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Anuran Species Richness and Endemism in Four Long-Term Ecological Research Sites in Mindanao, Philippines

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ABSTRACT

Anurans or frogs and toads have high endemism in the Philippines but their presence is threatened due to continuous habitat loss. This study was conducted to determine the species richness and endemism of anurans in four Long-Term Ecological Research (LTER) sites in Mindanao, namely: Mts. Apo, Kitanglad, Hamiguitan and Malindang. Twelve randomly selected 20mx20m plots inside the 1-hectare plot were surveyed. Forest floor, leaf litter, fern fronds, tree branches, leaves, trunks, soil, and holes were surveyed extensively for occurrence of anurans. Eighteen species of anurans were documented in four LTER sites with eight species (44%) endemic. Among the four LTER sites, Mt. Malindang had the highest species richness (n=11) with six endemic species while Mt. Apo showed the least richness (n=5). Both Mts. Kitanglad and Apo had the least number of endemic species (n=4). Five species such as the Mindanao endemic *Ansonia muelleri, Philautus acutirostris,* and *P. poecilius* and the Philippine endemic *Megophrys stejnegeri* and *Oreophryne anulata* are of vulnerable conservation status. Results indicate the need for strengthened conservation efforts on anurans and habitats in Mindanao LTER sites.

Key words: Frogs, Mt. Apo, Mt. Hamiguitan, Mt. Kitanglad, toads

INTRODUCTION

The Philippines, the second largest archipelago in the world (Diesmos & Brown, 2011) is known for its high proportion of endemic fauna especially amphibians of which at least 97% is composed of anurans (frogs and toads) (Brown *et al.,* 2012a). As of 2015, the Philippines has a total of 110 anuran species (AmphibiaWeb, 2016) and more species are expected to be discovered in the coming years especially in the remaining rainforest since over 70% of amphibians are confined in forests particularly lowland forests (Diesmos & Brown, 2011).

Mindanao, the second largest island, remains to have one of the largest remaining forest cover and is rich with biological resources (DENR, 2011). However, Mindanao gains lesser attention regarding herpetological studies compared to Luzon and some areas of the Visayas (David *et al.,* 2006).Herpetological biodiversity especially in northern Philippines is still substantially underestimated. In the case of the northern Sierra Madre Mountain Range in Luzon, it was recently found to house at least 101 species of herpetofauna with approximately 70% endemic species, a first ever report on the amphibian and reptile diversity in the area (Brown *et al.,*2013). In the northern Cordillera Mountain Range and in the southern Sierra Madre Mountain Range, new distribution records of 58 and 35 species of herpetofauna, respectively, were reported (Siler *et al.,* 2011; Brown *et al.,* 2012b). Further efforts could also lead to possible discovery of new anuran species. In just a span of three years since 2012, two new species of frogs were discovered, namely: *Platymantis quezoni* from the karst limestone area of Quezon Protected Landscape in south-eastern Luzon Island and *Pulchrana guttmani* from Mt. Busa, Sarangani and South Cotobato provinces in southern Mindanao Island (Brown, 2015; Brown *et al.,* 2015; AmphibiaWeb, 2016).

Data on species richness of anurans in forested areas in Mindanao included those studies conducted by Nuñeza *et al.* (2006a) who recorded 26 species in Mt. Malindang, Rivera (2010) who reported 17 frog species in Mt. Apo, Relox *et al.* (2010) who documented nine species of anurans in Mt. Hamiguitan, and Beukema (2011) who recorded 10species in Mt. Kitanglad. Nuñeza *et al.* (2012) reported 22 species of anurans in Mts. Sambilikan, Ararat, and Berseba of Diwata range in Agusan del Sur. Almeria and Nuñeza (2013) documented 17 species of anurans in the swamp forests of Agusan Marsh in Agusan del Sur, and Calo and Nuñeza (2015) recorded 13 species of anurans in Bega Watershed, Prosperidad, Agusan del Sur. Montane forests have records of peak anuran diversity (Diesmos *et al.,*2002a). Habitat destruction which includes forest clearance and fragmentation was found to be the most immediate and clear threat to herpetofauna and affects no less than 85% of the species including frogs (Diesmos *et al.,* 2002a).

