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HERPETOFAUNAL ENDEMISM AND DIVERSITY IN TROPICAL FORESTS OF MT. HAMIGUITAN IN THE PHILIPPINES

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***Abstract.*—We conducted a survey of the amphibians and reptiles found in lowland dipterocarp forest of the Philippines. We used line transect and visual encounter surveys to study eight sites located in dipterocarp, montane, and mossy forests. We found 15 reptiles (one order and six families) and nine amphibians (one order and five families). Endemicity in lower elevations reached 80% for reptiles and 77.8% for amphibians. Reptiles endemic to Mindanao Island constituted 13.3% of the Reptilia we identified. The species found in lowland dipterocarp forest face threats from anthropogenic disturbances such as habitat conversion, and may be good indicators of biotic integrity. We suggest that lowland forest habitats are critical for endemic species because these areas have significantly higher species richness and diversity than found in the tropical forests at higher elevations.**

Key Words.—amphibians; diversity; elevation; endemic; lowland dipterocarp forest; reptiles; tropical rainforest

INTRODUCTION

As the forests of the Philippines disappear and human population explodes, this unique island nation proportionately loses large numbers of wildlife (Conservation International 2006). The past two decades saw extensive removal of virgin forest (Pereira, R., J. Epting, D. Juhn, O. Coroza, L. Miller, and F. Maon. 2007. Forest clearance and fragmentation in Palawan and Eastern Mindanao Biodiversity Corridors (1990–2000): A time sequential analysis of LANDSAT imagery. Abstract presented in the 16th Wildlife Conservation Society of the Philippines.) and wide displacement of wild animals. One of the largest remaining forest blocks in the Philippines occurs near Mindanao (Fig. 1). It has abundant forest cover in the eastern region, of which a significant portion is on Mt. Hamiguitan (1500–1800 m). There are 172 native amphibians and reptiles in the Phillipines, 111 (64%) of which are endemic; thus the archipelago has one of the highest per-area levels of endemism in the world in terms of numbers and percentage (Heaney and Regalado 1998). To date, there are 80 known species of frogs and 92 species of reptiles in the Philippines (Arances et al. unpubl. report; Crombie unpubl. report). Eight (8/35; 22.86%) species of frogs are indigenous to Mindanao Island and 60 (75%; 60/80) species are restricted to the Philippine archipelago. We sought to further define the herpetofauna of the forests near Mindanao in the Philippines.

MATERIALS AND METHODS

We surveyed eight sites in tropical rainforest of Mt. Hamiguitan, Davao Oriental, Eastern Mindanao, Philippines (Fig. 2) from July 2006 to March 2007 in seven consecutive months. The area is composed of four

FIGURE 1. Map of the Philippines showing the location of Mt. Hamiguitan (red circle), Eastern Mindanao in the southernmost region.

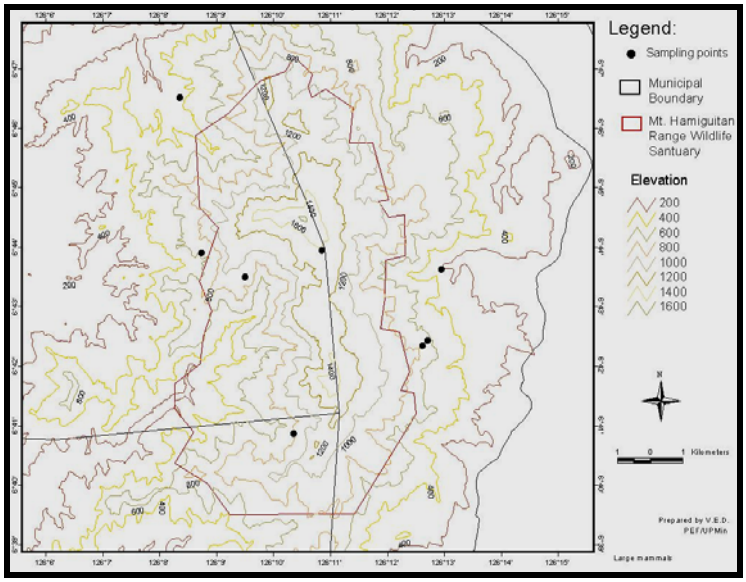

FIGURE 2. Map of the sampling sites in Mt. Hamiguitan Wildlife Sanctuary, Eastern Mindanao, Mindanao Island, Philippines.

