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Preliminary Herpetofaunal Inventory of a Logging Concession in the Upper Baram, Sarawak, Borneo

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The island of Borneo is the largest of the Sundaic subregion (which comprises the Malay Peninsula, Sumatra, Java, Borneo, Bali, and smaller associated islands), and is the second largest tropical island in the world. Previously covered in mixed dipterocarp forest, it contains some of the last remaining continuous tracts of tropical rainforest in Southeast Asia and is recognized as one of the most biodiverse areas of the Indo-Malayan region (MacKinnon et al. 1996). However, Borneo experiences one of the highest deforestation rates in the world, with 1.7% of its forests converted annually primarily through commercial timber harvesting and conversion of forests to monoculture plantations (Koh 2007; Langer et al. 2007). While about 9% of the land area is afforded some level of protection, such protected areas are isolated and dwarfed by the vast areas designated for timber extraction and monoculture plantations (Brodie and Giordano 2011). The viability of such protected areas for the conservation of Borneo's biodiversity is thus questionable (Meijaard et al. 2005).

Borneo boasts high herpetofaunal species richness and endemism, with 290 reptiles and 164 amphibian species currently described, making it the richest in terms of herpetofaunal diversity of the greater Sundas (compared to Sumatra: 218 reptiles and 93 amphibians, Java: 173 reptiles and 36 amphibians and Sulawesi: 115 reptiles and 40 amphibians; Das and van Dijk 2013).

Most herpetofaunal studies in Borneo have focused on protected areas. Little work has been conducted in modified landscapes such as logging concessions and monoculture plantations. In the Malaysian state of Sarawak, only 4% of the total land area is protected, whereas 35% is designated for

