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Cave Herpetofauna of Siargao Island Protected Landscape and Seascape, Philippines

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Abstract:

The Philippines is home to a diverse group of amphibians and reptiles with high percentage of endemism. **However, cave herpetofaunal studies particularly in Mindanao, the second largest island in the country is poorly known. In this study, 10 caves on Siargao Island were surveyed using the modified cruising method to determine species richness, diversity, endemism, relative abundance, and conservation status of herpetofauna. Eight species were identified consisting of three amphibians and five reptiles. Endemism was 100% for amphibians and 40% for reptiles. *Platymantis corrugatus* and *P. dorsalis* were found only in Million-bat cave which had the highest species richness of herpetofauna. Relative abundance was highest in Million-bat cave (28.6%) for amphibians and Buho cave (43.3%) for reptiles. Dominant species were *Pinoyscincus jagori jagori* and *Hylarana grandocula*. No threatened species was documented. Threats to herpetofauna were observed such as utilization of caves for bird's nest and guano collection, spelunking, recreational activities, and as household garbage site. Considering the large number of caves on Siargao Island, surveys of more caves in other parts of the island could yield more species of herpetofauna.**

Keywords: Amphibians, Conservation, Endemism, Guano, Reptiles

1. Introduction:

Caves are considered as one of the most fragile and unusual habitats to a variety of organisms that have developed diverse, specialized, and high degree of physiological adaptations (Biswas, 2010; Castillo *et al.*, 2009, Juan *et al.,* 2010). Thus, caves harbor fauna unique to subterranean environments (Culver *et al.,* 2004). This may be due to the characteristics of the caves having total darkness, almost constant air and water temperature, relative humidity approaching saturation and a relatively poor supply of nutrients (Engel, 2007). In the Philippines, karst habitats including caves are found to potentially play important role in the evolution of specialized forms of animals (Siler *et al.*, 2010). Caves are also used to provide den sites, nest substrates, roost sites, maternity sites, water sources, predation or foraging sites, and hibernation sites for vertebrate species (Strong and Goodbar, 2005). Cave surveys in the Philippines on vertebrate species specifically the herpetofauna have resulted in the discovery of new and endemic species of frogs and lizards (Brown and Alcala, 1982 and 2000; Siler *et al.*, 2009 and 2010).

Mindanao, the second largest island in the Philippines, harbors 37% of the not less than 1,500 caves the country has (DENR-PAWB, 2008), yet only few studies on cave fauna present on this island were done. The discovery of a new species of cavernicolous crab from Latay Cave in Agusan del Sur at the eastern part of Mindanao (Takeda and Ng, 2001) could lead to further discoveries of new species as well as interesting faunal records in the great number of caves in Mindanao. Cabauatan *et al.*, (2014) who surveyed seven selected caves among the 200 cave systems in Northern Sierra Madre Natural Park in Luzon found a total of 38 cave vertebrate species of which six species were reptiles and five species were amphibians. The recent report of Abantas and Nuñeza (2014) in the Mighty cave of Tagoloan in the province of Mindanao recorded five species of mammals, one species of birds, and two species of herpetofauna. Two Philippine endemic species, *Rhinolophus inops* and *Cyrtodactylus annulatus* were also documented to inhabit the cave.

Cave is very crucial for the conservation of biodiversity since it provides habitat to some of the country's endangered animals (DENR-PAWB, 2008). The amphibians and reptiles are very

important animals in the environment and are very sensitive to habitat changes that serve as biological indicators for the health of the environment (Fabricante and Nuñeza, 2012). Moreover, it is known that the Philippines is one of the most important centers of herpetofaunal diversity in Southeast Asia (Diesmos *et al.,* 2002) consisting 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). Belleza and Nuñeza (2014) recorded eleven herpetofauna species in selected caves of Glan, Sarangani Province and Wao, Lanao del Sur of which four (36%) are endemic species, two of which are Mindanao Faunal Region endemic and are of vulnerable conservation status.

