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# Frequency modulated song of the cicada *Maua albigutta* (WALKER 1856) (Auchenorrhyncha: Cicadoidea) from South East Asia

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## ABSTRACT

The song and calling behaviour of the cicada *Maua albigutta* (WALKER, 1856) from S.E. Asia is described. The majority of the investigations have been carried out in Endau Rompin National Park, Malaysia. The calling song comprises three main parts (A - C) with characteristic amplitude and, especially in the third part, with intense frequency modulation. The duration of the whole song is  $38.2 \pm 5.1$  s and is often repeated without interruption many times in succession. Amplitude and frequency modulation is accompanied with movements of the abdomen and during frequency modulated calls also with changes of its shape. Songs from other localities (Kuala Lompat – Malaysia, Krui – Sumatra) are slightly different but clearly follow the same general pattern, and can be attributed with certainty to the same species.

**Key words:** *Maua albigutta*, cicada, song, acoustics, frequency modulation

## IZVLEČEK

**Frekvenčno modulirani napev škržada *Maua albigutta* (WALKER 1856) (Auchenorrhyncha: Cicadoidea) iz jugovzhodne Azije.** -V članku sta opisana napev in akustično vedenje škržada *Maua albigutta* (WALKER, 1856) iz jugovzhodne Azije. Večino zvočnih in video posnetkov smo naredili v narodnem parku Endau Rompin v Maleziji. Pozivni napev sestoji iz zaporedja treh segmentov (A – C) z značilno amplitudno in predvsem v tretjem segmentu izrazito frekvenčno modulacijo. Trajanje celotnega napeva, ki ga škržadi ponavljajo večkrat zaporedoma brez prekinitve, je  $38,2 \pm 5,1$  s. Modulacijo jakosti in zvočnega spektra spremljajo gibi zadka in v frekvenčno moduliranem delu tudi spremembe oblike zadka. Napevi osebkov z drugih lokacij (Kuala Lompat – Malaysia, Krui – Sumatra) se nekoliko razlikujejo od napevov iz Endau Rompina, vendar nedvomno kažejo isti osnovni vzorec, ki ga lahko pripisujemo isti vrsti.

**Ključne besede:** *Maua albigutta*, škržad, petje, akustika, frekvenčna modulacija

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## Introduction

During our first visit to Endau Rompin National Park in 1996 we heard for the first time a very characteristic song that was produced, as eventually discovered by us, by a cicada *Maua albigutta* (WALKER, 1856) (Cicadidae: Dundubiini: Leptosaltriina) (Fig. 1). The song is very complex and has pronounced frequency modulated parts. During our next visit to this region in 1999, we heard and recorded many cicadas of this species around our Base Camp on the right bank of the Endau River near the present Nature Education and Research Centre (NERC). On this occasion we succeeded in recording singing animals on video tape as well. During the third visit in 2000 to Lubuk Tapah, Endau Rompin National Park, we heard this species at the entrance to the park (near the Asli village Selai). Despite the much wider distribution of this species (see Fig. 2), we neither heard nor recorded *M. albigutta* at other localities in Peninsular Malaysia or Borneo, but Martijn Kos, at that time a student of the Zoological Museum, Amsterdam, recorded the song of this species in Kuala Lumpur, Pahang.

The only recordings of this species from other countries in S.E. Asia have been provided by Koen Smets, University of Antwerpen, Belgium, who worked in southern Sumatra, Indonesia.

Since there are, to our knowledge, no other publications on songs of any *Maua* species, there is a good reason to describe the results of our bioacoustic study of this species.

## Material and Methods

The **recordings** of the songs were made in the field using TELINGA PRO III and PRO V parabolic microphones (parabola diameter 54 cm) connected to SONY DAT—recorders TCD-D3 and TCD-D10 (sampling rate 48 kHz, 16 Bit dynamic range).

In the lab, DAT recordings were transferred to the Hard Disk of a POWER MACINTOSH G3/233 or G4 computers through AUDIOMEDIA III sound card. Software used for viewing, editing and analysing the song signals were DIGIDESIGN PROTOOLS 5, CANARY 1.2.4 and RAVEN 1.1 (Cornell University, NY-USA).

Spectrograms and spectra were produced with the software CANARY using the following settings: filter bandwidth - 349.70 Hz, frame length 512 points, FFT size 4096 points, Hamming window, logarithmic amplitude scale, smooth display.

The **distribution map** has been printed from the »Biodiversity Database of the Cicadas of Southeast Asia and the West Pacific« in the Zoological Museum Amsterdam with MAPINFO 4.03 for Macintosh on maps of ADC-WORLDMAP 2.0 vol. 4, Southern Asia & Australia. The localities and other data from the specimen labels in the database are filed in FILE-MAKER PRO 5.5.

**Voucher specimens** of cicadas are kept in the collection of the Slovenian Museum of Natural History (PMSL) in Ljubljana, the Zoological Museum Amsterdam, and the Centre for Insect Systematics, University Kebangsaan Malaysia, Bangi, Malaysia.

**Video recordings** of the singing animals were made with the SONY MiniDV camera DCR-TRV D9E Pal. Video recordings were analysed with FINAL CUT EXPRESS and ADOBE PHOTOSHOP 7, using similar methods as described earlier (GOGALA & TRILAR 2003), but without the interlacing procedure.

We **recorded** and **collected** this species of singing cicadas in Endau Rompin National Park, Peninsular Malaysia, during our visits on June 10<sup>th</sup>-12<sup>th</sup>, 1996, March 19<sup>th</sup>-23<sup>rd</sup>, 1999, and April 6<sup>th</sup>, 2002. Altogether, 49 recordings of calling songs from Endau Rompin were analysed, probably belonging to more than 21 animals. In March 1999, *M. albigutta* was common near the old base-

