COLLECTION, MANAGEMENT AND UTILIZATION OF ANURAN SPECIMENS AND DATA FOR CONSERVATION

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ABSTRACT. - Conservation of biodiversity, an imperative component of natural resources, requires systematic and extensive collection, management and utilization of specimens and data. Anurans (Amphibia: Anura) or simply frogs and toads, deserve the long overdue serious attention in conservation efforts because of its multifarious and indispensable roles in the environment. Inventory-based studies on anurans were intensified by the Institute for Tropical Biology and Conservation (ITBC), Universiti Malaysia Sabah (UMS) since 2000. In 2000, collection was undertaken at north-eastern Tabin Wildlife Reserve, in 2001 at the vicinities of Agathis Camp, southern Maliau Basin Conservation Area as well as Trus Madi, in 2002 at Crocker Range Park and in 2003 at Pulau Banggi as well as Lower Segama. A total of 59 species of anurans representing all five families in Sabah were collected. Ten species were from Bufonidae, five species from Megophryidae, seven species from Microhylidae, 21 species from Ranidae and 16 species from Rhacophoridae. Anuran specimens were preserved and deposited at BORNEENSIS, ITBC, UMS while respective data are being digitalized into a specialized Collection Data Management System: MUSEBASE. MUSEBASE; an accommodating software to store and manage large sets of collection data in both text and multimedia formats, enables efficient data retrieval and effective data sharing globally. Anuran specimens and data properly managed are invaluable for long term scientific references, environmental education such as through 'ITBC Frog Museum' and innovative utilization via nature tourism ('Anurans Tourism'), all towards conservation of biodiversity to achieve environmental sustainability in the 21st Century.

Key words: *Anurans, collection, management, utilization, specimens and data, conservation*

INTRODUCTION

Conservation of biodiversity is becoming increasingly significant. Biodiversity: genetic, species and ecosystem variety and variability, is an imperative component of natural resources besides minerals, energy, land and water. Biodiversity proffers essential ecological services in gaseous and nutrients cycles, groundwater retention, climatic regulation and interspecies equilibrium, as well as food, medicines, commodities and venues for recreation. However, the erosion of biodiversity is accelerating, mainly due to the exponential explosion of human population over the years (e.g., Chantavong, 1998; Chou et al., 1998; Claveria & Cruz, 1998; Ghazally et al., 1998; Khim & Barom, 1998; Latiff & Zakri, 1998; Martinah et al., 1998; Napompeth & Rodcharoen, 1998; Soleh & Rokhmin, 1998). The growing human population demands more goods and services

besides basic needs and hence, putting more pressure on the already overwhelmed biodiversity. Eventually, such a phenomenon shall dictate the destruction of humans too.

Conservation of biodiversity requires systematic and extensive collection, management and utilization of biological specimens and data. Feasible conservation has to be substantiated by comprehension of the composition of biodiversity that prescribes the best strategies (e.g., Stuebing, 1998; Stuebing & Wong, 2000; Inger, 2003; Ng, 2005) for restoration, maintenance, monitoring and sustainable usages.

ANURANS

Anurans (Amphibia: Anura) are tailless amphibians or simply frogs and toads. Depending on the vertebrae, anurans in Borneo are categorized into six families, namely Bombinatoridae, Bufonidae, Megophryidae, Microhylidae, Ranidae and Rhacophoridae. Presently, there are 32 genera and approximately 150 species. Close to 100 species can be found in Sabah.

Anurans deserve the long overdue serious attention in conservation efforts because of the multifarious and indispensable roles in the environment. Anurans form a crucial part of environmental food webs. Being herbivores feeding on microscopic plants and fungi as tadpoles, except for *Hoplobatrachus rugulosus* that is known to feed on other tadpoles too (Inger & Stuebing, 1997), and carnivores feeding largely on ants, termites, invertebrates and even other anurans, small lizards, small crustaceans, small snakes, small birds and small mammals, anurans become primary, secondary and tertiary users. The niche as predators of insects and invertebrates also enables anurans to be biological control agents for agricultural pests. This anuran-man relationship reduces the dependence of planters on chemical pesticides which pollute and kill the environment. Anurans are good bioindicators to indicate environmental health as well. Anurans possess permeable skin for water to travel freely from both directions for water intake and keeping the skin moist for breathing. Such a characteristic, coupled with the semi-aquatic lifestyle, make anurans capable of detecting the slightest existence of pollutants in water sources causing abnormality and total disappearance.

