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Preliminary report on anurans in the forest fragment of Gamut, Tago, Surigao Del Sur, Philippines

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Abstract

The Philippines is considered as a herpetofaunal center in the Southeast Asian region with high species richness and endemicity. The study investigates to document the anurans in the forest remnant in Gamut, Tago, Surigao del Sur. Transect and ocular survey for a total of 150 man-hours were carried out to document the species. A total of 10 species belonging to 8 genera under 6 families were recorded. Among these species, *Pulchrana grandocula* was the most abundant comprising 54% of the total population while the species *Megophrys stejnegeri* and *Polypedates leucomystax* were the least abundant with a relative abundance of 2% for each species. As for the species diversity, the anuran community shows moderate diversity index with Shannon-Weinner diversity index (H') of 1.59 with species evenness (J') of 0.69. Most of the anuran species observed were aquatic dwelling species wherein some are indicator of good water quality while the others indicate the presence of water pollution. Sixty percent of the total species are reported to be endemic that includes *Fejervarya vittigera*, *Limnonectes leytensis*, *Limnonectes magnus*, *Megophrys stejnegeri*, *Platymantis guentheri*, and *Pulchrana. grandocula*. With respect to the conservation status, only the species *L. magnus* was assessed as a Near-Threatened, however, 40% of the composition have a decreasing population trend. Major threat observed in the area includes water contamination due to deforestation. Despite the limitation of various ecological supports as manifestations gradual habitat loss, the habitat still houses various anuran species with high species endemicity.

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Introduction

Amphibians are tetrapod comprising three living groups; Gymnophiona, Caudata, and Anura wherein toads and frogs belong (Alcala and Brown, 1998). According to Stuart *et al.* (2004), the study of amphibians has contributed greatly to basic research in vertebrate evolution, physiology, and pharmacology, whereas anurans represent a very important part of the overall diversity of life. Hopkins (2007) on the other hand reported that anurans serve as a great ecological indicator since it is more sensitive to the environment than other wildlife. This is agreed by Toledo-Bruno *et al.* (2017) that as exothermic organisms, anurans are dependent on moisture and temperature that makes them as great indicators of the quality of the environment.

The Philippines is a center of herpetofaunal diversity in the South East Asian (SEA) region (Diesmos *et al.*, 2002) with 108 species of anurans of which 80% of the species are reported to be endemic (Brown *et al.*, 2013; Diesmos *et al.*, 2015). However, the forests which are the main habitat of anurans are rapidly transformed for industrial and agricultural purposes. This is evident from the report of Estoque *et al.* (2018) and ESSC (1999) that the Philippines have now less than 22% of its original forest cover as compared to the year 1900s. These anthropogenic activities posed an ecological threat to anurans for most of the species are forest dependent. These threats could result in the decrease in anuran population and extinction of the less adaptive species which are mostly endemic species. Knowledge and information about those living fauna inhabiting the site should be documented for public awareness and for the sake of conserving the wildlife.

Research gaps on anurans include the lack of evidences on anthropogenic activities which contributed to the constant changes on the anuran's assemblages, behavior, physiology, and distribution. Most of the studies (Relox *et al.*, 2011; Diesmos and Brown 2011; Beukema, 2011; Nuñeza *et al.*, 2012; Plaza and Sanguila, 2015; Coritco *et al.*, 2018) are focused on forest reserved, protected areas, and major mountain ecosystems; but not in the once forested ecosystem and its remnants. Yet, this is important for these are the areas that are more pressured and vulnerable to the total destruction of the habitat and extinction of the wildlife living in it.

Barangay Gamut is among the 18 Barangays in the Municipality of Tago located at the Province of Surigao del Sur. The area is generally categorized as rural where most of the households are located at the foot range of the mountain ecosystem. Most of the forest in the mountain covered by the barangay and by the neighboring barangays are already converted into agricultural landscapes wherein most of the planted trees are coconuts and bananas. Despite the gradual forest conversion in the area, there are still forest patches where wildlife particularly the anurans clings for survival. However, to conserve the species, ecological information is necessary to serve as a basis for coming up with conservation measures. This is one thing that is lacking in the area. Thus, this study was conducted to provide baseline ecological information on the anurans in the forest remnants of Barangay Gamut.

