Philippine Journal of Science
147 (3): 393-409, September 2018
ISSN 0031 - 7683
Date Received: 13 Sep 2017

The Zoogeographic Significance of Caraballo Mountain Range, Luzon Island, Philippines With Focus on the Biogeography of Luzon's Herpetofauna

Paul Henric P. Gojo Cruz[1]*and **Leticia E. Afuang**[2]

[1]Faculty, Department of Biological Sciences, College of Arts and Sciences,
Central Luzon State University, Science City of Muñoz, Nueva Ecija
[2]Faculty, Animal Biology Division, Institute of Biological Sciences,
College of Arts and Sciences, University of the Philippines Los Baños, Laguna

Our recent survey in the Caraballo Mountain Range contributed knowledge about the distribution of herpetofauna of Luzon Island, and allowed comparison of species composition among Luzon's biogeographic regions. Data collection was done using intensive herpetofaunal survey in the sampling area in Pantabangan-Carranglan Watershed in Carranglan, Nueva Ecija in the Caraballo Mountains. Comparison with Luzon's mountain ranges was done using presence-based Jaccard similarity index. Extensive literature survey of available distribution data for Luzons' herpetofauna revealed 153 native and non-native species (45 species of frogs, 65 lizards, 40 snakes, and 3 turtles) representing about 44% of the Philippine herpetofauna. Twenty-five (25) species of frogs and 71 species of reptiles are considered as restricted range, found only in one to three biogeographic regions. Jaccard similarity index showed that the herpetofauna of the Caraballo is most similar to that of the northern Sierra Madre (J= 0.50) and Cordillera Mountain Ranges (J=0.45). The available data showed that the Caraballo has a variable role with regards to Luzon's herpetofaunal biogeography. The Caraballo possess frogs and snakes that are also found in the Sierra Madre and Cordillera, implying that the mountain range is a site of amalgamation for these faunas. On the other hand, it serves as a filter zone and dispersal barrier for burrowing and diminutive skinks and frugivorous varanids, based on the observed distribution of some members of the genus *Brachymeles, Parvoscincus*, and *Varanus*. This result confirms the importance of the Caraballo Range as an important biogeographic link between Sierra Madre and Cordilleras. This maybe attributed to the physical connection that provides shared topography and bioclimatic conditions among the biogeographic regions.

Key words: Caraballo, herpetofauna, Pleistocene aggregate island complexes, similarity index, zoogeography

INTRODUCTION

Philippine amphibians and reptiles exhibit high diversity and endemicity. The latest studies listed 112 species of amphibians and 357 species of reptiles in the country, with about 84% endemicity of recorded amphibians and 66% of recorded reptiles (Diesmos et al. 2002; Diesmos et al. 2015). Several studies (Auffenberg 1988; Brown et al. 1996; Diesmos et al. 2005; Siler et al. 2011; Welton et al. 2010, 2012; Brown et al. 2013) on amphibians and reptiles have shown or explained possible dispersal routes, zoogeographical ranges and relationships, and land-bridge connections. Diesmos and co-authors (2002) recognized nine herpetofaunal regions or Pleistocene aggregate island complexes (PAIC) as follows: Batanes PAIC, Babuyanes

*Corresponding authors: paulhenricgojocruz@yahoo.com

PAIC, Luzon PAIC, Mindoro PAIC, Romblon PAIC, Visayas PAIC, Palawan PAIC, Mindanao PAIC, and Sulu PAIC. PAICs have often provided the settings for speciation, with differential dispersal abilities of the isolated species on the palaeo-islands that increased genetic isolation leading to speciation. Species that have higher dispersal abilities become widely distributed, whereas species that have limited dispersal capabilities and narrow ecological niches become restricted in range. Although the relationship of the herpetofauna elements among the faunal regions is generally known, the relationships of the herpetofauna within some areas are still limited. For instance, our ability to interpret processes related to the generation of the diversity of fauna of Luzon has been limited due to an incomplete knowledge of distribution patterns (Siler et al. 2011). Data from recent studies suggest that amphibians and reptiles have a tendency towards fine-scale isolation and differentiation, thereby making them appropriate organisms to use in identifying sub-centers of endemism (Diesmos et al. 2002).

Luzon is the largest island in the Philippine Archipelago. The modern island of Luzon formed from the accretion of four or five paleoislands that correspond to the five montane forests of Luzon: the Zambales Mountain Range, the mountains of south central Luzon, the Cordillera Central, the Sierra Madres, and the Bicol volcanoes (Auffenberg 1988; Devan-Song & Brown 2012). Vallejo (2014) recognized seven biogeographic regions in mainland Luzon. This includes the Caraballo Mountain Range (Nueva Ecija and Nueva Vizcaya), Northern Sierra Madre (Aurora, Cagayan, and Isabela provinces), Southern Sierra Madre (Bulacan, Quezon, and Laguna), Cordillera Mountain Range (Mountain Provinces up to Ilocos Province), Zambales Mountain Range (Zambales and Bataan), and Bicol Peninsula. Geographical connections and topography of the area play important roles in Luzon's herpetological diversity. Shared bioclimatic conditions play an important role in the distribution of the herpetofauna of Luzon. The Zambales Mountain Range and Cordillera Mountain Range generally exhibit different bioclimatic conditions compared to Sierra Madre and Caraballo. According to Heaney and co-authors (2016b), temperature variations in lowland and mountainous areas are not very much different but in general, mountains have cooler temperatures. Seasonality in Luzon is primarily influenced by the amount of rainfall, with areas in Southern Luzon receiving about 15 cm of rain per month. The central and northern portion of the island shows conspicuous seasonality, with portions of Zambales and Ilocos having a distinct dry season. These variations in climatic conditions within Luzon is due to its location, the presence of nearby tropical seas, and variation in elevation.

Climatic conditions affects herpetofauna in two ways: (1) direct effects of moisture on biophysiology, in particular reproduction and (2) indirect effects on vegetation types that provide resources and niches for species to utilize. It is expected that areas with similar topography, climatic conditions, and habitat types will show similarity in species composition.

The Caraballo Mountain Range is located at the boundary between the provinces of Nueva Vizcaya, Nueva Ecija, and Quirino and is connected to the southern tip of the Central Cordillera to the west and the central portion of the Sierra Madre in Aurora to the east, forming a connection between the two mountain ranges. The Caraballo Mountain Range constitutes a volcanic center of Pliocene–Pleistocene origin, part of a volcanic belt complex of the Santa Ana Volcanic Belt–Luzon Central Cordillera Belt–Central Luzon Belt–Cuyo Belt (Yumul et al. 2008). At 1707 m, Mount Palali in Nueva Vizcaya (peak at 16°25'40''N, 121°13'17''E) is the highest point in the Caraballo Mountains. The mountain range has been designated as one of the 19 biodiversity corridors in the Philippines and recognized as a high-priority area for research and conservation (Ong et al. 2002).

