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Diversity of anuran of the three different habitat types (Riparian, Agricultural and Residential) along the River of Barangay Mananum, Bag-o, Medina, Misamis Oriental, Philippines

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Abstract

Anuran belongs to the group of amphibians that are sensitive to the alterations of their environment and they could be used as bio-indicator organisms to follow changes in their habitats. The diversity of anurans was studied in the three sites located along the river of Mananum, Bag-o, Misamis Oriental, Philippines. Visual encounter survey was used to capture the target species. Diversity indices such as species richness, relative abundance, Shannon-Weiner function, evenness, similarity index were analyzed. Environmental variables were measured to know the species-habitat relationships using Canonical Correspondence Analysis (CCA). Results of the study revealed that the area is composed of 6 species of anurans namely: *Rana magna, Hylarana signata, Polypedates leucomystax, Occidozyga laevis, Limnonectes leytensis* and *Rhinella marina*. It was found out that riparian area has the highest species richness and showed higher diversity index compared from the two areas. Based from CCA, it was found out that the area is composed of three (3) habitat types namely: forested; shrub land; and rocky area. Certain species of anurans were greatly associated according to the types where they are exposed. Several threats both man-made and natural-made have been identified that greatly affected the diversity of anuran species in the area.

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Introduction

The Philippine archipelago is one of the most mega diverse countries in the world. Many of the endemic plant and animal species can be found in rainforests in different regions of the country (Lavides *et al*., 2004). Situated at the Indomalayan–Australasian faunal zone interface, the Philippines have captured the attention of amphibian systematists for over 150 years. Results of intensive field studies in the past two decades reveal that the Philippines is a major center of amphibian diversity and endemism (Diesmos *et al*., 2004). To date, there are 80 known species of frogs and 92 species of reptiles in the Philippines (Ascano *et al*., 2015). Amphibians are critical components of both aquatic and terrestrial communities; therefore anthropogenic factors that negatively affect amphibians may influence entire ecosystems (Petranka and Murray 2001).

In recent centuries, rapid expansion of human population has a deleterious impact in the environment, and sustainable practices have resulted in well documented population declines across a broad range of species (Pimm *et al*., 2001). As the Philippine forest disappears and human population explodes, this unique island nation proportionately loses large numbers of wildlife (Conservation International, 2006).

Causes of species decline in both the terrestrial and marine environments are increasingly linked to human activities, and both the number and magnitude of threats has increased dramatically in modern times. Current threats to biodiversity include habitat loss (Vitousek *et al*., 1997), invasive species (Burgman and Lindenmayer 1998, Briggs *et al*., 2005), pollution (Rowe *et al*., 2001, Davidson *et al*., 2007), and infectious diseases (Daszak *et al*., 2004, Araujo *et al*., 2008),

Habitat loss secondary to land conversion for agricultural, industrial and residential purposes is seen in Medina, Misamis Oriental. One of the Barangays in this municipality is Mananum, Bag-o where the river is located whose environs are exposed to anthropogenic disturbance. To date no study has been conducted in the area in terms of biodiversity assessment as affected by man-made activities. Thus this study was conducted.

The study aims to assess the diversity of anuran species in the three habitat types along the river of Barangay Mananum Bag-o, Medina, Misamis Oriental. Specifically the study aims to assess the species composition of the three habitats; species profile; conservation status and economic value of the anurans; species richness (Shannon –Weiner index, species evenness, relative abundance, anurans species similarity). Further, it also assess how the environmental variables namely: air temperature, relative humidity, rock cover, canopy cover, shrub percentage, and elevation are related to the presence of anurans; and assess the presence of possible threats affecting diversity of anurans.

Materials and methods

Description of Study Area

The study was conducted in the Municipality of Medina in the riparian area along the river of Barangay, Mananum Bag-o, Medina Misamis Oriental. According to the 2010 census, Medina is a fourth class municipality in the province of Misamis Oriental. It has a population of 31, 154 people. Medina has 19 barangays belong to the partly urban areas and one of the barangays is Barangay Mananum, Bag-o. The estimated terrain elevation is 171 masl. The study was conducted at the riparian, agricultural, and residential area along the river.

