CROTOPSALTA LEPTOTIGRIS, A NEW SPECIES OF TICKING CICADA (HEMIPTERA: CICADOIDEA: CICADIDAE) FROM CRAVENS PEAK, SOUTHWEST QUEENSLAND

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Abstract

An additional species of ticking cicada, belonging to the genus *Crotopsalta* Ewart, *C. leptotigris* sp. n., is described from the northeastern Simpson Desert. It is a very small species (9-11 mm body length), inhabiting grassland (other than spinifex) with associated low shrubland. The ticking song of *C. leptotigris* is described and each tick is shown to comprise two closely-spaced pulses. Based on tick repetition rates and inter-pulse intervals, the song is distinct from the other four allopatric Queensland species of *Crotopsalta*.

Introduction

This study arose from a multidisciplinary scientific survey, undertaken during January-April 2007, of the Cravens Peak Reserve, organised by The Royal Geographical Society of Queensland. Cravens Peak is an Australian Bush Heritage Fund property located in the northeastern Simpson Desert, approximately 180 km SW of Boulia, falling within the Channel Country and Simpson Strezlecki Dunefields bio-regions. During this survey, 17 cicada species were found, 14 of which are undescribed (Ewart in press). One of these was a previously unknown ticking cicada, the focus of this paper.

Four species of ticking cicadas belonging to the genus *Crotopsalta* Ewart were described by Ewart (2005). Three species occur widely throughout southeastern and central Queensland, with a fourth (*C. poaecetes* Ewart) from northwestern Queensland. They occur within woodland (*C. fronsecetes* Ewart, *C. plexis* Ewart) and grassland (*C. strenulum* Ewart, *C. poaecetes*). No species of *Crotopsalta* were previously known from southwestern Queensland. They are very small cicadas, ≤15 mm total body length, very cryptic, wary and mobile. The ticking songs of the four species are distinct in the combined characters of their tick repetition rates and detailed pulse structures (specifically the inter-pulse separation).

Methods and abbreviations

Higher classification and anatomical terminology follow Moulds (2005) for general body, wing and genitalia characters, de Boer (1999) for opercula 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 posterior (adjacent to timbal plate).

Song recording procedures and analyses follow those described in Ewart and Marques (2008). The recordings were carried out using a Sony Minidisk recorder MZ-NH900 in PCM mode, with Sennheiser microphone model K6/ME66, with insects in a 30 cm diameter x 35 cm cylindrical net cage, in the field.

Abbreviations used are: *Collections*: ANIC, Australian National Insect Collection, Canberra; AE, private collection of A. Ewart, Caloundra; BMNH, The Natural History Museum, London; MSM, private collection of M.S. Moulds, Kuranda; QM, Queensland Museum, Brisbane. *General*; Hstd, homestead; R, river; Recorded = aural/electronic song recording; sp, species; xing, crossing; *Morphological*; BL, total body length; FWL, fore wing length; FWB, fore wing maximum breadth; HW, head width; PW, pronotum width; AW, abdomen width; FWL/BR, fore wing length/breadth ratio.

Systematics

Crotopsalta leptotigris sp. n.

(Figs 1-6)

Type material. *Holotype* ♂, SOUTHWESTERN QUEENSLAND: 2.3 km N. Cravens Pk. Hstd., via Boulia, grassland-mixed *Senna* sp., 7.ii.2007, 23°18.28'S 138°34.69'E, AE, QMT156220 (QM). *Paratypes*: 1 ♂, Recorded open net, 2.3 km N. Cravens Pk. Hstd., via Boulia, grassland-mixed *Senna* sp., 3.ii.2007, 23°18.28'S 138°34.69'E, AE; 2 ♂♂, Recorded open net, same data, 4.ii.2007; 1 ♂, same data, 5.ii.2007; 6 ♂♂, 2 ♀♀, same data, 6.ii.2007; 6 ♂♂, 1 ♀ (in cop.), Recorded open net, same data, 7.ii.2007; 1 ♂, Recorded open net, same data, 19.ii.2007; 1 ♂ Recorded open net, Mulligan R. xing, 16 km N. Cravens Pk. Hstd, 5.ii.2007, AE, 23°13.51'S 138°37.60'E; 1 ♂, 3 km W. Cravens Pk. Hstd., via Boulia, mixed spinifex and grassland, 8.ii.2007, 23°19.15'S 138°33.89'E (AE). 1 ♀, 2.3 km N. Cravens Pk. Hstd., via Boulia, grassland-mixed *Senna* sp., 3.ii.2007, 23°18.28'S 138°34.69'E, AE (QM). 1 ♂, 2.3 km N. Cravens Pk. Hstd., via Boulia, grassland-mixed *Senna* sp., 7.ii.2007, 23°18.28'S 138°34.69'E, AE (MSM). 1 ♂, 2.3 km N. Cravens Pk. Hstd., via Boulia, grassland-mixed *Senna* sp., 6.ii.2007, 23°18.28'S 138°34.69'E, AE (ANIC). 1 ♂, 2.3 km N. Cravens Pk. Hstd., via Boulia, grassland-mixed *Senna* sp., 6.ii.2007, 23°18.28'S 138°34.69'E, AE (BMNH).

