KIMBERPSALTRIINI, A NEW TRIBE FOR A NEW AUSTRALIAN CICADA ALLIED TO *TALCOPSALTRIA* MOULDS (HEMIPTERA: CICADOIDEA: CICADIDAE)

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Abstract
A new tribe, Kimberpsaltriini, subfamily Cicadinae, is described to accommodate *Kimberpsaltria taenia* **gen. n.**, **sp. n.**, a species that is known only from the central Kimberley, Western Australia. Relationships of the new tribe are discussed, a key to the tribes of Australian cicadas in the subfamily Cicadinae is provided, and the song of the new species is analysed.

Keywords. *Talcopsaltria*, key to Cicadinae, cicada song, Kimberleys, Western Australia

Introduction
In a molecular phylogeny of world cicadas in preparation (Owen *et al*. pers comm.), an undescribed Australian cicada was found to be sister to the Australian species *Talcopsaltria olivei* Moulds, 2008, tribe Talcopsaltriini. Following morphological examination this undescribed species was found to represent both a new genus and a new tribe. The species, genus and tribe are described here together with an analysis of the species' song. The last published key to tribes of Australian cicadas in the subfamily Cicadinae (Moulds 2008) is updated to include the Talcopsaltriini and three tribes described in Marshall *et al*. (2018).

Terminology for morphological features follows that of Moulds (2005, 2012). The following abbreviations are used: LWP, collection of L.W. Popple, Cairns; MSM, collection of M.S. Moulds, Kuranda; WAM, Western Australian Museum, Perth; UCS, University of Connecticut, Storrs, USA.

Male calling songs were digitally recorded in the field with a 96 kHz sampling frequency using a Zoom H4n audio recorder connected to a Sennheiser (Old Lyme, CT, USA) ME66 super-cardioid short shotgun microphone, which has a frequency response that is approximately flat from 40 Hz–20 kHz (+/- 2.5 dB). One additional recording at Mitchell Falls Campground was recorded using a Tascam DR-07 digital recorder with an Audio-Technica ATR-55 cardioid condenser shotgun microphone (frequency response 70 Hz–18 kHz). Air temperatures were recorded but cicadas are known to behaviourally thermoregulate by basking, so such temperatures do not necessarily correspond to body temperature (Heath 1967; Sanborn 2002). Oscillograms, spectrograms (sonograms), and power spectra were generated using Raven Pro v1.5.0 (Cornell Bioacoustics Laboratory, Ithaca, NY, USA). Summary characteristics of the songs were determined by

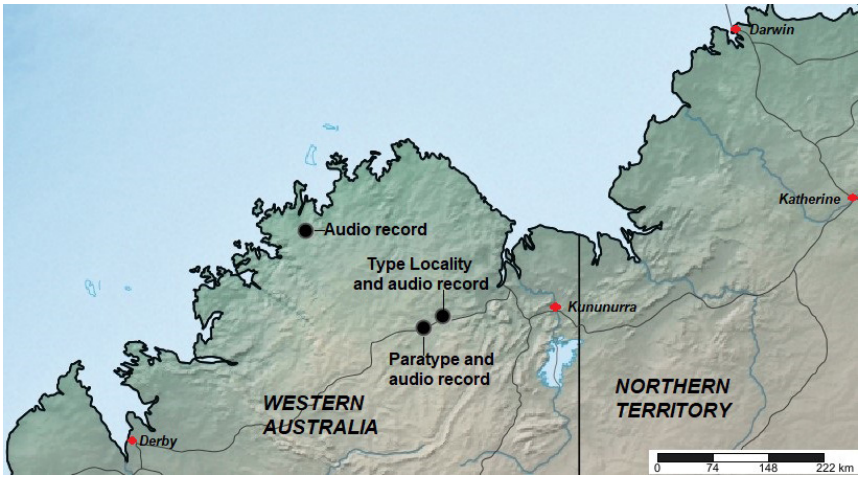


Fig. 1. Distribution of *Kimberpsaltria taenia* **gen. n.**, **n. sp.** showing the three known localities in the Kimberley region of north-eastern Western Australia.

examination of the recordings in Raven Pro. Audio spectra were generated with a 512-sample Hann window, 3 dB filter bandwidth of 270 Hz, a hop size of 256 samples, and a DFT size of 512 points.