COLLECTION OF ANURAN SPECIMENS AND DATA

(A) Collection of anuran specimens

The collection of anuran specimens through inventory-based studies were intensified by Institute for Tropical Biology and Conservation (ITBC), Universiti Malaysia Sabah (UMS) since 2000. The inventory-based studies were undertaken during various scientific expeditions organized by ITBC as UMS' centre of excellence on terrestrial biology. ITBC was set up on 1st June 1996 as Tropical Biology and Conservation Unit and upgraded to an institute on 1st June 1999. In June 2000, ITBC registered her second postgraduate student researching on anurans who studied the application of biogeographical data of anurans for conservation area prioritization in Borneo by using WORLDMAP Programme (Kueh, 2003) and in July 2003, employed the student as her first herpetologist upon his convocation.

In 2000, collection was undertaken at north-eastern Tabin Wildlife Reserve on 16th – 22nd October 2000 for seven nights during the wet season. A total of 14 species were recorded from four families (Kueh & Maryati, 2003) as shown in Table 1. A new addition to the anuran inventory of the wildlife reserve was made during the collection:

Metaphrynella sundana (Kueh & Maryati, 2003; Kueh, 2005). This secretive species is endemic to Borneo.

In 2001, collections were conducted at Agathis Camp, southern edge of Maliau Basin Conservation Area, and Trus Madi. At Agathis Camp, collection was done on 12th – 14th May 2001 for three nights and sampled eight species from three families (Kueh & Maryati, 2005) (Table 1). Seven of the species are endemic to Borneo. At Trus Madi, collection carried out on 30th October – 4th November 2001 for five nights recorded 11 species representing five families (Kueh, 2004a) (Table 1). Eight of the species are endemic to Borneo with two which are endemic to Sabah, namely *Philautus bunitus* and *Rhacophorus angulirostris*.

The following year, collection was undertaken at Crocker Range Park on 26th August – 12th September 2002 and amassed specimens from 46 species (excluding unidentified species) and five families (Kueh et al., 2004) (Table 1). The number of species collected was the largest ever from a single collection by ITBC. Besides, the collection added 16 new locality records to the inventory of the park (Kueh, 2005).

In 2003, premier collections were carried out for Pulau Banggi and Lower Segama. At the former locality, collection was done on 25th July – 2nd August 2003. Six species representing three families were sampled (Kueh, in press) (Table 1). Two species: *Microhyla borneensis* and *Limnonectes leporinus*, are endemic to Borneo. At the latter locality, collection was conducted on 17th – 26th September 2003 for 10 nights. A total of 15 species from three families were sampled (Kueh & Yambun, in press) (Table 1). Two species are endemic to Borneo, namely *Microhyla borneensis* and *Rhacophorus harrissoni*.

Accumulatively, 59 species representing all five families in Sabah were recorded from the collections (Table 1). Ten species were from Bufonidae, five species from Megophryidae, seven species from Microhylidae, 21 species from Ranidae and 16 species from Rhacophoridae. The percentage of representation of the total species for each family by the number of species sampled varies from 26.3% to 53.8% (Fig. 1). Hence, the number of species sampled represents approximately 39% of the currently described species in Borneo.

(B) Collection of anuran data

Data on the specimens were yielded during collections and recorded manually. Manual records are without the risk of being spoiled in the field as compared to electronic and digital versions and therefore, preferred (Matsui, 2003). Specimens are only half of its value without proper records that hold crucial data (Kueh, 2004b). These data are scientific name, family, date of collection, locality (name and GPS coordinate), altitude, microhabitat where the specimen was sampled, behaviour of the anuran when located, method of collection, snout-vent length (SVL), weight, collector, identifier, specimen number (BORNEENSIS number) and notes (for miscellaneous data such as the vernacular name, development stage, known ethnozoological usages and identification features).

