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Gullela bicolor

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Pusat Penelitian Biologi - LIPI
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Fauna Indonesia merupakan Majalah Ilmiah Populer yang diterbitkan oleh Masyarakat Zoologi Indonesia (MZI). Majalah ini memuat hasil pengamatan ataupun kajian yang berkaitan dengan fauna asli Indonesia, diterbitkan secara berkala dua kali setahun

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1. Redaksi FAUNA INDONESIA menerima sumbangan naskah yang belum pernah diterbitkan, dapat berupa hasil pengamatan di lapangan/ laboratorium atau studi pustaka yang terkait dengan fauna asli Indonesia yang bersifat ilmiah popular.
2. Naskah ditulis dalam Bahasa Indonesia dengan *summary* Bahasa Inggris maksimum 200 kata dengan jarak baris tunggal.
3. Huruf menggunakan tipe Times New Roman 12, jarak baris 1.5 dalam format kertas A4 dengan ukuran margin atas dan bawah 2.5 cm, kanan dan kiri 3 cm.
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    a. Judul: ditulis huruf besar, kecuali nama ilmiah spesies, dengan ukuran huruf 14.
    b. Nama pengarang dan instansi/ organisasi.
    c. *Summary*
    d. Pendahuluan
    e. Isi:
        i. Jika tulisan berdasarkan pengamatan lapangan/ laboratorium maka dapat dicantumkan cara kerja/ metoda, lokasi dan waktu, hasil, pembahasan.
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       Chamberlain. C.P., J.D. Blum, R.T. Holmes, X. Feng, T.W. Sherry & G.R. Graves. 1997. The use of isotope tracers for identifying populations of migratory birds. *Oecologia* 9:132-141.
    b. Buku
       Flannery, T. 1990. *Mammals of New Guinea. Robert Brown & Associates*. New York. 439 pp.
       Koford, R.R., B.S. Bowen, J.T. Lokemoen & A.D. Kruse. 2000. Cowbird parasitism in grasslands and croplands in the Northern Great Plains. Pages 229-235 *in Ecology and Management of Cowbirds* (J. N.M. Smith, T. L. Cook, S. I. Rothstein, S. K. Robinson, and S. G. Sealy, Eds.). University of Texas Press, Austin.
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       NY Times Online . 2007."*Fossil find challenges man's timeline*". Accessed on 10 July 2007 (http://www.nytimes.com/nytonline/NYTO-Fossil-Challenges-Timeline.html).

6. Tata nama fauna:
    a. Nama ilmiah mengacu pada ICZN (zoologi) dan ICBN (botani), contoh *Glossolepis incisus*, nama jenis dengan author *Glossolepis incisus* Weber, 1907.
    b. Nama Inggris yang menunjuk nama jenis diawali dengan huruf besar dan italic, contoh *Red Rainbowfish*. Nama Indonesia yang menunjuk pada nama jenis diawali dengan huruf besar, contoh Ikan Pelangi Merah.
    c. Nama Indonesia dan Inggris yang menunjuk nama kelompok fauna ditulis dengan huruf kecil, kecuali diawal kalimat, contoh ikan pelangi/ rainbowfish.
7. Naskah dikirim secara elektronik ke alamat: fauna_indonesia@yahoo.com

PENGANTAR REDAKSI

Dipenghujung tahun 2011 ini, Majalah Fauna Indonesia kembali hadir dihadapan pembaca dalam bentuk digital di dunia maya. Dengan memanfaatkan media online, kami harapkan informasi yang disajikan semakin mudah disebarkan dan diakses oleh masyarakat. Kami sadari bahwa dua penerbitan online di tahun ini masih dalam tahap awal untuk dikatakan media online sejati dan profesional. Walaupun demikian, transformasi ini akan terus berjalan menuju kesempurnaan.

Edisi Desember 2011 menampilkan delapan artikel fauna yang mencakup berita dari dunia vertebrata dan invertebrata. Tiga tulisan herpetofauna menghiasi terbitan ini yang mewartakan Labi-labi (Suku Trionychidae), kodok endemik Sumatra dan karakter suara kodok di daerah hunian manusia. Informasi menarik dari kelompok invertebrata meliputi artikel mengenai Udang Putih (*Litopenaeus vannamei*), invasi Kijing Taiwan (*Anodonta woodiana*), potensi Kumbang Lembing dan Keong Karnifora (*Gulella bicolor*). Ulasan fauna dan klimat di Gua Anjani yang terletak di kawasan karst Menoreh akan membuka wawasan kita tentang pentingnya ekosistem karst dan upaya konservasinya.

Kami harapkan informasi pada edisi ini akan memperkaya khasanah fauna Indonesia dan meningkatkan kepedulian terhadap upaya pelestarian ekosistem dan komponen pengisinya. Akhir kata segenap redaksi Fauna Indonesia dan Masyarakat Zoologi Indonesia mengucapkan Selamat Tahun Baru 2012 dan semoga ditahun depan kami bisa hadir dengan lebih baik lagi.

Redaksi

DAFTAR ISI

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VOCALIZATION OF COMMON FROGS AROUND HUMAN HABITATIONS

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Ringkasan

Deskripsi suara 15 jenis kodok di Jawa yang biasa dijumpai disekitar pemukiman manusia dijelaskan pada artikel ini, yaitu *Bufo asper, B. biporcatus, B. melanostictus, Microhyla achatina, Huia masonii, Fejervarya limnocharis, Limnonectes kuhlii, L. microdiscus, Rana chalconota, R. erythraea, R. hosii, R. nicobariensis, Occidozyga lima, Polypedates leucomystax* dan *Rhacophorus reinwardtii*. Tiga jenis yang juga umum dijumpai di daerah sekitar pemukiman manusia belum bisa disajikan di sini, yaitu *Kaloula baleata, F. cancrivora* dan *O. sumatrana*. Suara dari 15 jenis kodok yang dideskripsikan pada artikel ini dapat didengar pada situs jejaring dari Laboratorium Herpetologi pada alamat: http://www.biologi.lipi.go.id/bio_bidang/zoo_indonesia/download_ suara_ kodok.php.