identified types of habitats: lowland dipterocarp forest (sites 1–4 and 7), lower, mid to upper montane forest (sites 5–6), and mossy pygmy and dipterocarp forest in the higher elevation (site 8). We visited each site for 3–4 days. Surveys spanned terrestrial, arboreal, and aquatic strata. We collected reptiles exclusively during the day from late morning to early afternoon. We surveyed anurans every night. We searched the leaf litter, pandins, streams, rocks, soil, trees, ferns, shrubs, trunks, branches, and leaves for three to four nights from 1900–2100 at each sampling site. We used line transects to sample each site (Alcala 1986). We photographed all vouchers and then preserved them in 70% ethanol in the University of the Philippines in Mindanao. We noted distinguishable phenotypic characters and morphometric data.

RESULTS

Species composition and abundance.—We captured 140 herptiles belonging to 24 species, of which 15 were reptiles and nine were amphibians. We spent 472.5 person-hours sampling in the different vegetation types. Of the 140 captured individuals, only 17.9% were reptiles and the rest were amphibians. All of the reptiles identified were snakes and lizards (Order: Squamata). We encountered reptiles from three vegetation types, which were distributed as follows: lowland dipterocarp forest with 13 individuals belonging to 11 species; montane forest with seven individuals belonging to six species; and mossy forest with five individuals belonging to five species (Table 1). Of all the reptilian species captured, only *Calamaria gervaisii* was encountered in all three vegetation types (Fig. 3).

All of the amphibians we encountered in this study also belonged to the order Anura (Fig. 4). Amphibians were more commonly encountered than reptiles accounting for 82.1% of the total herptiles captured. We found amphibians in all vegetation types, occurring highest in the lowland dipterocarp forest with 90 captures belonging to nine species, followed by montane forest with 16 captures belonging to four species, and mossy forest with nine captures belonging to two species (Table 2).

Our study was able to document 11 more species of reptiles in Mt. Hamiguitan. However, we did not find 17 species previously reported. For amphibians, we also did not find any previously unreported species or seven species earlier listed (Table 3).

Endemism and conservation status.—We documented 21 Philippine endemic species of herptiles composed of 14 squamates and seven anurans. The reptilian endemics constituted 93.3% of the total captured species of reptiles. We identified two of the 14 endemic reptiles as Mindanao Faunal Region endemics. We captured endemic reptiles from all vegetation types with the lowland dipterocarp forest harboring the highest number with nine species. All of the reptiles encountered are of unknown conservation status based on the 2007 IUCN Red Data List (Table 1).

The amphibian endemics made up 77.8% of the total amphibian species captured. With reference to the 2007 IUCN Red Data List, we identified three endemic species with vulnerable conservation status. These include *A. muelleri*, *M. stejnegeri*, and *P. acutirostris*.

TABLE 1. The number of lizards and snakes documented in vegetation types across elevations in Mt. Hamiguitan, Davao Oriental, Philippines.