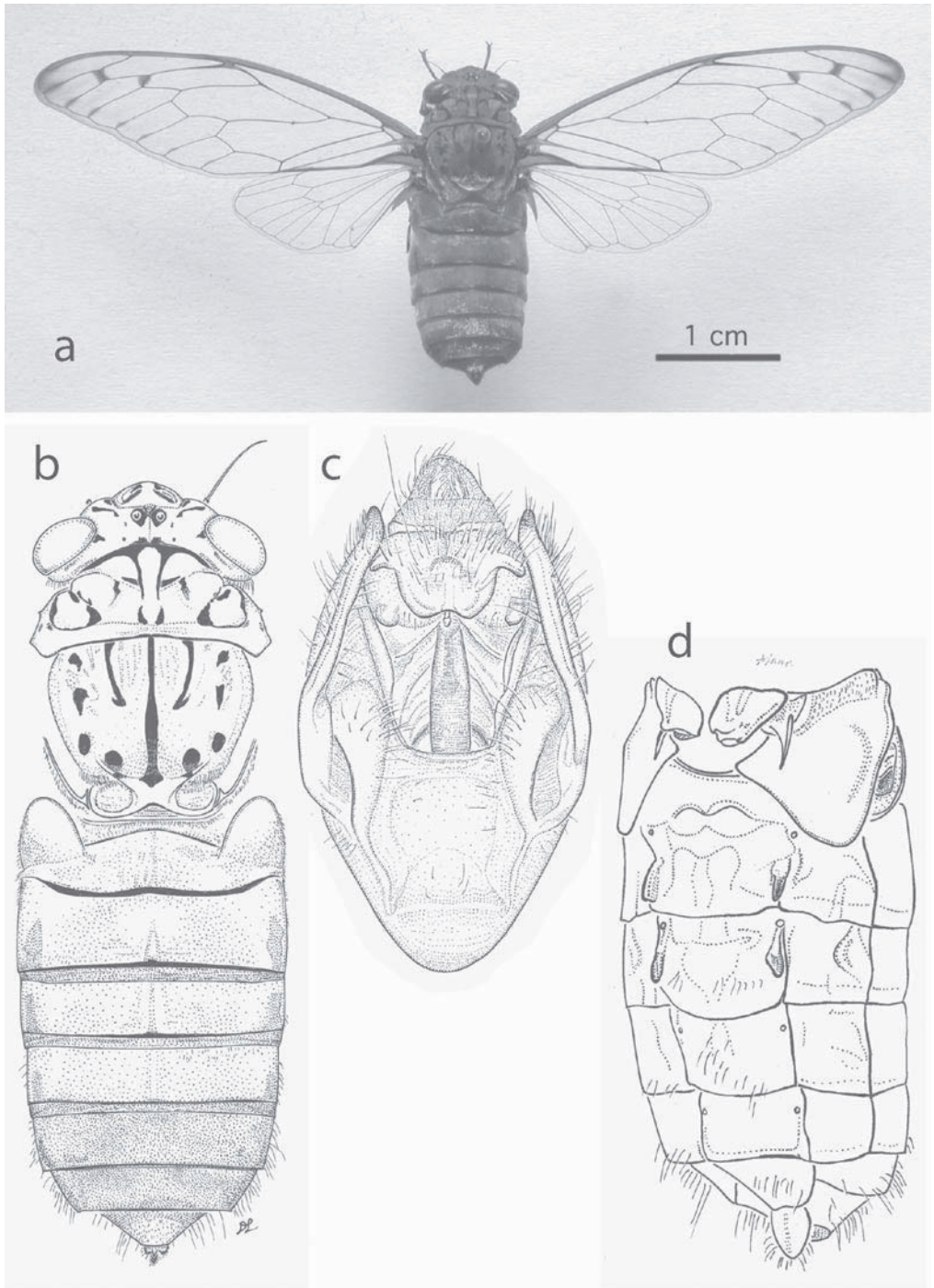


Fig. 1. Morphological characteristics of *Maua albigutta*. a - male, b - dorsal view of the body, c - pygophor, d - ventral side of abdomen with characteristic opercula and tubercles.

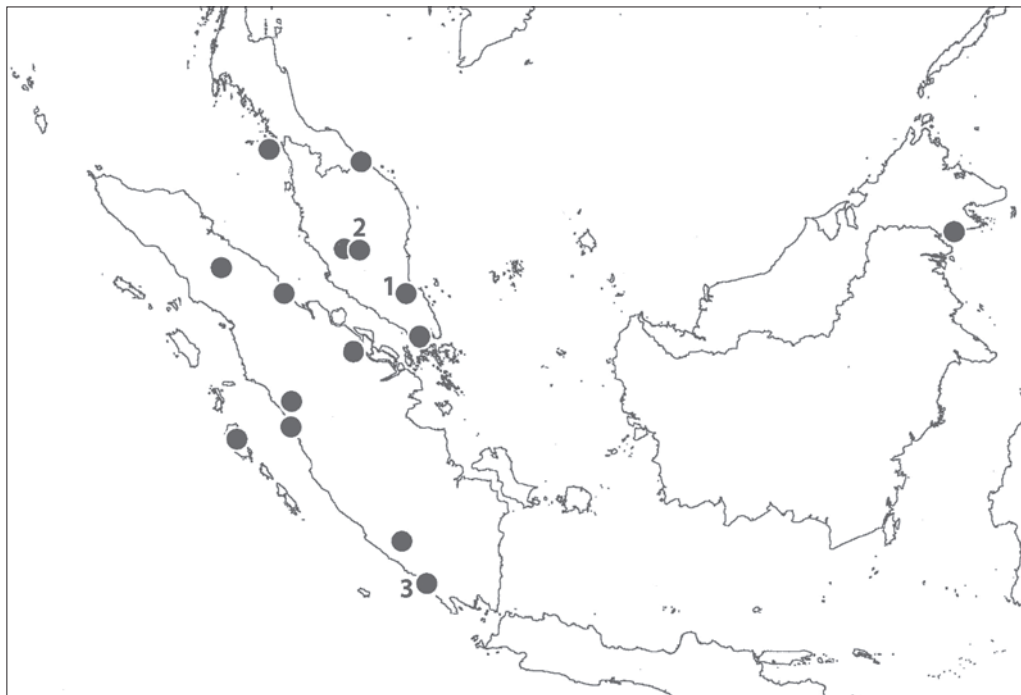


Fig.2. Geographic distribution of *Maua albigutta*: 1 - Endau Rompin, 2 - Kuala Lompat, 3 - Krui.

camp in Endau Rompin NP in the successional forest close to the river ( $2^{\circ}31'38''$  N,  $103^{\circ}22'25''$  E). Aggregations of males were singing low on tree trunks. From August to November this species was less common and sitting higher up in the canopy (SCHOUTEN et al., in print).

Martijn Kos recorded these cicadas in Krau Wildlife Reserve, Kuala Lompat sector, 8 km W of Kuala Krau near the Rangers Post on November 17<sup>th</sup>, 1996, between 10 and 12 a.m. The coordinates for Kuala Lompat are:  $3^{\circ}41'$  N,  $102^{\circ}10'$  E. Kos kindly gave us permission to use his recordings for evaluation in this paper.

Koen Smets recorded the song of *M. albigutta* with a simple recording device (dictaphone) in Sumatra, near Krui, province Lampung during September – November 2001. He kindly offered us a copy of these recordings for comparison.

## Results

### Morphology and geographic distribution

Habitus of *M. albigutta* is shown in Fig. 1. *Maua albigutta* has a relatively broad abdomen and two pairs of tubercles on sternites III and IV (Fig. 1d). The broad abdomen is an apomorphy for the genus *Maua*. The two pairs of tubercles form a synapomorphy for three genera of the subtribe Leptopsaltriina of the tribe Dundubiini: *Purana* DISTANT, *Leptopsaltria* STLL, and *Maua* DISTANT.