Introduction

Approximately 33 native frog species are known in Java (Iskandar, 1998); of which 18 species can adapt to human settlements or man-made habitats (Kurniati, 2006). Frog species that live in the vicinity of human settlements are usually common and easy to find. They also have a distinctive call for each species. In general, a description of each type of frog that lives in the vicinity of human settlements in Java has not been published in scientific magazines. Frog calls are available through websites or stored on CDs. This article describes vocalizations of 15 frog species, which live in Java and are common around human settlements. All calls from this publication can be heard through the website address of Herpetology Laboratory at: http://www.biologi.lipi.go.id/bio_bidang/zoo_indonesia/download_suara_kodok.php. However, the article is still lacks voice recordings of the species *Kaloula baleata, Fejervarya cancrivora* and *Occidozyga sumatrana* that can also adapt to man-made habitats.

Descriptions of frog sounds outside of Java have been published by Preininger *et al.* (2007) for *Bufo asper,* Christensen-Dalsgaard *et al.* (2002), Marquez & Eekhout (2006), Narins *et. al.* (1998) and Sheridan (2008) for *Polypedates leucomystax*; while information for *B. biporcatus, B. melanostictus, F. limnocharis, Rana chalconota* and *R. nicobariensis* can be found in Marquez & Eekhout (2006), and detailed vocalization of *Huia masonii* has been published by Boonman & Kurniati (2011).

Vocalizations

Generally, frog calls can be divided into two types: pure tones and impulse or pulse. A good example in this paper of a species of frog that uses pure tones is *Limnonectes microdiscus*, (Figure 8B) and example of a frog species using impulses is *R. nicobariensis* (Figure 12B). Several frog species have both types of calls, including *R. chalconota* (Figure 9B) and *R. erythraea* (Figure 10B). Usually, the impulses that frogs produce have a broad bandwidth and sub harmonics are mainly found in the sounds of frogs that use impulsed sounds, such as broad band frequency of *O. lima* (Figure 13B) and *P. leucomystax* (Figure 14B). Frog species that produce pure tones generally produce narrow-band frequencies and several clear harmonics, including *H. masonii* (Figure 5B) and *L. microdiscus* (Figure 8B). For more detailed, descriptions of 15 frog species which are

common around human settlements see below:

A. Family Bufonidae

1. *Bufo asper* (Figure 1A)

The basic elements of the vocalization of *B. asper* are a pure tones (900-1200 Hz) and calls consisting of impulses (carrier frequency: 700-800 Hz) (Figure 1B). The impulsed call consists of about 13-15 impulses, slowly disappearing into noise due to decreasing call intensity. The repetition rate of the impulses is about 160 Hz. There appears to be little or no audible sensation of repetition pitch to the human ear, even not at close range. However, the roughness of the impulse calls is apparent. Impulse call duration is about 80 millisecond (ms). Pure tone duration about 80-100 ms. The pure tone is usually followed by the first impulsed call after about 320-400 ms and a second impulsed call is produced about 450-550 ms after that. Sometimes, only 1 impulsed call is produced after the pure tone. Single, very quiet impulsed calls may also be produced. The amplitude of the three calls can differ by more than 6 dB and the loudness of the calls appears to vary randomly. The sequence of three calls is repeated at intervals of 2.5-3 seconds during active calling bouts, but may become minutes during inactive phases.

Figure 1A. *B. asper* (Photograph by A. Sumadijaya).

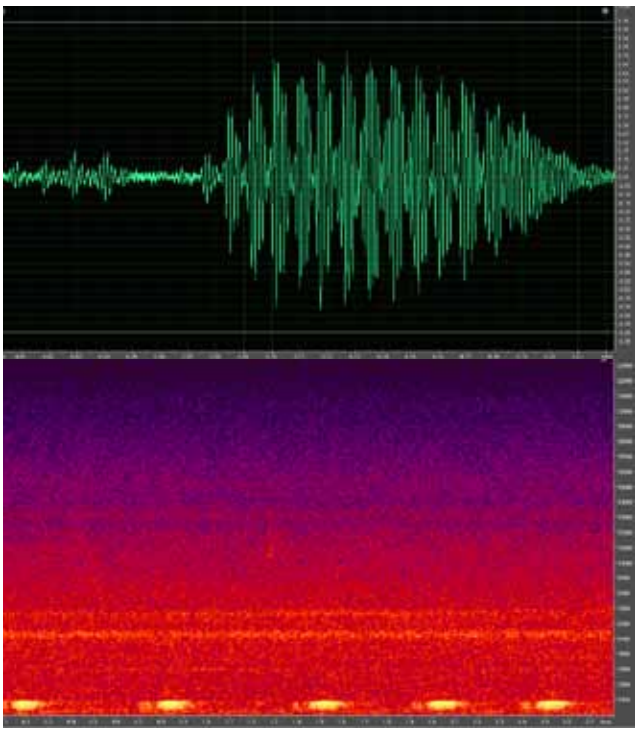

Figure 1B. Sound spectrogram of *B. asper*

2. *Bufo biporcatus* (Figure 2A)

The basic elements of the vocalization of *B. biporcatus* are relatively long (max 20 ms) impulses having a clear 2nd and 3rd (strongest) harmonic. The first harmonic (fundamental) is at around 700 Hz and possibly slightly weaker than the 3rd harmonic (Figure 2B). The second harmonic is the weakest (about 6 dB lower in intensity than the other two). It remains unclear how such a sharp filtering / amplification can take place in the frog's vocal apparatus. It could be argued that the impulses are in fact pure tones of very short duration; however no clear physical definition exists for either of the two. The carrier frequency of the impulse (700 Hz) and harmonics define the timbre of the vocalization. However, the vocalizations of this species, to the human ear, have a characteristic roughness, which one could describe as having an r-sound, or rattling quality. This quality is the effect of amplitude modulation (AM). Two strong impulses are usually separated by 10-12 ms, or from peak to peak: 25-30 ms. Just two consecutive impulses are already sufficient to cause the rattling sensation. To the human auditory system, the sensation persists at half the replay speed, but the sound is interpreted as two consecutive tones at ¼ the normal replay speed. It is unknown how frogs process these sounds, but the double impulsed sound may be important in species recognition by conspecifics. The intervals between the double clicks are typically 30-35 ms. More recordings of single individuals are needed to study the vocalizations in more detail.

