

Conservation Biology of
AMPHIBIANS
OF ASIA

*Status of Conservation and Decline of Amphibians:
Eastern Hemisphere*

Edited by

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Natural History Publications (Borneo)

Kota Kinabalu

2014

Published by

Natural History Publications (Borneo) Sdn. Bhd. (216807-X)

A913, 9th Floor, Wisma Merdeka Phase 1,

P.O. Box 15566,

88864 Kota Kinabalu, Sabah, Malaysia.

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website: www.nhpborneo.com

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First published July 2014.

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This is Volume 11, Part 1, of Amphibian Biology

ISBN 978-983-812-154-5

Printed in Taiwan.

CHAPTER 18

Conservation Status of the Amphibians of Brunei Darussalam

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Abbreviations in text and references: BTPF = Bukit Teraja Protection Forest; CBD = Convention on Biological Diversity; EIA = Environmental Impact Assessment; GAA = Global Amphibian Assessment; GDP = Gross Domestic Product; HoB = Heart of Borneo Project; SICF = Sungai Ingei Conservation Forest; UTNP = Ulu Temburong National Park.

I. INTRODUCTION

Brunei Darussalam is located on the northern coast of the island of Borneo and has a total land area of 5766 km². It is divided into two disjunct regions: the districts of Brunei/Muara, Tutong, and Belait in the west and Temburong in the east (Fig. 1). The two parts are completely surrounded and separated by the Malaysian state of Sarawak. The major forest types in Brunei are (1) lowland mixed-dipterocarp rainforests, (2) peatswamp forests, (3) heath forests (Kerangas), and (4) mangrove forests (Ashton *et al.* 2003).

