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Inventory and Morphometrics of Anuran Species Found in Mt. Kilala of the Mt. Hamiguitan Range Wildlife Sanctuary, Governor Generoso, Davao Oriental, Philippines

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Mt. Kilala is part of Mt Hamiguitan Range Wildlife Sanctuary located in Governor Generoso, Davao Oriental, Philippines, which hosts diverse and endemic species of flora and fauna – including amphibians. This inventory of anuran species yielded eight species of anurans that belong to six families. The highest species richness recorded was D=1.010 and species diversity was *H'*=1.73, which was moderately high, with 48 individual captures recorded in Site 1 (198 masl). The other two sites only yielded two captures in total despite spending 54 person-hours in search of anurans. The most number of anuran species encountered preferred the aquatic microhabitat. Also, the body size of anurans was a better predictor than its weight for the type of habitat it will occupy. The study recorded one Southeast Asia endemic species, two Philippine endemic species, and four Mindanao island endemic species. Most of these species found were located in the aquatic microhabitat that favors reproduction and development. The differences in their relative abundance are a reflection of the species tolerance limits to their habitats. Included in the inventory of species are *Megophrys stejnegeri* (Taylor, 1920) and *Limnonectes magnus* (Stejneger, 1909), which were identified as Mindanao island endemic with vulnerable conservation status in the IUCN red list. The advertised calls of various anurans were from four different species, namely: *Kalophrynus sinensis* (Peters, 1867), *Limnonectes leytensis* (Boettger, 1893), *Polypedates leucomystax* (Gravenhorst, 1829), and *Staurois natator* (Günther, 1859). Specific call parameters make the vocalization of each species unique. This study, along with other literature, confirms that higher elevation sites harbor fewer anuran species. The occurrence of a high number of endemic and vulnerable anuran species in the area indicates the need for practical conservation and protection measures, which include zoning for access and no access parts in the buffer zone – especially those that harbor aquatic habitats.

Key words: anurans, biodiversity, Davao Oriental, Governor Generoso, morphometrics, Mt. Kilala

INTRODUCTION

Anurans are considered as one of the most diverse and threatened taxa in the tropical ecosystem. The Philippine anuran fauna consist mostly of the orders Anura and Gymnophiona with the exclusion of Caudata. At present, there are approximately 110 species of anurans in 23 genera of eight families of anurans in the Philippines (Brown *et al*. 2012). Anurans are considered indicator species in the ecosystem (Plaza & Sanguila 2015, Verdade *et al*. 2010) because they possess highly permeable skin that is

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sensitive to environmental stressors such as sudden change in temperature and toxic chemicals (Gonzalez *et al*. 2004). The population status of anurans is an important indicator of health status of the forest ecosystem as these amphibians are sensitive to environmental change. Moreover, anurans play a vital role in the trophic food chain by serving as prey for predators and food for humans (Cortés-Gomez *et al*. 2015, Hocking & Babbitt 2014). They are ecologically important as they reduce the population of disease carrying insects such as flies and mosquitoes, thus protecting humans from potential diseases. They also have vital functions in nutrient cycling through waste excretion, direct and indirect pollination, and seed dispersal (Cortés-Gomez *et al*. 2015, Hocking & Babbitt 2014). The anuran acoustic communication is also widely considered as an important character for species identification and as a valuable tool for studying the ecology and distribution of anurans (Roy & Elepfandt 1993). The acoustic communication signals among anurans vary and this variability conveys a significant meaning that is species-specific and highly stereotyped. For this reason, the structure and functions of the signals have importance in areas such as in sexual selection, speciation, and reproductive isolation. Male and female anurans facilitate communication signals. Usually, only the male anurans give an advertisement call while the female anuran calls are suppressed during the mating. The female call functions are mainly for locating males, coordinating elaborate courtship, and essential in other physiological functions (Emerson & Boyd 1999, Kelley 2004). The recent threats to anurans include destruction of their natural habitats, pollution from mine tailings, pesticide and herbicide run-offs, introduction of alien invasive species, climate change, increase of ultraviolet radiation, and epidemics (Ascano *et al*. 2015, Gonzalez *et al*. 2004, Verdade *et al*. 2010). The Philippine archipelago is home to various amphibians and recognized in Southeast Asia as one of the important centers of herpetofaunal diversity (Brown *et al*. 2013). In Davao Oriental, the Mt. Hamiguitan Range Wildlife Sanctuary is a mountain range formed along the Pujada peninsula, and straddles the municipalities of San Isidro, Governor Generoso, and Mati City. Mt. Hamiguitan has a peak elevation of 1650 m above sea level. Anurans from this mountain are mostly accounted from sites within the area of San Isidro and Mati City but not in Governor Generoso (Ates & Delima 2008, Relox *et al*. 2010). The primary goal of this study was to conduct an inventory of the anurans present in Mt. Kilala of the Mt. Hamiguitan Range Wildlife Sanctuary, which can be useful for further biodiversity studies. The other objectives include recording the note calls of anuran species to characterize and associate the various calls, measure their various morphometric data, examine their relationship with anuran body weight, and relate these data to microhabitats. The field data collection was conducted in the three sites with sampling duration of 6 d.

