30.i.2009, K. Hill, D. Marshall, A Emmott; 1♂, 1♀, (teneral), Noonbah Stn, Vergemont R. channels, 24° 5.327S 143° 8.773'E, 14.i.2002, Cooley, Hill, Cowan, Marshall, Moulds; 2♂, 2♀, Noonbah Stn, 24° 07'S 143° 11'E, 17.i.2002, A.J. Emmott & R. Ballard (MSM). 1♂, 7.7 km N. Milroy Hstd, ~70 km N Quilpie, SWQ, grass, A.E., I.R., 9.i.2000; 25°59.98'S 144°24.37'E; 1♀, ~8.2 km E Longreach, C.Q., grass, A.E., 16.i.2002, 23°26.67'S 144°19.19'E (QM). 1♂, 7.7 km N. Milroy Hstd, ~70 km N Quilpie, SWQ, grass, A.E., I.R., 9.i.2000; 25°59.98'S 144°24.37'E (ANIC)

Description. (Male). Fig. 1, Plates 1C, D, 2A, B. Specimens exhibit continuous variability in the extent and intensity of the darker pigmentation of especially the thorax and abdomen. The darker forms are more prevalent, but in the following descriptions, note is made of the deviations of pigmentation in the paler specimens.

Head. Supra-antennal plate, vertex and frons generally shiny black, small pale brown patches adjacent to pedicels; mandibular plate and gena shiny black to deep brown, covered by silvery-yellow pubescence; sandy brown along the depressed epicranial suture, extending between the lateral ocelli, and joining with the pronotal central fascia; ocelli pale red; compound eyes dark brown. Postclypeus shiny black to deep brown medially and dorsally, extending outwards along tranverse ridges into the pale brown outer margins; diffuse dorso-medial pale brown spot; anteclypeus deep brown, paler towards rostrum; rostrum brown, darker apically.

Thorax. Pronotum in most specimens predominantly deep brown to black, paler brown along and adjacent to paramedian fissures; central fascia narrow, pale brown, not quite reaching pronotal collar, with black margins widening along the anterior and posterior pronotal margins; pronotal collar mostly black, lateral margin ampliate; in paler specimens, pronotum has extensive but broken black colouration between paramedian and lateral fissures, extending to pronotal collar, the remainder brown, central fascia off-white to pale brown with more prominent narrow black margins widening along anterior and posterior

TABLE 1. Summary of song parameters of calling song of *Terepsalta infans.*

Location within phrase	Vergemont channels Noonbah, 135 km SW Longreach, S.W. Q.(1)	6.7 km E. Longreach, central Queensland(2)
1. **Phrase lengths** (seconds)(3)	13.9±4.0 [7.1-25.0] n=28	14.6±2.8 [10.9-20.8] n=8
2. **Initial echeme element**		
Durations of closed macrosyllables		
Mean (ms)	222±59 [114-339] n=46 (4.5Hz) (8.8-3.0Hz)	171±40 [81-314] n=33 (5.8Hz) (12.3-3.2Hz)
First 3 sets (ms)	150±29 [114-205] n=15	136±28 [81-154] n=6
Final 3 sets (ms)	275±36 [205-337] n=15	232±49 [193-314] n=6
3. **Repetition Rates of ticks** within closed macrosyllables		
Mean (ms)	9.4±1.1 [8.0-13.9] n=98 (106Hz) (125-72Hz)	10.1±1.7 [8.4-13.7] n=53 (99Hz) (119-73Hz)
First 2 ticks	11.5±1.3 [9.3-13.9] n=10 (87Hz) (108-72Hz)	13.4±2.4 [9.9-17.5] n=6 (74Hz) (101-57Hz)
Final 5 ticks	8.6±0.4 [8.0-9.1] n=25 (116Hz) (116-110Hz)	8.7±0.3 [8.4-9.1) n=15 (115Hz) (119-110Hz)
Primary-secondary pulse durations within ticks (ms)	2.79±0.13 [2.6-3.0] n=62 (358Hz) (385-333Hz)	3.49±0.29 [3.1-3.9] n=39 (358Hz) (323-256Hz)
4. **Open macrosyllables – tick repetition rates**		
Mean (ms)	37.8±6.2 [20-51] n=53 (26Hz) (50-20Hz)	47.9±8.6 [23-75] n=47 (21Hz) (43-13Hz)
Primary-secondary pulse durations within ticks (ms)	2.77±0.17 [2.5-3.1] n=41 (361Hz) (400-323Hz)	3.32±0.10 [3.1-3.5] n=21 (301Hz) (323-286Hz)
5. **Post-echeme microsyllable element**		
Number of microsyllables	23.2±8.1 [9-42] n=30	26.0±4.4 [16-32] n=9
Microsyllable repetition rates (ms)	323±24 [298-382] n=34 (3.1Hz) (3.4-2.6Hz)	267±19 [246-315] n=28 (3.7Hz) (4.1-3.2Hz)
Tick repetition rates within microsyllables (Hz)	136±3 [129-140] n=29 (7.4ms) (7.8-7.4ms)	126±3 [119-131] n=26 (7.9ms) (8.4-7.6ms)
Number of ticks per microsyllable	3-5	4-5
Primary-secondary pulse durations within ticks (ms)	2.87±0.12 [2.6-3.1] n=54 (348Hz) (385-323Hz)	3.74±0.15 [3.3-4.0] n=34 (267Hz) (303-250Hz)

(1) Recorded in open net, in the field with microphone, 30.i.2009, 24°05.25'S, 143°07.75'E, Mitchell grassland.
(2) In situ field recording with microphone, 10.i.2008, 23°26.73'S, 144°20.18'E, Mitchell grassland.
(3) Figures represent: Mean; ± 1s; range (in square brackets); n=number of measurements; and equivalent Hz (or ms) in pa.

TABLE 2. Summary of song parameters of calling song of Terepsalta leichhardti (1)

Location in phrase	**Mean**	σ	**n**	**Range**
1. **Phrase lengths** (seconds)	15.5	6.5	12	3.5-25.5
2. **Echeme**				
A. Initial microsyllables				
Number of ticks per microsyllable	5.3	1.6	39	2-8
Primary-secondary pulse duration within ticks (ms)	3.96	0.40	60	3.0-4.4
Tick repetition rate within each microsyllable (Hz)	120 (8.3ms) (2)	4	32	112-129 (8.9-7.8ms)
B. Macrosyllable ticking phase				
Number of ticks	31	7	10	17-40
Tick repetition rates (ms)	41.1 (24Hz)	4.1	88	32.2-53.6 (31-19Hz)
Primary-secondary pulse durations (ms)	3.22 (311 Hz)	0.14	68	2.9-3.7 (345-270Hz)
3. Post-echeme microsyllable phase				
Number of microsyllabales	44	19	12	14-76
Number of ticks per microsyllable	3.3	0.6	207	2-5
Microsyllable repetition rates (all data) (ms)	323 (3.1Hz)	71	140	149-436 (6.7-2.3Hz)
Microsyllable repetition rates – First 20 microsyllables (ms)	262 (3.8Hz)	49	60	149-346 (6.7-2.9Hz)
Microsyllable repetition rates – Final 20 microsyllables (ms)	361 (2.8Hz)	42	60	279-436 (3.6-2.3Hz)
Tick repetition rates within each microsyllable (Hz)	129 (7.8ms)	6	52	114-135 (8.9-7.4ms)
Primary-secondary pulse durations within ticks (ms)	3.59 (278Hz)	34	119	3.0-4.1 (333-244Hz)

(1) Container recordings, specimens from 2.2 km south of Mt Isa town, NW Queensland, 22.i.2002, 20°44.62'S, 139°29.72'E.

(2) Figures in parentheses are equivalent values in Hz or ms, as appropriate.

pronotal margins. Mesonotum predominantly dark brown to black, often obscuring the outlines of the sigilla; parapsidal sutures pale brown extending distally as thin, diffuse brown lines along inner margins of lateral sigilla; lateral sigilla extend to just beyond anterior cruciform elevation arms; cruciform elevation translucent pale brown, dark brown to black between anterior and lateral arms; pale brown along and between wing grooves; in paler specimens, the sigilla are more clearly defined, the intervening colouration varying from pale yellow to brown.