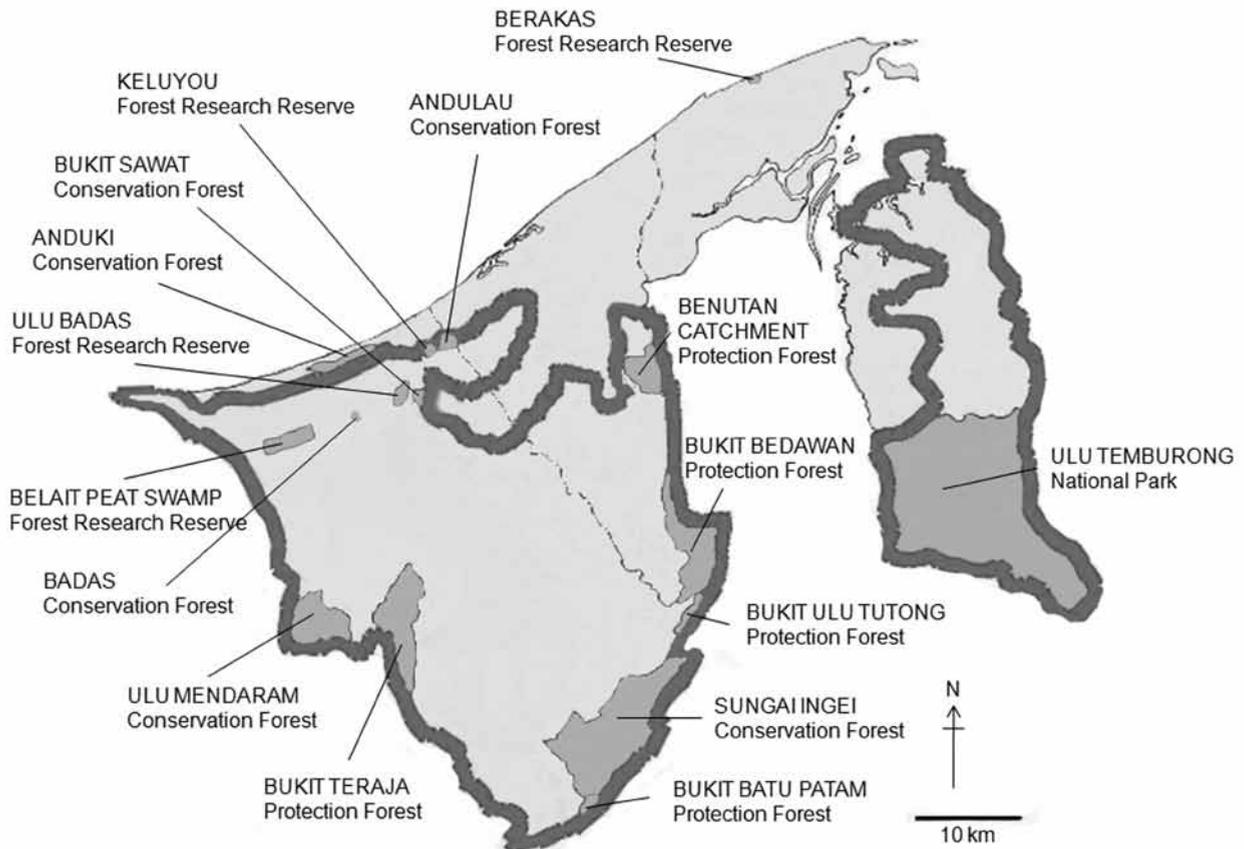


Fig. 1. Protected areas in Brunei Darussalam and the outline of the Heart of Borneo initiative (gray border). Modified from Wong and Kamariah (1999).

A. Biogeography

Brunei Darussalam lies within the Sundaland biodiversity hotspot (Myers *et al.* 2000), an area of exceptional concentrations of endemic species that is experiencing a high degree of habitat loss (Brooks *et al.* 2002). Within Borneo, 65% of amphibians are endemic, underlining the importance of the region for amphibian conservation (Inger and Stuebing 2005; Haas and Das 2010). In the western part of the country, the coastal area is characterized by alluvial, swampy plains that give way to low hills and swamps in the interior. Peatswamp forests along the basin of the Baram River, the Belait River, and the middle reaches of the Tutong River are still in a nearly pristine condition (Anonymous 2010). The dipterocarp forests cover most of the hilly country in western Brunei, rising to almost 400 m in the extreme west. The Temburong district in eastern Brunei is of particular interest as it is only sparsely populated. It harbours extensive mangrove forests and peat swamps near the coast and mixed-dipterocarp rainforests and submontane vegetation in the hilly and mountainous interior, respectively. The terrain rises to above 1500 m with Bukit Pagon on the border with Sarawak standing at 1850 m (Anonymous 2010). Temburong lies in the transitional zone of two biogeographical units in Borneo: East Sarawak and the

hilly heart of Borneo (Auliya 2006). Such transitional zones typically show a high diversity of breeding habitats (Duellman 1988) and the forests in eastern Brunei satisfy the reproductive requirements of a large proportion of the Bornean anuran amphibian fauna. Furthermore, Brunei lies within a major Pleistocene refuge for the flora of perhumid equatorial climates (Ashton 2010), suggesting that high species richness in this area may have been caused by long periods of forests' isolation.

A remarkable 17% of Brunei is formally protected either as protection/conservation forest or as national park (Table 1). Extensive amphibian surveys have been conducted only in three areas: the Ulu Temburong National Park (UTNP; formerly the Batu Apoi Forest Reserve) (Das 1994, 1995, 2007; Grafe and Keller 2009; Grafe *et al.* 2010), the Tasek Merimbun Heritage Park (Das *et al.* 2008) and more recently, the Bukit Teraja Protection Forest (BTPF; Fig. 1) (Grafe *et al.* 2010; Ahmadsah 2011). Less intensive surveys have been conducted in the Sungai Ingei Conservation Forest (SICF) and the Berakas Forest Reserve (Fig. 1) (Grafe unpublished).

Table 1. Classification of forests in Brunei Darussalam according to the 4th National Report by the Brunei Forestry Department (Anonymous 2010).

Forest Category	Gazetted Area (ha)	Proposed Area (ha)	Total Area (ha)	Percent of Forest	Percent of Total Land Area
Protection Forest	18,562	0	18,562	3.96	3.22
Conservation Forest	28,562	3173	31,684	6.75	5.50
National Park	46,210	2644	48,854	10.41	8.47
Production Forest	138,026	80,624	218,650	46.62	37.92
Recreation Forest	4211	234	4445	0.95	0.77

B. Species Richness and Regional Complementarity

Our herpetological surveys since 1991 provided the raw data for information on the distribution, threats, and conservation status for all amphibians in Brunei (Fig. 2). This information is available within the Global Amphibian Assessment (GAA) database. Furthermore, hitherto unavailable data are included here and provide a current update. In addition, an extensive literature review was conducted to identify current threats to amphibians in Brunei.