Fig. 1 shows the research setting of the area. It shows the map where the three sampling sites are found. The riparian area has an elevation of 304 masl, located North 08°53'40.3", East 124°59'09.7". Agricultural area is situated at the North 08°54'08.1", East 124°58'47.3" having an elevation of 217 masl. While the residential is located North 08°54'30.2", East 125°00'21.7",with an elevation of 63 masl.

Riparian area (Fig. 2) has different kind of species of shrubs, herbs and ferns. Some of the trees were

covered with vines, fallen logs, and trunks of large trees were also noticed. There were lots of huge rocks along and within the river and some of the rocks were surrounded with moss. Agricultural area (Fig. 3) is considered as less disturbed because of agricultural plantations such as coconut, lanzones, cacao and banana. There were also few houses built in agricultural area and they raise pigs and other domesticated animals to raise income. Residential area (Fig. 4) has houses built on the left side of the river. During the sampling period the river was dry, it is only filled up with water when there is heavy rain.

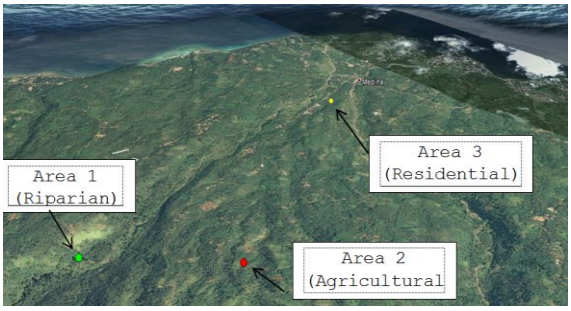

Fig. 1. Map of the River in Barangay Mananum Bag-o, Medina, Misamis Oriental.

Fig. 2. Riparian area with an elevation of 304 masl, located North 08°53'40.3", East 124°59'09.7".

Reconnaissance Survey and Establishment of Transect Line

An ocular inspection was conducted to gather information on what type of environment present in the study area. Emphasis was given on what kind of habitat and microhabitat is present that provides environment conducive for the existence of anuran species. Global Positioning System (GPS) was used in determining the elevation of the area.

Transect lines were established in both sides of each of the sampling areas along the river of Barangay Mananum, Bag-o, Medina, Misamis Oriental. Each transect line has a measurement of 10 meters width by 100 meters length (Fig. 5.).

Fig. 3. Agricultural area with an elevation of 217 masl, located North 08°54'08.1", East 124°58'47.3".

Fig. 4. Residential area with an elevation of 63 masl, located North 08°54'30.2", East 125°00'21.7".

Each transect line was customary to facilitate the case in identifying the captured anuran species. The tools such as colored plastic twines, bamboo sticks and transect meter was used for the establishment of transect lines.

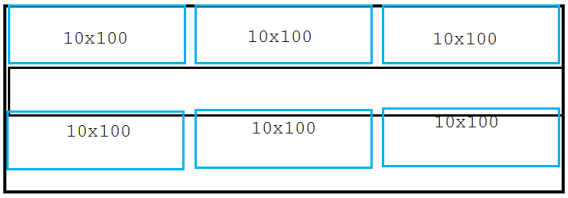

Fig. 5. Establishment of transect lines with a measurement of 10x100 meters in both sides of the river in Barangay Mananum, Bag-o, Medina, Misamis Oriental.

Data Collection Method

Visual Encounter Survey (VES)

This method was used to capture the anurans. Microhabitats such as beneath stones, beneath rotting logs, leaf litter, water, tree trunks, stems; upper and lower surface of the leaves were searched for three hours per night and day from 6-9pm at night and 3-6am at day. Each anuran species encountered was collected. Samples were released after it was marked by the used of quick dry nail polish. Sampling was continued until the number of species documented no longer increased significantly (Heyer *et al.*, 2014). Sampling stops when no new species are found or when plateau is reached.

Identification of the Specimen

Photo documentation was used in identifying each of the species. Captured anuran species were identified by the local residents who helped caught the anuran species for identification of the local names. Identification of the specimen was done using the methods of Alcala and Brown (1998) for initial identification and was confirmed by an expert.