Alcala *et al.* (2012) reported that habitat fragmentation and destruction, over- exploitation, and climate change are the reasons for the decline of the

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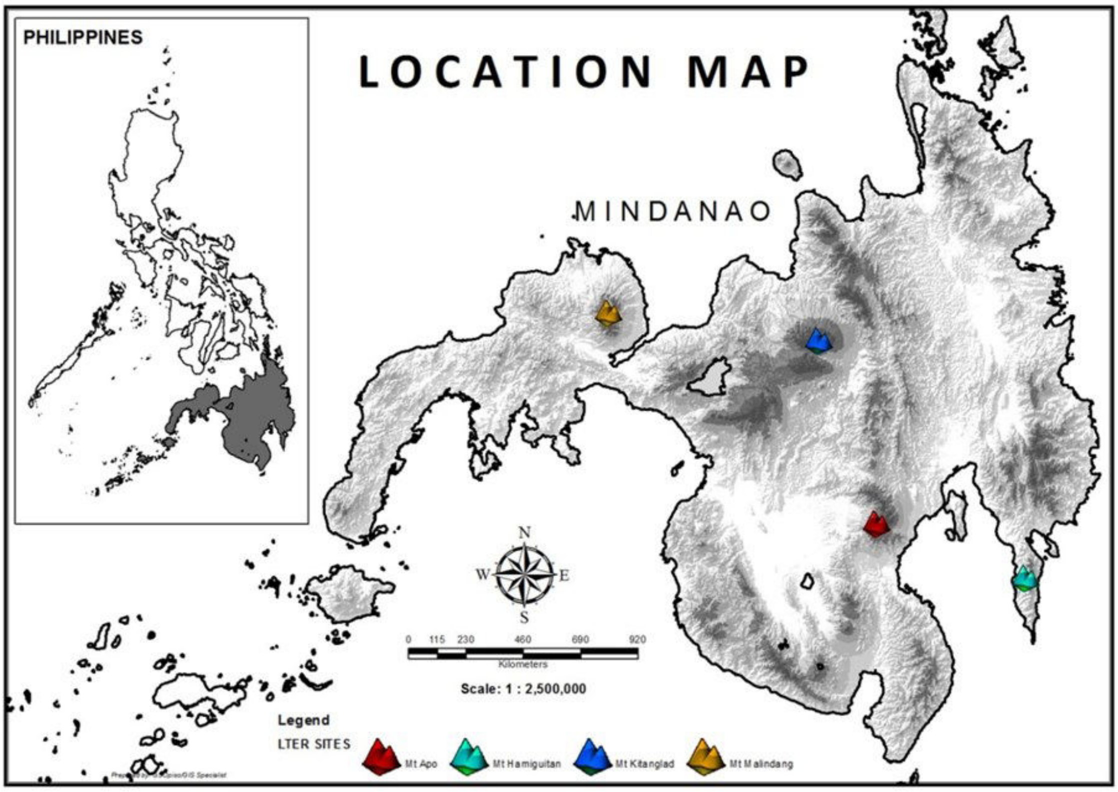

Figure 1. Map of the Philippines showing the location of the four LTER sites.

population of herpetofauna. On the other hand, the ecological importance of amphibians is crucial to the ecosystem serving a big role in the food web especially on insect control and as natural bio-indicators of ecosystem health (Hocking & Babbitt, 2014). For these concerns, Long Term Ecological Research (LTER) assists in addressing complex environmental challenges through comprehensive information to the broader ecological community and different sectors with goal to conserve ecosystems and biodiversity even at global scales (Amoroso, 2006; Magnuson, 2006). However, long term studies on various aspects of biodiversity in the Philippines are few (Alcala, 2006) and monitoring studies on fauna in Mindanao forests through establishment of long -term ecological research (LTER) sites are lacking (Mohagan *et al.,* 2015). The importance of LTER cannot be underestimated. This could lead to potential rediscovery or new discovery of species. In the case of Balbalasang-Balbalan National Park in Luzon which was surveyed from 1998 to 2003, at least nine species from the genus *Platymantis* were found to be potentially new to science, and the five "lost species" from the Cordillera Central mountain range such as *P. cornuta*, *Rana igorota,* and *Sphenomorphus luzonensis* which were all considered previously as rare or in the verge of extinction were rediscovered (Diesmos *et al.,*2005). This paper determined the species richness and endemism of anurans in the four LTER sites in Mindanao with notes on their diversity, species evenness, and conservation status.

