

PERICALLEA KATHERINA, A NEW CICADA GENUS AND SPECIES FROM WESTERN AUSTRALIA (HEMIPTERA: CICADIDAE: CICADETTINI)

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Abstract

A new genus, *Pericallea* **gen. n.**, is described to accommodate the new species *Pericallea katherina* **sp. n.**, a species endemic to inland districts of south-western Western Australia. Relationships of the new genus are discussed, and the male calling song of the new species is described and analysed.

Key words. cicada song, colour polymorphism, Cicadoidea

Introduction

Here we describe a beautiful and distinct species of cicada from inland districts of the south-western quarter of Western Australia. It occurs in two colour morphs, one jade green with silver markings, the other golden brown with silver markings. It represents a distinct new genus that is also described. The song is analysed and the phylogenetic relationships of the new species are discussed.

Methods and abbreviations

Male calling songs were digitally recorded in the field at a sampling rate of 44.1 kHz or 48.0 kHz using one of several models of Marantz (Mahwah, NJ, USA) audio recorders (e.g., PMD-670) together with a Sennheiser (Old Lyme, CT, USA) ME62 omnidirectional microphone with a windscreen and, in most cases, a Sony PBR-330 parabolic reflector (otherwise a ME66 short shot gun microphone plus windscreen was used). The microphones were powered by Sennheiser K6 power modules, and they have a frequency response that is approximately flat from 40 Hz–20 kHz (± 2.5 dB).

Terminology for morphological features follows that of Moulds (2005, 2012). Measurements of adult specimens were taken using vernier calipers accurate to 0.1 mm, those of the head and prothorax measured under 10x magnification. Terminology for male calling song descriptions is as follows: A *pulse* is a burst of sound energy containing multiple sound *waves* (the primary pressure-amplitude waveform), which dampen to zero if not followed by another sound burst; pulses often appear in pairs as *doublets*. This definition does not assume a specific mechanical basis, so a pulse could be created by one timbal collapsing or rebounding, both timbals collapsing/rebounding in synchrony, or one or more ribs of one or both timbals collapsing/rebounding (e.g., Fleming 1975). A *syllable* is a group of pulses or doublets repeated at an approximately uniform rate. A *phrase* is a repeated pattern of syllables of more than one type.

Measurements of acoustic features were made using Raven Pro version 1.5 (Cornell Lab of Ornithology, Ithaca, NY, USA). Repetition rates of sound components were measured from oscillograms (waveforms) to the nearest 0.001 s and are presented here as ranges of observed values. Recordings were filtered to remove sound energy below about 8 kHz. Spectrograms were made using the following parameter settings: Hann window, window size 256 samples, 23 decibels (dB) filter bandwidth 270 Hz, DFT (discrete Fourier transform) size 256 samples, grid spacing 188 Hz, overlap 50%, hop size 128 samples, averaging 1 spectrum, with no clipping. Air temperatures were recorded with an Omega HH-25KF temperature meter (accuracy $\pm 0.5\% + 1.0\text{ }^{\circ}\text{F}$) and type K thermocouple (OMEGA Engineering, Stamford, CT, USA), or in some cases with an ordinary household digital thermometer. Some males were recorded while kept in 1.5 litre mesh fabric 'Port-a-Bug' cages obtained from Insect Lore, P.O. Box 1353, Shafter, CA, USA.

The following abbreviations are used for collections housing specimens: DE, collection of David Emery, Sydney; LP, collection of Lindsay Popple, Cairns; MSM, collection of M.S. Moulds, Kuranda; PMH, collection of Paul M. Hutchinson, Perth; WAM, Western Australian Museum, Perth; UCS, University of Connecticut, Storrs, CT, USA.

***Pericallea* gen. n.**

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Type species: *Pericallea katherina* sp. n., here designated.

Included species: monotypic, *Pericallea katherina* sp. n.

