

Mating Calls Description of Five Species of Frogs from the Genus *Hylarana* Tschudi 1838 (Amphibia, Anura, Ranidae) from Sarawak, Malaysia

(Pencirian Panggilan Pengawanan Lima Spesies Katak Genus *Hylarana* Tschudi 1838 (Amphibia, Anura, Ranidae) dari Sarawak, Malaysia)

RAMLAH ZAINUDIN, MUSTAFA A. RAHMAN, BADRUL MUNIR M. ZAIN,
M. N. SHUKOR, R. F. INGER & A. NORHAYATI*

ABSTRACT

Recordings of frog calls from the genus Hylarana were conducted at seven study sites in Sarawak, Malaysia. The results showed that each species differs in terms of call characteristics, in which a high number of pulsed note belongs to H. baramica, while high repetition note belongs to the sibling species, H. glandulosa. Higher pitched and number of amplitude spectrum, however, belong to H. signata. Pulsed note and note repetition differed significantly among species, except for spectrum amplitude. Advertisement calls for each species were described in detail. This study provide a baseline data on advertisement call characteristics of frogs from the genus Hylarana for future studies of these frogs particularly and the Oriental frogs generally.

Keywords: Acoustic characteristic; amplitude spectrum; Hylarana, note; pitch; pulse

ABSTRAK

Rakaman panggilan katak daripada genus Hylarana telah dijalankan di tujuh kawasan kajian di Sarawak, Malaysia. Hasil kajian menunjukkan bahawa setiap spesies berbeza daripada segi ciri panggilan, iaitu nota yang bernada banyak ditunjukkan oleh Hylarana baramica, manakala nota berulang yang tinggi ditunjukkan oleh H. glandulosa. Nota yang berfrekuensi tinggi dan bilangan spektrum amplitud yang lebih tinggi dimiliki oleh H. signata. Nota bernada dan nada berulang berbeza dengan ketara di kalangan spesies, kecuali spektrum amplitud. Panggilan mengawan untuk setiap spesies diterangkan dengan terperinci. Kajian ini menyumbang kepada pangkalan data asas untuk ciri panggilan mengawan katak daripada genus Hylarana untuk kajian mengenai katak ini khususnya dan katak Oriental amnya.

Kata kunci: Ciri akustik; denyut; hylarana; nota; pic; spektrum amplitud

INTRODUCTION

Studies on advertisement call characteristics of frogs are very limited in Malaysia. A study on advertisement call characteristics of Malaysian *Leptolalax* was successfully conducted by Matsui (1997). The study revealed that advertisement call characteristics of *Leptolalax heteropus* differs from the others suggesting phylogenetic divergence. Call characteristics were also used as one of the characters to revalidate *Hylarana laterimaculata* from the synonym of *Hylarana baramica* (Leong et al. 2003). In addition, Lardner and Lakim (2004) investigated call preferences in female tree-hole frogs and since then no other intensive study on frog advertisement calls of Bornean *Hylarana* has been carried out. This paper aims to document and describe call characteristics of selected frogs from genus *Hylarana* Tschudi 1838 from Sarawak, Malaysia.

MATERIALS AND METHODS

Since the genus *Hylarana* is widely distributed and occupies various habitats it is highly recommended that sampling localities represent most of their habitats. For this, seven study sites in Sarawak were chosen for data collection as shown in Figure 1. The study sites consisted of four National parks (Kubah/Matang, Bako, Mulu and Similajau) and three unprotected areas (Borneo Height, Sadong Jaya and Bario).

Different habitats were surveyed at night making digital recordings of the Bornean *Hylarana* encountered using Sony ICD-SX30 recorder and Sony microphone. Data on air temperature were measured using data logger. The call variables measured in this study followed Matsui (1997) and Bee (2003). Size of calling frogs was taken,



FIGURE 1. Map of Sarawak, Malaysia showing location of study sites

to allow an analysis of how the calls vary due to these ecological factors but the data was presented elsewhere (Ramlah et al. 2009). Several calls (2-3 individuals) of each male of Bornean *Rana* were recorded. Sample size (n) was indicated as the number of calls or notes analyzed in 60 seconds, and means were given for the number of calls recorded. The size of calling frogs was taken, to allow an analysis of how body size varies due to basal body temperature (°C) and fundamental frequency (kHz) of the calling frogs. Calls were analyzed from 2 to three individuals (Leong et al. (2003)) or depending on the number of males caught, using SoundRuler Acoustic Analysis ver 0.9.6.0 (Gridi-Papp, M (ed.) 2003-2007).

