JOURNAL OF TROPICAL BIOLOGY AND CONSERVATION 9(1) : 27 – 34, 2012

Research Article

Diversity of frogs and their microhabitats in the riparian area of Mahua and Ulu Kimanis Substations, Crocker Range Park, Sabah, Malaysia

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ABSTRACT. This study presented the diversity of frog species living in the riparian area at two substations in Crocker Range Park (CRP): Mahua and Ulu Kimanis substations. The microhabitat information of each species was also recorded. Sampling had been carried out from September 2008 to January 2009 and the specimens were collected along eight transects by using Visual Encounter Survey (VES) and hand-grabbing technique.The process of collecting and recording of data, were carried out according to the standard method. A total of 30 species of frogs had been collected along with their substrates and microhabitat information. The Simpson Diversity Index (Ds) for Mahua Substation was slightly higher than in Ulu Kimanis and the substrate of green leaves was found to be the most preferred microhabitat for frogs.

Keywords: Species diversity, riparian, Mahua, Ulu Kimanis, microhabitat.

INTRODUCTION

Frogs are the most diverse and abundant group of amphibians, occurring in all terrestrial and freshwater habitats. Their locomotion, feeding diet and reproductive specialization enable frogs to explore almost any habitat, which range from tropics to sub-arctic regions, but most are found in tropical rainforests (Beebee, 1996; Duelman & Trueb, 1994; Hickman *et al.*, 2006). In such complex habitats, the specific location an individual frog species occurs is known as a microhabitat (Inger, 1994).

The Crocker Range Park (CRP) is located at the southern section of the Crocker Range in Northwest Borneo, Sabah, Malaysia. The park is the largest gazetted terrestrial Park and protected area in Sabah.The vegetation in the park consists of primary and old secondary forests. Due to its variety of habitats, CRP has been the subject of numerous studies that include frogs (Ramlah *et al.*, 2001; Kueh *et al.*, 2004; Das, 2006). These studies were mainly concerned with species diversity and refuge of frogs in CRP. However, very little published information is available on the microhabitat of frogs in the park.

Riparian systems are transitional semi-terrestrial areas regularly influenced by freshwater. These systems are usually high in biodiversity and extend from the edge of water bodies to the edge of upland communities (Naiman *et al.*, 2005), which consist of land immediately alongside small streams and rivers including riverbanks; areas which surround lakes and wetlands and river floodplains that interact with the river in times of flood (Nagle, 2003). A stream is a small narrow river or brook, while a river is a large natural stream of water flowing in a channel towards the sea.This paper presents the

Received 11 July 2011. Revision accepted 14 October 2011

diversity of frogs and their microhabitats in the riparian area at two substations in CRP and their microhabitat preference.

METHODOLOGY

Study sites

CRP located at the West Coast of Sabah (139, 919 ha) is a valuable natural asset of the state as it is the largest protected area in Sabah (Figure 1). It is also known as the "Backbone of Sabah". CRP has variation of altitude between 300 - 1,900 m above sea level (Inger *et al.*, 2000).

In this study, frog specimens were collected from two sites: Mahua Substation (05° 07'- 27.0° 0' N, 115° 56'-30.8° 0' E) and Ulu Kimanis Substations (05° 30'-19.6° 0' N, 116° 08'-24.2° 0'E) as shown in Figure 1. The Mahua Sub station is a secondary forest consisting of lower montane vegetation (1,000 m a.s.l) whereas Ulu Kimanis is a primary