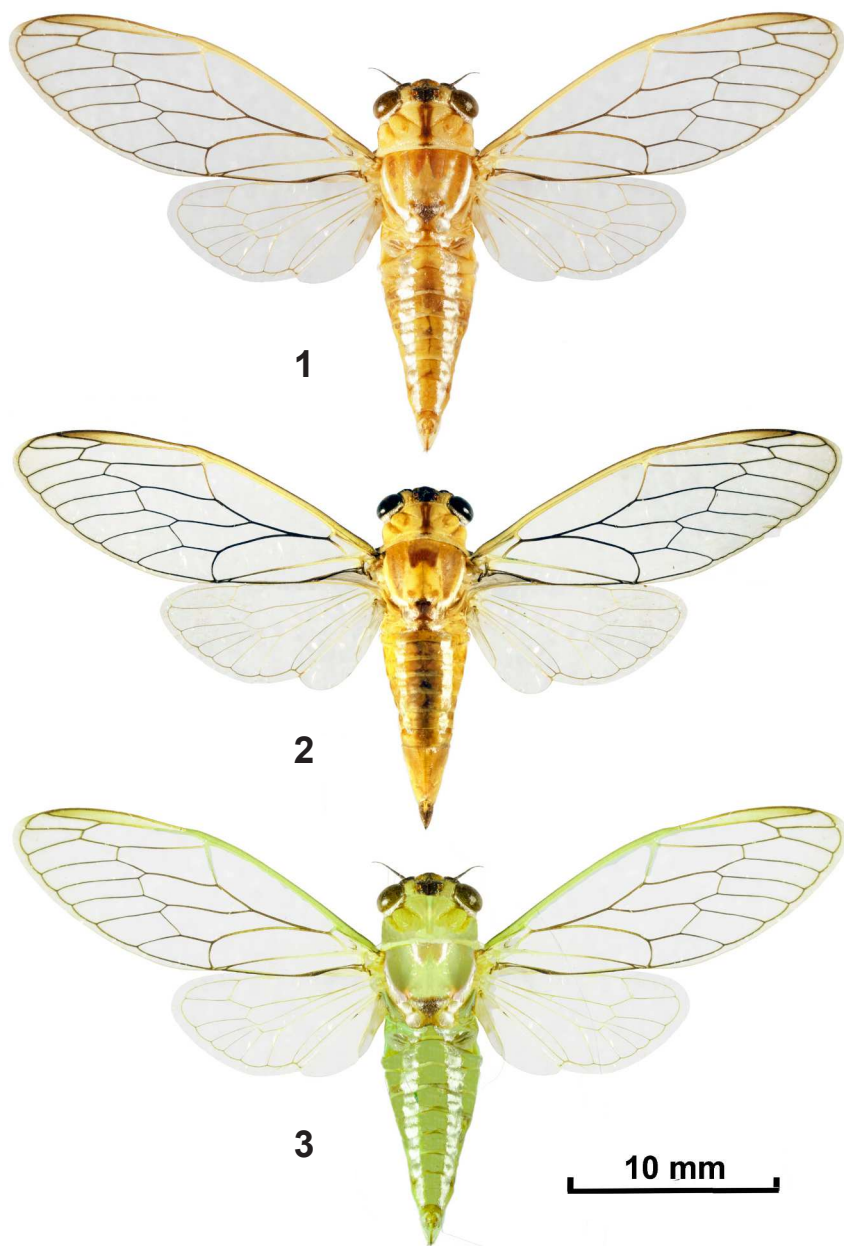
Tribe: Cicadettini Buckton, 1890.

Etymology: From the Greek *perkalles*, meaning very beautiful, and referring to the beautiful appearance of this species with its silver, green and gold colours. Feminine.

Distribution: Drier, inland regions of south-western Western Australia.

Diagnosis

Head including eyes wider than mesonotum; supra-antennal plate meeting eye; postclypeus broadly rounded transversely across ventral midline, in lateral profile angulate between 'top' and 'sides'. *Thorax*: pronotum in dorsal view parallel-sided or narrowing towards posterior; pronotal collar width at dorsal midline much less than diameter of eyes; paranota confluent with adjoining pronotal sclerites, no mid lateral tooth; cruciform elevation wider than long; epimeral lobe not reaching operculum. *Forewings* hyaline; with 8 apical cells; subapical cells absent; ulnar cell 3 angled to radial cell; basal cell long and narrow; costal vein (C) clearly higher than R+Sc; costa parallel-sided to node, costa of male gently and evenly curved; pterostigma present; vein CuA only weakly bowed so that cubital cell no larger than medial cell; veins M and CuA meeting basal cell with their stems completely fused as one; vein RA₁ aligned closely with Sc for its length and not diverging in subapical region; vein CuA₁



Figs 1–3. *Pericallea katherina* gen. et sp. n.: (1) male, brownish yellow morph; (2) female, brownish yellow morph; (3) male, green morph.