MATERIALS AND METHODS

Study area

This study was conducted in one-hectare permanent plots established as LTER sites in Mts. Malindang, Apo, Kitanglad, and Hamiguitan in Mindanao (Figure 1).

Sampling Sites

Site1 is in the upper montane forest of Mt. Apo at an altitude of 1,900-2000 meters above sea level (masl) with coordinates 6°59′47′′N, 125°15′12′′E. Temperature during sampling ranged from 13-19°C. The site has a close-canopy layer and inhabited by *Ascarina philippinensis* C.B.Rob., *Clethra canescens* Reinw. Ex Blume, *Ardisia* sp., *Freycinetia* sp., *Sarcopyramis nepalensis* Wall., *Elatostema* sp., *Hedyotis* sp., *Ardisia japonica* (Thunb.) Blume, *Plagiogyria christii* Copel., *Alsophila heterochlamydea* R.M. Tyron, *Tmesipteris* sp., and *Lindsaea linearis* Sw. Soil leaf litter was thick and moist. There were fallen trees in the site. The distance of the area to the nearest water body (stream) is around 100-300 meters (m). In this site, three sampling visits with a total of 15 sampling nights were carried out on November 15-18, 2012, February 5-10, 2013, and May 4-9, 2013.

Site 2 is a lower montane forest in Mt. Hamiguitan at an altitude of 1000-1100 masl with coordinates 6° 43′58′′N, 126°9′58′′E. Temperature during sampling ranged from 18-25°C. The area has a close to slightly open canopy layer and inhabited by *Syzygium* sp., *Palagium* sp., *Terminalia* sp., *Calophyllum blancoi* Planch., Triana, *Syzygium simile* (Merr.) Merr., *Freycinetia* sp., *Appendicula* sp., *Calamus* sp. cf *merrillii*, *Piper aduncum* L., *Agalmyla* sp., *Selaginella involvens* (Sw.) Spring, *Oreogrammitis fasciata* Parris, *Lindsaea longifolia* Copel., *Selliguea triloba* (Houtt.) ex M.G. Price, and *Lindsaea hamiguitanensis* Karger, Lehtonen, Amoroso, and Kessler. Moist soil leaf litter was present. Fallen

Trees and other plants were moderate in abundance. There was running water in some areas inside the plot while there was stagnant water in the creek along the boundary of the plot. In this site, two sampling visits with a total of 12 sampling nights were carried out on January 25-30, 2013 and April 3-8, 2013.

Site 3 is at the upper montane forest of Mt. Kitanglad at 2100-2200 masl with coordinates 8°5′46′′N, 124°55′17′′E. Temperature ranged from 9-17°C during the sampling. The close-canopy layer (some areas are slightly open) is inhabited by *Flacourtia* sp., *Prunus* sp., *Alsophila fuliginosa* H. Christ, *Mastixia trichotoma* Blume, *Phyllocladus hypophyllus* Hook.f., *A. japonica*, *S. napalensis*, *Agalmyla* sp., *Elatostema* sp., *P. aduncum*, *Asplenium normale* D.Don, *Lycopodium clavatum* L., *Huperzia serrate* (Thunb.) Rothm., *Acrophorus nodosus* C. Presl, *Hymenophyllum* sp., *Prosaptia* sp., and *Plagiogyria glauca* (Blume) Mett. Soil leaf litter is thick to average in abundance while fallen trees and other plants were moderately present. The distance of the plot to the nearest body of water (stream) was around 150-350 m. In this site, four sampling visits with a total of 14 sampling nights were carried out on December 16-18, 2012 May 27-30, 2013 October 27-30, 2013, and December 16-18, 2013.