MATERIALS AND METHODS

Description of the Study Sites

The study was conducted for 6 d on May 2017 in Mt. Kilala of the Mt. Hamiguitan Range Wildlife Sanctuary, Barangay Upper Tibanban, Governor Generoso, Davao Oriental, Philippines (Figure 1). Sampling happened in May, although the permit to work was granted around Mar 2017 because March and April were much hotter months to do the work in the area while June and July are rainy and therefore difficult months for work conduct and mountain climbing. Mt. Kilala has a peak elevation of 676 m above sea level and is considered a significant site because of its established Almaciga Ecology Park. This mountain is characterized by chromite mineral deposits where mining and logging took place in the past. The area is covered by an agroecosystem and dipterocarp forests where the three sites of the study were located (see Figure 2A). Random diurnal and nocturnal search for anurans were conducted during the fieldwork for 6 d. There were two three-day periods (5–7 May 2017 and 12–14 May 2017) when the fieldwork was conducted to give sufficient man-hours of sampling and to locate the anuran species in the area. The coordinates of the three sites were recorded using a GPS device (Garmin Ltd., American Multinational Technology, Lenexa, Kansas City, USA). Habitat description of each study site was based on the assessment of Haribon Foundation Inc. Site 1 (Figure 2A) is an agroecosystem of almaciga (*Agathis dammara*) plantation located at 198 m above sea level with coordinates of 06.60259°N and 126.13718°E. The site was characterized by a nearby flowing stream, large and small trees, and nearby coconut and banana plantations. The stream was slow moving with prominent logs and huge boulders found in the area. Leaf litter was rarely present (2 mm thick). Site 2 has a secondary dipterocarp forest located at 427 m above sea level with coordinates of 06.36369°N and 126.07593°E. The site was characterized by vegetation of small and short stature trees, ferns, and shrubs, with few leaf litter cover on the ground (2 mm thick); exposed rocks were abundant and about 2–3 km away from a stream. Plant species present in the area include pitcher plants, *tambiling*, and almaciga trees. Site 3 has primary dipterocarp forest cover located at 676 m above sea level with coordinates of 06.61129°N and 126.13976°E. The site was located at the peak of Mt. Kilala between Barangay Upper Tibanban and Tandang Sora. Mosses are present in the area and covered fallen logs, trunks of trees, and rocks. Plantations such as ferns, cidar, pine trees, rattan, and almaciga trees were also dominant in the site. Leaf litter was about 2.5 cm thick above the ground.

Sampling Protocol

The anurans were sampled using the cruising method (Calo & Nuñeza 2015), which was performed through a randomized walk that was done in each study site.

It employed man-hour of search during day and night time during the three-day field sampling. Field transect surveys are more efficient to provide greater records of species richness compared to using pitfall traps or funnel traps for amphibians (Sung *et al*. 2011). The man-hour of sampling spent a total of 72 h, with 18 h spent in Site 1 (found 48 captures; see Table 1 and Figure 2B), 20 h in Site 2 (no captures), and 34 h spent in Site 3 (found 2 captures). More time was devoted to Site 3 compared to the other two sites during the field activity, but it also yielded only two anurans. All searches relied on sight and call to locate the various anuran species. The following morphometrics were recorded (all in mm) using a Vernier caliper: snout-vent length (SVL, from snout tip to posterior

