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RECORD OF THE CICADA, *PURANA USNANI* DUFFELS & SCHOUTEN IN SINGAPORE, WITH PRELIMINARY ACOUSTIC ANALYSIS (HOMOPTERA: CICADIDAE: CICADINAE)

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INTRODUCTION

An initial investigation of the cicada diversity in Singapore based on specimens deposited at the Zoological Reference Collection (ZRC) of the Raffles Museum of Biodiversity Research (RMBR) at the National University of Singapore listed five *Purana* species (Zaidi & Ruslan, 1997). These included *Purana albigutta* (Walker), *Purana guttularis* (Walker), *Purana nebulilinea* (Walker), *Purana pryeri* (Distant), and *Purana tigrina* (Walker). Since then, comprehensive taxonomic revisions have been performed for various species groups of *Purana* within the Southeast Asian region, resulting in generic reassignments as well as new species being recognised (Kos & Gogala, 2000; Schouten & Duffels, 2002; Duffels et al., 2007; Duffels, 2009; Lee, 2009). Key updates of relevance to the Singapore fauna include the transfer of *Purana albigutta* to the genus *Maua* (Gogala et al., 2004; Duffels, 2009), and the description of a new species, *Purana usnani* Duffels & Schouten, within the *Purana tigrina* species group (Duffels et al., 2007). The geographic distribution of *Purana usnani* includes Lingga Island and Bunguran Island (Indonesia), Sarawak, Brunei (Borneo), and Singapore (based on a male specimen in the Natural History Museum in London). In this article, the occurrence of *Purana usnani* in Singapore is supported with recent observations and descriptions of its characteristic call sequence.

OBSERVATIONS

Between Jun–Jul.2011, a healthy population of *Purana usnani* (identified by J. P. Duffels) was found to occur in the landward edge of the mangrove forests of Pasir Ris at the north-eastern corner of Singapore Island. On days with fine, sunny weather, male cicadas were regularly heard and sometimes observed calling while perched on trees at eye-level and beyond (Fig. 1). Female cicadas were also seen individually, often well camouflaged against the pale bark on which

Fig. 1. A male *Purana usnani* individual (body length = 24 mm, forewing length = 30 mm), perched just above eye-level on the trunk of a sea hibiscus tree (*Talipariti tiliaceum*, Malvaceae) at the landward edge of mangrove forest at Pasir Ris on 5 Jul.2011 (1200 hours).

they were perched. A representative series was obtained for detailed morphological examination and measurements (body length = BL; forewing length = FW). These include: ZRC.6.22172 (coll. 5 Jul.2011): 1 male, BL = 24 mm, FW = 30 mm, pygofer height = 2.8 mm; 4 females, BL = 20–21 mm, FW = 29–30 mm; 1 exuvia (female, BL = 20 mm); ZRC.6.22174 (coll. 6 Jul.2011): 1 female, BL = 21 mm, FW = 30 mm; ZRC.6.22175 (coll. 14 Jul.2011): 1 male, BL = 25 mm, FW = 32 mm, pygofer height = 3.1 mm. The preserved specimens (Fig. 2) agreed closely with the detailed original descriptions for the species (Duffels et al., 2007: 375–380). The everted male genitalia (pygofer, Fig. 3) also matched the illustration of the original description (Duffels et al., 2007: 378, Fig. 14). The basal pygofer lobes, lateral pygofer lobes, and uncus were heavily chitinised black. The basal pygofer lobes consisted of prominent, inward pointing spines, while the uncus was triangular with a narrow apex. The lateral pygofer lobes were short and recurved with rounded apices.