Family	Scientific Name	Common Name	Local Name	Geographic Distribution and Conservation Status (2007 IUCN Red List)	Lowland Dipterocarp Forest	Montane Forest	Mossy Forest
Agamidae	*Gonyocephalus semperi*	White-Spotted Anglehead	*Tabili*	Philippine Endemic Unknown	1	1	-
Gekkonidae	*Gekko mindorensis*	Mindoro Narrow-Disked Gecko	*Tabili*	Philippine Endemic Unknown	1	1	-
Scincidae	*Sphenomorphus variegatus*	Black-Spotted Sphenomorphus	*Tabili*	Philippine Endemic Unknown	1	2	-
Scincidae	*Sphenomorphus beyeri*	Beyer's Sphenomorphus	*Tabili*	Philippine Endemic Unknown	-	-	1
Scincidae	*Lipinia pulchella*	Yellow-Striped Slender Tree Skink	*Tabili*	Philippine Endemic Unknown	-	1	-
Scincidae	*Eutropis multicarinata borealis*	Northern Two-Striped Mabuya	*Tabili*	Philippine Endemic Unknown	1	-	-
Scincidae	*Eutropis englei*	Six-Striped Mabouya	*Tabili*	Mindanao Endemic Unknown	-	-	1
Colubridae	*Boiga dendrophilia*	Mangrove Blunt-Headed Snake	*Bitin*	Philippine Endemic Unknown	1	-	-
Colubridae	*Psammodynastes pulverulentus*	Dark- Spotted Mock Viper	*Bitin*	Philippine Endemic Unknown	1	1	-
Colubridae	*Oxyrhabdium leporinum*	Banded Philippine Burrowing Snake	*Bitin*	Philippine Endemic Unknown	1	-	-
Colubridae	*Oligodon maculatus*	Barred Short-Headed Snake	*Bitin*	Mindanao Endemic Unknown	2	-	1
Colubridae	*Calamaria gervaisii*	Gervais' Worm Snake	*Bitin*	Philippine Endemic Unknown	2	1	1
Colubridae	*Lycodon dumerili*	Dumeril's Wolf Snake	*Bitin*	Philippine Endemic Unknown	1	-	-
Viperidae	*Tropidolaemus wagleri subannulatus*	Wagler's Pit Viper	*Dupong*	Southeast Asia Unknown	1	-	-
Pythonidae	*Phyton reticulatus*	Reticulated Phyton	*Baksan*	Philippine Endemic Unknown	-	-	1
				Captures/habitat:	**13**	**7**	**5**
Total number of Orders: 1				Total captures in Mt. Hamiguitan:	**25**		
Total number of Families: 6				No. of species/habitat:	**11**	**6**	**5**
Total number of Philippine Endemic Reptiles: 12 (80%)				Total species in Mt. Hamiguitan:	**15**		
Total number of Mindanao Endemic Reptiles: 2 (13.3%)				Person-hours/habitat:	**291.5**	**110.0**	**88.6**
				Total person-hours in Mt. Hamiguitan:	**472.5**		

Like the reptilian population distribution, we encountered endemic amphibians from all vegetation types with the lowland dipterocarp forest harboring the most number of endemic species with seven (Table 2).

Species diversity.—Jaccard's similarity coefficient showed that reptile species in lowland dipterocarp forest resemble montane forest (CCj = 0.41) more than mossy forest (CCj = 0.14). Mossy and montane forest hold more similar anuran species composition (CCj = 0.5) compared to lowland dipterocarp forest and montane forest (CCj = 0.44), however it is highly varied in lowland dipterocarp forest and mossy forest (CCj = 0.22). Simpson's diversity index and evenness determined highest reptile diversity and uniform distribution in lowland dipterocarp forest (D = 9.94, Ep = 0.904) followed by montane forest (D = 5.4, Ep = 0.9) and mossy forest (D = 5.0, Ep = 1.0). Otherwise, montane forest has a highly diverse anuran species and even distribution (D = 3.66, Ep = 0.9) compared to lowland dipterocarp forest (D = 3.6, Ep = 0.4) while it is lowest in mossy forest (D = 1.8, Ep = 0.9).

DISCUSSION

Our study provides an updated profile of the herpetofaunal species richness occurring on Mt. Hamiguitan. While our study encountered fewer herpetofaunal species than previous reports (Delima et al. 2007), this does not exactly indicate herpetofaunal species decline in Mt. Hamiguitan as the surveys were conducted on a yearly interval. We do not suggest that

the decrease in number of species captured is due to local species loss considering that our survey added 11 more species to the records. We suppose that this decrease could be due to either samples being missed, especially if individuals are small in size and residing in the clumped leaf litter, species being well camouflaged, or the ability of individuals to escape even before they were noticed. Such cases of non-capture of species expected to occur on a particular site was similar to what Ates and Delima (2008) found in their surveys at Mt. Sinaka and Mt. Hamiguitan of the Philippines. These reasons may also account for the lower capture of