Currently, 84 species are recognized from Brunei, none of them endemic to the country (Appendix 1). Since its description, *Rhacophorus belalongensis* from the Ulu Temburong National Park (Dehling and Grafe 2008) has been found in Sarawak (Malaysia) at the Gunung Mulu National Park (Grafe unpublished). In comparison, there are 172 amphibian species in the neighbouring Malaysian states of Sabah and Sarawak (Das *et al.* 2013).

Complementarity analysis indicates that the UTNP and the BTPF have a low degree of species overlap, suggesting the need for conservation of both areas (Ahmadsah 2011). On a larger regional scale, the diversity of stream-associated frogs within lowland mixed-dipterocarp rainforest sites in northern Borneo show significant differences in species richness and composition, with width of stream being a good predictor of frog assemblages, both locally and regionally (Keller *et al.* 2009; Grafe *et al.* 2011). Thus, beta diversity plays a significant role in maintaining regional diversity of stream-associated frogs in Brunei and neighboring Malaysia. In regard to its high beta diversity, and in order to protect the diversity of riparian anurans of northwestern Borneo, it is necessary not only to focus on a few hotspots such as the Ulu Temburong National Park, but to engage in conservation efforts at other, less diverse, sites as well. The rate of species turnover in northwestern Borneo is comparable to that of New Guinea and Bolivia and this calls for proprietary attention to amphibian conservation (Goutte and Grafe unpublished).