Anuran Species Diversity Parameters

Species Richness (R)

Species richness is one component of concept of species diversity, which also incorporates evenness that is the relative abundance of species. Species richness is the number of species present in a community or taxonomic group (Hogan *et al.*, 2010).

Shannon-Weiner Function

A quantitative measure that reflects how many species present in the sample of certain size. Index Diversity using Shannon-Weiner Function (H') is the formula that is commonly adopted.

$H' = -\sum-(n_i/N)\log(n_i/N)$

Where:

p_i= is the proportion of the individuals for the *ith* species out of the total number of individuals (i.e the number of a species divided by total number of individuals recorded in sample). $Log_n p_i$= is the natural logarithm (log_e) of p_i.

Species Evenness

Evenness measure the variation in the abundance of individuals per species within a community. Communities with less variation in the relative abundance of species are considered to be more "even" than a community with more variation in relative abundance. Evenness (E) according to Shannon was used to check if the calculated value results from the equal distribution.

$$E = \frac{Hs}{LogS}$$

Where,

H' = Diversity (Shannon – Weiner Index).

S = Species Richness

Evenness is calculated as the ratio between the value of Shannon and the highest possible diversity at the same number of species. This was attained when every species shows the same part of the total abundance of all species.

Relative Abundance

Relative Abundance is the abundance of species divided by the total abundance of all species combined. It was determined using the formula (Morrison *et al.*, 2000).

$R.A\ (\%) = n_i/N \times 100$

Where n_i = number of individuals per species and N = total number of individuals of all species encountered.

Anuran Species Similarity

The Jaccard similarity (Real *et al.,* 1996) is a common index of binary variables. The degree of which the species composition per sampled area is measured its alike and different.

The similarity between the microhabitat with regards to the absence or presence of the species was used to evaluate. The following formula was obtained the similarity of the species percentage.

$$J_{\text{accard Coefficient}} = Ccj = \frac{C}{S1+S2-C}\ x\ 100$$

Where,

S1&S2 = numbers of species in communities I and II

C = number of species in common to both areas.

Data Analysis

In analysis of data the Diversity Indices (Dominance, Shannon's Index, and Evenness) and Canonical Correspondence Analysis (CCA) were made using the Past Software version 2.14. CCA was made in determining the association of anuran species and the environmental variable present in its habitat. Thus, Paleontological statistics version 3 Application was performed in getting the One-Way ANOVA which was used in determining whether there were any significant differences among the selected anuran species.

Environmental Variables Determination

The determination of environmental variables was conducted according to the following procedures:

a) Air Temperature: Temperature is known not only to affect behavioral performance of anurans but also affects life history-traits, growth-rates, developmental rates and adult body size. Temperature is one of the most influential factors in species diversity (Lotz, 2007).

In measuring air temperature, the standard mercury thermometer was used in the study. It was recorded at 2m above the ground (standard reference height for meteorological stations). Temperature in centigrade was recorded in a data sheet at the beginning and ending of anuran species collection (Bertoluci *et al.*, 2002).

b) Relative Humidity: Anurans permeable skin is critical for both gas exchange and osmo-regulation that makes them sensitive to any kind of conditions (Cui *et al.,* 2011), which is connected to the extreme changing of relative humidity. An anemometer was used for measuring the moisture content in the environmental air or humidity. Measurement was done at the beginning and ending of anuran species collection. The data gathered was then recorded in a data sheet.

c) Canopy Cover: Skelly *et al.*, 2002 stated that some species of amphibians experience lower growth and survival rates, or are less likely to occur, within heavily shaded wet lands.