Terminologies for acoustic characteristics (Appendix) follow Littlejohn (2001), Matsui (1997) and SoundRuler variables (Bee 2003). The Euclidean distance ($Ed_{ij} = \sqrt{\sum (X_{ik} - X_{jk})^2}$) and the PCA analysis were performed on call variables to determine which variables were good characters in describing the species of Bornean *Hylarana* and the data were presented elsewhere (Ramlah et al. 2009). Identification of frog captured was done by using various reference books (Inger & Stuebing 2005; Inger et al. 1985).

RESULTS AND DISCUSSION

Each species of *Hylarana* showed different call characteristics (Table 1). High number of pulsed note belongs to *H. baramica*, while high repetition notes belongs

to the sibling species, *H. glandulosa*. Higher pitched and number of amplitude spectrums, however, belong to *H. signata*. Additionally, pulsed note and note repetition differ significantly among species (Table 1) except for spectrum amplitude. The results were consistent with other studies that shown significant difference of note repetition rate among species (Leong et al. 2003; Straughan 1975), thus suggesting that the character (note repetition rate) is a good indicator for species discrimination. The study, however, also implies that amplitude spectrum is not a good character for species discrimination. Call characteristics of five species of *Hylarana* were described below.

HYLARANA BARAMICA

The Brown marsh frog (*H. baramica*) produced repeated low-pitched notes, as noted by Inger and Stuebing (2005) and Leong et al. (2003). The call notes, dominant frequency, and call harmonic were comparable to those Leong et al. (2003) (Table 1). Two types of advertisement calls were also heard as in Leong et al. (2003), but for simplicity, the call analysis was only done for the normal type Leong et al. (2003) of advertisement call. Generally, the normal advertisement call of *H. baramica* (example, RZ223 *Hylarana baramica* from Matang population) consists of 10 pulses in a note (Figure 2) with 8 repetitive notes in one minute (60s) of calling period (Figure 2a). Spectrogram of note 1 (Figure 2c) shows a low-pitched call between 1-3 kHz, and only one peak of amplitude as shown by the amplitude spectrum of note 1 of *H. baramica* (Figure 2d).

TABLE 1. Summary of call characteristics of the five species of Bornean Hylarana

Species	Call Characteristics			
	Number of Pulsed Note	Note Repetition/1 min	Pitch (KHz)	Amplitude Spectrum (kHz)
<i>H. baramica</i>	10	8	Low (1-3)	1
<i>H. glandulosa</i>	1	34	Very Low (1-2)	2
<i>H. signata</i>	6	2	High (2-4)	3
<i>H. picturata</i>	2-3	14	Moderate high (2-3)	1
<i>H. luctuosa</i>	1	3	Very low (1-2)	1
χ^2	0.6*	0*		1.6 ^{NS}