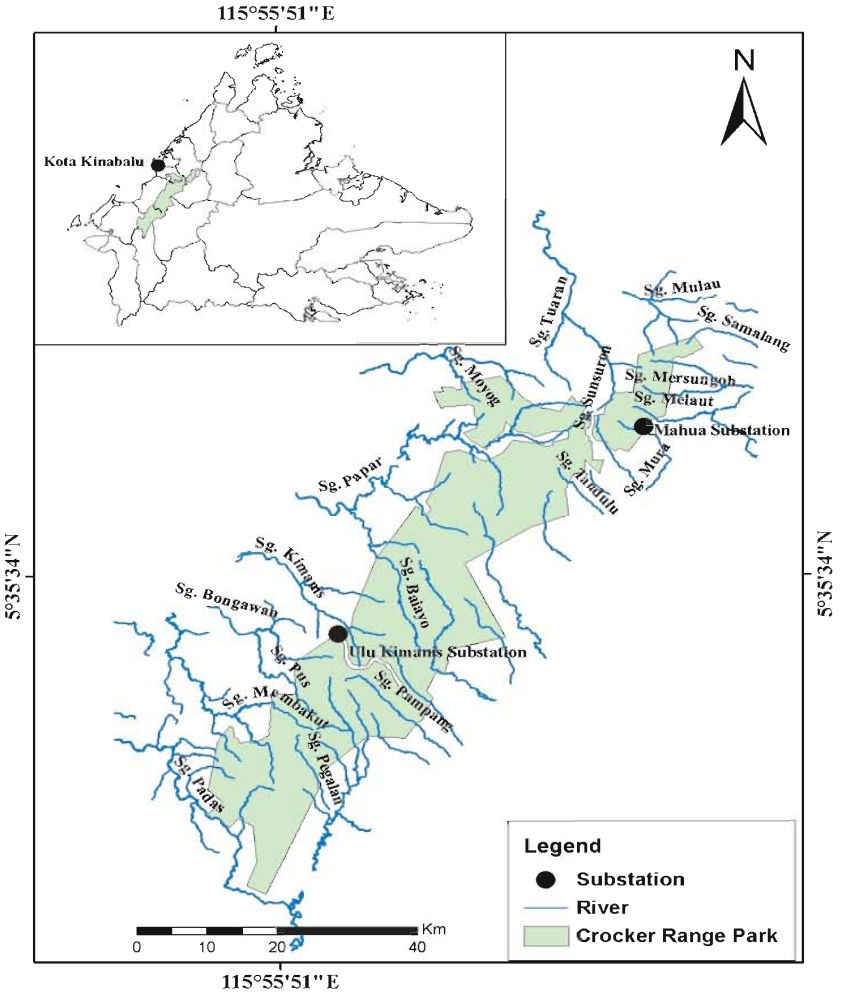


Figure 1. Map of Sabah showing the location of Crocker Range Park and the study sites of Mahua and Ulu Kimanis substations.

forest consisting of lowland forest vegetation (600 m a.s.l). The average temperature at both sites is around 23°C and 27°C, respectively.

Sampling methods

Studies were carried out in multiple visits from September 2008 to January 2009 and most visits coincided with wet periods over several days. A total of eight 250 m transects were established along streams.

Visual Encounter Survey and hand-grabbing technique (Heyer *et al.*, 1994; Matsui, 2006) were applied throughout the study. Live frogs were placed in separate plastic bags accordingly while important details such as date and time of capture, microhabitat, and weather data were recorded on prepared data sheets (Inger & Voris, 1993; Voris & Inger, 1994). All of the specimens collected were processed the following day. The specimens were killed using chlorobutanol, fixed in 10% formalin, and subsequently transferred to 70% ethanol for long-term preservation.The identification of frog specimens was carried out using the key of Inger and Stuebing (2005) assisted by species description and photographs.

RESULTS AND DISCUSSION

Species diversity

A total of 258 frogs from 30 species were collected throughout this study (Table 1). They consisted of 14 genera from five families (Bufonidae, Megophryidae, Microhylidae, Ranidae and Rhacophoridae). There were 154 frogs from 14 species collected from Ulu Kimanis substation, while, 104 frogs from 20 species were collected from Mahua Substation.

The Ranid was the most dominant frog obtained in this study (12 species), followed by Bufonids, Megophryids and Rhacophorids (five species, each). There were only three species of Microhylids. In Mahua Substation, the most dominant species found was *Ansonia hanitschi* (26.9%), followed by *Meristogenys orphnocnemis* (26%) forming half of the numbers of individuals found (Figure 2). The most dominant species found in Ulu Kimanis was *Staurois natator* (28.6%), followed by *Ansonia longidigita* (20.1%) and *Staurois* sp. (16.2%), which combined (64.9%) formed approximately 2/3 of the number of individuals found in Ulu Kimanis.