In the absence of a scientific apparatus. An improvised device was used in measuring the canopy cover. Using a base roll of tissue paper and string; four quadrats were formed using a string of which each quadrat represents 25% (Bell *et al.*, 2006). After calculations were made data gathered and were recorded on the data sheets.

a) Rock Cover: Adults amphibians are often associated with rocky stream beds and drainage channels in well drained rocky soils (Sullivan *et al.,* 2005). In the absence of scientific apparatus, Ocular survey was used in getting the estimated rock cover percentage in each sampling area. The data gathered was placed in a data sheet.

b) Shrub Percentage: Anuran species usually attached egg masses to shrubs, which may explain why anuran species oviposit more eggs masses with substantial vegetation complexity including extensive coverage by shrubs and persistent non-woody vegetation (Egan and Paton 2004). In each sampling area the shrub percentage was estimated through ocular survey. The data gathered was placed in a data sheet.

c) Elevation: Ashton 2002 stated that amphibian species have morphological changes with elevation, but these changes vary greatly between species. A Digital GPS was used to measure the exact location of the three stations with its precise elevation.

Results and discussion

Anuran Species Composition of the Three Sampling Areas.

A total of six (6) species of anurans were found along the river of Barangay Mananum, Bag-o, Medina, Misamis Oriental. The anurans present in the sampling sites are shown in Fig. 6.

Anuran Species Profile, Conservation Status & Economic Value Species Profile

H. signata (Fig. 6a). It is abundant in lowland forests, including swamp and heath forest, and is commonly found in the riparian vegetation along stream banks. Metamorphs disperse through the forest and when they are half grown they return to the stream banks. Tadpoles develop in quiet side-pools at the edge of streams.

Limnonectes leytensis (Fig. 6b). It inhabits streams and rivers in low elevation forests, forest edges, and in some populations, swamps and other wetlands. Eggs are deposited on vegetation overhanging bodies of water.

Occidozyga laevis (Fig. 6c). In Peninsular Southeast Asia this species inhabits shallow muddy puddles and pools near small forest streams and is occasionally found in gentle stream sections and is apparently purely aquatic. It is a species of the forest edge, but not a human commensal of strongly disturbed or dynamic areas. In the Philippines it is found in anthropogenic habitats in the lowlands and occasionally in undisturbed lower montane and lowland forests. This species is most often seen in marshy areas, small puddles and small streams in lowland rainforest. Tadpoles have been seen most often in marshes on the peninsula and in any standing body of available water in the Philippines.

Polypedates leucomystax (Fig. 6d). It is a very adaptable opportunist and commensal, occurring from beach vegetation through all manner of human habitats (such as agricultural areas, ditches, artificial ponds and lakes, gardens, even in houses) and natural edge habitats to closed primary forest. It appears to be dependent on human activities to create suitable habitats.

Rana magna (Fig. 6e). The largest stocky-bodied frog in the Philippines .A pair of bony processes at the front of the lower jaw. The fingers have distinctly enlarged round disks. The toes are completely webbed to the round disks. A conspicuous flap of skin on the outer edge of fifth toe and metatarsal. Inhabits clear and unpolluted forest streams.

Rhinella marina (Fig. f). A nocturnal and terrestrial toad that inhabits humid areas with adequate cover, including cane fields, savannah, open forest, well-watered yards and gardens. It also inhabits dry equatorial forests. It 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.

It tends to avoid more densely vegetated areas, which can then act as a barrier to their dispersal. It can be found by day beneath fallen trees, loose boards, matted coconut leaves, and similar cover. It feeds on arthropods (especially ants and termites) and small vertebrates. It is flexible regards breeding site (Evans *et al,.*2003); eggs and larvae develop in slow or still shallow waters of ponds, ditches, temporary pools, reservoirs, canals, and streams. Clutch size is between 8,000 and 17,000. Eggs and tadpoles are poisonous and displace native tadpoles. Larvae are tolerant of high temperatures.