*Maua albigutta* can be separated from other *Maua* species by its small size (body length males: 25-26 mm). *Maua albigutta* is only slightly smaller than *M. linggana* (body length males: 27 mm). The very characteristic male opercula of *M. albigutta* strongly taper to the apex, reach to

halfway abdominal segment III and possess a medial protrusion (Fig. 1d), while those of *M. linggana* are broader than long, apically broadly rounded and do not extend beyond segment II. *Maua albigutta* and *M. linggana* are much smaller than the other species of the genus (males body length more than 30 mm) (MOULTON 1923).

Apart from its broad abdomen and the characteristic male operculum, the following combination of features may help to separate *M. albigutta* from *Purana* species of the same size: tegmina with brownish suffused apical part, with brown spots on basal veins of 2<sup>nd</sup> and 3<sup>rd</sup> apical areas and lighter brown spot at apices of the longitudinal veins of the apical areas (Fig. 1a), lateral fasciae on mesonotum consisting of three distinct black spots in a row (Fig. 1b), posterior margins of the male abdominal segments dark brown to black, and morphology of the male genitalia as in Fig. 1c.

The geographic distribution of this species is shown in Fig. 2. *Maua albigutta* is widely distributed in Peninsular Malaysia and Sumatra. Recently, ZAIDI et al. (2000) collected this species in Borneo (Sabah, Tawau). In spite of more intensive collecting in Borneo (mainly Sabah) in the last decades, this is the only record of *M. albigutta* from Borneo.

**Bioacoustics.** The following song description is based on material from Endau Rompin National Park. A comparison with recordings from Kuala Lompat and Sumatra is added at the end of this chapter.

The calling song of *M. albigutta* is typically  $38.2 \pm 5.1$  s long regular sequence of acoustic events repeated many times by the same male at the same place without interruption. Males are usually calling from tree trunks, fly to another tree and call from this place again. They repeat this behaviour for a prolonged period of time during the day, starting around 9 a.m. and ending around 3 p.m.

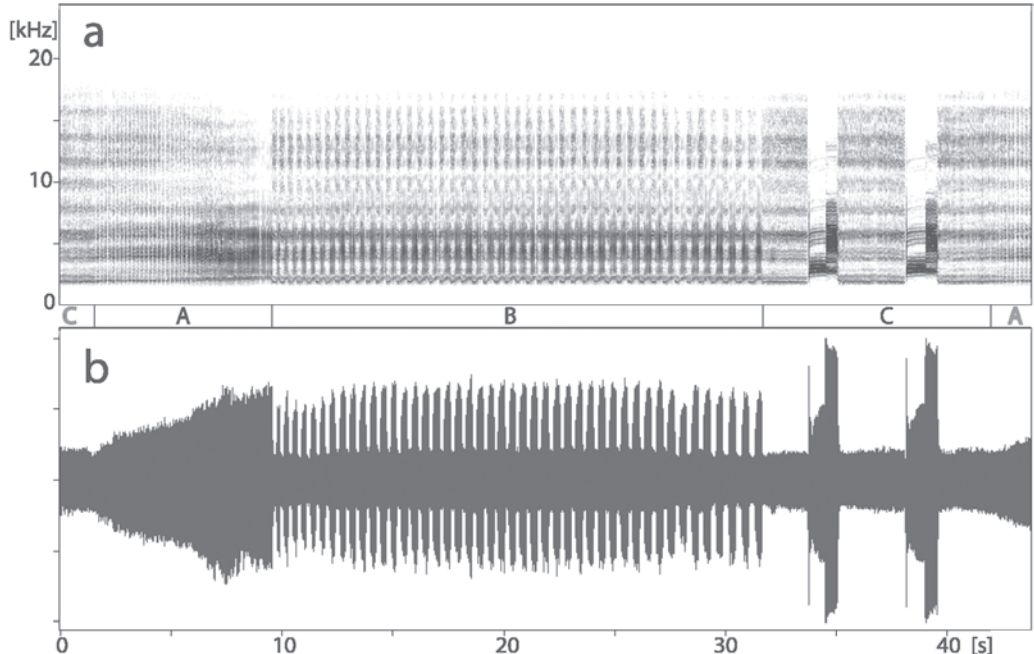


Fig. 3. Full calling song of *Maua albigutta* - a selection from continuous repetitions recorded in Endau Rompin in March 1999. Phrases are marked A, B and C. The loudest parts are frequency modulated calls in C. a - spectrogram, b - oscillogram.

The song sequence can be divided into 3 main parts or phrases (A-C) (Fig. 3).

**Phrase A)** The first part consists of a broad band buzzing sound, which becomes intermittent (pulsed), while the intensity slowly and linearly increases to at least a double value (Fig. 4a, b). The pulses comprise 4 to 6 double clicks at the beginning (Fig. 4c') and end as a series of double or single clicks (Fig. 4d). The whole phrase A lasts for  $9.65 \pm 3.32$  s. The broad frequency spectrum of this part covering a range between 1.5 and 15 kHz has a basic frequency at 2 kHz and the dominant peak at the first and second harmonics (around 4 and 6 kHz). Towards the end of the phrase, the singing male slowly raises its abdomen, and higher frequencies above 6 kHz become fainter (Fig. 4a).

**Phrase B)** Then the song suddenly changes to the slow, frequency and amplitude modulated pattern (Fig. 5). During this part of the song, cicadas move the abdomen down and up in a rhythm of the song modulation (Fig. 6). Louder short echemes (SE) with similar intensity and frequency spectrum as the end of phrase A (Figs. 4a, b, d) are periodically interrupted by periods of fainter »basic buzzing sound« (BS) (Figs. 4, 5). The number of the short louder echemes in a phrase is on average  $34 \pm 7$  and the duration of the whole phrase B is  $16.73 \pm 1.83$  s. The occurrence of such short echemes lasting on average  $286 \pm 52$  ms begins with a repetition frequency of about 2.7 Hz and slows down towards the end of this phrase to about 1.5 Hz. The duration of short echemes is at the beginning of a phrase much shorter ( $168 \pm 43$  ms), rises asymptotically and reaches a steady value ( $286 \pm 52$  ms) only after the first 14 occurrences. Similarly, the periods of the basic buzzing