Materials and methods

Place and Duration of the Study

The study site was located at the Barangay Gamut, Tago, Surigao del Sur where it is situated at 8˚31'49" North and 126˚14'32" East (Fig. 1). The study was conducted from October 1 to 5, 2016.

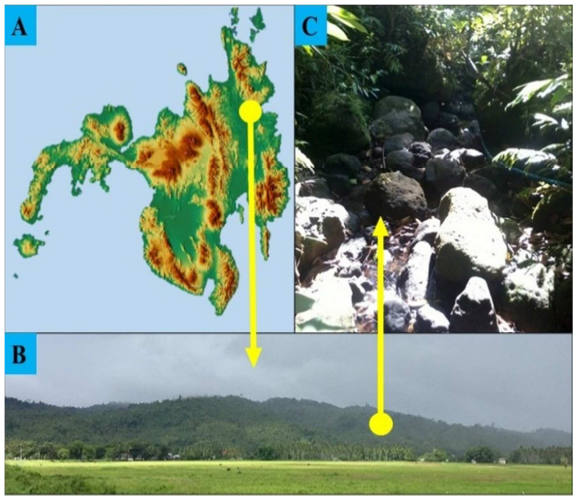

Fig. 1. Spot Map (A), Panoramic View (B), and Forest Interior of the Study Site (C).

Habitat Description

The study site is a forest patch where it is considered as Secondary Mixed-dipterocarp forest. The plant species in the area were composite of dipterocarp trees (*Shorea* spp.), *Pandanus* sp., shrubs, herbs, epiphytes, and coconut trees in the periphery. Fern species such as *Angiopteris palmiformis*, *Davallia sordida*, *Nephrolepis* sp., *Gleichenia* sp., and *Pteridium* sp. were also dominantly observed. The area has a stream with an approximate length of 500 meters with varying width. At the terminal point of the stream (Northern part) a waterfall is observed, while near the starting point, there is a so-called "mini-dam". The leaf litter in the area is thin to moderate with few fallen logs across the stream. The distance of the study site to the nearest human settlement is about 100 meters from the starting point. The terrain of the study site is plain at the starting point but gets stepper along the way up to the end-point. During the conduct of the study, the air temperature was around 27 to 28^{0}C.

Data Collection, Identification, and Analysis

A transect walk and ocular survey were carried out along the stream and peripheral vegetation. Encountered anurans were collected and were placed to a temporary container for eventual processing. The transect survey was performed between 6:00 PM to 9:00 PM resulting in a total sampling hour of 150 man-hours. All captured anurans were taken the morphometrics that includes the Snout-Vent Length (SVL), Hind Limb (HL), Fore Limb (FL), Hind Foot (HF), webbing on the hind limbs and forelimbs, and distinct morphological characteristics for these are the bases for identification. The book of Alcala and Brown (1998) entitled "Field Guide for Philippine Amphibians" and articles with existing keys were used as a guide for the identification. After taking the morphometrics and the identification, the anurans were released to the wild. On the other hand, a maximum of 2 samples was considered as voucher specimens for the least concern species. Data analysis includes the determination of the abundance, diversity index, species dominance, and evenness using a BioPro version 2 software.