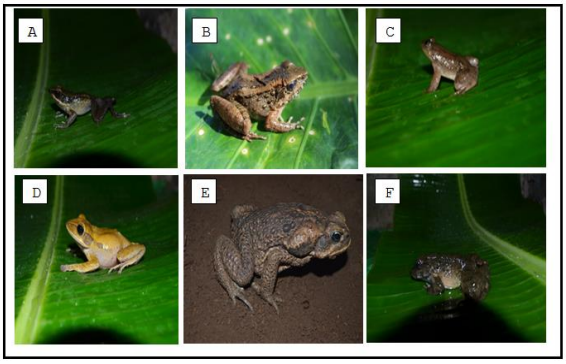

Fig. 6. Species Composition of Anuran Species captured in the three different habitat types (Riparian, Agricultural, & Residential) along the river of Barangay. Mananum, Bag-o, Medina, Misamis Oriental.
(Legend: A= H. signata, B= L. leytensis, C= O. laevis, D= P. leucomystax, E= R. magna, F= R. marina)

Conservation Status and Economic Importance

The conservation status based from List I.R. IUCN, (2015) and species economic importance is presented in table 1. A total of 6 anuran species that belong to 4 families were identified in the study area.

Species under the family of *Ranidae* is the most abundant. In terms of its conservation status, most of the identified species were least concern only one species which is the *R. magna* has no data appeared in the List I.R. IUCN, 2015. For its economic value, four species namely *H. signata, L. leytensis, O. laevis,* and *R. magna* are identified as edible while two species which are the *P. leucomystax* and *R. marina* are inedible or not fit to be eaten.

Table 1. Species Profile of Anurans found in the three sampling areas along the river of Barangay Mananum, Bag-o, Medina, Misamis Oriental.

Scientific name	Common name	Family	Conservation Status (IUCN, 2015)	Economic Value
H. signata	Spotted Stream Frog	Ranidae	Least concern	Edible
R. magna	Giant Philippine Frog	Ranidae	No Data	Edible
L. leytensis	Swamp Frog	Dicroglossidae	Least concern	Edible
O. laevis	Common Puddle Frog	Dicroglossidae	Least concern	Edible
P. leucomystax	Common Tree Frog	Rhacophoridae	Least concern	Inedible
R. marina	Cane Toad	Bufonidae	Least concern	Inedible

Anuran Species Richness and Distribution

The result presented in table 2 shows that a total of 328 individual species of anurans were counted during the conduct of the study. With this, 150 individual anuran species were encountered in riparian area. Followed by the agricultural area with 119 totals of individual species, and 59 individuals found in residential area. Further, the results in the study revealed that 4 species of anurans were found in riparian area and in agricultural area while 2 species were found in the residential area.

Table 2. Distribution of Anuran Species captured along the river of Barangay Mananum, Bag-o, Medina, Misamis Oriental.

Anuran Species	Riparian	Agricultural	Residential	Total
H. Signata	51	46	0	97
L. leytensis	9	0	0	9
O. laevis	0	7	0	7
P. leucomystax	10	6	0	16
R. magna	80	60	38	178
R. marina	0	0	21	21
TOTAL	150	119	59	328

Diversity Indices

Table 3 presents the following parameters, species richness, species dominance, Shannon's Index and Evenness. Result showed that the riparian area is composed of 4 species of anurans having a total of 150 individuals. It has a dominance value of 0.4081, this is attributed to the high number of *R. magna (*53.3%). This type of species thrives in shaded area with high moisture for growth *(*Wright*,* 2010*)* and then followed by *H. signata* (34.0%), *P. leucomystax* (6.7%) *and L. leytensis* (6.0). Shannon's Index revealed that the area was moderately diverse with a value of 1.051. The evenness value is 0.7154, which means that the species present in the area was unevenly distributed.

Table 3. Species distribution, richness, diversity, and evenness of anuran species.

Diversity indices	Riparian	Agricultural	Residential
Taxa_S	4	4	2
Individuals	150	119	59
Dominance_D	0.4081	0.4096	0.5415
Shannon_H	1.051	1.03	0.651
Evenness_e^H/S	0.7154	0.7002	0.9588

Agricultural area is composed of 4 species of anurans with 419 individuals. It has a dominance value of 0.4096, due to the abundance of *R. magna* (50.4%), followed by *H. signata* (38.7%), *O. laevis* (5.9%) and *P. leucomystax* (5.1%).

Shannon's Index revealed that the area has low diversity with a value of 1.03. The evenness value is 0.7002 which indicates that the species was unevenly distributed.