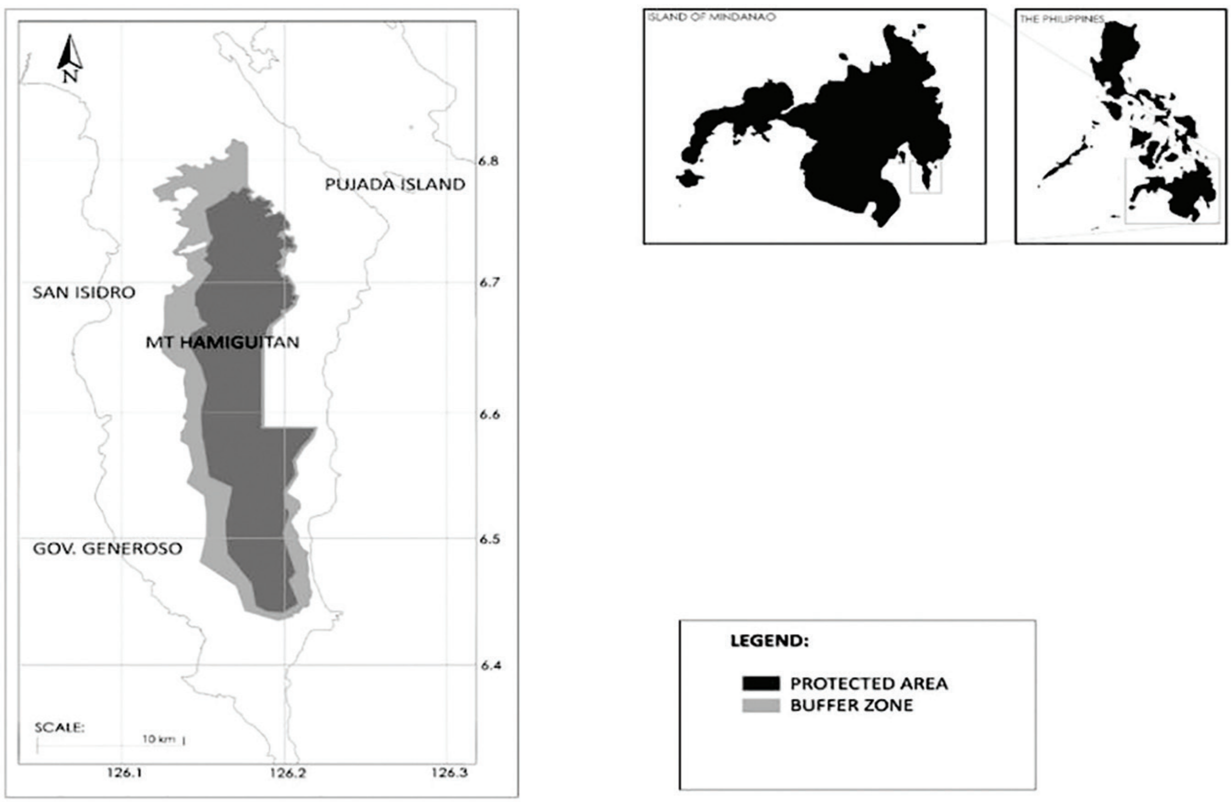

Figure 1. Map showing the study area located in the protected zone of Mt. Hamiguitan Wildlife Sanctuary, Governor Generoso, Davao Oriental, Philippines.

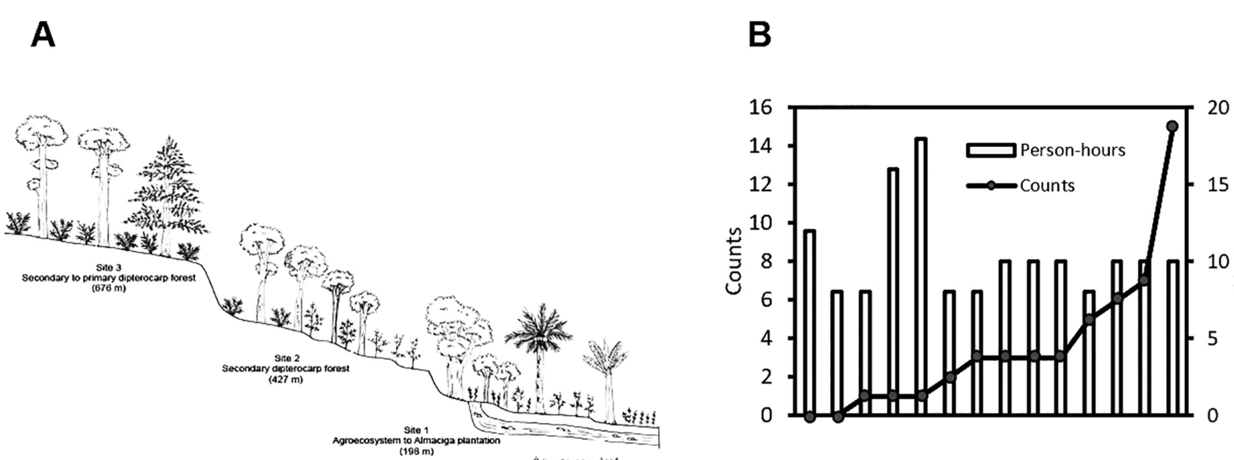

Figure 2. Diagram of the three study sites in Mt. Kilala (A) and the person-hours spent to search for anurans (B) in Governor Generoso, Davao Oriental, Philippines.

Table 1. Species composition of anurans in Mt. Kilala of the Mt. Hamiguitan Range Wildlife Sanctuary, Governor Generoso, Davao Oriental, Philippines.