Results and discussion

Species Composition and abundance

A total of 67 individuals of anurans were recorded and classified into 10 species belonging to 8 genera under 6 families. Among the anurans, only 1 species represents the toad (*Rhinella marina*) while 9 species are frogs. Meanwhile, among these species, *Pulchrana grandocula* was the most abundant with 36 individuals comprising 54% of the total population. This was followed in decreasing order by *Limnonectes magnus* (n=9; 13%), *Occidozyga laevis* (n=6; 9%), *Limnonectes leytensis* (n=5; 7%), *Platymantis guentheri* (n=3; 4%), *Fejervarya moodiei* (n=2; 3%), *Fejervarya vittigera* (n=2; 3%), *Polypedates leucomystax* (n=1; 2%), and *Megophrys stejnegeri* (n=1; 2%) (Table 1). The high abundance of *P. grandocula* is primarily associated with the type of area surveyed wherein it has the presence of a stream. The species is reported to dwell on the aquatic ecosystem or near the aquatic ecosystem. This agrees with the report of Warguez *et al.* (2013) and Vidal *et al.* (2018) that *P. grandocula* are abundantly observed on stream rocks. This is in consonance with the statement of Oda *et al.* (2016) that the species under the family Ranidae where the *P. grandocula* belongs inhabit the streams in either pristine or forest remnants. Another reason was that the area is at the lowland which is the ideal elevational range of this species.

The low abundance of *P. leucomystax* and *M. stejnegeri* is associated with various factors. First is the sampling effort, during the conduct of the field work, the searching for anurans was more focus on the anurans that could be found along the stream and its periphery. Less effort was given on trenching the leaf litters where the terrestrial dwelling species such as *M. stejnegeri* is usually found. The same less effort was allotted for searching the frogs on the leaves, fern fronds, and plant branches of the understorey trees where the arboreal frog species such as the *P. leucomystax* usually inhabits. This is for the reason that the land terrain in the interior of the forest where there is better vegetation is steppe. Thus, serves as a hindrance for further searching the anurans to these microhabitats.

Table 1. Species composition and abundance of anurans in the forest fragment of Gamut, Tago, Surigao del Sur, Philippines.

Taxon	Abundance	Relative Abundance (%)
Bufonidae		
Rhinella marina	2	3
Ceratobatrachidae		
Platymantis guentheri	3	4
Dicroglossidae		
Fejervarya moodiei	2	3
Fejervarya vittigera	2	3
Limnonectes leytensis	5	7
Limnonectes magnus	9	13
Occidozyga laevis	6	9
Megophryidae		
Megophrys stejnegeri	1	2
Ranidae		
Pulchrana grandocula	36	54
Rhacophoridae		
Polypedates leucomystax	1	2
Total Number of Individuals	67	
Total Number of Species	10	
Total Number of Genera	8	
Total Number of Families	6	

Another factor could be the limitation of ecological support that the habitat can offer to these kinds of species. Generally, the study site is a remnant forest, with limited land area, and with high anthropogenic pressure because of its nearness to the human settlements. According to Sanguila *et al.* (2016), the *M. stejnegeri* is reported to inhabit in montane and lowland tropical rainforest. In connection with this, since the *M. stejnegeri* inhabit this kind of habitat, and the site does not look to be like one anymore because of disturbances, it could possibly mean that the population of the species is affected and declining as the effect of gradual deforestation, hence, limited individual was seen in the area. As for the case of *P. leucomystax*, though reported to be well adaptive to various types of habitat that stretches from agricultural clearings, suburban areas, forests, and wetlands (Diesmos *et al.*, 2004), this species was limitedly observed. According to Kuraishi *et al.* (2013), *P. leucomystax* is uncommon in the deep and shaded forest, thus, explaining its low abundance in the site for it is covered with 80-90% of the tree canopy.

As for the case of the other species, their abundance was significantly lower as compared to *P. grandocula*. Even the species *Limnonectes* spp. and *Fejervarya* spp. were less observed despite the fact that these species are reported to dwell in the aquatic ecosystem particularly in streams (Alcala and Brown, 1998). This is due to the fact that during the sampling, the area was suffering from a long drought where it has been reported by the local people that it was almost 2 months that there was no rain. In the instance that it will rain, it just lasted for a couple of minutes and the downpour is not that strong. This is evident in the actual site wherein the flow of the water in the stream was slow because there was a relatively lower volume of running water. In consideration with the physiologic requirements of the frogs and toads, water is one of the limiting factors that affect its assemblages and abundance. Anurans are organisms that are associated with temperature, moisture, and water bodies because of their thin integument, mode of gas exchange which is through subcutaneous respiration, and reproductive process. Most of the anurans particularly the species that are found in aquatic microhabitat are susceptible to this kind of climatic condition because it has less tolerance to the dry and warm environment for its physiologic activities will be interfered.

