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Herpetofaunal Diversity and Endemism in Selected Caves of Sarangani Province and Lanao del Sur, Philippines

[1]Bryan George D. Belleza and [2]Olga M. Nuneza

[1,2]*Department of Biological Sciences, College of Science and Mathematics, MSU-Iligan Institute of Technology, A. Bonifacio Ave., Tibanga, Iligan City, 9200, Philippines*

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ABSTRACT

Amphibians and reptiles (herpetofauna) are essential components of the Earth's biodiversity. This study was conducted to determine the species richness, endemism, diversity, and relative abundance of amphibians and reptiles in selected caves of Glan, Sarangani Province and Wao, Lanao del Sur. Herpetofaunal sampling was conducted using the modified cruising method. Eleven species of herpetofauna belonging to six families were recorded. Moderate diversity with more or less even distribution was documented in the cave sites. There were four (36%) endemic species documented of which two are Mindanao Faunal Region endemic and are of vulnerable conservation status. The presence of endemic and vulnerable species indicates the need to protect the caves and the surrounding forest patches

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INTRODUCTION

Cave ecosystems are perhaps the most fragile ecosystems on Earth. This is due to the hypersensitivity of most cave-roosting bats and other cave-dwelling critters to human disturbance. Cave-adapted and cave-limited organisms (troglobites and stygobites) are often the most sensitive [1]. Cave is characterized by total darkness, almost constant air and water temperature, relative humidity approaching saturation and a relatively poor supply of nutrients [2] but it harbors unique and sensitive organisms, many of which are cave obligates [3]. Disturbance including human visitation, as well as surface impacts such as pollution and deforestation can dramatically alter the subterranean world. Sometimes these impacts can cause great damage to these organisms. As a result, many of these species may be endangered with extinction [4].

Caves are nutrient-starved environments [1], subject to strong environmental filters; as the lack of light and scarce energy input constitutes a challenge to the adaptation of the organisms [5]. Most cave ecosystems rely on inputs from the surface to support life underground. Nutrient inputs include dead vegetation brought into the cave from flooding, and by bats and crickets in the form of guano, and to a lesser extent wind-blown vegetation or nutrients percolating through the cap stone into the cave environment [1]. Animals occurring in these nutrient-starved ecosystems have strange names such as "troglobite," "stygobite," "trogloxene" and "troglophile." Troglobites and stygobites are cave-adapted (troglomorphic) animals [6]. Troglobites are terrestrial cave-adapted species that occur only in caves or similar subterranean habitats. Troglophiles are animals that can use either the cave or surface environment. Some examples of troglophiles include amphibians (frogs, salamanders) and reptiles (snakes) [7].

Amphibians and reptiles are both widely distributed around the world [8] and are essential components of the Earth's biodiversity because of their role in food webs as herbivores, predators, and prey, as well as connecting aquatic terrestrial ecosystems [9]. They are notably abundant and species-rich in wet tropical areas [10]. Herpetofauna are very sensitive to habitat changes, thus they serve as biological indicators for the health of the environment [11].

South Asia hosts high amphibian diversity [12] and a high proportion of threatened reptilian species [13]. This area is inhabited by at least 900 described species of reptiles and 700 described species of amphibians [14]. The Philippine Archipelago is a country in Southeast Asia that is recognized as one of the most important

Corresponding Author: Olga M. Nuňeza, Department of Biological Sciences, College of Science and Mathematics, Mindanao State University-Iligan Insitute of Technology, Iligan City, 9200, Philippines.
E-mail: olgamnuneza@yahoo.com

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centers of herpetofaunal diversity [15]. It consists of 102 amphibian species [16] of which 78 are endemic and 258 reptile species of which 170 species (66%) are recognized to be endemic [15]. However, there is increasing habitat loss and fragmentation, which are rapidly depleting amphibian and reptile populations [17].