Site 4 is located at the upper montane forest of Mt. Malindang at 1600-1700 masl with coordinates 8° 17′45′′N, 123°36′34′′E. Temperature during the sampling ranged from 14-25°C. The close to slightly open canopy layer was inhabited by *Hydrangea serratifolia* (Hook. and Arn.) Phil.f., *Macaranga dipterocarpifolia* Merr., *Eusideroxylon zwageri* Teijsm. and Binn., *Ficus odorata* (Blanco) Merr., *Justicia* sp., *Pinanga philippinensis* Becc., *Impatiens platysepala* Y.L. Chen, *Freycinetia* sp., *P. aduncum*, *Gomphostemma javanicum* (Blume) Benth and *Elatostema* sp., *Selaginella tamariscina* (P. Beauv.) Spring, *Huperzia squarrosa* (G.Forst.) Trevis., *Asplenium decorum* Kunze, *Asplenium phyllitidis* D. Don, and *Araiostegia hymenophylloides* (Blume) Copel. Fallen trees and other plants were found to be moderate in number. Although stagnant rain water was observed near the plot, the distance of the plot to the nearest body of water (stream) was around 1000 m while the distance of the plot to the nearest anthropogenic area was around 700-1000 m. In this site, three sampling visits with a total of 17 sampling days were carried out on February 22-28, April 23-27, and December 7-11, 2013.

Sampling, Processing, and Identification

Twelve randomly selected 20m x 20m plots inside the 1 hectare plot were surveyed. Forest floor, leaf litter, fern fronds, tree branches, leaves, trunks, soil, and holes were surveyed extensively for occurrence of anurans. Sampling was conducted at 1830 hours to 2100 hours. Morphometric data included total length, snout to vent length, tibia length for adult anurans only, head length, forelimb length and hind limb length. Two to three individuals per species were kept as voucher specimens. Inger (1954), Alcala (1986), Alcala &Brown (1998), were used as guides for preliminary identification. Identification was confirmed by the third author. Paleontological Statistics (PAST) software was used to compute for biodiversity indices and perform seriation analysis.

RESULTS AND DISCUSSION

Eighteen species of anurans belonging to seven families and11 genera were documented in four LTER sites (Table 1).

Among the four LTER sites, Mt. Malindang had the highest species richness (n=11), followed by Mts. Hamiguitan (n=10), Kitanglad (n=6), and Apo (n=5). This shows a “hump-shaped”species richness pattern with respect to elevationpeaking at mid-elevation at 1600 Masl in Mt. Malindang, and decreased as elevation increased. Similar findings were reported by Diesmos *et al.* (2005) at Balbalasang-Balbalan National Park, Luzon Island in the Philippines in which species richness of herpetofauna was generally highest at lower elevations and at these areas most anuran species especially those requiring water bodies for reproduction congregate around bodies of water such as streams and rivers for *L. macrocephalus, R. luzonensis,* and *R. igorota* and stationary pools of water for *R. pardalis, P. leucomystax,* and *O. cf. laevis*. However, in the case of frogs which are direct developers which do not require water for reproduction, diversity increased with increasing elevation particularly at the montane forest. Previous ecological studies of anuran species richness distribution per elevation gradient in certain Philippine mountains also revealed indirect relationship between species richness and increasing elevation (Diesmos *et al.,* 2002a; Nuñeza*et al.,* 2010; Siler *et al.,* 2011). In the Hengduan Mountains in China, frog total species richness peaks at mid-elevations as well (Fu *et al.,* 2006). Varying elevational gradients exhibit varied complexity in abiotic conditions such as water availability and temperature which arefound to be related to elevational trend of species richness which follows four common patterns including mid-elevation peaks (McCain & Grytnes, 2010).In terms of temperature at the sites during the sampling, Mt. Malindang was documented to have the temperature range of 14 to 25°C which is closer to Mt. Hamiguitan in terms of temperature values (18 to 25°C) than Mts. Apo (13 to 19°C) and Kitanglad (9 to 17°C). In terms of presence of water bodies in the area, near the plot established in Mt. Malindang was a stagnant rainwater and the distance of the plot to the nearest body of water (stream) was around 1000 m. The condition was similar in Mt. Hamiguitan in which a running water was observed in some areas inside the plot while stagnant rain water was observed in the creek along the boundary of the plot. In Mts. Apo and Kitanglad, the distance of the plots to the nearest water body (streams) ranges from 100 to 350 m. Kudavidanage*et al.* (2012) reported that structural habitat parameters are the best predictors of amphibian abundance and richness patterns with species richness highest in a forest habitat, and community composition differs between forest and disturbed habitats. But Giaretta*et al.* (1999) reported that species richness and abundance of litter frogs in a montane forest of Southeastern Brazil were significantly associated with environmental parameters particularly at higher elevations where mist-generated humidity is notable and greater densities of frogs were found.

