ELBA BIOFLUX
Extreme Life, Biospeology & Astrobiology
International Journal of the Bioflux Society

Species richness and endemism of cave herpetofauna in Northern Mindanao, Philippines

[1]Olga M. Nuñeza, [2]Marie R. Calizo-Enguito, [2]Yunalyn Labajo-Villantes, [1]Amy G. Ponce

[1]Department of Biological Sciences, College of Science and Mathematics Mindanao State University - Iligan Institute of Technology, Tibanga, Iligan City, 9200 Philippines; [2]Department of Natural Science, College of Arts and Sciences, Misamis University, Ozamis City, Philippines. Corresponding author: O. M. Nuñeza, olgamnuneza@yahoo.com

Abstract. The Philippines is a biodiversity-rich country with high percentage endemism of reptiles and amphibians. However, cave herpetofauna particularly in Mindanao, the country's second largest island, is poorly known. In this study, 19 caves in Mindanao were surveyed using the modified cruising method to document the herpetofaunal species present giving particular attention to endemic species. Nine species of herpetofauna (four amphibians and five reptiles) belonging to six families were recorded. The endemic *Hylarana grandocula* was the most abundant and widespread among the amphibian species while the endemic *Cyrtodactylus annulatus* was the most widely distributed reptile species. A 44 % endemicity was recorded. Kitaotao cave 5, which has suitable microhabitats, had the most species of herpetofauna. More reptilian species were found in a coastal cave. Assessment of more caves in Mindanao could increase the total number of herpetofaunal species. The presence of endemic species in caves indicates the need to protect these particular caves where the endemic species are found.
Key Words: amphibians, biodiversity, endemic, *Hylarana grandocula*, reptiles.

Rezumat. Filipine reprezinta o ţară bogată din punct de vedere al biodiversitaţii, unde se manifestă un enedemism ridicat la reptile şi amfibieni. In orice caz, herpetofauna cavernicolă, în mod particular în Mindanao, a doua insula din ţară ca suprafaţă, este puţin cunoscută. În acest studiu, 19 peşteri din Mindanao au fost explorate folosind metoda deplasării modificate pentru a documenta speciile de herpetofauna prezente, cu o atenţie specială pentru speciile endemice. Noua specii de herpetofaună (patru amfibieni şi cinci reptile) aparţinând la şase famili, au fost identificate. Endemitul *Hylarana grandocula* a fost cel mai abundent şi răspândit dintre speciile de amfibieni în timp ce endemitul *Cyrtodactylus annulatus* a fost specia de reptile cea mai răspândită. A fost observată o endemicitate cu un procent de 44 %. Peştera Kitaotao, care are microhabitate adecvate, adăposteşte cele mai multe specii de herpetofaună. Cele mai multe specii au fost găsite într-o peşteră de pe coastă. Studierea mai multor peşteri din Mindanao poate creşte numărul total de specii de herpetofaună. Prezenţa speciilor endemice in peşteri indică necesitatea de a proteja peşterile în care au fost găsite aceste speci endemice.
Cuvinte cheie: amfibieni, biodiversitate, specii endemice, *Hylarana grandocula*, reptile.

Introduction. The Philippine archipelago, which is composed of more than 7,100 distinct islands (Ambal et al 2012), holds a concentration of species diversity and endemism of global importance (Peterson et al 2000) and recognized as one of the most important centers of herpetofaunal diversity in Southeast Asia (Diesmos et al 2002). It consists of 102 amphibian species (Alcala et al 2006) of which 78 are endemic and 258 reptile species of which 170 species (66 %) are recognized to be endemic (Diesmos et al 2002). Biodiversity study on Mt. Malindang recorded 257 terrestrial vertebrate species of which 26 amphibians and 33 reptiles were identified (Nuñeza et al 2006). In the study conducted by Beukema (2011) in Mt. Kitanglad Range, 22 herpertofaunal species were recorded of which 12 are reptiles and 10 are amphibians and 15 of these species

constitute new records for the area. Brown & Alcala (1994) described several species of Philippine frogs of the *Rhacophoridae* family from Mindanao. Relox et al (2010) in their study in Mt. Hamiguitan reported that of the 15 reptiles and nine amphibians recorded, endemicity reached 80 % for reptiles and 77.8 % for amphibians. However, published studies of cave herpetofauna in the caves of Mindanao, the second largest island in the archiplegao, are limited although limestone habitats are abundant (DENR-PAWB 2008). Most of the surveys on limestone habitats were in the Visayas, notably by Alcala et al (2004), who surveyed limestone and non-limestone forest fragments to elucidate the effects of fragmentation and degradation of tropical rainforests on tropical herpetofauna. Siler et al (2009) also reported a new species of limestone-forest frog from Eastern Samar Island.

Cave is home for wildlife species (Biswas 2010) and characterized by total darkness, almost constant air and water temperature, relative humidity approaching saturation and a relatively poor supply of nutrients (Engel 2007). Its fauna constitutes one of the important components of biodiversity (Biswas 2009). However, cave herpetofauna in Mindanao is poorly known. In this study, 19 caves in selected areas in Mindanao were surveyed to document the herpetofaunal species present, giving particular attention to endemic, threatened, and socioeconomically important species.