divided by crossvein m-cu so that proximal portion shortest; distance between cross veins r and r-m about equal to or a little longer than distance between r-m and m; apical cells 3–6 shorter than ulnar cells; radial cell a little shorter than the distance from its apex to wing tip; infuscation absent (but apical cells 1–3 with subtle smoky colour distally); wing outer margin developed for its total length, never reduced to be contiguous with ambient vein. *Hindwings* with 6 apical cells; no infuscation on ambient vein; width of 1st cubital cell at distal end at least twice that of 2nd cubital cell; anal lobe broad with vein 3A curved distally, separated from wing margin; veins RP and M fused basally. *Foreleg* femoral primary spine erect. *Male opercula* more or less reaching margin of tympanal cavity, directed towards distomedial margin of tympanal cavity, apically broadly rounded, clearly not meeting; base (remnant of epimeron 3) not swollen or bubble-like. *Male abdomen* basally wider than thorax, thereafter tapering to apex; tergites in cross-section with sides straight or weakly convex, epipleurites reflexed ventrally from junction with tergites; tergite 1 narrow along dorsal midline; tergites 2–7 similar in width along dorsal midline; sternites IV–VII in cross-section convex, not unusually swollen. *Timbal covers* absent; posterior margin of timbal cavity rounded and completely lacking a ridge on lower half or so.

Male genitalia (Figs 8–10). Pygofer in ventral view ovoid to sub-ovoid; with distal shoulders not developed; upper pygofer lobes flat, small, set well away from dorsal beak, apically rounded in lateral view; basal lobes undivided, small, apically rounded in lateral view, close to upper lobes, abutted against or partly tucked behind pygofer margin; dorsal beak present as a pointed apex and a part of chitinated pygofer. Uncus small, short, flattened, strongly tapered on basal half, narrow and parallel-sided on apical half. Claspers well developed, large, dominant, beak-like and sharply pointed, curved in lateral view, not diverging, excavated ventrally, restraining aedeagus, unfused. Aedeagus with basal plate in lateral view arched, depressed on dorsal midline, in dorsal view slender, apically broadened with ‘ears’, basal portion of basal plate straight, ventral rib completely fused with basal plate; junction between theca and basal plate with a semi-functional ‘hinge’ that possesses a chitinous back; thecal shaft very short, undeveloped; pseudoparameres present, long and slender, apically pointed, unfused throughout their length, in dorsal view parallel, straight or almost so, in lateral view curved; endotheca exposed, not chitinous; endothecal ventral support present, long (longer than pseudoparameres), very slender; thecal subapical cerci absent; flabellum absent; conjunctival claws absent; vesical opening apical on theca. *Male reproductive system* unknown.

Female opercula curved in an arc, extending a little beyond tympanal cavity, and medially beyond meracanthus; dorsal beak with a developed apical spine (visible in dorsal view); abdominal segment 9 long and slender; sternite VII deeply incised in a sharp V-shape to, or almost to, sternite VI. *Female reproductive system* unknown.



Figs 4–6. *Pericallea katherina* gen. et sp. n., live specimens: (4) male, green morph in natural habitat; (5) male light brownish yellow morph in natural habitat; (6) female, green morph, on light sheet at MV light.

Distinguishing features and relationships

Pericallea gen. n. differs from all other genera in having, in combination, forewing veins M and CuA meeting the basal cell fused as one, the forewings lacking infuscations (only a subtle smokiness in the distal apical cells), the forewing costa even in width to node and evenly curved throughout its length,

the paranota without a small mid-lateral tooth, and the male genitalia with an aedeagus in which the fleshy endotheca and its ventral support are both longer than the long pseudoparameres.

A molecular phylogeny by Marshall *et al.* (2016, fig. 2) places *Pericallea* (as “goldsilver cicada”) sister to an allied undescribed species from Queensland, these in turn sister to *Nigripsaltria mouldsi* Boer, 1999 from New Guinea. These three belong to a larger clade that includes ‘wing snapping’ genera such as *Toxala* Moulds, 2012 (see Popple 2015), *Clinata* Moulds, 2012 (see Popple and Emery 2017) and (likely) *Froggattoides* Distant, 1910 (see Moulds 1990) and another clade containing *Platypsalta* Moulds, 2012, *Crotopsalta* Ewart, 2005, and related undescribed species.

Although *Pericallea* is sister to *Nigripsaltria mouldsi* in the molecular tree and they have a similar morphology (including the male genitalia), *N. mouldsi* differs significantly in having a greatly swollen node suggesting it is a ‘wing snapping’ species. *Pericallea* has no modification to its costal margin (Figs 1–3) and so is unlikely to use wing snaps as part of the male’s song. We noticed no wing-snapping by singing *Pericallea* in the field and or in cages, although our sample of observations was small. *Pericallea* does share similar male genitalia morphology with all the aforementioned ‘wing snapping’ genera, the aedeagus being trifid and in particular having a very long endotheca and ventral support that are almost as long as or longer than the pseudoparameres.