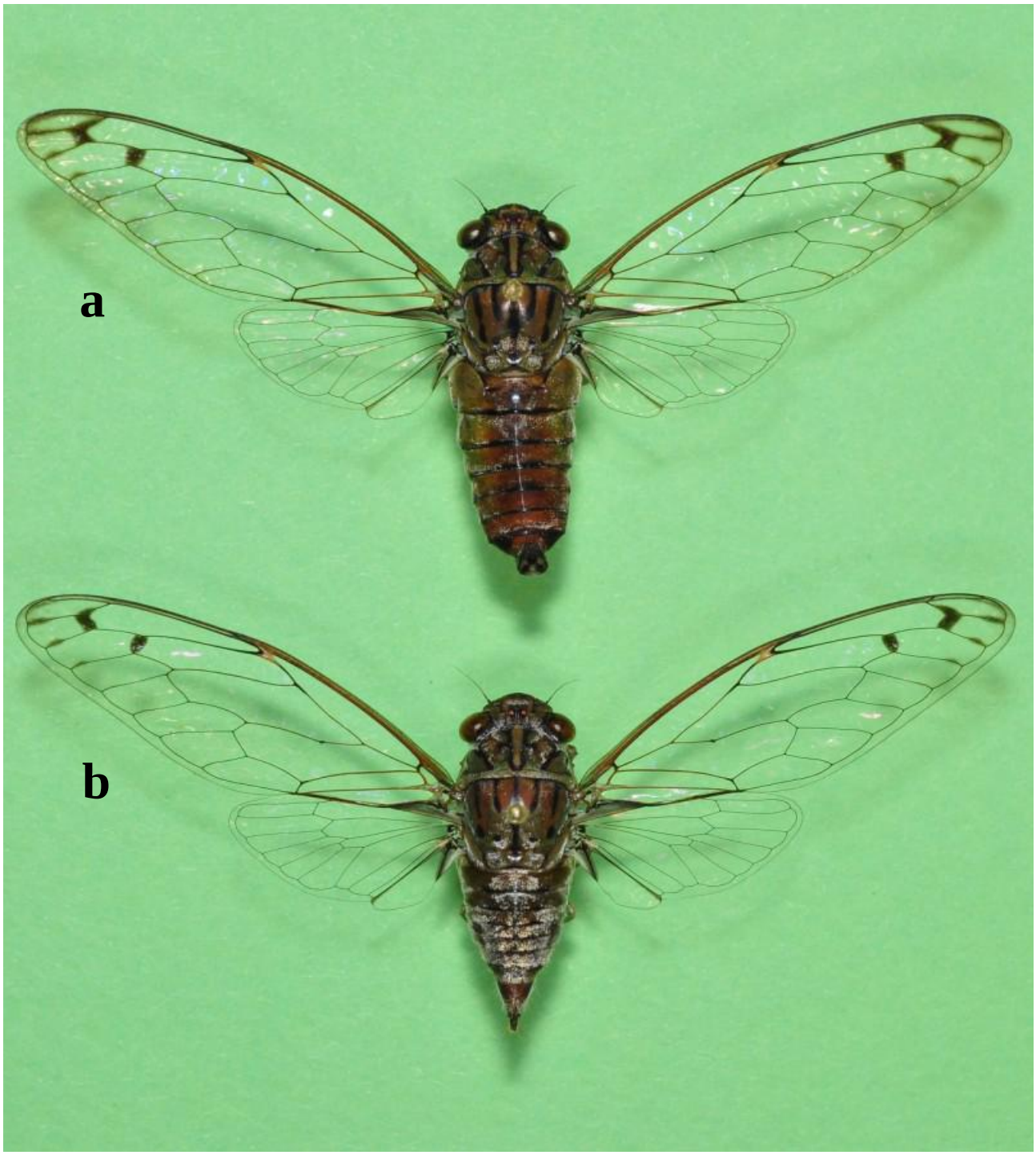

Fig. 2. Voucher specimens of male (a) and female (b) individuals (ZRC.6.22172) from Pasir Ris. The male cicada (body length = 24 mm, forewing = 30 mm) was preserved with its genitalia everted (see Fig. 3). The female cicada (body length = 20 mm, forewing = 29 mm), has a relatively shorter and narrower abdomen.