In residential area it has only 2 species of anuran identified with 59 individuals. The dominance value was 0.5415, and this is due to the number of species found in the area namely: *R. magna* (64.4%) and *R. marina* (35.6%). The area has a diversity value of 0.651 which means that it has low diversity and with an evenness value of 0.9588 an indication suggesting that the species was not evenly distributed in the area. The presence of *R. magna* in the three sampling areas suggests high tolerance of the organisms toward extreme environmental conditions. Based from the observations above, it is very obvious that the primary factor influencing the variation of the anuran composition between sampling areas is attributed to the land conversion.

Relative Abundance of Anuran Species

Table 4 shows the relative abundance of anuran species of the three sampling areas (Riparian, Agricultural, & Residential). The results revealed that among the six species, *R. magna* has the highest percentage of Relative Abundance followed by *H. signata* and *R. marina*.

The presence of *R. magna* in the three areas may be attributed to its nearness to the river thereby influences high moisture content. The presence of *R. marina* in the residential area indicates that this species prefer to inhabit open, non-forested area. This observation also coincides with the findings of Alcala and Brown (1998).

Anuran Species Similarity of the Three Different Habitat Types (Riparian, Agricultural, Residential)

Jaccard similarity index revealed that station 1 and 3, station 2 & 3 shows that it has a low similarity index of 20% because only one species of frog are similar to both area. Compared to stations 1 and 2 the similarity index is 60% due to three similar species to both areas as shown in table 5.

Table 4. Relative Abundance of Anuran Species in three different habitat types along the river of Barangay Mananum Bag-o, Medina, Misamis Oriental.

Species Name	Relative Abundance (%)			Total
	Riparian	Agricultural	Residential	
H. signata	34.0	38.7	-	29.6
L. leytensis	6.0	-	-	2.7
O. laevis	-	5.9	-	2.1
P. leucomystax	6.7	5.1	-	4.9
R. magna	53.3	50.4	64.4	54.3
R. marina	-	-	35.6	6.4
TOTAL	100	100	100	100

Table 5. Similarity Index of Anuran Species of the three Different Habitat Types.

Sampling Sites	# of Common Species	# of Species 1&11	Similarity Index
Station 1	3	4	60%
Station 2		4	
Station 2	1	4	20%
Station 3		2	
Station 1	1	4	20%
Station 3		2	

Canonical Correspondence Analysis (CCA) and One-Way ANOVA

In the Canonical Correspondence Analysis, environmental variables were used to determine the species-habitat relationships. Fig. 7 showed that there are three types of habitat in the study area.

The region located at the right side of the central axis represents *rocky area* as evidenced by Rock Cover (RC). The region located at the upper left side of the central axis represents *shrub land* as evidenced by high percentage of shrubs (SHR). While on the lower left side of the central axis represents *forested area* as evidenced of Canopy cover (CC), relative humidity

(RH), and Elevation (m). Fig. 8 shows the position of 6 anuran species associated in three habitat types. A group of species that are positioned at the right side of the axis were Rhma (*R. marina)* and Rama (*R. magna*). While in the upper left of the central axis, Ocla (*O. laevis*) and Hysi (*H. signata)* were observed. In the lower left side of the central axis Pole (*P. leucomystax*) and Lile (*L. leytensis*) were observed.

In Fig. 9, it is evident that there are three habitat types in the river namely: rocky area, forested area and shrub type area. On the right side of the central axis, it was characterized as rocky area where two species were collected namely; *Rhma (R. marina)* and *Rama (R. magna)*. The fairly common *R. marina* is a solitary species, but it may congregate during the breeding season when males call together for female attraction, courtship, and egg-laying in temporary water bodies (Savage, 2002). Thus, this observation is showing an uncommon and probably extreme behavior to survive severe periods of dryness and to avoid water loss. It is possible that the success of this species during colonization, and in turn, becoming an invasive species worldwide is due to this kind of adaptation (Urban *et al.*, 2008; Kearney *et al.*, 2008). *R. magna* breeds the year round, depositing eggs on moist or moss-covered rocks a few inches above water. Tadpoles are found in pools of mountain streams and metamorphose in about 150 days from egg-laying (Alcala and Brown 1998). By some factors like run-offs, and heavy rains, tadpoles are being distributed in the other part of the streams where the existence of *R. magna* takes in. Both species (*R. marina and R. magna)* was found in residential area.