Figure 2A. *B. biporcatus* (Photograph by A. Sumadijaya).

Figure 3A. *B. melanostictus* (Photograph by A. Sumadijaya

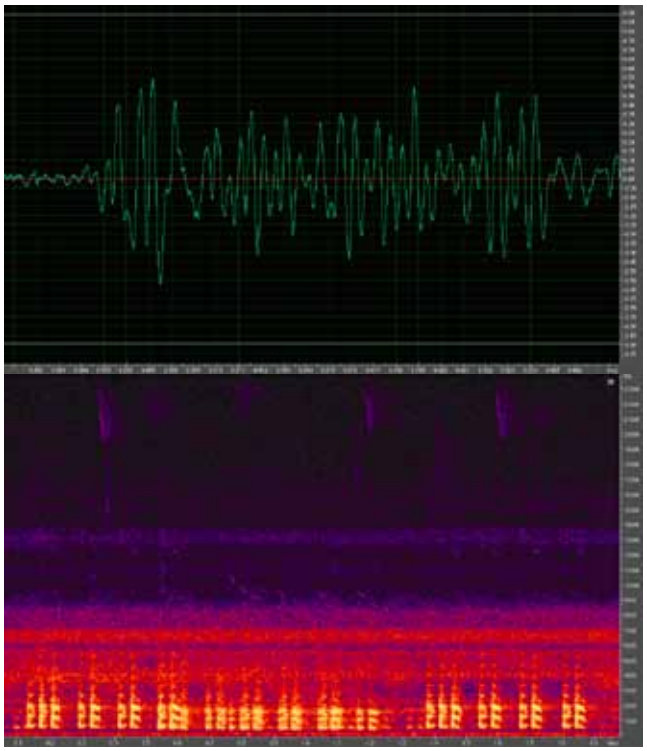

Figure 2B. Sound spectrogram of *B. biporcatus.*

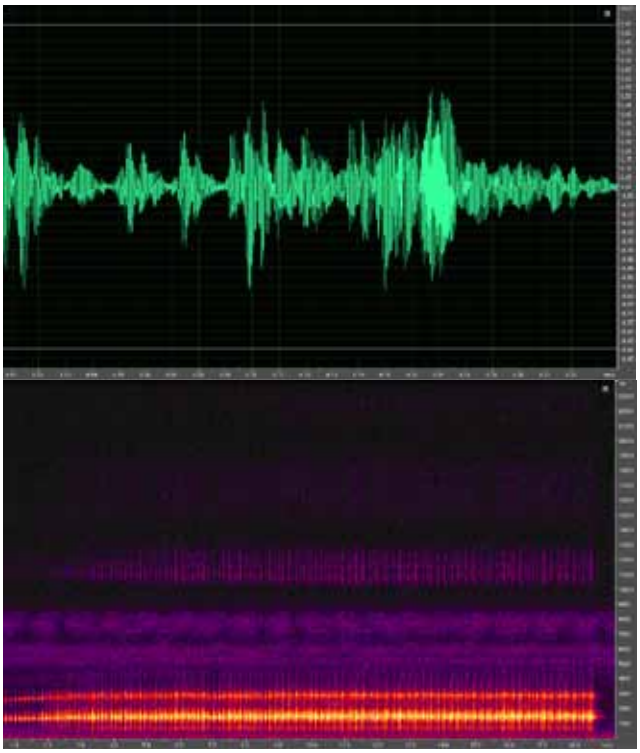

Figure 3B. Sound spectrogram of *B. melanostictus.*

3. *Bufo melanostictus* (Figure 3A)

The sound of *B. melanostictus* consists of two clear harmonics: the first one at 1450 Hz, the second at 2900 Hz, both having very little bandwidth (Figure 3B). To establish what the basic elements of the vocalization are, this species needs to be recorded in an echo-free environment. In the present recordings in our database, repeated elements are separated by 50-70 ms. However, each element, in turn, also appears to be amplitude modulated, hence consisting of impulses at a fairly random repetition rate. Even the smallest elements in our recordings, tones of 1450 Hz and 40 ms, also show amplitude modulations, but these may have easily resulted from interference due to reflections from nearby walls. Again, the sound has the characteristic *Bufo*-roughness due to the amplitude modulation.

B. Family Microhylidae

1. *Microhyla achatina* (Figure 4A)

M. achatina produces series of impulses, each lasting 5-6 ms, spaced at intervals of about 50 ms. Each series (call) lasts about 360 ms. Under normal conditions, the intervals are the same throughout a call. However, in very active phases, the last couple of

impulses are delivered at intervals of only 20 ms. The impulses have a special quality, despite their short duration. The second harmonic of each impulse, at 3 kHz is dominant, whereas the first and third are suppressed (Figure 4B). Individuals with the second harmonic at 2.4 kHz have also been recorded. The bandwidth of the dominant harmonic is only 1 kHz (FFT size: 512 points). This is a remarkable accomplishment since each impulse may only consist of 7-9 periods. Echo-free recordings are needed to measure the duration-bandwidth product faithfully. Intervals between series (calls) last 2-3 seconds during active phases.

Figure 4A. *M. achatina* (Photograph by A. Sumadijaya).