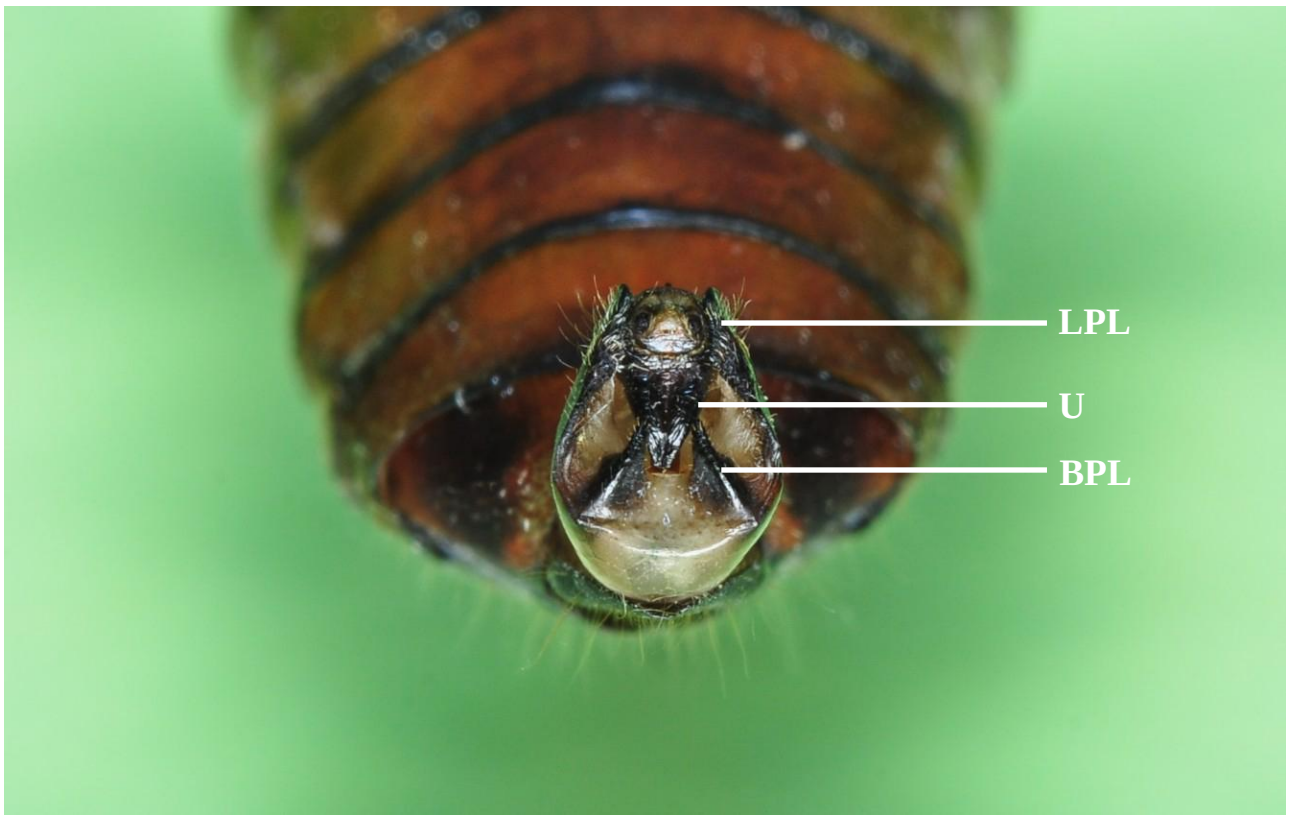

Fig. 3. Close-up of everted pygofer of a male individual (ZRC.6.22172). The height of the pygofer was 2.8 mm. LPL = lateral pygofer lobe, U = uncus, BPL = basal pygofer lobe.

BIOACOUSTICS

Tymbalisation by male cicadas was typically accompanied with rhythmic pulsations of their abdomens, expanding and contracting in time with the respective portions of the song sequence. A brief video clip (2 min 49 s) of this activity was recorded on 2 Jun.2011 (ca. 1230 hours) and subsequently uploaded (http://www.youtube.com/watch?v=1JaFdTA7U6I). Audio recordings of individual males were acquired in the field on 5 Jul.2011 and analysed to determine their acoustic properties. A sample of this tymbalisation (MP3 format, ca. 2 min) is available for download, and serves as the basis for the following description of its call.