*Wings***.** Fore wing costal vein very pale brown tending to translucent; remaining venation colour medium brown proximally, becoming paler brown apically; basal membrane translucent pale grey-brown. Hind wing mostly very pale brown, darker proximal to mesonotum; weakly developed off-white plaga around anal cell 3 and adjacent to veins 3A and 2A; 5 apical cells most common, but a few

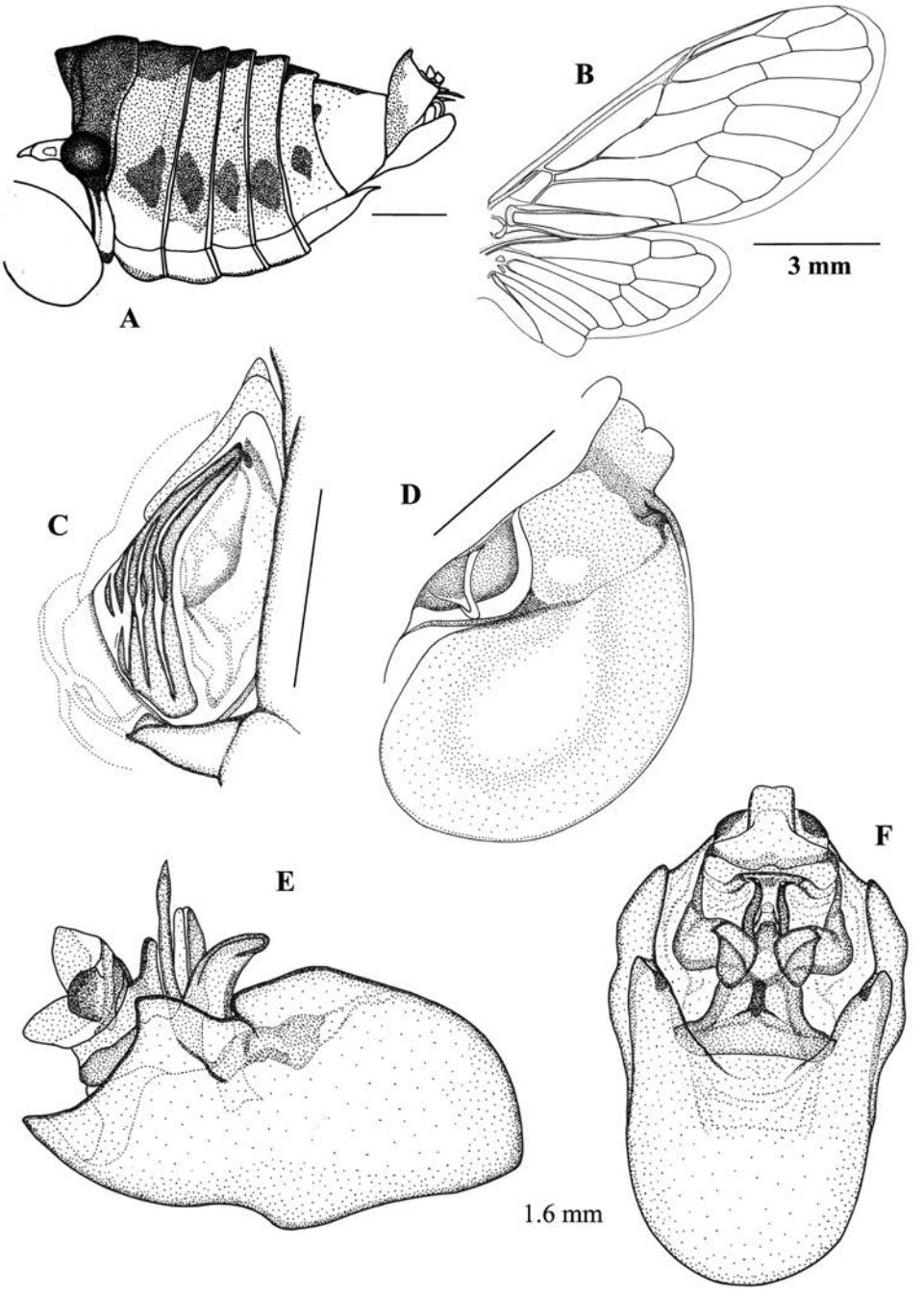

FIG.1. *Terepsalta infans*. 7.7 km N. Milroy H.S., ~ 80 km N. of Quilpie, SW Queensland. (A), lateral abdomen view; (B), fore and hind wings; (C), timbal (posterior margin at right, dorsal edge at top); (D), right operculum; (E) and (F), pygofer and male genitalia, lateral and ventral views, respectively. Scale bars 1 mm, except wings (3 mm).

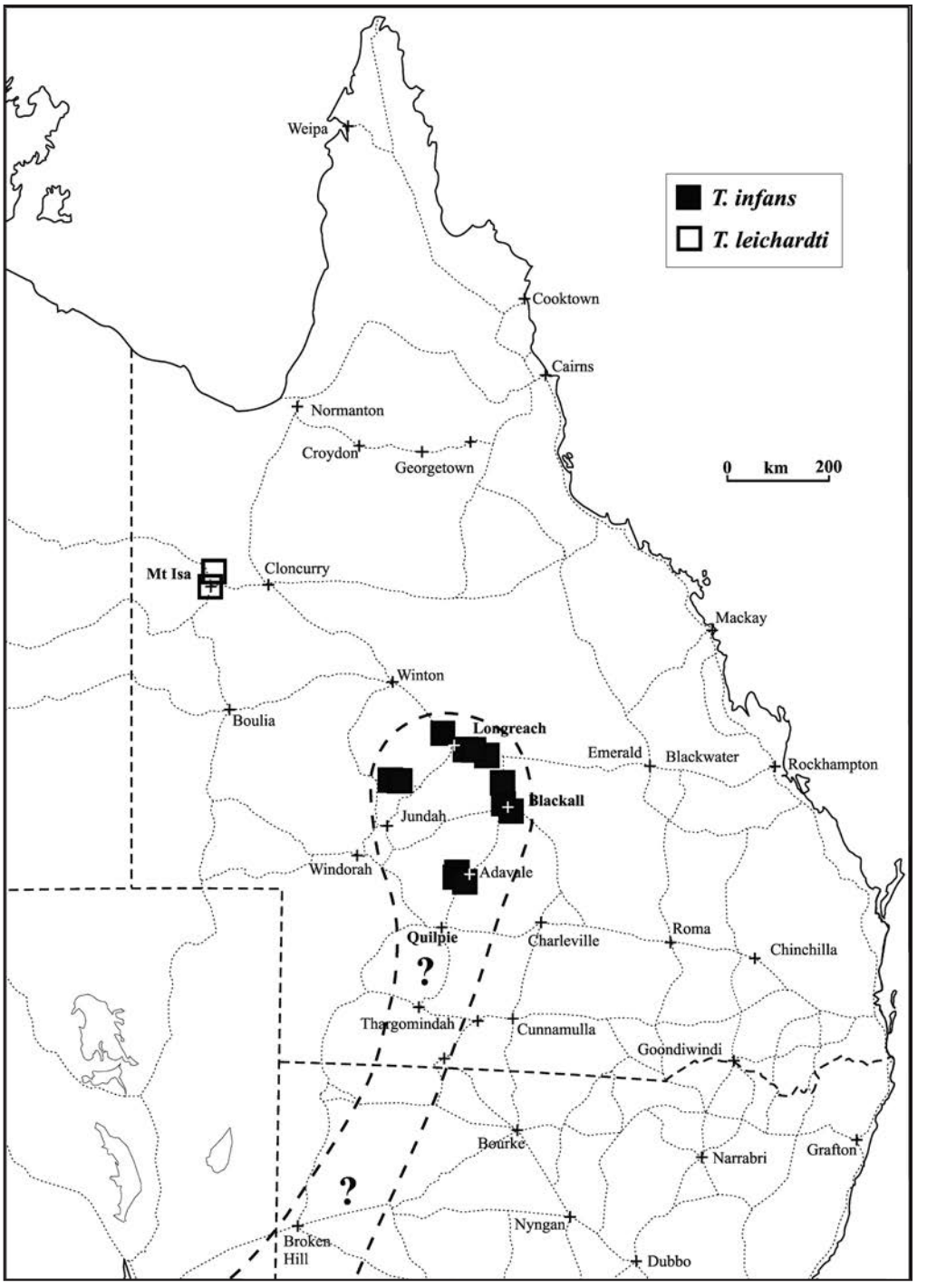

FIG. 2. Distribution records of the two known *Terepsalta* species in Queensland.