Another factor which may also contribute to the high species richness in Mt. Malindang was the number of sampling hours. Highest number of sampling days

Table 1. Species composition of anurans in Mindanao Long-Term Ecological Research (LTER) sites.

	Taxa	Distribution and Conser-vation Status	Mt. Apo	Mt. Kitanglad	Mt. Hamiguitan	Mt. Malindang
BUFONIDAE						
1	Mueller's Stream Toad *Ansonia muelleri* (Boulenger, 1887)	ME (Vu)	3	1	---	4
2	*Pelophryne* sp.	---	---	---	---	12
CERATOBATRACHIDAE						
3	Rough-back Forest Frog *Platy-mantis corrugatus* (Duméril,1853)	PE (LC)	---	---	6	---
DICROGLOSSIDAE						
4	Giant Philippine Frog *Limnonectesmagnus* (Stejneger, 1909)	NPE (NT)	---	---	12	---
5	*Limnonectes* sp.	---	---	---	---	1
MEGOPHRYIDAE						
6	Java Spadefoot Toad *Leptobrachium hasseltii* (Tschudi, 1838)	NPE (LC)	---	---	9	8
7	Mindanao Horned Frog *Megophrys stejnegeri* (Taylor, 1920)	PE (Vu)	2	1	3	9
MICROHYLIDAE						
8	Black-spotted Sticky Frog *Kalophrynus pleurostigma* (Tschudi, 1838)	NPE (LC)	---	---	1	---
9	Montane Narrow-mouthed Frog *Oreophryne anulata* (Stejneger, 1908)	PE (Vu)	393	---	---	---
RANIDAE						
10	Big-eyed Frog *Hylaranagrandocula* (Taylor, 1920)	PE (LC)	---	---	5	5
11	Mindanao Splash Frog *Stauroisnatator*(Günther, 1859)	NPE (LC)	---	---	11	---
RHACOPHORIDAE						
12	Shrub Frog *Philautusacutirostris*(Peters, 1867)	ME (Vu)	56	18	18	94
13	Mottled Tree Frog *Philautus poecilius*(Brown and Alcala, 1994)	ME (Vu)	---	283	3	31
14	Bubble-nest Frog *Philautussurdus* (Peters, 1863)	PE (LC)	---	---	---	1
15	*Philautus* sp1	---	6	---	---	4
16	*Philautus* sp2	---	---	28	3	68
17	*Philautus* sp3	---	---	---	---	2
18	*Philautus* sp4	---	---	4	---	---
Total Number of Individuals			460	335	71	225
Total Number of Species			5	6	10	11
Total Number of Endemic			4	4	5	6
Total Number of Vulnerable Species			4	4	3	4

Legend: NA (not assessed); Vu (Vulnerable); LC (Least concern); DD (Data deficient); NT (Near Threatened); NPE (Non-Philippine endemic); PE (Philippine endemic), ME (Mindanao endemic).