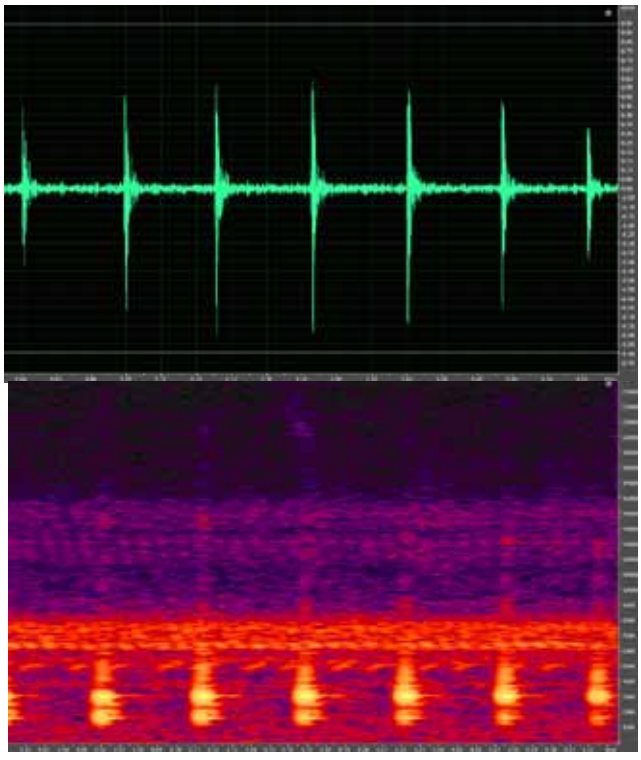

Figure 4B. Sound spectrogram of *M. achatina*.

C. Family Ranidae

1. *Huia masonii* (Figure 5A).

H. masonii produces single pure calls, sometimes with harmonics of varying frequency. Each call is rapidly frequency modulated (FM), exhibiting different patterns, such as V, W, inverted U or downward sweeps, each time with a different pattern (Figure 5B). The lowest frequency of such calls measured was 4.5 kHz (with prominent harmonics) and the highest 16.5 kHz, already close to the human upper limit of hearing. The second harmonic of the high calls is completely ultrasonic.

Figure 5A. *H. masonii* in amplexus position (Photograph by A. Sumadijaya).

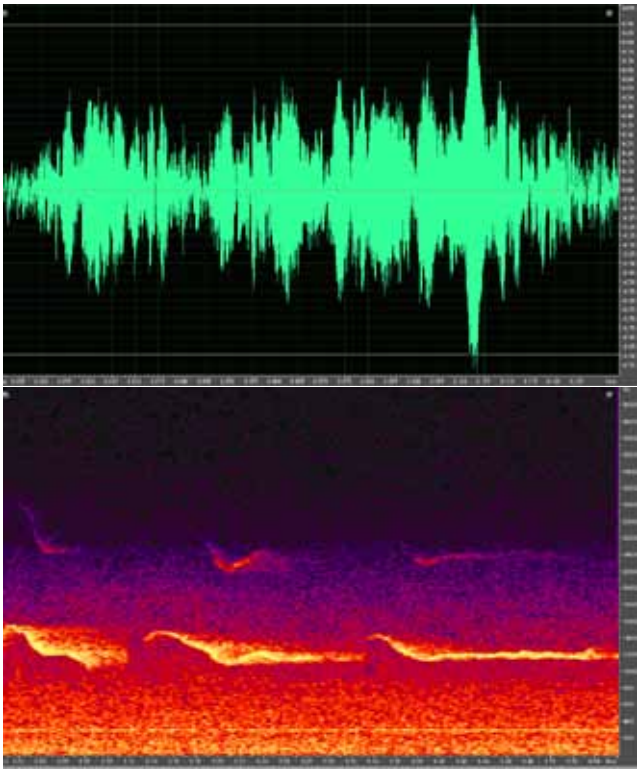

Figure 5B. Sound spectrogram of *H. masonii.*

Duration of the calls is around 6-19 ms. Due to nonlinearity of microphones it cannot be established how much lower in amplitude the second harmonic is, but it is definitely more than 10 dB weaker than the first. This implies that communication takes place by using the first harmonic only. Short "buzzes" are also produced by *H. masonii*. The buzz consists of about 5-9 impulses, each with a duration of about 10 ms, 15 ms apart. Each impulse consists of 3 harmonics, the first at 3.5 kHz. It looks as if shifts can take place within buzzes from low to higher frequencies, reminiscent of formant filtering, but further investigations are required to clarify this issue. The frogs seem to answer each other in active calling bouts. However, as much as an hour may pass between calling bouts.

2. *Fejervarya limnocharis* (Figure 6A)

The human auditory perception of the vocalizations produced by this frog species is completely dominated by pulse repetition pitch. The first harmonic of this species (defining the perception of pitch) is at 1.1 kHz (Figure 6B). This is the same frequency as used by *B. asper* in producing the pure tone. However, when we were playing this tone results in a perception of a much higher frequency than playing the sounds of *F. limnocharis*. This effect is due to the fact that the human hearing system interprets a rapid series of impulses as a single tone with a certain pitch. The pitch corresponds to the pulse repetition rate which is about 110 Hz in the species. Although humans perceive this frog as having a frequency close to the human male voice, its carrier (true) frequency that is measured in spectrograms is in fact 10 times higher. *F. limnocharis* also revealed another surprise: the two "harmonics" the species