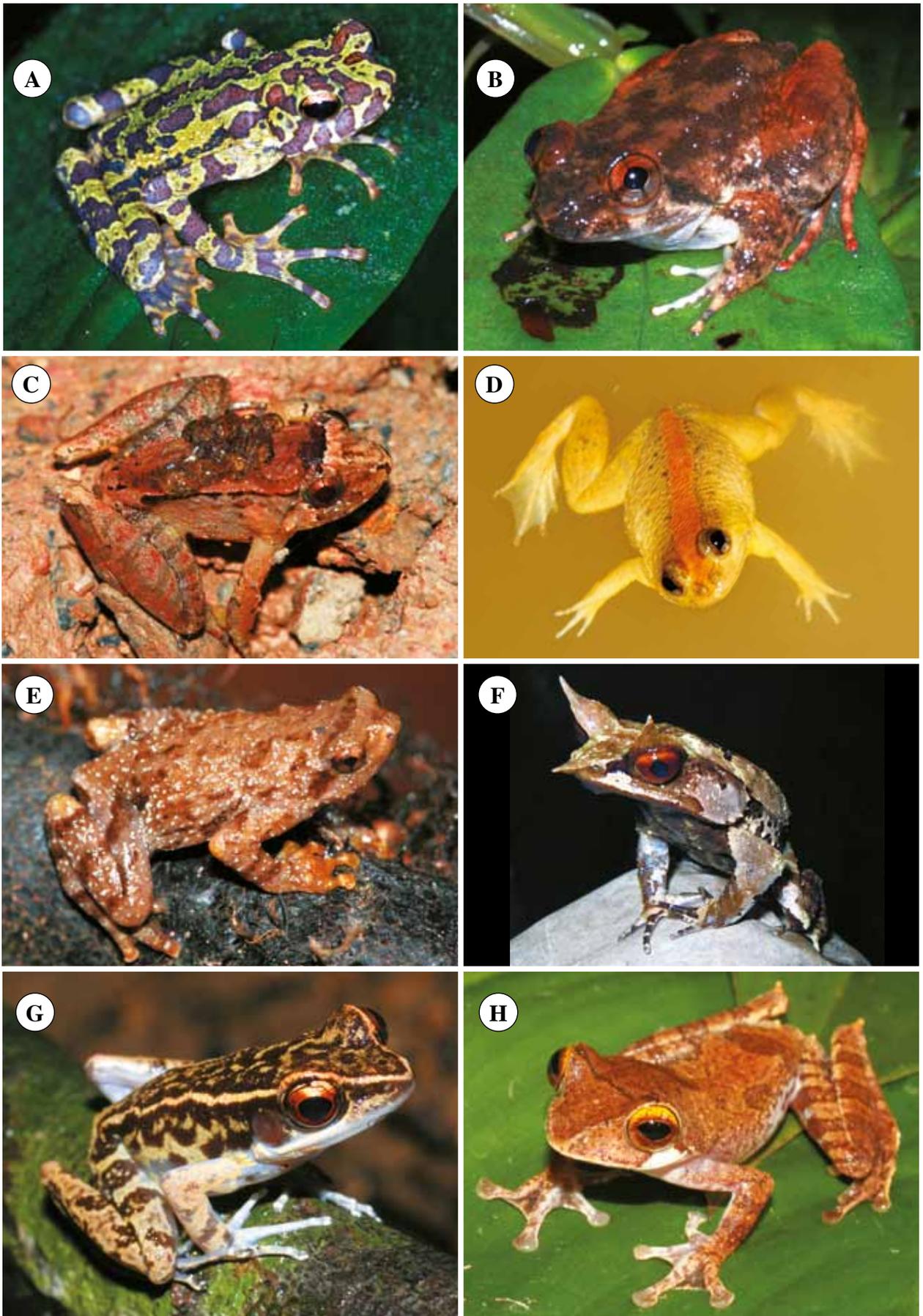


Fig. 2. Representative amphibians of Brunei Darussalam. **A.** *Pedostibes rugosus* (Bufonidae). **B.** *Ingerana baluensis* (Ceratobatrachidae). **C.** *Limnonectes palavanensis* male carrying tadpoles (Dicroglossidae). **D.** *Occidozyga baluensis* (Dicroglossidae). **E.** *Megophrys nasuta* (Megophryidae). **F.** *Metaphrynella sundana* (Microhylidae). **G.** *Hylarana signata* (Ranidae). **H.** *Rhacophorus belalongensis* (Rhacophoridae) for which Brunei Darussalam is the type locality.

II. ASSESSMENT OF THREATS

A. Alteration of Habitats and Change in Patterns of Land Use

Land and forests in Brunei are under governmental jurisdiction, with biodiversity issues largely governed by the 1984 Forestry Act of Brunei, which regulates the establishment and management of forest reserves (Anonymous 2010). The Brunei Town and Country Planning Act empowers the Town and Country Planning Department to prepare national development plans that prioritize patterns of land use. A Wildlife Protection Act passed in 1978 and revised in 1984 serves to protect endangered wildlife. An environmental protection and conservation order has been proposed. However, the lack of a Wildlife Department has hampered efforts to enforce the protection of threatened fauna. Brunei is a party to the Convention on Biological Diversity (CBD) by accession but currently still does not have a specific law requiring mandatory environmental impact assessments (EIAs) for projects. Existing EIA procedures are mostly administered on a discretionary and haphazard basis. Furthermore, a lack of coordination by governmental departments was recently identified as a key problem that needs attention, with current threats including expansion of forestry (logging) and the quarrying of gravel in protected areas (Hab 2010). Prospecting for coal in the SICF has highlighted the need to come to terms with changes in land use patterns that are increasing the pressure on protected areas. Past logging activities and repeated fires, some of them drought-induced, have caused deterioration of the Kerangas forests of Brunei (Becker and Wong 1992), whose effect on mammals has been recorded (Charles and Ang 2010). Similar studies are yet to be conducted on the area's amphibian fauna.

In general, the streams and rivers within the forested areas of Brunei Darussalam must be regarded as having low levels of environmental contaminants (Lim 1992). As there are no large-scale plantations such as oil palm in Brunei, chemical contamination with pesticides must be considered low. Likewise, no significant impact on rainwater acidity from aerial pollution is evident (Radojevic and Tan 2000). However, as the country attempts to decrease its dependency on rice imports, the area designated for cultivation of rice has increased significantly and with it the use of pesticides. In particular, the streams and rivers within the Brunei Muara district, which is highly urbanized, are already mildly polluted (Moncherry 2010). These streams receive effluents from sewage treatment plants and are rich in chironomid larvae, indicating high input of organic materials. The absence of fresh water shrimp within the channelized waterways of urbanized areas is also indicative of poor quality of water (Moncherry 2010). High input of sediment resulting from construction of roads is another disturbance that can seriously affect the abundance and distribution of tadpoles that graze on algae (Whiles *et al.* 2006).