Compared to the other mountain ranges of Luzon, the Caraballo Mountain Range has not been surveyed extensively. Our recent herpetological survey done at selected portions of the Pantabangan-Carranglan Watershed in the Caraballo Mountain Range contributed to the existing knowledge on Luzon's herpetofauna. The survey revealed the presence of 59 species of herpetofauna (17 frogs, 14 skinks, 9 lizards, 2 varanids, and 17 snakes), of which 40 are Philippine endemics and 26 are found only in Luzon (Table 1). Only one species (*P. palaliensis*) was endemic to the Caraballo Mountain Range. This high-elevation species was first recorded from Mt. Palali in Nueva Vizcaya (Linkem & Brown 2013). This makes the area an important center of herpetofaunal diversity and endemicity. Together with this information and records from other studies (Brown et al. 1996; Brown et al. 2000; Diesmos et al. 2005; McLeod et al. 2011; Siler et al. 2011; Brown et al. 2012; Devan-Song & Brown 2012), we determined possible relationship between mainland Luzon's biogeographic regions in terms of shared species of herpetofauna. Since the Caraballo Mountain Range lies between two other biogeographic regions (Sierra Madre and Cordillera), we determined the role of the Caraballo with regards to Luzon's biogeography i.e., could it be a: (a) hard barrier preventing dispersal from the two other biogeographic regions, (b) an amalgamation of the three different regions, or (c) a subcenter of herpetofaunal endemism while also serving as a dispersal route for species from the adjacent biogeographic regions. If the Caraballo serves as a barrier to dispersal, we expect to see markedly different herpetofaunal elements between Sierra Madre and Cordillera, since species will not be able to disperse beyond the two biogeographic regions.

If the second hypothesis is correct, then we expect that there will be some similarities and differences in species composition between the three biogeographic regions. If the last scenario was true, we expect that the Caraballo will harbor several unique species while also harboring species from the Sierra Madre and Caraballo.

METHODS

Presence-absence based Jaccard's similarity index (j) was used in the comparison of the herpetological similarities of Luzon's biogeographic regions recognized by Vallejo (2014). The Southern Luzon Volcanic Belt (Batangas and Cavite) was excluded from analysis due to lack of herpetofaunal list from the region. Although Jaccard's Index tends to underestimate the actual similarity in species composition and is often affected by sampling bias and the presence of rare species (Chao et al. 2006; Krebs 2014), it is still a good measure particularly if species lists are the only available data.

$$j = \frac{S12}{(S1 + S2 - S12)} \qquad (1)$$

where: S1 = number of species in 1st community

S2 = number of species in 2nd community

12 = number of species common in both communities

Species lists were taken from published survey results from the Northern Sierra Madre (Brown et al. 2000; Siler et al. 2011), Southern Sierra Madre (McLeod et al. 2011), Cordillera Mountain Range (Diesmos et al. 2005; Brown et al. 2012), Zambales Mountain Range (Brown et al. 1996; Devan-Song & Brown 2012) and Bicol Peninsula (Brown & Gonzalez 2007; Siler et al. 2010; Brown et al. 2015). The species list for the Caraballo Mountain Range was based on the works of Siler and co-authors (2009) and Fuiten and co-authors (2011) and the result of our survey, which recorded 33 additional species from the Caraballo (voucher specimens are currently housed at the Department of Biological Sciences, College of Arts and Sciences, Central Luzon State University). The list of species (Appendix I) is likely incomplete since a vast portion of Luzon is yet to be surveyed. Still, the available data allowed us to get a glimpse about the herpetofaunal relationship of the different biogeographic regions. Introduced species of frogs (*R. marina, H. rugulosus, L. catesbianus, K. pulchra*, and *H. erythraea*) and native house lizards (*G. mutilata, H. frenatus*, and *H. cosymbutus*) were excluded in the similarity analysis, since their distribution patterns do not reflect natural biogeographic distribution but resulted from human-mediated dispersal.

RESULTS AND DISCUSSION

Luzon's Herpetofaunal Diversity

Based on existing literature on mainland Luzon's herpetofauna, there are 153 herpetofaunal species (45 species of frogs, 65 species of lizards, 40 species of snakes, and 3 turtle species) found within the island (Appendix I). Diversity patterns for the reasonably well surveyed areas of Luzon include 72 species for the Cordillera (Diesmos et al. 2005; Brown et al. 2012), 79 species for Bulacan Province, southern Sierra Madre (McLeod et al. 2011), 54 species from the Zambales Mountains (Brown et al. 1996; Devan-Song & Brown 2012), 112 species from northern and central Sierra Madre (Brown et al. 2000; Siler et al. 2011), 61 species from the Bicol Peninsula (Brown & Gonzalez 2007; Siler et al. 2010; Brown et al. 2015) and 66 species from the Caraballo Mountain Ranges (Gojo Cruz 2017; Siler et al. 2009; Fuiten et al. 2011). This represents about 44% of the Philippine herpetofauna (approximately 350 species; Diesmos et al. 2002; Brown & Gonzalez 2007; Diesmos & Brown 2011; Brown & Stuart 2012; Brown et al. 2013). The Northern Sierra Madre and Southern Sierra Madre have the highest number of recorded species (111 and 82 species, respectively). This is not surprising since these areas have been extensively studied compared to the other biogeographic regions. The Caraballo Mountain Range, Zambales Mountain Range, and Bicol Peninsula are relatively unexplored, thus the number of species presented here is likely just a portion of the total diversity of the area.

We consider twenty (20) species of frogs and 37 species of reptiles to be widespread, being recorded in four to six of the biogeographic regions. We defined twenty-five (25) species of frogs and 71 species of reptiles as restricted range, found only in one to three biogeographic regions. The number of species with restricted range may decrease once additional fieldwork is done in areas not yet surveyed. Species-rich taxa such as *Platymantis, Kaloula*, and *Parvoscincus* are represented by some widespread and many restricted-range species. This may mean that these groups of herpetofauna have a tendency for fine-scale isolation and differentiation. Taxa including *Sanguirana, Luperosaurus, Brachymeles*, and many of the snakes are represented by restricted range species. Explanations for this includes: (1) unavailability or incomplete distribution data due to the species being newly described; (2) reptiles in general, particularly fossorial and arboreal species, are oftentimes under-represented in field collections due to their cryptic nature; and (3) presence of dispersal barriers, limited dispersal capability, and narrow microclimatic preference.

The Caraballo Mountain Range shares many Philippine endemic and native species of herpetofauna with the Sierra Madre Mountain Range, in particular the northern

Table 1. Amphibians (anurans) and reptiles (lizards and snakes) from Caraballo Mountain Range, Luzon Island. N: Major new species distribution record for Carranglan, Nueva Ecija; F11: Reported from Mt. Palali, Nueva Vizcaya by Fuiten and co-authors (2011); S09: Reported from Mt. Palali, Nueva Vizcaya by Siler and co-authors (2009); LB13: Linkem & Brown (2013); S14: Siler and co-authors (2014). * - endemic to the Caraballo Mountain Range.

		Distribution Record					
Taxon	**Records**	N. Sierra Madre	S. Sierra Madre	Cordillera Mt. Range	Zambales Mt. Range	Bicol Peninsula	**Status**
AMPHIBIA							
Bufonidae							
Rhinella marina (Linnaeus, 1758)	N, F11	√	√	√	√	√	Introduced
Ceratobathrachidae							
Platymantis cornutus (Taylor, 1922)	F11	√	√	√			Luzon endemic
Platymantis dorsalis (Dumeril, 1853)	N, F11	√	√	√	√	√	Phil. endemic
Platymantis mimulus (Brown, Alcala, and Diesmos,1999)	N	√	√		√		Luzon endemic
Platymantis montanus (Taylor,1922)	F11		√				Luzon endemic
Platymantis pollilensis (Taylor,1922)	F11	√	√	√		√	Luzon endemic
Dicroglossidae							
Hoplobatracus rugulosus (Wiegmann, 1854)	N, F11	√	√	√		√	Introduced
Limnonectes macrocephalus (Inger, 1954)	N, F11	√		√	√	√	Luzon endemic
Limnonectes woodworthi (Taylor, 1923)	N, F11	√	√	√	√	√	Luzon endemic
Occidozyga laevis (Günther, 1858)	N, F11	√	√	√	√	√	Native
Microhylidae							
Kaloula kalingensis (Taylor, 1922)	N	√	√	√		√	Luzon endemic
Kaloula rigida (Taylor, 1922)		√		√			Luzon endemic
Ranidae							
Pulchrana similis (Günther, 1873)	N, F11	√	√	√	√	√	Luzon endemic
Sanguirana aurantipunctata (Fuiten, Diesmos,Welton, Barley, Oberheide, Rico, and Brown, 2011)	N, F11						Luzon endemic*
Sanguirana igorota (Taylor, 1922)	F11			√			Luzon endemic
Sanguirana luzonensis (Boulenger, 1896)	N, F11	√	√	√	√	√	Luzon endemic
Sanguirana tipanan (Brown, McGuire, and Diesmos, 2000)	F11	√					Luzon endemic
Rhacophoridae							
Philautus surdus (Peters, 1863)	F11	√	√	√	√	√	Phil. endemic
Polypedates leucomystax (Gravenhorst, 1829)	N, F11	√	√	√	√	√	Native
REPTILIA (Lizards)							
Agamidae							
Bronchocela marmorata (Gray, 1845)	N	√	√	√	√		Phil. endemic
Draco spilopterus (Weigmann, 1834)	N, S09	√	√	√	√	√	Native
Hydrosaurus pustulatus (Eschcholtz, 1829)	N	√	√			√	Phil. endemic