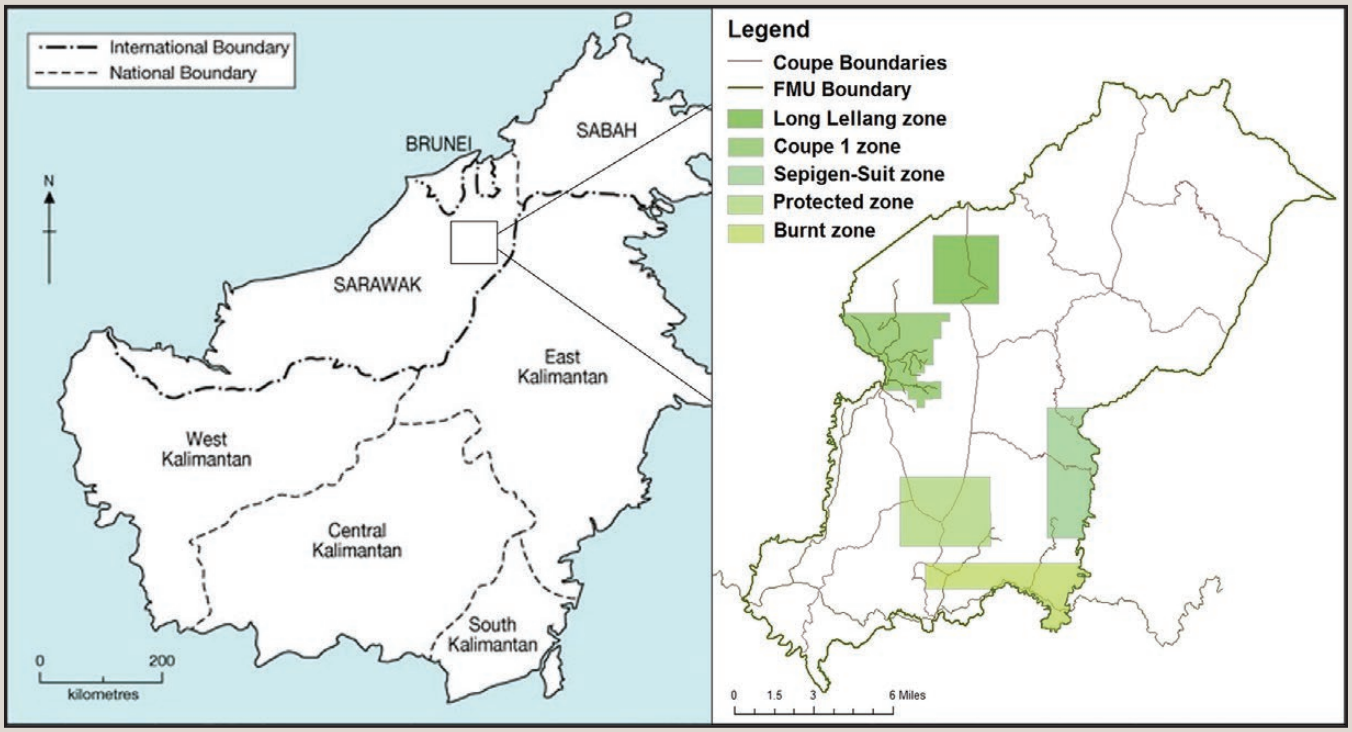

FIG. 1. Map of Borneo featuring the location of the Sela'an Linau Forest Management Unit (FMU) and location of our study sites therein. Study site habitat types, elevation range, and anthropogenic disturbance are as follows (modified from Mathai and Buckingham 2014). Long Lellang: Hill and submontane primary forest with some montane forest in higher elevation areas, 575–1200 m elev., low anthropogenic disturbance. Coupe 1: Secondary-growth lowland forest; the majority of the area was subject to reduced impact logging in 2006 and 2007; some unlogged lowland and hill forest, 500–900 m elev., moderate anthropogenic disturbance. Sepigen-Suit Zone: Lowland (mainly secondary) forest with active *temudas* and rice paddies, 250–475 m elev., high anthropogenic disturbance. Protected Zone: Primary submontane forest with some montane forest in the higher elevation areas, 750–1550 m elev., low anthropogenic disturbance. Burnt Zone: Secondary-growth lowland forest (the majority of the area was burned during the 1997–1998 El Niño event), 250–750 m elev., high anthropogenic disturbance.

logging activities (Sarawak Forest Department 1997). To better manage biodiversity in these modified landscapes, it is essential that assessment and monitoring of ecosystem dynamics and community structure be conducted. Thus providing more comprehensive data for conservation management (Meijaard et al. 2005).

The present study was conducted in the Sela'an Linau Forest Management Unit (FMU), a logging concession of 55,949 ha located in the Upper Baram region of northern Sarawak, Malaysian Borneo (Fig. 1). The licensed concessionaire is Samling. Roughly half the area was conventionally logged in the past and since 2003, a reduced impact logging (RIL) has been applied. The majority of the area supports mixed dipterocarp forest (60%), with some montane forest (4%), tropical heath forest (*kerangas*) (21%), and slash and burn areas (*temuda*) (15%). Roughly 3000 ha of forest was destroyed during the 1997–1998 El Niño event though secondary growth, regenerating forest has now reclaimed the area. Elevation ranges from 250–2000 m above sea level. The area receives high rainfall with 3400–5900 mm falling annually and temperatures averaging 26°C and 14°C in the low and high elevation areas, respectively (Mathai et al. 2010).

Methods.—The herpetofaunal records presented in this paper are opportunistic detections obtained during an ongoing small carnivore camera-trapping and habitat modelling study. Five field trips totalling 178 days were made between April 2013 and July 2014. During this time, opportunistic herpetofaunal surveys were conducted in five survey sites (Protected zone, Burnt zone, Sepigen-Suit zone, Coupe one zone, and Long Lellang zone) each of an area 10–15 km^2. These areas compromised a mix of undisturbed and disturbed lowland, hill, submontane and montane forest with elevations ranging between 220–1300 m elevation (see Fig. 1).

Observations were made during the day (0800–1700 h) while walking transects for habitat analysis and setting of camera-traps. Between three to seven kilometers were walked each day; however, it is acknowledged that as researchers were not specifically surveying for herpetofauna, many specimens may have been missed and microhabitats specific to herpetofauna (tree buttresses, beneath logs/rocks, and within tree cavities) were rarely searched.

When possible, night walks were conducted along streams and old logging roads, specifically targeting herpetofauna. Such walks were conducted mainly after rain and microhabitats specific to herpetofauna were searched.

All specimens detected were photographed. GPS coordinates of detection sites, date, time of encounter, and habitat type were recorded. Snout–vent length (SVL) and brief behavioral notes were taken wherever possible. All voucher specimen photographs have been registered with the Lee Kong Chian Natural History Museum, National University of Singapore.