Family	Scientific Name	Common Name	Activity[1]	Sites		
				1	2	3
Bufonidae	*Rhinella marina* (Linnaeus, 1758)	Cane toad	D	11		
Dicroglossidae	*Limnonectes leytensis* (Boettger, 1893)	The swamp frog	N	7		
Dicroglossidae	*Limnonectes magnus* (Stejneger, 1909)	Mindanao fanged frog	N	5		
Megophryidae	*Megophrys stejnegeri* (Taylor, 1920)	Mindanao horned frog	D, N			2
Microhylidae	*Kalophrynus sinensis* (Peters, 1867)	Philippine sticky frog	D	3		
Ranidae	*Pulchrana grandocula* (Taylor, 1920)	Big-eyed frog	N	1		
Ranidae	*Staurois natator* (Günther, 1859)	Rock frog	D	15		
Rhacophoridae	*Polypedates leucomystax* (Gravenhorst, 1829)	Fourlined tree frog	N	6		
		Total captures		48	0	2

[1]Activity (24 h): D= diurnal, N=nocturnal

margin of vent); head length (HL, from tip of snout to posterior margin of jaw articulation); eye diameter (ED); and eye-tympanum distance (ETD, from posterior margin of eye to anterior margin of tympanum). Body weights (BW) were measured using a weighing scale in grams (g) and morphological description was based on species account guidelines (AmphibiaWeb 2011). The samples were referred to Philippine amphibians an illustrated field guide by Alcala and Brown (1998), and amphibians of the Philippines, Part I: Checklist of the Species by Diesmos *et al*. (2015) for identification. Species richness was calculated using the Menhinick's index and biodiversity was computed using the Shannon-Wiener's index.

Microhabitat Classification

Classification of the microhabitat was referred based on categories made by Ates and Delima (2008) as follows:

- Type I – Arboreal microhabitats referring to those elevated from the ground (5–10 m) including branches and stems of plants, leaves, and leaf axils.
- Type II – Ground microhabitat refer directly to microhabitats on the ground (0–5 m) such as crevices, cracks on trees or rotting logs, and tree buttresses.
- Type III – Aquatic microhabitats include streams, rivers, and creeks as well as standing bodies of water.

Conservation Status

Identified species of anurans were classified as endangered (EN), critically endangered (CR), vulnerable (VU), data deficient (DD), and least concern (LC) according to the International Union for Conservation of Nature Red list categories (IUCN 2016). The various ecological statuses of anurans in this study are the following: Philippine endemic, Mindanao endemic, Mindanao island endemic, and Southeast Asian endemic.

Data Analysis

Multiple linear regression analysis was used to examine which of the morphometric data (SVL, HL, ED, ETD) best predict the BW of the anuran species. A binary logistic regression analysis was carried out to evaluate whether there was any relationship of the various anuran habitat types (arboreal, ground, and aquatic) and the body size (snout-vent) and weight (BW). All the measurement data was first explored using descriptives and tested for normality using graphical means [probability plots (PP plots) and box plots] and Levene's test. The assumptions for linear regression are homoscedasticity of data, normal distribution, and independence of data. When normality was violated, the data was transformed and then tested again for normality. When the assumption for normal distribution was still violated after data was transformed, the analysis was still done; hence, the statistics must be interpreted with caution. As the data per species was unequal and many are low, the data was analyzed in terms of categories or factors such as which morphometric data best predicts BW or which habitat is best predicted by the given weight. A sample size of 50–70 cases are required for predictors in a linear regression for meaningful interpretation (Field 2005). The calculation of descriptives preceded the analyses. The method used for the multiple linear regression was forward step-wise, and the simplest terms for the model that was significant was included as predictor in the model. For the evaluation of BW and body size *i.e.*, which of these best predicts what habitat type, a simple binary logistic regression was used. Although there were three microhabitat types found – above the ground (n=5), on the ground (n=9), and aquatic (n=36) – logistic regression requires at least 10 samples for one of the categorical dependent variables so the habitat type was coded as either aquatic or non-aquatic in the logistic regression (0=non-aquatic; 1=aquatic); all arboreal and ground dwelling anurans were pooled as one. The independent variables are body size and BW since the other predictors are very much correlated like ED and ETD or HL. In a logistic regression, the assumptions do not have to satisfy the same assumptions followed in linear regression (see also application in Macusi *et al*. 2017). All analyses were done using SPSS (SPSS Statistics for Windows, version 21.0. Armonk, NY: IBM Corp).

RESULTS

Species Abundance and Composition

In Site 1, *Staurois natator* (Günther, 1859) was found to be most abundant (31%), followed by *Rhinella marina* (Linnaeus, 1758) (23%) and *Pulchrana grandocula* (Taylor, 1920) (2%) – the least abundant of all the species captured. In Site 2, no species were found as this was located along a disturbed patch near a mountain trail. Also, *Megophrys stejnegeri* (Taylor, 1920) (100%) was the only species found in Site 3 (Table 1).