Table 1. continued . . .

		Distribution Record					
Taxon	**Records**	N. Sierra Madre	S. Sierra Madre	Cordillera Mt. Range	Zambales Mt. Range	Bicol Peninsula	**Status**
Gekkonidae							
Cyrtodactylus philippinicus (Steindacher,1867)	N, S09	√	√	√	√	√	Phil. endemic
Gehyra mutilata (Weigmann, 1834)	N	√	√	√	√	√	Native
Gekko gecko (Linnaeus, 1758)	N	√	√	√	√	√	Native
Hemidactylus frenatus (Dumeril and Bibron, 1836)	N, S09	√	√	√	√	√	Native
Hemidactylus garnoti (Dumeril and Bibron, 1836)	N						Native*
Hemidactylus platyurus (Schneider, 1797)	S09	√	√	√	√	√	Native
Lepidodactylus cf. *lugubris* (Dumeril and Bibron,1836)	N	√	√	√			Luzon endemic
Scincidae							
Brachymeles bicolor (Gray, 1845)	N	√		√			Luzon endemic
Brachymeles elerae (Taylor, 1917)	N						Luzon endemic
Brachymeles muntingkamay (Siler, Rico, Duya, and Brown, 2009)	S09	√		√			Luzon endemic
Eutropis cumingi (Brown and Alcala, 1980)	N	√		√	√		Luzon endemic
Eutropis multicarinata borealis (Brown and Alcala, 1980)	N, S09	√	√	√	√	√	Luzon endemic
Lamprolepis smaragdina (Lesson, 1829)	S09	√	√	√	√	√	Native
Otosaurus cumingi (Gray, 1845)	N	√	√	√	√	√	Phil. endemic
Parvoscincus aurorus (Linkem and Brown, 2013)	N, LB13	√					Luzon endemic
Parvoscincus agtorum (Linkem and Brown, 2013)	N, LB13	√					Luzon endemic
Parvoscincus beyeri (Taylor, 1922)	S09		√	√			Luzon endemic
Parvoscincus decipiens (Linkem and Brown, 2013)	N, LB13	√	√	√		√	Luzon endemic
Parvoscincus duwendorum (Siler, Linkem, Cobb, Watters, Cummings, Diesmos, and Brown, 2014)	N, S14	√					Luzon endemic
Parvoscincus jimmymcguirei (Linkem and Brown, 2013)	N, LB13	√	√	√			Luzon endemic
Parvoscincus leucospilos (Peters, 1872)	N, S14	√	√	√		√	Luzon endemic
Parvoscincus manananggalae (Siler, Linkem, Cobb, Watters, Cummings, Diesmos, and Brown, 2014)	S14		√				Luzon endemic
Parvoscincus palaliensis (Linkem and Brown, 2013)	N, LB13						Luzon endemic*
Pinoyscincus abdictus aquilonius (Brown and Alcala,1980)	N	√	√	√	√	√	Phil.endemic
Pinoyscincus jagori (Peters, 1864)	S09					√	Phil. endemic

Table 1. continued . . .

Taxon	Records	Distribution Record					Status
		N. Sierra Madre	S. Sierra Madre	Cordillera Mt. Range	Zambales Mt. Range	Bicol Peninsula	
Varanidae							
Varanus marmoratus (Weigmann, 1834)	N	√	√	√	√	√	Phil. endemic
Varanus cf. *bitatawa* (Welton, Siler, Benett, Diesmos, Duya, Dugay, Rico, van Weerd, and Brown, 2010)	N	√					Luzon endemic
REPTILIA (Snakes)							
Boidae							
Malayopython reticulatus (Schneider, 1801)	N	√	√	√	√		Native
Colubridae							
Ahaetulla prasina preocularis (Taylor, 1922)	N	√	√	√	√		Native
Calamaria bitorques (Peters, 1872)	N	√		√			Phil. endemic
Calamaria gervaisi (Dumeril and Bibron,1854)	N	√	√	√			Phil. endemic
Cyclocorus lineatus lineatus (Reinhardt, 1843)	N	√	√	√	√		Luzon endemic
Dendrelaphis luzonensis Leviton, 1961	N	√	√	√	√		Luzon endemic
Gonyosoma oxycephalum (Boie, 1827)	N	√		√	√		Native
Hologerrhum philippinum (Günther, 1858)	N	√	√				Luzon endemic
Lycodon muelleri (Dumeril, Bibron and Dumeril,1854)	N	√					Phil. endemic
Oligodon ancorus (Girard, 1858)	N	√	√		√		Phil. endemic
Pseudorhabdion cf. *mcnamarae* (Taylor, 1917)	N	√					Phil. endemic
Ptyas luzonensis (Günther, 1873)	N	√	√	√	√		Phil. endemic
Tropidonophis dendrophiops (Günther, 1883)	N	√					
Elapidae							
Ophiophagus hannah (Cantor, 1936)	N	√	√		√		Native
Lamprophiidae							
Oxyrhabdium leporinum leporinum (Günther, 1858)	N	√	√	√			Phil. endemic
Typhlopidae							
Ramphotyphlops braminus (Daudin 1803)	N	√	√	√	√		Phil. endemic
Viperidae							
Trimeresurus flavomaculatus (Gray, 1842)	N	√	√	√	√		Phil. endemic

half of this mountain range (including Aurora, Cagayan, and Isabela provinces). Seventeen species of Philippine endemic and native frogs have been documented in the Caraballo Mountain Range. This includes 11 species collected during our survey and an additional six species based on Fuiten and co-authors (2011). Fourteen (14) species are shared with the Northern Sierra Mountain Range, 13 species with the Cordillera Mountain Range, and 10 species with the Southern Sierra Madre and the Bicol Peninsula (Fig. 1). Aquatic species of frogs were