The entire call duration per song may vary from just under 2 min to more than 6 min in total. A typical call structure consists of a continuous sequence of four distinct segments (A-B-C-D), often with repetition of segments B-C-D after the first cycle (Fig. 4). The transitions from one segment to the next are distinct and immediate, without pauses. The first segment (A) is the introductory or warm-up segment, with pulsed, constant frequency phrases interspersed with brief pauses (1.5–3.0 s). The fundamental frequency is 3.0 kHz, and is multiplied in four harmonics, with the second harmonic (9.0 kHz) being weakest, and the third harmonic (12.0 kHz) being the dominant frequency (Fig. 5). Each phrase begins with a smooth, initial ascent from 11.2 kHz to a plateau at 12.0 kHz, with a pulse rate of 50–55 pulses s^{-1}. The final phrase prior to segment B is longest (3.9 s) and the pulse rate is rapidly increased (105–110 pulses s^{-1}) towards the end.

Segment B (Fig. 6) consists of a long series (37.8 s) of brief, frequency modulated (FM) notes (0.5–0.6 s, descending from 11.8 to 11.5 kHz, each note producing sub-harmonics), evenly interspersed with pulsed, constant frequency (CF) buzzing (0.3–0.4 s, pulse rate ca. 50 pulses s^{-1}). Towards the end of this segment, the duration of both FM notes and CF buzzing is progressively reduced to produce a more rapid series. Segment C (Fig. 7) consists of a pulsed, constant frequency phrase, lasting ca. 21.3 s. The initial pulse rate is relatively consistent (ca. 50–55 pulses s^{-1}), but later accelerates to 70–75 pulses s^{-1} (with increased intervals between closely spaced pulse groups), prior to the transition to segment D.

Segment D (Fig. 7) is the shortest of the segments (7.8 s), but it exhibits the greatest degree of frequency modulation. It rises in a series of three to four rapid spikes to a peak frequency of 13.2 kHz, then gradually slides down in a controlled descent (with multiple harmonics) to the original dominant frequency, and concludes with a brief (1.0 s), decelerating, pulsed CF buzz. The entire song may either terminate at this point, or continue with a repetition of the segments B-C-D.

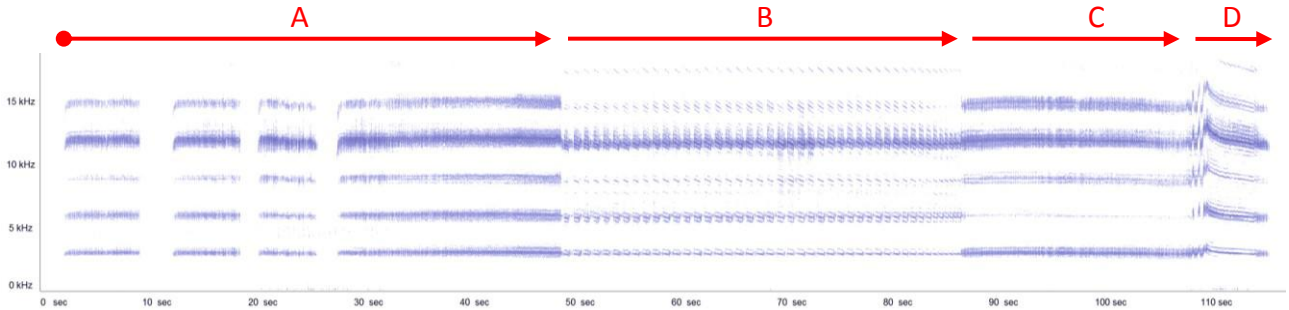

Fig. 4. The typical call sequence (total duration ca. 2 min) of *Purana usnani* is composed of four distinct segments (A-B-C-D), with the possibility of segments B-C-D being repeated immediately after the initial cycle. Each segment is typified by unique qualitative and quantitative properties. The respective segments are expanded (Figs. 5–7) to view their call patterns in detail.

