

# Advertisement calls of *Rhacophorus angulirostris* AHL, 1927 and *Rhacophorus everetti macroscelis* BOULENGER, 1896 from Gunung Kinabalu, Sabah, East Malaysia (Borneo) (Anura: Rhacophoridae)

Anzeigerufe von *Rhacophorus angulirostris* AHL, 1927 und *Rhacophorus everetti macroscelis* BOULENGER, 1896 vom Gunung Kinabalu, Sabah, Ostmalaysia (Borneo)  
(Anura: Rhacophoridae)

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## KURZFASSUNG

Wir beschreiben die Anzeigerufe von zwei Arten der Gattung *Rhacophorus*, *R. angulirostris* und *R. everetti macroscelis*, aus dem Montanwald des Gunung Kinabalu in Sabah, malaysisches Borneo. Der Anzeigeruf von *R. angulirostris* ist eine einzelne hohe Note, die sich aus zwei, selten drei Pulsen zusammensetzt, mit einer durchschnittlichen Dauer von  $190 \pm 12$  ms und einem Energiemaximum bei  $4198 \pm 148$  Hz. *Rhacophorus everetti macroscelis* hat zwei verschiedene Ruftypen. Ruftyp 1 besteht aus 9 (7-12) Pulsen, ist schwach frequenzmoduliert bei Energiemaxima zwischen  $1628 \pm 58$  und  $1688 \pm 39$  Hz. Ruftyp 2 wird nach Ruftyp 1 ausgestoßen oder unabhängig von diesem und besteht aus einer Serie von 1-8 kurzen, frequenzmodulierten Noten mit einer Dominanzfrequenz zwischen 1600 und 2100 Hz.

## ABSTRACT

We describe the advertisement calls of two species of the genus *Rhacophorus*, *R. angulirostris* and *R. everetti macroscelis*, from the montane forest of Gunung Kinabalu in Sabah, Malaysian Borneo. The advertisement call of *R. angulirostris* is a single high-pitched note consisting of 2 (rarely 3) pulses with an average call duration of  $190 \pm 12$  ms and an energy maximum at  $4198 \pm 148$  Hz. *Rhacophorus everetti macroscelis* has two different call types. Call type 1 consists of 9 (7-12) pulses, is slightly frequency-modulated with energy maxima between  $1628 \pm 58$  and  $1688 \pm 39$  Hz. Call type 2 is emitted subsequent to call type 1 or independently and consists of a series of 1-8 short, frequency-modulated, single-pulsed notes with a dominant frequency between 1600 and 2100 Hz.

## KEY WORDS

Amphibia: Anura: Rhacophoridae: *Rhacophorus angulirostris*, *Rhacophorus everetti macroscelis*, treefrog, bioacoustics, advertisement call, call activity, Gunung Kinabalu, Mount Kinabalu, Kinabalu National Park, Borneo, Sabah, Malaysia

## INTRODUCTION

Gunung Kinabalu (4095 m) in Sabah, northern Borneo, is the highest mountain of Southeast Asia. With 79 species of anurans recorded from its slopes, it harbors exactly half of the 158 described frog species known from Borneo (MALKMUS et al. 2002; MATSUI et al. 2007). The advertisement calls of only 49 of those species are sufficiently known, i.e. published analyses of the calls in which the diagnostic characteristics were described and audiospectrograms and oscillograms were provided (MATSUI 1982a, 1982b; DRING 1983a, 1987; MALKMUS & RIEDE 1993, 1996a,

1996b, 1996c; SANCHEZ-HERRAIZ et al. 1995; MALKMUS 1996; MATSUI et al. 1996; MATSUI 1996, 1997; MALKMUS & MATSUI 1997; HÖDL & AMÉZQUITA 2001; MALKMUS et al. 2002; GRAFE & WANGER 2007; ARCH et al. 2007). In 29 of the 49 species, the analysis of the advertisement call was based on recordings obtained within the Gunung Kinabalu National Park.

We provide analyses of the advertisement calls of two species of *Rhacophorus*, one of the least studied Bornean frog genera regarding their bioacoustics.

## MATERIALS AND METHODS

Advertisement calls were recorded in the field using a Sony® WM-D6C stereo cassette recorder and a Sony® ECM-S959C microphone. Recordings were obtained between 1 and 11 November 2007 along Sg. Silau-Silau and Sg. Liwagu in the surroundings of the headquarters of the Kinabalu National Park (1400-1600 m a.s.l.). Calling specimens were photographed in situ after finishing the recordings. Photo vouchers and original recording tapes are in the col-

lection of the first author. Call recordings were digitized at 16 bits and 44.1 kHz and analyzed using Syrinx® 2.6h sound analysis program (John Burt, <http://www.syrinxpc.com>) and Adobe® Audition 1.5 software. Temporal data were obtained from the oscillograms and frequency information was obtained from the audiospectrograms using fast Fourier transforms (1024-point Blackman window). Measurements are given as mean  $\pm$  standard deviation.