Overall, the most dominant species found were *Staurois natator* and *Ansonia longidigita* (17.1%), followed by *Meristogenys orphnocnemis* (12.4%), *Ansonia hanitschi* (10.9%) and *Staurois* sp. (9.7%). Frog species that appeared at both sites were *Ansonia longidigita, Meristogenys orphnocnemis, Limnonectes kuhlii,* and *Megophrys nasuta.* Species recorded only in Mahua Substation were *Limnonectes finchi, Staurois tuberilinguis, Meristogenys kinabaluensis, Meristogenys whiteheadi, Fejervarya limnocharis, Huia cavitympanum, Rana picturata, Ansonia hanitsci, Pedostibes rugosus, Leptobrachella baluensis, Leptobrachella* sp., *Leptolalac pictus, Polypedates leucomystax, Polypedates macrotis, Philautus aurantium,* and *Kalophynus pleurostigma.* Species recorded only in Ulu Kimanis were *Staurois latopalmatus, Staurois natator, Staurois* sp., *Ansonia platysoma, Ansonias pinulifer, Leptobrachella parva, Philautus hosii, Philautus* sp., *Kalophrynus* sp., and *Metaphrynella sundana.*

The Simpson Diversity Index (Ds) at Mahua Substation was 0.9739 and at Ulu Kimanis it was 0.9390. However, there was no significant difference of species diversity between the Mahua and Ulu Kimanis substations (Mann-Whitney U, $Z=-1.862$, $p>0.05$).

Microhabitat selection of frogs in CRP

There were four groups of microhabitats namely vegetation, rocky area, soil and forest litter, each of which consisted of different substrates. From the result, a total of 225 individual frogs were found in vegetation,

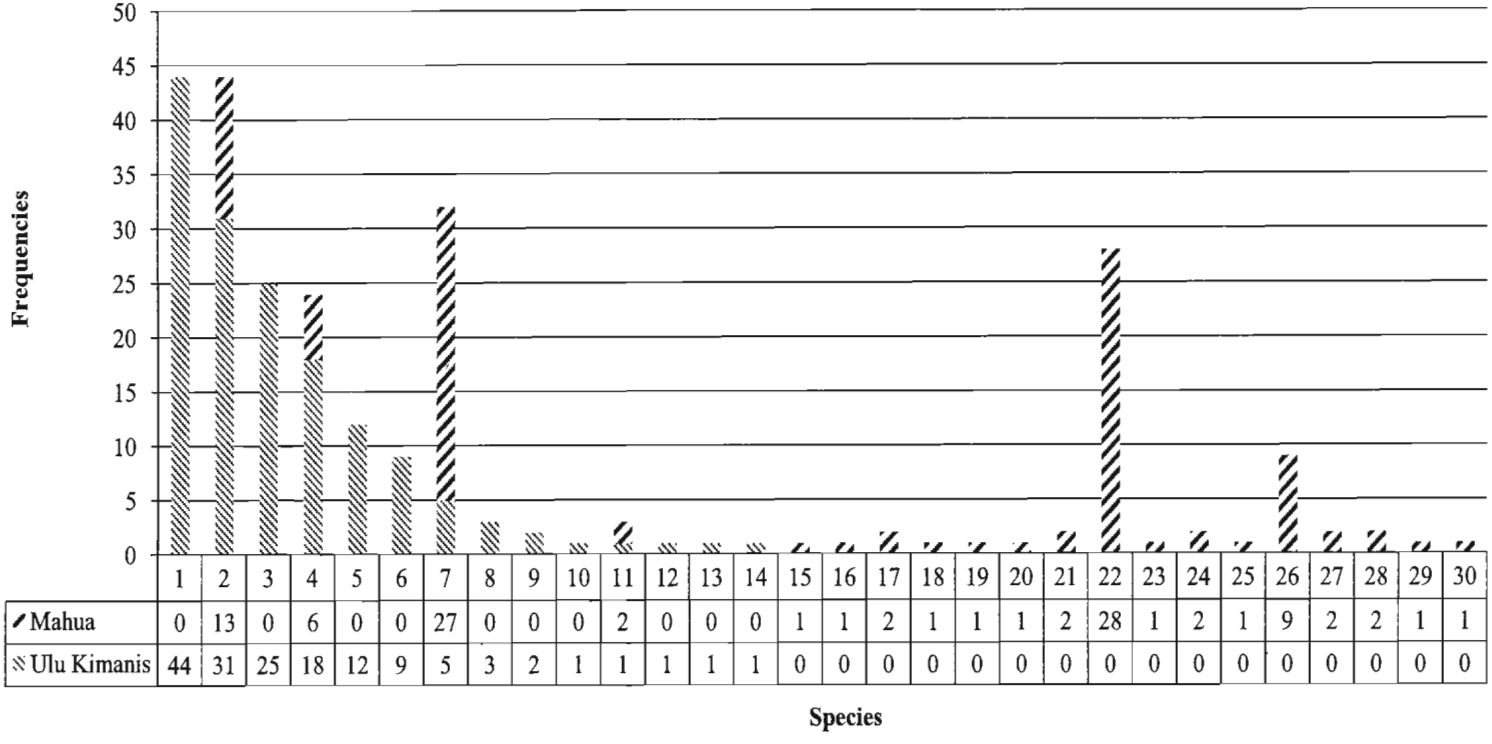
including 222 that were found on green leaves (Table 2). Sixteen individual frogs were found in forest litter of which 10 were found on leaf litter. Twelve individual frogs were found in rocky areas where eight of them were found on boulders higher than 256 mm. There were only five individual frogs found on soil component, all of them found on sandy areas (Table 2). The proportion and distribution of frogs found according to the types of substrates in each microhabitat are illustrated in Figure 3.