The study also documented eight species belonging to six families of anurans found at the different study sites. Table 1 shows the species abundance and composition of anurans found in the three study sites. Anurans were found in all study sites except in Site 2, occurring in Site 1 with 48 captures and followed by Site 3 with two captures. Among the three sites, only Site 1 showed the highest value of species composition comprised of seven species in the area, followed by Site 3 with one species and finally Site 2 with no species found. Menhinicks' index showed *D*=1.010 species richness in Site 1, *D*=0 in Site 2, and and *D*= 0.7071 in Site 3. The anuran species *Megophrys stejnegeri* (Taylor, 1920) was observed during the fieldwork to blend in color with the leaf litter, hence possibly explaining the low individual captures.

Four species were identified as nocturnal species since they were encountered only during the night. These anuran species were: *Limnonectes magnus* (Stejneger, 1909)*, Limnonectes leytensis* (Boettger, 1893), *Pulchrana grandocula* (Taylor, 1920), *and Polypedates leucomystax* (Gravenhorst, 1829). Also, three other species of anurans – *Rhinella marina* (Linnaeus, 1758)*, Kalophrynus sinensis* (Peters, 1867), *and Staurois natator* (Günther, 1859) – were identified as diurnal species because they were mostly encountered during daytime sampling. However, the individuals of *M. stejnegeri* (Taylor, 1920) were identified as both nocturnal and diurnal species. The biodiversity of anuran species in the study area shows that Site 1 had moderate species diversity (*H'*=1.73) while the other two sites have zero species diversity because of the low capture in the other two sites. The discrepancy in relative abundance of anurans found in Site 1 could have been more related to the presence of favorable microhabitats and presence of stream of low current in the area as opposed to those found in Sites 2 and 3.

Description of Species Captured

Rhinella marina (Linnaeus, 1758) (Figure 3A) or the cane toad is a true toad that was characterized by projected warts. It has a robust body with large belly and skin in the dorsum and is entirely rough. It has a broad large head with pointed snout. The tips of its fingers and toes are rounded. Its fingers have basal webbing while the toes are half-webbed.

Kalophrynus sinensis (Peters, 1867) (Figure 3B) or the black spotted narrow-mouthed anuran is a medium sized anuran with narrow-head and pointed snout. Body color is reddish to brown with distinct black spot above its hind limb. The fingers also have basal webbing while the toes are half-webbed.

Limnonectes leytensis (Boettger, 1893) (Figure 3C) or the swamp anuran is a medium-sized anuran with distinct tympanum. It has a narrow head with rounded and pointed snout; the hind limbs are long with finger tips that are slender and rounded. The webbing on fingers is basal while the toes are half-webbed.

Limnonectes magnus (Stejneger, 1909) (Figure 3D) or the Mindanao fanged anuran has a robust body having 55 mm snout vent length. It has morphological characteristics such as broad head and pointed snout. The skin of the dorsum is rough, and rarely smooth while the eyes are large having completely visible tympanum. It has long, robust limbs with expanded digits. The fingers have basal webs while the toes are ¾ webbed.

Megophrys stejnegeri (Taylor, 1920) (Figure 3E) or the Mindanao horned anuran is a small to medium-sized anuran. It has a broad head with truncated snout; the fingers and toe tips are rounded with basal webbing. These species have scattered wart-like projections and have pointed protrusion of skin above the eyes known as the horn.

Polypedates leucomystax (Gravenhorst, 1829) (Figure 3F) is a small- to medium-sized common tree anuran with slender and flattened body. This species has round pointed snout and large tympanum. Its fingers have basal webs and the toes are ¾ webbed. Its dorsal body color is brown to golden brown with longitudinal stripes.

Figure 3. Representative species of captured anurans in Mt. Kilala of the Mt. Hamiguitan Range Wildlife Sanctuary, Governor Generoso, Davao Oriental, Philippines. The various species are: *Rhinella marina* (A), *Kalophrynus sinensis* (B), *Limnonectes leytensis* (C), *Limnonectes magnus* (D), *Megophrys stejnegeri* (E), *Polypedates leucomystax* (F), *Pulchrana grandocula* (G), and *Staurois natator* (H).

Pulchrana grandocula (Taylor, 1920) (Figure 3G) is a species belonging to the Ranidae family. It has a medium-sized body with large tympanum and eyes. The head is narrow and its snout is pointed. Its body color is yellow to moderate green and the dorsal skin is smooth with slight visible patches.

Staurois natator (Günther, 1859) (Figure 3H) or the rock anuran is a small- to moderate-sized anuran. This species has pointed snout with slender and flattened body shape. Limbs are long with rounded and expanded toe tips. Its tympanum is distinct with fully-webbed toes. Dorsal body color is dark green to black with scattered spots.