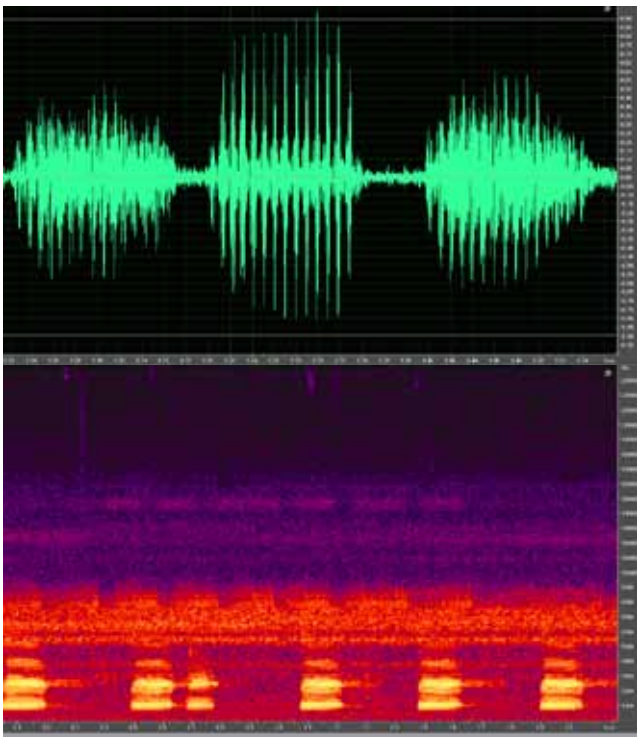

Figure 6B. Sound spectrogram of *F. limnocharis.*

produces are not exactly related by a factor of two. The first "harmonic" is consistently at 1.1 kHz, but the second at 2.5-2.6 kHz, instead of 2.2 kHz! The cause for this phenomenon is subject of investigation. The basic elements of the vocalization are impulses of 5-6 ms, repeated at 9.5 ms intervals. Each call typically lasts 110-150 ms. Intervals between calls last 50 ms half a second during active calling periods.

3. *Limnonectes kuhlii* (Figure 7A)

This frog has extremely soft calls (50 ms), repeated at 10 minute intervals. Main intensity at 2.7 kHz (Figure 7B). The call consists of many impulses and the AM dominates the perceived pitch of this call, which sounds much lower than 2.7 kHz. Further description difficult due to low quality of recordings.

Figure 6A. *F. limnocharis* (Photograph by A. Sumadijaya).

Figure 7A. *L. kuhlii* (Photograph by A. Sumadijaya).

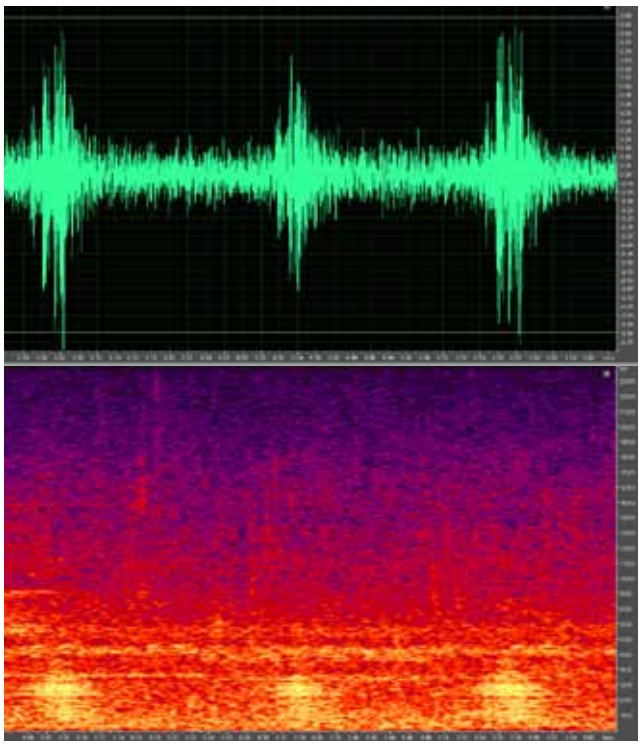

Figure 7B. Sound spectrogram of *L. kuhlii*.

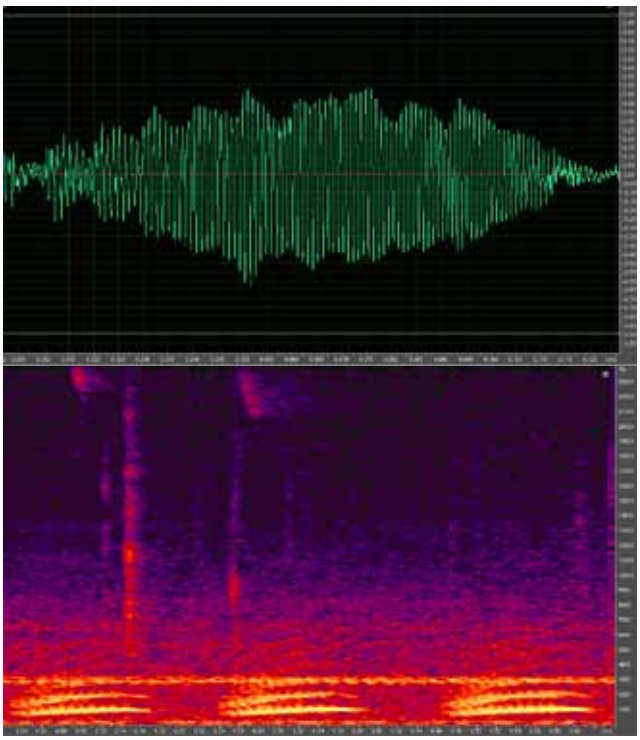

Figure 8B. Sound spectrogram of *L. microdiscus*.

4. *Limnonectes microdiscus* (Figure 8A)

Calls are about 130-160 ms in duration, sweeping upwards slowly from 750 to 1000 Hz (Figure 8B). Each call appears to consist of a pure tone, shallowly amplitude modulated by about 90 Hz. Still, the roughness due to the AM is clearly audible to the human ear. The second harmonic is only 4 dB less strong at the start of the call, but looses in power quickly, becoming about 16 dB weaker relative to the first harmonic. Very likely, the second harmonic enters a filtered zone above about 1600 Hz, suppressing the second harmonic. During active phases, calls follow each other at 1.2-1.5 second intervals. The frog can be hard to localize and appears extremely sensitive to disturbance including light. The calls of this species are comparatively weak.