Besides text data, multimedia data are imperative as well. Photographs, video footages and audio recordings are utmost useful to record, especially the colour of the specimens before preservation, anuran postures, anuran pupils (colour, size and shape), localities (habitats and microhabitats) and anuran calls.

MANAGEMENT OF ANURAN SPECIMENS AND DATA

(A) BORNEENSIS

Anuran specimens collected were preserved in 70% ethanol as wet specimens and deposited in the Vertebrate Collection Room, BORNEENSIS. BORNEENSIS is the reference collection centre for ITBC which gather and store dead and live specimens as well as related data of Bornean biodiversity, particularly from Sabah (Maryati & Mohd. Fairus, 1998; Ahmad & Maryati, 1999). Besides anurans, BORNEENSIS houses specimens of lower plants, invertebrates and other vertebrates in four collection rooms. Shouldering two of the major onuses that are to promote the importance of taxonomy in conservation and build up of local and regional capacity in taxonomy, BORNEENSIS is anticipated to preponderate both in specimens and data collection as well as national and international recognition as a centre for biosystematics and taxonomy. Inevitably, BORNEENSIS has been and shall always be a pride of ITBC, but is for all who strive for biodiversity conservation.

(B) MUSEBASE

Text and multimedia data of anurans are being digitalized into a specialized Collection Data Management System: MUSEBASE, at ITBC. MUSEBASE is a software specially developed by Fujitsu (Japan) for ITBC and acquired via Japan International Cooperation Agency (JICA) under the 'Bornean Biodiversity and Ecosystems Conservation (BBEC) Programme in Sabah, Malaysia'. The software is a modification of MUSETHEQUE that is widely used by museums and galleries in Japan. With the installation of four licenses at ITBC on 5th September 2003, MUSEBASE, a brainchild of the second author as the Director of ITBC cum Head of Research and Education Component under the BBEC Programme, was made ready to be utilized and entrusted to the coordination under the first author as MUSEBASE Project Manager.

MUSEBASE is an accommodating software to store and manage large sets of collection data for efficient data retrieval and effective data sharing globally. Data are registered through user-friendly Collection Data Registration procedures. Pre-existing or new data in Excel format can be uploaded into MUSEBASE too by converting the data into a Comma Separated Value (CSV) file. Multiple multimedia data can be registered for a single registration. All data digitalized are stored in a Database Server. The entire database is searchable but only by permitted personnel as set by the institution under the User Authority Management. Therefore, data are definitely secured from unscrupulous parties even from the same institution. Thus far ITBC has digitalized about 17,000 data into MUSEBASE. Specimen labels and barcodes are automatically produced by the software for each registration to replace hand-written labels and for convenient data retrieval for every specimen by simply scanning respective barcode. Various reports on daily, weekly, monthly or yearly data registration and total data registration can be prepared by the software through its Statistics Management and printed out either in HTML or PDF format.

MUSEBASE is also furnished with Schedule Management and Lending Management operations. Schedule Management assists users to plan and monitor the utilization of specimens within own institution while Lending Management deals with lending of specimens to other institutions. Both functions allow users to record the purpose, date, duration and venue of specimen utilization as well as the personnel and

institution concerned. Reminders can be pre-prepared and sent to the decided recipient(s) on pre-determined date by e-mails.

As for data sharing, the software comes with Web Site Management. A web site is automatically generated by the software to display authorized data through a Web Server. The display of data is strictly in adherence with the permission granted by each user through the Release Flag application. Data given the limited status during registration absolutely do not appear in the web site while those indicated as unlimited are viewable in the internet. The data are searchable in the Collection Search page via three methods: simple, detailed and classified search. The other pages of the web site are News, Museum Info, What's New, Floor Plans, Feedback, Site Map and URL Links. The web site address for ITBC MUSEBASE is http://itbcmuse.ums.edu.my.