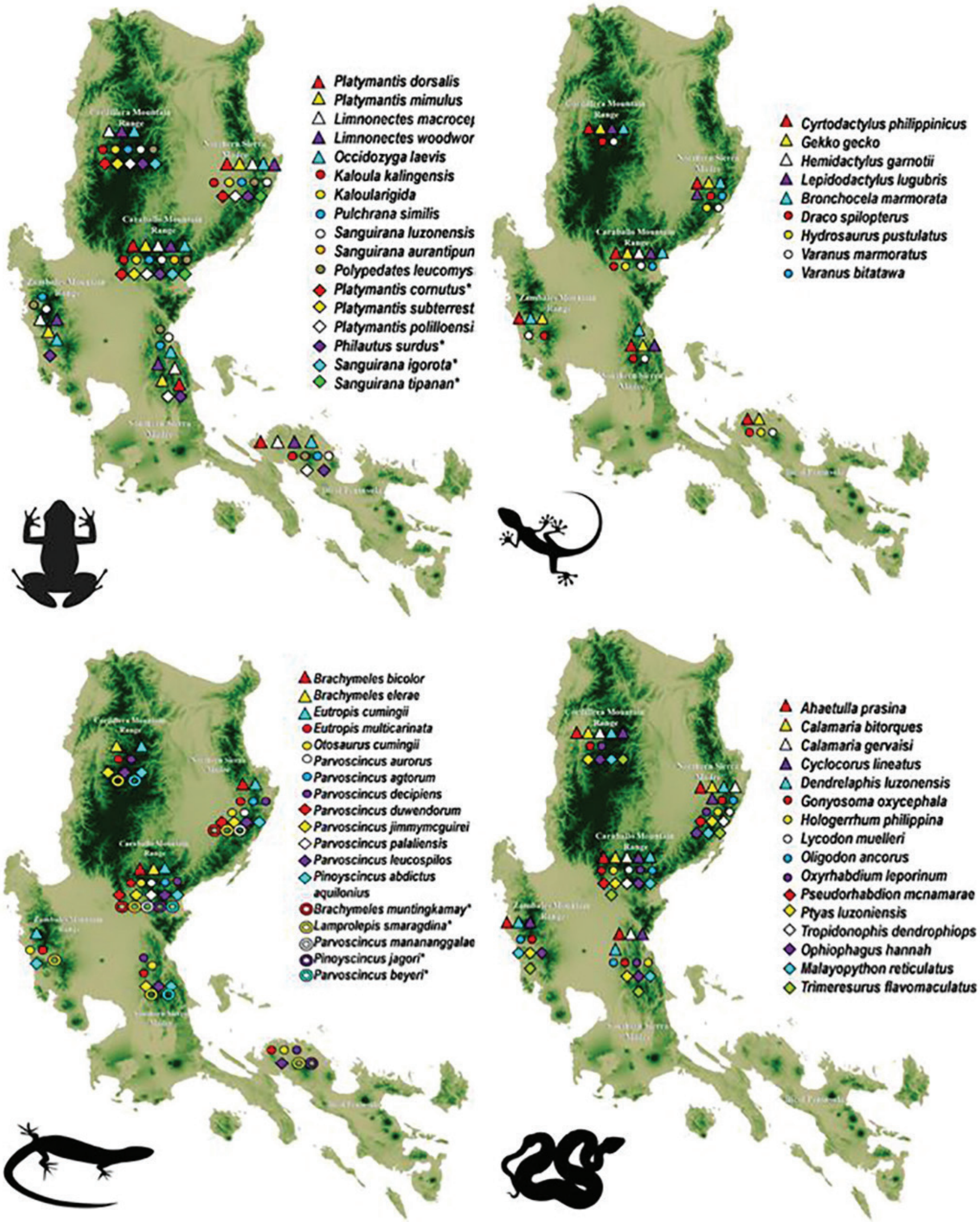

Figure 1. Geographic distribution of endemic and native amphibians and reptiles recorded from the Caraballo Mountain Range (map from PhilGIS.org; retrieved on 6 Dec 2016).

the most commonly shared species among the different biogeographic regions. These species are associated with aquatic habitats, implying the presence of a network of aquatic habitats facilitating dispersion throughout Luzon. The Caraballo Mountain Range may be an important link connecting populations of these species and may have served as the corridor aiding in the dispersal of these species from the Sierra Madre towards the Cordillera Mountain Range and vice versa. The similarity in the species of frogs recorded from the Caraballo with those recorded from the Sierra Madre and the Cordillera shows that the Caraballo is an amalgamation of frog species from the other two biogeographic regions.

Eighteen (18) species of skinks are known from the Caraballo Mountain Range. Thirteen (13) species were recorded during our survey with an additional 5 species reported by Siler and co-authors (2009). The Caraballo shares 16 species of skinks with the Northern Sierra Madre, while nine species were shared with the Cordillera Mountain Range (Fig. 1). The Zambales Mountain Range has the least number of shared species (5), all of which are widely distributed throughout Luzon. Low to mid-elevation species of skinks (e.g., *Eutropis* spp. and *O. cumingii*) were recorded in most of the biogeographic region. Fossorial skinks and diminutive forest skinks (*Parvoscincus*) recorded from the Caraballo are not as widespread compared to other skinks. *B. bicolor, B. muntingkamay, P. agtorum, P. aurorus*, and *P. duwendorum* are shared only with the northern portion of Sierra Madre, and the rare *B. elerae* is shared only with the Cordilleras. The observed pattern of distribution of skinks showed that the Caraballo plays different roles with regards to the distribution of skink between Sierra Madre and Cordillera. Large-bodied species such as *Eutropis* and *Otosaurus* are able to disperse between the three biogeographic regions, attributed to their ability to disperse better. Fossorial skinks (*Brachymeles*) were unable to cross beyond the Caraballo, as evidenced by the presence of some species (*B. elerae* and *B. wrighti*) in the Caraballo and the Cordillera but not in the Sierra Madre, as well as the presence of *B. bicolor* and *B. muntingkamay* in the Caraballo and Sierra Madre but not in the Cordillera. For *B. elerae* and *B. wrighti,* the Caraballo is possibly their southernmost distribution range since it shares similarities with the topography and climate of the Cordilleras where they were originally recorded. On the other hand, the Caraballo serves as a possible subcenter of endemism for diminutive forest skinks as evidenced by the presence of *P. palaliensis,* which was recorded only from Mt. Palali and in PCWFR. Linkem and Brown (2013) pointed out that high-elevation species of *Parvoscincus* appear to be endemic to their respective mountain ranges, implying the importance of high elevation mountains in the diversification of diminutive forest skinks. The burrowing lifestyle and the preference for mid-elevation forest may have also limited the dispersal of this set of species. It is also possible that the secretive lifestyle of this group of skinks may have affected the observed distribution patterns i.e., they are not often encountered during surveys, thus they may appear to be absent in an area.

Among the endemic and native lizards (agamids, gekkonids, and varanids) recorded from the area, eight species were shared with the northern Sierra Madre and six species with the Cordillera Mountain Range and Southern Sierra Madre (Fig. 1). Only five species were shared with Zambales Mountain Range. With the exception of *H. pustulatus* and *V. bitatawa,* all the other species of lizards recorded from the study area are found throughout Luzon. *H. pustulatus* and *V. bitatawa* are shared only with the northern portion of the Sierra Madre. It appears that the Caraballo is the westernmost range of these two species since they were not recorded in the Cordilleras. It is not surprising that lizards are more widely distributed throughout Luzon since they are more mobile, more adaptable to various habitat types, and more tolerant to anthropogenic disturbances than are other reptiles and most frogs.