5. *Rana chalconota* (Figure 9A).

The song of *R. chalconota* is far more complex than of any of the other frogs (Figure 9B). It is very quiet and probably serves for short distance communication only. The song is more complex than that of many birds and may consist of impulse series with a first harmonic at 1 kHz, but also pure tones, with a first harmonic at 3 kHz and all frequencies in between. The pure tones may be frequency modulated. Pure tones are most commonly encountered and they appear to have a varying harmonic content. Some are strongly AM and therefore sound scratchy, whereas other tones sound like whistles. The song is more or less continuous and elements are probably never 100% identical.

Figure 8A. *L. microdiscus* (Photograph by H. Kurniati)

Figure 9A. *R. chalconota* (Photograph by A. Sumadijaya).

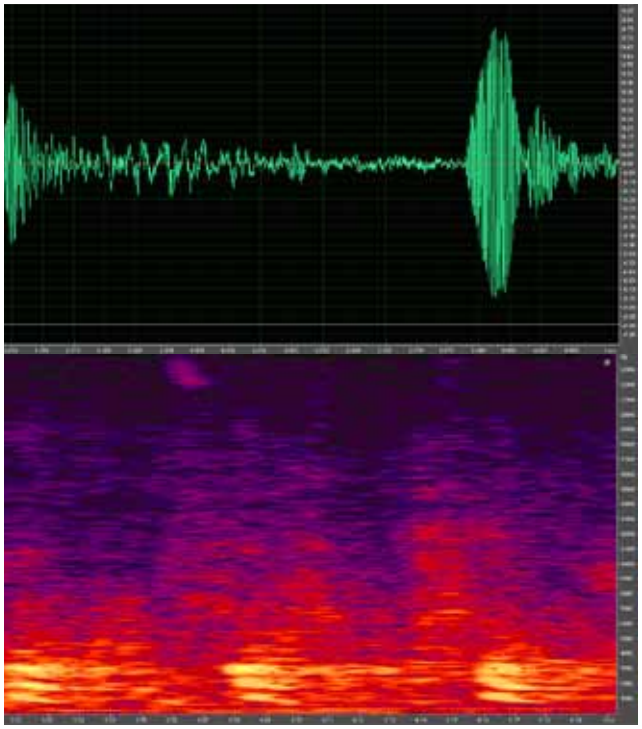

Figure 9B. Sound spectrogram of *R. chalconota*.

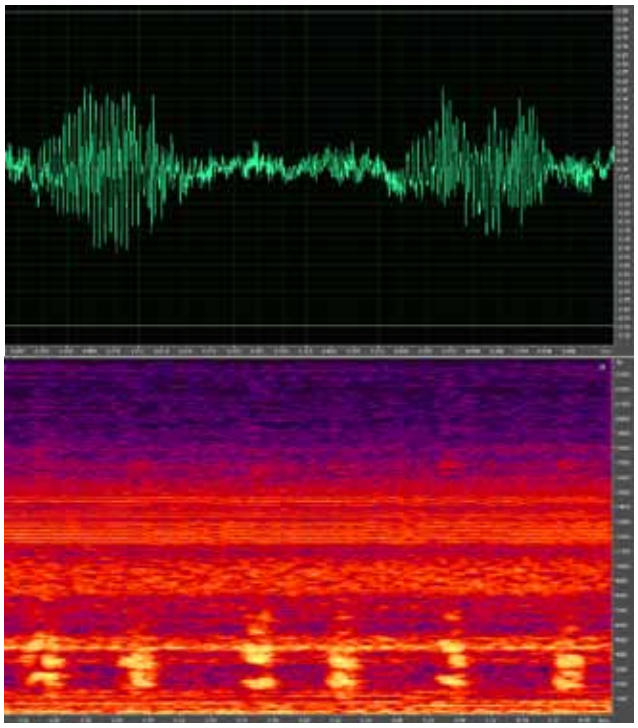

Figure 10B. Sound spectrogram of *R. erythraea*.

6. *Rana erythraea* (Figure 10A)

The song of *R. erythraea* is as complex as that of *R. chalconota* and very similar in nearly all aspects. Impulses/ tones (10-110 ms) with a first harmonic (invisible) at 0.9-1.3 kHz are produced with a strong second and third harmonic (Figure 10B). Below about 1.7 kHz the frog's vocal apparatus probably suppresses all sounds. The tones are often strongly frequency modulated, often like an inverted V. Some sweep down from about 3.5-4 kHz. Long tones modulate up and down in frequency similar to *H. masonii*. Differences with *R. chalconota* are as follows: longer impulse/tone durations, mostly above 20 ms in *R. chalconota*. First harmonic nearly always fully suppressed. Less often scratchy AM sounds, lacks the smacking impulses.

Figure 10A. *R. erythraea* (Photograph by H. Kurniati)

7. *Rana hosii* (Figure 11A).

R. hosii produces multiple harmonic down sweeping calls, typically from 1.5 to 2.4 kHz in 20-85 ms (Figure 11B). 2.4 kHz, less modulated calls have also been recorded. Within the 60 ms, only 5-15 ms may be of high amplitude. The suitability of these calls to communicate near rushing streams is very questionable. It is possible that this species limits its communication to short distances.

Figure 11A. *R. hosii* (Photograph by A. Sumadijaya).