B. Emerging Diseases

The emerging fungal pathogen *Batrachochytrium dendrobatidis* has been suggested to have had an immense impact on amphibian populations (Lips *et al.* 2006; Rachowicz 2006). Fortunately, a recent preliminary survey of amphibians in northwestern Borneo has provided no evidence of the chytrid fungus occurring in Brunei (Kaiser and Grafe 2011). Further vigilance, however, will be needed to monitor the potential presence and spread of the fungus, a daunting task given the small number of herpetologists working in Borneo.

C. Invasive Alien Species

No amphibian species in Brunei are listed as invasive aliens (Anonymous 2010), although the recent records of two species from human habitations, *Duttaphrynus melanostictus* (Charles and Das 2008) and *Kaloula pulchra* (Charles 2008), suggest that these species have invaded the country in recent years. Additionally, commensal species, abundant in urban and disturbed landscapes in Brunei, are encroaching on protected areas. With the opening up of forest areas, frog species that are human commensals have the opportunity of invading forested areas, often at the expense of resident species. The highly visible *Hylarana erythraea*, a human-commensal, previously unrecorded from the Ulu Temburong area, was first noticed on 17 July 1992 during a study that commenced in January 1992. More recently, several commensal species have invaded the Ulu Temburong National Park along a newly constructed dirt road; these include *Fejervarya limnocharis*, *Limnonectes ingeri*, *Hylarana glandulosa*,

and *Polypedates leucomystax* (Konopik *et al.* 2014). In particular, the impact of *Limnonectes ingeri* can be felt up to 500 m into the forest on both sides of the road (Konopik *et al.* 2014). Despite these observations, the ecological effects (competition, predation) of invasive alien species on local forest-dwelling amphibian species remain largely undocumented.

D. Use by Humans

Frogs are considered 'haram' (= forbidden food) by Islam (Niekisch 1986; Wan-Hassan and Awang 2009), the predominant religion of Brunei, and the local Malays do not catch amphibians for consumption. On the other hand, the minority Iban and Dusun tribesmen of Brunei, who constitute 6% of the population (Jones 1997), occasionally capture large frogs as a source of proteinaceous food (personal observations). The species affected are the riparian species of *Limnonectes* (primarily, *L. leporinus*, although *L. ingeri* and *L. malesianus* may also feature in the diet of these tribes on occasions). No large-scale commercial trade in amphibian species, either local or international, has, however, been recorded for Brunei Darussalam.

III. RECOMMENDATIONS FOR CONSERVATION

Over half (55%) of Brunei's amphibian fauna are Bornean endemics, suggesting high vulnerability and need for conservation. Using the IUCN criteria to evaluate the conservation status of single species, one species in Brunei, *Ansonia platysoma*, is endangered. Seven species are Vulnerable with restricted ranges: *Leptotalax pictus*, *Philautus tectus*, *Philautus ingeri*, *Megophrys edwardinae*, *Kalophrynus intermedius*, *Meristogenys jerboa*, and *Rhacophorus fasciatus*. An additional 24 species are classified as Near Threatened. In comprehensive analyses of the drivers of amphibian declines, large body size and small geographic range were identified as the most common threats (Cooper *et al.* 2008; Sodhi *et al.* 2008). This implies that conservation efforts should be directed toward protecting areas that contain many frog species with small geographic ranges. In Brunei such areas include the UTNP, BTPF, and the SICF.

The current data on amphibians clearly support the UTNP as the centre of Brunei's amphibian diversity. However, recent surveys in the BTPF suggest that substantial amphibian diversity remains undetected there and, from what is known, exhibits significant high complementarity to the UTNP (Ahmadsah 2011). Thus, the data support the assessment taken from a botanical viewpoint that the Bukit Teraja area merits the highest priority for further exploration and for assessment of biodiversity (Ashton 2010). Other conservation areas within Brunei that have not been sampled extensively may hold similar value for biodiversity, especially heath forests, peat swamp forests, and submontane forests. We recommend that the BTPF and other areas within the Heart of Borneo Project (HoB), such as the SICF, be placed under the same degree of protection as the UTNP.

The small human population of Brunei Darussalam (currently 401,890) (Anonymous 2011) is largely urban. However, urban areas of the country were created out of lowland forests and wetland areas (most famously, the Kampong Ayer within the capital city of Bandar Seri Begawan) within the past several decades, and continue to expand, reducing the extant of forested land, especially forest fragments. While exposed to ideas of rapid affluence via logging of tropical rainforests in southeastern Asia (including the highest relative rate of deforestation of any major tropical region) (see Sodhi *et al.* 2004), the government of Brunei Darussalam needs to be complimented for retaining as much forest cover as exists at present.