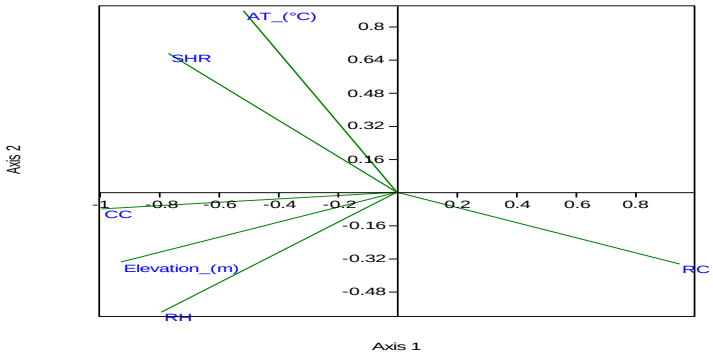

Fig. 7. Ordination of habitat vectors of anuran species. The following are codes for the six environmental variables: AT_(C)- air temperature, Elevation_(m)- Elevation, RH- relative humidity, CC- canopy cover, SHR- Percentage of Shrubs and RC- Rock Cover.

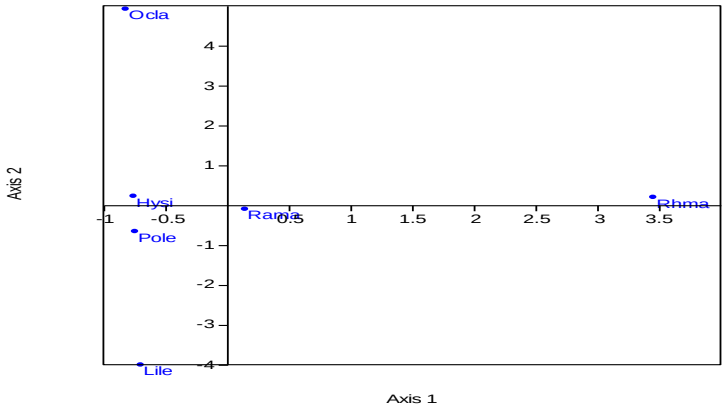

Fig. 8. The species ordination plot of the six anuran species. Species were coded as follows: *Hysl- H. signata; Lile- L.leytensis; Ocla- O. laevis; Pole- P.leucomystax; Rama- R. magna; Rhma- R. marina.*

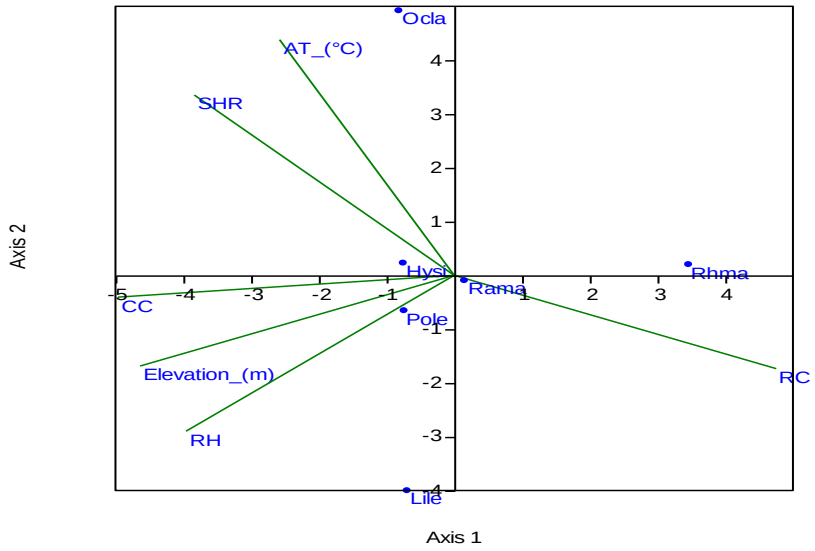

Fig. 9. Superimposition of the habitat parameter vectors and centroids of anuran species.