Description. Male (Figs 1A, 2). *Head*. Head width across compound eyes slightly greater than width across lateral pronotum margins and narrower than width across ampliated lateral angles of pronotal collar. Outer ventral margins of compound eyes clearly separated from pronotum; distance between lateral ocelli slightly less than, to equal to, distance between lateral ocellus and compound eyes. Supra-antennal plate black adjacent to pedicels, pale brown adjacent to postclypeus; vertex predominantly black, small pale brown area between pedicel and compound eye and pale sandy-brown triangular fascia extending posteriorly from midway between lateral ocelli to pronotal margin. Gena and mandibular plate pale brown, becoming black towards compound eyes and adjacent to anteclypeus, respectively; both covered by silvery pubescence. Ocelli red. Compound eyes dark brown. Postclypeus shiny black with sandy-brown margins extending between transverse ridges; small pale brown spot dorsomedially, extending discontinuously on to frons. Anteclypeus predominantly shiny black with pale brown ventromedial patch. Rostrum pale brown grading to black apically; extends to posterior margins of mid coxae. Antennae dark brown.

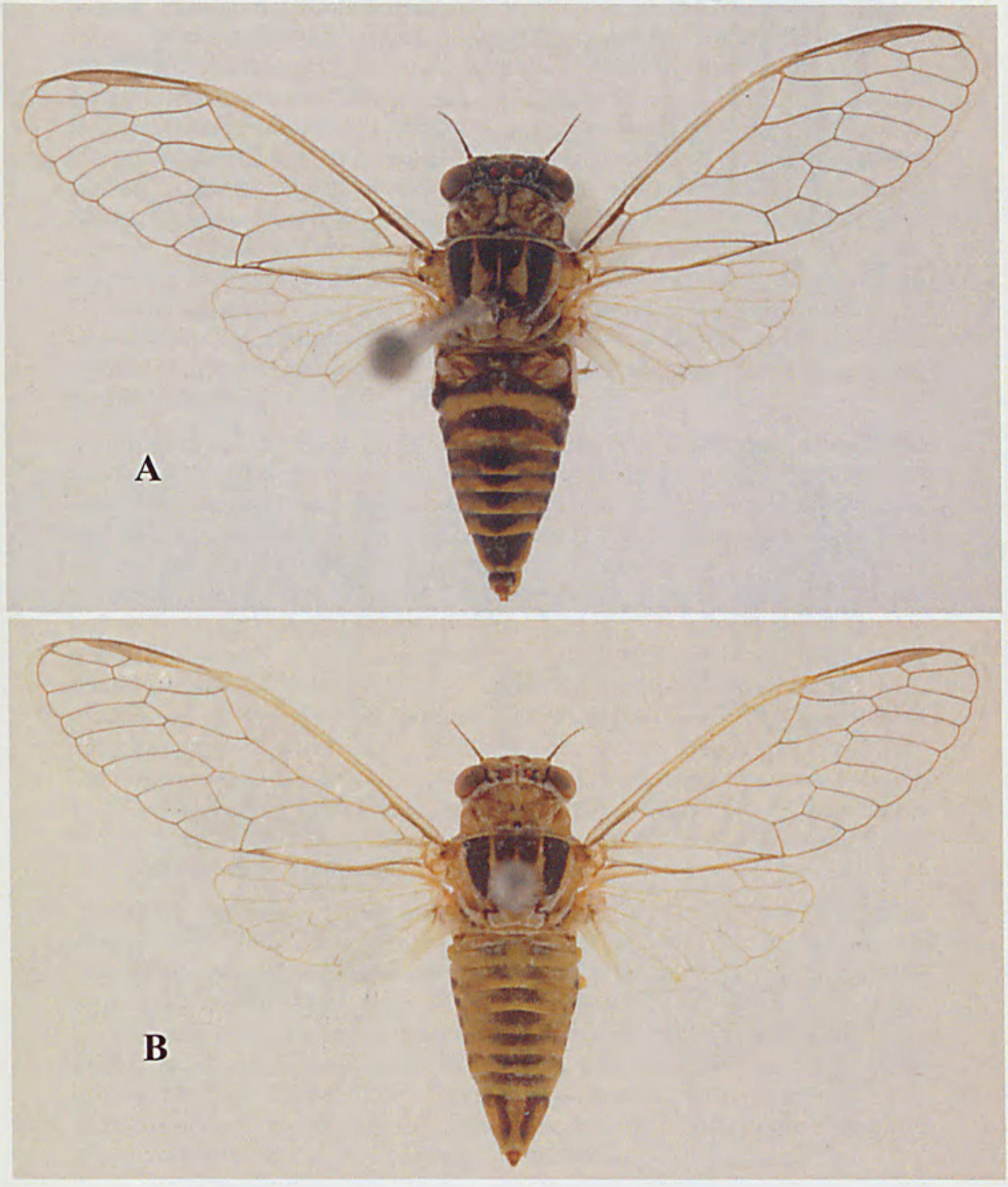

Fig. 1. *Crotopsalta leptotigris*. (A), male from 2.3 km N. of Cravens Peak Hstd, southwest Queensland, body length 9.5 mm. (B), female, locality as previously, body length 10.3 mm.