Material and Methods

Sampling Sites. This study was conducted in the provinces of Bukidnon and Misamis Oriental and in the cities of Iligan and Valencia (Figure 1). Nineteen caves were sampled, of which four caves (Hindang Cave 1, Hindang Cave 2, Hindang Cave 3 and Dalipuga Cave) are in the city of Iligan, two caves (Gitagum Cave 1 and Gitagum Cave 2) are in Gitagum, Misamis Oriental, six caves (Minsalirac Cave 1, Minsalirac Cave 2, Minsalirac Cave 3, Minsalirac Cave 4, Blue Waters Cave and Kabyao Cave) are in Quezon, Bukidnon, five caves (Kitaotao Cave 1, Kitaotao Cave 2, Kitaotao Cave 3, Kitaotao Cave 4, Kitaotao Cave 5) are in Kitaotao, Bukidnon and two caves (Salawaw Cave and Kariis Cave) are in Valencia City. Table 1 shows the 19 caves sampled with corresponding description.

Sampling Methods. A modified cruising method was employed to document the herpetofauna in the caves. The caves were sampled for a total of 2521 man-hours from April to August 2010 at 700 hours-1500 hours and 1800 hours-2100 hours. Cave sites were described following Alcala et al (2007). Reference works such as Inger (1954), Brown & Alcala (1978, 1980), Alcala (1986), and Alcala & Brown (1998) were used for species identification. Distribution and conservation status of herpetofauna species was based on IUCN Red List of Threatened Species (2014) while a list of socioeconomically important species was based on key informant interviews. Paleontological Statistics Software Package by Hammer et al (2001) was used for cluster analysis.

Figure 1. Map of the world (A) (www.marloncabilan.wordpress.com 2012) and the Philippines (B) (www.google.com.ph/maps 2015) showing the location of 19 caves (red dots) (C) (www.car-navi.ph 2010).

Table 1

Description of the 19 caves sampled in Northern Mindanao, Philippines

Cave Sites	Coordinates	Elevation meters above sea level	Water Bodies/ Droplets	Diameter of cave entrance (m)	Height of the cave entrance (m)	Type of Substrate	Type of Disturbances	Presence of stalactites, stalagmites, crevices and boulders	Guano depth	Temperature °C			Relative Humidity %		
										E	T	I	E	T	I
Iligan City															
Hindang Cave 1	08°18'121'' N 124°21'394 '' E	2522	Absent	8.3	5.44	muddy	-	Few Stalactites, Big boulders	20 cm depth	27.3	27.3	25.4	89	89	91
Hindang Cave 2	08°18'122" N 124°21'389' ' East	531	Absent	2.8	3.30	muddy	markings and graffiti	Moderate stalactites Few Stalagmites, Cave crevices, Small boulder	absent	26.5	26.5	27	81	81	84
Hindang Cave 3	08°18'104'' N 124°21'373' ' E	525	absent	3.9	2.93	-	markings and graffiti	Moderate Stalactites, Few crevices, boulders	25 cm depth	26.5	26.5	27	87	87	89
Dalipuga Cave	08°18'112'' N 124°21'39'' E	239	present	15	9.45	muddy	spelunking and treasure hunting	Moderate stalactites, wall crevices and boulders	absent	24	24	24	82	82	82
Gitagum, Misamis Oriental															
Gitagum Cave 1	08°34'322" N 124°22'55" E	90	absent	4.14	2.24	dry	Cooking inside cave	Few stalactites	absent	26	26	27	73	73	74

Gitagum Cave 2	08°34′272′′ N 124°22′510′′ E	77	absent	1.9	0.82	dry	Low human disturbance	Few stalactites, Moderate crevices		27	27	26	74	74	76
Quezon, Bukidnon																
Minsalirac Cave 1	07^0 42′017′′ N $125^0$03′322′′ E	282	absent	7	6	dry	Low human disturbance	Moderate stalactites, Few stalagmites, wall crevices	Rare	24	24	23	85	85	86
Minsalirac Cave 2	07^0 42′014′′ N $125^0$03′219′′ E	356	absent	3	5	dry	Low human disturbance	Moderate stalactites, Few stalagmites, Moderate wall crevices	Rare	28	28	26	83	83	87
Minsalirac Cave 3	07^0 42′014′′ N 125^0 03′219′′ E	356	absent	2.5	2	dry	Low human disturbance	Moderate stalactites, Few stalagmites, Moderate wall crevices	Rare	28	28	26	83	83	87
Minsalirac Cave 4	07^0 42′006′′ N $125^0$03′209′′ E	341	absent	2	2	dry	-	Moderate stalactites, Few stalagmites, wall crevices	Rare	28	28	27	91	91	90
Blue Waters Cave	07^0 42′062′′ N $125^0$03′249′′ E	241	present	4	5	dry	treasure hunting	Few Stalactites and stalagmites, Few wall crevices	Rare	27	27	27	79	79	84

Kabyao Cave	07^0 42′062′′ N 125^{0}03′249′′ E	278	absent	6	7	dry	spelunking and treasure hunting	Numerous Stalactites and stalagmites, wall crevices	4 cm depth	24	24	24	85	85	89
Kitaotao, Bukidnon															
Kitaotao Cave 1	07^0 42′062′′ N 125^{0}03′249′′ E	316	absent	8	10	muddy	Low human disturbance	Few stalactites and stalagmites	absent	26	26	26	88	88	88
Kitaotao Cave 2	07^0 42′062′′ N 125^{0}03′249′′ E	328	Absent	4	5	dry	Low human disturbance	Stalactites and stalagmites	Few	27.5	27	26	87	87	89
Kitaotao Cave 3	07^0 42′062′′ N 125^{0}03′249′′ E	372	Absent	2.5	5	Dry	vandalism was noted on the walls	Moderate stalactites and stalagmites	Few	25	25	25	74	74	74
Kitaotao Cave 4	07^0 42′062′′ N 125^{0}03′249′′ E	333	Present	7	7.5	-	Low human disturbance	Moderate stalactites and stalagmites	absent	25	25.5	25.5	89	89	89
Kitaotao Cave 5	07^0 42′062′′ N 125^{0}03′249′′ E	360	Absent	3.5	4	-	Low human disturbance	Moderate stalactites and stalagmites	Rare	26	26	25	89	89	89
Valencia City, Bukidnon															
Salawaw Cave	07^0 42′062′′ N 125^{0}03′249′′ E	728	Present	3	6	muddy	Low human disturbance	Numerous Stalactites, stalagmites, and columns	Moderate	23.5	22.5	23.5	75.5	95.5	91
Kariis Cave	07º 42.062″ N 125º03.249″ E	437	present	20	25	muddy	Low human disturbance	Numerous Stalactites, stalagmites, and columns	Abundant	25.5	27	24	-	-	-