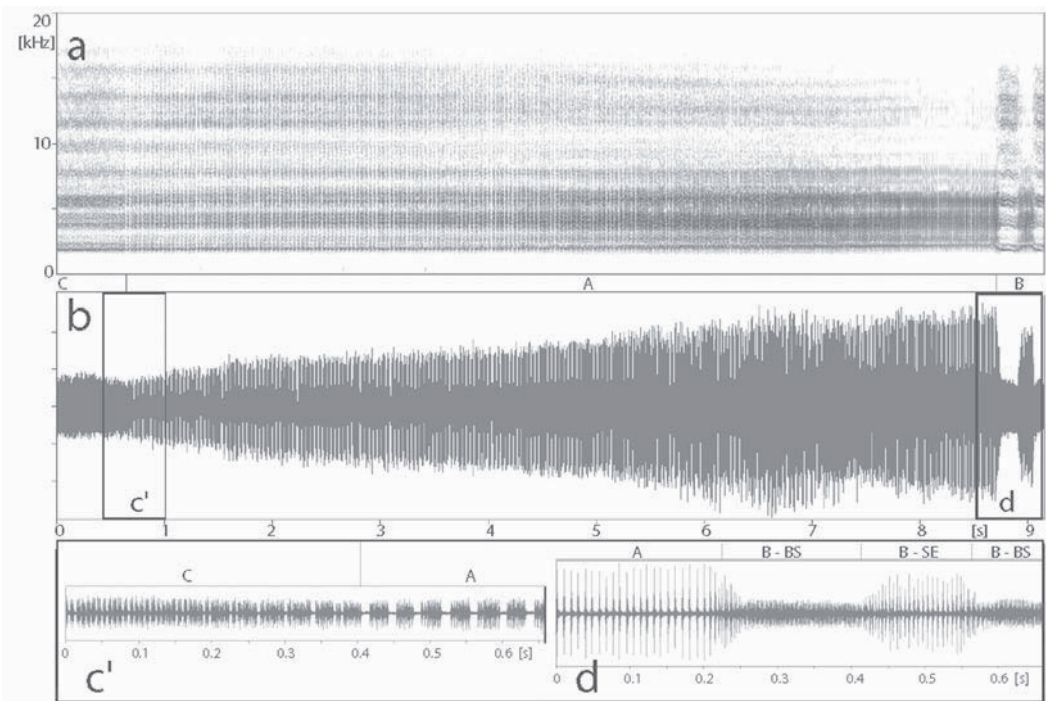


Fig. 4. Phrase A of the song of *Maua albigutta*. a - spectrogram, b-d - oscillograms. In c', the transition from the continuous basic buzzing song of phrase C to pulsed tymbal clicks in groups of 4 double clicks in phrase A is shown. d - shows the last part of phrase A (A) and transition to phrase B. B-BS: basic buzzing sound in phrase B with double pulsed structure, B-SE: short echeme with single clicks as at the end of phrase A.

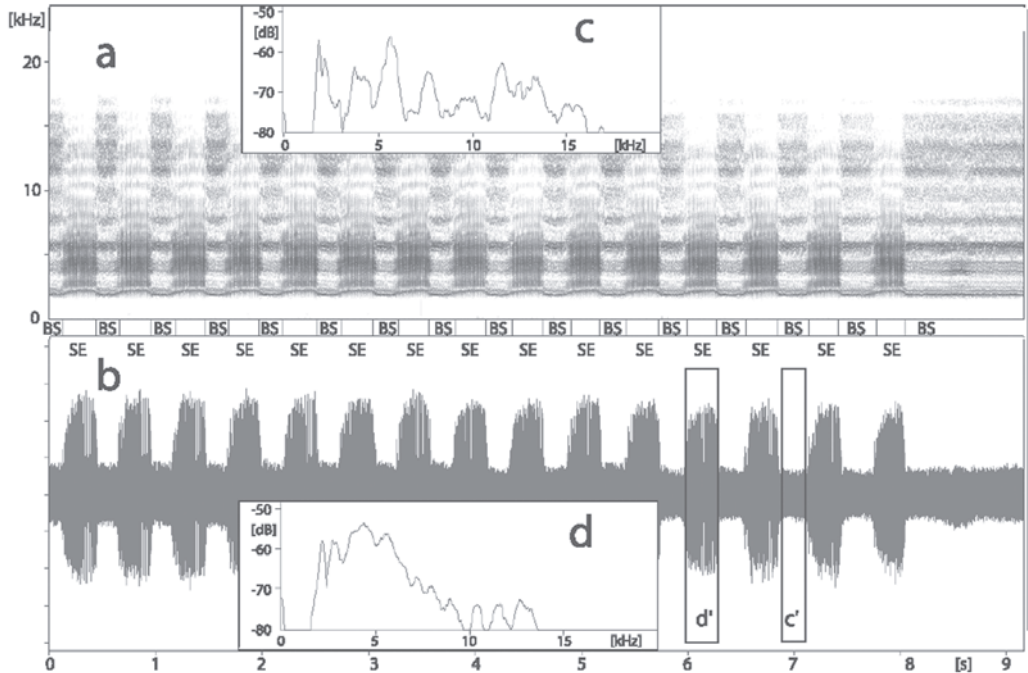


Fig. 5. Part of phrase B of the song of *Maua albigutta*. a - spectrogram, b - oscillogram, c and d - frequency spectra. c - spectrum of a selection c' (basic buzzing sound) shows many prominent frequency components between 1.8 and 16 kHz. d - spectrum of a selection d' (short echeme) with a broadband emission peaks between 1.9 and 8 kHz. Higher frequencies are attenuated.

sound in between last on average  $210 \pm 51$  ms but increase in duration towards the end of the phrase B, in the last periods to more than double values. The basic buzzing sound covers the frequency range between 1.4 and 15 kHz with many prominent peaks, a basic frequency peak at 1.8 kHz, a dominant frequency of 5.35 kHz (2<sup>nd</sup> harmonics) and high peaks between 12 and 14 kHz (Fig. 5a, c). In contrast to this, the frequency range of the louder short echemes shows most energy between 1.3 and 7 kHz with a basic peak at 1.9 kHz and a broad dominant peak at  $3.8 \pm 0.2$  kHz (Fig. 5a, d). The movement of the abdomen during amplitude and frequency modulation is shown in Fig. 6.