UTILIZATION OF ANURAN SPECIMENS AND DATA

Anuran specimens and data collected and properly managed are invaluable for numerous utilizations towards biodiversity conservation. Three types of utilization are highlighted in this paper, namely for scientific references, environmental education (EE) and 'Anurans Tourism'. These utilizations aim to proffer holistic conservation approach encompassing the scientific community, general public, local people and international society.

Anuran specimens and data, similarly for any other biological specimens and data, are immensely needed for long term scientific references in a wide spectrum of researches and conservation area management. These range from researches on taxonomy and biogeography to molecular biology and biodiversity advancement as well as from conservation area prioritization to the enforcement of conservation area and wildlife management legislations. Even under the present progression of DNA technologies, genetic knowledge must be complemented with specimens that bear morphological and anatomical information as well as text and multimedia data which record the ethological, ethnobiological and habitat information.

At ITBC, anuran specimens and data have been utilized for the prioritization of conservation areas (Kueh, 2003). A 24-month research was conducted on Borneo by using WORLDMAP Programme (Version IV) aimed at identifying new conservation priority areas based on high species richness and range-size rarity, irreplaceability (near-minimum sets) and Gap Analyses in order to synergize the 'know-hows' of conservation with the 'know-where'. A total of 139 biogeographical data of anurans were digitalized into WORLDMAP Programme to reveal four suggested new conservation priority areas: Tubau and Sungai Mengiong in Sarawak as well as Sanggau and Kubu in West Kalimantan.

Currently, ethnozoological research is being undertaken to document traditional usages of anurans as a source of food and medicines that conduces the survivability of traditional knowledge and enhances the blooming alternative treatment sector. The ripple effect galvanizes more of the general public and local people to conserve anurans and the habitats due to the realization of the scientific, economic, social, cultural and health boons of anurans. The research not only utilizes anuran specimens and data at ITBC, but also augments the collection.

Anuran specimens and data are also being utilized for EE via 'ITBC Frog Museum'. As another brainchild of the second author, 'ITBC Frog Museum' was launched on 14th December 2003 and entrusted to the coordination under the first author as Museum Manager (I). The museum aims to make aware and educate the general local public and international visitors on the biology and importance of anurans. Threats

on the survival of anurans are exposed too to inspire visitors to love and subsequently, participate in the conservation of anurans and the habitats. The museum is a combination of anuran specimens, models, dioramas, touch screens, video show, information and data, publications and children craftworks.

Lastly is a rather unorthodox genre of utilization of anuran specimens and data which is for 'Anurans Tourism'. Nature tourism, an industry worth billions, has long been regarded as a practical contemporary remedy for the erosion of biodiversity and deterioration of the environment (e.g., Ceballos-Lascuráin, 1996). Nature tourism generates revenues to propel economic development and existing conservation efforts and at the same time, lures people from all over the globe to appreciate the biodiversity and environment to the extent that it initiates even more conservation efforts. 'Anurans Tourism' means 'responsible travel to relatively undisturbed natural areas with the intension to see, admire, enjoy and learn about anurans, including the relationships with humans in the past and at present, that eventually conserves anurans and the environment as well as sustains the well being of local people' (Kueh, 2004c). The definition captivates the descriptive and prescriptive components which comply with the definitions of both nature tourism and ecotourism provided by World Tourism Organization (WTO) and The International Ecotourism Society (TIES). Anuran specimens and data are utilized to prospect potential species and sites to be promoted under this new nature tourism product.

CONCLUSION

Conservation of biodiversity is turning more and more pertinent due to rapid erosion of biodiversity with systemic repercussions. Conservation of biodiversity requires systematic and extensive collection, management and utilization of anurans, organism group with multifarious and indispensable roles in the environment, specimens and data. Inventory-based studies on anurans were intensified by ITBC, UMS since 2000. A total of 59 species from all five families in Sabah were collected, preserved as wet specimens in BORNEENSIS and with data being stored in and managed by MUSEBASE. Anuran specimens and data have been and are being utilized for several undertakings: scientific references for researches, EE via 'ITBC Frog Museum' and 'Anurans Tourism', all towards conservation of biodiversity to achieve environmental sustainability in the 21st Century.