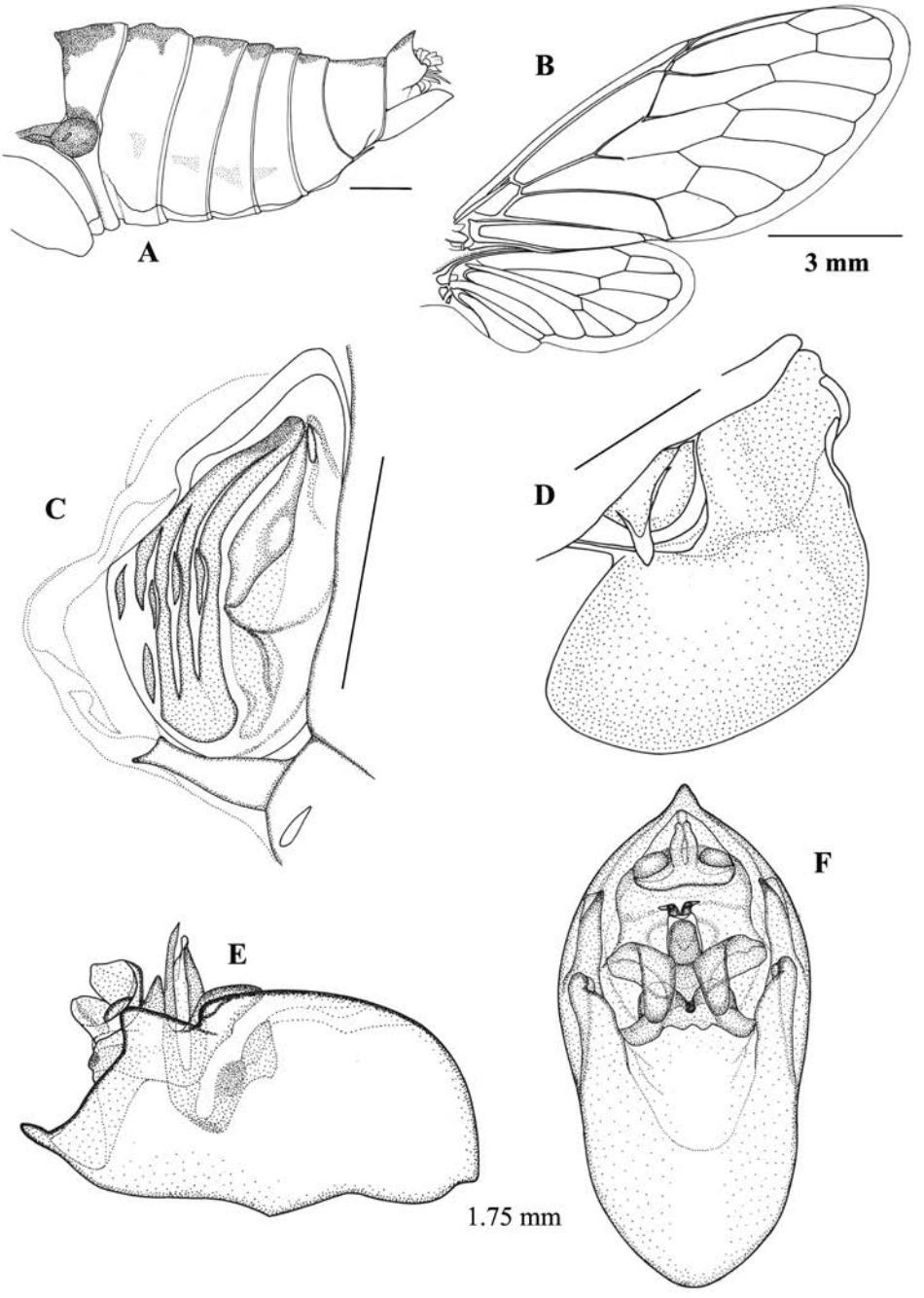

FIG. 3. *Terepsalta leichhardti* sp.nov., 2.2 km S. of Mt Isa and 6 km NE Mt Isa. (A), lateral abdomen view; (B), fore and hind wings; (C), timbal (posterior margin at right, dorsal edge at top); (D), right operculum; (E) and (F), pygofer and male genitalia, lateral and ventral views, respectively. Scale bars 1 mm, except wings (3 mm).

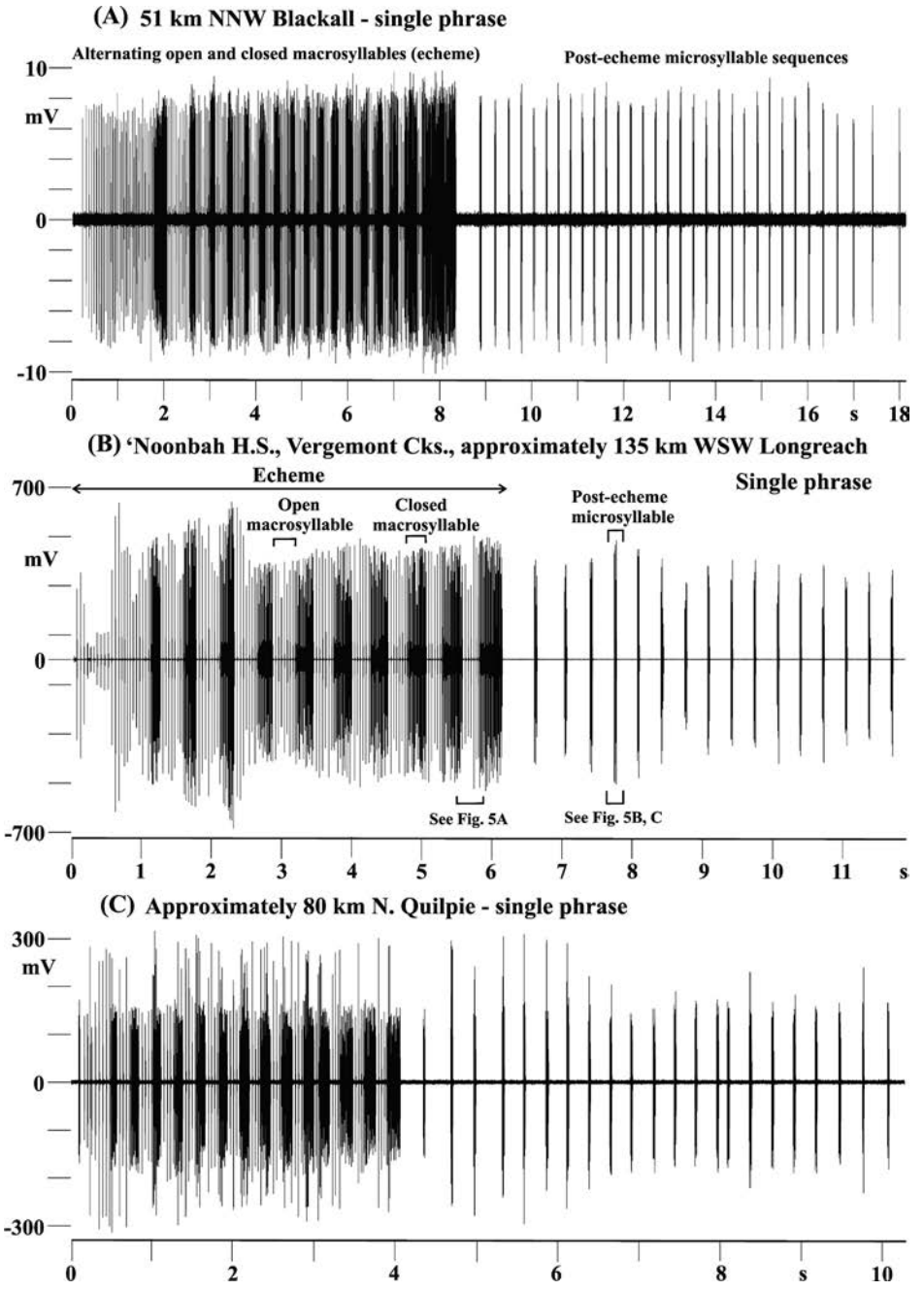

FIG. 4. *Terepsalta infans*. Waveform plots of calling songs showing the gross temporal structures of the phrases, specifically the echeme and post-echeme microsyllable elements. (A), 51 km NNW of Blackall, Central Queensland, container recording, 15.i.2002, filtered to 14 kHz. (B), 'Noonbah' H.S., Vergemont Creeks, approximately 135 km WSW of Longreach, SW Queensland, field recording in open cage, 30.i.2009, filtered to 14 kHz. (C), 80 km N. of Quilpie, SW Queensland, container recording, 9.i.2000, filtered to 1 kHz.