Sarangani and Lanao del Sur provinces in Mindanao are some of the areas in the Philippines where herpetofaunal species diversity in caves is poorly known. Recent published reports on cave fauna were on crickets [18, 19], ants [20, 21], spiders [22, 23], and cockroaches [24]. In this study, two selected caves from Glan, Sarangani Province and one cave from Wao, Lanao del Sur were assessed to determine the species richness, diversity, relative abundance, and endemism of reptiles and amphibians. Existing threats to the cave fauna were also observed.

MATERIALS AND METHODS

Study Sites:

Three cave sites (Fig. 1) were assessed. Cave 1 (5° 49′ 0″ N, 125° 12′ 0″ E) and Cave 2 (5°49'13"N, 125°10'35"E) at 400-550 meters above sea level (masl) are both located in Barangay Taluya, Glan, Sarangani Province, Mindanao, about 7-10 km from the town site. The area consists mainly of mangroves along the coastline where these two limestone caves are located. Cave site 3 (7° 41' 0" N, 124° 40' 0" E) at 250-350 masl is located within Barangay Amoyong, Wao, Lanao del Sur, about 25 km from the town. The cave is located within corn and pineapple farms and patches of disturbed lowland dipterocarp forest.

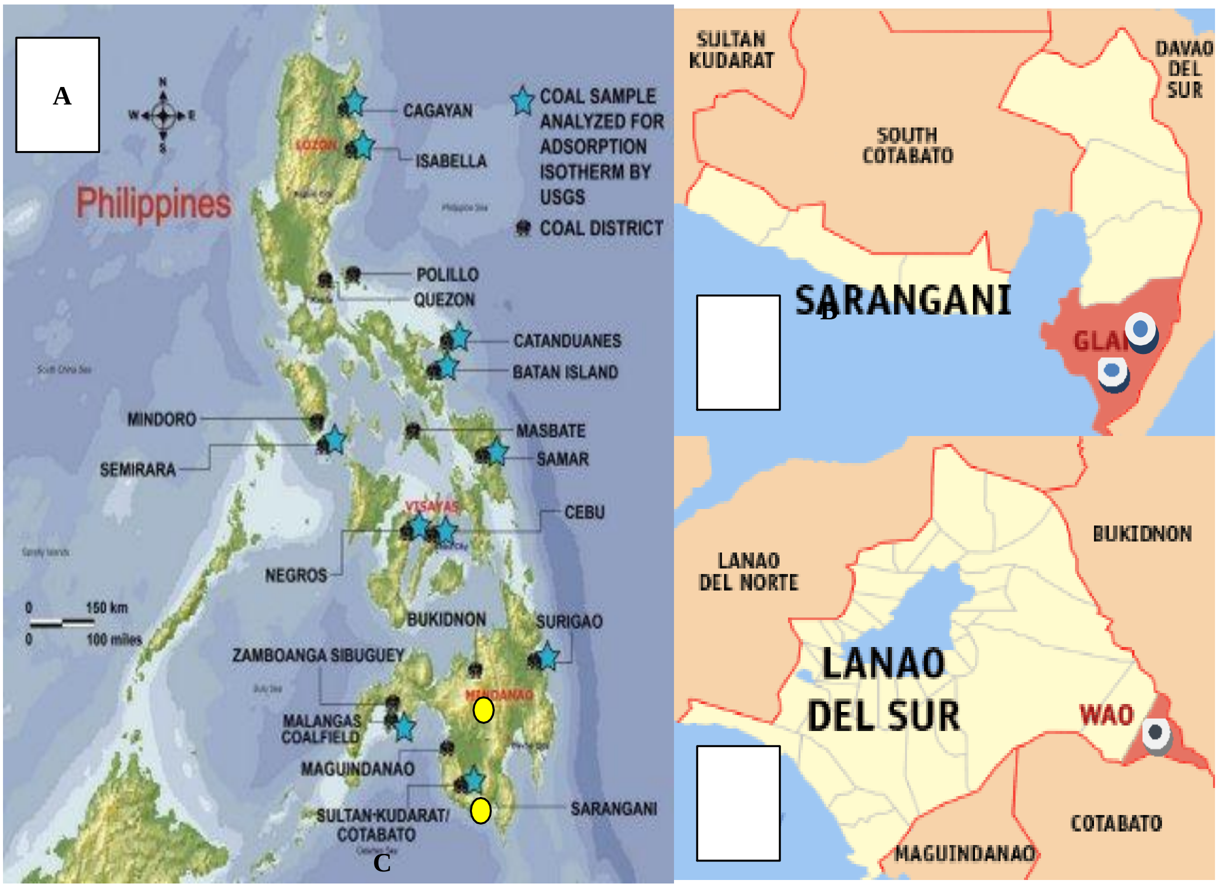

Fig. 1: The area where the sampling sites are located. (A) Map of the Philippines showing the island of Mindanao where the provinces of Sarangani and Lanao del Sur are located; (B) the location of the first two caves (blue dots) within Barangay Taluya in Glan, Sarangani Province [57]; (C) the location of the third cave (black dot) within Barangay Amoyong, Wao, Lanao del Sur [58].

Caves Sites:

Cave 1 has only one opening. The entrance of the cave is approximately 1.48 meter in width and 1.35 meter in height. There are chambers inside the cave but were blocked by a fallen-off part because of previous attempt on treasure hunting. The temperature in the twilight zone of the cave was 25˚C and the light illumination was 1.2 lux, recorded four meters from the entrance. Drippings of water from the roof and wall were observed and roots of plants along the walls and roof were seen. Relative humidity within the twilight zone was 74%. Stalactites and stalagmites were absent.