Caves are "endangered arks" of biodiversity (Clements *et al.,* 2006) and in the Philippines most caves are in peril due to lack of specific statutory protection, increased demand for recreational sites, treasure hunting, mining, pollution, illegal collection of cave resources and rapid urbanization (DENR-PAWB, 2008), yet very few karst areas in Mindanao are currently known to have direct protected area status. Protection made on most of the 35,000 km^2-karst landscape in the Philippines is indirect, wherein a karst landscape is only protected when its area of location is accorded with protected status (Restificar *et al.,* 2006). There are only seven caves with protected area status in the country, representing less than 1% while the other caves in the country were initially assessed for the purpose of cave management plan preparation (DENR-PAWB, 2008).

Siargao Island in the province of Surigao del Norte is one of the key biodiversity areas of the country (Philippine Clearing House Mechanism for Biodiversity, 2009) and is recognized as a protected landscape and seascape in 1996 (Siargao Islands Protected Landscapes and Seascapes, 2013). However, the cave herpetofauna of Siargao Island is poorly known. This study documents the cave-dwelling herpetofauna from selected caves on Siargao Island.

2. Materials and Methods:

2.1 Sampling Sites:

Rapid sampling was conducted on October 28-31, 2011 for 140 man-hours in 10 limestone caves of the four selected municipalities on Siargao Island (Fig. 1).