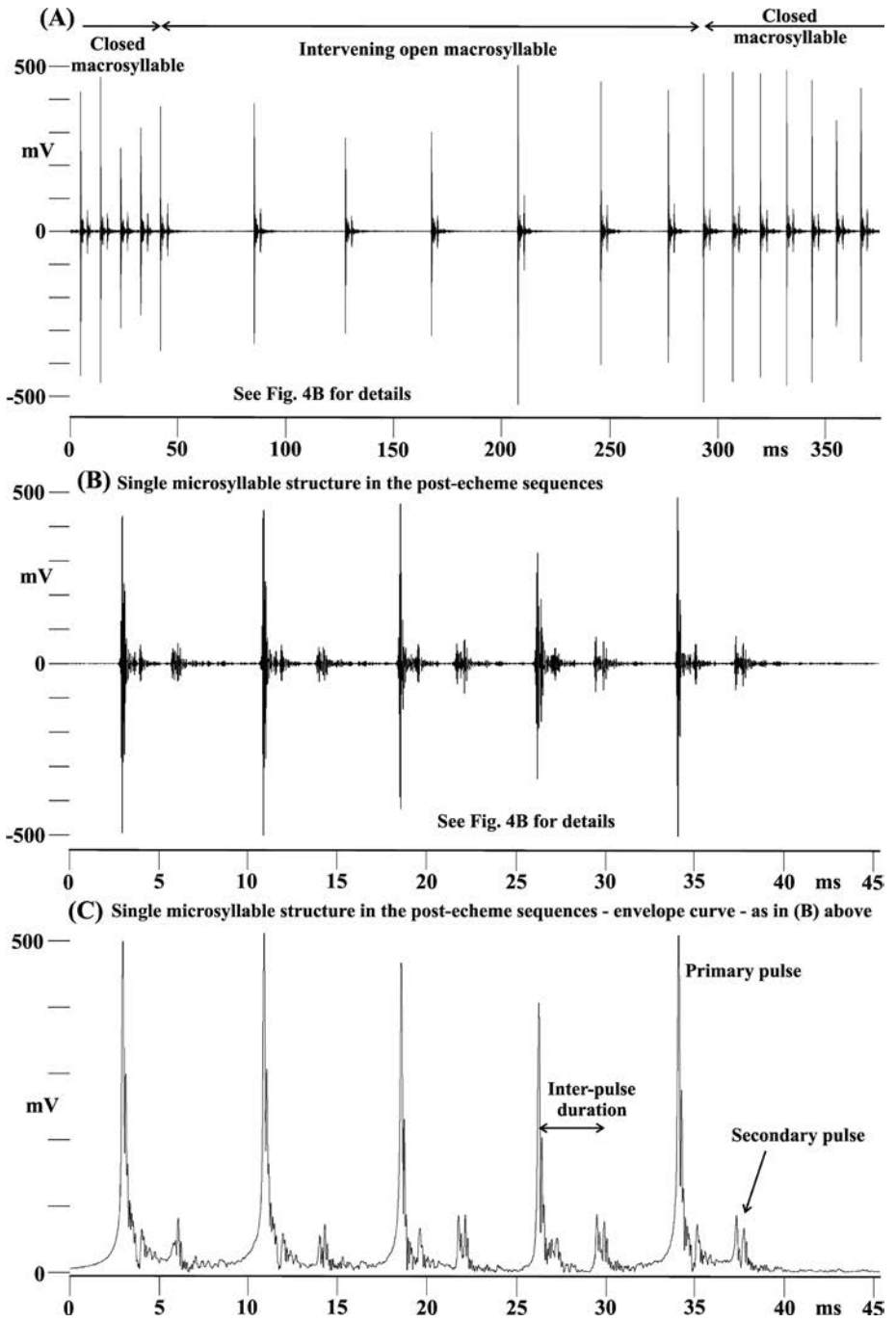

FIG. 5. *Terepsalta infans*. (A), time expanded waveform plots showing the tick structures within the closed macrosyllables and the intervening open macrosyllable. (B), higher resolution waveform plot of the tick structures within a single post-echeme microsyllable. (C), envelope curve plot of the same tick sequence shown in (B). The precise locations of these plots within each recording is shown in Fig. 4B.

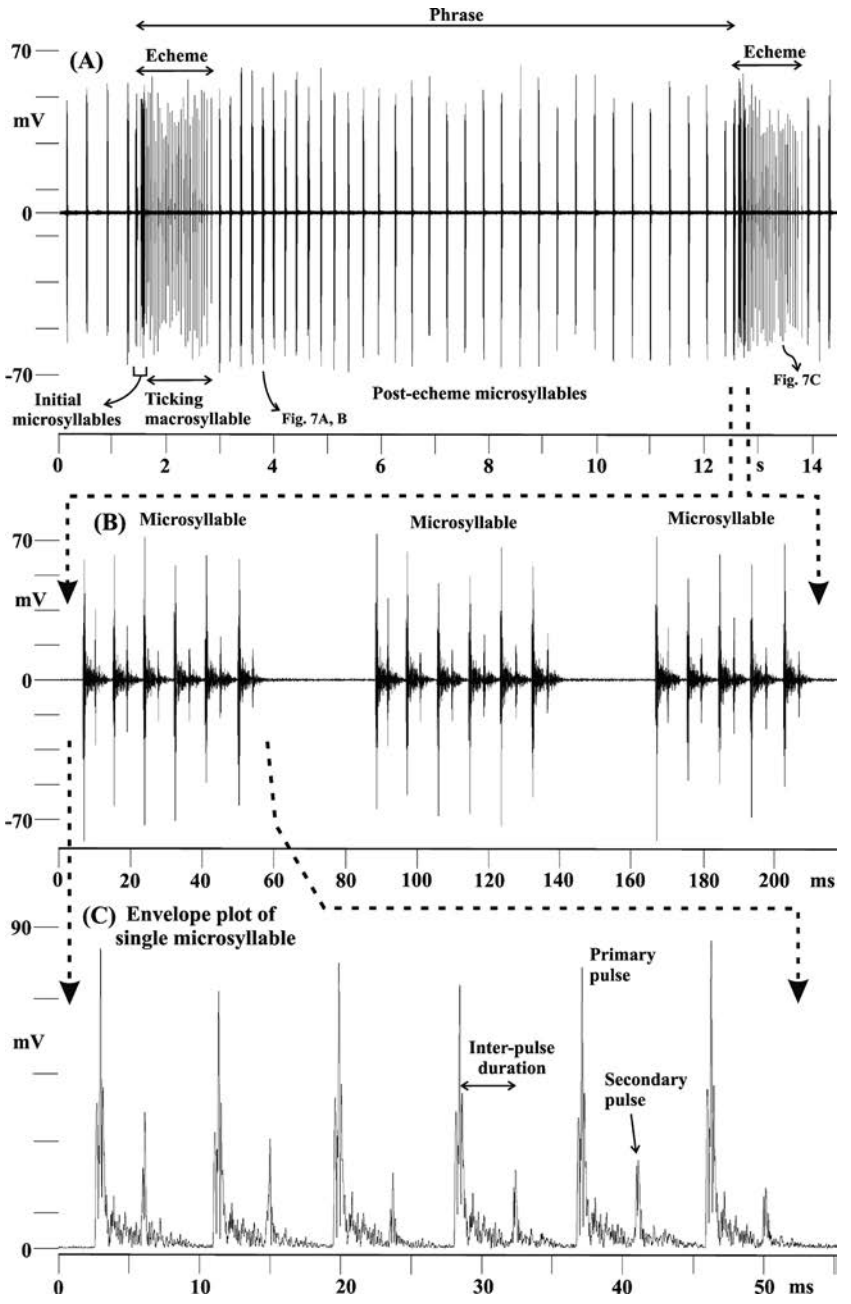

FIG. 6. Waveform plots of the calling song of *Terepsalta leichhardti* sp. nov., from 2.2 km S. of Mt Isa, container recording, 22.i.2002, filtered to 1 kHz. (A), plot of one complete phrase and segments of adjacent phrases, illustrating the echeme and the post-echeme microsyllable elements. (B), time expanded plot of three discrete microsyllables marking the beginning of a phrase, showing the detailed structures of the coalesced ticks. (C), higher resolution envelope curve plot of a single microsyllable shown in (B), revealing greater detail of the pulses and inter-pulse intervals.