Galoyan *et al.* (2017) cited that the anuran abundance is comparatively lesser in the dry season as compared with the wet season because frogs are known to aestivate during the dry periods of the year. While Bickford *et al.* (2010) pointed out that the reduced in the level of precipitation (rainfall) has a direct effect on anurans through reduction of breeding cues and available breeding sites. Thus, affecting the reproductive cycle and process and eventually the population of the organism. This is in consonance with the premise of Donelly and Crump (1998) that with less precipitation or extended droughts, eggs and tadpoles will be vulnerable to mortality from dying. Longer droughts could also lead to reproductive failure in consecutive years, causing population crashes of many species (Bickford *et al.*, 2010).

Moreover, Shoemaker (1992) stated that anurans have a physiological aspect that is highly sensitive to temperature increase.

The organisms are dependent on the water balance due to their permeable skin and high evaporation rates. Also, anurans are poiquiloterms, their thermoregulatory performance is related to the water balance, digestion, oxygen supply, emergence from hibernation, development, metamorphosis, and growth (López-Alcaide, 2011). According to Bickford *et al.* (2010), one of the most obvious and direct effects of reduced precipitation in SE Asia on herpetofauna is a reduction in breeding cues and available breeding sites for amphibians.

Species Diversity

The species diversity index of anurans was determined and revealed that the Shannon-weinner diversity index (H') is 1.59 with species evenness (J') of 0.69 (Fig. 2). This suggests that the community of anurans in the area is moderately diverse. For an ecological survey that involves diversity indices, the community with species evenness near to a value of one (maximum) is considered as highly diverse; while the value that is farther than one is interpreted as less diverse with zero as the minimum indicating no diversity at all. For the case of anurans in this study, the species evenness is shown to fall at the middle bracket of the species evenness value range. Thus, the interpretation is moderately diverse.

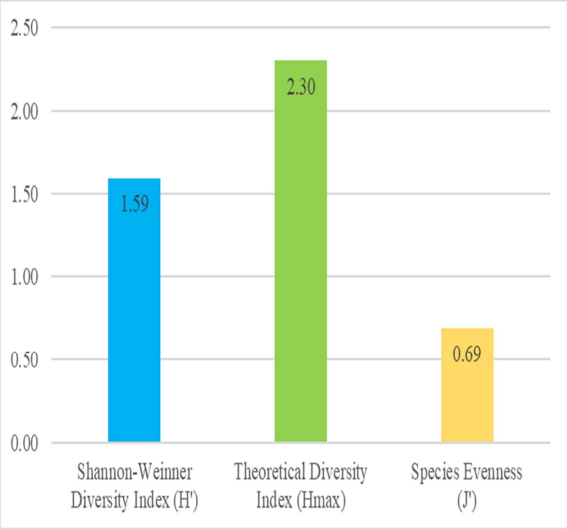

Fig. 2. Diversity indices of anurans in the forest fragment of Gamut, Tago, Surigao del Sur, Philippines.

Fig. 3. Some of the Anurans Observed in the forest Fragment of Gamut, Tago, Surigao del Sur. A: *Limnonectes magnus* (endemic); B: *Limnonectes leytensis* (endemic); C: *Megophrys stejnegeri* (endemic); and D: *Pulchrana grandocula* (endemic).

The reason for an average species evenness value is due to the presence of a dominant population in the area. It can be observed that the population of *P. grandocula* is the most abundant species with 36 individuals as compared with other populations that range only from 1 to 9 individuals. This makes a population discrepancy of 27 to 35 individuals. The species diversity is known to be directly proportional to the species evenness which refers to the even distribution of abundance across species. Thus, indicating that if the community shows an uneven distribution of population, indicates low diversity as well. This is supported by the fact that the H' index is comparatively lower as compared with the theoretical diversity or equitability (Hmax) of the species in the area which is 2.30, giving a 0.71 difference. In ecological perspectives, a diversity index (H') which is nearer to the value of the theoretical diversity (Hmax) value indicates high diversity; while the value that shows the high difference is interpreted to be less diverse.