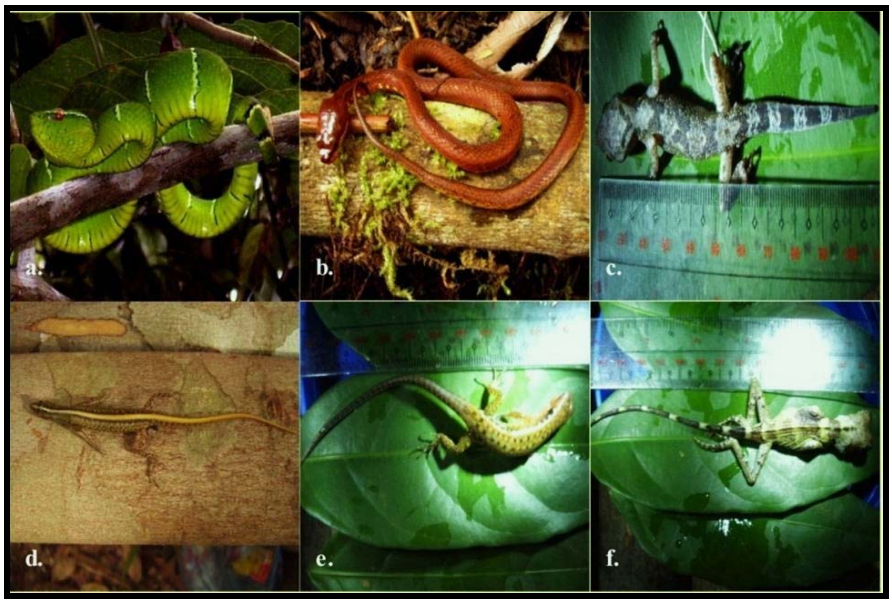

FIGURE 3. Species of reptiles (a. *Tropidolaemus wagleri subannulatus,* b. *Psammodynastes pulverulentus,* c. *Gekko. mindorensis,* d. *Lipinia pulchella,* e. *Sphenomorphus variegatus,* and f. *G.onyocephalus semperi*) collected from varied vegetation types at Mt. Hamiguitan, Davao Oriental, Mindanao Island, Philippines.

FIGURE 4. Species of amphibians (a. *Staurois natator,* b. *Rana grandocula,* c. *Limnonectes magnus,* d. *Ansonia muelleri,* e. *Megophrys stejnegeri,* and f. *P hilautus acutirostris*) collected from varied vegetation types at Mt. Hamiguitan, Davao Oriental, Mindanao Island, Philippines.

TABLE 2. The number of anuran species collected in vegetation types across elevations in Mt. Hamiguitan, Davao Oriental.

Family	Scientific Name	Common Name	Local Name	Geographic Distribution and Conservation Status (2007 IUCN Red List)	Lowland Dipterocarp Forest	Montane Forest	Mossy Forest
Ranidae	*Staurois natator*	Rock Frog	*Tig-tig*	Philippine Endemic Least Concern	37	3	3
Ranidae	*Rana grandocula*	Big-eyed Frog	*Tig-tig*	Philippine Endemic Least Concern	6	6	-
Ranidae	*Limnonectes magnus*	Mindanao Fanged Frog	*Bak-bak*	Philippine Endemic Near Threatened	28	3	-
Ranidae	*Platymantis corrugata*	Rough-backed Forest Frog	*Tig-tig*	Philippine Endemic Least Concern	2	-	-
Bufonidae	*Ansonia muelleri*	Mueller's Toad	*Tig-tig*	Philippine Endemic Vulnerable	3	-	-
Pelobatidae	*Megophrys stejnegeri*	Mindanao Horned Frog	*Baki sungayan*	Philippine Endemic Vulnerable	4	-	-
Rhacophoridae	*Polypedates leucomystax*	Four-lined Tree Frog	*Tig-tig*	Southeast Asia Least Concern	4	-	-
Rhacophoridae	*Philautus acutirostris*	Pointed-Snouted Tree Frog	*Tig-tig*	Philippine Endemic Vulnerable	3	4	6
Microhylidae	*Kalophrynus pleurostigma*	Black-spotted Narrow-mouthed Frog	*Bak-bak*	Southeast Asia Least Concern	3	-	-