The seventeen (17) species of snakes recorded from the Caraballo were also known to exist in the Northern Sierra Madre. Twelve (12) species are shared with Southern Sierra Madre, eleven (11) species were shared with Cordillera, and nine with the Zambales Mountain Ranges (Fig. 1). Four species including *H. philippinum, L. muelleri, P. mcnamarae*, and *T. dendrophiops* has restricted biogeographic range, shared only with the Northern Sierra Madre, while the remaining species were known as widespread Luzon endemics and natives. The snake fauna of the Caraballo is an amalgamation of the snake fauna from the adjacent mountain ranges. An exception to this is the genus *Pseudorhabdion* with a single recorded representative (*P. mcnamarae*) in the Caraballo. The other members of the genus, *P. oxycephalum* and *P. talonuran*, were recorded only from the Sierra Madre. It is also noteworthy that the species of *H. philippinum* from Southern Sierra Madre has a distinct coloration (reddish-orange to salmon ventrals) compared to those collected from Northern Sierra Madre and Caraballo (bright-yellow ventrals). It is possible that the populations in the Northern Sierra Madre and Caraballo represent a distinct species (Brown et al. 2012). Comparison between the snakes of Caraballo Mountain Range and Bicol Peninsula were not possible due to absence of snake list from Bicol.

Biogeographic Role of the Caraballo Mountain Range

Based on the available data, it appears that the Caraballo has a variable role as a biogeographic region with regards to its relation with the Sierra Madre and the Cordilleras. In the case of frogs and snakes, the area harbors species from the two adjacent biogeographic regions, making the Caraballo an amalgamation site for these taxa. In the case of burrowing skinks and frugivorous varanids, the Caraballo is a dispersal barrier preventing certain species from the Sierra Madre from dispersing to the Cordillera and vice versa. The Caraballo is also possibly a subcenter of endemicity, as evidenced by the presence of *P. palaliensis.* The different climate and vegetation in these mountain ranges also likely played a role in influencing the distribution of herpetofauna.

Several genera of frogs and reptiles such as *Kaloula, Sanguirana, Platymantis, Parvoscincus, Brachymeles*, and *Varanus* have a distinct northern and southern Luzon element. Within Luzon, this pattern of distribution was also recorded for murine mammals, fantails (*Rhipidura*) and *Rafflesia* (Vallejo 2014). Most of these studies looked at colonization events and the possible role of geographic barriers (i.e., fault lines) in the distribution of this species. Phylogenetic studies done on the fantails and murines showed that the northern clades are more basal than the southern clades, suggesting dispersal from the north to the south. Phylogenetic studies on *Sanguirana* (Brown et al. 2017) and *Parvoscincus* (Linkem & Brown 2013) showed that the two species found in the Caraballo – *S. aurantipunctata* and *P. palaliensis* – were basal to the southern representatives of each genus. This provides support to the possibility that the Caraballo was an important link allowing representatives from these taxa to disperse from the north into the southern portions of Luzon.

Relationship Among Luzon's Biogeographic Regions

The Jaccard's similarity index showed that Caraballo Mountain Range has its highest herpetofaunal similarity with the Northern Sierra Madre (0.50) and the Cordillera Mountain Range (0.45) (Table 2). This is not surprising since the three mountain ranges are geographically connected, apparently allowing species to disperse among these mountains. Fourteen (14) species of frogs, 16 species of skinks, four gekkonid species, three species of agamids, two species of varanid, and 16 species of snakes are shared between Caraballo and Northern Sierra Madre. Although the three biogeographic regions share many species of amphibians and reptiles, there are some species which are shared by only two biogeographic regions.

The list of herpetofauna from the Caraballo is likely far from complete since a very large portion of the mountain range still needs to be surveyed. Dissimilarities in species composition include fewer arboreal species (e.g., members of the *Platymantis hazelae* group, *Philautus, Gonocephalus, Lepidodactylus*) that are quite common in the Sierra Madres. However, this dissimilarity is more likely the result of inadequate sampling of the canopy than actual absence of species. It is also not surprising that we fail to detect species that are associated with karst habitats (e.g., *Platymantis diesmosi, P. biak*, and *Gekko carusadensis*) since the Caraballos is part of a volcanic belt complex (Alviola et al. 2011) and lacks limestone forest that serves as microhabitats for these species.

Only one species, *P. palaliensis* are so far known to be restricted to the Caraballo. Based on the recent phylogenetic studies, *P. palaliensis* forms a clade with large-bodied, high elevation species of *P. beyeri* complex (Linkem & Brown 2013). The presence of endemic species with unique evolutionary lineage at high elevations in the Caraballo shows that the higher elevations may serve as local centers of endemism within the mountain range. According to Heaney and co-authors (2016b),

Table 2. Jaccard's similarity index of the different biogeographic regions of the Greater Luzon Faunal Region. Occurrence data is based on our recent study in Caraballo Mountain Range together with species list from Brown and co-authors (2000, 2012, 2014, 2015), Brown & Gonzalez (2007); Diesmos and co-authors (2005; 2015), Fuiten and co-authors (2011); McLeod and co-authors (2011), Siler and co-authors (2009, 2010, 2011, 2014, and Devan-Song & Brown (2012). Number in parentheses indicates number of shared species. Values in bold face indicate the two highest similarity values between each pair of biogeographic regions.

Area	Caraballo Mountain Range	Northern Sierra Madre	Southern Sierra Madre	Cordillera Mountain Range	Zambales Mountain Range	Bicol Peninsula
Caraballo Mountain Range	----	**0.50 (56)**	0.40 (39)	**0.45 (41)**	0.30 (26)	0.24 (23)
Northern Sierra Madre		----	**0.49 (59)**	0.48 (57)	0.40 (44)	0.28 (36)
Southern Sierra Madre			----	0.40 (41)	**0.41 (36)**	0.38 (36)
Cordillera Mountain Range				----	0.39 (34)	0.26 (26)
Zambales Mountain Range					----	0.25 (22)
Bicol Peninsula						----

high mountains serve as "sky islands" surrounded by a sea of lowland forest. The case of non-volant mammals clearly reflects this pattern of endemicity. Many of Luzon's endemic non-volant mammals are found only in a single biogeographic region, with some species found only in high elevation mountains (Heaney et al. 2016a). This makes them ideal sites for supporting endemic species such as high-elevation species of forest skinks (*Parvoscincus* spp.).

Aside from the Caraballo Mountain, the Northern Sierra Madre also has a high Jaccard's similarity index with the Southern Sierra Madre (0.49) and the Cordillera Mountain Range (0.48). Geographical connectivity, similar climatic conditions, and habitat types explains the similarity in species composition between Northern Sierra Madre and Southern Sierra Madre.

It is surprising that the Southern Sierra Madre has a higher Jaccard's similarity index with Zambales Mountain Range compared to the Bicol Peninsula (0.41 vs. 0.38). This is despite the fact that the Bicol Peninsula is geographically connected to Southern Sierra Madre more than the Zambales Mountain Range. Zambales Mountain Range also has high similarity value with Northern Sierra Madre (0.40) compared to the Caraballo Mountain Range (0.30), which is geographically nearer to it compared to Northern Sierra Madre. Herpetofaunal affinities between Zambales, Northern Sierra Madre, and Cordillera were also observed by Diesmos and co-authors (2005). Devan-Song and Brown (2012) also recorded fewer *Platymantis, Brachymeles*, and *Parvoscincus* in the Zambales biogeographic region that are common in northern, central, and southern portions of Luzon, yet it still showed high similarity index with the other biogeographic regions. It is important to note that many of the species that the Zambales Mountain Range shares with other of Luzons' mountain ranges were low to mid-elevation species that are widely distributed throughout Luzon. The insufficient data on the herpetofaunal diversity of Bicol Peninsula (particularly about reptiles) likely affected the results of comparison between Bicol Peninsula and the other mountain ranges.