Cave 2 is also located near the coastline surrounded by mangroves approximately 25 meters from cave 1. It is a man-made cave built during the Japanese occupation. The entrance is small with approximately 1.30 meter in width and 1.38 meter in height. There were no other chambers and passages and the inside was filled with sea water during high tide. The temperature in the twilight zone of the cave was 22˚C and the relative humidity was 72%. The floor, roof and wall of the cave are made of limestone. Roots from plants above the cave were seen. The light illumination was 1.8 lux, 3.4 meters from the cave. There were small drippings of water from the roof. Stalactites and stalagmites were absent.

Cave 3 is located at the foot of a mountain near the bank of a river. It has two main openings. The entrance of the cave, also usually used as the exit, is approximately 1.65 meter in width and 1.37 meter in height. The second opening, which is located at the other end of the cave, is wider with approximately 2 meters wide and 2.35 meters high, but is partly blocked by a fallen-off part of the cave caused by the previous attempt to permanently close the cave. The cave is somewhat honeycomb in structure consisting of numerous irregular huge and small chambers, and with lateral and downward passages. The main tunnel is approximately 275 meters long from the entrance to the exit. The temperature in the twilight zone of the cave was 27.3˚C and the light illumination was 11.8 lux, 2.8 meters from the entrance. Relative humidity was 76%. Stalactites and stalagmites were observed in this cave. Drippings of water from the roof and wall caused the floor to be muddy on some areas of the cave.

Herpetofaunal Sampling and Collection:

Caves 1 and 2 were surveyed using the modified cruising method for a total of 30 man-hours. Cave 3 was surveyed for a total of 54 man-hours. Microhabitats known to be preferentially inhabited by herpetofauna (leaf axils, cavities in rocks, rock caves) were examined. Identification was done using the works of Inger [25], Brown and Alcala [26], Alcala [27], Alcala and Brown [28], Bacon *et al.* [29], and Nuñeza *et al.* [30]. The voucher specimens were preserved in 70% ethanol and deposited at the Wildlife Laboratory of the Mindanao State University – Iligan Institute of Technology (MSU-IIT). Geographic distribution and conservation status of the species captured were noted using the IUCN Red List of Threatened Species [31].