In the upper left side of the central axis it was characterized as a shrub type area associated with percentage of shrubs found in the area where *Ocla (O. laevis)* was found. *O. laevis* can be found in forest, open areas, and areas near human habitation. This species was adapted to a variety of microhabitats, from polluted puddles in areas of human habitation to pools of clear mountain streams (Alcala and Brown 1998). This species was found in the agricultural area or near residential area.

The forested area was associated with environmental variables influences by Canopy cover and Elevation and was located at the lower left side of the central axis. The species found in the area were *H. signata*, *Rama (R. magna, Pole (P. leucomystax)* and *Lile (L. leytensis)*. *H. signata* inhabits mountain streams and have been observed in water or on rocks in close proximity to water (Alcala and Brown 1998), *P. leucomystax* occupies a wide variety of microhabitat ranging from open areas near human habitations to forests (Alcala and Brown 1998) and *L. leytensis* can be found in the swampy areas or near dried swampy area of mixed lowland dipterocarp (Nuňeza, 2012). These species can be found in forested or riparian area.

One-Way ANOVA Analysis with regards to its environmental variables (Air Temperature, Relative Humidity, Canopy Cover, Rock Cover, Shrub Percentage and Elevation)

Statistical analysis with One-way ANOVA, at 5% level of significance showed that in terms of air temperature, relative humidity and canopy cover the three habitat types almost have similar values ($p>0.05$). While rock cover, shrub percentage and elevation showed that there is significant differences in the three habitats ($p<0.05$). Adult amphibians are often associated with rocky stream beds and drainage channels in well drained rocky soils and due to rock covered area, there is a least amount of moisture content and high amount of air temperature that is not conducive for the survival of anuran species. Anuran species deposits eggs to areas with substantial vegetation. Amphibian species have morphological changes with elevation, but these changes vary greatly between species and the higher the elevation, the less disturbance occur.

Threats of Anuran Species

There are several factors which threaten the survival of anuran species in the three habitat areas (Fig.10).

A. Anthropogenic Factors

A.1 Harvesting of Edible Frogs- Overharvesting of edible frogs in the area (Fig.10a) can threaten the existence of this species due to the fact that it can

decline the number of species and can alter this species as a bio-indicator for environmental health. A.2 Land Conversion- The conversion of riparian area to agricultural area and residential area (Fig. 10b) are one of the factors that threatens the anuran species. By converting the forest to croplands and construction of houses, the natural habitat of frog species was disturbed and may cause for their migration.

A. 3 Lack of Awareness of the Residence about the Importance of Frogs- Without exact knowledge on how important the anuran species in nutrient cycling and as a bio-indicator of environmental health, the residents in the area don't give importance to this frog species. If the residents will continue to ignore this phenomenon, the harvesting of edible frog species and destruction of their natural habitat will continue and can threaten their survival and distribution.

Fig. 10. Shows some possible threats of anuran species along the River of Barangay Mananum, Bag-o Medina, Misamis Oriental. (Legend: A= Harvesting of Edible frogs, B= Land Conversion).

B. Natural Factors

B.1 Grass fire- A natural phenomenon that is observed in the area which is due to extreme temperature and the absence of shaded area that threatens the diversity of anuran species. The effect of grass fire have negative consequences on frog species, it includes direct mortality, loss of suitable habitat, and food source deficiency.

B.2 Flood-The natural occurrence of heavy rain is one of a factor of flooding. The extreme flood that flows through the streams can cause depletion of frog species especially for their eggs and tadpoles. The heavy currents of water will also washout the habitats of frogs.

Conclusion

The study revealed that the areas along the River of Barangay Mananum, Bag-o Medina, Misamis Oriental were composed of six species of anurans. Riparian area is more diverse compared to the other two areas. CCA significant habitat association of anurans with environmental variables namely: elevation, percentage of shrubs and rock cover. Anthropogenic and natural factors had also influenced the differences between anuran diversity. This study would like to recommend implementation of laws regarding protection of anuran species especially in the areas wherein it has low diversity to prevent further reduction of anuran population and to conserve it for the future generation.

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