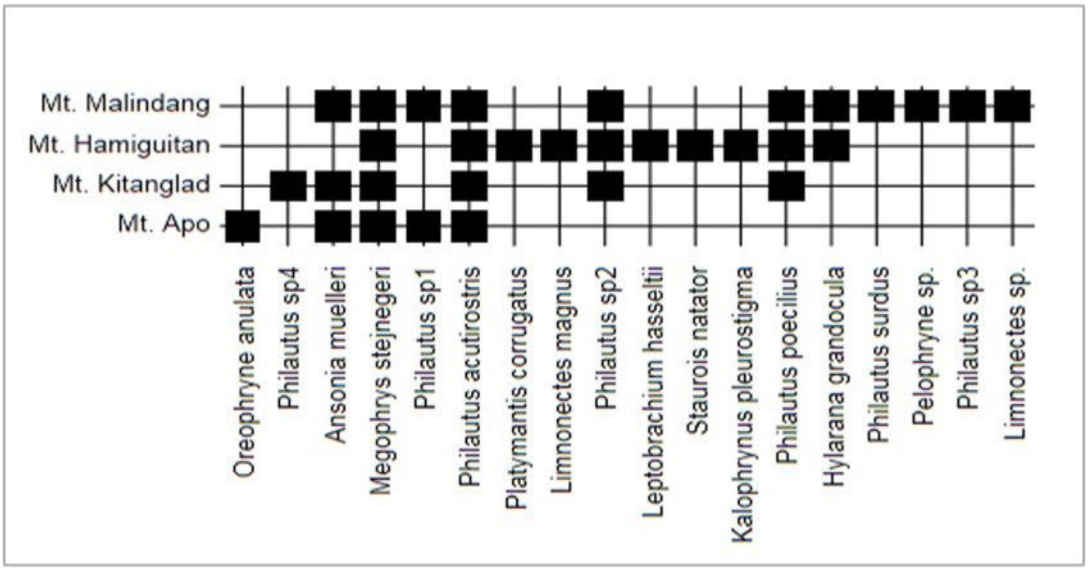

Figure 2. Presence or absence of anurans in Mindanao Long-Term Ecological Research (LTER) sites.

(n=17) was done in Mt. Malindang giving a more probability of capturing more species. Days of sampling spent on other sites ranged from 12 to 15 days only.

Eight endemic species of anurans were recorded in four LTER sites, namely: *Ansonia muelleri, Philautus acutirostris, P. poecilius*, *P. corrugatus, P. surdus, Hylarana grandocula, M. stejnegeri*, and *Oreophryne anulata.* The first three species are geographically restricted to Mindanao (IUCN, 2015).It was observed that sampling areas that are located at the higher elevations and farther from anthropogenic activities have higher endemism. Mts. Apo and Kitanglad, both below 1900 masl, had the highest percentage of endemism, 80% and 67% endemism, respectively. Anuran endemism in the other LTER sites was 54.5% for Mt. Malindang (1700 masl) and 50% for Mt. Hamiguitan (1100 masl). This generally shows an increasing trend of anuran endemism along increasing elevational gradient. The proportion of endemic species of amphibians increases as elevation increases such that those species documented on or near mountain peaks tend to have highly restrictedgeographic distribution (Diesmos & Brown, 2011). Some frogs under the families Ranidae, Microhylidae, and Rhacophoridae (including *Philautus*) and certain species under the genus *Platymantis* are known to exhibit terrestrial development type of reproductive mode, thus capable of undergoing direct development and not anymore requiring water bodies for reproduction (Alcala, 1962; Alcala & Brown, 1982). In the present study, at least 50% of the total number of endemic species belongs to these families and genera.

In this study, seven species areunder the genus *Philautus*, with four species still waiting for verification if these are new to science. An average of 3.8 species of *Philautus*was present in each study site, with Mt. Kitanglad having the greatest percentage (67%) of *Philautus*species richness (n=4) and abundance (n=333, 99%).This could be attributed to the location of study sites at lower to upper montane forests, extending to the transitional zone between montane and mossy forests. *Philautus* species were found not congregating in water bodies but documented in montane forests in Balbalasang -Balbalan National Park, Luzon Island (Diesmos *et al.,*2005). Due to the direct development mode of reproduction of the frogs under this genus, water bodies are not necessary for the species to reproduce (Alcala, 1962; Alcala & Brown, 1982), thus, enabling them to successfully thrive in montane and mossy forests, which apparently many frog species do not select as habitat (Duellman &Trueb, 1994).