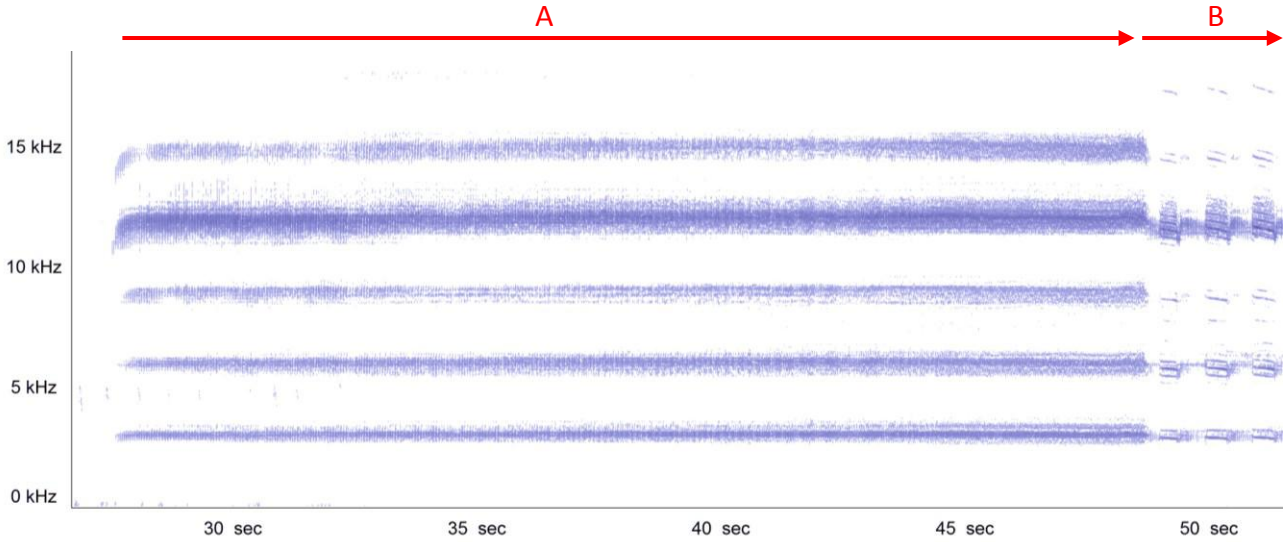

Fig. 5. Transition from segment A to B. The final phrase of segment A is often the longest (ca. 20 s). Its pulse rate is predominantly between 50–55 pulses s^{-1}, but steadily accelerates to 105–110 pulses s^{-1} towards the end, just before commencement of segment B. Four harmonics are clearly displayed, with the third being dominant (12.0 kHz).