Phrase C) The climax of the song with the highest intensity and abrupt frequency modulation follows in the last part of the song (Fig. 7). The basic buzzing sound (BS) from the previous phrase is interrupted with a series of 2 to 5 frequency modulated units (FM). After the end of phrase B, the basic buzzing sound (BS) continues for about  $1.68 \pm 0.26$  s until it is interrupted for 30 to 70 ms (FM0), then the  $33 \pm 7$  ms long broad band transient (FM1) goes over to two loudest frequency modulated parts of the song (FM2 and FM3) (Fig. 8c, d). The first follows the loudest, narrow band call FM2, lasting for approximately 0.5 to 1.1 s ( $0.74 \pm 0.1$  s), with a dominant peak at  $2.9 \pm 0.2$  kHz and a faint (-20 to -30 dB) 1<sup>st</sup> harmonics at a double frequency and sometimes detectable 2<sup>nd</sup> and 3<sup>rd</sup> harmonics (Figs. 8a, c). The basic frequency rises slightly from the beginning of this sound towards the end for about 5%. This narrow banded sound changes abruptly to the next part - FM3, lasting on average  $561 \pm 96$  ms but with completely different frequency spectrum (Figs. 8b, c). The basic frequency of this sound is slightly lower, but the dominant frequency band (not a single peak!) covers the range of a 4 to 6.6 kHz with highest values at  $5 \pm 0.18$  kHz. Highest frequencies

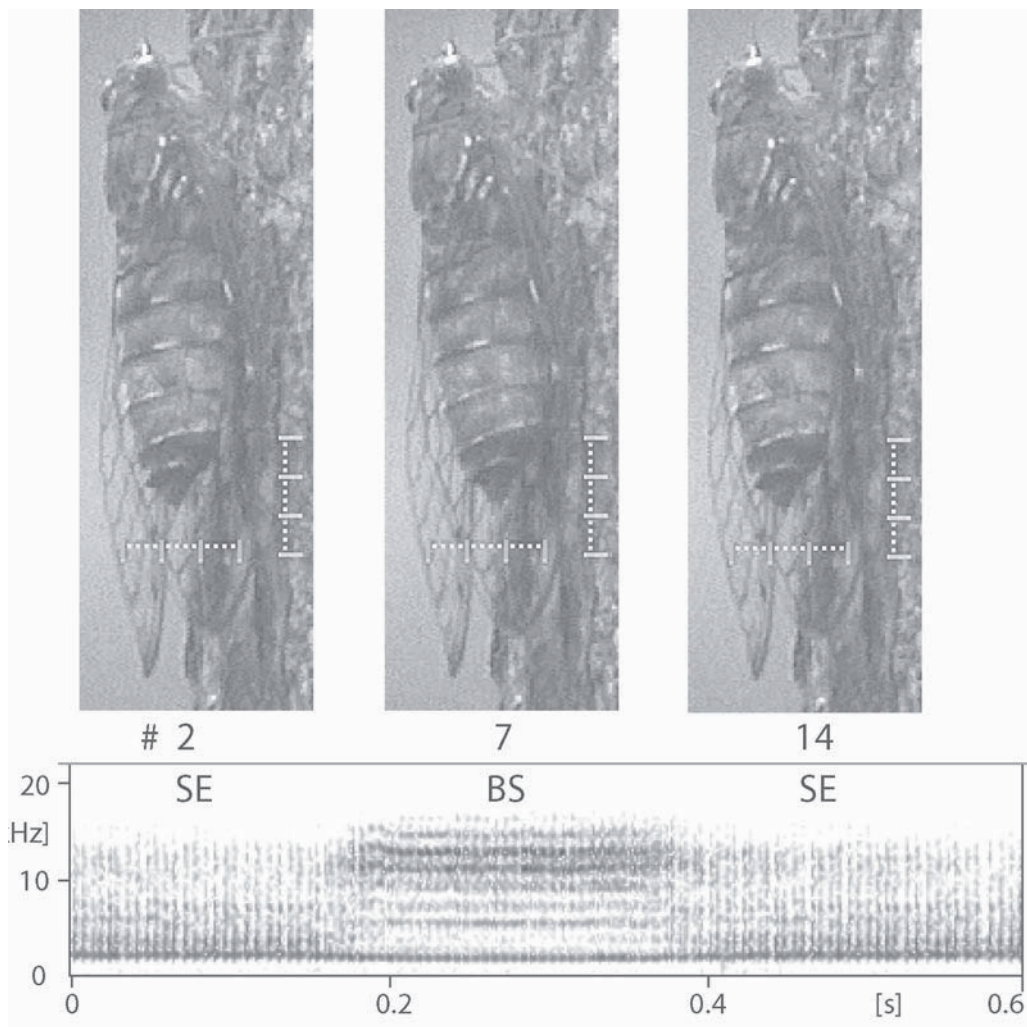


Fig. 6. Video frames and corresponding part of emitted sound during phrase B of *Maua albigutta*. #2, 7 and 14 respectively are the numbers of frames. Frames 2 and 14 show the elevated abdomen during SE part of phrase and 7 dropped, linear position of the abdomen during BS part.

in this sound reach over 13 kHz. During the next transitional phase (FM4) with duration of only 50 to 60 ms, the sound intensity falls to the level of the basic buzzing sound (BS) and the frequency spectrum reaches the characteristics described above (in B and C) (Figs. 5c, 7a, 8c). After some seconds, this FM song pattern is repeated again with slightly different temporal parameters. The number of FM call repetitions is usually 2 (75 %), sometimes 3 (20 %), and can exceptionally reach 4 or even 5.

In the FM phrases and in most of the other song parts of *M. albigutta*, the occurrence of the so-called side bands of the spectral peaks is very obvious. These side bands are the result of amplitude modulation of basic sound units – single tymbal clicks or groups of clicks (Figs. 8a, b, e). The distance of sound band peaks in the spectrum compared to the frequency of the main peak corresponds to the frequency of amplitude modulation.



After the last FM call in a sequence, the basic buzzing sound (BS) continues for  $3.11 \pm 0.86$  s and then without interruption usually a new sequence begins with phrase A, or the cicada stops singing and flies to another place.

Emission of FM calls is again accompanied by abdominal movements and characteristic deformations of the abdomen's tip. From the **video recordings**, made in free nature in Endau Rompin base camp, we can attribute the movements of abdomen to single parts and particular characteristics of the song as shown in Figure 9. The emission of sounds with a lower frequency band is associated with raised abdomen and a wider gap between substrate, opercular plane and abdomen (compare also phrase B, Fig. 6). During the BS parts, the abdomen is straightened and shortened. In the FM2 parts of the song, the abdomen is extended and elevated, but the tip of the abdomen is clearly bent ventrally. During the FM3 phase, the abdomen is raised even further and the tip bent downward, which is associated with the abrupt change in the frequency spectrum (Fig. 9).

Kos made two recordings of the song of *M. albigutta* in **Kuala Lompat** in November 1996. These recordings, one continuous recording lasting for 5 min 48 s, show the same basic song pattern but also some differences in time parameters. Part A is in these recordings shorter ( $1.47 \pm 0.25$  s), substantially longer is part B ( $24 \pm 3.5$  s), but the number of short echemes is similar ( $30 \pm 1$ ). The duration of SE and BS elements is therefore also longer (Table 1 and Fig. 10). BS part between B phrase and first FM call is shorter ( $960 \pm 129$  ms), the same as FM calls themselves. There are 4 FM calls in each C phrase and the first FM2 segment is shorter ( $345 \pm 24$  ms) than in other repetitions ( $443 \pm 35$ ,  $479 \pm 39$ ,  $489 \pm 55$  ms).