Total number of Orders: 1	Captures/habitat:	**90**	**16**	**9**
Total number of Families: 5	Total captures in Mt. Hamiguitan:	**115**		
Total number of Philippine Endemic Frogs: 7 (77.7%)	No. of species/habitat:	**9**	**4**	**2**
Total number of Threatened Frogs: 4 (44.4%)	Total species in Mt. Hamiguitan:	**9**		
	Searching nights/habitat:	**13**	**5**	**2**
	Person-hours/habitat:	**74**	**40**	**8**
	Total Person-hours in Mt. Hamiguitan:	**122**		

reptiles compared to amphibians. In this study, amphibians appeared to be more abundant than reptiles. We suppose that the swifter nature of reptiles compared to amphibians and their limited or absence of vocalization may have accounted for their rarity of capture. Amphibians vocalize and are less mobile than reptiles, and these factors may have made them an easier group to locate, thus their higher rate of capture. Revealed also in our results is the apparent high occurrence of herptile endemism and species richness in the lowland dipterocarp forest.

Generally, there is a higher abundance, species richness, and diversity of herptiles in lowland dipterocarp forest than in upper elevations. Mindanao Island endemics reside only in the vegetation at higher elevations, while Philippine endemics are found at lower elevations. Non-endemics were found to occupy disturbed lowland dipterocarp forest along with other endemic species. Reptiles of Mt. Hamiguitan typically occur in sites with well-illuminated lowland dipterocarp forest, although refuge habitats occur in the montane forest and mossy forest. Thus, reptile diversity is declining as elevation increases specifically at cool higher elevations. On the other hand, anurans prefer riparian, ground and arboreal strata as microhabitats, which are relatively prominent in montane forest and humid lower elevated forests. Water bodies and other moist locations such as rivers, streams, and pools are used by aquatic amphibians undergoing indirect development or complete metamorphosis specifically those species laying eggs. Ground cover and litter of terrestrial habitats serve as microhabitats of anurans and constant foraging areas that allow anurans to complete their metamorphosis (Kardong 1995). Few of the anuran species were arboreal, preferring low vegetation such as shrubs, pandans, and grasses. This finding indicates that these microhabitats support more endemics and rich herptiles.

The distribution of herptiles in Mt. Hamigutan in the eastern part of Mindanao has similar patterns based on species richness and diversity that is decreasing as altitudinal ranges increase to the central region of Mindanao (Fernandez and Nuńeza 2007). This island characteristic of herptiles proved the comparable spatial association to their habitats. Geographically restricted species are vulnerable to mass extinction (Wake and Vredenburg 2008) due to their limited habitats, sedentary lifestyle, and isolated distribution in the Philippines. This is supported by the populations of snakes, geckos, angleheads (a.k.a. lizards), and frogs that are relatively

abundant in the lower slopes but declining as elevation and vegetative cover gradients increase. However, due to continuing threats, amphibians face immediate extinction trends brought about by human intervention, such as temperature fluctuation and spatiotemporal heterogeneity (Rohr et al. 2008) at all elevations in tropical countries like in the Philippines. Most of these anthropogenic disturbances include habitat destruction, introduced species, pollution, contaminants, pathogens and diseases, and climate change (McCallum 2007). Extreme temperatures can lead to the desiccation of streams, rivers, and other bodies of water, which obviously is detrimental to the breeding behavior of aquatic frogs (Mcmenamin et al. 2008). Meanwhile, land use conversion for agricultural system, which is a common scenario in the lowland forest than in higher elevations, will displace arboreal frogs from their habitats. This has occurred in the marginal areas of the lowland dipterocarp forest on Mt. Hamiguitan. Thus, there is a need for conservation and protection of diverse and endemic herpetofauna and their habitats as they are the most threatened taxa locally and globally.

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