Kimberpsaltriini tribe n. Moulds, Marshall and Popple

ZooBank registration: urn:lsid:zoobank.org:act:DD6042C3-D8FF-47F9-84DE-7944F239DEF2

Type genus. *Kimberpsaltria* **gen. n.** (type species *Kimberpsaltria taenia* **sp. n.**).

Included genera. *Kimberpsaltria* **gen. n.**

Diagnosis. Head with distance between supra-antennal plate and eye about equal to length of supra-antennal plate. Postclypeus shape in transverse cross-section rounded, in lateral profile rounded between 'top' and 'sides'; postclypeal ridges lacking transverse grooves towards distal ends. Pronotal collar with lateral margin moderately ampliate; its width at dorsal midline less than diameter of eyes; with no mid-lateral tooth. Epimeral lobes not quite reaching opercula. Forewing pterostigma present; vein RA_1 aligned closely with subcosta (Sc) for its length; vein CuA_1 divided by crossvein so that distal portion is longest. Hindwing with anal lobe broad and vein 3A curved, long, separated from wing margin; width of 1st cubital cell at distal end longer than 2nd cubital cell. Foreleg femoral primary spine prostrate. Hindcoxae lacking a large inner protuberance. Meracantha gradually tapering to a point, triangular or nearly so. Male abdominal tergites with sides convex in cross-section; tergites 2 and 3 similar in size to 4–7; epipleurites reflexed to ventral surface, without an inward V-shaped kink; sternites IV–VI in cross-section convex. Timbals extended below wing bases. Timbal covers flat,

Fig. 2. *Kimberpsaltria taenia* **gen. n.**, **sp. n.**, male. Live adult of morph with partly yellowish dorsal midline. Specimen same locality as holotype.

reduced dorsally and reaching only about halfway to metathorax, lower margin extending anteriorly from or very near auditory capsule.

Male genitalia (Figs 7–10) with pygofer dorsal beak present as a part of chitinized pygofer; upper lobe absent, basal lobes undivided, moderately developed. Uncus with median lobe large, dominant, bifurcate with lateral branch. Aedeagus restrained by apical ventral protrusion on either side of the uncus. Basal plate with ventral rib completely fused; theca with shaft recurved basally through 180° or more; without appendages. Male and female reproductive systems unknown.

Distinguishing features. Kimberpsaltriini **tribe n.** is distinguished from all other tribes in having, in combination, forewing basal cell tending rounded so that the two sections of the arculus are of similar length, the timbal covers not covering the timbal and reduced dorsally, a deeply divided uncus, and a thecal shaft that turns through 180º at its base.

Phylogenetic relationships

In the molecular phylogeny of Owen *et al*. (in prep.) *Kimberpsaltria* was found to be sister to *Talcopsaltria* Moulds, 2008, sole genus of the tribe Talcopsaltriini. The males bear similarities in their short bodies and small eyes, their reduced timbal covers, the prostrate primary spine on their fore femora, and in the abundance of silver pubescence mixed with a fine waxy secretion that covers much of the body.

They differ in having the epimeral lobe reaching the operculum only in *Talcopsaltria*, the lateral margin of the pronotal collar smooth in *Kimberpsaltria* but minutely spined in *Talcopsaltria*, forewing vein CuA_1 divided by crossvein m-cu in *Kimberpsaltria* so that proximal section is shortest but longest in *Talcopsaltria*, the width of the 1st hindwing cubital cell at its distal end longer than 2nd cubital cell in *Kimberpsaltria* but shorter in *Talcopsaltria*, the hindwing anal lobe narrow in *Kimberpsaltria* but broad in *Talcopsaltria,* and the timbal covers of *Kimberpsaltria* reduced dorsally but extending anteriorly from their uppermost point in *Talcopsaltria*. In the male genitalia the uncus is deeply divided in *Kimberpsaltria* but not in *Talcopsaltria*, the distal shoulders are undeveloped in *Kimberpsaltria* so that the dorsal beak becomes large and prominent whereas in *Talcopsaltria* the distal shoulders are well developed and the dorsal beak very small, and the shape of the aedeagus is markedly different.