## SPECIES ACCOUNTS

*Rhacophorus angulirostris*  
AHL, 1927

The Masked Treefrog (*Rhacophorus angulirostris*; Fig. 1) is a medium-sized species (SVL 30-35 mm in males, up to 51 mm in females) which has been collected at Gunung Kinabalu, Gunung Trusmadi, and the Crocker Range in Sabah/Borneo and at Padang on Sumatra (INGER 1966; INGER & STUEBING 1992; DEHLING 2008). It can be found in abundance in the vegetation along the streams in the surroundings of the Kinabalu Park headquarters at heights between one and four meters above the ground. The advertisement call of *R. angulirostris* has been described verbally and onomatopoeically in the literature by several authors (e.g. MALKMUS 1992; HOFFMANN 1995; MANTHEY & GROSSMANN 1997; INGER & STUEBING 2005), and was analyzed by MALKMUS et al. (2002). Since the call description of the latter does not contain all the information we obtained from our analysis, we herein provide an extended description.

During the study period, males of *R. angulirostris* called from dusk until at least 3 a.m. Intervals between bouts of calling were generally very long, from one minute to more than half an hour. We recorded and analyzed 27 calls from four males. Air temperature ranged between 17.8 and 19.5 °C. The call is a single, very short, high-pitched note (Fig. 3). Twenty-four calls consisted of two pulses, the other three of three pulses. The average call duration of two-pulse calls

was  $190 \pm 12$  ms. The three-pulse calls had a duration of 216, 225, and 253 ms, respectively. Dominant frequency spectrum lay between 3.6 and 4.9 kHz, with an energy maximum at  $4198 \pm 148$  Hz (range: 4050-4565). Calls had prominent harmonics at 8100-8300 Hz (Fig. 3). There was no significant frequency modulation within the pulses of a single call. The second pulse usually had a slightly greater amplitude than the first and – in three-pulse calls – the third pulse. The intervals between the amplitude maxima of the pulses ranged between 36 and 43 (median 40) ms.

*Rhacophorus everetti macroscelis*  
BOULENGER, 1896

The Mossy Treefrog (*Rhacophorus everetti macroscelis*; Fig. 2) is a medium-sized species (SVL of males up to 32 mm, of females up to 55 mm) and is distributed in the mountainous parts of northern Borneo (INGER & STUEBING 1992). It is common along the upper reaches of the Sungai Silau-Silau and the smaller tributaries of Sungai Liwagu. Its call was verbally and onomatopoeically described by MALKMUS (1986, 1989), MALKMUS et al. (2002), and INGER & STUEBING (2005).

During the study period, males of *R. everetti macroscelis* called at night from leaves and twigs of the vegetation along the streams. We recorded and analyzed 92 calls from six males. Air temperature ranged between 18.4 and 20.3 °C. We recorded two



Fig. 1: Male of *Rhacophorus angulirostris* AHL, 1927, Sungai Silau-Silau, Headquarters, Kinabalu National Park, Sabah, East Malaysia (Borneo).

Abb. 1: Männchen von *Rhacophorus angulirostris* AHL, 1927, Sungai Silau-Silau, Hauptquartier, Kinabalu Nationalpark, Sabah, Ostmalaysia (Borneo).



Fig. 2: Male of *Rhacophorus everetti macroscelis* BOULENGER, 1896, Sungai Liwagu, Headquarters, Kinabalu National Park, Sabah, East Malaysia (Borneo).

Abb. 2: Männchen von *Rhacophorus everetti macroscelis* BOULENGER, 1896, Sungai Liwagu, Hauptquartier, Kinabalu Nationalpark, Sabah, Ostmalaysia (Borneo).