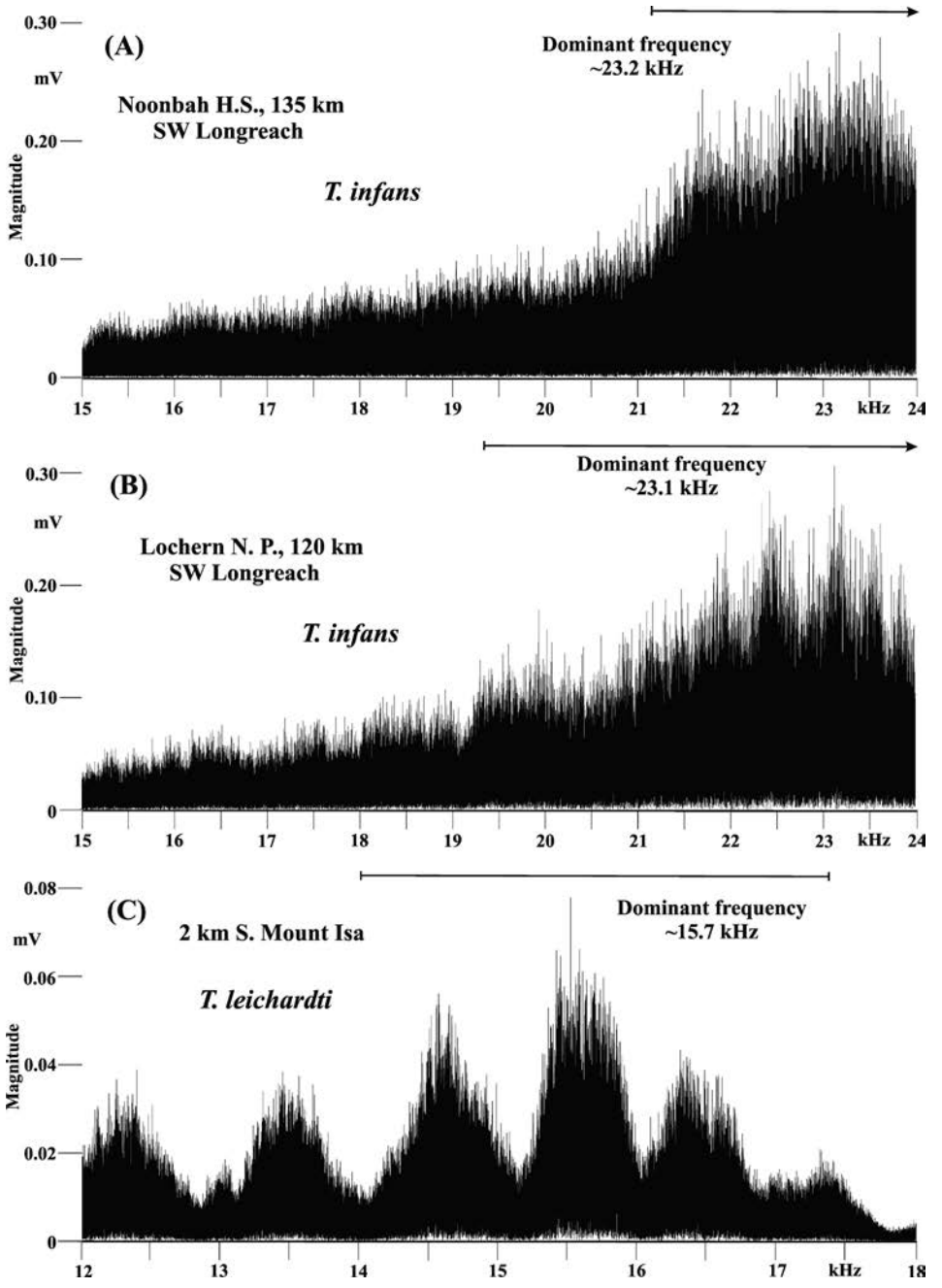

FIG. 7. Higher resolution plots in waveform and envelope curve of the calling song of *Terepsalta leichhardti* sp.nov., details as in Fig. 6 caption. (A) Waveform plot of the tick structures within a single post-echeme microsyllable (location shown in Fig. 6A). (B), envelope curve of the tick structures illustrated in (A), defining more clearly the pulse structures. (C), two single ticks within the ticking macrosyllable phase of the echeme (see Fig. 6A). Note the identical tick structures in the different segments of the song.

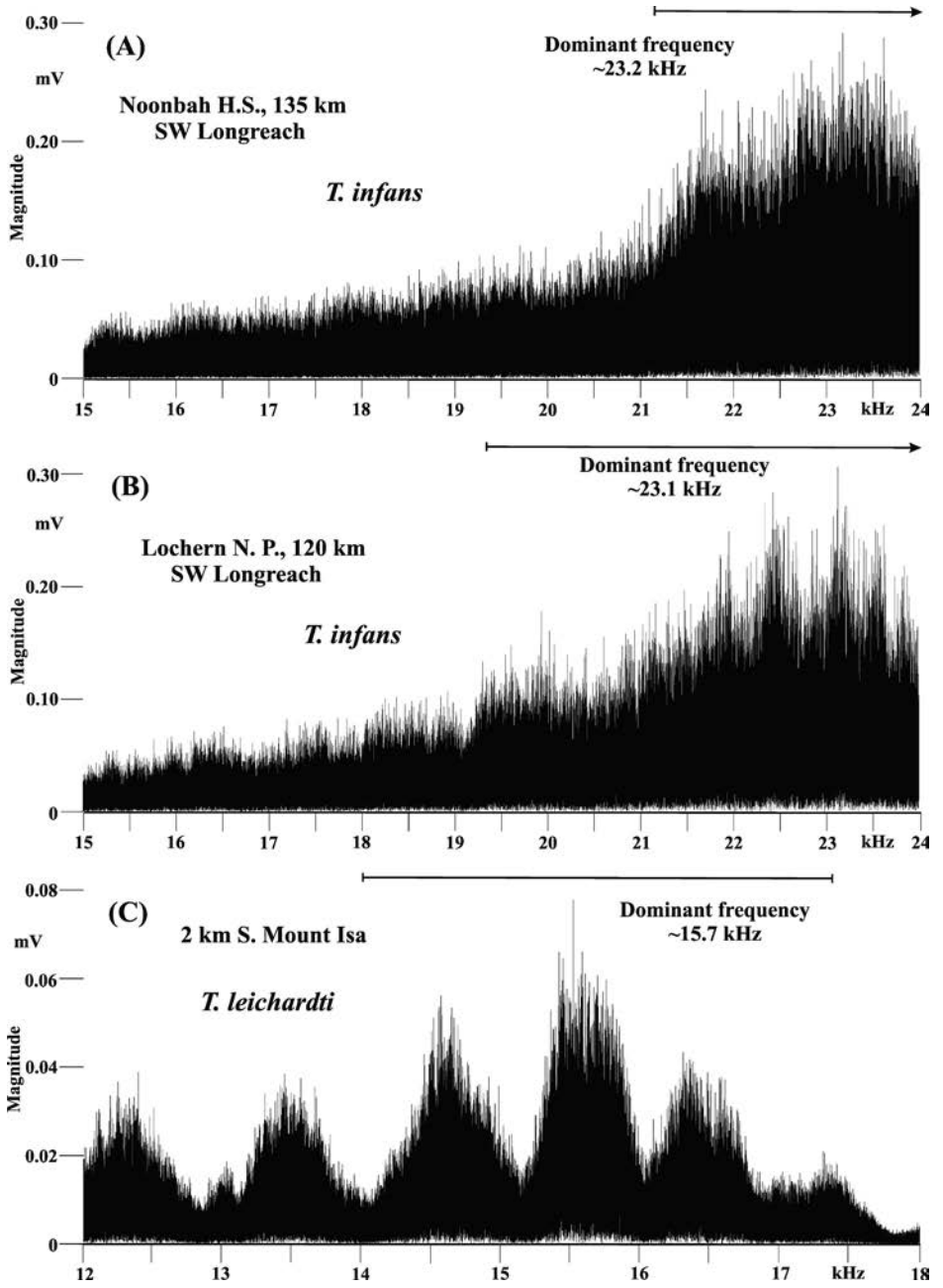

FIG. 8. *Terepsalta infans* (A,B) and *Terepsalta leichhardti* sp. nov. (C); amplitude spectra of songs from (A), Noonbah H.S., ~135 km SW Longreach, SW Queensland, field recording in open net, 30.i.2009. (B), Lochern N.P., 120 km SW Longreach, in situ field recording, 20.ii.2009. (C), 2.2 km S Mt Isa, container recording, 22.i.2002. The horizontal bars indicate the inferred high amplitude envelope of each spectrum, used to estimate (in part) the dominant frequency. Note in A, B, that the higher amplitude envelope extends to >24 kHz, but this is limited by the higher frequency resolution (24 kHz) of the recorder used.