All the preceding characters are phylogenetically informative at tribal level (*sensu* Moulds 2005). The large number of these not shared with *Talcopsaltria* (type species of tribe Talcopsaltriini) means that *Kimberpsaltria* cannot be included in the Talcopsaltriini. Its attributes are also incompatible with other described tribes (compare tribal definitions in Moulds (2005) and Marshall *et al.* (2018)). Thus, we establish here the Kimberpsaltriini **tribe n.**

Key to tribes of Australian Cicadinae

The key to Australian Cicadinae (Australian species whose males have timbal covers) in Moulds (2008) is here revised to incorporate the new tribe described below and the three new Australian tribes added by Marshall *et al.* (2018). Some characters used for distinguishing Australian members of some tribes (Cosmopsaltriini, Platypleurini) may not be applicable to some non-Australian species belonging to these tribes. Characters used in the key were selected because they best separated taxa, not because they necessarily defined monophyletic groups. Male genitalia are not used here to avoid the necessity for doing dissections although they are important in tribal diagnoses.

1. Fore leg femoral primary spine lying flat, prostrate 2
– Fore leg femoral primary spine erect 3

2. Lateral margin of pronotal collar (paranotum) dilated horizontally; male timbal cover reaching, or almost reaching, metathorax ..... **Platypleurini** Schmidt, 1918
– Paranotum not dilated horizontally; male timbal cover only reaching about half way to metathorax ..... **Talcopsaltriini** Moulds, 2008

3 Head including eyes clearly wider than lateral angles of pronotal collar 4
– Head including eyes about as wide or narrower than lateral angles of pronotal collar 5

4. Male abdominal segments 2 and 3 occupying at least half the length of abdomen; female indistinguishable ..... **Psaltodini** Moulds, 2018
– Male abdominal segments 2 and 3 occupying much less than half the length of abdomen; female indistinguishable **Thophini** Distant, 1904

5. Hindwing apical cell 1 very short, very much shorter than apical cell 3 ..... **Jassopsaltriini** Moulds, 2005
– Hindwing apical cell 1 very long, about as long as apical cell 3 6

6. Fore wing veins C and R+Sc widely separated ..... **Cyclochilini** Distant, 1904
– Fore wing veins C and R+Sc abutted for their length 7

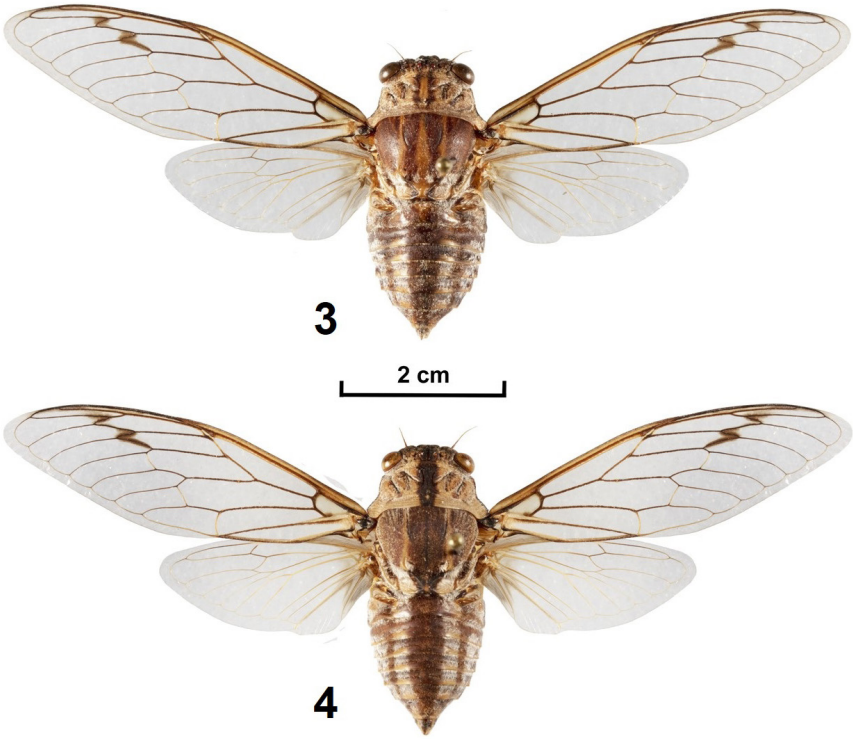
7. Forewing basal cell long and slender, the two sections of the arculus together far shorter than its remaining inner side (base of vein CuA) 8
– Forewing basal cell tending rounded, the two sections of the arculus together about as long as its remaining inner side (base of vein CuA) 9