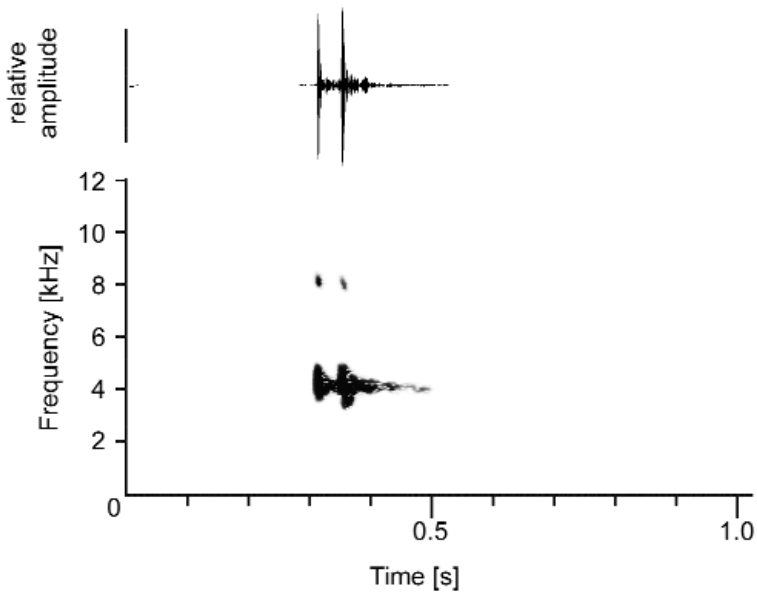


Fig. 3: Oscillogram and sound spectrogram of an advertisement call of *Rhacophorus angulirostris*.  
 Abb. 3: Oszillogramm und Schallspektrogramm eines Anzeigerufs von *Rhacophorus angulirostris*.

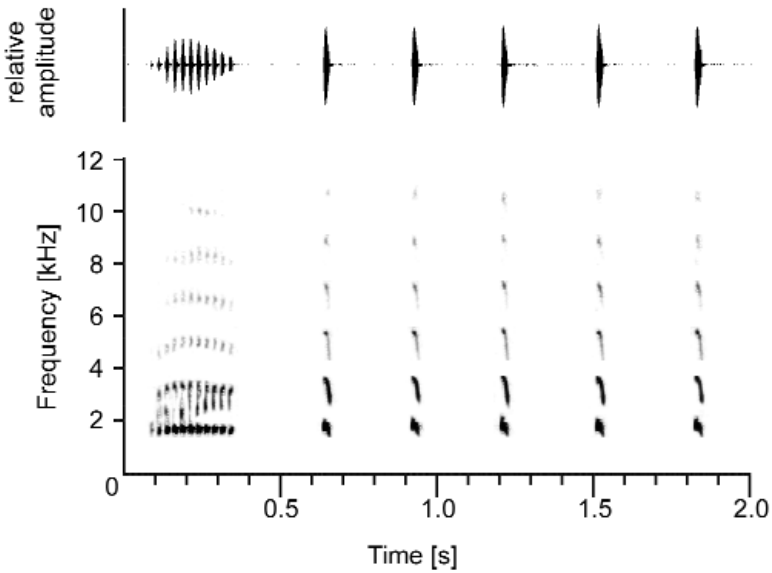


Fig. 4: Oscillogram and sound spectrogram of an advertisement call of *Rhacophorus everetti macroscelis* (call type 1 followed by a five-note call type 2).  
 Abb. 4: Oszillogramm und Schallspektrogramm eines Anzeigerufs von *Rhacophorus everetti macroscelis* (Ruftyp 1, gefolgt von einem 5-Noten-Ruftyp 2).

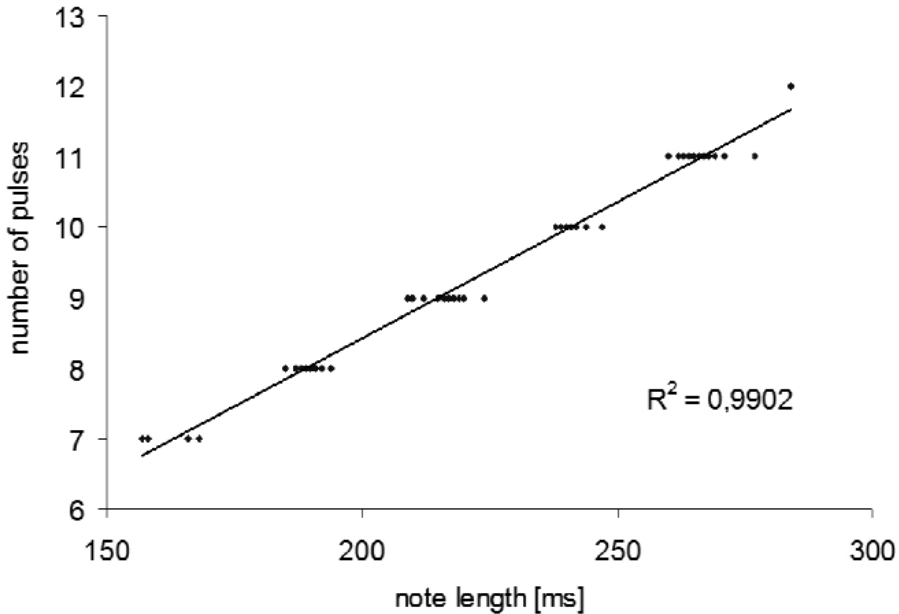


Fig. 5: Relation between number of pulses and note length in type 1 advertisement calls of *Rhacophorus everetti macroscelis*.  
 Abb. 5: Relation zwischen der Anzahl der Pulse und der Notenlänge in Typ 1-Anzeigerufen von *Rhacophorus everetti macroscelis*.