On the other hand, the moderate diversity of anurans in the area is also associated with the limited area and resources it can offer to the anurans. As mentioned above, the area is a forest remnant found in the midst of agroecosystem with limited size. According to da Silva (2011), the size of a habitat and landscape are factors that affect species diversity.

Area increases diversity because a larger plot offers wider and heterogeneous habitats, hence niches, to support a greater variety of species. This further agrees with the statement of Tews *et al.* (2004), that a greater range of habitat tend to promote biodiversity better than the smaller habitat because it has more available niches for species to occupy. Also, it can sustain higher population numbers for each species, thus, increases species evenness which is proportional to diversity index.

Microhabitat Preference of anurans and Species Occurrence Implication

Among the recorded anurans, 6 species (*F. moodiei*, *F. vittigera*, *L. leytensis*, *L. magnus*, *O. laevis*, and *P. grandocula*) were observed to dwell the aquatic microhabitat or shows association with the aquatic ecosystem. Three species (*M. rhinella*, *M. stejnegeri*, and *P. guentheri*) were terrestrial dwelling, and the species *P. leucomystax* was the only arboreal species observed (Table 2). Most of the species categorized to the aquatic microhabitat are species that are found mainly on the rocks along the stream and on the streamside with stagnant water bodies or with the slow water current. While the terrestrial species were found camouflaging in the leaf litters, twigs, and decaying logs in the riparian ecosystem. The arboreal species *P. leucomystax* was seen hanging on the plant foliage. As observed, anurans have different microhabitat preference. This is for the reason that every species has different modalities of adaptation for their reproduction and survival.

Table 2. Microhabitat preference of anurans in the forest fragment of Gamut, Tago, Surigao del Sur, Philippines.

Taxon	Microhabitat	
Bufonidae		
Rhinella marina	Terrestrial	Forest litter and Streamline
Ceratobatrachidae		
Platymantis guentheri	Terrestrial	Forest litter
Dicroglossidae		
Fejervarya moodiei	Aquatic	Streambanks
Fejervarya vittigera	Aquatic	Streambanks
Limnonectes leytensis	Aquatic	Streambanks
Limnonectes magnus	Aquatic	Streambanks
Occidozyga laevis	Aquatic	Small water pond
Megophryidae		
Megophrys stejnegeri	Terrestrial	Forest litter
Ranidae		
Pulchrana grandocula	Aquatic	Above rocks and streambanks
Rhacophoridae		
Polypedates leucomystax	Arboreal	Fern Frond

The species that are aquatic dwelling are reported to have a generalized reproductive mode wherein they deposit their eggs directly to the water and have an aquatic developmental stage (Causaren, 2009). While the species like *Platymantis guentheri* have a specialized reproductive process with direct development as the mode of reproduction, with direct-developing egg masses deposited by females in the forest floor (AmphibiaWeb, 2012). As for the *M. stejnegeri*, though reported to breed in the streams most of its time is spent in the terrestrial ecosystem hiding in detritus and forest litter, where they hunt preys and hide from predators (IUCN, 2018).

On the other hand, the presence of *L. magnus* indicates good quality of water wherein the decrease in the population of this species implies that the area is already exposed to pollution and other contributing factors that affect the forest (Alcala, Brown 1998). However, as discussed above, the population of *L. magnus* is not that abundant, thus, entailing that the water quality in the area is somehow deteriorating. As for this claim, it could be attributed to the physical characteristic of the upper portion of the mountain wherein there is no longer vegetation that can help in filtering the water that flows down to the lower portion of the forest. This is further supported by the presence of *O. laevis*.

The species is reported to be an indicator of the polluted aquatic ecosystem because it mostly inhabits polluted puddles and marshes to clear mountain streams (AmphibiaWeb, 2019).