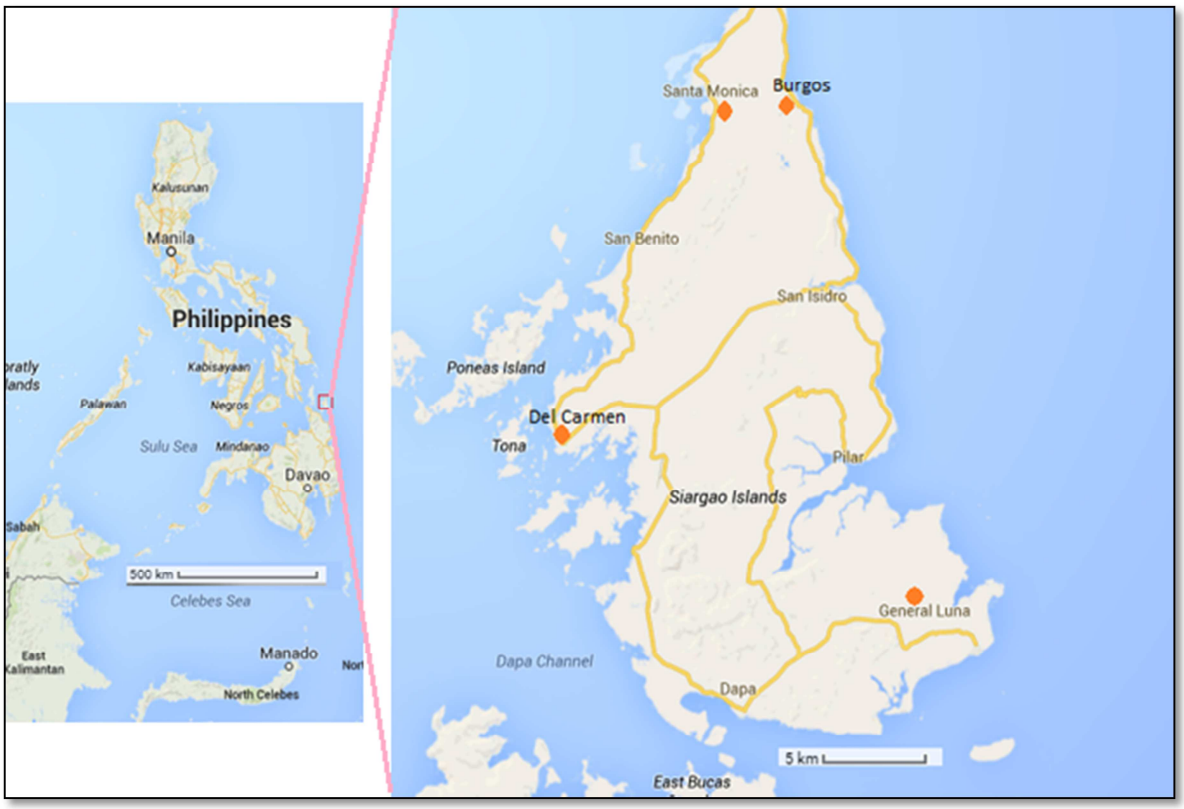

Fig. 1. Map showing the four municipalities (Santa Monica, Burgos, Del Carmen, and General Luna) on Siargao Island where limestone caves are located (Google Maps, 2014).

2.2. Cave Sites: Cave sites (Table 1) were described using Alcala *et al.,* (2007).

Table 1: Description of the cave sites

Cave	Coordinates and Elevation	Number of Openings	Speleothems and boulders	Water Bodies	Cave Utilization	Signs of Human Disturbance
A	9° 48' 11" N and 126 ° 06' 22.6" E; 62 masl	2	Few; Stalactites and stalagmites	Absent	spelunking, and treasure hunting site	wood poles, broken stalagmites, and man-made holes
B	9° 49' 07.6" N and 126 ° 00' 48.7" E; 47 masl	1	Few; Stalactites and stalagmites	Absent	bird's nest collection site	None
C	9° 49' 07.7" N and 126 ° 00' 48.7" E; elevation 44 masl	1	Few; Stalactites and stalagmites	Absent	Once a bird's nest collection site	presence of wood slabs, gated cave entrance
D	9° 49' 38.2" N and 126 ° 00' 55.7" E; 57 masl	1	Few; Stalactites, stalagmites, boulders	Absent	site for guano collection	rhum bottles, and broken stalagmites
E	9° 49' 38.1" N and 126 ° 00' 55.7" E; 60 masl	1	Stalactites	Present (underground pool)	suspected treasure hunting area	None
F	9° 45' 49.1" N and 126 ° 02' 21.4";16 masl	1	Abundant; Stalactites, stalagmites, boulders	Present (pool)	Spelunking, recreational site for swimming	broken stalagmites
G	9° 59' 54.8" N and 126 ° 04' 48.4" E; 22 masl	1	Numerous and highly variable; Stalactites, stalagmites, boulders, etc.	Present (stream)	spelunking area, and a water resource to nearby rice fields	broken stalagmites
H	10° 01' 04.8" N and 126 ° 04' 27.2" E; 33 masl	1	Few; Stalactites, stalagmites, boulders	Absent	treasure hunting and guano collection	bottles, wood poles, broken speleothems, and man-made holes
I	9° 58' 58.5" N and 126 ° 03' 13.1" E; 51 masl	1	Few; Stalactites and stalagmites	Absent	treasure hunting	broken speleothems, and man-made holes
J	9° 47' 46.2" N and 126 ° 06' 27.7" E; 29 masl	1	None	Absent	incidental trash area	household trashes

Legend: (A) Buho Cave, (B) Bulod Cave 1, (C) Bulod Cave 2, (D) Million-bat Cave, (E) Naogon Cave, (F) Sumiyot Cave, (G) Patag Cave, (H) Guano Cave, (I) Cave II, (J) Cave III

2.3. Sampling Methods

:A modified cruising method was used in the collection and observation of herpetofauna in the cave sites. Identification of samples was done using Alcala (1986), and Alcala and Brown (1998) for amphibians and reptiles. Determination of distribution and conservation status of identified species was done using IUCN 2014 Red List of Threatened Species, and published data in refereed journals and photographic guides. Species readily identified in the field were released after photo documentation. Samples not readily identified were further examined in the laboratory and sent to the Philippine National Museum for verification by the experts. Specimens collected were deposited at the Mindanao State University – Iligan Institute of Technology (MSU-IIT) Natural Science Museum.