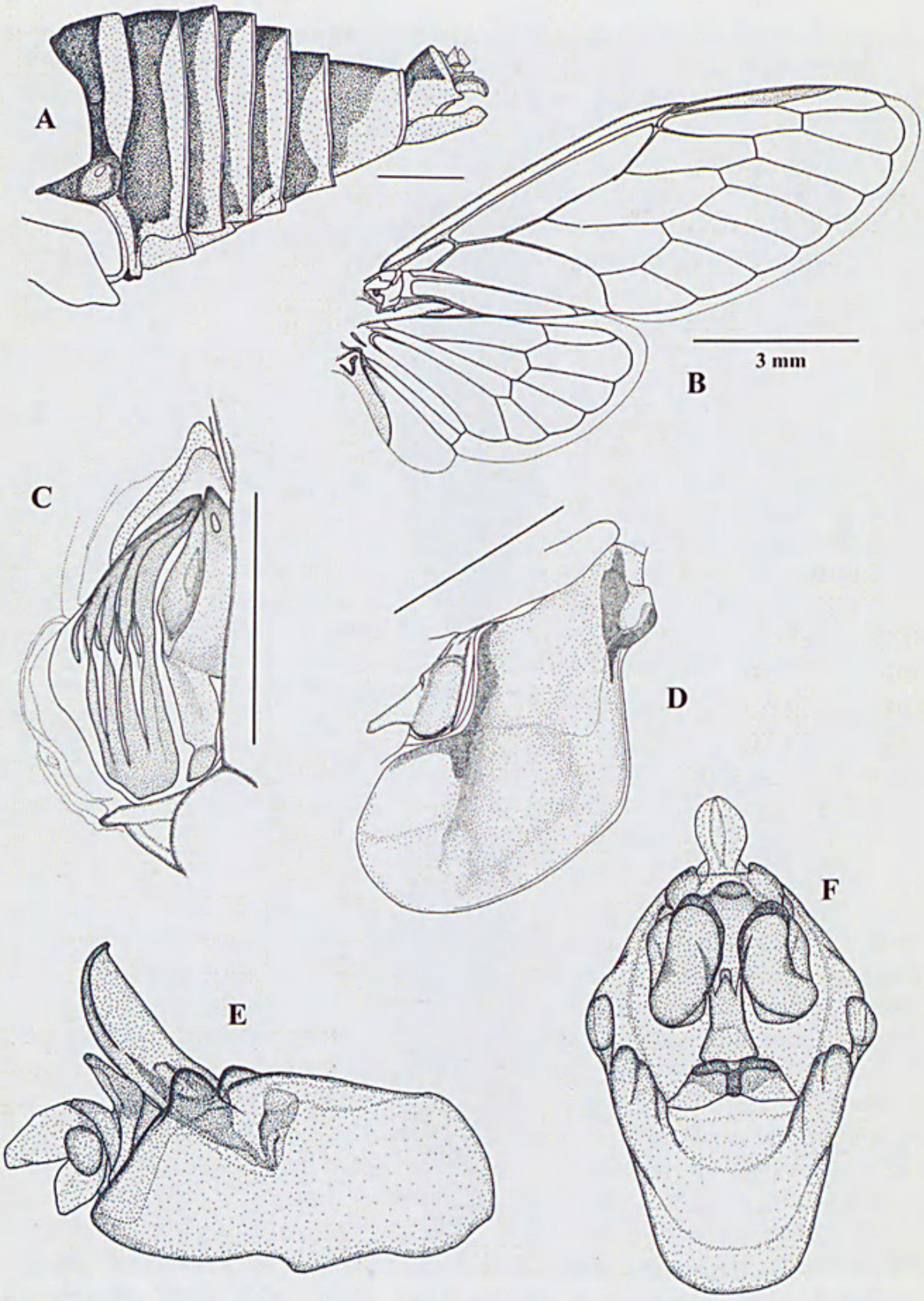

Fig. 2. *Crotopsalta leptotigris*. Male: (A), lateral abdomen view; (B), fore and hind wings; (C), timbal, posterior margin to the right, dorsal margin at the top; (D), operculum. Scale bars 1 mm except wings (3 mm). (E), pygofer, lateral view; (F), pygofer, ventral view. Length of pygofer 1.3 mm.

Thorax. Pronotum predominantly pale brown with black central fascia which splays out along anterior margin, and posteriorly splays out more extensively along, and adjacent to, the pronotal collar and the ventrolateral pronotal margins; discontinuous lens-shaped, pale yellow fascia within black central fascia; pronotal collar and narrow anterior pronotal margin pale brown. Mesonotal submedian sigillae black, coalesced anteriorly, medial sections of sigillae extending to, and broadening towards arms of anterior cruciform, coalescing and completely filling area between, and anterior to, arms of anterior cruciform elevation; lateral sigillae black, roughly triangular, extending posteriorly to fill areas between lateral arms of cruciform elevation; margins of wing grooves, cruciform elevation, and areas surrounding the lateral sigillae, and between the lateral and submedian sigillae, sandy-brown, sparsely covered by short silvery pubescence, more distinct near wing grooves.

Wings (Fig. 2B). Fore wings hyaline, relatively short and broad with length/width ratios between 2.50-2.69; fore wing length slightly greater than total body length; costal vein even in width with minor thickening towards, and adjacent to node; costal vein very gently curved anteriorly; sclerotised anterior margin of costal vein narrow, much thinner than width of costal vein; costal vein and R+Sc vein fused; CuA intersecting with M well beyond basal cell so that length of first section of inner margin of radial cell approximately one half of length of second section; three distal vein sections of M forming inner margins of radial cell of unequal length; cubital and medial cells roughly of similar size; pterostigma brown, darker apically; 8 apical cells approximately equal in length to ulnar cells (some longer, some shorter); basal membrane off-white, opaque; venation brown, tending darker apically. Hind wings hyaline with 5 apical cells; anal lobe slightly broader than cubital cell 1; white opaque plaga extending along margins of veins 3A and 2A, but no associated brown infuscation.