Legend: E- entrance zone, T-twilight zone, I- inner zone

Results and Discussion. Nine herpetofaunal species (four amphibians and five reptiles) belonging to six families were recorded in the caves surveyed (Table 2). This result was lower than the recorded number of species in forest habitats of Mt. Sambilikan (Nuñeza et al 2012) but higher than the recorded number of herpetofauna species in Fiji PABITRA (Morrison & Naikatini 2008).

According to Jones et al (2003) species diversity within caves is affected by food or resource availability. Stevens & O'Connor (2006) also reported that habitat area, temperature, humidity, rainfall, latitude and altitude also affect species diversity. Kitaotao cave 5 was the most species-rich probably because it has low human disturbance.

Table 2

Species richness of herpetofauna in 19 caves in Northern Mindanao

Sampling Site	Amphibians	Reptiles	Total
Iligan City			
Hindang Cave 1	1	2	3
Hindang Cave 2	1	2	3
Hindang Cave 3	0	0	0
Dalipuga Cave	0	1	1
Gitagum, Misamis Oriental			
Gitagum Cave 1	2	1	3
Gitagum Cave 2	1	1	2
Quezon, Bukidnon			
Minsalirac Cave 1	0	1	1
Minsalirac Cave 2	0	1	1
Minsalirac Cave 3	1	0	1
Minsalirac Cave 4	1	0	1
Blue Waters Cave	1	0	1
Kabyao cave	0	1	1
Kitaotao, Bukidnon			
Kitaotao Cave 1	0	1	1
Kitaotao Cave 2	1	0	1
Kitaotao Cave 3	1	0	1
Kitaotao Cave 4	1	0	1
Kitaotao Cave 5	4	0	4
Valencia, Bukidnon			
Salawaw Cave	1	1	2
Kariis Cave	1	0	1
Total Number of Species	4(2)	5(3)	9(5)

Legend: (endemic species)

This observation concurs with the study of Heinen (1992) that species richness and diversity of herpetofauna are higher in less disturbed sites. Moreover, anuran diversity and species richness are lower in disturbed areas (Suazo-Ortuno et al 2008). This indicates that less disturbed sites could harbor many species. The Kitaotao cave 5 was an easy walk through because it has only one opening and one chamber. The presence of a body of water makes it a good microhabitat for breeding amphibians. According to the Natural Resources Conservation Service (2006), amphibians usually dwell in areas with water and cool areas where the air is humid enough to keep their body moist. Alcala et al (2006) reported that 85 % of the Philippine amphibians are highly dependent on and sensitive to moisture. This factor could also explain the richness of Kitatotao cave 5. However, in the Blue Waters cave only one species was recorded, while in Hindang cave 3 no single species was documented. Blue Waters cave is a tourist destination because of its clear water. Residents and tourists use the cave as picnic grounds leaving trash behind. In Hindang cave 3, human disturbance as seen from markings and graffiti was

moderate in the entrance zone and none in the inner zone. Amphibians and reptiles are particularly sensitive to habitat disturbance (Natural Resources Conservation Service 2006) and thus disturbed areas have significantly lower herpetofauna diversity than in the undisturbed area (Surasinghe 2007), however there are also few species that can tolerate disturbance (Heinen 1992) like some frog and toad species which could tolerate or even increase after disturbances (Moorman et al 2011). Human activities can have adverse effects on animal distribution and abundance (Ruddock & Whitfield 2007). Moreover, human disturbance is increasingly becoming a concern to conservationists because, as human populations continue to expand, ecotourism is increasing as a potential revenue source, and wildlife in diminishing areas of refuges are exposed to greater human recreational and other anthropogenic activities (Wight 2002; Christ et al 2003). In Hindang Cave 1, Hindang Cave 2, and Gitagum Cave 1 three herpetofauna species were documented in each cave. Hindang Cave 1 is the biggest cave among Hindang caves. It was also least disturbed, being located far from human settlements and the landowner prohibited people from exploring the cave. Hindang cave 1 is located near a forest which makes this cave a good site for reptiles and amphibians. Many crickets were observed that might serve as food for reptiles and amphibians. The same observation was obtained by Browne (2009) that amphibians prefer elongated prey such as crickets or insect larvae. Hindang Cave 2 has three interconnecting chambers. There was a small extraneous debris found in the three cave zones in addition to fallen rocks and boulders that created holes suitable for reptiles, which also provide quick escape from predators. Gitagum Cave 2 is a small three-chambered cave with open canopy cover. Just like Hindang Cave 1 and Hindang Cave 2, Gitagum Cave 2 consists of abundant holes and crevices. Spiders, ants, cockroaches, bugs and crickets were observed in the caves, which are available for reptiles and amphibians as food. Macro-invertebrates serve as the primary food base of many amphibians and reptiles (Poulton 2004). Moreover, human disturbances in this site were low.