*exact significant at P=1.00; ^{NS}Not significant

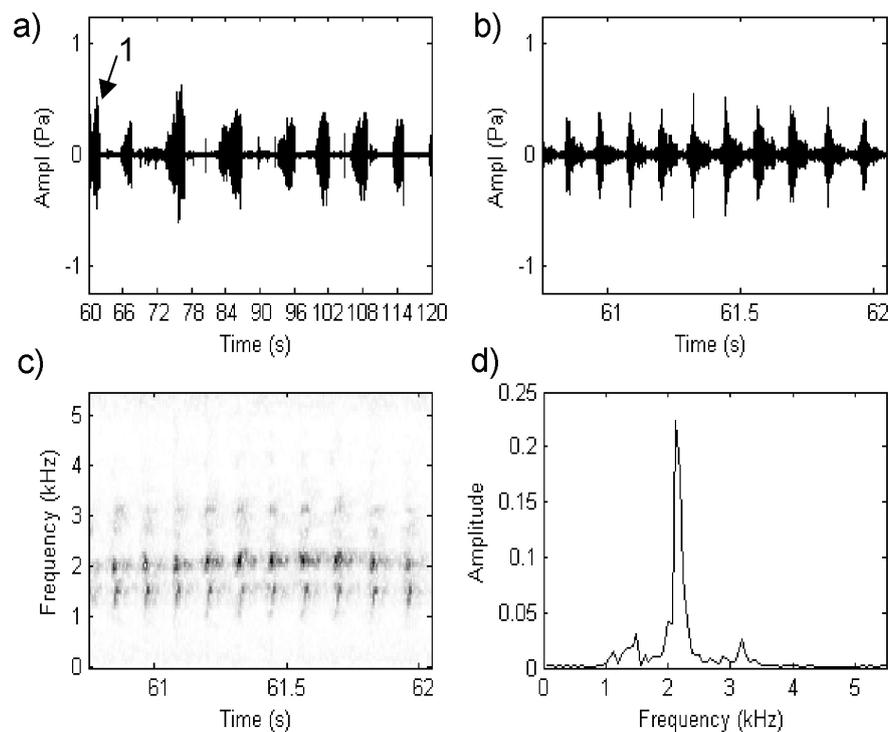


FIGURE 2. Call characteristics of RZ223 *Hylarana baramica* showing a) oscillogram of the call (60s), b) oscillogram of note 1, c) spectrogram of note 1, and d) amplitude spectrum of note 1

HYLARANA GLANDULOSA

The Rough-sided frog (*H. glandulosa*) produced a loud resonant sequence of 'WAHK' as in Inger and Stuebing (2005). The advertisement call consists of 1 pulse in a note (Figure 3b) with 34 repetitive notes in one minute (60s) of calling period (Figure 3a). Frequency spectrogram of note 3 (Figure 3c) shows lower pitch (below 2 kHz) compared to that of *Hylarana baramica*, but there are two peaks (one minimum and one maximum peak) as shown by amplitude spectrum of note 3 (Figure 3d).

HYLARANA SIGNATA

Advertisement call of the Striped stream frog (*Hylarana signata*) consists of 6 pulsed notes of sharply decreasing intensity (Figure 4b) with only two repetitive notes in one minute (60s) of calling period (Figure 4a). The call description was similar with that of *Hylarana picturata*, as described by Inger and Stuebing (2005). Frequency spectrogram of note 2 (Figure 4c) showed higher pitch (up to 4 kHz) as compared to those of *Hylarana baramica* and *Hylarana glandulosa*, and there are three peaks (two

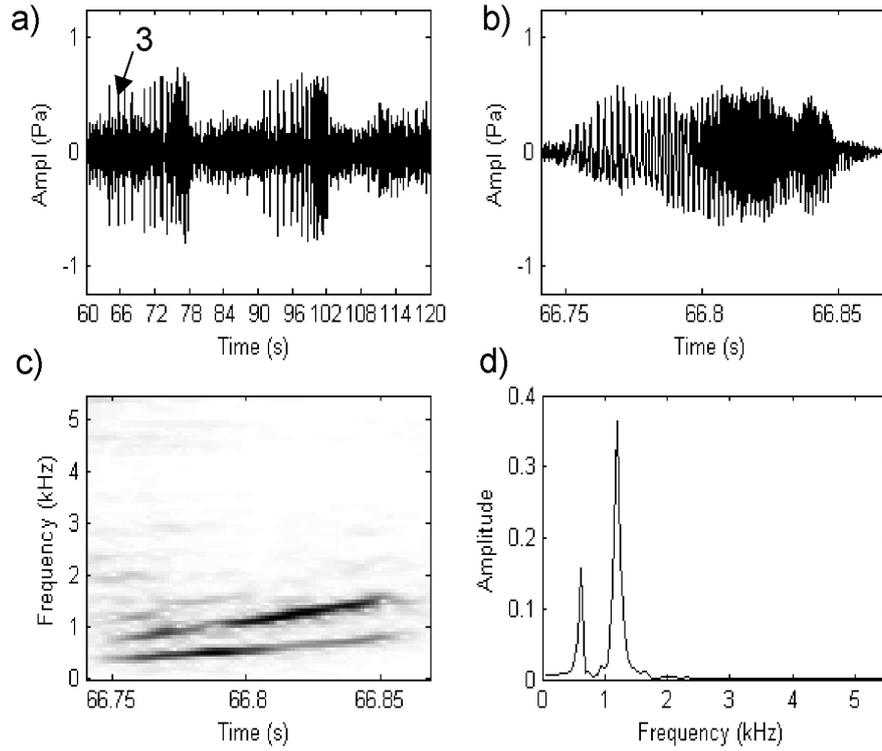


FIGURE 3. Call characteristics of RZ260 *Hylarana glandulosa* showing a) oscillogram of the call (60s), b) oscillogram of note 3, c) spectrogram of note 3, and d) amplitude spectrum of note 3