Light penetration was determined using a lux/light meter. The temperature was measured using field thermometer while relative humidity was measured with the use of a sling psychrometer. Cave structures were examined for the presence of stalactites and stalagmites. The size of the cave and the cave openings (height, length, and width) were measured. Biodiversity indices were computed using Biodive Pro software.

RESULTS AND DISCUSSION

Species Richness and Endemism:

Eleven herpetofaunal species belonging to six families were captured during the sampling period, of which eight species (73%) were reptiles and three (27%) were amphibians (Table 1). This result was lower than the recorded number in forest habitats in Mt. Sambilikan [32], Mt. Kitanglad Range [33], Eastern United States [34], and in semi-deciduous forest of Ghana [35]. However, this result is higher than the recorded number of herpetofauna in Fiji PABITRA sites [36] and in California [37]. Low species richness of reptiles and amphibians was reported Chiquibul Cave, Central America [38]. Species diversity within caves is also affected by food or resources availability [39], abiotic factor (habitat area, temperature, humidity, rainfall, latitude, altitude) and biotic factor (vegetation type) [40].

Six species were observed in Cave 1, four species in Cave 2 at Glan, Sarangani Province and five species in Cave 3 at Wao, Lanao del Sur. The documented cave herpetofauna comprised three species of anurans (Bufonidae), one species of snake (Colubridae), one species of flying lizard (Agamidae), one species of gecko (Gekkonidae), four species of skink (Scincidae), and one species of monitor lizard (Varanidae). Cave 1 had the highest species richness. This could be due to the difference in cave structure. Cave 1 was surrounded with mangroves which partly explains why a number of reptile species particularly belonging to family Scincidae were encountered. Alcala [27] mentioned that *Emoia atrocostata*, *Sphenomorphus fasciatus* and *Eutropis multicarinata* are commonly seen in mangrove areas located within intertidal zones. *Parvoscincus steerei* was found in all cave sites, mostly on the floor of the caves under rock crevices.

All captured specimens are not known cave dwellers. They are considered as troglophiles and only use the caves as shelter and source of food. Gunn [41] also observed that many amphibians visit caves occasionally as temporary shelter from unfavorable environmental conditions outside, such as summer drought or winter frost. Hobbs [42] reported the same observation on reptiles. The presence of two species of frogs *(Ansonia muelleri* and *Ansonia mcgregori)* and the lizards (*Draco volans* and *P. steerei*) which feed mainly on insects in Cave 3 indicated the presence of food source in or near the cave.

Table 1: Reptiles and amphibians documented in different cave sites within Sarangani Province and Lanao del Sur, Philippines.

Species	Scientific Name	Common Name	Geographic Distribution	Conservation Status 2014 IUCN Red List	Cave 1 Sarangani	Cave 2 Sarangani	Cave 3 Lanao del Sur
AMPHIBIANS							
Order: Anura							
Family Bufonidae	*Ansonia mcgregori*	Mcgregor's Toad	Mindanao Endemic	vulnerable			1
	Ansonia muelleri	Mueller's Toad	Mindanao Endemic	vulnerable			1
	Rhinella marina (Bufo marinus)	Cane Toad	Non-Philippine Endemic	least concern	1		
REPTILES							
Order: Squamata							
Family Colubridae	*Ahaetulla prasina*	Asian Vine Snake	Non-Philippine Endemic	least concern			1
Family Agamidae	*Draco volans*	Common Flying Dragon	Non-Philippine Endemic	not yet assessed			1
Family Gekkonidae	*Gekko gecko*	Toko Narrow-disked Gecko	Non-Philippine Endemic	not yet assessed	1		
Family Scincidae	*Emoia atrocostata*	Mangrove Skink	Non-Philippine Endemic	not yet assessed		1	
	Eutropis multicarinata	Two-striped Mabouya	Non-Philippine Endemic	not yet assessed	1	1	
	Sphenomorphus fasciatus	Banded Sphenomor-phus	Philippine Endemic	least concern	1	1	
	Parvoscincus steerei (Sphenomorphus steerei)	Steere's Sphenomor-phus	Philippine Endemic	least concern	1	1	1
Family Varanidae	*Varanus salvator*	Common Water Monitor	Non-Philippine Endemic	least concern	1		
Total number of individuals captured per cave site					20	8	10
Total number of species captured per cave site					6	4	5
Total number of reptile species captured						8 (73%)	
Number of amphibian species captured						3 (27%)	
Total number of captured species						11	