Legs. Fore femora with three spines; predominantly pale brown with lozenge-shaped medium to deep brown fasciae located centrally on lateral and anterior faces; mid and hind coxae pale sandy-brown with localised darker brown patches on lateral faces; fore and mid femora and trochanters brown on anterior faces, pale brown with broad darker brown longitudinal fasciae on lateral faces; hind femora and trochanters pale sandy-brown with darker brown irregular longitudinal discontinuous fasciae; fore tibiae and tarsi medium to dark brown; mid and hind tibiae and tarsi mostly pale to medium brown; claws brown, darker apically.

Opercula (Fig. 2D). Moderately elongated roughly parallel to abdomen, but markedly inwardly curved towards abdominal midline in medial-distal area; distal and medial margins broadly rounded; elongated dome-like structure developed along distal and basal areas; inner margins clearly separated; opercula developed asymmetrically around meracantha; spikes on

meracantha not clearly overlapping opercula plates; colour predominantly sandy-brown except for two localised medium brown patches adjacent to area around meracantha and near basal crests; opercula broadly confluent with, but separated from distal and lateral margins of tympanal cavity, with overlap only occurring medially; operculum margin not overlapping anterior margin of sternite II in lateral view.

Timbals (Fig. 2C). Four well developed long ribs (1-4), rib 5 much reduced in length; ribs 1-4 fused together ventrally and dorsally fused to basal spur; four short ribs, the most anterior one weakly developed; narrow dome on timbal plate.

Abdomen (Fig. 2A). In dorsal and lateral views, regularly tapered from tergites 2 to 8, widest across auditory capsules; width across auditory capsules greater than width across lateral margins of pronotal collar, slightly greater than width across outer margins of compound eyes. Sternites not strongly convex in lateral view and often not visible beyond sternite V. Tergites black and orange-brown to yellow-brown. Posterior dorsal to ventrolateral margins of tergites, and intersegmental membranes, orange-brown to yellow-brown; anterior margin of tergite 2 always black, extending anteriorly to tergite 1 filling area between timbals and extending ventrally to enclose the auditory capsule; central area of auditory capsule brown to yellow-brown; tergite 3 with dorsal black area, extending ventrolaterally, but not quite reaching the ventrolateral margin, where it widens towards both the anterior and posterior margins of tergite; anteriodorsal areas of tergites 4 to 8 predominantly brown to black, the darkest areas being widest medially and narrowing laterally, and extending ventrolaterally towards, but not reaching ventrolateral margins of tergites; intensity of dark pigmentation on anteriomedial areas on tergites variable, sometimes absent, or faded brown or fully black, commonly covered by short silvery pubescence; dark anterior areas, combined with orange-brown to yellow-brown background, produces the overall appearance of 'tiger-like' banding. Sternite II with median black area, otherwise sternites pale sandy-brown, tending to orange-brown towards sternite VIII.

Genitalia (Figs 2E-F). Pygofer predominantly black dorsally, otherwise orange-brown; broadly pear-shaped (pyriform) in dorsal view; claspers prominent and strongly descending in lateral view, thickened and rounded apically; upper and basal lobes clearly defined, roughly triangular, pointing ventrally but not extending strongly, apices rounded; dorsal beak absent; median lobe of uncus small (relative to claspers); aedeagus trifid with pair of sclerotised dorsal pseudoparameres longer than ventral support and well defined flexible (membraneous) hinge; aedeagal basal plate Y-shaped in dorsal view, undulated in lateral view.

Female (Fig. 1B). Similar in colour to male, but with greatly reduced extent and intensity of areas of black pigmentation. Supra-antennal plate and vertex

predominantly sandy-brown, pale brown adjacent to compound eyes and frons, and adjacent to lateral ocelli; gena and mandibular plate sandy-brown with long silvery pubescence; postclypeus with broad dorsomedial yellow fascia extending posteriorly on to frons otherwise pale sandy-brown, slightly darker medially along transverse ridges; anteclypeus sandy-brown; rostrum pale brown, darker apically. Pronotum almost entirely pale sandy-brown; pale yellow central fascia barely visible with a small black spot marking its posterior termination against pronotal collar; scattered short golden pubescence. Mesonotum with black submedial sigillae less extensively fused, each rounded posteriorly, and not extended towards cruciform elevation; black lateral sigillae similar to male, not extending posteriorly to lateral arms of cruciform elevation; remaining colouration pale sandy-brown; short silvery pubescence, most notably developed adjacent to wing grooves and between anterior arms of cruciform elevation. Coxae pale sandy-brown with variable pale brown patches on anterior faces; fore femora, trochanters and tibiae sandy-brown with broader darker brown fasciae on faces, darkest on anterior faces; mid and hind femora pale sandy brown with more broken darker brown longitudinal fasciae, least developed on hind femora; mid and hind trochanters and tibiae predominantly pale sandy-brown; tarsi pale sandy-brown, darker brown apically and on claws. Abdomen with areas of darker colouration anteriorly on tergites greatly reduced in intensity and extent, varying from pale to darker brown, slightly darker distally towards tergites 4 to 8, and on ventrolateral areas of tergites 3 to 8; tergite 9 with a pair of thin dark brown to black submedial fasciae which terminate approximately three-quarters along length of tergite, and do not coalesce; remaining areas of tergites pale sandy-brown to pale orange-brown on tergites 3 to 6. Sternites pale sandy-brown. Ovipositor sheath extending ≤0.5 mm beyond apex of tergite 9.