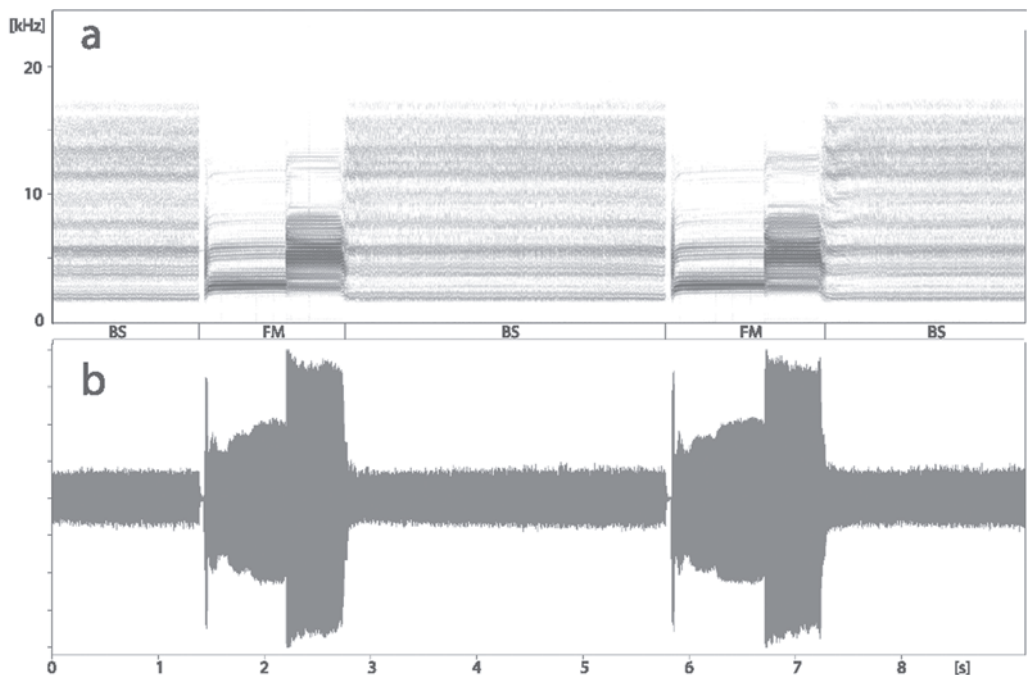


Fig. 7. Phrase C of the song of *Maua albigutta*. a - spectrogram, b - oscillogram. BS - basic buzzing sound as in phrase B, FM - frequency modulated call, the loudest part of a song. For details see Fig. 8.

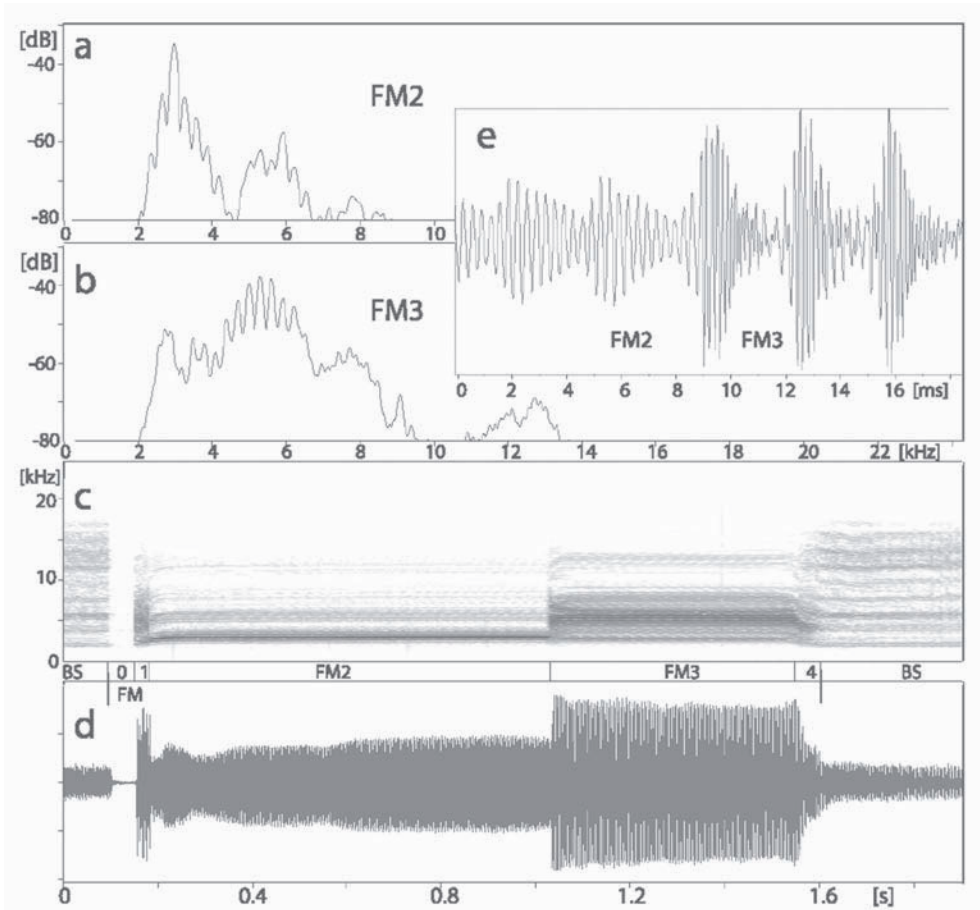


Fig. 8. Details of FM call of *Maua albigutta*. a, b - frequency spectra, c - spectrogram, d, e - oscillograms. In c and d parts of FM call are shown: the silent phase FM0, transient phase FM1, narrow band call FM2, broad band call FM3 and a short closing transient phase FM4. a and b - spectra of FM2 and FM3 respectively with evident side bands. e - oscillogram of the transition of FM2 to FM3 in extended time scale.

In the recordings of the *M. albigutta* song made by Smets in **Sumatra** we could clearly detect and recognize the FM phrases, but other song characteristics were not measurable due to the background noise. Therefore we could only measure or estimate, for comparison, the parameters connected with FM calls, i.e. the duration of the song sequence (33.2 to 33.5 s), number of FM calls in a sequence (2x2, 2x3 and 4), the duration of FM2 part ( $690 \pm 87.7$  ms), the duration of FM3 part ( $520 \pm 112$  ms), the intervals between the first two FM segments in a sequence measured 2.7 to 2.94 s and the only measurable interval between the second and the third FM calls was 2.26 s. The frequency peaks in FM2 segments increased from 3.02 to 3.18 kHz at the end of this segment. In a few clear recordings available we noticed, as the most significant difference to the Endau Rompin population, slightly higher frequencies in FM calls and shorter FM2 and FM3 segments (Fig. 11). Nevertheless, the general pattern of these recordings corresponds very well with values measured on our recordings from Endau Rompin. Therefore, there is no doubt that the population from Sumatra and Endau Rompin as well as Kuala Lompat in Peninsular Malaysia all belong to the same species of singing cicadas – *M. albigutta*.