Green leave substrate was found to be the most preferred vegetation for frogs due to the presence of food sources. Insects likely fly around on the surface of green leaves. Frogs have a wide range of diet and this includes many types of insects such as arthropods, ants,

Table 1. Number of individuals and species of frogs caught from the study sites at Mahua and Ulu Kimanis substations, CRP Sabah.

Family	Species	Ulu Kimanis	Mahua	Total
Ranidae	**Limnonectes kuhlii*	18	6	24
	Limnonectes finchi	0	1	1
	Staurois latopalmatus	3	0	3
	Staurois natator	44	0	44
	Staurois tuberilinguis	0	1	1
	Staurois sp.	25	0	25
	**Meristogenys orphnocnemis*	5	27	32
	Meristogenys kinabaluensis	0	2	2
	Meristogenys whiteheadi	0	1	1
	Fejervarya limnocharis	0	1	1
	Huia cavitympanum	0	1	1
	Rana picturata	0	2	2
Bufonidae	**Ansonia longidigita*	31	13	44
	Ansonia platysoma	9	0	9
	Ansonia spinulifer	1	0	1
	Ansonia hanitschi	0	28	28
	Pedostibes rugosus	0	1	1
Megophryidae	**Megophrys nasuta*	1	2	3
	Leptobrachella parva	12	0	12
	Leptobrachella baluensis	0	2	2
	Leptobrachella sp.	0	1	1
	Leptolalac pictus	0	9	9
Rhacophoridae	*Polypedates leucomystax*	0	2	2
	Polypedates macrotis	0	2	2
	Philautus hosii	2	0	2
	Philautus aurantium	0	1	1
	Philautus sp.	1	0	1
Microhylidae	*Kalophrynus pleurostigma*	0	1	1
	Kalophrynus sp.	1	0	1
	Metaphrynella sundana	1	0	1
Total		154	104	258

* Species that occurs at both study sites.



	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
Mahua	0	13	0	6	0	0	27	0	0	0	2	0	0	0	1	1	2	1	1	1	2	28	1	2	1	9	2	2	1	1
Ulu Kimanis	44	31	25	18	12	9	5	3	2	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Figure 2. The frog species 1.*Staurois natator,* 2.**Ansonia longidigita,* 3.*Staurois* sp., 4.**Limnonectes kuhlii,* 5.*Leptobrachella parva,* 6.*Ansonia platysoma,* 7.**Meristogenys orphnocnemis,* 8.*Staurois lato palmatus,* 9.*Philautus hosii,* 10.*Ansonia spinulifer,* 11.**Megophrys nasuta,* 12.*Philautus* sp., 13.*Kalophrynus* sp., 14.*Metaphrynella sundana,* 15.*Limnonectes finchi,* 16.*Staurois tuberilinguis,* 17.*Meristogenys kinabaluensis,* 18.*Meristogenys whiteheadi,* 19.*Fejervarya limnocharis,* 20.*Huia cavitympanum,* 21.*Rana picturata,* 22.*Ansonia hanitschi,* 23.*Pedostibes rugosus,* 24.*Leptobrachella baluensis,* 25.*Leptobrachella* sp., 26.*Leptolalac pictus,* 27.*Polypedates leucomystax,* 28.*Polypedates macrotis,* 29.*Philautus aurantium,* and 30.*Kalophrynus pleurostigma,* that occur in Ulu Kimanis and Mahua substations.