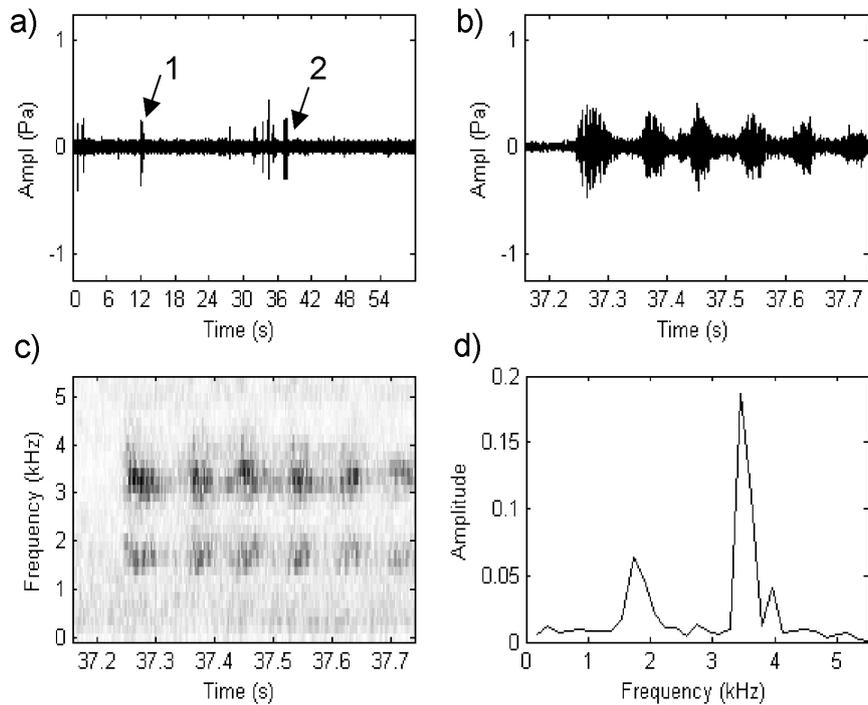


FIGURE 4. Call characteristics of RZ214 *Hylarana signata* showing a) oscillogram of the call (60s), b) oscillogram of note 2, c) spectrogram of note 2, and d) amplitude spectrum of note 2

minima and one maximum peaks) as shown by amplitude spectrum of note 2 (Figure 4d).

HYLARANA PICTURATA

The sound produced by the Spotted stream frog (*H. picturata*) consists of 2-3 consists of 2-3 pulsed notes (Figure 5b) with quick, high pitches. The call of *H. picturata* has higher note repetition rate (Ramlah et al. 2009) meaning that the species produced 14 repetitive notes per 60s (Figure 5a), which differed from the sibling species, the Striped stream frog *H. signata*, which only has 2 repetitive notes per min (Figure 4a). Spectrogram of note 3 (Figure 5c) of *Hylarana picturata* showed low pitched call between 2-3 kHz, and only one peak of amplitude (Figure 5d). It was difficult to determine which calls belong to which species as both species have been treated as the same species in the past (Malkmus et al. 2002). Unfortunately, Inger and Stuebing (2005) and Malkmus et al. 2002 have not published or described the call of *H. signata*. It is likely that their recorded call of *H. picturata* might belonged to that of *H. signata*, since the call description of 4-6 pulsed notes of sharply decreasing intensity (*H. picturata* in Inger and Stuebing 2005) was similar to the call of *H. signata* in this study.

HYLARANA LUCTUOSA

The Mahogany frog (*Hylarana luctuosa*) produced a call that resembles the 'MEOW' of a cat as in Malkmus et al. 2002. The advertisement call consists of 1 pulse in a note

(here note 3, Figure 6b) with only three repetitive notes in one minute (60s) of calling period (Figure 6a). Frequency spectrogram of note 3 (Figure 6c) shows much lower pitches (1-2 kHz) as compared to other Bornean *Hylarana*, but possesses one apparent peak (Figure 6d). The males formed calling communities at natural ponds at Kubah National Park with each male calling from a small hole excavated adjacent to the pond.

CONCLUSION

The results of this study were consistent with other studies (Leong et al. 2003; Matsui 1997) that revealed advertisement call characteristics are good characters for species recognition. Calls are also a good character that can be used in addition to genetical distances to infer speciation and reproductive isolation. Females can discriminate between different calls and choose males on this basis, thereby generating sexual selection on call traits (Jennions & Petrie 1997; Lardner & Lakim 2004; Sullivan et al. 1996). Studies on the pattern of geographic variation that evaluated the effects of selection and ecological constraints show substantial differences among populations in signals emitted (Castellano et al. 2000; Ryan et al. 1996). Given enough data, advertisement call of a frog can be a powerful tool for discriminating species, and much cheaper than using molecular tools. Thus, this study provides a baseline data on advertisement call characteristics of Bornean frogs for future studies of these frogs particularly, and the Oriental frogs generally.