Table 3 shows the species of amphibians and reptiles found in the caves surveyed. The Philippine endemic, *Hylarana grandocula* was found in eight sites and was the most abundant species. This species was found mostly in cave entrance and mid inner zone. According to Gunn (2004), amphibians are commonly encountered at the entrance of the cave with high air humidity and buffered temperature changes. *Hylarana grandocula* is an inhabitant of undisturbed and disturbed streams and rivers in lowland forests (Diesmos et al 2004a). The presence of *Hylarana grandocula*, which feeds mainly on invertebrates (Alcala & Brown 1998), indicates the presence of food source in the cave. This species was also recorded in the study of Alcala et al (2012a) in caves and limestone habitat. *Kalophrynus pleurostigma* was found only in Kitaotao Cave 5 where two individuals were found. According to Diesmos et al (2004b), *Kalophrynus pleurostigma* is found occasionally in disturbed forests and breeds in small pools of water. This could be the reason for the existence of *Kalophrynus pleurostigma* in Kitaotao Cave 5 which is a less disturbed habitat with presence of bodies of water. *Limnonectes magnus* was found in three sites (Gitagum cave 1, Kabyao cave and Kitaotao cave 5) while *Platymantis* sp. was found in five sites (Kitaotao cave 2, Kitaotao cave 3, Kitaotao cave 4, Kitaotao cave 5 and Salawaw cave) and both were usually seen at the cave entrance up to five meters inwards for *L. magnus* and up to 10 meters for *Platymantis* sp. Alcala et al (2012b) reported that frogs are generally found in moist and cooler portions of the caves, particularly near the entrance and in moist rock crevices which are also the location of amphibian species found in this study. Calls of *Platymantis* sp. were heard in the four caves in Kitaotao (caves 1-4). This species made its call inside rock crevices and holes where it cannot be seen. It was observed to be very sensitive to noise that it automatically stopped calling with just one small noise. It took 1-3 hours before it made another call. Calls of *Limnonectes magnus, Hylarana grandocula,* and *Kalophrynus pleurostigma* were also heard in Kitaotao cave 4. The calls emanated from the accumulated debris at the entrance of the cave which was observed to be the microhabitat of these anurans. Of the reptiles, *Cyrtodactylus annulatus* was found to be widespread being found in eight sites, which is expected since this species is known to occur in limestone caves.

Table 3

Species list of herpetofauna in 19 caves in Northern Mindanao

SPECIES	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	Total
AMPHIBIANS																				
Family Dicroglossidae																				
Limnonectes magnus+ (Large Swamp Frog)	0	0	0	0	3	0	0	0	0	0	0	2	0	0	0	0	5	0	0	10
Family Microhylidae																				
Kalophrynus Pleurostigma (Black-spotted Narrow-mouthed frog)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	2
Family Ranidae																				
Platymantis sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	3	5	2	2	1	0	13
*Hylarana grandocula** (Big-eyed Frog)	2	1	0	0	2	1	0	0	0	1	2	0	0	0	0	0	3	0	2	14
REPTILES																				
Family Elapidae																				
Ophiophagus hannah^ (King Cobra)	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Family Gekkonidae																				
*Cyrtodactylus annulatus** (Small Bent-toed Gecko)	0	1	0	1	0	1	1	1	1	0	0	0	1	0	0	0	0	0	1	8
Family Scincidae																				
*Sphenomorphus fasciatus** (Banded Sphenomorphus)	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
*Sphenomorphus jagori** (Jagor's Sphenomorphus)	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Sphenomorphus variegatus (Blacked –spotted Sphenomorphus)	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Total Number of Individuals	4	3	0	1	6	2	1	1	1	1	2	2	1	3	5	2	12	1	3	51
Total Number of Species	3	3	0	1	3	2	1	1	1	1	1	1	1	1	1	1	4	1	2	9

Legend: (A) Hindang Cave 1, (B) Hindang Cave 2, (C) Hindang Cave 3, (D) Dalipuga Cave, (E) Gitagum cave 1, (F) Gitagum Cave 2, (G) Minsalirac Cave 1, (H) Minsalirac Cave 2, (I) Minsalirac Cave 3, (J) Minsalirac Cave 4, (K) Blue Waters Cave, (L) Kabyao Cave, (M) Kitaotao Cave 1, (N) Kitaotao cave 2, (O) Kitaotao Cave 3, (P) Kitaotao Cave 4, (Q) Kitaotao Cave 5, (R) Salawaw Cave, (S) Kariis Cave; *endemic, + near threatened, ^vulnerable

These species is also found in a wide variety of microhabitats, including among detritus on the forest floor, under rotting logs in forests and it also congregates in suitable habitat close to rivers and streams (Brown & Rico 2009). The endemic *Sphenomorphus jagori* was only found in Hindang cave 1 with only one individual, although this species has wide distribution, presumed large population and has tolerance to habitat modification (Brown et al 2009).