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TABLE 1. Collection of anuran specimens and data by Institute for Tropical Biology and Conservation (ITBC), Universiti Malaysia Sabah (UMS) since 2000.

	Tabin Wildlife Reserve	Agathis Camp	Trus Madi	Crocker Range Park	Pulau Banggi	Lower Segama
(I) Family BUFONIDAE						
(1.) *Ansonia hanitschi* Inger			✓	✓		
(2.) *Ansonia leptopus* (Günther)		✓				
(3.) *Ansonia longidigita* Inger			✓	✓		
(4.) *Ansonia platysoma* Inger				✓		
(5.) *Ansonia spinulifer* (Mocquard)				✓		
(6.) *Bufo divergens* Peters		✓				
(7.) *Bufo juxtasper* Inger		✓		✓		
(8.) *Leptophryne borbonica* (Tschudi)				✓		
(9.) *Pedostibes hosii* (Boulenger)	✓					
(10.) *Pedostibes maculatus* (Mocquard)				✓		
(II) Family MEGOPHRYIDAE						
(11.) *Leptobrachella baluensis* Smith			✓	✓		
(12.) *Leptobrachella parva* Dring				✓		
(13.) *Leptobrachium montanum* Fischer				✓		
(14.) *Leptolalax dringi* Dubois				✓		
(15.) *Megophrys nasuta* (Schlegel)				✓		
(III) Family MICROHYLIDAE						
(16.) *Chaperina fusca* Mocquard	✓		✓	✓		✓
(17.) *Kalophrynus heterochirus* Boulenger		✓		✓		
(18.) *Kalophrynus pleurostigma* Tschudi				✓		

(19.) *Kaloula baleata* (Müller)						✓
(20.) *Metaphrynella sundana* (Peters)	✓			✓		
(21.) *Microhyla berdmorei* (Blyth)						✓
(22.) *Microhyla borneensis* Parker				✓	✓	✓
(IV) Family RANIDAE						
(23.) *Fejervarya limnocharis* (Gravenhorst)	✓			✓		✓
(24.) *Ingerana baluensis* (Boulenger)				✓		
(25.) *Limnonectes finchi* (Inger)				✓		
(26.) *Limnonectes ingeri* (Kiew)	✓			✓		
(27.) *Limnonectes kuhlii* (Tschudi)	✓	✓	✓	✓	✓	✓
(28.) *Limnonectes leporinus* (Andersson)		✓		✓	✓	
(29.) *Limnonectes malesianus* (Kiew)	✓					
(30.) *Limnonectes palavanensis* (Boulenger)			✓	✓		
(31.) *Meristogenys kinabaluensis* (Inger)				✓		
(32.) *Meristogenys orpnochemis* (Matsui)				✓		
(33.) *Occidozyga baluensis* (Boulenger)	✓			✓		
(34.) *Occidozyga laevis* (Günther)	✓					✓
(35.) *Rana chalconota* (Schlegel)	✓			✓	✓	
(36.) *Rana erythraea* (Schlegel)				✓		
(37.) *Rana glandulosa* Boulenger						✓
(38.) *Rana luctuosa* (Peters)				✓		
(39.) *Rana nicobariensis* (Stoliczka)	✓					✓
(40.) *Rana picturata* Boulenger		✓				

(41.) *Staurois latopalmatus* (Boulenger)				✓		
(42.) *Staurois natator* (Günther)			✓	✓		
(43.) *Staurois tuberilinguis* Boulenger		✓	✓	✓		
(V) Family RHACOPHORUS						
(44.) *Nyctixalus pictus* (Peters)				✓		✓
(45.) *Philautus aurantium* Inger				✓		
(46.) *Philautus bunitus* Inger, Stuebing & Tan			✓	✓		
(47.) *Philautus hosii* (Boulenger)				✓		
(48.) *Philautus mjöbergi* Smith				✓		
(49.) *Philautus petersi* (Boulenger)				✓		
(50.) *Polypedates leucomystax* (Gravenhorst)				✓		
(51.) *Polypedates macrotis* (Boulenger)				✓		✓
(52.) *Polypedates otilophus* (Boulenger)	✓			✓		
(53.) *Rhacophorus angulirostris* Ahl			✓	✓		
(54.) *Rhacophorus appendiculatus* (Günther)					✓	✓
(55.) *Rhacophorus dulitensis* Boulenger	✓					✓
(56.) *Rhacophorus everetti* Boulenger				✓		
(57.) *Rhacophorus gauni* (Inger)				✓		
(58.) *Rhacophorus harrissoni* Inger & Haile			✓			✓
(59.) *Rhacophorus pardalis* Günther	✓			✓	✓	✓
Total Species	14	8	11	46	6	15