The similarity of species composition between closely geographically associated areas was also observed for birds found in the Philippines (Peterson et al. 2000). However, there are exceptions to this pattern. In the same study, closely geographically associated areas such as Luzon and Samar did not cluster together in their analysis. Geographic proximity thus plays a variable role in determining similarity and difference in faunal elements (Peterson et al. 2000). This is similar to the case of the Zambales Mountain Range, which has more similarity with Northern Sierra Madre and Bicol Peninsula than Southern Sierra Madre or the Caraballo. The observed pattern of faunal similarity between the biogeographic regions provides support to the hypothesis of Vallejo (2014) that dispersal may have obscured historical and area relationships of the biogeographic regions.

It was observed that members of the genus *Brachymeles* and *Parvoscincus* showed a distinct disjunct distribution. Many of the species from the north (e.g., *B. elerae, B. wrighti, B. bicolor, P. duwendorum, P. aurorus*) were not recorded from the southern portions of Luzon. Species from the south that were not recorded from the north include *B. makusog, B. samarensis, P. boyengi*, and *P. laterimaculatus.* Welton and co-authors (2012) recorded the same pattern of distribution for the frugivorous varanids of Luzon. The presence of the active Philippine Fault in the southern portion of Aurora served as a barrier to dispersal for these species. Some species (e.g., *B. boulengeri* and *P. leucospilos*) were found in the northern and southern portion of Luzon. It is possible that these species were able to pass through the barrier by other means. The disjunct distribution of some reptile genera in Luzon is evident and can be explained by the presence of a dispersal barrier; however, the distribution of frogs is apparently not influenced by the presence of a barrier. Instead, it appears that endemic frog distribution is influenced by the presence of unique habitat types such as the presence of karst habitats or high montane forests. It should be noted that the observed similarity based on the current available data may change once additional data were available. According to Ferreira and co-authors (2016), any study of geographic patterns of biodiversity – whether for conceptual or practical conservation purposes – must be viewed with skepticism unless it is solidly grounded in thorough, intensive field surveys that are coupled with equally intensive studies of morphology and genetics that produce reliable information about the extent and distribution of biodiversity.

Conservation of the Caraballo Mountain Range

The Caraballo Mountain Range is an important biogeographic link between Sierra Madre and Cordillera, harboring species from these two mountain ranges and at the same time having its own unique species (*P. palaliensis*). The area is currently not included in the recognized conservation priority areas for amphibians and reptiles, although it is recognized as one of the corridors (Ong et al. 2002). The forest of the Caraballo serves as one of the major watersheds in Luzon that act as the headwaters of many major rivers providing water to the provinces including Nueva Ecija, Nueva Vizcaya, and Quirino. The protection of the forest will not only help sustain the diversity but also serve the interests of the people of Central Luzon. The area's diversity, high number of Luzon endemics, presence of rare species, and biogeographic significance merits its inclusion in the list of conservation areas.

ACKNOWLEDGMENTS

The authors would like to thank the Rufford Small Grant for Nature Conservation (Project no. 19494-1), DOST-ASTHRDP-NSC, and IdeaWild Organization for generously funding this research. The Protected Areas Management Board (now BMB) of Pantabangan-Carranglan Watershed, DENR Region III and PASu J. Domingo provided the collection permit for this study. The authors would like to thank R.M. Brown, J.C. Gonzalez and W. Gruezo for their valuable support and comments to help improve the study. Special thanks to the following members of the survey team for their support: J. Lepting and family, F. Palangyos, R. Julian, A. Yangag, P. Binaliw, R. Carangian, S. Lepting, T. Palangyos and D. Laoyan. The authors would also like to thank the two anonymous reviewers for their comments on earlier drafts of the manuscript.

NOTE ON APPENDICES

The complete appendices section of the study is accessible at http://philjournsci.dost.gov.ph

REFERENCES

ALVIOLA PA, DUYA MRM, DUYA MV, HEANEY LR, RICKART EA. 2011. Chapter 2: mammalian diversity patterns on Mount Palali, Caraballo Mountains, Luzon. Fieldiana Life and Earth Sciences p. 61-74.

AUFFENBERG W. 1988. Gray's Monitor Lizard. Gainesville: University of Florida Press. 419p.

BROWN RM, DE LAYOLA LA, LORENZO II A, DIESMOS ML, DIESMOS AC. 2015. A new species of limestone karst inhabiting forest frog, genus Platymantis (Amphibia: Anura: Ceratobatrachidae: subgenus Lupacolus) from southern Luzon Island, Philippines. Zootaxa 4048(2): 191-210.

BROWN RM, FERNER JW, SISON RV, GONZALES PC, KENNEDY RS. 1996. Amphibians and reptiles of the Zambales Mountains of Luzon Island, Republic of the Philippines. Herpetological Natural History 4(1): 1-22.

BROWN RM, GONZALEZ JC. 2007. A New Forest Frog of the Genus *Platymantis* (Amphibia: Anura: Ranidae) from the Bicol Peninsula of Luzon Island, Philippines. Copeia (2): 251-266.

BROWN RM, MCGUIRE JA, FERNER JW, ICARANGAL N JR., KENNEDY RS. 2000. Amphibians and Reptiles of Luzon Island, II: Preliminary Report on the Herpetofauna of Aurora Memorial National Park, Philippines. Hamadryad 25(2): 175-195.

BROWN RM, OLIVEROS CH, SILER CD, FERNANDEZ JB, WELTON LJ, BUENAVENTE PAC, DIESMOS ML, DIESMOS AC. 2012. Amphibians and Reptiles of Luzon Island (Philippines), VII: Herpetofauna of Ilocos Norte Province, Northern Cordillera Mountain Range. Check List 8(3): 469-490.

BROWN RM, PRUE A, ONN CK, GAULKE M, SANGUILA MB, SILER CD. 2017. Taxonomic Reappraisal of the Northeast Mindanao Stream Frog, Sanguirana albotuberculata (Inger 1954), Validation of Rana mearnsi, Stejneger 1905, and Description of a New Species from the Central Philippines. Herpetological Monographs: 31(1): 210-231.

BROWN RM, SILER CD, OLIVEROS CH, WELTON LJ, ROCK A, SWAB J, WEERD M VAN, BEIJNEN J VAN, JOSE E, RODRIGUEZ D, DIESMOS AC. 2013. The amphibians and reptiles of Luzon Island, Philippines, VIII: the herpetofauna of Cagayan and Isabela Provinces, northern Sierra Madre Mountain Range. ZooKeys 266: 1-120. doi: 10.3897/zookeys.266.3982

BROWN RM, STUART BL. 2012. Patterns of biodiversity discovery through time: an historical analysis of amphibian species discoveries in the Southeast Asian mainland and island archipelagos. p. 348–389. *In:* Gower, D. J., K. G. Johnson, J. E. Richardson, B. R. Rosen, L. Rüber, and S. T. Williams (Eds.) Biotic Evolution and Environmental Change in Southeast Asia. Cambridge University Press.

CHAO A, CHAZDON RL, COLWELL RK, SHEN TJ. 2006. Abundance-based similarity indices and their estimation when there are unseen species in samples. Biometrics 62(2): 361-371.

DEVAN-SONG A, BROWN RM. 2012. Amphibians and Reptiles of Luzon Island, Philippines, VI: The Herpetofauna of the Subic Bay Area. Asian Herpetological Research 3(1): 1-20.

DIESMOS AC, BROWN RM. 2011. Diversity, Biogeography, and Conservation of Philippine Amphibians. p. 26-49. In: Biology and Conservation of Tropical Asian Amphibians. Proceedings of the Conference "Biology of the Amphibians in the Sunda Region, South-east Asia." In: Das I, Haas A, Tuen AA. 2011. Institute of Biodiversity and Environmental Conservation, Universiti Malaysia Sarawak, Kota Samarahan, Sarawak, Malaysia.