8. Lateral margin of pronotal collar with a midlateral tooth; male timbal covers covering timbal cavity ..... **Cosmopsaltriini** Kato, 1932
– Lateral margin of pronotal collar without a midlateral tooth; male timbal covers much reduced and exposing much of timbal membrane ..... **Tamasini** Moulds, 2005

9. Pronotal collar very wide, occupying almost one third the length of pronotum ..... **Macrotristriini** Moulds, 2018
– Pronotal collar narrower, occupying no more than a quarter the length of pronotum 10

10. Lateral margin of pronotal collar with minute teeth; male timbal covers covering timbal cavity ..... **Arenopsaltriini** Moulds, 2018
– Lateral margin of pronotal collar smooth, without minute teeth; male timbal covers much reduced and exposing much of timbal membrane 11

11. Head wider than lateral margin (paranotum) of pronotal collar ..... **Burbungini** Moulds, 2005
– Head as wide as lateral margin (paranotum) of pronotal collar ..... **Kimberpsaltriini tribe n.**



Figs 3, 4. *Kimberpsaltria taenia* **gen. n.**, **sp. n.**, male. (3) male holotype, dorsal, morph with partly yellowish dorsal midline; (4) male, dorsal, of morph with entirely dark reddish brown dorsal midline, same locality as holotype.

Kimberpsaltria Moulds, Marshall and Popple gen. n.

ZooBank registration: urn:lsid:zoobank.org:act:11050239-BEF6-4BB7-9939-652EE1A301C1

Type species. ***Kimberpsaltria taenia*** **sp. n.**, here designated.

Included species. Monotypic, ***Kimberpsaltria taenia*** **sp. n.**

Etymology. Derived from the name of the region where the genus is found, *Kimberley*, and the Greek *psaltria*, a female harpist and a traditional ending for many cicada generic names; feminine.

Distribution (Fig. 1). Central Kimberley, Western Australia.

Diagnosis. Male body tending rounded in cross-section. *Head* including eyes narrower than mesonotum; postclypeus with ventral midline keeled, not grooved. *Thorax* with cruciform elevation with its dome wider than long; epimeral lobe not reaching operculum. *Fore wings* hyaline; infuscation overlaying veins at bases of apical cells 2, 3 and 4; with 8 apical cells; subapical cells absent; ulnar cell 3

angled to radial cell; costal vein (C) no higher than R+Sc; costa parallel-sided to node; vein CuA only weakly bowed so that cubital cell no larger than medial cell; veins M and CuA widely separated at basal cell making basal cell broad and tending to be rounded; wing outer margin developed for its total length, never reduced to be contiguous with ambient vein. *Hind wings* with 6 apical cells; no infuscation on ambient vein. *Male opercula* completely encapsulating meracanthus, reaching distal margin of tympanal cavity, not meeting. *Male abdomen* shorter than head plus thorax; sternite VIII strongly tapered so that its distal end is only about half the length of base. *Timbal* with four long ribs with prominent intermediate short ribs; basal dome small.

Male genitalia (Figs 7–10) with pygofer dorsal beak well developed and about an equilateral triangle; basal lobes in lateral view gradually tapering to a rounded apex, slender in ventral view. Uncus divided, lateral branch of uncus with a flat, 'blinker'-shaped, dorsal projection apically each side. Aedeagus with basal plate strongly arched in lateral view, its basal portion tending parallel to thecal shaft with midline deeply furrowed; apical margin of basal plate nearly straight, without spreading arms; junction between theca and basal plate rigid, without a 'hinge'; theca parallel-sided, its apex entirely chitinized with two small triangular lobes ventrally, one behind the other; vesica opening apical on theca, sloping backwards dorsally; vesica retractable; thecal subapical cerci absent; legula absent; conjunctival claws absent.

Female unknown.

Distinguishing features. The attributes that distinguish the tribe also distinguish the genus from all other genera.