***Pericallea katherina* sp. n.**

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(Figs 1–13)

Synonymy

“goldsilver cicada” Marshall *et al.* 2016: fig. 2.

Types. *Holotype* ♂ [yellow morph], molecular voucher 06.AU.WA.WSS.01 (song recorded, Fig. 12), 30.5 km W of Sandstone, Western Australia, 28°00.692’S 118°59.922’E, 570 m, 16,17.ii.2006, Hill, Marshall, Moulds (WAM).

Paratypes: WESTERN AUSTRALIA: 1 ♂ [yellow morph], 21 km S of Menzies, 30.i.1992, T.M.S. Hanlon; 1 ♂ [yellow morph], AU.WA.MZS, 25 km S of Menzies on Goldfields Hwy, 29°55.143’S 121°07.278’E, 392 m, 22.ii.2016, D. Marshall & L. Popple (DE). 1 ♂, 1 ♀, [both yellow morph], AU.WA.WSS, same locality as holotype, 16,17.ii.2006, Hill, Marshall, Moulds (LP). 4 ♂♂ [yellow morph] [1 genitalia prep GOL1], 4 ♀♀ [3 yellow morph, 1 green morph], same locality as holotype, 16,17.ii.2006, Hill, Marshall, Moulds; 1 ♂ [molecular voucher 09.AU.WA.CGC.01], ~45 km WSW of Coolgardie on the Great Eastern Hwy, 31°6.571’S 120°44.080’E, 443 m, 8.ii.2009, K. Hill, D. Marshall; 2 ♂♂ [green morph] [1 genitalia prep. YER3; 1 molecular voucher 09.AU.WA.YER.01], No. 5 Pump Station ‘Yerbillon’, 0.3 km S of Great Eastern Hwy, ca. 60 km WSW of Southern Cross, 31°23.386’S 118°44.194’E, 386 m, 8.ii.2009, K. Hill, D. Marshall; 2 ♂♂ [green morph], [genitalia prep. FLY2], AU.WA.BCW, 17.1 km W of Beacon, 30°26.159’S 117°40.852’E, 341 m, 9.ii.2009, K. Hill, D. Marshall; 4 ♂♂ [green morph] [2 genitalia prep. FLY6 and FLY7; 2 molecular vouchers 09.AU.WA.GIL.05 and 09.AU.WA.GIL.06], 0.8 km SW of Esperance Hwy on Lake King/Peak Charles road, nr Lake Gilmore, 32°37.714’S 121°32.354’E, 240 m, 7.ii.2009, K. Hill, D. Marshall; 1 ♂

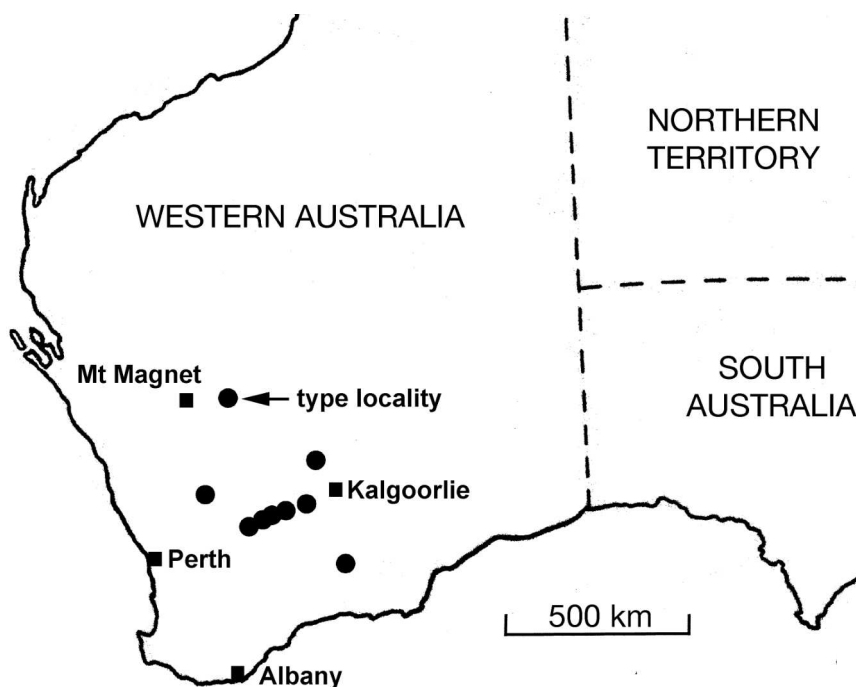


Fig. 7. Distribution of *Pericallea katherina* **gen. et sp. n.** through drier regions of south-western Western Australia.