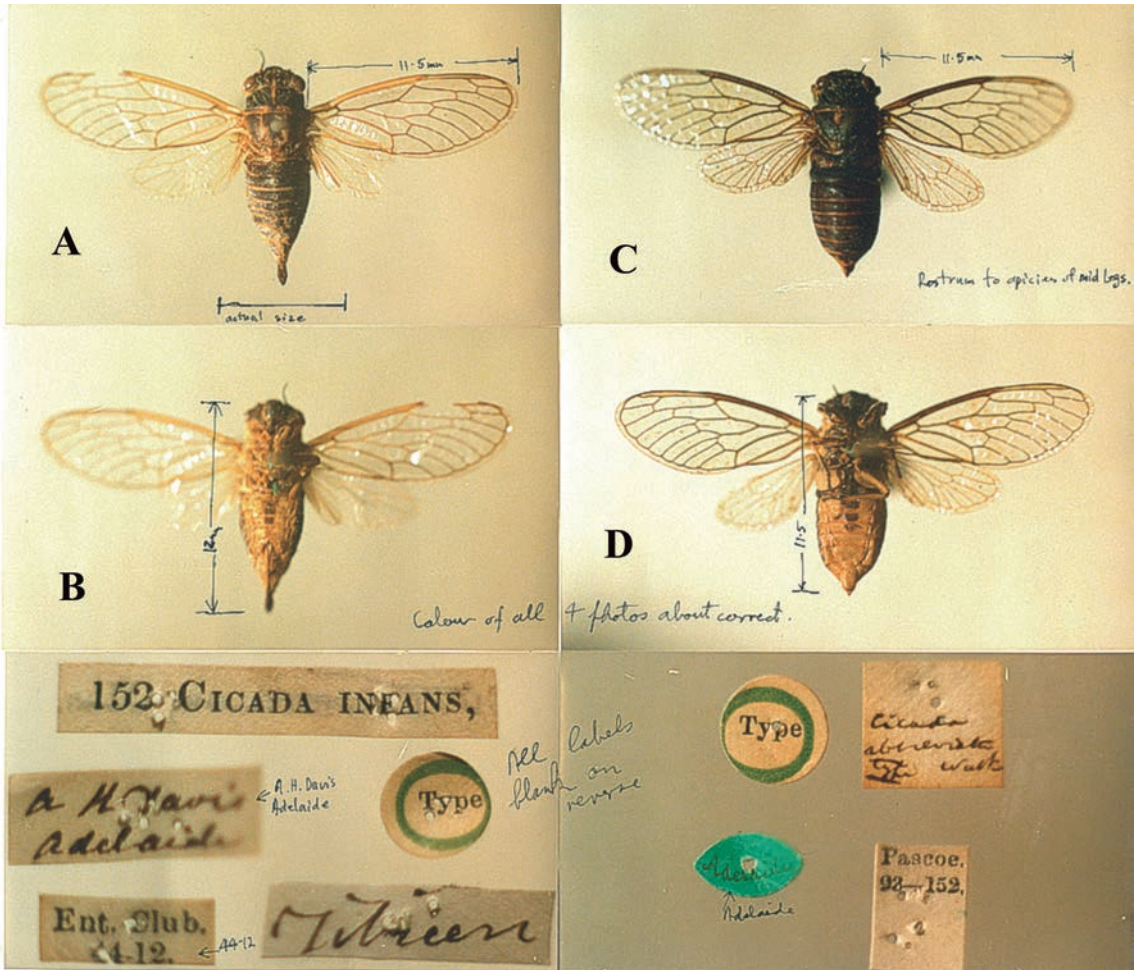

PLATE 1. Holotypes of *Cicada infans* Walker (♀) and *C. abbreviata* Walker (♂), dorsal and ventral views, also with label data. Photos by Dr. M.S. Moulds. Fore wing and total body lengths (mm) marked on photos.

specimens have 4, very rarely 3 apical cells; even in specimens with 5 apical cells, some of the cells are small and poorly developed.

Legs. Coxae medium brown with darker brown fasciae on anterior and lateral faces; fore femora medium brown with broad fasciae on lateral faces; mid and hind femora pale brown with thin darker brown fasciae on anterior and dorsal faces, tending paler on hind femora; trochanters brown; tibiae and tarsi of fore legs medium dark brown, pale brown on mid and hind legs; claws brown; spines black to deep brown.

Opercula. Pale brown, black around crest at disto-lateral corner and adjoining lateral margin; black on meracantha, meracantha spikes brown; gently domed in disto-medial area. Shape as in diagnostic details.

Timbals. As in diagnostic details.

Abdomen. Colouration variable in detail. Tergite 1 dominantly black between timbals; tergite 2 is normally dominantly black, in some specimens grading to deep brown distally, extending ventrally to, and on the auditory capsules; tergite 3 deep brown to black, with small

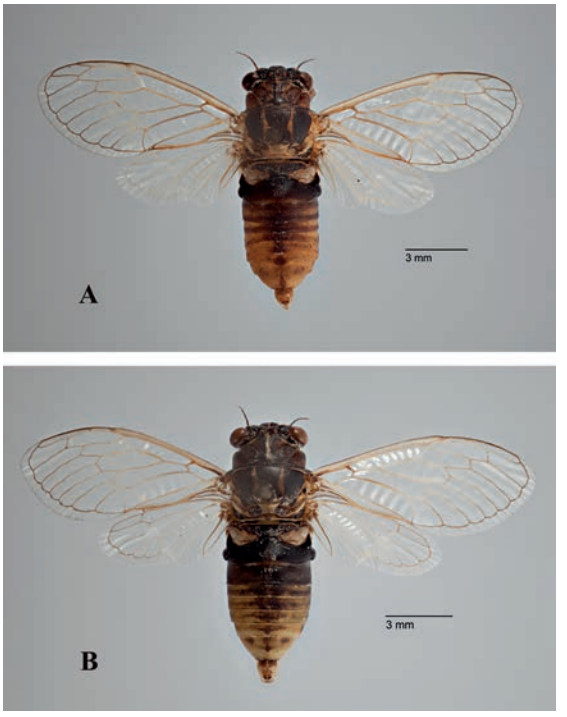

PLATE 2. Males of *Terepsalta infans* from: A, (PS1942), 35 km W. Barcaldine, C.Q., 15.i.2002, 23°31.94'S 144°56.51'E; total body length 10.7 mm; example of slightly paler colouration. B, (PS1943), 10 km ESE Blackall, W.Q., 25.ii.2007, 24°27.56'S 145°33.27'E; total body length 10.7 mm; example of slightly darker colouration.

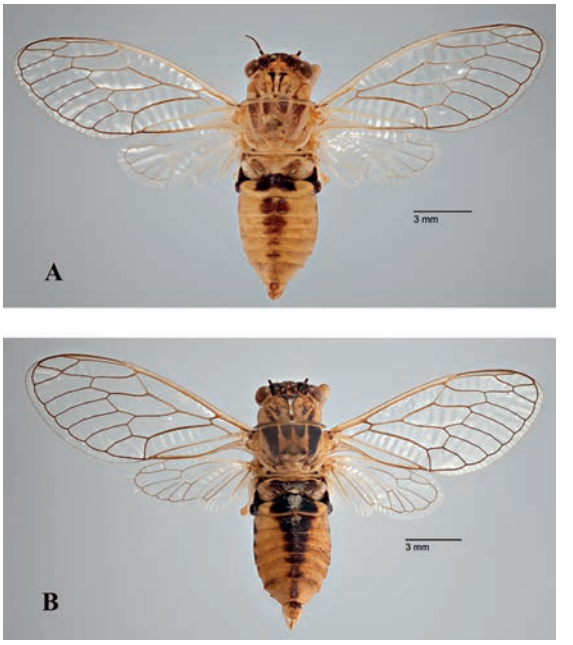

PLATE 3. Males of *Terepsalta leichhardti*: A, (PS1946), male holotype; total body length 11.5 mm; example of paler colouration: B, example of darker colouration; total body length 12.2 mm. Both specimens from Duchess Rd, 2.2 km S. Mt Isa, NWQ, 22.i.2002, 20°44.62'S 139°29.72'E.

paler brown area developed laterally; tergites 4 and 5 deep brown to black dorsally, along distal margins (excluding the narrow paler intersegmental membranes), and ventrally grading from medium to dark brown anterio-laterally; tergites 6 and 7 usually with reduction of dorsal darker pigmentation which may tend towards dark brown, with dark brown patches ventrally; remaining colouration medium to dark brown, sometimes with faint greenish tinge, usually paler on tergite 7; tergite 8 pale to medium brown with small black area dorsally along distal margin. In paler specimens, a distinct reduction in the extent of the darkest pigmentation is evident, for example, tergite 2 is dominantly black grading to brown on the disto-medial area; tergites 3 to 7 mainly medium brown with black dorso-medial areas, broadest on tergite 3, becoming notably smaller on tergites 4 through to 7; in addition, darker brown ventro-lateral areas extend from near anterior margins distally to intersegmental membranes, but not reaching the ventral tergite margins; tergite 8 is uniformly pale brown. Sternites are pale brown and in most specimens with a well-defined darker brown ventro-medial area (not crossing intersegmental membranes), darkest in sternites II and III, paler and progressively smaller from sternites IV through to VI, forming only a thin fascia in sternite VII, and absent on sternite VIII; these darker dorso-medial areas give general appearance of a dark venter in ventral view; in the paler specimens, the sternites are pale yellow-brown, and the darker ventro-medial areas are more weakly developed, rarely even absent.