Table 2. Microhabitat selection of frogs along with their substrate

Microhabitat	Keys	Substrate	No of Individuals
Vegetation	a	Green leaves	222
	b	Bough of vegetation	0
	c	Stem of vegetation	2
	d	Root of vegetation	1
		Subtotal	255
Rocky location	e	Gravel (2-6mm)	2
	f	Coble (64-256mm)	2
	g	Boulder (>256mm)	8
		Subtotal	12
Soil	h	Clay (<0.002mm)	0
	i	Silt (0.002-0.05mm)	0
	j	Sand (0.05-2.00mm)	5
		Subtotal	5
Forest litter	k	Leaflitter	10
	l	Rotten twig	1
	m	Dead stump (diameter >10mm)	5
	n	Dead vegetation (diameter <10mm)	0
		Subtotal	16
Total			258

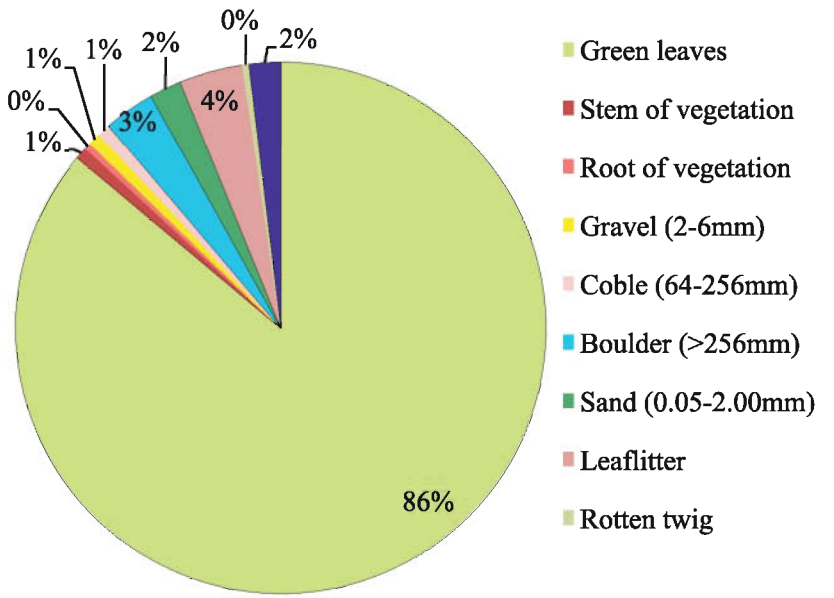


Figure 3. The substrate where frogs were found during the survey.

beetles, dipterans and spiders. This is in line with findings that frogs are likely to eat any insects that surround their habitats (Hirai & Matsui, 2002).

Gravel substrate had been selected as the most preferred rocky area for *Polypedates leucomystax* and *Fejervarya limnocharis*. Both of these frogs typically live near human populated areas such as playgrounds, gardens or paddy fields, while *Limnonectes kuhlii* typically live in riparian areas and selects substrates of coble and boulder as its microhabitat. *Staurois latopalmatus* had been found in cobble and they typically like to select large dimensional rocks to perch on (Inger & Stuebing, 2005).

Soil substrate was selected as a microhabitat by *Limnonectes kuhlii*, *Leptolalax pictus* and *Huia cavitympanum*; soil was the main substrate at the surrounding of the sampling area. Frogs also take the opportunity to dig out and forage on soil macro fauna (Vonesh, 2001). Soil also serves as an ideal environment for camouflage providing cryptic colouration to blend with the colours of frogs.

The leaflitter also served suitable thermoregulation control for frogs by insulating them from extreme temperatures. When the temperature drops, frogs hide themselves in leaflitter to increase their body temperature, or vice versa. Leaflitter also provides food supply for frogs. This fact is well indicated among *Kalophrynus pleurostigma* which feeds on ants and termites (Inger & Stuebing, 2005). Leaflitter might also offer an ideal environment for frogs to camouflage by blending their skin colour with the leaflitter colour.

CONCLUSION

There were 258 individuals from 30 species of frogs that were found at the Mahua and Ulu Kimanis substations, CRP. Mahua Substation recorded 20 species with 104 individuals frogs while Ulu Kimanis recorded 14 species with 154 individuals. Simpson Diversity Index at Mahua Substation (Ds=0.9739) was higher than at Ulu Kimanis (Ds=0.9390). There were some factors that affected the differences of frog composition at the Mahua and Ulu Kimanis substations such as altitude and stream size.