Cluster analysis (Figure 2) shows that the first group consists of cave sites situated in Bukidnon area (caves N, P, O, R). These N, P, O, R caves are less disturbed and serve as good habitats for herpetofauna because of the high number of insects found at the time of study. *Platymantis*, which is known to be karst habitat-specialised as reported by Siler et al (2010), was commonly found or shared in N, P, O, R cave sites. Furthermore, the most similar sites in this group are caves N and P, which are less disturbed, with presence of water droplets or bodies of water and high availability of food such as insects. The other group of sites, J to L, had low to moderate disturbance with sparse vegetation. The Caves E, Q, L formed a branch at <40% similarity because of the presence of human disturbance in this group affecting the presence of the near threatened species *Limnonectes magnus*. According to Diesmos et al (2004c) *Limnonectes magnus* inhabits undisturbed and disturbed streams and rivers in lowland forests and is threatened by habitat loss due to logging and harvesting for human subsistence. Moreover, the presence of *Limnonectes magnus* in caves E, Q and L could be due to the abundant availability of spiders and crickets which serve as food. The similarity of Caves E and Q at >50% was observed to be due to the occurrence of anthropogenic activities in both caves where there were occasions that farmers cooked and took meal inside the cave affecting the presence of *Limnonectes magnus* and the endemic *Hylarana grandocula*. Another group branches out at <30 similarity forming the group of caves J, B, F, K, S, A. Caves J, B, F are then further clustered to caves B and F possibly due to sharing of two endemic species found in the sites, namely *Hylarana grandocula* and *Cyrtodactylus annulatus*. Caves K, S, A had >60% similarity but further clustered to caves K and S at >75% because of the presence of similar species in these sites. On the other hand, caves M, D, G, H, I, which clustered together, are characterized by low human disturbance and almost the same ambient temperature values. Moreover, the reptile species, *Cyrtodactylus annulatus* was the only species present and shared by these cave sites.

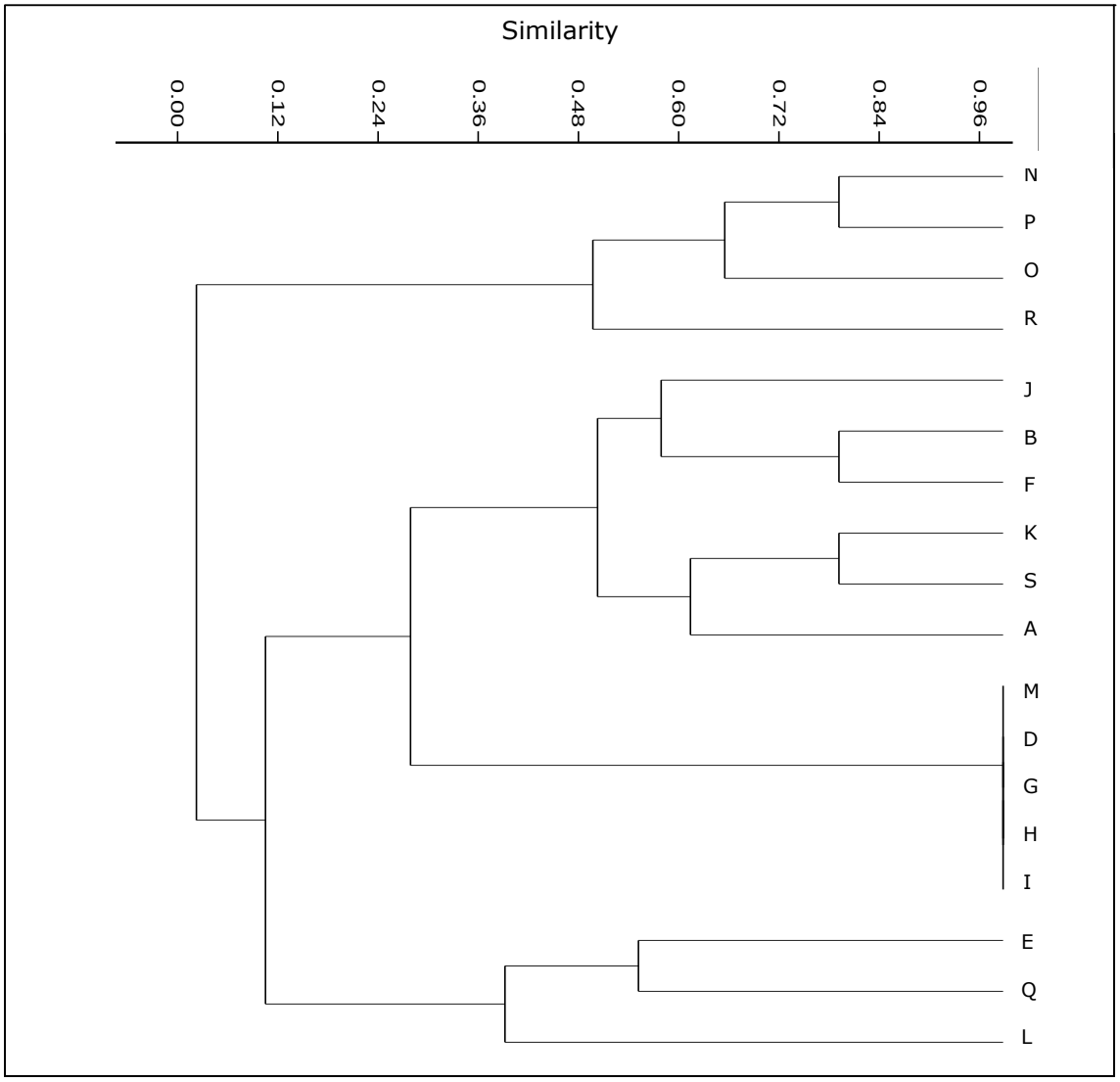

Figure 2. Similarity of cave sites in Northern Mindanao using cluster analysis (Bray-curtis). (A) Hindang Cave 1, (B) Hindang Cave 2, (C) Hindang Cave 3, (D) Dalipuga Cave, (E) Gitagum cave 1, (F) Gitagum Cave 2, (G) Minsalirac Cave 1, (H) Minsalirac Cave 2, (I) Minsalirac Cave 3, (J) Minsalirac Cave 4, (K) Blue Waters Cave, (L) Kabyao Cave, (M) Kitaotao Cave 1, (N) Kitaotao cave 2, (O) Kitaotao Cave 3, (P) Kitaotao Cave 4, (Q) Kitaotao Cave 5, (R) Salawaw Cave, (S) Kariis Cave; *endemic, + near threatened, ^vulnerable.