Measurements (mm; ranges and mean). *N* = 15 ♂♂, 4 ♀♀. *BL*: ♂ 9.2-10.5 (9.6); ♀ 9.7-10.7 (10.3). *FWL*: ♂ 9.8-10.9 (10.5); ♀ 11.3-11.9 (11.6). *FWB*: ♂ 3.7-4.3 (4.0); ♀ 4.3-4.5 (4.4). *HW*: ♂ 2.8-3.1 (2.9); ♀ 3.0-3.2 (3.1). *PW*: ♂ 2.5-2.7 (2.6); ♀ 2.7-3.0 (2.8). *AW*: ♂ 3.0-3.3 (3.1); ♀ 3.2-3.4 (3.3). *FWL/BR*: ♂ 2.50-2.69 (2.63); ♀ 2.59-2.67 (2.64).

Distribution, habitat and behaviour (Fig. 3). *Crotopsalta leptotigris* is known only from the eastern Cravens Peak Reserve, within the northeastern Simpson Desert, southwest Queensland. It is, however, likely to occur more widely in appropriate habitats within the wider Simpson Desert region and far western Queensland. It inhabits low mixed open grassland or mixed low grassland within open shrubland and woodland environments. It normally rests on grass stems, less often on associated shrubs or forbs, but has not been observed on spinifex. The dominant grassland species include *Hybanthus aurantiacus, Chloris virgata, Eriachne aristidea, Aristida inaequiglumis, Gossypium australe, Eulalia aurea, Urochloa subquadripara* and *Paspalidium rarum.*

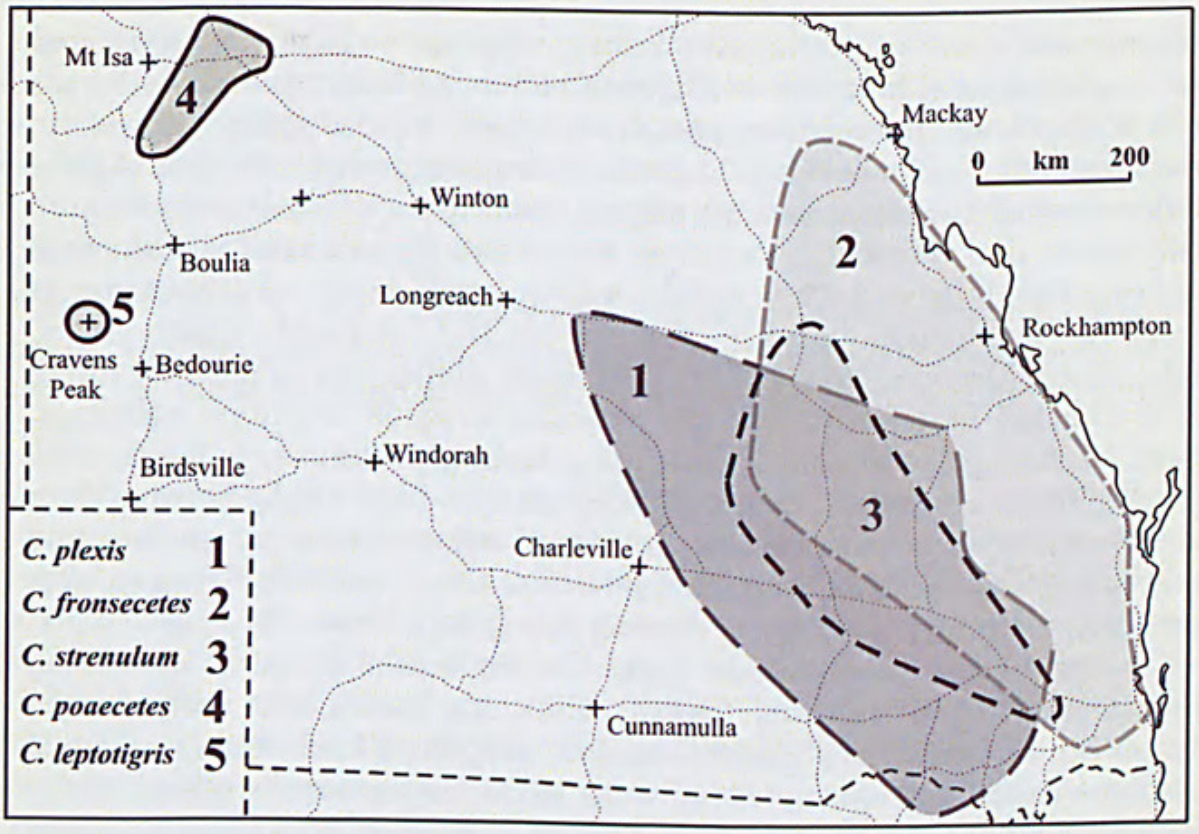

Fig. 3. Generalised distribution map of the five *Crotopsalta* species in Queensland.

This cicada is extremely cryptic, wary and fast flying, moving its singing positions frequently. Its small size adds to the difficulty of its capture and location. It occurs in localized populations, although relatively abundant within these populations, favouring those environments receiving strongest water run-off, including riverine flood plains and some inter-dune areas. The song is a distinctive, soft, rapid ticking (see below). This cicada was found only during February, following atypical, very heavy monsoonal rains (Ewart in press).

Etymology. From the Greek *leptos* meaning small, and Latin/Greek *tigri-n* meaning tigerlike colouration, referring to its small size and the tiger-like patterning of the abdominal tergites.

Distinguishing characteristics. The only single morphological character that appears to distinguish *C. leptotigris* from the four *Crotopsalta* species previously known (*C. plexis, C. fronsecetes, C. strenulum, C. poaecetes*) is the number of hind wing apical cells, which are 5 in the available *C. leptotigris* specimens and normally 6 in the remaining species. Observations, however, on related genera (*e.g. Drymopsalta* Ewart) indicate that the number of hind wing apical cells can be unstable. This character should be used with some caution.