Substrate of green leaves was the most preferred site (86.05%), followed by leaflitter (3.88%), boulders (3.1%), dead stumps and sand (1.94%), and others (3.09%). However, some substrates were not frequented by any frog species in this study such as bough of vegetation, clay silt and dead/dry vegetation. This may due to several factors, including thermoregulation behaviour, availability of food and escape routes from predators.

ACKNOWLEDGEMENTS

The authors are very thankful to the Director of the Institute for Tropical Biology and Conservation (ITBC) and Sabah Parks for the opportunity to carry out this research. We extend our gratitude to field assistants from Sabah Parks who worked with us in the field. Thanks to Ms. Azniza Mahyudin for the accommodation and transportation arrangement. This work was partly funded by ITBC, for which we are grateful.

REFERENCES

Beebee, T.J.C. 1996. *Ecology and conservation of amphibians*. London: Chapman and Hall, pp. 132-180.

Duelman, W.E. & L. Trueb. 1994. *Biology of Amphibians*.London: The Johns Hopkins University Press.

Das, I. 2006. Crocker Range National Park, Sabah, as a refuge for Borneo's montane herpetofauna. *Amphibian and Reptile Conservation* 4(1): 3-11.

Heyer, W.R., M.A. Donnelly, R.W. McDiarmid, L.C. Heyek & Foster, M.S (eds). 1994. *Measuring and monitoring biological diversity, standard methods for amphibian.* Library of Congress Cataloging-in-Publication Data. Smithsonian Institution, pp. 41-73.

Hickman, C.P. Jr., L.S. Roberts, A. Larson, H. I'Anson & D.J. Eisenhour. 2006. *Integrated principles of zoology.* (13th ed.). New York: McGraw-Hill Companies, pp. 527-567.

Hirai, T. & M. Matsui. 2002. Food habits of an endangered Japanese frog, *Rana porosabrevipoda.*

Ecological Research 16 (4): 737–743.

Inger, R.F. & H.K. Voris. 1993. A comparison of amphibian communities through time and from place in Bornean forests. *Journal of Tropical Ecology* 9: 409-433.

Inger, R.F. & R. Stuebing. 2005. *A field guide to the frogs of Borneo.* Kota Kinabalu: Natural History Publications (Borneo).

Inger, R.F. 1994. Microhabitat Description. In: Heyer, W.R., M.A. Donnelly, R.W. McDiarmid, L.C. Heyek & M.S. Foster. (eds.). *Measuring and monitoring biological diversity, standard methods for amphibian.* Library of Congress Cataloging-in-Publication Data. Smithsonian Institution, pp. 60-63.

Inger, R.F., F.L. Tan & P. Yambun. 2000. The frog fauna at three parks in Sabah Malaysia-Kinabalu Park, Crocker Range Park and Tawau Hills Park. *Sabah Parks Nature Journal* 3: 7-28.

Kueh, B.H., Ahmad Sudin, M. Matsui & Maryati Mohamed. 2004. Notes on the anurans of Crocker Range Park. In: Maryati Mohamed, Zulhazman Hamzah, T. Tachi & J. Nais. (eds.). *CrockerRange Scientific Expedition 2002.* Kota Kinabalu: Universiti Malaysia Sabah, pp. 103-112.

Matsui, M. 2006. Collecting and preserving amphibians. In: Hashimoto, Y., R. Homathevi & Maryati Mohamed (eds.). *Inventory and collection: Total protocol for understanding biodiversity.* (2nd ed.). Kota Kinabalu: Institute for Tropical Biology and Conservation, UMS and Japan International Cooperation Agency (JICA), pp. 175-181.

Nagle, G. 2003. *Access to geography-rivers and water management.* London: Hodder & Stoughton.

Naiman, R.J., H. Décamps & M.E. McClain. 2005. *Riparia, ecology, conservation, and management of streamside communities.* California: Elsevier Academic Press.

Ramlah Zainudin, Lizanah Wasly & Haidar Ali. 2001. An account of anuran at Crocker Range National Park, Sabah. In: Ismail, G. &L. Ali. (eds.). *A Scientific Journey through Borneo. Crocker Range National Park, Sabah. Volume 1. Natural ecosystem and species components.* London: ASEAN Academic Press, pp. 137-146.

Vonesh, J.R. 2001. Patterns of richness and abundance in a tropical African leaf-litter herpetofauna. *Biotropica* 33 (3): 502-510.

Voris, H.K. & R.F. Inger. 1994. Frog abundance along streams in Bornean forests. *Journal of Conservation Biology* 9(3): 679-683.