Results and discussion.—Opportunistic sampling detected 36 reptile species (16 lizards, 18 snakes, and two turtles) comprising 12 families, including 12 species endemic to Borneo. A total

TABLE 1. Herpetofaunal species recorded from Sela'an Linau Forest Management Unit, Upper Baram, Sarawak, East Malaysia, between April 2013 and July 2014. Catalogue number refers to ZRC (Zoological Reference Collection, Lee Kong Chian Natural History Museum, National University of Singapore) digital voucher numbers.

Taxon	Catalogue numbers
Amphibians	
Bufonidae	
Ansonia longidigita Inger, 1960	ZRC(IMG) 1.45-1.46
Pelophryne signata (Boulenger, 1894)	ZRC(IMG) 1.47
Dicroglossidae	
Fejervarya limnocharis (Wiegnmann, 1835)	ZRC(IMG) 1.54
Limnonectes ingeri (Kiew, 1978)	ZRC(IMG) 1.48
Limnonectes kuhlii (Tschudi, 1838)	ZRC(IMG) 1.49
Megophryidae	
Leptobrachella parva Dring, 1984	ZRC(IMG) 1.72a–b
Microhylidae	
Kalophrynus subterrestris Inger, 1960	ZRC(IMG) 1.61
Ranidae	
Hylarana picturata (Boulenger, 1920)	ZRC(IMG) 1.53
Hylarana signata (Günther, 1872)	ZRC(IMG) 1.71
Staurois latopalmatus (Boulenger, 1887)	ZRC(IMG) 1.58
Staurois natator (Günther, 1858)	ZRC(IMG) 1.59
Rhacophoridae	
Feihyla kajau (Dring, 1984)	ZRC(IMG) 1.56
Nyctixalus pictus (Peters, 1872)	ZRC(IMG) 1.69a–b
Philautus hosii (Boulenger, 1895)	ZRC(IMG) 1.70a–c
Philautus ingeri Dring, 1987	ZRC(IMG) 1.50
Philautus macroscelis Boulenger, 1894	ZRC(IMG) 1.57
Philautus petersi (Boulenger, 1900)	ZRC(IMG) 1.51
Polypedates otilopus (Boulenger, 1893)	ZRC(IMG) 1.52
Reptiles	
Agamidae	
Bronchocela cristatella (Kuhl, 1820)	ZRC(IMG) 2.215
Draco cornutus Günther, 1864	ZRC(IMG) 2.188-189
Gonocephalus bornensis (Schlegel, 1848)	ZRC(IMG) 2.184
Gonocephalus grandis (Gray, 1845)	ZRC(IMG) 2.185-186
Phoxophrys spiniceps Smith 1925	ZRC(IMG) 2.187
Anguidae	
Dopasia buettikoferi (van Lidth de Jeude 1905)	ZRC(IMG) 2.232a–c
Eublepharidae	
Aeluroscalabotes felinus (Günther, 1864)	ZRC(IMG) 2.190–191
Gekkonidae	
Cyrtodactylus consobrinus (Peters, 1871)	ZRC(IMG) 2.192
Cyrtodactylus malayanus (De Rooji, 1915)	ZRC(IMG) 2.233a–c
Cyrtodactylus pubisulcus Inger, 1957	ZRC(IMG) 2.234a–b
Gekko smithi (Gray, 1842)	ZRC(IMG) 2.235a–b
Ptychozoon kuhli Stejneger, 1902	ZRC(IMG) 2.236a–d
Scincidae	
Dasia vittata Edeling, 1864	ZRC(IMG) 2.195
Tropidorhorus beccarii Peters, 1871	ZRC(IMG) 2.193
Tropidorhorus micropus van Lidth de Jeude, 1905	ZRC(IMG) 2.194
Varanidae	
Varanus rudicollis Gray, 1845	ZRC(IMG) 2.196