C. poaecetes is the geographically closest *Crotopsalta* species (Fig. 3). It is readily distinguished from *C. leptotigris* by its generally pale tergite colouration, weaker meracantha development, lack of ventral fusion of longrib 4 to ribs 1 to 3, and slightly more elongated upper pygofer lobe. The songs are distinct (see below).

Modification to key of *Crotopsalta* species

The key in Ewart (2005) is here modified at couplet 3 as follows:

3 Sternite II with small black area medially; central area of auditory capsules pale to medium brown or yellow-brown, enclosed by either thin or broader darker brown to black areas; pale to dark brown or black areas, sometimes irregular, laterally on tergites 3 to 7; timbal ribs 1 to 4 fused ventrally 4

\- Sternites without black medial marking; auditory capsule sandy brown; no darker lateral colouration on tergites; timbal long rib 4 not fused ventrally with ribs 1 to 3 ..... *C. poaecetes*

4 Anterior area of tergite 2 black extending ventrally to enclose auditory capsule; anterior areas of tergites 3 to 8 predominantly brown to black extending venrolaterally, but not reaching ventrolateral margin; upper pygofer lobe relatively short and rounded in lateral view; hind wing with 5 apical cells ..... *C. leptotigris*

\- Anterior dorsal areas of tergites 2 to 8 black; tergites 3 to 8 with irregular, sometimes localised, medium to dark brown lateral areas; upper pygofer lobe extended into small, acutely rounded shape in lateral view; hind wing with 6 apical cells ..... *C strenulum*

Note that a number of characters are listed in each couplet, a reflection of the inherent variability within each species.

Song characteristics (Figs 4-6)

The song of *C. leptotigris* is comprised of repetitive sequences of sharp, closely spaced double pulses (pulse doublets; Figs 4A-B), each doublet sounding as a single tick. The pulse repetition rate varies between 3.0-7.1 (mean 4.6) Hz (Fig. 4B) and the inter-pulse intervals between 4.1-8.2 (mean 5.5) ms (Fig. 4C). In the time expanded envelope curve (Fig. 4C) of a single set of pulse doublets (a single tick), the details of the two component pulses are shown, the initial pulse always with the highest amplitude. The initiation of each pulse is sharply defined, each decaying approximately exponentially. Lengths of each individual pulses range between 0.7-2.0 (mean 1.1) ms. In the example shown, a 'pulse disturbance' is shown, consisting of an additional set of very low amplitude pulses, 0.4-2.0 (mean 0.8) ms in length, that follow each of the two pulses after an interval varying between 1.3-4.3 (mean 2.2) ms. These are not, however, clearly observed within all sets of pulse doublets. If the two pulses comprising each tick represent the alternate