Production of oil and gas accounts for over half of the country's GDP, and over 90% of its exports (Anonymous 2011), and pressure on forests for timber is minimal, compared to the adjacent states in Borneo. Nonetheless, certain activities linked to Brunei's growing population and industry create pressure on forests and the biodiversity housed therein. These include mining and proposals to dam rivers in the upland areas.

Finally, invasive species may be a cause for concern (Ng and Tan 2010). Although no extra-Bornean invasive amphibian species has been recorded from Brunei, two exotic amphibian species farmed in adjacent Sabah and Sarawak (*Lithobates catesbeianus* and *Hoplobatrachus rugulosus*) have the potential to spread across the island. Introduced freshwater fish may pose an even greater threat to the native amphibians whose larval stages, in particular, are more vulnerable. These may be baitfish that survived, fish released from aquaria, or escapees from pet shops or from farms raising fish for the food markets, and many originate from the Asian mainland, Eurasia,

Java, and Africa. Likewise, the globally invasive, red-eared slider (*Trachemys scripta elegans*), a semi-aquatic turtle, is readily available in Brunei's pet shops and adults have been found in urban parks (Grafe unpublished). These turtles are known to be voracious feeders on tadpoles and their impact on local fauna must be regarded as severe (Ramsay *et al.* 2007). Improvement of quarantine laws and monitoring of pet shops and frog farms, should these be permitted in the future, may be important activities that could reduce the introduction and spread of undesirable invasive species.

As most of the amphibians in Brunei are stream-breeders, proper management of streams and rivers are needed to protect these species. Moncherry (2010) compiled several recommendations to reduce the threats to Brunei's stream ecosystems. They include: the need for further research on freshwater ecology and on ecosystem functioning, setting up a national ecological database, systematic education of the public on the importance of conserving rivers, and the need for long-term monitoring.

A recent analysis of the stomach content of 30 species of stream-associated frogs in the UTNP showed that frogs play an important role as predators of social insects and herbivorous insects in the rainforest food web (Knapp 2012). Frogs were capable of consuming 44 g of prey dry mass per kilometer of stream per day, which corresponds to a total consumption of more than 21 tones per year in the 49,000 ha forest area of the UTNP (Knapp 2012). Such studies highlight the central role that frogs play in ecosystem processes and the service they provide as potential top-down regulators of insect populations.

Brunei Darussalam has allocated more than half the country to the Heart of Borneo project (Anonymous 2008). The landmark HoB declaration was signed by the governments of Brunei, Indonesia, and Malaysia in 2007 to protect large contiguous forest areas of the interior of Borneo. The continued support of the HoB initiative by His Majesty, the Sultan of Brunei, and his government in international forums is likely to strengthen the conservation agenda in the region. The long-term goal of the HoB by 2020 is a zero rate of conversion of natural forests with high value for conservation to other land use and the establishment of a 24-million-ha mosaic of protected areas, transboundary reserves, and sustainably managed areas for use by humans (M. Kavanagh, personal communication). In Brunei, several extensions to existing protected areas have been proposed and the establishment of a system of Totally Protected Areas has been recommended that would include all the areas so far identified as having high value for amphibian conservation (Anonymous 2008). Despite these positive initiatives, further degradation of natural habitats will be inevitable as the pressure to use land for housing, industry, and agriculture intensifies.

IV. ACKNOWLEDGEMENTS

We thank our respective institutions, Universiti Brunei Darussalam and Universiti Malaysia Sarawak for support of our research. David S. Edwards and Joseph K. Charles provided information and companionship during fieldwork. Many new records and distributional observations were made by Hanyrol Ahmadsah, Sandra Goutte, and Oliver Konopik. Joseph K. Charles made helpful comments on the manuscript. We thank Hans Dols for providing maps of the area. We are also grateful to the Brunei Museums Department, especially Samhan bin Nyawa, for facilities; Helen Y. K. Pang for assistance with the amphibian collection; and the staff of the Kuala Belalong Field Studies Centre and the directors, Kamariah Abu Salim, and Kushan Tennakoon for logistical support.

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Appendix 1

Checklist of amphibians of Brunei Darussalam. Current as of 1 March 2011.