[green morph] [molecular voucher 09.AU.WA.CGD.01], 49 km WSW of Coolgardie, 136 km E of Southern Cross, Great Eastern Hwy, 31°08.308'S 120°41.198'E, 473 m, 8.ii.2009, K. Hill, D. Marshall; 3 ♂♂ [yellow morph], 21 km S of Menzies, 30.i.1992, T.M.S. Hanlon; 4 ♂♂, 1 ♀ [all yellow morph] (1 ♂ song recorded and molecular voucher 16.AU.WA.MZS.02), 25 km S of Menzies on Goldfields Hwy, 29°55.143'S 121°07.278'E, 392 m, 22.ii.2016, D. Marshall, L. Popple; 2 ♂♂, 2 ♀♀ [all yellow morph], Pianto Rd, 23 km S of Menzies, 8.ii.2012, P. Hutchinson (MSM). 1 ♀ [green morph], 23 km S of Menzies, 6.ii.2006, on Acacia, P. Hutchinson; 1 ♂ [green morph], 22 km S of Menzies, 10.ii.2007, P. Hutchinson; 5 ♂♂, 5 ♀♀ [all yellow morph], Pianto Rd, 23 km S of Menzies, 8.ii.2012, P. Hutchinson; 1 ♂ [green morph], 23 km S of Menzies, 27.i.2016, P. Hutchinson (PMH). 1 ♂, 1 ♀ [both yellow morph], AU.WA.WSS, same locality as holotype, 16,17.ii.2006, Hill, Marshall, Moulds; 2 ♂♂, 1 ♀ [all yellow morph], AU.WA.MZS, 25 km S of Menzies on Goldfields Hwy, 29°55.143'S 121°07.278'E, 392 m, 22.ii.2016, D. Marshall, L. Popple; 1 ♂ [yellow morph], AU.WA.COA, 32 km W of Coolgardie, 31°02.052'S 120°49.455'E, 450 m, 21.ii.2009, K. Hill, D. Marshall (WAM). 3 ♂♂ [1 green morph, 2 yellow morph] [2 molecular vouchers 06.AU.WA.WSS.07 and 06.AU.WA.WSS.08 (in alcohol)], same locality as holotype, 16,17.ii.2006, Hill, Marshall, Moulds; 1 ♂ [green morph] [molecular voucher 09.AU.WA.CGF.01], ca. 71 km W of Coolgardie, 31°10.886'S 120°29.086'E, 382 m, 8.ii.2009, K. Hill, D. Marshall (UCS).

Other material examined: 1 ♀ (teneral, with exuviae), AU.WA.WSS, same locality as holotype, 16.ii.2006, Hill, Marshall, Moulds; 1 ♀ (teneral), 42 km E of Yellowdine, 7.ii.2006, D. Knowles; 1 ♀ (teneral), Lake Deborah Rd (east) T-junction, 6.ii.2006, D. Knowles (MSM).

Aural record: AU.WA.BCN, Beacon, east edge of town, 30°27.193'S 117°52.174'E, 374 m, 9.ii.2009, K. Hill, D. Marshall.

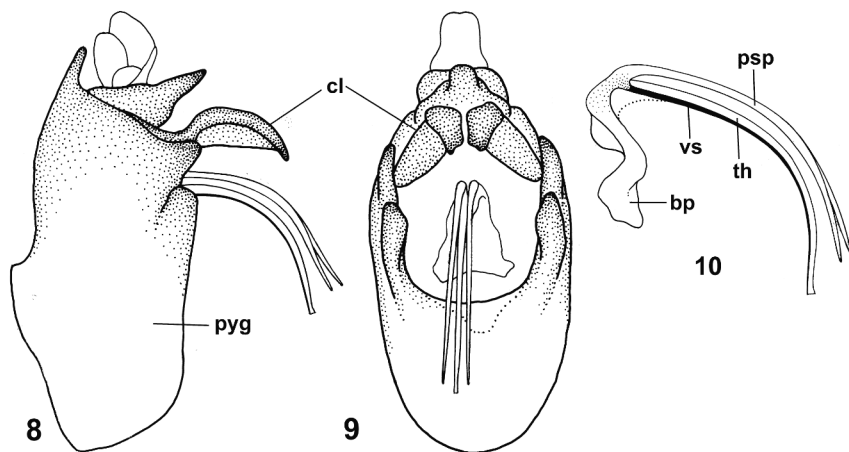
Distribution and habitat (Figs 7, 11). Inland districts of south-western Western Australia from near Sandstone in the north to beyond Norseman in the south. The most western record is from 17 km west of Beacon and the most inland records are from 25 km south of Menzies. Most records are from along the Great Eastern Highway between Merredin and Coolgardie.