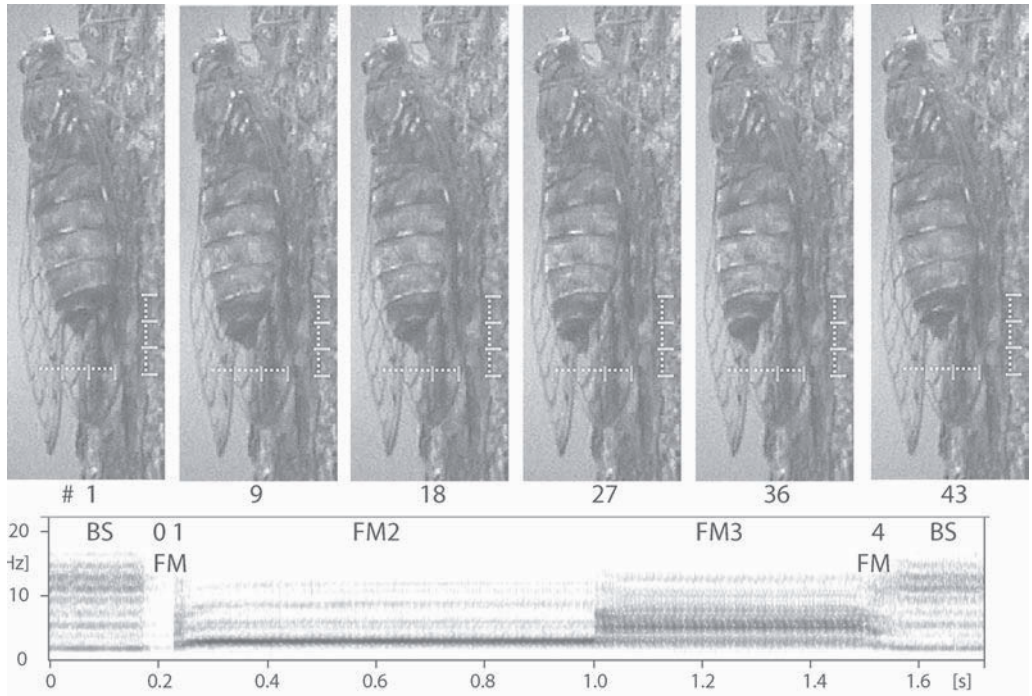


Fig. 9. Video frames and corresponding part of emitted sound during FM call of phrase C. #1, 9, 18, 27, 36 and 43 are the numbers of frames. Frames 1 and 43 show the shape and position of abdomen during BS emission. Frames 9 and 18 correspond to the FM2 call and frames 27 and 36 to FM3.

A	Endau Rompin	Kuala Lompat
Song duration	38.2 ± 5 s	39.8 ± 3.8 s
Phrase A duration	9.7 ± 3.3 s	1.47 ± 0.25 s
Phrase B duration	16.7 ± 1.8 s	24 ± 3.5 s
Phrase B: BS duration	210 ± 51 ms	354 ± 61 ms
Phrase B: SE duration	286 ± 52 ms	397 ± 47 ms
Phrase B: number of SE	N = 34 ± 7	N = 30 ± 1
Phrase C: number of FM	<b>N = 2 - 5</b>	<b>N = 4</b>
Average FM2 duration	739 ± 106 ms	441 ± 69 ms
Average FM3 duration	561 ± 96 ms	381 ± 32 ms

Table 1: Comparison between time parameters in songs of *Maua albigutta* from Endau Rompin and Kuala Lompat (average ± st. dev.)

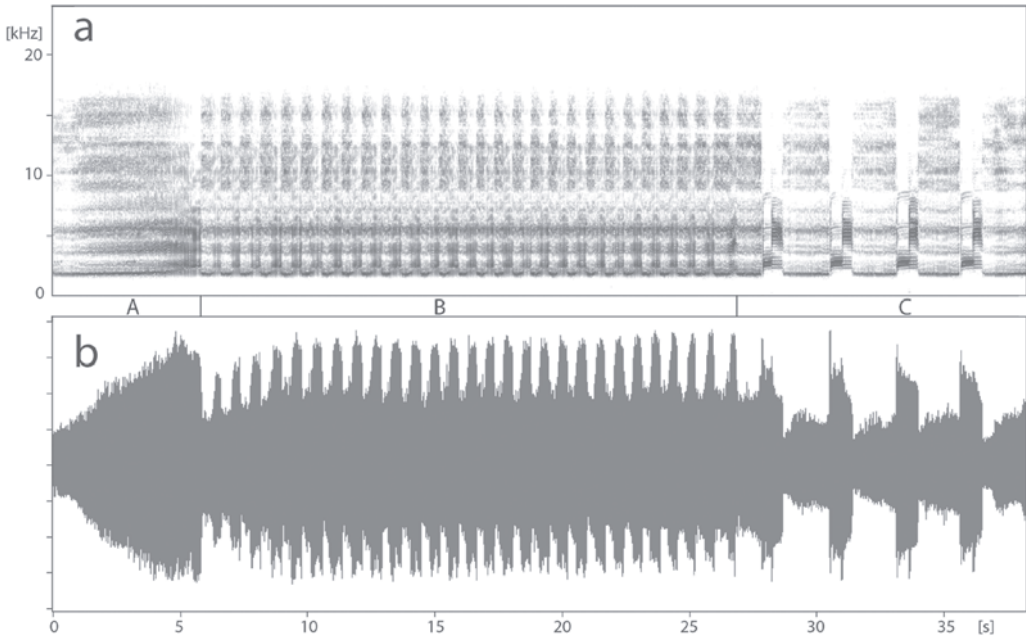


Fig. 10. Full calling song of *Maua albigutta* - a selection from continuous repetitions recorded in Kuala Lompat in November 1996 by Kos. a - spectrogram, b - oscillogram. Phrases are marked A, B and C. Phrase C contains 4 (shorter) FM calls. The amplitudes are not real due to automatic gain control used during this recording.