Bioacoustics Inventory

Among the eight-species found, only four species had been recorded in the field. Table 2 shows the call parameters recorded as the number of calls per species, call duration, call period, intercall, note number, note duration, internote, and dominant frequency. For the various sample calls that were recorded, *K. sinensis* (Peters, 1867) produced 13 calls in 5 min. Call duration lasted approximately 6 s, while call period and intercall are 19s and 11s, respectively. The note duration was about 0.1 s and the interval between notes was 0.5 s. The dominant frequency was 9250 Hz (see Table 2 for the various call notes and frequency). The call of *K. sinensis* (Peters, 1867) sounds to the human ear as "rawk…rawk….rawk." The ambient temperature recorded was 25.5 °C. The call duration of *L. leytensis* (Boettger, 1893) approximately lasted up to 6 s while the call period and intercall lasted 17.9 s and 9.9 s, respectively. Duration of each note lasted for 0.04 s having a dominant frequency of 14063 Hz. The call *of L. leytensis* (Boettger, 1893) was perceived as "tik…tik….tik" and because of this strange call, local folks termed this species as *tik-tik*. Notes of individual calls vary in interval, the first note with longer time interval compared to the next. The *S. natator* (Günther, 1859) call was perceived in the human

Table 2. Call parameters of selected anurans found in Mt. Kilala of the Mt. Hamiguitan Range Wildlife Sanctuary, Governor Generoso, Davao Oriental, Philippines.

Species	Call				Note			Frequency
	Number	Duration (s)	Period (s)	Intercall (s)	Number	Duration (s)	Internote (s)	Dominant (Hz)
Kalophrynus sinensis (Peters, 1867)	13	6	19	11	9	0.1	0.5	9250
Limnonectes leytensis (Boettger, 1893)	16	6	17.9	9.9	7	0.04	2	14063
Staurois natator (Günther, 1859)	9	19	27.2	14.7	9	0.13	1.22	2579
Polypedates leucomystax (Gravenhorst, 1829)	38	0.15	7.4	4.8	38	0.15	4.8	4938

ear as "wret…wret..wret." It has call duration of 19 s, while its call period and intercall lasted 27.2 s and 14.7 s, respectively. The note duration was about 0.13 s. The interval among notes varies measuring for about 1.22 s. Dominant frequency of the call is 2579 Hz and with 25 °C recorded ambient temperature. The call of *P. leucomystax* (Gravenhorst, 1829) exhibit distinguishing characteristics among the recorded calls. Thus, each call it produced consist of a single note. It sounds like "kwek… kwek... kwek" when perceived by the human ear. Interval between notes varies but each note almost has the same duration of 0.15 s. It has a dominant frequency of 4938 Hz and the recorded ambient temperature was 26 °C.

Microhabitat and Morphometrics

The results on the microhabitat classification and the morphometrics of the various anuran species encountered are shown in Table 3. There were three types of anuran microhabitats that were characterized by Ates and Delima (2008) (see Table 3). Species thriving directly on the ground (0–5 m) or on rotting logs and tree buttresses were classified as type II microhabitat dwelling species. Among the eight species of anurans, one ground dweller species thrived solely in type II microhabitat – *M. stejnegeri* (Taylor, 1920). Others found in the study area include *L. magnus* (Stejneger, 1909), *R. marina* (Linnaeus, 1758), and *P. grandocula* (Taylor, 1920). In this study, *S. natator* (Günther, 1859) was observed in type I and III microhabitats. Besides, species that occupy type II and III microhabitats includes *K. sinensis* (Peters, 1867) and *L. leytensis* (Boettger, 1893). Moreover, individuals of *P. leucomystax* (Gravenhorst, 1829) were found in three microhabitat types classified as arboreal, ground, and aquatic microhabitat. Two species do not have visible ETD (*K. sinensis* and *M. stejnegeri*). The three largest sample of anurans are mostly *R. marina* (SVL=77.55 mm; BW=85.45 g) followed by *L. magnus* (SVL=58.20 mm; BW=28 g) and *M. stejnegeri* (SVL=55 mm; BW=25 g), while the smallest was *S. natator* (SVL=32.27 mm; BW=6 g) (see Table 3).

For the result of the multiple linear regression of the morphometrics, the final model was highly significant (SS=0.133, df=2, MS=0.067, F=501.76, P=0.000; R^2=0.95) only HL and SVL were significant among the four included independent variables [model constant was B=–1.97 (SE=0.103), t-stat=–19.268, P=0.000; HL was B=1.513 (SE=0.301), t-stat=5.030, P=0.000; SVL was B=1.140 (SE=0.307), t-stat=3.709, P=0.000]. The collinearity between HL and SVL was however high at almost 1 and the VIF was high at 13.38 or near 14, showing collinearity between the two variables.

The result of the logistic regression on whether BW or size will influence what habitat type the frog will be found showed that, at step 1 of the regression, BW was not significant [B=0.047 (SE=0.027), Wald=3.101, df=1, P=0.078] while body size was significant at step 2 of the regression [B=-0.173 SE(0.084),Wald=4.26, df=1, P=0.039; and the constant term was the same [B=5.46 (SE=2.53), Wald=4.64, df=1,P=0.031]. The equation shows that for BW, this would have ability to correctly classify anurans in their habitats to be 72% while including both BW and body size can correctly classify them to their habitats at 80%. The overall statistics in the variables not in the equation show a chi-square statistic of 4.84 and significant (df=1; P=0.027).