ORDER ANURA: Family Bufonidae

Ansonia albomaculata Inger 1960
Ansonia leptopus (Günther 1872)
Ansonia longidigita Inger 1960
Ansonia platysoma Inger 1960
Ansonia sp.
Duttaphrynus melanostictus (Schneider 1799)
Ingerophrynus divergens (Peters 1871)
Ingerophrynus quadriporcatus (Boulenger 1887)
Pedostibes hosii (Boulenger 1892)
Pedostibes rugosus Inger 1958
Pelophryne signata (Boulenger 1894)
Phrynoidis aspera (Gravenhorst 1829)
Phrynoidis juxtaspera (Inger 1964)

Family Ceratobatrachidae

Ingerana baluensis (Boulenger 1896)
Ingerana sp.

Family Dicroglossidae

Fejervarya cancrivora (Gravenhorst 1829)
Fejervarya limnocharis (Gravenhorst 1829)
Limnonectes ibanorum (Inger 1964)
Limnonectes ingeri (Kiew 1978)
Limnonectes kuhlii (Tschudi 1838)
Limnonectes laticeps (Boulenger 1882)
Limnonectes leporinus (Andersson 1923)
Limnonectes malesianus (Kiew 1984)
Limnonectes palavanensis (Boulenger 1894)
Limnonectes paramacrodon (Inger 1966)
Occidozyga baluensis (Boulenger 1896)
Occidozyga laevis (Günther 1859)

Family Megophryidae

Leptobrachella mjobergi Smith 1925
Leptobrachella parva Dring 1983
Leptobrachium abbotti (Cochran 1926)
Leptobrachium montanum Fischer 1885
Leptotalax fritinniensis Dehling and Matsui 2013
Leptotalax gracilis (Günther 1872)
Leptotalax pictus Dubois 1987
Megophrys edwardinae Inger 1989
Megophrys nasuta (Schlegel 1858)

Family Microhylidae

Calluella sp.
Chaperina fusca Mocquard 1892
Kalophrynus intermedius Inger 1966
Kalophrynus pleurostigma Tschudi 1838

Kalophrynus subterrestris Inger 1966
Kaloula baleata (Müller 1836)
Kaloula pulchra Gray 1831
Metaphrynella sundana (Peters 1867)
Microhyla borneensis Parker 1928
Microhyla nepenticola Das and Haas 2010
Microhyla perparva Inger and Frogner 1979
Microhyla petrigena Inger and Frogner 1979

Family Ranidae

Huia cavitympanum (Boulenger 1893)
Hylarana baramica (Boettger 1901)
Hylarana erythraea (Schlegel 1837)
Hylarana glandulosa (Boulenger 1882)
Hylarana luctuosa (Peters 1871)
Hylarana megalonesa Inger, Stuart and Iskandar 2009
Hylarana nicobariensis (Stoliczka 1870)
Hylarana picturata (Boulenger 1920)
Hylarana signata (Günther 1872)
Meristogenys jerboa (Günther 1872)
Meristogenys orphnocnemis (Matsui 1986)
Meristogenys poecilus (Inger and Gritis 1983)
Odorrana hosii (Boulenger 1891)
Staurois latopalatus (Boulenger 1887)
Staurois guttatus (Günther 1859)
Staurois parvus Inger and Haile 1960

Family Rhacophoridae

Feihyla kajau (Dring 1983)
Kurixalus appendiculatus (Günther 1859)
Nyctixalus pictus (Peters 1871)
Philautus hosii (Boulenger 1895)
Philautus ingeri Dring 1987
Philautus tectus Dring 1987
Polypedates colletti (Boulenger 1890)
Polypedates leucomystax (Gravenhorst 1829)
Polypedates macrotis (Boulenger 1891)
Polypedates ottilophus (Boulenger 1893)
Rhacophorus belalongensis Dehling and Grafe 2008
Rhacophorus cyanopunctatus Manthey and Steiof 1998
Rhacophorus dulitensis Boulenger 1892
Rhacophorus fasciatus Boulenger 1895
Rhacophorus harrissoni Inger and Haile 1960
Rhacophorus nigropalmatus Boulenger 1895
Rhacophorus pardalis Günther 1859
Rhacophorus rufipes Inger 1966
Theoderma sp.

ORDER GYMNOPTIONA: Family Ichthyophiidae

Caudacaecilia nigroflava (Taylor 1960)