different call types. Call type 1 is a short trill, consisting of a single note (Fig. 4). The average duration of the note was  $216 \pm 35$  ms (range 157-284 ms). The note was composed of 9 (7-12) pulses. There was little variation in pulse repetition rate (38-42 per minute), and note length was positively correlated to the number of pulses (Fig. 5). The pulses in the middle of the note had a higher amplitude and a slightly higher frequency (energy maximum at  $1688 \pm 39$  Hz) than those at the beginning ( $1628 \pm 58$  Hz) and the end of the note ( $1629 \pm 57$  Hz). There were prominent harmonics at 3200-3400, 5000-5200, 6400-6600, 8200-8400, and 9850-10050 Hz.

Seventy-six calls consisted of only this call type. Call type 1 was repeated at irregular intervals between 2 and 48 seconds. Occasionally, calls were repeated at high rates to form a call series. In ten cases, the last call of such a series was immediate-

ly followed by another call, call type 2 (Fig. 4). This call was a series of 1-8 short, single-pulsed notes. The length of the interval between the end of call type 1 and the beginning of the first note of call type 2 was  $464 \pm 188$  ms (range 281-884). Note length of call type 2 was  $21 \pm 2$  ms (range 19-27). The length of the interval between the amplitude maxima of the individual notes of call type 2 was  $301 \pm 34$  ms (range 253-401). Dominant frequency of the notes lay between 1600 and 2100 Hz. There were prominent harmonics at about 3400, 5200, 7000, 8600, and 10050 Hz (Fig. 4; frequencies measured at the amplitude maximum of the note). Notes were frequency-modulated. Whereas the dominant frequency dropped only slightly ( $<100$  Hz) from the beginning to the end of the note, the frequency of the harmonics dropped considerably for about 800 Hz.

## DISCUSSION

The advertisement calls of *R. angulirostris* and *R. everetti macroscelis* differ strongly from each other in structure and frequency. *Rhacophorus angulirostris* can be found along the fast-flowing sections of the streams, whereas *R. everetti macroscelis* is most commonly found along the upper reaches of the streams and along smaller tributaries where the current is much slower. The high-frequency call of *R. angulirostris* is certainly an adaptation to the species' specific environment and can be heard above the loud, low-frequency dominated background noise of the flowing water. The calls of all other Bornean stream-breeding species of *Rhacophorus*, i. e., *Rhacophorus belalongensis* DEHLING & GRAFE, 2008, *R. cyanopunctatus* MANTHEY & STEIOF, 1998, *R. gadingensis* DAS & HAAS, 2005, *R. gauni* (INGER, 1966), *R. kajau* DRING, 1983, and *R. penanorum* DEHLING, 2008 are very similar to the call of *R. angulirostris*. They are strongly pulsed, short, consisting of only 1-4 pulses, and have high frequencies with energy maxima between 3500 and 6000 Hz (DRING 1983b; DEHLING & GRAFE 2008; DEHLING 2008, unpubl. data). In contrast, the advertisement calls of similarly sized pond-breeding species like *R. appendiculatus* (GÜNTHER, 1858) and *R. rufipes* INGER, 1966 have comparatively much lower frequencies (MALK-

MUS et al. 2002; DEHLING, unpubl. data). High-frequency advertisement calls are a common adaptation in stream-breeding frogs and have likewise evolved in several species that occur sympatrically with *R. angulirostris* and *R. everetti macroscelis* like *Leptolalax arayai* MATSUI, 1997, *Ansonia hanitschi* INGER, 1960, *Meristogenys kinabaluensis* (INGER, 1966), and *M. whiteheadi* (BOULENGER, 1887) (MATSUI 1997, MALKMUS et al. 2002, unpubl. data).

Although the background noise is much lower in the preferred habitat of *R. everetti macroscelis*, it may interfere with the call of the species. The prominent harmonics in the call of *R. everetti macroscelis* could serve to increase the audibility of the call above the sound of the flowing water.

We recorded and described two types of calls in *R. everetti macroscelis*. The two call types are likely to have different functions. Six of the 92 calls recorded consisted only of a call type 2 series, which indicates that this call type is not only an addition to call type 1 but is used as an independent signal. Since we heard call type 2 only in situations when two or more males were calling in proximity to each other, we assume that this call type serves as an aggressive call (sensu WELLS 2007) mediating spacing among neighboring males.

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