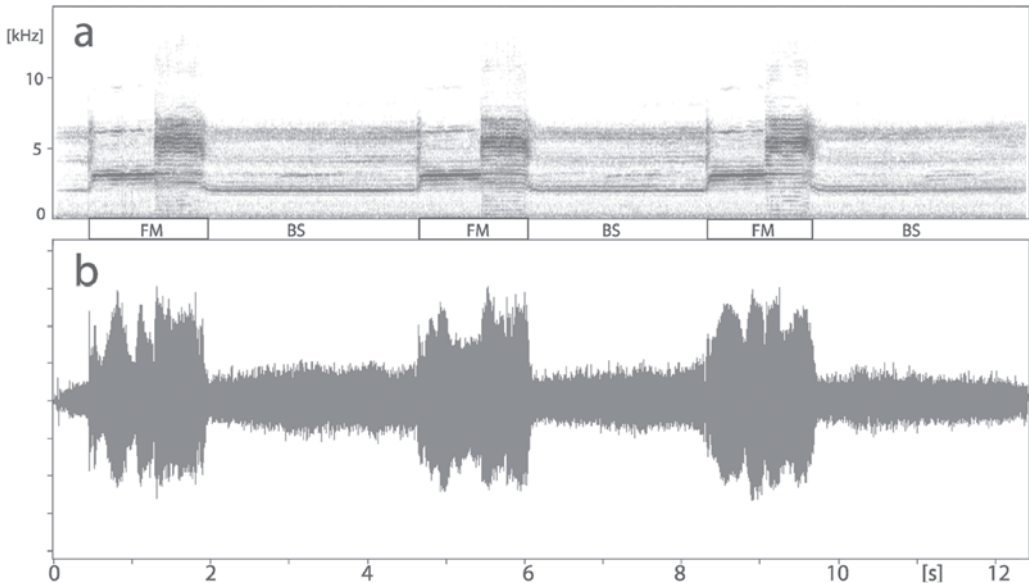


Fig. 11. Phrase C of the song of *Maua albigutta* from Krui, Sumatra, recorded by Smets with a simple analogue recorder. a - spectrogram, b - oscillogram. BS - basic buzzing sound, FM - frequency modulated calls.

## Discussion

Since this is the first description of the acoustic behaviour of any *Maua* species, we cannot compare the song characteristics to those of other species of this genus. However, more bioacoustic information is available for the closely related genus *Purana*. About ten years ago was described the song of *Purana* aff. *tigrina* from the island of Tarutao in the extreme South of Thailand close to Malaysian Langkawi island (GOGALA 1994), followed by descriptions of the songs of *P. nebulilinea* (WALKER) (KOS & GOGALA 2000) and *P. sagittata* SCHOUTEN & DUFFELS (TRILAR & GOGALA 2002), both from Peninsular Malaysia. The descriptions of two new *Purana* species, *P. khuanae* and *P. atroclunes* from Northern Thailand, were published by BOULARD (2002) together with the song characteristics of these species.

In comparison to the songs of various *Purana* species mentioned above we find certain similarities between songs of *M. albigutta* and *Purana* species from Peninsular Malaysia and Tarutao island in Southern Thailand. One of such similarities is the long song (30 seconds to 2 or more minutes). The song pattern is repeated many times successively in *M. albigutta*, *P. aff. tigrina*, *P. nebulilinea* and *P. sagittata*, comprising a sequence of different phrases, with abrupt changes of spectral characteristics and periods of narrow and broad band sounds and with a certain degree of frequency modulation. The song pattern of *P. ubina* (in preparation) is also similar in many aspects. Among the compared species, the degree of frequency modulation is most pronounced in *M. albigutta*. Songs of *Purana* species from Northern Thailand described by BOULARD (2002) show partly different characteristics.

A comparison of the songs of *M. albigutta* from the three localities, Endau Rompin, Kuala Lompat and Krui (Sumatra), shows some differences mainly in temporal and partly in spectral parameters, but as mentioned already in the previous chapter they clearly show the same basic structure and pattern. The differences are quantitative, not qualitative. Besides, we do not know whether these differences are characteristic of different populations or are just individual deviations from the average song structure. The recordings from Kuala Lompat belong to two individuals and also measurable recordings from Krui just to two or three. Another factor possibly influencing the song structure is the season in which recordings were made. In Endau Rompin this was in March and April, in Krui between July and November, and in Kuala Lompat again in November.

We do not know much about mechanisms involved in modification of emitted sound of *M. albigutta*. Some information about the possible mechanisms and structures enabling cicadas to make spectral changes in a few milliseconds can be obtained from our video recordings. Rising of the abdomen in phrase B is connected with the change of frequency peaks in the range of 10 to 15 kHz to less than 8 kHz (Fig. 5). A possible explanation might be the increased size of the resonant space ventrally. Similarly, during the FM2 call the abdomen is extended and raised as well, but the last abdominal segment is bent downwards and this is even more pronounced during the FM3 part of the song. During this phase of the song, the abdomen is extended for about 2.5 mm in comparison with the relaxed position in the BS part of the song. During the transition to the basic buzzing sound (BS), this clearly convulsive posture changes abruptly to a relaxed, lowered, linear position of the abdomen (Fig. 9). Consequences of this posture change are again emphasized by higher frequencies in the emitted sound. For the change of the narrow band (FM2) to the broadband call (FM3), we do not have any explanation, although the change of abdominal posture is evident. Fig. 8e shows that the almost pure but slightly pulsed sinusoid oscillation during FM2 part of the song changes in FM3 abruptly to distinct pulses with a sweep to higher frequencies in every pulse.

From Fig. 4d it is evident that in phrase B of the *M. albigutta* song the repetition rate of tymbal clicks differs in SE and BS parts, probably due to synchrony or metachrony of tymbal action, which also influences the song characteristics, especially the frequency spectrum.

Again we do not know enough what happens with important parts of the body, such as the gap to the tympana, opercula, action of certain abdominal muscles, which for instance play an important role in the case of *Tympanistalna gastrica* STÄLL (FONSECA & POPOV 1994). The form of sound oscillations and the narrow band spectrum during FM2 parts of phrase C, which remind us of the songs of *Magicalada septendecim* (LINNAEUS) (YOUNG & JOSEPHSON 1983) and the bladder cicada *Cystosoma saundersii* WESTWOOD (BENNET-CLARK & YOUNG 1998), can be explained only with highly resonant structures (Fig. 8a,e). This is clearly different in FM3 parts of FM calls. Our video analyses suggest that a tension of longitudinal ventral muscles in the abdomen are involved in this change. The thickness or stiffness of the tymbal (BENNET-CLARK & YOUNG 1992) cannot be the explanation, since the song spectrum changes in about a millisecond. It is interesting that the dominant frequency in the pure tone sound FM2 is only approximately half the frequency expected from the body size according to the relationship between both parameters shown by BENNET-CLARK & YOUNG (1994) in other species of cicadas.

Therefore, physiological experiments would be needed to understand the mechanisms of the frequency modulation in *M. albigutta*.

The spectrogram assumed to belong to a species of *Maua* (with a question mark) in GOGALA & RIEDE (1995: Fig. 2d, page 301) in fact belongs to *Dundubia vaginata*, from a population in Peninsular Malaysia.

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