Kimberpsaltria taenia sp. n. Moulds, Marshall and Popple

ZooBank registration: urn:lsid:zoobank.org:act:F8F77E6E-814F-4874-9003-8F788936821D

(Figs 1–12)

Types. *Holotype* ♂, AU.WA.DRK, Western Australia, Gibb R. Rd at Durack R./Bamboo Ck jct., 15°51.61'S 127°21.96'E, 240 m, 19.xi.2011, K. Hill, D. Marshall (in WAM, Registration No. WAM E109771). *Paratypes* as follows: WESTERN AUSTRALIA: 4 ♂ (1 genitalia prep. KIM 1, 1 molecular voucher 11.AU.WA.DRK.04), same data as holotype; 1 male (genitalia prep. RS 1 and molecular voucher 11.AU.WA.DRX.10), Gibb River Rd, ~11 km WSW of Durack R. x-ing, 15°58.83'S 127°7.78'E, 340 m, 19.xi.2011, K. Hill, D. Marshall (MSM). 1 ♂, same data as holotype (LP). 1 ♂ (molecular voucher 11.AU.WA.DRK.06), same data as holotype (UCS). 2 ♂, same data as holotype (WAM, Registration Nos WAM E109772, WAM E109773).

Additional localities based on audio recordings. Mitchell Falls Campground, 14.8212°S 125.7169°E, 8.x.2009, L. Popple.

Distribution and habitat (Fig. 1). Western Australia where the species is known from only three localities in the Kimberley region; two are along the Gibb River Road, one at the Durack R./Bamboo Ck. confluence and the other 11 km WSW of the Durack River crossing. The third location is at Mitchell Falls Campground on

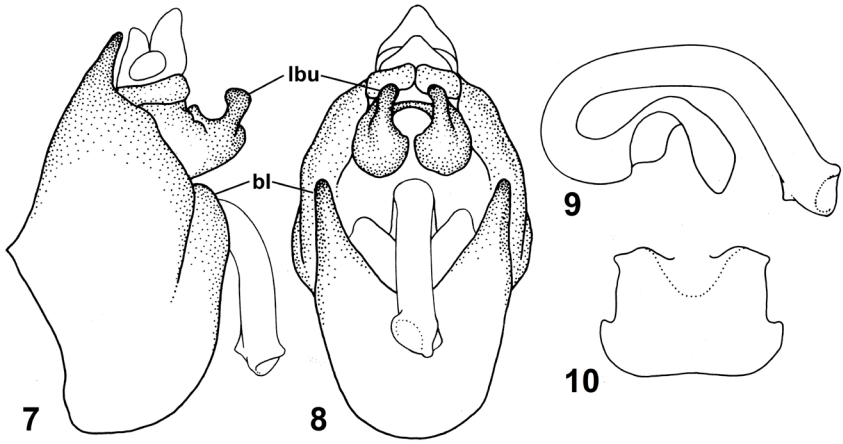
the Mitchell Plateau. Those from the site WSW of the Durack R. crossing were found well away from the road (K. Hill pers. comm.). Adults inhabit eucalypts but are usually not very high and are not particularly wary. There are records for mid October and mid November.

Etymology. Derived from the Latin *taenia* meaning band or stripe, and referring to the bold dorsal body stripe and the striped abdomen so distinct in live specimens.

Adult description

Male (Figs 2–10). Head, body and legs of live specimens extensively covered in a 'dusting' of fine silver white pubescence partly mixed with a fine, white, waxy exudation. In two colour morphs, one with a bold, very dark reddish-brown stripe down the dorsal length, the other with the interior of this stripe on the thorax yellowish.

Head black with a brown spot on posterior midline and another over each supra-antennal plate; a brown patch not always distinct either side of ocelli reaching to posterior margin of head and sometimes to back of eyes; eyes of live specimens light brown. Postclypeus light brown, black dorsally, and with black transverse ridges ventrally. Anteclypeus light brown to black, variable between individuals. Rostrum black with base light brown laterally to variable degrees; reaching mid length of hind coxae. *Pronotum* brown, one colour morph with a distinct yellowish midline bordered either side by a very dark reddish brown stripe that turns inwards on pronotal collar, as in the holotype (Figs 2–3), the other morph with a broad, very dark reddish-brown midline (Fig. 4); hints of black in paramedian and lateral fissures, and black edging to paranota and lower lateral



Figs 7–10. *Kimberpsaltria taenia* **gen. n.**, **sp. n.**, male genitalia, paratype (genitalia prep KIM 1). (7) pygofer in lateral view; (8) pygofer in ventral view; (9) aedeagus in lateral view; (10) basal plate in dorsal view. *bl*, basal lobe; *lbu,* lateral branch of uncus.