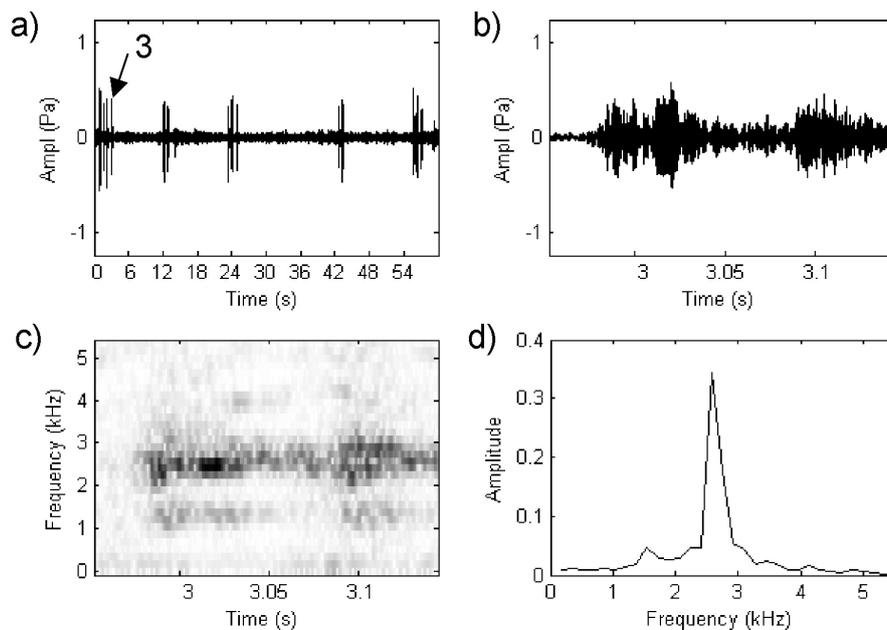


FIGURE 5. Call characteristics of RZ195 *Hylarana picturata* showing a) oscillogram of the call (60s), b) oscillogram of note 3, c) spectrogram of note 3, and d) amplitude spectrum of note 3

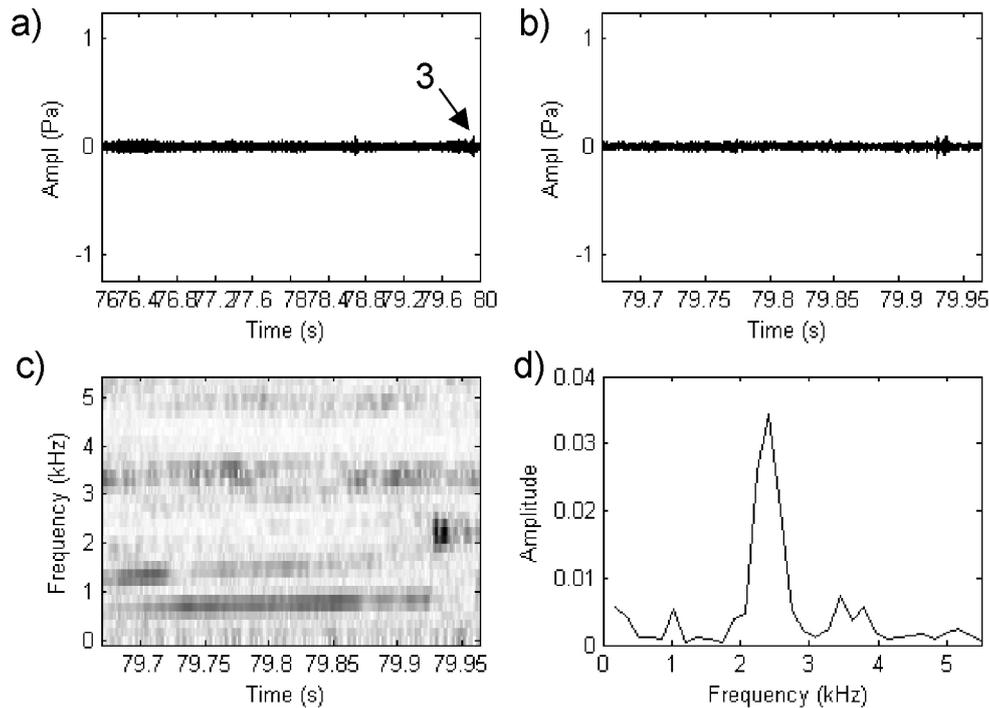


FIGURE 6. Call characteristics of No31 *Hylarana luctuosa* showing a) oscillogram of the call (60s), b) oscillogram of note 3, c) spectrogram of note 3, and d) amplitude spectrum of note 3

ACKNOWLEDGEMENTS

Funding for this study was provided by the UNIMAS research grant 01(124)513(05)(12). We would like to thank everyone who were directly or indirectly involved in this project.