Seriation analysis (Figure 2) shows that most anurans as well as the endemic species were recorded in Mt. Malindang. The elevation(1600-1700masl) of this mountain appears to be favorable for anurans to thrive. Higher elevation sites like Mts. Apo and Kitanglad have low species richness. This finding concurs with the results of anuran studies on several mountains (Diesmos *et al.,* 2002b; Nuñeza *et al.,* 2010; Siler *et al.,* 2011).

The endemic species *Platymantis corrugatus* (Diesmos *et al.,* 2004a)*,* and the non-endemic frogs *Limnonectes magnus, Leptobrachium hasseltii,* and *Kalophrynus pleurostigma* were only found in Mt. Hamiguitan. Relox *et al.* (2010) reported the presence of *P. corrugatus* in Mt. Hamiguitan but Amoroso (2000) also reported the occurrence of this species in Mt. Kitanglad. *P. corrugatus* has a wide range of distribution from lowland to montane forests (Diesmos *et al.,* 2004a; Alcala *et al.,* 2012). *P. corrugatus* was documentedin Dipiningan branch of the Cobatangan River of Mt. Maling-aling in Aurora, Luzon at 880–1320 m above sea level (Brown *et al.,* 2000) and in Million-bat Cave on Siargao Island in Mindanao at elevation of 57 masl (Nuñeza & Galorio, 2015). Nuñeza *et al.* (2006b) and Beukema (2011) reported no occurrence of this species in Mts. Malindang and Kitanglad, respectively. Nuñeza *et al*. (2006b) reported previous occurrence of *Leptobrachium hasseltii*at 1235 to 1290 masl in Mt. Malindang. Inthis study, frog assessment was conducted at an elevation of 1600-1700 masl in Mt. Malindang. The difference could be attributed to the difference in elevational gradient assessment of the same mountain. *L. hasseltii* is known to inhabit the forest floor litter of montane and lowland rainforests of Palawan, Mindoro, Bohol, Basilan, and Mindanao in the Philippines and in Java, Sumatra in Indonesia from sea level up to 1,570 masl elevation (Diesmos *et al.,*2009).For *Limnonectes magnus*, it can be noted that this study was conducted at a higher elevation in Mt. Kitanglad (at 2100-2200 masl) compared to previous records of elevational occurrence of *L. magnus* at 1,200-1,800 masl in undisturbed and disturbed streams and rivers in lower montane and lowland forests in the Philippines such as on Mindanao, Basilan, Bohol, Camiguin, Samar and Leyte Islands in the Philippines and in Sulawesi, Indonesia (Diesmos *et al.,* 2004c) and at approximately 800 masl in Mt. Kitanglad (Beukema, 2011).

Philautus surdus, Pelophryne sp., *Philautus* sp.3 and *Limnonectes* sp. were only found in Mt. Malindang in this study. *P. surdus*was previously reported by Nuñeza*et al.* (2006b) in Mt. Malindang at 980 to 2175 masl, but this species was also noted by Beuekema (2011) in Mt. Kitanglad at approximately 800 masl. Relox *et al.* (2010) reported no occurrence of *P. surdus* in Mt. Hamiguitan. The same is the case with Mt. Apo (Rivera, 2010).*P. surdus,* one of the most common forest species of Philippine frogs is common to very common in forested areas even in certain disturbed areas adjacent to forested sites and inhabits a wide elevational distribution including lower montane and lowland forests (Diesmos *et al.,* 2004b).

Oreophryne anulata was only recorded in Mt. Apoin this study. Blackburn *et al.* (2013) reported the occurrence of this species in Mt. Apo. Rivera (2010), Relox *et al.* (2010), and Beukema (2011) reported no occurrence of this species in Mts. Kitanglad, Hamiguitan and Apo, respectively.Diesmos *et al.* (2004d) noted that this species has some population in the protected area of Mt. Malindang National Park, but this was not documented by Nuñeza*et al.* (2006b). This could potentially mean the loss of this species in this area. This species is known to inhabit the arboreal microhabitats in mossy forest but has also been found in disturbed lower montane forest, and from several montane localities in Mindanao, Philippines (Diesmos *et al.,* 2004d).