All herpetofauna documented were encountered at the entrance and twilight zone of the caves (Table 2). Gunn [41] also reported that amphibians are commonly encountered at the entrance and twilight zone of the caves, which are characterized by high air humidity and buffered temperature changes while Hobbs [42] reported that reptiles mostly remain near cave entrances. Majority of the herpetofauna were located on the floor of the cave under rock crevices. Only *Gekko gecko* and *D. volans* were seen foraging on the wall of the cave. Iskali [43] mentioned that cave ecosystems rely almost entirely upon allochthonous energy supplies originating from surface ecosystems and this could be the reason why most herpetofauna encountered are also seen on the floor, where they prey for food.

Table 2: Species distribution of herpetofauna in cave zones of Sarangani Province and Lanao del Sur.

Species	CAVE 1			CAVE 2			CAVE 3		
	1	2	3	1	2	3	1	2	3
Amphibians									
Order Anura									
Family Bufonidae									
Ansonia mcgregori	-	-	-	-	-	-	(F)	-	-
Ansonia muelleri	-	-	-	-	-	-	(F)	-	-
Rhinella marina	(F)	-	-	-	-	-	-	-	-

Reptiles									
Order Squamata									
Family Colubridae									
Ahaetulla prasina	-	-	-	-	-	-	(F)	-	-
Family Agamidae									
Draco volans	-	-	-	-	-	-	(W)	-	-
Family Gekkonidae									
Gekko gecko	(W)	-	-	-	-	-	-	-	-
Family Scincidae									
Emoia atrocostata	-	-	-	(F)	-	-	(F)	-	-
Eutropis multicarinata	(F)	-	-	(F)	-	-	-	-	-
Sphenomorphus fasciatus	F)	-	-	(F)	-	-	-	-	-
Parvoscincus steerei	(F)	-	-	(F)	-	-	(F)	-	-
Family Varanidae									
Varanus salvator	(F)	-	-	-	-	-	-	-	-

Legend : (-) - absent, F- Floor, W- Wall; 1- Twilight zone, 2- Transition zone, 3-Deep zone.

Ansonia mcgregori and *Ansonia muelleri* which are Mindanao endemic species were only seen in Cave 3. Alcala [27] reported that most Philippine anurans live in habitats where the relative humidity is always at or near saturation. High value of relative humidity was noted at the twilight zone in Cave 3 where *A. muelleri* and *A. mcgregori* were encountered. Amphibians have a slimy skin that is not well suited to prevent desiccation and body temperature corresponding directly to ambient temperature [41]. This partly explains why in the case of amphibians, their reliance to cutaneous respiration and their subsequent sensitivity to dehydration necessitate the settling of most of the species in areas where there is continuous moisture.