Average annual rainfall for the localities ranges from 250 to 350 mm. Botanically the region is mostly semi-arid eucalypt woodland with a mixture of *Acacia*, *Melaleuca* and *Allocasuarina* understorey becoming mulga scrubland north of Menzies. Adults are usually found inhabiting small shrubs including *Acacia* but sometimes also inhabit *Eucalyptus*. There are records from late January to late February.

Etymology. From the Latin form of the Greek *Alkaterine*, meaning 'pure', the origin of the English name Katherine, and here applied to honour Kathy Hill in recognition of her substantial contribution to Australian cicada systematics.

Adult description

Male (Figs 1, 3–5, 8–10). In two colour morphs, either light brownish yellow with highlights of silver pubescence, or jade green with silver highlights. **Yellow morph** (Figs 1, 5): *Head* light brownish yellow with a broad black fascia along dorsal midline encompassing ocelli; supra-antennal plates black; postclypeus light yellowish brown with dorsal surface black and a large black anterior spot extending along ventral midline variable between individuals; anteclypeus black; rostrum light yellowish brown becoming black distally, reaching apices of hind coxae. Eyes in life light to dark brown. *Thorax* light brownish yellow, the pronotum a little paler than mesonotum. Pronotum with a black or dark brown fascia along midline often with its interior partly light brown on anterior half or so. Mesonotum with submedian and lateral sigilla sometimes darkened, sometimes not, and often a line of silver pubescence between them, along lateral margins and between arms of cruciform elevation. *Wings* hyaline. Forewing venation black except for yellow costa and much of vein CuP+1A; sometimes weak infuscation along ambient vein and distal ends of veins forming apical cells; basal cell hyaline; basal membrane whitish. Hindwing venation pale yellow; plaga white. *Legs* light yellowish brown except for foretibiae and all tarsi brown. Meracantha pale yellow with hint of brown basally. *Opercula* pale yellow, in life usually covered in silver pubescence. *Timbals* with four long ribs spanning timbal membrane and merging dorsally, dark brown to black against a white timbal membrane; posterior margin of cavity broadly rounded. *Abdomen* with tergites light brown with a subdorsal and a sublateral band of silver



Figs 8–10. *Pericallea katherina* **gen. et sp. n.**, male genitalia with aedeagus freed from claspers: (8) lateral view; (9) ventral view; (10) aedeagus in lateral view. *bp* basal plate, *cl* clasper, *psp* pseudoparamere, *pyg* pygofer, *th* theca, *vs* ventral support.



Fig. 11. Type locality of *Pericallea katherina* **gen. et sp. n.**, site AU.WA.WSS, 30.5 km W of Sandstone, Western Australia.

pubescence; sternites pale yellow with a band of silver pubescence along lateral margins and usually a hint of brown at base of sternite III and apex of sternite VIII. **Green morph** (Figs 3, 4): Similar to yellow morph but body green instead of light brownish yellow. Thorax with cruciform elevation partly black becoming dark brown distally; wing grooves darkened; and pronotum often lacking a dark fascia along its midline. Postclypeus sometimes lacking black markings. Dorsal abdomen usually darker than the dorsal thorax.

Genitalia (Figs 8–10). See generic description above.

Female (Figs 2, 6). Colouration and markings similar to male. Abdominal segment 9 light brownish yellow or green with a broad, blurred, light brown to blackish subdorsal band either side, darkening towards a black apical spine; ovipositor sheath brown or green tending black dorsally, protruding about 1.5 mm beyond apical spine.

Measurements. Range and mean (in mm) for 10 males and 10 females (includes largest and smallest of available specimens). *Length of body*: male 15.6–17.0 (16.4); female (including ovipositor) 18.6–22.3 (19.9). *Length of forewing*: male 18.1–19.2 (18.7); female 21.5–25.5 (22.1). *Width of head*: male 4.8–5.1 (4.9); female 5.3–5.9 (5.4). *Width of pronotum*: male 4.9–5.2 (5.0); female 5.5–6.6 (5.7).