DIESMOS AC, BROWN RM, ALCALA AC, SISON RV, AFUANG LE, GEE GVA. 2002. Philippine Amphibians and Reptiles: An Overview of Species Diversity, Biogeography and Distribution. In: Ong P, Afuang L, Rosell-Ambal R, editors. Philippine biodiversity conservation priorities: a second iteration of the national biodiversity strategy and action plan. Quezon City (Philippines): Department of Environment and Natural Resources Protected Areas and Wildlife Bureau

DIESMOS AC, BROWN RM, GEE GVA. 2005. Preliminary report on the amphibians and reptiles of Balbalasang-Balbalan National Park, Luzon Island, Philippines. Sylvatrop, The Technical Journal of Philippine Ecosystems and Natural Resources 13(1&2): 63-80

DIESMOS AC, WATTERS JL, HURON NA, DAVIS DR, ALCALA AC, CROMBIE RI, AFUANG LE, GEE-DAS G, SISON RV, SANGUILA MB, PENROD ML, LABONTE MJ, DAVEY CS, LEONE EA, DIESMOS ML, SY EY, WELTON LJ, BROWN RM, SILER CD. 2015. Amphibians of the Philippines, Part I: Checklist of the Species. Proceeding of the California Academy of Sciences 62(3): 457-539.

FERREIRA, C, RIOS-SALDANA CA, DELIBES-MATEOS M. 2016. Hail local fieldwork, not just global models. Nature 534: 326.

FUITEN AM, WELTON LJ, DIESMOS AC, BARLEY AJ, OBERHEIDE B, DUYA MV, RICO ELB, BROWN RM. 2011. A New Species of Stream Frog (*Sanguirana*) from the Mountains of Luzon Island, Philippines. Herpetologica 67(1): 89-103.

GOJO CRUZ PH. 2017. Diversity and Ecology of Herpetofauna in the Pantabangan-Carranglan Watershed. [M.S. Thesis]. Los Baños, Laguna: University of the Philippines Los Baños. 218p. (Available at the UPLB Library).

HEANEY LR, BALETE DS, DUYA MRM, DUYA MV, JANSA SA, STEPPAN SJ, RICKART EA. 2016a. Doubling diversity: a cautionary tale of previously unsuspected mammalian diversity on a tropical oceanic island. Frontiers of Biogeography 8(2).

HEANEY LR, DS BALETE, EA RICKART. 2016b. The mammals of Luzon Island: biogeography and natural history of a Philippine Fauna. Johns Hopkins University Press, Baltimore.

KREBS CJ. 2014. Ecological Methodology 2nd Edition. Addison Wesley Longman, Inc. p. 1-607.

MCLEOD DS, SILER CD, DIESMOS AC, DIESMOS ML, GARCIA VS, ARKONCEO AO, BALAQUIT KL, UY CC, VILLARESAN MM, YARRA EC, BROWN RM. 2011. Amphibians and Reptiles of Luzon Island, V: The Herpetofauna of Angat Dam Watershed, Bulacan Province, Luzon Island, Philippines. Asian Herpetological Research 2(4): 177-98.

LINKEM CW, BROWN RM. 2013. Systematic revision of the Parvoscincus decipiens (Boulenger, 1894) complex of Philippine forest skinks (Squamata: Scincidae: Lygosominae) with descriptions of seven new species. Zootaxa 3700(4): 501-533. www.mapress.com/zootaxa/

ONG P, AFUANG LE, ROSELL-AMBAL RG. EDS. 2002. Philippine Biodiversity Conservation Priorities: A Second Iteration of the National Biodiversity Strategy and Action Plan. Philippine Department of the Environment and Natural Resources, Quezon City.

PETERSON AT, BALL LG, BRADY KW. 2000. Distribution of the birds of the Philippines: biogeography and conservation priorities. Bird Conservation International 10(2): 149-167.

PhilGIS. Philippine GIS Data Clearinghouse. La Salle University, Ozamiz City, Philippines. Accessed at www.philgis.org. (Retrieved on 6 Dec 2016).

SILER CD, DIESMOS AC, BROWN RM. 2010. New Loam-Swimming Skink, Genus Brachymeles (Reptilia: Squamata: Scincidae) from Luzon and Catanduanes Islands, Philippines. Journal of Herpetology 44(1): 49-60.

SILER CD, LINKEM CW, COBB K, WATTERS JL, CUMMINGS ST, DIESMOS AC, BROWN RM. 2014. Taxonomic revision of the semi-aquatic skink Parvoscincus leucospilos (Reptilia: Squamata: Scincidae), with description of three new species. Zootaxa 3847(3): 388-412. www.mapress.com/zootaxa/

SILER CD, RICO EL, DUYA MR, BROWN RM. 2009. A New Limb-Reduced, Loam-Swimming Skink (Squamata: Scincidae: *Brachymeles*) from Central Luzon Island, Philippines. Herpetologica 65(4): 449-459.

SILER CD, WELTON LJ, SILER JM, BROWN J, BUCOL A, DIESMOS AC, BROWN RM. 2011. Amphibians and Reptiles, Luzon Island, Aurora Province and Aurora Memorial National Park, Northern Philippines: New island distribution records. Check List: Journal of Species List and Distribution 7(2): 182-195.

VALLEJO B. 2014. The Biogeography of Luzon Island. Telnov D. (ed.) 2014: *Biodiversity, Biogeography and Nature Conservation in Wallacea and New Guinea*, Volume II.

WELTON LJ, SILER CD, BENET D, DIESMOS AC, DUYA MR, DUGAY R, RICO EL, WEERD M VAN, BROWN RM. 2010. A spectacular new Philippine monitor lizard reveals a hidden biogeographic boundary and a novel flagship species for conservation. Biology

Letters 6: 654-658. doi: 10.1098/rsbl.2010.0119

WELTON LJ, SILER CD, DIESMOS AC, DIESMOS MLD, LAGAT R, CAUSAREN R, BROWN RM. 2012. Genetic identity, geographic range, and major distribution records for frugivorous monitor lizards of Luzon Island, Philippines. Herpetological Review 43: 226-30.

YUMUL GP JR., DIMALANTA CV, MAGLAMBAYAN VB, MARQUEZ EJ. 2008. Tectonic setting of a composite terrane: A review of the Philippine island arc system. Geosciences Journal 12: 7-17.

Appendix I. List and distribution of the herpetofauna of selected mountain ranges in Luzon. PCWFR – Pantabangan-Carranglan Watershed and Forest Reserve; CarMR – Caraballo Mountain Range (Nueva Ecija and Nueva Vizcaya); SSM – Southern Sierra Madre (incl. Bulacan, Laguna, and Quezon); NSM – Northern Sierra Madre (incl. Aurora, Isabela, and Cagayan); CorMR – Cordillera Mountain Range (CAR and Ilocos Provinces); ZMR – Zambales Mt. Range (incl. Zambales, Subic, and Bataan); BP – Bicol Peninsula.