Figs 5, 6. *Kimberpsaltria taenia* **gen. n.**, **sp. n.**, male, same locality as holotype. (5) ventral view, mid- and hindlegs at left removed to be used as sequencing samples; (6) timbal, exposed after removal of timbal cover.

angles of pronotal collar. *Mesonotum* with one colour morph having a yellowish stripe along midline that gradually widens towards its posterior and bordered either side by very dark reddish brown, as in the holotype (Figs 2–3), the other morph with a very broad dark reddish brown midline (Fig. 4); a submedian pair of yellowish stripes, narrower than median stripe, extending from anterior margin to anterior arms of cruciform elevation; cruciform elevation yellowish brown with a black band across each anterior arm at about mid length, and a black patch between anterior and posterior arms that extends across upper part of posterior arms. *Wings* hyaline. Forewing with infuscation on crossveins r and r-m and sometimes at base of apical cell 4; costa light brown, venation otherwise black or nearly so. Hindwing venation brown and mostly very pale, except base of vein 3A black; a narrow white plaga on 2A and a wider plaga on 3A, both reaching almost full length. *Legs* mostly mid to dark brown, the hindlegs tending a little paler than others and sometimes with tibiae yellowish; mid and hind coxae yellowish with a black fascia on anterior face; meracantha dark brown basally becoming yellow at apex. Opercula broad and rounded except for partly straight distal margin, not quite meeting, confined to margins of tympanal cavity, black fading to dull yellow distally to varying extent but mostly so at distal outer quarter. *Abdomen* with tergites brown, the dorsal midline with a broad dark brown fascia tapering at its posterior end, and a narrower lateral fascia of similar colour; in life abdomen laterally densely covered in silver pubescence except for a brown pubescent lateral stripe (Fig. 2). Sternite II black, others light brown.

Timbal covers brown becoming black on dorsal and ventral thirds; reaching about halfway across timbal cavity. *Timbals* with 4 long ribs spanning timbal membrane, none of which are joined dorsally (Fig. 6).

Genitalia (Figs 7–10), see generic description above.

Measurements. Range and mean (in mm) for 10 males (all known specimens). *Length of body*: 22.0–24.5 (23.5). *Length of forewing*: 29.1–32.5 (31.1). *Width of head* (including eyes): 7.5–8.3 (7.9). *Width of pronotum* (across lateral angles): 9.7–10.6 (10.1).

Female unknown.

Song

The description below is based on 110 seconds of unobstructed male calling song sampled from two males from the AU.WA.DRK site and 1–2 from the AU.WA.DRX site (see *Types* for locations). The recordings included additional partly informative sound sample that contained overlapping songs or background noise. The recordings were taken during the afternoon of 19 November 2012, about 14:30 at DRK and 16:15 for DRX, both under sunny, hot conditions (*ca*. 34°C). One clear recording of 50 s duration, taken at dusk and treated here as conspecific with the DRK and DRX recordings, was obtained from Mitchell Falls in 2009.

Males sing continuously for indefinite periods of time. The fine structure of the sound appears as sound pulses lasting approximately 0.5–1.0 ms followed by much quieter pulses with a much less predictable pattern (not shown). Without further study and timbal mutilation experiments (e.g., Fleming 1975), it is not possible to link these sound pulses to the presumed in-out click mechanisms of the paired timbals, and when we use the term ‘pulse’ below we refer only to the large-amplitude sound bursts.

The primary pulses are produced at steady or slightly accelerating rates in two kinds of syllable or echeme, one with strong pulses produced at a relatively slow rate (here called the ‘slow-pulse echeme’, with pulse rates of about 81–88/s at 34°C), and the other with pulses of approximately half the intensity produced at rate about 1.5 times faster (‘fast-pulse echeme’, 119–137/s at 34°C) (Fig. 11). In all recordings, the male continuously alternates between these two echemes, leaving a very short gap of about 0.01–0.03 s in most cases. The male may produce longer fast-pulse echemes or longer short-pulse echemes, but for most of our recorded sample the slow-pulse echemes are longer and the durations of the two echemes are within the same order of magnitude (approximately 0.08–0.6 s). In one exception, a male produced one fast-pulse echeme for about five seconds, and this might have been due to a close approach by the recordist. In the dusk recording from Mitchell Falls, the pulse rates are all slower, but the same ratio of 1.5/1 is found between the rates of the fast-pulse and slow-pulse echemes.