As for the presence of other species particularly the *P. grandocula*, this species is reported to have a wide range of preference where it inhabits either polluted or unpolluted water bodies. Meanwhile, the presence of *M. rhinella* does not only indicates low water quality but also poses a threat to the anuran's community. This species is widely known as a non-native invasive species that compete with the native species (Shine, 2012). It is also reported to consume other frog eggs (Crossland and Shine, 2011), thus, affecting the reproductive cycle of other species that could eventually lead to species extension. According to Solania and Fernandez-Gamalinda (2018), the presence of non-native species can increase competition pressure to the native frogs with regards to food and habitat.

Endemism, Conservation Status, and threats

Out of the 10 species recorded, 6 (60%) species were assessed as geographically restricted or endemic. These are the species *F. vittigera*, *L. leytensis*, *L. magnus*, *M. stejnegeri*, *P. guentheri*, and *P. grandocula*. Furthermore, among these species, two species (*M. stejnegeri* and *P. guentheri*) are the Greater Mindanao endemic while the rest are Philippine endemic. As for the conservation status, 8 (80%) of the 10 species are under the Least Concern criterion of the IUCN Redlist (2018) while the species *F. moodiei* and *L. magnus* have an assessment status of Data Deficient and Near-Threatened, respectively. However, even though most of the anurans are classified as Least Concern, this does not mean that the species are exempted from gradual extinction because of the habitat deterioration. This is evident with the population trend of the species wherein 40% (4) have a decreasing population. Not to mention that these species are reported to be endemic to the country which includes the Near-threatened species *L. magnus* (Table 3).

Table 3. Distribution and Conservation Status of Anurans in the forest fragment of Gamut, Tago, Surigao del Sur with notes on ecological threats. For the Distribution Status, the following Legends are as follows: NE, Non-Endemic; IAS, Invasive Alien Species; GME, Greater Mindanao Endemic; and PE, Philippine Endemic. For the Conservation Status, the following legends are LC, Least Concern; DD, Data Deficient; and NT, Near-Threatened. For the threats, the legends are WP, Water Pollution, OH, Overharvesting, and FCtAL, Forest Conversion to Agricultural Land.

Taxon	Status		Population trend	Threats observed
	Distribution	Conservation		
Bufonidae				
Rhinella marina	NE/IAS	LC	Increasing	None
Ceratobatrachidae				
Platymantis guentheri	GME	LC	Decreasing	WP/
Dicroglossidae				
Fejervarya moodiei	NE	DD	Unknown	WP/FCtAL
Fejervarya vittigera	PE	LC	Decreasing	
Limnonectes leytensis	PE	LC	Decreasing	WP/FCtAL
Limnonectes magnus	PE	NT	Decreasing	WP/FCtAL/OH
Occidozyga laevis	NE	LC	Stable	FCtAL
Megophryidae				
Megophrys stejnegeri	GME	LC	Unknown	FCtAL
Ranidae				
Pulchrana grandocula	PE	LC	Stable	WP/FCtAL
Rhacophoridae				
Polypedates leucomystax	NE	LC	Stable	FCtAL

As for the ecological threat, aside from the effect of global warming which is in a form of drought, which was somehow experienced in the area, the expansion of the agricultural land and conversion of forest land could further increase the pressure on the anuran's community.

This is for the reason that most of the anurans documented are forest-dependent and has a low ecological range in terms of habitat preference (macro level). Also, the increasing population of the invasive species *R. marina* could pose a further threat to the endemic species population for it competes with the native species and at the same time serves a predator to some anurans.

Conclusion

Despite the limited land size of the forest patch in Barangay Gamut, it still holds various species which were represented by 10 species in 8 genera under 6 families. The habitat also shows moderate to near-high diversity despite its condition and high anthropogenic pressures indicating that it still offers good ecological support for the survival of the anurans in the area. Also, although the habitat is categorized as lowland and fragmented forest, it is home to various endemic species which consist of 60% of the anuran composition wherein most species have a decreasing population trend.

Recommendation

With all these findings and interpretation, and in consideration to high deforestation rate, it is recommended that the amendments on the conservation of wildlife species must not only be focused in the major ecosystems but also to the often-neglected habitat such as a forest fragment. Also, issues on invasive alien species must be addressed as well in this kind of habitat to hinder further damage on the native species that are inhabiting the area.

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