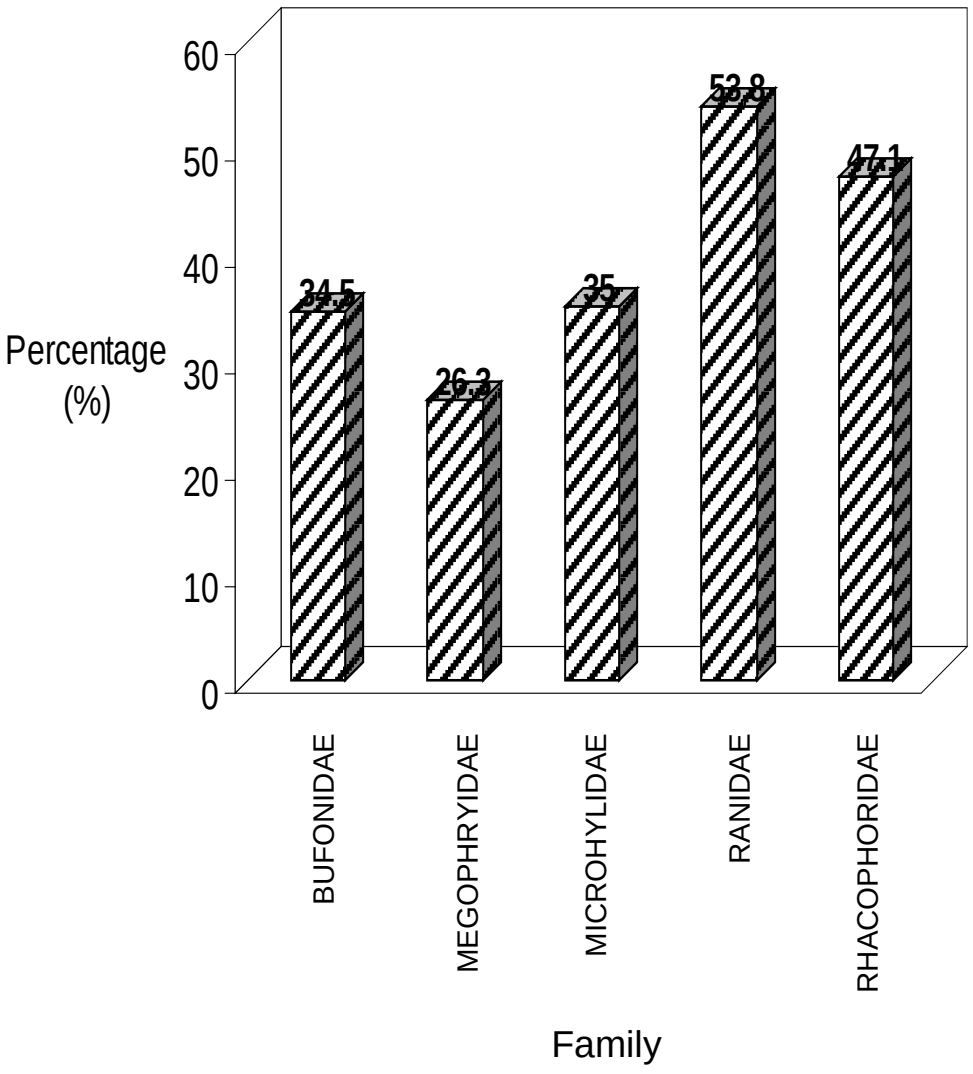

FIGURE 1. Percentage of representation of the total species for each anuran family by the number of species sampled.