Notably, the dusk-singing male at Mitchell Falls produced a longer gap of 0.08 s three times. This gap in each case was preceded by an unusual slow-pulse echeme in which several of the last pulses were produced with the reduced amplitude of the fast-pulse echemes; the gap was then followed by a normal fast-pulse echeme as the alternation resumed. These song structures were not recorded at the AU.WA.DRK or AU.WA.DRX sites. These gaps could be a distinct feature of the song of the Mitchell Falls population, or they might be a change to the song structure that occurs at dusk, a phenomenon observed in some other Australian cicadas (e.g. Ewart 2001; Popple, 2017).

Frequency profiles taken across 8–50 s samples of the recordings show that sound is produced across a range of at least 4.5–20 kHz, but most of the energy is concentrated at lower frequencies (Fig. 12). The dominant pitch varies from 7.9–9.3 kHz across the sampled song segments, with most around 8.8–9.3 kHz; in the case of the 7.9 kHz sample a second peak of nearly equal intensity was found at 9 kHz. The -10 dB frequency envelope (the range in which the spectrum remains within 10 dB of the peak) ranges from approximately 7–10.5 kHz. Separate measurements of the fast- and slow-click echemes suggest only subtle

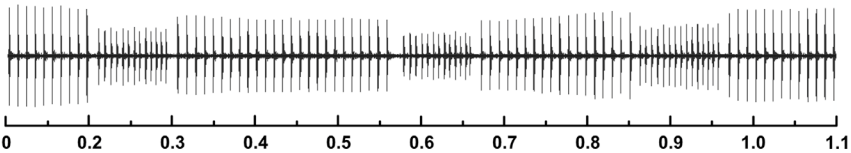


Fig. 11. Oscillogram of *Kimberpsaltria taenia* **gen. n.**, **sp. n.**, male calling song sample from Gibb R. Rd. 11 km WSW of the Durack R. crossing showing three fast-pulse echemes, two complete slow-pulse echemes, and two partial slow-pulse echemes.

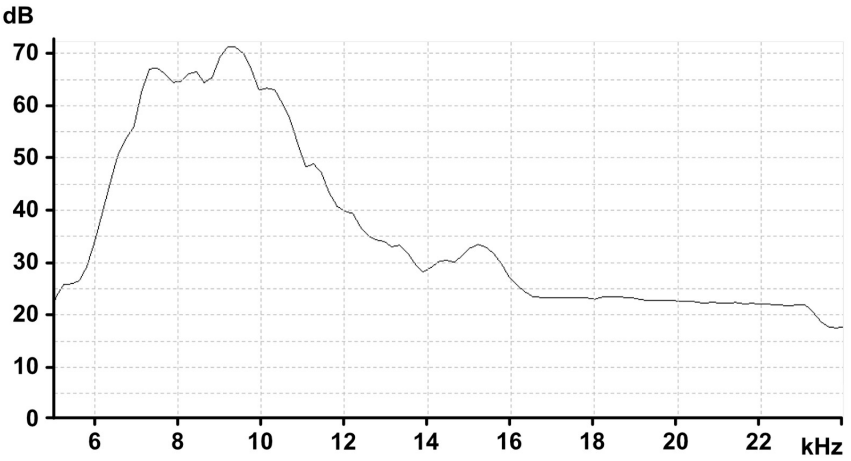


Fig. 12. Frequency spectrum of a 3.5 s sample of *Kimberpsaltria taenia* **gen. n.**, **sp. n.**, male calling song from Gibb R. Rd. 11 km WSW of the Durack R. crossing.

differences in their frequency profiles, with the former having a flatter frequency profile and the latter a greater peak close to the overall song dominant pitch.

The pulse pattern and quality of the slow-pulse echeme is superficially similar to that of *Talcopsaltria olivei*, the sound of which is illustrated in Moulds (2008). However, *Talcopsaltria* is lower in dominant frequency and is not known to produce a pulsed song of alternating echemes.

Acknowledgements
For the genitalia drawings we thank Ivan Nozaic. Kathy Hill helped collect the type and paratype specimens. We thank Stéphane Puissant and Allen Sanborn for helpful comments that improved the manuscript. Specimens were collected under permit to DM and K. Hill (permit number SF008256) from the Western Australian Department of Environment and Conservation, with assistance from D. Stefoni. Financial support for field work and line drawings was provided by NSF grants DEB1655891, DEB0955849, DEB0720664, DEB0529679, and DEB0089946 to C. Simon, D. Marshall, J. Cooley, M. Villet and M. Moulds. Fig. 1 was compiled with simplemappr.net.

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