Furthermore, the two endemic and vulnerable species, *Megophrysstejnegeri* and *Philautusacutirostris* were the only species present in the four LTER sites. *M.stejnegeri* was documented at 120 to 1790 masl in Mt. Malindang (Nuñeza*et al*., 2006b), and in lowland dipterocarp forests in Mt. Hamiguitan (Relox *et al.,*2010). *M.stejnegeri* is usually found in leaf-litter of montane and lowland rainforests with populations of this species also present in Mount Malindang National Park (Diesmos*et al.,*2004e). *Philautus acutirostris*was reported to occur in lowland dipterocarp forests, montane forests, and mossy forests in Mt. Hamiguitan (Relox *et al.,*2010) and at 285 to 2175 masl elevation in Mt. Malindang (Nuñeza*et al.,* 2006b).Beukema (2011) did not find this species in Mt. Kitanglad and Rivera (2010) has not documented this in Mt. Apo. *P. acutirostris* is known to inhabit arboreal and occasionally terrestrial microhabitats in montane and mossy rainforests and in disturbed areas adjacent to forest sites (Diesmos *et al.,* 2004f).

Among the four LTER sites, Mt. Hamiguitan had the highestanuran diversity, (H' = 2.056). Mt. Malindang had moderate diversity (H'= 1.531) while both Mts. Apo and Kitanglad had low diversity. A more or less even distribution was documented for Mt. Hamigutan but Mts. Apo, Malindang, and Kitanglad have uneven distribution (Figure 3.). Relox *et al.* (2010) reported high diversity of anurans in Mt. Hamiguitanwhile Nuñeza*et al.* (2006a) found high diversity of anurans in Mt. Malindang.

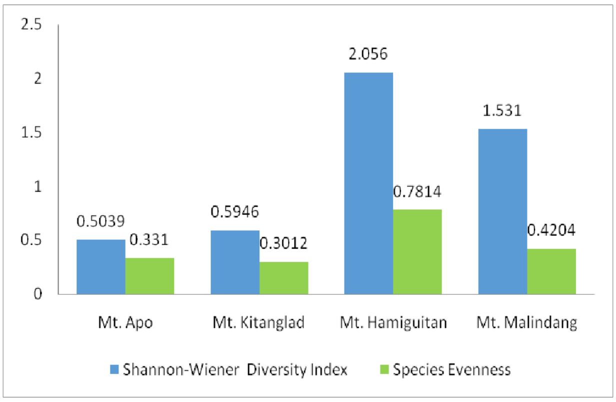

Figure 3. Shannon-Weiner Diversity Index values of anurans in the four Mindanao LTER sites.

The uneven distribution of anuran species in Mts. Apo and Kitanglad was due to dominance of certain frogs on these areas such as *O. anulata* (393 individuals) in Mt. Apo,*P. poecilius* (283 individuals)in Mt. Kitanglad, and *P. acutirostris* in Mt. Malindang.

Five species such as the three Mindanao endemic, *A nsonia muelleri, P. acutirostris,* and *P. poecilius* and the two Philippine endemic, *Megophrys stejnegeri* and *Oreophryneanulata* are the anurans of vulnerable conservation status in this study (IUCN, 2015). All these vulnerable species are also recorded from previous studies like in the study of Relox*et al.*(2010) and Beukema (2011) in Mt. Kitanglad. Rivera (2010) recorded only one vulnerable species of frog, *A. mcgregori,* in Mt. Apo. In Mt. Malindang, one endangered species, *Philautus surrufus* and eight vulnerable species such as *A. mcgregori, Limnonectes parvus, Nyctixalus spinosus, P. acutirostris, P. poecilius, P. worcesteri, M.stejnegeri,* and *Rhacophorus bimaculatus* were documented by Nuñeza *et al.* (2006b).

CONCLUSION

The notable species richness, abundance, high endemism of anurans and the presence of vulnerable Philippine endemic and Mindanao endemic frog species in the four Mindanao Long-Term Ecological Research (LTER) sites, indicate the need to further strengthen protection and conservation in the area. Long-term monitoring is recommended to provide a better picture of the richness and endemism of herpetofauna in Mindanao LTER sites.

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