3. Results and Discussion:

3.1. Species Richness and Relative Abundance:

Eight species of herpetofauna of which five (62.5%) reptiles and three (37.5%) amphibian species were recorded from the 10 caves in Siargao Island (Table 2). This result is higher than the recorded number of herpetofauna species found in the Mighty Cave, Tagoloan, Lanao del Norte (Abantas and Nuñeza, 2014). However, this study was lower than the 11 herpetofauna species reported by Belleza and Nuñeza (2014) in the selected caves of Sarangani Province and Lanao del Sur. Morrison and Naikatini (2008) also recorded higher number of herpetofauna species in Fiji sites in the PABITRA. According to Stevens and O'Connor (2006) abiotic factors (habitat area, temperature, humidity, rainfall, latitude, and altitude) and biotic factor (vegetation type) as well food or resource availability affect the species diversity in caves (Jones *et al.,* 2003).

In Million-bat Cave, relative abundance amphibians was relatively high (28.6%). This may be due to the presence or abundance of guano materials inside this cave which serve as food source for cave invertebrates and these invertebrates also serve as food for amphibians. According to Pape (2014), guano serves as the foundation of the cave invertebrates (Bernard *et al.,* 1997) which in turn serve as primary dietary items for amphibians, reptiles, birds and small mammals. *Hylarana grandocula* had the highest distribution among amphibians in the caves. This species is known as both a terrestrial and freshwater species (Diesmos *et al.,* 2004a; Alcala and Brown, 1998) which is an inhabitant of undisturbed and disturbed streams and rivers (Diesmos *et al.,* 2004a). This factor could be the reason for the distribution of *H. grandocula* in the caves sites, occurring on twilight zones with relative humidity value up to 97%, and was the only frog recorded in caves where water bodies were present at the twilight zone such as the underground pool in Naogon Cave and the stream in Patag Cave. This species was also recorded by Alcala *et al.,* (2012) in the forested streams and Warguez *et al.,* (2013) in the forest of Mt. Kalatungan. In caves where water bodies were absent, juvenile individuals were found which were of the same size as the specimen captured in Guano Cave having snout-vent length (SVL) of 25 mm, while mature specimens with SVL 31-38 mm were recorded from cave sites having water bodies.

The two other anurans, *Platymantis corrugatus* and *P. dorsalis*, were restricted to Million-bat Cave with the former found at the cave mouth particularly on the floor and in the wall crevice, while the latter was recorded from the cave floor near the wall of the twilight zone. Alcala (1986) and Diesmos *et al.,* (2004b) both reported that *P. dorsalis* can be found on forest floor where eggs are laid and at certain period directly developed into froglets without passing into the tadpole stage; a mechanism for adaptation. *P. corrugatus* also inhabits the forest floor stratum in undisturbed and disturbed lower montane and lowland forests (Diesmos *et al.,* 2004c) and its offsprings also undergo direct stage of development (Alcala, 1986; Diesmos *et al.,* 2004c). Direct development is common among the many members of *Platymantis* as well as certain species under other genera (Alcala, 1986). The presence of these anurans on humid areas indicates the habitat requirement among amphibians where high moisture content in the area is necessary for the substantial replacement of water which is easily lost on their thin, permeable skin and more importantly for purposes of reproduction and breeding (Alcala and Brown, 1998). Thus, cave habitats where water bodies are present and humidity is high are important sites for anuran conservation.

Table 2: Species richness and relative abundance of herpetofauna in the 10 cave sites on Siargao Island.