TABLE 1. Continued

Taxon	Catalogue numbers
Colubridae	
Ahaetulla prasina (Boie, 1827)	ZRC(IMG) 2.197
Amphiesma sarawacense (Günther, 1872),	ZRC(IMG) 2.198
Boiga cynodon (Boie, 1827)	ZRC(IMG) 2.199
Calamaria grabowskyi Fischer, 1885	ZRC(IMG) 2.237a–c
Coelognathus flavolineatus (Schlegel, 1837)	ZRC(IMG) 2.238a–b
Gonyosoma oxycephalum (Boie, 1827)	ZRC(IMG) 2.200
Macropisthodon rhodomelas (Boie, 1827)	ZRC(IMG) 2.201
Psammodynastes pulverulentus (H. Boie in F. Boie, 1827)	ZRC(IMG) 2.239a–b
Rhabdophis chrysargos (Schlegel, 1837)	ZRC(IMG) 2.202
Sibynophis melanocephalus (Gray, 1834)	ZRC(IMG) 2.203
Xenochrophis trianguligerus (Boie, 1827)	ZRC(IMG) 2.204
Viperidae	
Parias sumatranus (Raffles, 1822)	ZRC(IMG) 2.205
Popeia sabahi (Regenass & Kramer, 1981)	ZRC(IMG) 2.206
Trimeresurus borneensis Peters, 1871	ZRC(IMG) 2.240a–c
Elapidae	
Naja sumatrana Müller, 1887	ZRC(IMG) 2.216 a–b
Pareatidae	
Aplopeltura boa Boie, 1828	ZRC(IMG) 2.208–209
Asthenodipsas laevis (Boie, 1827)	ZRC(IMG) 2.210–2.211
Pythonidae	
Malayopython reticulatus (Schneider, 1801)	ZRC(IMG) 2.207
Bataguridae	
Heosemys spinosa (Gray, 1831)	ZRC(IMG) 2.214
Notochelys platynota (Gray, 1834)	ZRC(IMG) 2.212–2.213

of 18 amphibian species comprising six families, including 11 species endemic to Borneo, were also detected (see Table 1). This represents 12.41 and 11.92% of all known Bornean reptile and amphibian species, respectively (calculated from Das 2011; Haas et al. 2013). All reptiles encountered (with the exception of two montane species, *Phoxophrys spiniceps* and *Popeia sabahi*) were lowland forest-dwelling species.

Of the 36 reptile species recorded, 10 were detected on more than one occasion: three snake species, *Aplopeltura boa, Asthenodipsas laevis,* and *Parias sumatranus,* and seven lizard species, *Gonocephalus grandis, Cyrtodactylus consobrinus, C. malayanus, C. pubisulcus, Aeluroscalabotes felinus, Draco cornutus,* and *Dasia vittata*; the latter three are often associated with anthropogenically altered habitats (Das 2010). *Draco cornutus* and *Dasia vittata,* as well as *Naja sumatrana* and *Bronchocela cristatella,* were only encountered in a lowland village area.

Of the 18 amphibians detected, all were lowland forest dwellers with the exception of four exclusively montane species: *Ansonia longidigita, Philautus ingeri, Philautus macroscelis,* and *Philautus petersi.* Half of all species detected were exclusively riparian and/or dependent on riparian habitats for breeding (Inger et al. 1997).

A total of nine amphibian species were observed on more than one occasion with five of these observed with considerable frequency. *Philautus petersi, Feihyla kajau,* and *Leptobrachella parva* were commonly heard and sighted at night along riparian margins in the higher elevation areas (800–1200 m elev.), and *Staurois natator* and *Staurois latopalmatus* were commonly sighted by day among fast-flowing rivers in lower elevation areas (350–500 m elev.).

Two amphibians, *Pelophryne signata* and *Kalophrynus subterrestris* are considered lowland species, and have only previously been recorded below 1000 m and 300 m elevation, respectively (Inger et al. 1997). During this study *P. signata* was detected at 1200 m elevation, with *K. subterrestris* detected at 1100 m elevation, significantly increasing the known elevation ranges of these amphibians.

Due to the limited time frame and opportunistic nature of our observations, no inferences can be drawn regarding true herpetofaunal diversity and abundance in the region. As such, it is recommended that more surveys specifically targeting herpetofauna be conducted within this logging concession and other concessions and modified landscapes throughout Sarawak and Borneo. Understanding of herpetofaunal diversity and community dynamics within these large unprotected regions is crucial to identify areas of high conservation priority and identify possible management strategies that could alleviate further biodiversity loss, particularly in the face of Borneo's rapid deforestation, forest conversion, and proposed mega-dam projects.

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