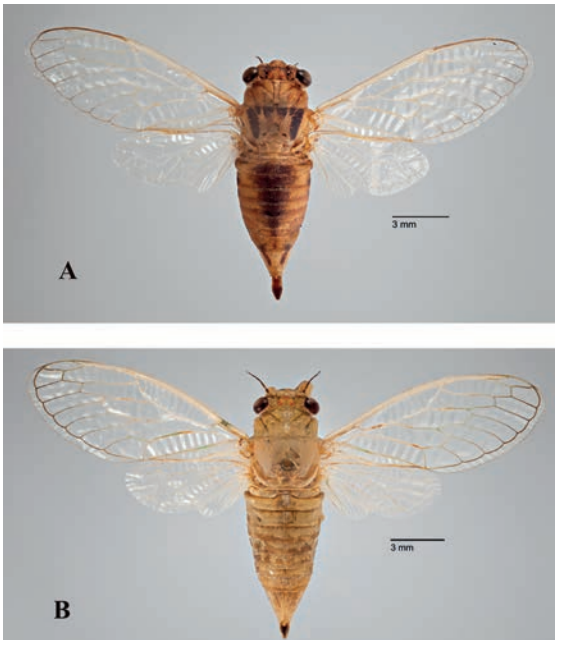

PLATE 4. A. Female *Terepsalta infans* (PS1944) from ~8.2 km E Longreach, C.Q., 16.i.2002, 23°26.67′S 144°19.19′E; total body length 11.4 mm. B. Female *Terepsalta leichhardti* (PS1947) from Duchess Rd, 2.2 km S. Mt Isa, NWQ, 22.i.2002, 20°44.62′S 139°29.72′E; total body length 12.5 mm.

Genitalia. Pygofer pale brown laterally, darker brown dorsally, becoming black on beak. Details as in diagnosis.

Female. (Plates 1A, B, 4A) Generally comparable to male, but with a consistent reduction of the extents of the areas of darker pigmentation. Supra-antennal plate pale sandy-brown, vertex and frons pale brown around and between ocelli, extending to pronotal margin; mandibular plate and gena pale sandy brown, silvery pubescence; postclypeus pale brown with darker brown transverse ridges, midline pale yellow; anteclypeus pale brown, brown medial spot; rostrum pale brown, darker apically; ocelli pink; dark brown compound eyes. Pronotum pale brown with some darkening along the paramedian and lateral fissures, and darker thin margin to the central fascia, itself pale brown; mesonotum pale sandy-brown to brown with short, dark brown submedial sigilla; lateral sigilla well defined, with a broken, discontinuous dark brown colour. Legs similar to male. Abdomen: tergite 1 pale yellow–brown; tergites 2-7 pale brown with darker brown dorso-medial areas, broadest on tergites 2 and 3, but progressively narrowing on tergites 4 through to 7, these areas extending across widths of tergites excepting tergites 6 and 7; auditory capsules (tergite 2) pale to medium brown; additionally, small brown patches present ventro-laterally on tergites 3 to 7, extending across widths of tergites to intersegmental membranes but not reaching ventral tergite margins; tergite 8 pale yellow-brown; tergite 9 pale sandy-brown to pale brown with a pair of paramedial dark brown fasciae which extend distally for three-quarters of length of tergite, to stigma. Sternites uniformly pale sandy-brown with darker ventro-medial pigmentation either weak or absent; ovipositor sheath brown, darker apically, extending 1-2 mm beyond apex of tergite.

Measurements. N = 12♂, 7♀. Ranges and means (in parentheses), mm; BL: ♂ 10.2-11.3 (10.7); ♀ 10.5-11.7 (11.1). FWL: ♂ 10.1-11.2 (10.5); ♀ 10.7-11.3 (10.9). HW: ♂ 3.0-3.4 (3.2); ♀ 3.1-3.3 (3.3). PW: ♂ 2.8-3.1 (2.9); ♀ 2.8-3.1 (3.0). AW: ♂ 3.5-4.0 (3.8); ♀ 3.3-3.8 (3.6). FWL/BR: ♂ 2.32-2.50 (2.40); ♀ 2.38-2.60 (2.47).

Distribution, Habitat and Behaviour. (Fig. 2) Distributed through southern central and south-western Queensland. Specific locations include Blackall (easternmost location), areas between Barcaldine and Longreach, and around Longreach, locations approximately 70-80 km north of Quilpie, and locations in and west of the Lochern National Park extending westwards to the Noonbah HS region, all some 120-135 km southwest of Longreach. It has not been found further north than approximately 25 km north-west of Longreach, or other westerly locations including Windorah, Boulia or further west in the desert areas. The habitat is grassland, sometimes open Mitchell grassland, or grassland within open forest. In all locations, these cicadas occur within the proximity of seasonal water, including near rivers and shallow gullies, dams, ephemeral ponds, and on flood plains. The populations are localised although the cicadas are very mobile within these areas. The relatively high frequency and soft songs

(below), plus their small size make these species inconspicuous in the field. The occurrence of the types in South Australia suggests that this species should occur through the far southwest of Queensland (e.g. Thargomindah and south), far western NSW into South Australia, but peripheral to the desert regions.

Terepsalta leichhardti sp.nov.
(Figs 2, 3, 6-8, Plate 3A, B, Plate 4B, Table 2)

Material. HOLOTYPE: ♂, QMT183443, Duchess Rd, 2.2 km S. Mt Isa, NWQ, grassland, A.E., 22.i.2002, 20°44.62'S 139°29.72'E, PS1946 (QM).

Paratypes. 21♂, 3♀, Duchess Rd, 2.2 km S. Mt Isa, NWQ, grassland, A.E., 22.i.2002, 20°44.62'S 139°29.72'E; 2♂, 2.1 km N. along Moondarra Rd, via Mt Isa, N.W.Q., A.E., 23.i.2002, 20°40.42'S 139°30.52'E. (AE). 1♀, Duchess Rd, 2.2 km S. Mt Isa, NWQ, grassland, A.E., 22.i.2002, 20°44.62'S 139°29.72'E, PS1947 **(**QM**)**. 1♂, Duchess Rd, 2.2 km S. Mt Isa, NWQ, grassland, A.E., 22.i.2002, 20°44.62'S 139°29.72'E (MSM). 1♂, Duchess Rd, 2.2 km S. Mt Isa, NWQ, grassland, A.E., 22.i.2002, 20°44.62'S 139°29.72'E (LWP). 1♂, Duchess Rd, 2.2 km S. Mt Isa, NWQ, grassland, A.E., 22.i.2002, 20°44.62'S 139°29.72'E (ANIC). 1♂, Duchess Rd, 2.2 km S. Mt Isa, NWQ, grassland, A.E., 22.i.2002, 20°44.62'S 139°29.72'E (BMNH).

Description. (Male) Fig. 3, Plate 3A, B. Specimens exhibit variability in the detail of the extent and intensity of the areas of darker pigmentation of especially the thorax and abdomen.

Head. Supra-antennal plate pale sandy-brown anteriorly; vertex black adjacent to compound eyes, dark brown on frons and adjacent to median ocellus, in part the area anterior of lateral ocelli, and two small areas distally to each lateral ocellus and adjacent to pronotum; remaining areas between and distal to lateral ocelli, including epicranial suture, pale sandy-brown; ocelli pale pink to yellow-brown; compound eyes dark brown. Postclypeus predominantly pale sandy to yellow-brown, black on dorsal surface, with short segments of brown colouration on transverse ridges adjacent to midline; anteclypeus pale yellow-brown, narrow brown along midline; rostrum pale brown, darker brown apically.

*Thorax***.** Pronotum dominantly pale brown, darker in proximity to paramedian and especially lateral fissures, with pale yellow-brown central fascia extending distally from anterior pronotal margin, not quite reaching pronotal collar; deep brown to black margin on either side of central fascia, broadening anteriorly and splaying outwards along anterior margin; pronotal collar pale yellow-brown, lateral margins ampliate. Mesonotum variable in colour between specimens with broken pale brown to black submedian sigilla and broken pale brown to continuous black colouration defining the lateral sigilla which extend to just beyond the anterior cruciform elevation arms; parapsidal suture defined by a thin golden line; remaining colouration pale to medium sandy brown; cruciform elevation very pale yellow, tending translucent; pale yellow to yellow-brown along and between wing grooves.

*Wings***.** Fore wing costal vein very pale yellow, translucent; venation pale yellow-brown; basal membrane translucent, off-white to very pale yellowish. Hind wing venation very pale yellow-brown; very weakly developed off-white plaga around anal cell 3 and adjacent veins 3A and 2A; 5 apical cells most common, but a significant number of specimens have 4, very rarely 3 or even 6 apical cells; apical cells often variable in size.