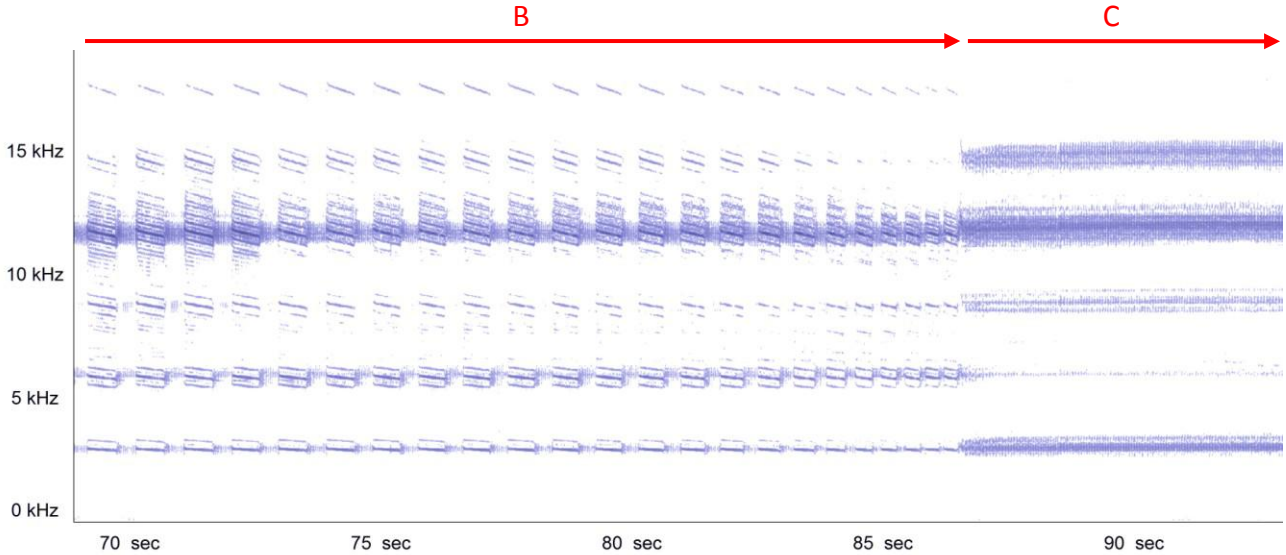

Fig. 6. Transition from segment B to C. Segment B is essentially a juxtaposition of multiple, frequency modulated (FM) notes (descending from 11.8 kHz to 11.5 kHz) with pulsed, constant frequency (CF) notes. Towards the end of segment B, a steady acceleration is discernible as the individual durations of the FM and CF notes become reduced progressively.

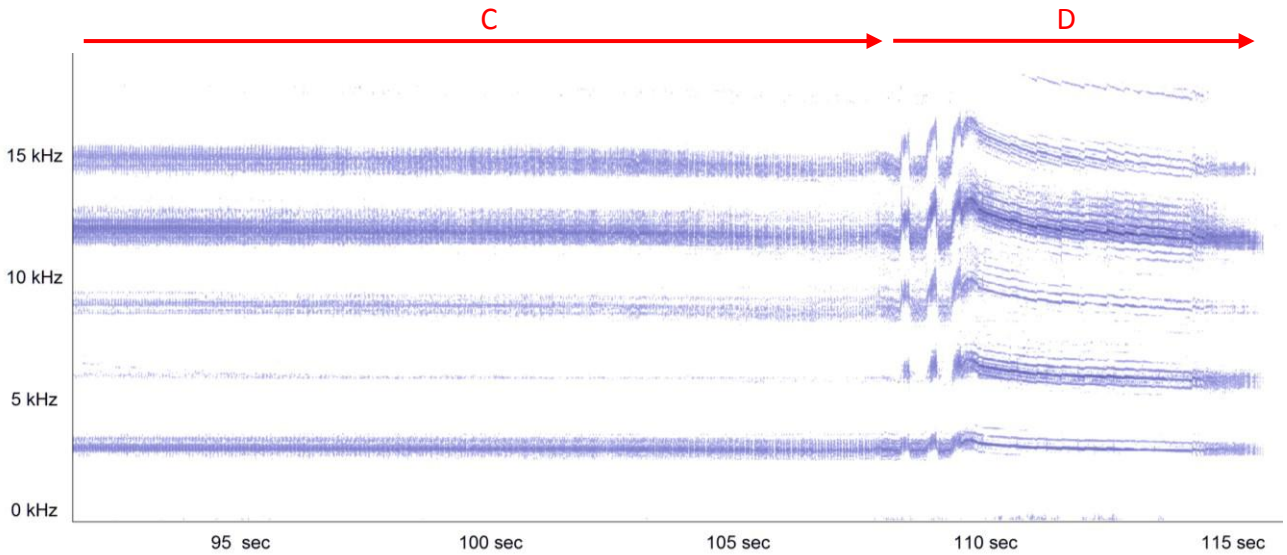

Fig. 7. Transition from segment C to D. Segment C has a constant frequency, with a steady pulse rate (50–55 pulses s^{-1}) for most of its duration. Towards the end, aggregations of distinct pulse groups increase the pulse rate to 70–75 pulses s^{-1}. Segment D may be the shortest segment (7.8 s), but it displays the most dramatic acoustic signature, as it climbs to a peak frequency of 13.2 kHz via a rapid series of spikes, then gently descends to finish at the original dominant frequency with a brief, pulsed buzz.

The unique call structures of other species of *Purana* in the region have also been described and analysed, serving as important tools to distinguish between species and species groups. Examples include *Purana nebulilinea* from Peninsular Malaysia (Kos & Gogala, 2000), *Purana sagittata* from Peninsular Malaysia (Trilar & Gogala, 2002), *Purana metallica* from Thailand (Gogala & Trilar, 2007), and *Purana latifascia* from Borneo (Gogala & Trilar, 2007).

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