SPECIES	DISTRIBUTION						
	PCWFR	CarMR	NSM	SSM	CorMR	ZMR	BP
Bufonidae							
Rhinella marina	√	√	√	√	√	√	√
Ceratobatrachidae							
Platymantis banahao				√			
Platymantis biak				√			
Platymantis cagayanensis			√		√		
Platymantis cornutus		√	√		√		
Platymantis corrugatus			√	√	√	√	√
Platymantis diesmosi							√
Platymantis dorsalis	√	√	√	√			√
Platymantis indeprensa				√			√
Platymantis isarog							√
Platymantis luzonensis			√	√			√
Platymantis mimulus	√	√	√	√		√	
Platymantis montanus		√		√			
Platymantis naomiei				√			
Platymantis polliloenis		√	√	√	√		√
Platymantis pseudodorsalis				√			
Platymantis pygmaeus			√	√	√		
Platymantis quezoni							√
Platymantis sierramadrensis			√				
Platymantis subterrestris					√		
Platymantis taylori			√				
Dicroglossidae							
Fejervarya cancrivora						√	
Fejervarya moodiei			√		√		√
Fejervarya vittigera			√		√	√	√
Hoplobatrachus rugulosus	√	√	√	√	√		√
Limnonectes macrocephalus	√	√	√	√	√	√	√
Limnonectes woodworthi	√	√	√	√	√	√	√
Occydozyga laevis	√	√	√	√	√	√	√

Appendix I continued . . .

SPECIES	DISTRIBUTION						
	PCWFR	CarMR	NSM	SSM	CorMR	ZMR	BP
Microhylidae							
Kaloula conjuncta							√
Kaloula kalingensis	√	√	√	√	√		√
Kaloula kokacii							√
Kaloula picta			√		√	√	√
Kaloula pulchra			√	√	√		√
Kaloula rigida	√	√	√		√		
Kaloula walteri				√			√
Ranidae							
Hylarana erythrea			√	√		√	
Pulchrana similis	√	√	√	√	√	√	√
Sanguirana aurantipunctata	√	√	√				
Sanguirana igorota		√			√		
Sanguirana luzonensis	√	√	√	√	√	√	√
Sanguirana tipanan		√	√				
Rhacophoridae							
Philautus surdus		√	√	√	√	√	√
Polypedates leucomystax	√	√	√	√	√	√	√
Kurixalus appendiculatus			√	√			√
Rhacophorus bimaculatus			√				√
Rhacophorus pardalis			√	√	√		√
Agamidae							
Bronchocela cristatella							√
Bronchocela marmorata	√	√	√	√	√	√	
Draco spilopterus	√	√	√	√	√	√	√
Gonocephalus sophiae			√	√			√
Hydrosaurus pustulatus	√	√	√	√			√
Gekkonidae							
Cyrtodactylus philippinicus	√	√	√	√	√	√	√
Gehyra mutilate	√	√	√	√	√	√	√
Gekko carusadensis				√			
Gekko gecko	√	√	√	√	√	√	√
Gekko kikuchii			√				
Gekko mindorensis			√	√			√
Hemidactylus brookii				√			
Hemidactylus frenatus	√	√	√	√	√	√	√
Hemidactylus garnoti	√	√					
Hemidactylus platyurus		√	√	√	√	√	√
Hemidactylus stejnegeri			√	√			
Lepidactylus lugubris	√	√	√	√	√		
Lepidodactylus planicaudus						√	
Luperosaurus angliit			√				

Appendix I continued . . .

SPECIES	DISTRIBUTION						
	PCWFR	CarMR	NSM	SSM	CorMR	ZMR	BP
Luperosaurus cumingi							√
Luperosaurus kubli			√				
Pseudogekko compressicorpus			√	√		√	√
Scincidae							
Brachymeles bicolor	√	√	√				
Brachymeles bonitae			√	√	√		
Brachymeles boulengeri			√	√			√
Brachymeles elerae	√	√			√		
Brachymeles ilocandia		√	√				
Brachymeles kadwa		√	√				
Brachymeles makusog							√
Brachymeles muntingkamay		√	√		√		
Brachymeles samarensis							√
Brachymeles wrighti					√		
Dasia grisea			√				
Emoia atrocostata			√			√	√
Eutropis cumingi	√	√	√		√	√	
Eutropis multicarinata borealis	√	√	√	√	√	√	√
Eutropis multifasciata			√	√	√	√	√
Lipinia pulchella levitoni			√		√	√	√
Lipinia vulcania			√				
Otosaurus cumingi	√	√	√	√	√	√	√
Parvoscincus abstrurus				√			√
Parvoscincus agtorum	√	√	√				
Parvoscincus arvindiesmosi				√			√
Parvoscincus aurorus	√	√	√				
Parvoscincus beyeri		√		√	√		
Parvoscincus boyengi						√	
Parvoscincus decipiens	√	√	√	√	√		√
Parvoscincus duwendorum	√	√	√				
Parvoscincus jimmymcguirei	√	√	√	√	√		
Parvoscincus laterimaculatus							√
Parvoscincus lawtoni					√		
Parvoscincus leucospilos	√	√	√	√	√		√
Parvoscincus manananggalae		√	√				
Parvoscincus palaliensis	√	√					
Parvoscincus tagapayo			√				
Parvoscincus tikbalangi			√				
Parvoscincus steerei			√	√	√		√
Pinoyscincus abdictus aquilonius	√	√	√	√	√	√	√
Pinoyscincus jagori		√					√
Sphenomorphus knollmanae					√		√

Appendix I continued . . .

SPECIES	DISTRIBUTION						
	PCWFR	CarMR	NSM	SSM	CorMR	ZMR	BP
Tropidophorus grayi				√			√
Varanidae							
Varanus marmoratus	√	√	√	√	√	√	√
Varanus olivaceus			√				√
Varanus dalubhasa							√
Varanus bitatawa	√	√	√				
Colubridae							
Ahaetulla prasina preocularis	√	√	√	√	√	√	
Boiga dendrophila divergens			√	√			
Boiga philippina			√			√	
Calamaria bitorques	√	√	√		√		
Calamaria gervaisii	√	√	√	√	√		
Cerberus rhyncops						√	
Coelognathus erythrurus			√	√	√	√	
Chrysopelea paradise				√		√	
Cyclocorus lineatus lineatus	√	√	√	√	√	√	
Dendrelaphis caudolineatus luzonensis	√	√	√	√	√	√	
Dendrelaphis marenae			√		√	√	
Dendrelaphis pictus pictus			√				
Dryophiops philippina			√	√		√	
Gonyosoma oxycephalum	√	√	√		√	√	
Hologerrhum philippinum	√	√	√	√			
Lycodon capucinus			√	√	√	√	
Lycodon muelleri	√	√	√				
Lycodon solivagus			√		√		
Myersophis alpestris					√		
Oligodon ancorus	√	√	√	√		√	
Psammodynastes pulverulentus			√		√		
Pseudorhabdion mcnamarae	√	√	√				
Pseudorhabdion oxycephalum			√				
Pseudorhabdion talonuran			√				
Ptyas luzonensis	√	√	√	√	√	√	
Rhabdophis barbouri					√		
Rhabdophis spilogaster			√	√	√	√	
Tropidonophis dendrophiops	√	√	√				
Zaocys luzonensis					√		
Elapidae							
Hemibungarus calligaster			√	√		√	
Naja philippinensis			√		√	√	
Ophiophagus hannah	√	√	√	√		√	

Appendix I continued . . .

SPECIES	DISTRIBUTION						
	PCWFR	CarMR	NSM	SSM	CorMR	ZMR	BP
Lamprophidae							
Oxyrhabdium leporinum	√	√	√	√	√		
Pythonidae							
Malayopython reticulatus	√	√	√	√	√	√	
Viperidae							
Trimeresurus flavomaculatus	√	√	√	√	√	√	
Tropidolaemus subannulatus			√	√			
Typhlopidae							
Acutotyphlops banaorum					√		
Rhamphotyphlops braminus			√	√	√	√	
Typhlops luzonensis			√				
Typhlops ruficaudus			√	√		√	
Bataguridae							
Cuora amboinensis			√	√	√	√	
Trionychidae							
Pelochelys cantorii			√				
Pelodiscus sinensis			√				
Total	53	66	112	79	72	54	61