Overall, this study documented four species as Mindanao Island Endemic (50%) and two Philippine endemic species (25%), one species as Southeast Asian endemic (12%), and one introduced species (13%) (Figure 4).

Table 3. Microhabitats of various anuran species found in Mt. Kilala, Governor Generoso, Davao Oriental, Philippines and their average morphometrics. (Habitat types: I=arboreal, II=ground, III=aquatic; SVL=snout-vent length; HL=head length; ED=eye diameter distance; ETD=eye tympanum distance; BW=body weight).

Species	Microhabitat			Morphometrics (mm)				
	I	II	III	SVL	HL	ED	ETD	BW (g)
Kalophrynus sinensis (Peters, 1867)		+	+	40.67	12.67	4.67	Not visible	13.33
Limnonectes leytensis (Stejneger, 1909)		+	+	42.14	13.00	5.00	3.71	10.00
Limnonectes magnus (Stejneger, 1909)			+	58.20	19.00	7.60	3.80	28.00
Megophrys stejnegeri (Taylor, 1920)		+		55.00	20.50	6.00	Not visible	25.00
Polypedates leucomystax (Gravenhorst, 1829)	+	+	+	41.00	12.00	6.00	3.00	10.00
Pulchrana grandocula (Taylor, 1920)			+	47.00	15.33	5.67	3.00	10.00
Rhinella marina (Linnaeus, 1758)			+	77.55	30.91	9.09	3.64	85.45
Staurois natator (Günther, 1859)	+		+	32.27	11.47	5.00	3.00	6.00

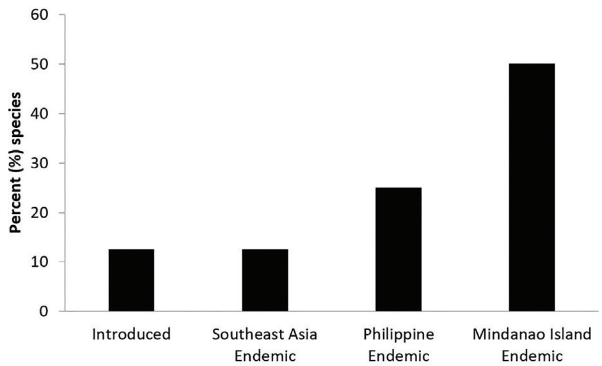

Figure 4. Conservation status of various anuran species found in Mt. Kilala of the Mt. Hamiguitan Range Wildlife Sanctuary, Governor Generoso, Davao Oriental, Philippines.

M. stejnegeri (Taylor, 1920), *L. magnus* (Stejneger, 1909), *P. grandocula* (Taylor, 1920), and *S. natator* (Günther, 1859) are considered Mindanao island endemic species. Meanwhile, *L. leytensis* (Boettger, 1893) *and P. leucomystax* (Gravenhorst, 1829) are Philippine endemic species. Lastly, *K. sinensis* (Peters, 1867) is the lone Southeast Asian endemic species. Further, the highly invasive, non-endemic *R. marina* (Linnaeus, 1758) was also observed. There were six species encountered, namely: *R. marina* (Linnaeus, 1758), *K. sinensis* (Peters, 1867), *P. leucomystax* (Gravenhorst, 1829), *S. natator* (Günther, 1859), *L. leytensis* (Boettger, 1893), and *P. grandocula* (Taylor, 1920) and categorized as least concern (75%) among all the species. Meanwhile, two were identified as vulnerable (25%): *M. stejnegeri* (Taylor, 1920) and *L. magnus* (Stejneger, 1909).