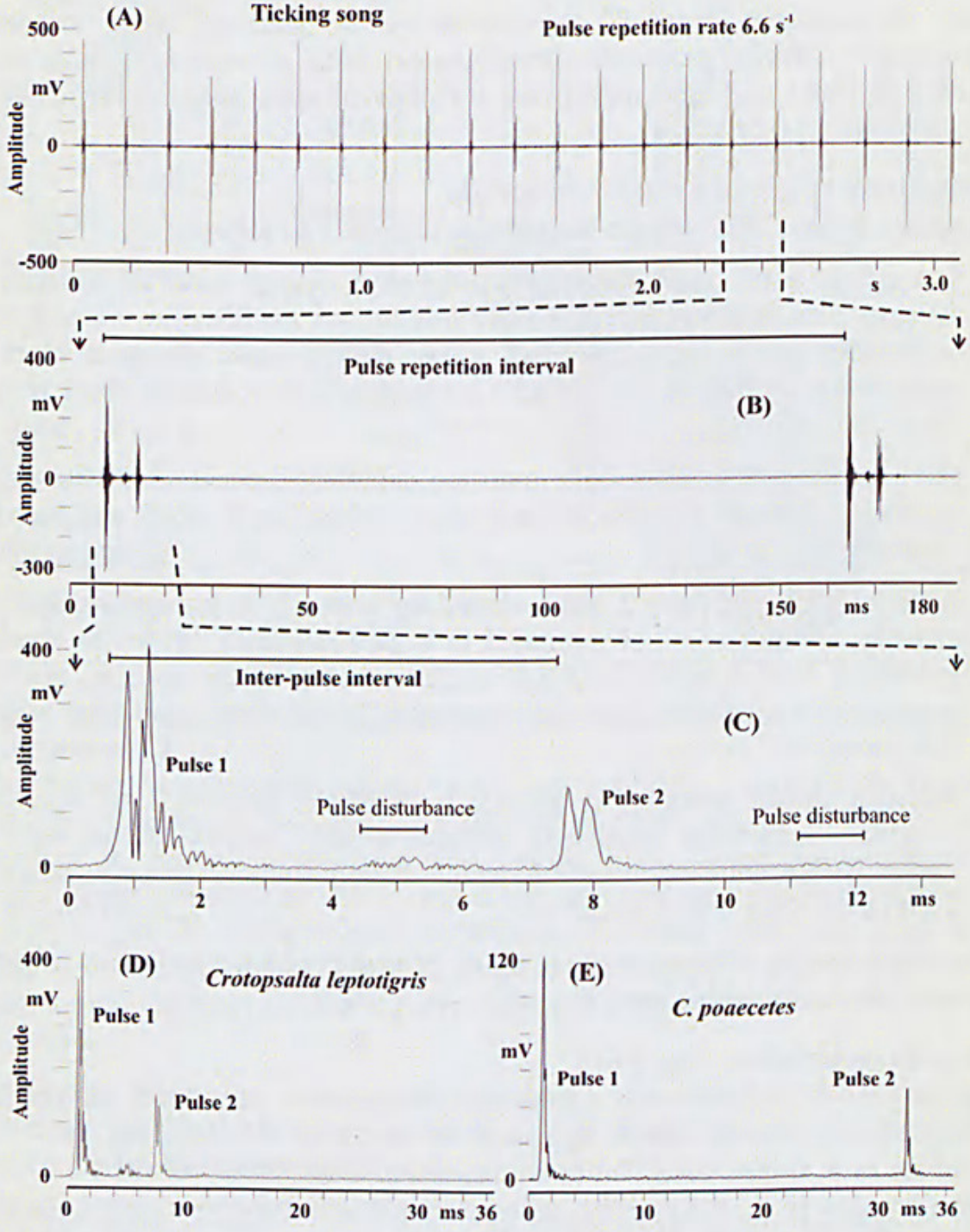

Fig. 4. *Crotopsalta leptotigris* waveform plots of: (A), ticking song; (B), time expanded plot showing two sets of ticks, each comprising two distinct pulses; (C), further time expanded envelope curve of the two pulses within a single tick, showing the definition of inter-pulse intervals and the 'pulse disturbances'; (D) and (E), comparative envelope curves of *C. leptotigris* and *C. poaecetes*, respectively, plotted on the same time scale, showing the strongly contrasting inter-pulse intervals between pulses 1 and 2, being 6.9 and 31.6 ms, respectively, in the two examples shown.

inward clicking of each timbal, as inferred, then these 'pulse disturbances' may represent the accompanying lower energy outward relaxation of each timbal.

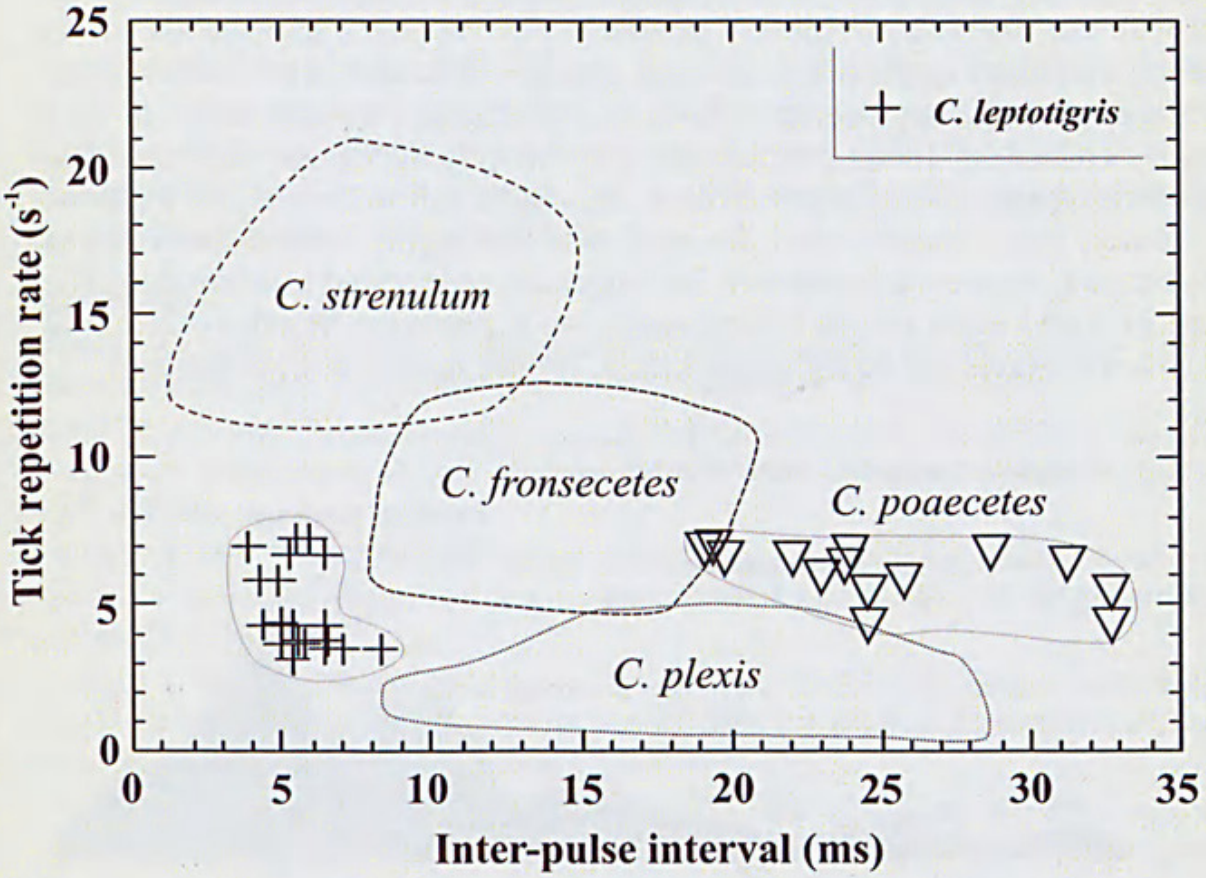

Fig. 5. Plot of tick repetition rates (s^{-1}), versus inter-pulse intervals (ms) for the five species of Queensland *Crotopsalta* ticking cicadas. The data for *C. strenulum*, *C. fronsecetes* and *C. plexis* are shown as enclosed areas only. Data modified from that presented in Ewart (2005) by using only field recordings, augmented by additional field recordings, and compared with field recordings of *C. leptotigris*. The data indicate the new Cravens Peak species to be distinct in its song from the other Queensland *Crotopsalta* species.