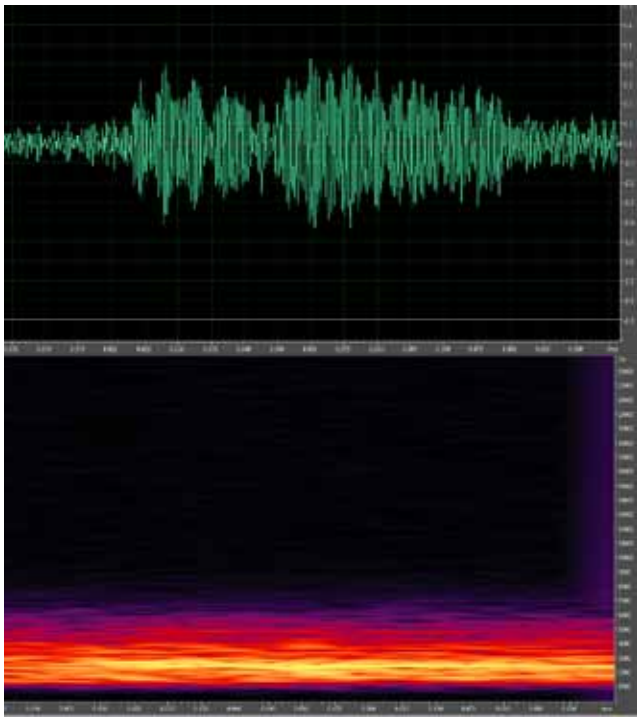

Figure 11B. Sound spectrogram of *R. hosii.*

8. *Rana nicobariensis* (Figure 12A).

R. nicobariensis produces sounds with very similar principles to the human voice. As in the human voice, the basic elements are impulses. In the human female voice, the first harmonic is at 200 Hz, in *R. nicobariensis* at 400 Hz. Harmonics span over a frequency range from 1.2 to 5.5 kHz (Figure 12B). Unlike in humans, the first 3 harmonics are suppressed. Similar to human vowel production, frequency zones of high intensity (formants) are visible in *R. nicobariensis*. In the frog the "vowel" is always the same one with energy at 1.4 kHz and in between 3 and 4 kHz. Each call lasts about 45-50 ms. Each call consists of a series of about 18 impulses, delivered at a rate of about 280-290 Hz. The rate, however, is not entirely constant which destroys the human perception of pulse repetition pitch, as present in *F. limnocharis*. Secondly, the impulses are remarkably variable in shape, which also destroys repetition pitch to some extent. Impulse variation also introduces the "kgggg", or noisy character of the sound. The timbre of the sound is not entirely noisy, but also has an impulsive character. It remains unclear how the variability in impulse structure in a series is generated by the frog to cause exactly the noisy, but pulsating timbre that it does. Calls are separated by about 120 ms and about 4 to 12 are produced in a row. We still lack clear recordings of single individuals to establish how often the series of repeated calls occur per time unit and also to study in more detail the variation of the impulse function

Figure 12A. *R. nicobariensis* (Photograph by H. Kurniati).

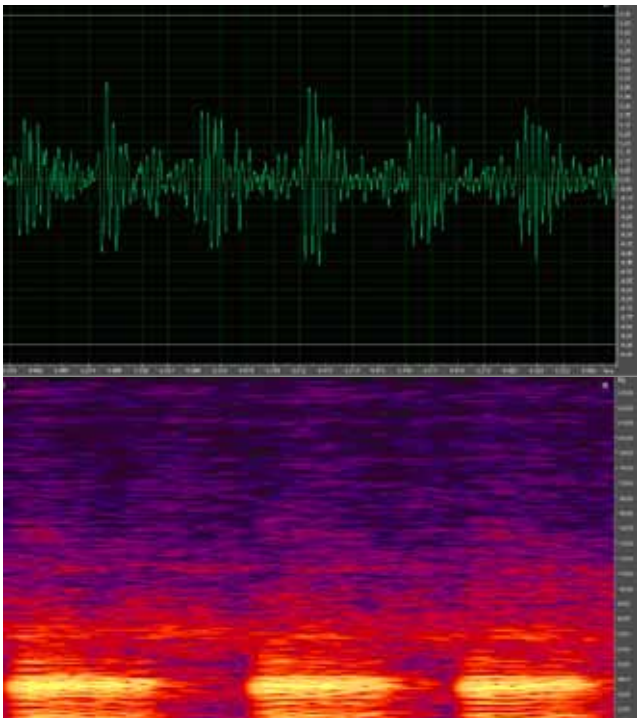

Figure 12B. Sound spectrogram of *R. nicobariensis.*

9. *Occidozyga lima* (Figure 13A)

The basic elements of the vocalisation of *O. lima* are impulses with a duration of 2 ms and a carrier frequency of 4.5 kHz (Figure 13B). The impulses are repeated irregularly. Intervals may be 4 ms, but often impulses overlap considerably. 6-8 impulses may occur in a series. Finally, a calling sequence may culminate in a buzz consisting of over 40 impulses with a repetition of 270 Hz, which is faster than bats and comparable to dolphin buzzing.

During a buzz, pulse intervals are shortened from 5 to 2 ms. The vocalisations of *O. lima* and *Rhacophorus reinwardtii* show strong similarities in impulse design and structuring.

Figure 13A. *O. lima* (Photograph by H. Kurniati)

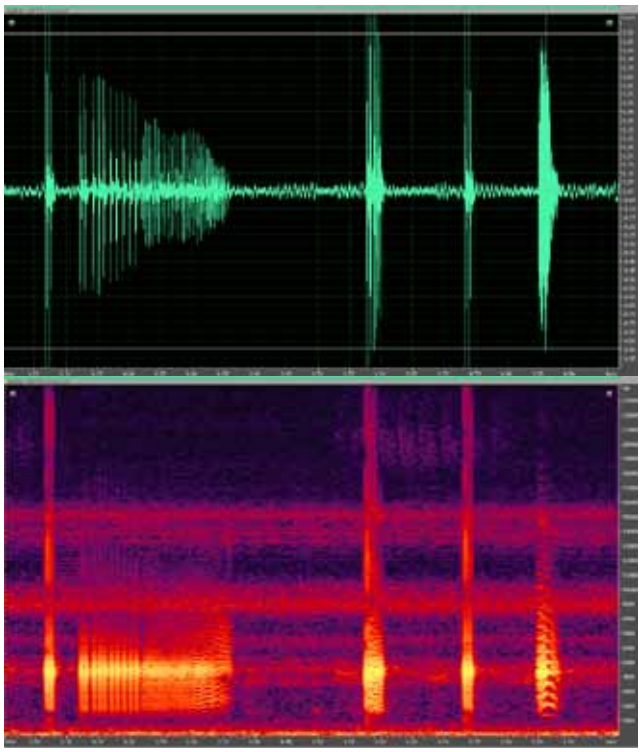

Figure 13B. Sound spectrogram of *O. lima*.