*Legs***.** Coxae and trochanters pale yellow-brown; femora pale brown with narrow darker brown longitudinal fasciae; fore tibiae and tarsi brown, darker apically; mid and hind tibiae and tarsi paler brown, darker apically; spines and claws dark brown.

*Opercula***.** Main opercula plate is off-white to pale yellow; remainder, including meracantha and spike are pale yellow-brown; gently domed from disto-lateral to disto-medial margins.

*Timbals***.** As in diagnosis.

*Abdomen***.** Tergite 1 pale sandy brown, some specimens with brown submedial patches, other specimens extensively dark brown to black between timbals; tergite 2 sandy brown with broad black area dorso-medially, not extending to distal margin, and black to deep brown area dorso-medially on, and immediately surrounding and extending anteriorly from auditory capsule; tergites 3 to 7 dominantly sandy

brown with dorso-lateral brown to black patches (varying between specimens), not always extending distally to intersegmental membranes, becoming progressively paler and smaller from tergites 3 to 7; tergite 8 sandy brown, usually with small brown to black area dorsally. Sternites uniformly sandy brown.

Genitalia. Pygofer sandy brown, medium brown dorsally extending to beak. Otherwise as in diagnosis.

Female. (Plate 4B). Similar to male, but without any well-defined darker markings or colouration. Head, including postclypeus pale sandy brown, ocelli pink, eyes dark brown; rostrum sandy-brown, darker apically. Pronotum pale sandy brown, mesonotum uniformly off-white to very pale brown, tending to translucent. Wings as in male. Legs, pale yellow-brown, slightly darker brown apically and on spines; claws dark brown. Tergites uniformly yellow-brown, intersegmental membranes pale brown. Sternites similarly pale yellow-brown; ovipositor sheath brown, paler apically, extending approximately 1 mm beyond apex of tergites.

Measurements. N = 16♂, 4♀. Ranges and means (in parentheses), mm; BL: ♂ 11.2-12.7 (11.9); ♀ 12.1-12.9 (12.6). FWL: ♂ 11.1-12.6 (11.8); ♀ 12.0-13.1 (12.4). HW: ♂ 3.0-3.5 (3.2); ♀ 3.3-3.4 (3.3). PW: ♂ 2.9-3.3 (3.1); ♀ 3.1-3.3 (3.2). AW: ♂ 3.9-4.5 (4.1); ♀ 3.7-4.1 (3.9). FWL/BR: ♂ 2.29-2.51 (2.43); ♀ 2.50-2.60 (2.53).

Distribution, Habitat and Behaviour. (Fig. 2) Known only from Mt Isa, at two locations, one approximately 2.2 km S of the town along the Duchess Road, and the second on the Lake Moondarra Road, approximately 6.4 km NNE of Mt Isa town. Habitats are grassland associated with sparse open woodland, both locations being in proximity to seasonal streams. The populations are apparently relatively localised, and the cicadas wary. Notably, this species has not been found east of Mt Isa, including the Cloncurry region.

Etymology. From the Leichhardt River which runs through Mt Isa and areas to the north and northeast. The grassland localities of this cicada are proximal to this river system.

CALLING SONGS. (Figs. 4-8, Table 1)

T. infans: Song recordings were made from six locations, three being container recordings, and three field recordings. Measurements of the songs parameters were performed on two of each of these sets of recordings, the data closely comparable. Table 1 presents the measured data on the two field recordings.

The songs are clearly separated into recognisable phrases, varying in length between 7-25 seconds. Each phrase consists of two distinct elements (Figs. 4A-C), an initial echeme followed by a repetitive sequence of microsyllables ('chirps').

The echemes are characterised by two well defined, but alternating sets of tick (strictly 'syllable', but term not used for clarity) arrangements, each termed here as macrosyllables; an 'open ticking' macrosyllable arrangement (referred to herafter as 'open macrosyllables'), with mean ticking repetition rates of 21-28 Hz (four recording sets). These open macrosyllables alternate with clearly defined 'closed ticking' macrosyllables (referred to hereafter as 'closed macrosyllables'), characterised by ticks, identical in structure to those in the open macrosyllables, but with mean repetition rates between 99-113 Hz (four recording sets). The initiation of each echeme commences with an open macrosyllable. The number of closed macrosyllables per echeme range from 6-18 (mean 11). The durations of each of the closed macrosyllables increases during echeme emission, as seen by comparing the mean values for the initial and final 3 sets of closed macrosyllables (Table 1). Within each of the closed macrosyllables, a corresponding increase in tick repetition rates is also observed during emission of each macrosyllable. Time expanded plots of the individual ticks (Fig. 5) show each to consist of a high amplitude primary pulse, followed by a low amplitude secondary pulse. The inter-pulse mean durations range from between 2.8-3.5 ms (four recording sets), the values overlapping for both the open and closed macrosyllables. The alternating open and closed macrosyllables within each echeme are always terminated by a closed macrosyallable.

The post echeme microsyllable sequences within each phrase comprise between 9-47 (mean values 23-32; four recordings) discrete microsyllables, the individual microsyllables comprising sets of between 2-5 individual coalesced ticks. The number of ticks per microsyllable decreases towards the end of the echeme. Mean microsyllable repetition rates range from 267-323 ms (3.7-3.1 Hz), the repetition rates tending to decrease at the end of each of the complete microsyllable sequences. Mean pulse repetition rates of the ticks within the microsyllables range between 126-147 Hz. Mean inter-pulse durations within the individual ticks range between 2.9-3.7 ms, similar to those in the echeme, with a small but distinct increase in inter-pulse duration occurring during emission of each microsyllable.

T. leichhardti sp. nov.: Two sets of container recordings were made, both from Mt Isa. The song is again divided into readily identifiable phrases, which range from 3.5 to >25 seconds in duration. The initial part of each phrase commences with a set of 2 to 4 microsyllables, followed by a well-developed ticking macrosyllable element, which together define an echeme, similar to, but simpler than in *T. infans* (Fig. 6). The initial sets of microsyllables of each echeme comprise from 2-8 (mean 5.3) coalesced ticks, with mean ticks repetition rates of 120 Hz. Immediately following is the ticking macrosyllable phase, consisting entirely of repeated single discrete ticks, from 17-40 in number, with repetition rates that clearly decrease through the emissions of the ticking sequence (Fig. 6-7) from 31 to 19 Hz (mean 24 Hz), similar in magnitude to those in the *T. infans* song.

The post-echeme microsyllables vary in number from 14-76 (mean 44), and exhibit a decreasing repetition rate with progressive emission, from mean rates of 3.8 Hz early in each sequence, to 2.8 Hz late in each sequence. The microsyllables comprise between coalesced 2-5 ticks, tending to reduce in number during the progressive emission of the microsyllables. Tick repetition rates within the microsyllables range from 114-135 Hz, similar to those in the initial microsyllables of the echeme. Inter-pulse durations are also similar to those within the initial macrosyllable and microsyllable phases of the echemes.

Comparative notes on the temporal song structures. The *T. infans* and *T. leichhardti* songs are clearly different, but nevertheless do share a number of structural and temporal characteristics. These include the echeme elements comprising repeated single tick macrosyllables, followed by the extended of extended post-echeme microsyllables. Additional similarities include the detailed syllable structures (Figs. 5-7), inter-pulse intervals within the ticks, and the microsyllable repetition rates and tick repetition rates within the post-echeme microsyllables (Tables 1 and 2). A significant difference is the development of the alternating open and closed macrosyllable elements, marked by mean tick repetition rates of 21-28 Hz and 99-113 Hz respectively, in the echemes of the *T. infans* song.

Song frequencies. These are illustrated by the amplitude spectra (Fig. 8). Both the *T. infans* songs illustrated (Fig. 8A, B), based on field recordings from separate locations, indicate a broadband frequency emission with the dominant frequencies lying between 23.1 to 23.2 kHz. These are within the ultrasonic range and account for the very soft audible song. In both these recordings, the upper frequency resolution limit of the recorder used is 24 kHz, thus cutting off the highest frequency components of the songs. Use of a bat detector suggests that the dominant frequency envelope probably extends to 28-30 kHz, and further, when close to the insects, extremely weak frequency components extending to 60 kHz.

The amplitude spectrum of the *T. leichhardti* song shows frequency splitting which often characterises container recordings. The song again appears to be broadband with an apparent dominant frequency of 15.5 kHz. The recorder used in this recording (see above) has an upper frequency resolution limit of 18 kHz, and thus the dominant frequency of this song could realistically be even higher.

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