Four species (44%) were recorded to be endemic with one species documented to be under Near Threatened (*Limnonectes magnus*) and Vulnerable (*Ophiophagus hannah*) category of IUCN (2014) (Table 4). General threats observed to the cave biodiversity were guano harvesting and treasure hunting which greatly disturb the cave fauna. According to DENR (2014) guano harvesting also leads to the loss of biodiversity, specifically of the guano-dependent animals. McFarlane (1986) and Mithra (2012) observed that caves with excessive disturbance associated with guano harvesting and tourism lead to the decrease of species. The endemic species were observed to have wide distribution in the caves, for instance, *Hylarana grandocula* was found in eight sites which have bodies of water or have moist environment. Likewise, *Limnonectes magnus* was found in three sites, also with bodies of water, and *C. annulatus* in eight sites. *C. annulatus* has wide distribution, presumed large population and inhabits wide variety of microhabitats (Brown & Rico 2009) while *Hylarana grandocula* is adaptable with a

presumed large population and is also at times common in disturbed habitats (Diesmos et al 2004a). These endemic species appear to thrive in the cave habitats in this study.

Table 4
Conservation status and distribution range of herpetofauna recorded in selected Caves in Northern Mindanao, Philippines

Species	Common Name	Distribution Status (IUCN, 2014)	Conservation Status (IUCN, 2014)
AMPHIBIANS			
Family Dicroglossidae			
Limnonectes magnus	Giant Philippine Frog		Near Threatened
Family Microhylidae			
Kalophrynus pleurostigma	Black-spotted Narrow-mouthed Frog		Least Concern
Family Ranidae			
Platymantis sp.			
Hylarana grandocula	Big-eyed Frog	Philippine Endemic	Least Concern
REPTILES			
Family Elapidae			
Ophiophagus hannah (King Cobra)	King Cobra		Vulnerable
Family Gekkonidae			
Cyrtodactylus annulatus	Small Bent-toed Gecko	Philippine Endemic	Least Concern
Family Scincidae			
Sphenomorphus fasciatus	Banded Sphenomorphus	Philippine Endemic	Least Concern
Sphenomorphus Jagori	Jagor's Sphenomorphus	Philippine Endemic	Least Concern
Sphenomorphus variegatus	Blacked–spotted Sphenomorphus		Least Concern
Total Number of Endemic Species		4	

Conclusion. Caves in Northern Mindanao support a considerable number of herpetofauna. Kitaotao cave 5 is the only cave site which had the presence of all documented amphibians in the study. The presence of endemic and threatened species in caves indicates the need for protection of the caves. Other caves in Mindanao need to be assessed in order to come up with a complete database of the cave herpetofauna in Mindanao.

References

Alcala A. C., 1986 Guide to Philippine Flora and Fauna Vol X. Amphibians and Reptiles. Natural Resources Management Center. Ministry of Natural Resources and University of the Philippines, Quezon City, pp. 195.

Alcala A. C., Brown W., 1998 Philippine Amphibians: An Illustrated Field Guide. Bookmark Inc. Makati City, Philippines, pp. 1-116.

Alcala E. L., Alcala A. C., Dolino C. N., 2004 Amphibians and reptiles in tropical rainforest fragments on Negros Island, the Philippines. Environmental Conservation 31(3): 254-261.

Alcala A. C., Alcalal E. L., Buot I. E. Jr., Diesmos A., Dolar J. M. L., Fernandos E. S., Gonzalez J. C., Tabaranza B., 2006 Philippine Biodiversity: Ecological Roles, Uses, and Conservation Status. Trans. Natl. Acad. Sci. Tech. Philippines 28: 203-214.

Alcala E. L., Averia L., Tababa L., Dagunan M. A., Tababa R., Dasian J., Libo-on E. V., Ocampo M., 2007 Assessment of the biophysical condition of caves promoted for ecotourism in Mabinay, Negros Oriental, Philippines. Silliman Journal 48(1): 19-31.

Alcala A. C., Bucol A. A., Diesmos A. C., Brown R. M., 2012a Vulnerability of Philippine Amphibians to Climate Change. Philippine Journal of Science 141(1): 77-87.

Alcala A. C., Bucol A. A., Alcala L., Brown R. M., 2012b Decreasing Population Size of the Philippine Limestone Frog, *Platymantis insulates.* FrogLog 20(5): 44-45.

Ambal R. G. R., Duya M. V., Cruz M. A., Coroza O. G., Vergara S. G., de Silva N., Molinyawe N., Tabaranza B., 2012 Key Biodiversity Areas in the Philippines: Priorities for Conservation. Journal of Threatened Taxa 4(8): 2788–2796.

Beukema W., 2011 Herpetofauna of disturbed forest fragments on the lower Mt. Kitanglad Range, Mindanao Island, Philippines. Salamandra 47(2): 90-98.