REFERENCES

- Bee M.A. 2003. Sound Ruler: A free, open code, multi-platform sound analysis and graphing package. *Bioacoustics* 14: 171-178.
- Castellano, S. A. Doglio R.S. & Giacoma C. 2000. Body size and calling variation in the green toad, *Bufo viridis*. *Journal of Zoology, London* 248: 83-90.
- Gridi-Papp M. 2003-2007. SoundRuler Acoustic Analysis ver 0.9.6.0. <http://soundruler.sourceforge.net>
- Inger, R.F. & Stuebing, R.B. 2005. *A Field Guide to the Frogs of Borneo*. 2nd Ed. Kota Kinabalu: Natural History Publications.
- Inger R.F., Voris, H.K. & Walker, P. 1985. A key to the frogs of Sarawak. *Sarawak Museum Journal* XXXIV (55): 161-182.
- Jennisons M.D. & Petrie, M. 1997. Variation in mate choice and mating preferences. A review of causes and consequences. *Biological Review* 72: 283-327.
- Lardner B. & Lakim, M. 2004. Female call preferences in tree-hole frogs: Why are there so many unattractive males. *Animal Behaviour* 68: 265-272.
- Leong T.M., Matsui M., Yong H.S. & Abdul Hamid A. 2003. Revalidation of *Hylarana laterimaculata* Barbour et Noble, 1916 from the synonym of *Hylarana baramica* Boettger, 1901. *Current Herpetology* 22(1): 17-27
- Littlejohn M.J. 2001. Pattern of differentiation in temporal properties of Acoustic signals of anurans. In *Anuran Communication* edited by Michael J. Ryan Smithsonian Institution Press. Washington. pp. 102-120.
- Malkmus R., Manthey U, Vogel G., Holmann, P. & Kosuch, J. 2002. *Amphibians and Reptiles of Mount Kinabalu (North Borneo)*. A.R.G. Gantner Verlag K.G.
- Matsui, M 1997. Call characteristics of Malaysian *Leptolalax* with a description of two new species (Anura: Pelobatidae). *Copeia* 1997 : 158-165.
- Ramlah Z., Rahman M.A., Badrul M.Z., Shukor M.N., Norhayati A. & Inger, R.F. 2009. Ciri-ciri panggilan Katak Borneo (Genus: *Hylarana*) dari Populasi Sarawak, Malaysia. *Sains Malaysiana* 38(5): 619-624.
- Ryan M.J., Rand A.S. & Weight L.A. 1996. Allozyme and advertisement call variation in the túngara frog, *Physalaemus pustulosus*. *Evolution* 50: 2435-2453.
- Sullivan B.K., Ryan M.J. & Verrel P.A. 1996. Female choice and mating system structure. In *Amphibian Biology*, Vol. 2. *Social Behavior*, ed. by H. Heatwole and Sullivan, B.K. Chipping Norton Australia: Surrey Beatty and Sons.
- Straughan I.R. 1975. An analysis of the mechanisms of mating call discrimination in the frogs *Hyla regilla* and *H. cadaverina*. *Copeia* 1975: 415-424.
- Ramlah Zainudin, Mustafa A. Rahman
Jabatan Zoologi
Fakulti Sains dan Teknologi Sumber
Universiti Malaysia Sarawak
94300 Kota Samarahan
Sarawak
Malaysia

Badrul Munir M. Zain, M. N. Shukor, A. Norhayati*
Pusat Pengajian Sains Sekitaran dan Sumber Alam
Fakulti Sains dan Teknologi
Universiti Kebangsaan Malaysia
43600 UKM Bangi, Selangor D. E.
Malaysia

R. F. Inger
The Field Museum of Natural History
1400 South Lake Shore Drive
Chicago, Illinois
60605 USA

*Corresponding author; email: noryati@ukm.my

Received: 17 March 2009
Accepted: 19 October 2009