Distinguishing features

The long, slender, green or light brownish yellow body, usually bearing prominent silver pubescence, makes this a distinctive species unlikely to be confused with any other. The male genitalia are unusual in having an aedeagus in which the fleshy endotheca and its ventral support are both longer than the long pseudoparameres.

Song (Figs 12, 13)

Thirteen minutes and 40 seconds of timbal song were recorded from at least eight individual males (but as many as 13 males as it was impossible to tell if separate recordings from free flying males were all from different individuals), across five sites (WA.WSS, WA.BCW, WA.CGC, WA.GIL, WA.YER; see paratype list for detailed locations). Seven minutes and 26 seconds of the sample involved caged males. Because this is a small sample, and because considerable variation was observed as described below, all measurements should be viewed as approximate.

The basic unit of song is a sound pulse lasting about 0.5–1.5 ms. (These usually appear to contain multiple sound bursts, but due to background sound and echoes we cannot resolve consistent patterns, so we treat the pattern as a single pulse.) Pulses are often produced in doublets with the paired pulses separated by about 1–2 ms (Fig. 12E). The pulses contain wave frequencies mainly between 10 and 19 kHz (the range within which the intensity remains within 30 dB of the peak amplitude) (Fig. 12B). The power spectrum is approximately flat from around

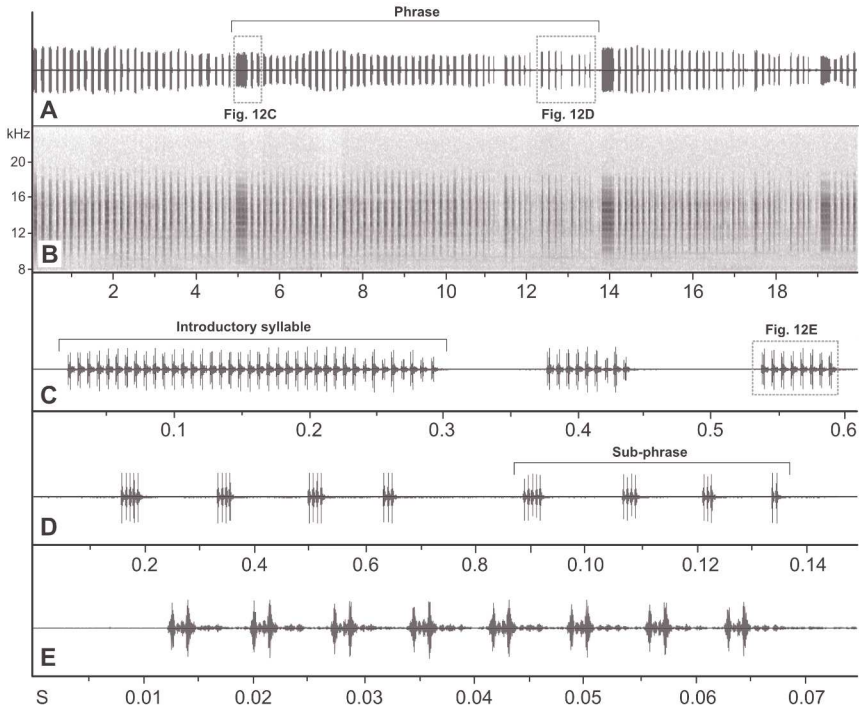


Fig. 12. Male calling song of *Pericallea katherina* **gen. et sp. n.**, holotype specimen 06.AU.WA.WSS.01 (track T01): (A, B) oscillogram and spectrogram showing parts of four song phrases; (C, D, E) oscillograms showing detail of specific song elements.

12–17 kHz. Pulses or doublets are produced at about the same rate in all song elements produced by a given male (approximately 142–147/s at 25° C environmental temperature at the WA.CGC site, and 193/s at 32.2° C at the WA.BCW site).