Biswas J., 2009 The biodiversity of Krem Mawkhyrdop of Mehaglaya, India on the verge of extinction. Current Science 96(7): 904-910.

Biswas W. J., 2010 Kotumsar Cave biodiversity: a review of cavernicoles and their troglobiotic traits, Biodiversity and Conservation 19(1): 275-289.

Browne R. K., 2009 Amphibian diet and nutrition. AArk Science and Research. Retrieved February 8, 2015 from: www.amphibianark.org/pdf/.../Amphibian%20diet%20nutrition.pdf

Brown R., Rico E., 2009 *Cyrtodactylus annulatus*. The IUCN Red List of Threatened Species. Version 2014.2. <www.iucnredlist.org>. Downloaded on 05 October 2014.

Brown W. C., Alcala A. C., 1978 Philippine Lizards of the Family Gekkonidae. Silliman University Natural Science Monograph Series 1. Dumaguete City, Philippines, pp. 146.

Brown W. C., Alcala, A. C., 1980 Philippine Lizards of the family *Scincidae*. Siliman University. Natural Science Monograph Series 1. Dumaguete City, Philippines, pp. 264.

Brown W., Alcala A. C., 1994 Philippine Frogs of the Family Rhacophoridae. Proceedings of the California Academy of Sciences 48(10): 185-220.

Brown R., Ledesma M., Diesmos M., Rico E., 2009 *Sphenomorphus jagori*. The IUCN Red List of Threatened Species. Version 2014.2. <www.iucnredlist.org>. Downloaded on 05 October 2014.

Christ C., Hillel O., Matus S., Sweeting J., 2003 Tourism and Biodiversity: Mapping Tourism's Global Footprint. United Nations Environment Program and Conservation International, Washington, DC.

Department of Environment and Natural Resources-Protected Areas and Wildlife Bureau (DENR-PAWB), 2008 A handbook on cave classification for the Philippines, pp 1-51. Retrieved February 8, 2015 from: www.chm.ph/index.php?option=com_docman&task=doc

Department of Environment and Natural Resources (DENR), 2014 Cave and Caves Resources. Visayas Avenue, Diliman, 1100 Quezon City, Philippines. Retrieved February 8, 2015 from: http://www.denr.gov.ph/index.php/component/content/article/288.html

Diesmos A. C., Brown R. M., Alcala A. C., Sison R. V., Afuang L. E., Gee G. V. A., 2002 Philippine Amphibians and Reptiles. In: Philippine Biodiversity Conservation Priorities: a Second Iteration of the National Biodiversity Strategy and Action Plan. Ong P., Afuang L., Rosell-Ambal R. (eds), pp. 26–44, Department of the Environment and Natural Resources–Protected Areas and Wildlife Bureau, Conservation International Philippines, Biodiversity Conservation Program–University of the Philippines Center for Integrative and Developmental Studies, and Foundation for the Philippine Environment, Quezon City, Philippines.

Diesmos A., Alcala A. C., Brown R., Afuang L., Dolino C, Genevieve G., Hampson K., Diesmos M. L., Mallari A., Ong P., Paguntulan L., Pedregosa M., Ubaldo D., Guiterrez B., 2004a *Hylarana grandocula*. The IUCN Red List of Threatened Species. Version 2014.2. <www.iucnredlist.org>.

Diesmos A., Alcala A. C., Brown R., Afuang L., Genevieve G., Sakumaran J., Yaakob N., Ming L. T., Chuaynkern Y., Thirakhupt K., Das I., Iskandar D., Mumpuni Inger R.,