Species	A	B	C	D	E	F	G	H	I	J	Total
AMPHIBIANS											
Hylarana grandocula (Big-eyed Frog)*	0	0	0	1	2	0	1	3	1	3	11
Platymantis corrugatus (Corrugated Ground Frog)*	0	0	0	1	0	0	0	0	0	0	1
Platymantis dorsalis (Common Forest Ground Frog)*	0	0	0	2	0	0	0	0	0	0	2
REPTILES											
Broghammerus reticulatus (Reticulated Python)	0	0	0	1	0	0	0	0	0	0	1
Coelognathus erythrurus (Reddish Rat Snake)	2	0	0	0	1	0	0	0	0	0	3
Gekko gecko (Tokay Gecko)	1	0	0	1	0	0	0	0	0	0	2
Gonocephalus semperi (White-spotted Anglehead)*	0	0	0	0	0	0	0	0	1	0	1
Pinoyscincus jagori jagori (Jagor's Sphenomorphous)*	10	1	2	2	1	1	1	3	2	0	23
Total Number of Individuals	13	1	2	8	4	1	2	6	4	3	44
Total Number of Species	3	1	1	6	3	1	2	2	3	1	8
Total Number of Amphibian Species	0	0	0	3	1	0	1	1	1	1	3
Total Number of Reptile Species	3	1	1	3	2	1	1	1	2	0	5
Total Relative Abundance (%)	29.5	2.2	4.5	18.2	9.1	2.1	4.6	13.6	9.1	6.8	100
Relative Abundance of Amphibians in each cave site (%)	0.0	0.0	0.0	28.6	14.3	0.0	7.1	21.4	7.1	21.4	100
Relative Abundance of Reptiles (%) in each cave site	43.3	3.33	6.6	13.3	6.67	3.3	3.3	10.0	10.0	0.0	100
Relative Humidity											
Entrance zone	80	77	78	77	83	78	80	83	90	84	-
Twilight Zone	81	77	79	74	84	77	80	84	93	83	-
Inner Zone	85	80	87	87	NA	81	97	98	94	85	-

Legend: (A) Buho Cave, (B) Bulod Cave 1, (C) Bulod Cave 2, (D) Million-bat Cave, (E) Naogon Cave, (F) Sumiyot Cave, (G) Patag Cave, (H) Guano Cave, (I) Cave II, (J) Cave III; Endemic=*

Another common factor among anurans on Siargao caves was their occurrence at the twilight zone, the zone near the cave entrance (Biswas, 2010). The same result was obtained by Belleza and Nuñeza (2014) in the caves of Sarangani Province and Lanao del Sur. According to Gunn (2004) amphibians are commonly encountered at the entrance and twilight zone of the caves, which are characterized by high air humidity and buffered temperature changes. Near the cave entry, natural day-night cycles as well as changes of the said environmental factors may play a significant part in the daily organization of the anuran activity. Deep areas of the cave where environmental conditions are constant or poorly fluctuating can have an effect on physiological traits such as vision for visual orientation on preys, skin color, as well as normal circadian rhythms (Castillo *et al.,* 2009). Related findings in the Philippines included the report of Brown and Alcala (2000) on *P. insulatus*, endemic only to the South Gigante Island of the Visayan Sea, which was documented to live only on the mouth of small karst caves particularly among rocks on the ground and nests on limestone crevices.

The anurans on Siargao Island were observed to occur on large caves such as the Million-bat Cave, Cave III and Guano Cave, which are the top 3 largest caves surveyed in this study with estimated accessed area that ranges from 1400 m^2 to 3000 m^2, and openings varying from 5 m to 10 m in diameter. According to Arita (1996), large caves can harbor diverse species assemblages and contain the largest populations.