The song, which is high-pitched but with a dull quality, is loosely organised into phrases that begin with an introductory syllable lasting around 0.15 s (range 0.11–0.29 s) and continue with series of shorter syllables that may vary in length (from 0.003–0.09 s) (Figs 12, 13). Each phrase is followed immediately by another phrase. A single phrase may last for a few seconds to longer than a minute, but durations of 3–15 s are common. In the most complex phrases, the series of shorter syllables ends with one or more sub-phrases containing syllables that progressively decrease in length (Fig. 12D). Sometimes these sub-phrases begin with syllables with intermediate lengths that are difficult to classify, meaning that the distinction between phrase and sub-phrase is not always clear. Phrase structure can vary during a singing bout in the lengths of the syllables, the

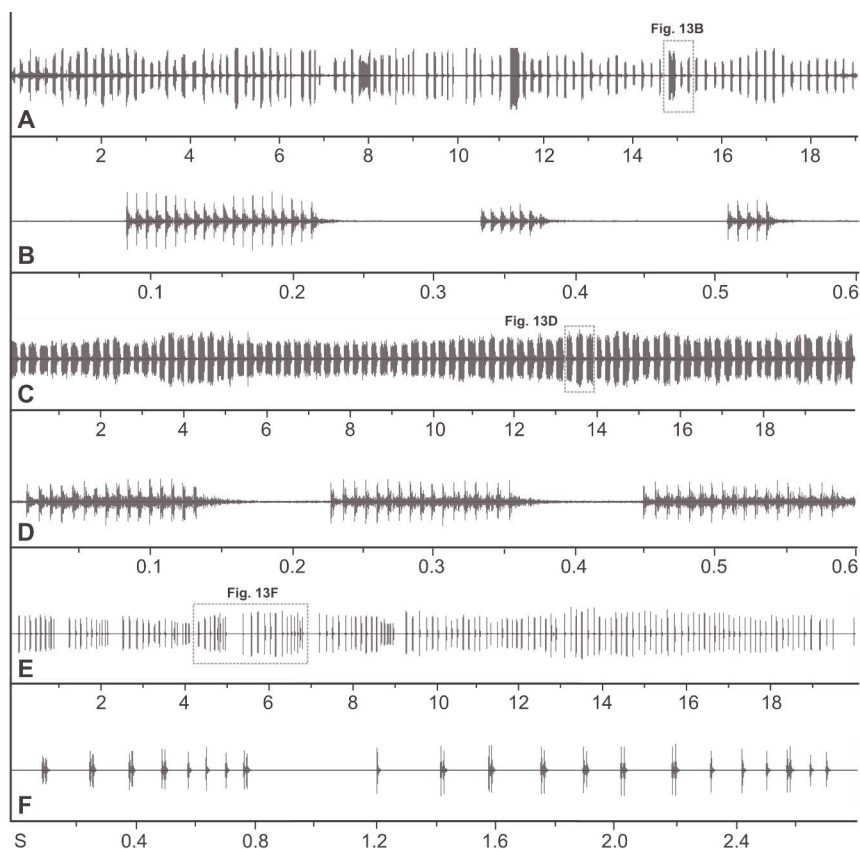


Fig. 13. Oscillograms showing additional examples of *Pericallea katherina* gen. et sp. n. male calling song: (A, B) song from uncollected male at site 45 km WSW of Coolgardie (track 09.AU.WA.CGC.T01); (C, D) putative dusk song from uncollected male at site 60 km WSW of Southern Cross (track 09.AU.WA.YER.T01) (green morph); (E, F) recording from specimen 09.AU.WA.GIL.06 (track T09) (green morph) singing in a cage.

numbers of syllables of different lengths, and the presence or absence of the sub-phrases.

One male at the WA.YER site, singing after sunset, was recorded for 41 seconds producing a song composed entirely of what appear to be introductory syllables (based on their lengths of 0.1–0.17 s), with no apparent phrase structure (Figs 13C, D). Other males heard and collected at the site were noted to have produced a song more like that shown in Figs 12A and 13A, so we suspect that the different song was a simplified dusk variation, a behaviour observed in some other Cicadettini (e.g., Popple 2017).

At the WA.GIL site, recordings were made only of caged males. The song from these males was composed of much shorter syllables overall (Figs 13E, F), with occasional introductory syllables of extreme length up to 41s (not shown). These males moved around in the cage and showed signs of agitation, possibly suggesting a courtship mode, an effect we have observed from the cage environment in some other species. Shorter syllables were also observed by some males at the WA.WSS site when the recordist neared the subject, suggesting that disturbance was involved. However, until recordings of free-singing males are obtained we cannot exclude the possibility that the WA.GIL population represents a morphologically cryptic song variant.

Behaviour

Males call from single stations, without flight, for one or more minutes at a time. If approached they cease most singing and tick occasionally. Males do not produce an alarm call when captured. No wing-snapping by singing males was observed. We did not have the opportunity to observe female responses to male song. Most individuals were observed during the day, however a series collected at Pianto Road, south of Menzies, were attracted to a 400w MV light (Fig. 6).

Acknowledgements

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