Stuebing R., Yambun P., Lakim M., 2004b *Kalophrynus pleurostigma*. The IUCN Red List of Threatened Species. Version 2014. 2. <www.iucnredlist.org>.
Diesmos A., Alcala A., Brown R., Afuang L., Genevieve G., Iskandar D. 2004c *Limnonectes magnus*. The IUCN Red List of Threatened Species. Version 2014.2. <www.iucnredlist.org>.
Engel S. A., 2007 Observations on the Biodiversity of Sulfidic Karst Habitats. Journal of Cave and Karst Studies 69(1): 187-206.
Gunn J., 2004 Encyclopedia of Cave and Karst Science. Fitzroy Dearborn. An Imprint of Taylor and Francis Group, New York, pp. 147-151.
Hammer O., Harper D. A. T., Ryan, P. D., 2001 PAST 1.10 Paleontological Statistics Software Package for Education and Data Analysis. Retrieved from http://www.palaeoelectronicaorg/ 2001_1/past/issue1_01.htm
Heinen J. T., 1992 Comparison of the leaf litter herpetofauna in abandones cacao plantations and primary rain forest in Costa Rica: Some Implications to Faunal Restoration. Biotropica 24(3): 431-439.
Inger R. F., 1954 Systematics and Zoogeography of Philippine Amphibia. Fieldiana Zoology 33(4): 183-531.
Jones W., Hobbs H. III., Wicks C., Currie R., Hose L., Kerbo R., Goodbar J., Trout J., 2003 Recommendations and Guidelines for Managing Caves on Protected Lands Volume 8. Karst Waters Institute, 2003, pp. 26.
IUCN Red List of Threatened Species. Version 2014. 2. <www.iucnredlist.org>. Downloaded on 05 October 2014.
McFarlane D. A., 1986 Cave bats in Jamaica. Oryx 20(1): 27-30.
Mithra S., 2012 What is Guano?. Retrieved October 3, 2014 from http://archive.today/hDVO.
Moorman C. E., Russell K. R., Greenberg C. H., 2011 Reptile and amphibian response to hardwood forest management and early successional habitats. In: Sustaining Young Forest Communities: Ecology and Management of Early Successional Habitats in the Central Hardwood Region, USA. Greenberg C. H., Collins B. Thompson F. R., III, (eds), Managing Forest Ecosystems 21: 191-208.
Morrison C., Naikatini A., 2008 Herpetofauna and bat monitoring at three Fiji sites in the Pacific-Asia Biodiversity Transect (PABITRA). Micronesica 40(1/2): 131-137.
Natural Resources Conservation Services, 2006 Amphibians and Reptiles. Fish and Wildlife Habitat Management Leaflet 35: 1-8.
Nuñeza O. M., Ates F. B., Alicante A. A. Enguito M. R. C., Bruno A. G. T., Labajo Y. I., Dejarme S. M., 2006 Vertebrate faunal diversity and relevant interrelationships of critical resources in Mt. Malindang, Misamis Occidental. Biodiversity Research Progamme for Development in Mindanao: Focus on Mt. Malindang and Environs. SEAMEO SEARCA, College, Laguna, Philippines, pp. 37-65.
Nuñeza O. M., Fabricante K. M. B., Alicante A. A., Sucaldito M. P., Ponce A. G., 2012 The herpetofauna of Mounts Sambilikan, Ararat and Berseba of the Diwata Range, Agusan del Sur, Philippines. Asia Life Sciences 21(1): 203-216.
Peterson A. T., Ball L. G., Brady K. W., 2000 Distribution of the birds of the Philippines: biogeography and conservation priorities. Bird Conservation International 10(2): 149-167.
Poulton B. C., 2004 Missouri River Benthic Macroinvertebrates. USGS science for changing world. Columbia Environmental Research Center. Retrieved February 8, 2015 from www.cerc.usgs.gov/pubs/center/pdfDocs/macroinverts.pdf
Relox R. E., Leańo E. P., Ates-Camino F. B., 2010 Herpetofaunal Endemism and Diversity in Tropical Forests of Mt. Hamiguitan in the Philippines. Herpetological Conservation and Biology 6(1): 107−113.
Ruddock M., Whitfield D. P., 2007 A Review of disturbance distances in selected bird species. A report from Natural Research (Projects) Ltd to Scottish Natural Heritage. Natural Research, Banchory, UK, pp. 1-181.
Siler C., Alcala A., Diesmos A., Brown R., 2009 A new species of limestone-forest frog, genus Platymantis (Amphibia: Anura: Ceratobatrachidae) from Eastern Samar Island, Philippines. Herpetologica 65(1): 92–104.

Siler C. M., Diesmos C. A., Linkem C. W., Diesmos M. L., Brown R. F., 2010 A new species of limestone-forest frog, genus *Platymantis* (Amphibia: Anura: Ceratobatrachidae) from central Luzon Island, Philippines. Zootaxa 2482: 49–63.

Stevens N. J., O'Connor P. M., 2006 Abiotic and Biotic Factors as Predictors of Species Richness on Madagascar. Primate Biogeography Developments in Primatology: Progress and Prospects, pp. 269-300.

Suazo-Ortuno I., Alvarado-D´Iaz J., Martinez-Ramos M., 2008 Effects of Conversion of Dry Tropical Forest to Agricultural Mosaic on Herpetofaunal Assemblages. Conservation Biology 22(2): 362–374.

Surasinghe T. D., 2007 Conservation Overview of Herpetofauna of Sinharaja and Biosphere Reserve of Sri Lanka. Zoo's Print Journal 22(1): 2535-2538.

Wight P., 2002 Supporting the principles of sustainable development in tourism and ecotourism: governments' potential role. Current Issues in Tourism 5: 222-243

www.car-navi.ph, 2010 Mindanao. Retrieved February 8, 2015 from http://www.car-navi.ph/2010/all-over-the-country-2/

www.google.com.ph/maps, 2015 Philippines. Retrieved February 8, 2015 https://www.google.com.ph/maps/place/Philippines/@11.6978351,122.6217542,6z/data=!3m1!4b1!4m2!3m1!1s0x324053215f87de63:0x784790ef7a29da57

www.marloncabilan.wordpress.com, 2012 Where in the world is Cebu. Retrieved February 8, 2015 from http://marloncabilan.wordpress.com/2012/11/11/where-in-the-world-is-cebu-2/

Received: 09 February 2015. Accepted: 28 February 2015. Published online: 07 April 2015.
Author:
Olga Macas Nuñeza, Department of Biological Sciences, College of Science and Mathematics Mindanao State University-Iligan Institute of Technology, Tibanga, Iligan City, 9200, Philippines, e-mail: olgamnuneza@yahoo.com
Marie Rosellyn Calizo-Enguito Department of Natural Science, College of Arts and Sciences, Misamis University, Ozamiz City 7200, Philippines, e-mail: roselle_888@yahoo.com
Yunalyn Labajo-Villantes, Department of Natural Science, College of Arts and Sciences, Misamis University, Ozamiz City 7200, Philippines, e-mail: xyzuna@yahoo.com
Amy Guanco Ponce, Department of Biological Sciences, College of Science and Mathematics Mindanao State University-Iligan Institute of Technology, Tibanga, Iligan City, 9200, Philippines, e-mail: amyguancoponce@yahoo.com

How to cite this article:
Nuñeza O.M., Calizo-Enguito M.R., Labajo-Villantes Y., Ponce A.G., 2015 Species richness and endemism of cave herpetofauna in Northern Mindanao, Philippines. ELBA Bioflux 7(1):10-24.