Of the reptiles documented, five species comprised three lizards and two snake species. This result was higher than the recorded number of reptile species by Abantas and Nuñeza (2014) in Mighty Cave, Tagoloan. However, the recorded number of reptile species in this study was lower than the eight reptile species in the selected caves of Sarangani Province and Lanao del Sur reported by Belleza and Nuñeza (2014) . Reptiles were absent in Cave 10 which is utilized as an incidental garbage site. According to the study conducted by Sobrepena and Nuñeza (2014) and Surasinghe (2007), garbage left inside the cave indicated disturbance and this could significantly lower the herpetofauna diversity because of their sensitivity to habitat disturbance (Marks, 2006). *Pinoyscincus jagori jagori,* the only representative species of the genus Scincidae, was the most widespread among reptiles with 23 individuals found in cave entrances on 90% of the caves surveyed. This species also had the highest species richness (n=10) in Buho Cave. It was observed in this study that this species was only present in caves with speleothems or boulders despite the disturbance on some caves where it was found. *P. jagori jagori* was also recorded to inhabit the forest, secondary dipterocarp and submontane, and non-forest (Mallari et al., 2013) . *Gekko gecko* was found on wall crevices of cave entrances in Buho and Million-bat caves. This finding concurs with the observation of Belleza and Nuñeza (2014) who also found *G. gecko* on the walls of the cave of Sarangani Province. The Philippine endemic and rare agamid, *Gonocephalus semperi,* was recorded in only one cave, on the wall of the twilight zone of Cave II in Sta. Monica. *G. semperi* was not commonly reported to occur in caves. Lizards were found only in the twilight zones or at the cave entrances in Siargao caves. Similar findings were reported by recent researches on cave herpetofauna. Belleza and Nuñeza (2014) reported the occurrence of *Eutropis multicarinata, Sphenomorphus fasciatus, Parvoscincus steerei and Varanus salvator* on the floor of the twilight zone of the caves surveyed in Sarangani Province. Brown and Alcala (2000) reported that *Gekko gigante* lives on the mouth of the Gigante Cave in Negros Island where the said species is endemic. Rosler *et al.* (2006) documented *Gekko ernstkelleri* from limestone cave entrances in Panay Island. According to Sievert and Hutchison (1988) light is a distinct factor that influences behavioral thermoregulation, the reason why species were seen only in the entrance and twilight zone of the cave where light still penetrates the surroundings. Moreover, the presence of anuran species in cave entrances may be due to the presence of food availability in the area Peck, 1976).

Coelognathus erythrurus, which was also reported to occur in several areas of Mindanao (Leviton, 1979) was documented in this study. Two individuals of this species were observed waiting to catch preys at an inner recess zone chamber in Buho Cave in General Luna where a colony of bats was roosting. One individual was also seen resting on the floor of the twilight zone of Naogon Cave in Del Carmen. This snake may have preferred bats as prey. Another interesting record was the presence of one individual of *Broghammerus reticulatus* in the Million-bat Cave. This species was found resting on the floor at the twilight zone where *R. arcuatus* bats are roosting.

3.2. Biodiversity Indices

Higher diversity was found in Million-bat Cave (Table 3) indicating that this cave is a favorable habitat for herpetofauna, and an important area for conservation since most of the endemic species recorded in this study inhabited the cave.

Table 3: Biodiversity indices of herpetofauna on Siargao Island.

	A	B	C	D	E	F	G	H	I	J
Species Diversity (1.408)	0.687	0.000	0.000	1.733	1.040	0.000	0.693	0.693	1.040	0.000
Amphibians (0.656)	---	---	---	1.040	0.000	---	0.000	0.000	0.000	0.000
Reptiles (0.841)	0.687	0.000	0.000	1.040	0.693	0.000	0.000	0.000	0.637	---
Evenness (0.677)	0.625	---	---	0.967	0.946	---	1.000	1.000	0.946	---
Amphibians	---	---	---	0.946	---	---	---	---	---	---
Reptiles	0.625	---	---	0.946	1.000	---	---	---	0.918	---
Dominance (0.346)	0.621	1.000	1.000	0.188	0.375	1.000	0.500	0.500	0.375	1.000
Amphibians	---	---	---	0.375	1.000	---	1.000	1.000	1.000	1.000
Reptiles	0.621	1.000	1.000	0.375	0.500	1.000	1.000	1.000	0.556	---