Ewart (2005) demonstrated that the songs of each of the four known *Crotopsalta* species had a characteristic combination of tick repetition rate and inter-pulse interval (Figs 4B-C; 5). Similarly, the song of *C. leptotigris* is distinct from the other Queensland *Crotopsalta* species based on a combination of these same parameters derived from field recordings (Fig. 5). Of particular significance is the comparison of these song parameters with those of *C. poaecetes*, the geographically nearest species to *C. leptotigris* (Fig. 3). Although the tick repetition rates of the two species completely overlap, their inter-pulse intervals are clearly different (Figs 4D-E, 5),

confirming their status as distinct species (see above). These differences are consistent within multiple field recordings of both species under comparable temperature conditions, and therefore not temperature dependent.

The frequency structure of the *C. leptotigris* song is relatively complex (Fig. 6), with the dominant frequency inferred to be 18.7-18.8 kHz, as shown by the two separate amplitude-frequency spectra illustrated. The spectra show broad band frequency distribution, as is characteristic of such songs of very small cicadas (*e.g.* Ewart 2005, Ewart and Marques 2008). An additional low amplitude peak occurs near 15 kHz. As discussed in Ewart (2005), these attributes, when coupled with the small size and highly mobile behaviour of the cicadas, negates the necessity for longer distance sound transmission. The repetitive and rapid simple ticking songs are expected to be relatively robust to sound degradation during transmission, further minimising predation.

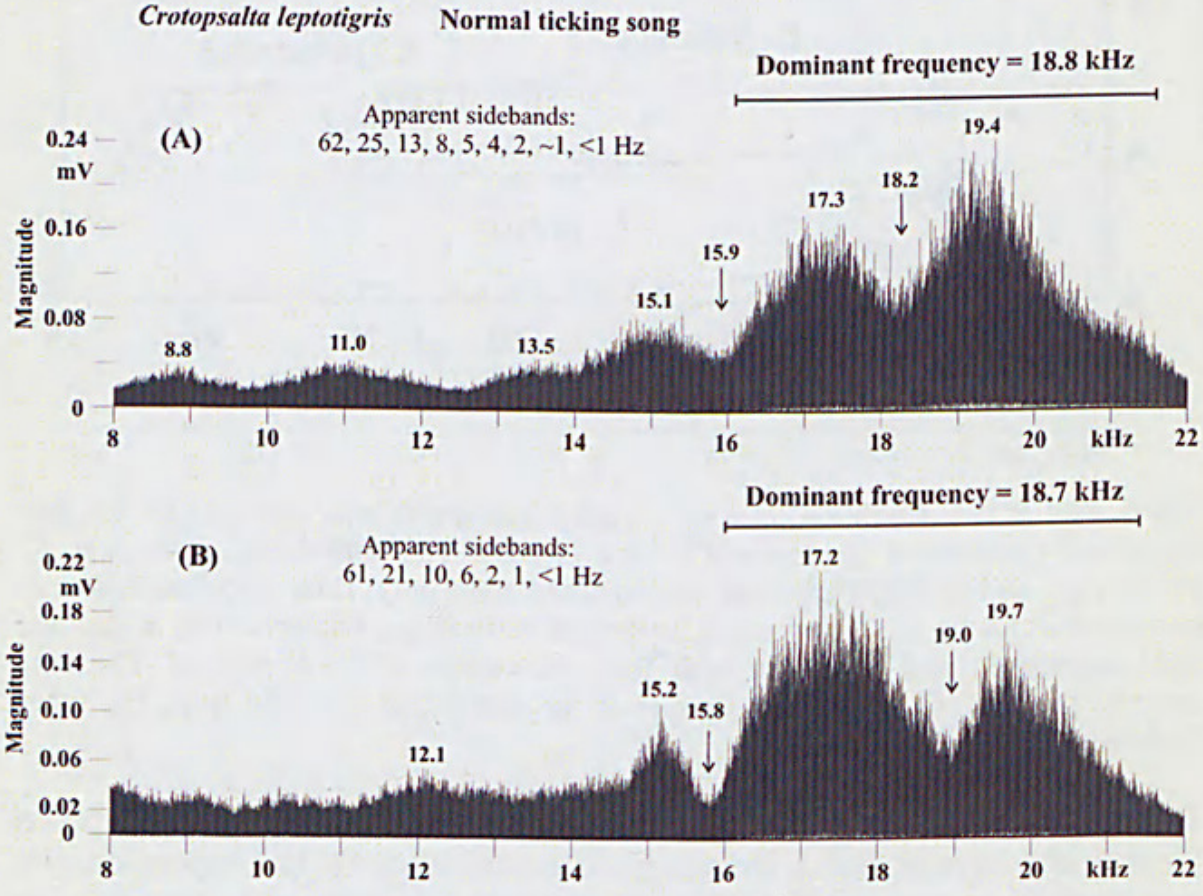

Fig. 6. *C. leptotigris*. Amplitude spectra, from field recordings of two separate specimens, showing the frequency distributions within the ticking songs. The dominant frequencies are defined by the mean frequency of the main frequency envelope in each plot. The figures are the measured frequencies (kHz) of the maximum amplitudes of the peaks. Also listed are apparent sidebands as measured within each spectrum.

Acknowledgements

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