Cave 1 located in Glan, Sarangani Province was situated near human settlements and cultivated lands, and this could be the reason why a number of *Rhinella marina* and *Gekko gecko* were found at the entrance of the caves. *R. marina* thrives in degraded habitats and man-made environments, and is occasionally found in pristine lowland and montane rainforests, but generally prefers open or disturbed habitat such as tracks, roads, low grassland and areas that are near human settlement [56]. Moreover, this species is tolerant of humans and is frequently found in disturbed areas and rarely encountered in undisturbed habitats [44]. Marine toads are nocturnal and attracted to house and patio lights that also attract the insects on which toads feed [45]. Also, some individuals of this species were encountered under rocks at the entrance of the cave. Their secretive behavior causes them to hide during the day in order to clump out of direct sunlight [46]. *G. gecko*, an arboreal species is commonly found in man-made environments and forest [47]. *G. gecko* demonstrates thermoregulatory behavior and it likely utilizes different microhabitats to maintain a preferred body temperature and is able to adapt to living in human habitations, which may provide a variety of microenvironments for behavioral thermoregulation [48]. Moreover, there was a number of *G. gecko* found in cave entrances because as Peck [49] reported, it is in this area where a major source of food input in the community is found.

All species recorded in this study were considered as non-obligate cave dwellers- troglophiles [50] or occasional guest in the entrances of caves [51]. Thus, Sievert and Hutchison [48] mentioned that 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.

The study documented two (18%) Philippine endemic species of reptiles belonging to Family Scincidae. Four reptile species were of least concern conservation status while the other four species are still not yet assessed based on the IUCN Red Data List [31]. Unlike the reptiles, the amphibian endemic species were only encountered in Cave 3. These two endemic species of amphibian which are of vulnerable conservation status [31] are mainly found in primary a forest [28], which indicates the need for strict conservation measures in or near caves. The structurally rich border between forests and agricultural/human-modified landscapes can contain relatively high species richness in lizards and anurans. However, anuran richness increases with distance into the forest away from agriculture while intact forest is known to support the highest species diversity of many reptile and amphibian assemblages [52].

Species Diversity:

Table 3 shows the biodiversity indices in the three cave sites. Moderate diversity with more or less even distribution was documented in the cave sites. The cave areas were not highly stratified in terms of food resources but the endemic species had adapted and survived. This indicates the high conservation importance of these cave sites.

Table 3: Biodiversity indices.

Biodiversity Indices	Site 1 SARANGANI		Site 2 Lanao del Sur
	Cave 1	Cave 2	Cave 3
Species	6	4	5
Individuals	20	8	10
Dominance	0.0842	0.1429	0.2000
Shannon (H')	1.6696	1.3209	1.1882
Evenness	0.9318	0.9528	0.7383

Existing threats to the herpetofauna:

Mining hole, graffiti on the walls and roof of the cave, remains of bonfire on the entrance zone, and garbage left inside the cave indicate disturbance in the cave sites. Based on information gathered from local guides, farmers stay in the cave during their rest hours and some may even stay there for the night. Guano collection is not active, but there are times of the year, especially during the Holy Week, when lots of people would go to the caves for spelunking. Treasure hunting activities were also being done inside the caves which also contributed to habitat disturbance. This result concurs with the observation of Wilson and McCranie [53] that the principal threats to the survival of members of the herpetofauna are uncontrolled human population growth and its corollaries, habitat alteration and destruction, pollution, pest and predator control, overhunting, and overexploitation.

Most of these anthropogenic disturbances could result to habitat destruction, especially seen in Cave Sites 1 and 2 as well as in Cave 3 which was attacked or pounded in an attempt to permanently close the cave. This finding coincides with the observation of Nuñeza *et al.* [54] that habitat destruction is the major threat to herpetofauna species. McCallum [55] also mentioned that introduced species, pollution, contaminants, pathogens and diseases, and climate change could also promote to such damage. The existing threats that are found in the sampling sites indicate the need for strict protection and conservation of these areas.

Conclusion:

Glan, Sarangani Province and Wao, Lanao del Sur are areas considered to have low abundance of cave herpetofauna but with a moderate degree of diversity and more or less even distribution. Cave structure and humidity are factors which appear to affect the distribution of the herpetofaunal species. Floor of the caves and rock crevices were the preferred microhabitats. The invasive species, *Rhinella marina* was the most abundant. The caves were basically disturbed but still support endemic species of herpetofauna.

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