Legend: (A) Buho Cave, (B) Bulod Cave 1, (C) Bulod Cave 2, (D) Million-bat Cave, (E) Naogon Cave, (F) Sumiyot Cave, (G) Patag Cave, (H) Guano Cave, (I) Cave II, (J) Cave III

Species evenness for amphibians was 0.946 which suggests that each amphibian species found has almost the same number of individuals, an interesting finding for low intraspecific competition potential. *H. grandocula* was found to be the dominant species, found in six caves. The Million-bat Cave, Naogon Cave, and Cave II had evenness values for reptiles close to or equal to 1 (E= 0.918) which means reptile species in the area had almost or the same number of individuals present, another interesting finding for potentially low intraspecific competition. *P. j. jagori* was dominating in 50% of the caves particularly Bulod Cave 1, Bulod Cave 2, Sumiyot Cave, Patag Cave and Guano Cave. Reptiles were very common in Buho Cave (43.3% relative abundance) but were totally absent in Cave III.

3.3. Distribution and Conservation Status:

In this study, higher endemicity (100%) was recorded for amphibians than reptiles (60%) (Table 4). The work of Relox *et al*., (2011) in the lowland dipterocarp forest of Mt. Hamiguitan found higher endemicity of reptile species (80%) compared to amphibians (77.8%). Belleza and Nuñeza (2014) in their survey on cave fauna in the Sarangani Province and Lanao del Sur in Mindanao also found higher endemism (36%) of herpetofauna. The presence of high endemicity of amphibians and reptiles in the caves of Siargao Island indicates conservation importance of the area.

Table 4: Distribution and conservation status of amphibians and reptiles in the 10 cave sites in Siargao Island

Species	Common Name	Conservation Status (IUCN, 2014)	Distribution (Alcala, 1986)
Amphibian			
Hylarana grandocula	Big-eyed Frog	Least Concern	Philippine endemic
Platymantis corrugatus	Corrugated Ground Frog	Least Concern	Philippine endemic
Platymantis dorsalis	Common Forest Ground Frog	Least Concern	Philippine endemic
Reptiles			
Broghammerus reticulatus	Reticulated Python	-	Non-Philippine endemic
Coelognathus erythrurus	Reddish Rat Snake	-	Non-Philippine endemic
Gekko gecko	Tokay Gecko	-	Non-Philippine endemic
Gonocephalus semperi	White-spotted Anglehead	Data Deficient	Philippine endemic; rare
Pinoyscincuss jagori jagori	Jagor's Sphenomorphus	-	Philippine endemic
Amphibian Endemism	**100%**		
Reptile Endemism	**40%**		
Herpetofauna Endemism	**62.5%**		

3.4. *Threats to Cave Herpetofauna:*

Threats to herpetofauna in Siargao caves were utilization of caves as sites for bird's nest collection, guano collection, spelunking, and recreational activities such as swimming in pools inside caves, and the presence of man-made ground holes indicating treasure hunting activities, presence of broken speleothems, bottles, wooden poles, and household trashes. Only the three caves (Bulod Cave 1, Bulod Cave 2, and Naogon Cave) in Del Carmen were found to have no anthropogenic signs of disturbance. The observed disturbances to the caves on Siargao Island could pose future ecological problems (Nuñeza and Galorio, 2014).

4.0 Conclusion and Recommendation:

Siargao Island has high amphibian endemism. The presence of man-made disturbances in these caves could affect herpetofaunal diversity. With the large number of caves on Siargao Island, surveys of more caves in other parts of the island could potentially yield discoveries of more herpetofaunal species. Strengthened conservation efforts by the local government are recommended especially in cave sites with high endemism of herpetofauna.

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