DISCUSSION

Found in Site 1 of this study were eight (8) species of anurans that belong to six (6) families. The area was mainly agricultural, having both timber and almaciga plantations and various aquatic habitats that are favorable for anuran reproduction and development. The other two sites (found at higher elevations) confirm the observation that as the sampling elevation increases, amphibian richness tend to decrease (Relox *et al*. 2010). Possible reasons for the lack of anurans captured in Site 2 could be due to missed encounters, geographic location, unsuitable habitat type, and the dry weather during the sampling (May) in the area. It is possible that the differences in the relative abundance of the species are due to their range of tolerances for the various habitats in the area (Calo & Nuñeza 2015). Moreover, the availability of water or stream in the area could have favored the higher abundance of anurans, which was critical for their survival and reproduction (Ates & Delima 2008, Supsup *et al.* 2016). In Site 3, where secondary to primary dipterocarp forest cover is located, its higher elevation could have played a significant role in limiting the distribution of anurans to the site (Calo & Nuñeza 2015). Further, the results have shown that various anuran species can occupy multiple microhabitats. In this study, HL and SVL of the anuran best predict its BW, while body size is a better predictor for the type of microhabitat it will occupy. The sample size was limited owing to the limited number of captures in the two other sites; however, body size could be more related to the type of habitat than the BW simply because the latter is dependent on food availability. Some of the captured anurans may not have fed for a time, but this could only be confirmed with gut analysis which was not done. Microhabitats presumably are refuge sites for some species to survive (Ates & Delima 2008, Plaza & Sanguila 2015). The inhospitable dry conditions due to temperature fluctuation during the sampling period may have caused desiccation to the anuran skin and this affected their reproduction which could kill all deposited eggs in some dried-up bodies of water (Alcala *et al*. 2012; Verdade *et al*. 2010). Overall, human interventions such as land use change and expanding croplands, timber harvest, and mining areas can alter habitat conditions for anurans, severely threatening their population abundance (Ascano *et al*. 2015, Bain *et al*. 2008, Calo & Nuñeza 2015, Verdade *et al*. 2010). The previous record of *Staurois natator* (Günther, 1859) in Mindanao included surveys in Mt. Sinaka and Mt. Apo (Ates & Delima 2008). The highly invasive *Rhinella marina* (Linnaeus, 1758) has been considered as non-endemic but it is widely distributed throughout the various regions of the Philippines (Diesmos *et al*. 2015). With reference to the IUCN Red list (2016), *M. stejnegeri* (Taylor, 1920), and *L. magnus* (Stejneger, 1909) are considered to be vulnerable species because their distribution was severely fragmented and continue to decline because of forest destruction (IUCN 2016). Also, the species *L. magnus* (Stejneger, 1909) was considered as near threatened in the recent survey of Sanguila *et al*. (2016) because this species was significantly declining due to widespread habitat loss and hunting for food. Categorized as least concern among the species found are *R. marina* (Linnaeus, 1758), *K. sinensis* (Peters, 1867), *P. leucomystax* (Gravenhorst, 1829), *S. natator* (Günther, 1859), *L. leytensis* (Boettger, 1893), and *P. grandocula* (Taylor, 1920), which all persist well in disturbed habitats and are ubiquitous in agriculture areas (Sanguila *et al*. 2016). The documented presence of the four Mindanao island endemic species during the survey and the moderately high biodiversity of anurans in the area points to a relatively pristine environment (Plaza & Sanguila 2015). Moreover, the call of anurans are significant because they can be distinguished in terms of their advertisement calls, though sometimes they also share common morphological features (Brown *et al*. 1999). In fact, herpetologists began to focus on bioacoustics characters with complementary applied molecular techniques to solve problem of species boundaries. In terms of threat related to climate change, Narins and Meenderink (2014) found significant changes in the advertisement calls of anurans – there was increase in pitch and shortening of their duration. Hence, long-term changes in temperature might impact the signal production and perception of anurans leading to mismatch between the call sender and receiver (Humfeld & Grunert 2015). The relatively large number of endemic and vulnerable anuran species found in the area indicates the need for practical conservation and protection measures that need to be implemented in the area. For specific protection measures, Site 1 where the relatively higher captures were encountered should be a priority. The decline of population of amphibians is a cause for concern because they are known as indicators of stressed ecosystem (Ascano *et al*. 2015). The access of harvesters for timber and agricultural production in many mountain ranges in Mindanao have been the number one reason for disturbance and decline of population of birds and amphibians and flora and fauna in general (Amoroso 2000, Beukema 2011). This has resulted to fragmented forests and fragmented protection for the various mountain ranges.

CONCLUSION

This inventory of various anuran species in Mt. Kilala provided evidence of a healthy and moderately pristine environment found in the area. It also showed that as the elevation of the sampling sites increased, there was general decrease in the relative abundance of the various anuran species. The most number of anuran species encountered preferred the aquatic microhabitat. Also, the body size of anurans was a better predictor for the habitat it will occupy. Two of the species found are Mindanao island endemic, which means that these are only found in the island of Mindanao; these are: *Megophrys stejnegeri* and *Limnonectes magnus.* Since most of the eight species found in the area are also endemic (four Mindanao island endemic, two Philippine endemic, one Southeast Asia endemic, and one introduced species), further protection are needed for the aquatic and forest habitats found in the buffer zone where timber and forest harvest occurs in Mt. Kilala. A leading cause of amphibian population decline is forest fragmentation and timber harvest or illegal logging; thus, a conservation policy on forest habitat protection and conservation of anuran species is needed in the area. Zoning for access and no access zones within the buffer zone of the mountain range is suggested. Without the afforded protection for these anurans by protecting the forest and especially the aquatic habitats, this can destroy their habitats and areas for reproduction and development.

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