D. Family Rhacophoridae

1. *Polypedates leucomystax* (Figure 14A).

The basic elements of the vocalization of *P. leucomystax* are impulses with a duration of 3 ms and a carrier frequency of 1.9 kHz (Figure 14B). This frequency may in fact be a second harmonic of a fundamental of 950 Hz. The impulses are delivered at a rate of 95 Hz (intervals: 6-15 ms). As in *F. limnocharis*, repetition pitch defines the frequency as perceived by the human ear completely: the sound does not sound high, but rather similar in frequency to a human male voice (100 Hz). Still, the perceived pitch may sound rough and wideband due to irregularities in the intervals between impulses. One call lasts about 150-200 ms and consists of about 13-15 impulses, decreasing in amplitude at the end of the call. Series of low-amplitude impulses, separated by 10-12 ms may be interspersed in between calls. During active phases, calls are repeated every 12-30 seconds. The amplitude onset of each impulse is very rapid. The decay time and exact duration must still be measured in an echo-free environment.

Figure 14A. *P. leucomystax* (Photograph by A. Sumadijaya).

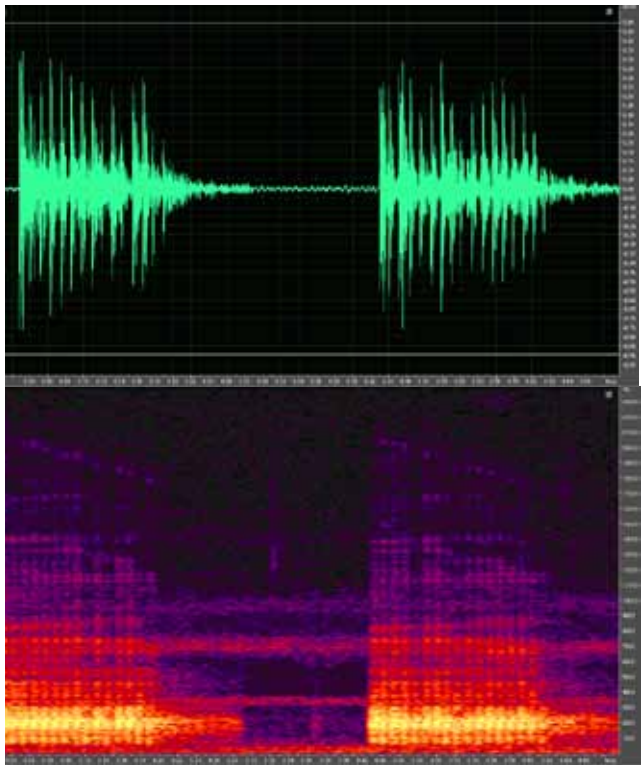

Figure 14B. Sound spectrogram of *P. leucomystax*.

2. *Rhacophorus reinwardtii* (Figure 15A)

The basic elements of the vocalization are Gabor-like impulses with a bandwidth of about 1.3 kHz (1-2.3 kHz) and a duration of about 2-4 ms with no higher harmonics (Figure 15B). 4-6 periods occur within one impulse. Impulses can occur in a series of 4 (intervals 6-8 ms) but also singly. Humans cannot resolve the individual impulses at 7 ms intervals, but the rapid AM lowers the sensation of pitch of the carrier frequency. A frequently uttered sequence by *Rh. reinwardtii* is an impulse followed 160 ms later by 3 impulses in rapid succession (4 ms intervals), then a pause of 190-200 ms followed by another series of 3 impulses (6 ms intervals). Sometimes such a series culminates in an extra series of impulses, separated by about 130 ms and hence discernable by the human ear. Many variations on this theme are used. The interesting remaining questions are how the frog is able to generate such perfect narrow bandwidth Gabor impulses and if the temporal resolution of this frog is superior to ours.

Figure 15A. *Rh. reinwardtii* (Photograph by H. Kurniati).

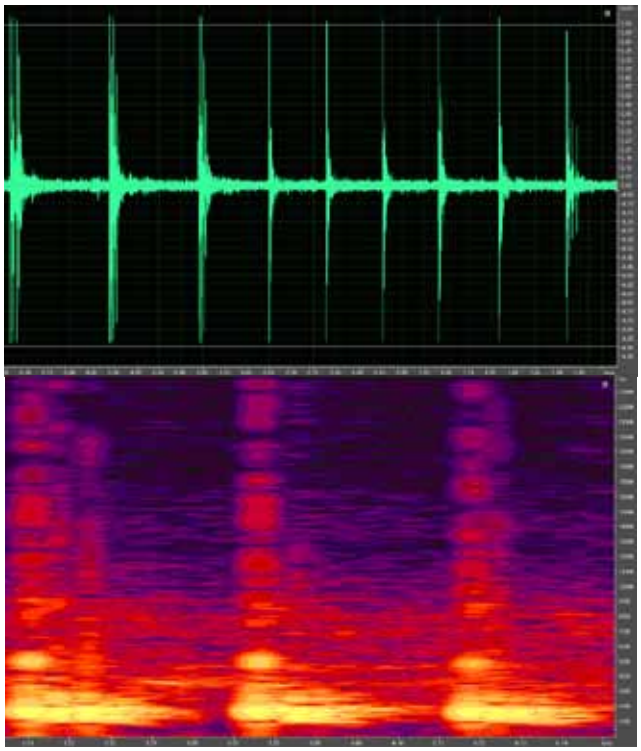

Figure 15B. Sound spectrogram of *Rh. reinwardtii*.

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