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Species richness and endemism of anurans in Bega Watershed, Prosperidad, Agusan del Sur, Philippines

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Abstract

A pioneering study on the anuran species in Bega Watershed, Barangay Mabuhay, Prosperidad, Agusan del Sur was conducted using the cruising method to determine the species richness and endemism of the anurans in the area. Thirteen species belonging to six families and 12 genera were recorded. Seven species (54%) are endemic which include a Mindanao Faunal Region endemic, *Leptobrachium lumadorum* and a Mindanao Island endemic, *Megophrys stejnegeri*. Among the recorded endemic species, three are of vulnerable status. Highest species richness (R=13) and species diversity (H'=2.147) were recorded in site 1, riparian area of Bega falls. Principal component analysis showed that all sampling sites shared majority of the species but some species are unique to site 1 where type I (arboreal), type II (ground), and type III (aquatic) microhabitats were most abundant. Canopy epiphytes, leaf litter, exposed rocks, and streams with slow moving current were also found to be common in site 1. Bray-Curtis cluster analysis revealed that type II (ground) and type III (aquatic) microhabitats are the most similar with regards to their species composition (BC=0.33). The presence of endemic and vulnerable anuran species in Bega Watershed indicates the need for conservation and protection of this watershed.

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Introduction

Diversity of species in an ecosystem is important in determining a stable environment. One of the excellent indicators of global environmental quality are the amphibians which represent a more ecologically sensitive taxa (Hero *et al.*, 2005). These species spend half of their lives in water and part on land with which they acquire highly permeable skin that makes them both vulnerable to losing water and to environmental stressors (Gonzalez *et al.,* 2004), making them sentinel species for ecological disturbances (Brodman *et al.,* 2006).

In the Philippines, at least 108 species of amphibians are currently known and over 80% of these are endemic, indicating that the country's amphibian diversity remains underestimated (Diesmos and Brown, 2009). This level of species endemism is one of the highest among amphibian fauna in the Indo-Malayan realm next to Singapore (Bain *et al.*, 2008). Of the recorded number of amphibian species in the country, 98 species are anurans representing 22 genera with exceptionally high number of endemic species and no known endemic genera (Diesmos *et al.,* 2002a). Anurans are found in most of the islands of the country and the most primitive species is the Palawan flat-headed frog (*Barbourula busuangensis*), a fully aquatic species inhabiting unpolluted mountain streams and rivers while the genus *Platymantis* is the most diverse (Diesmos *et al.,* 2002a). However, according to the results of the Global Amphibian Assessment conducted by Stuart *et al.,* (2004), some 43% of the world's over 6, 000 amphibian species are declining in abundance while 32% are threatened with extinction. The Philippines ranks to be among the top countries worldwide with the greatest concentrations of threatened amphibians with a total of 24 threatened species, of which seven are critically endangered, six species are endangered, and eleven species are vulnerable (Heaney, 2002). Among the existing amphibian records, the anurans (frogs and toads), are the most widely represented (Abantas and Nuñeza, 2014; Brown *et al.,* 2013; Vasanthi *et al.,* 2014).

Threats to anurans can be attributed to habitat loss, alteration, and fragmentation (Brook *et al.,* 2003; Gallant *et al.,* 2007). According to IUCN (2009) vast majority of anurans occupy regions that are increasingly being used for residential and urban development. As a result, vast portions of natural rainforest habitats are lost to make way for housing and infrastructure. Hence, defining conservation priorities is essential to minimizing biodiversity loss (Brooks *et al.*, 2006) as it ensures that conservation action focuses on the species at the greatest risk of extinction and on the sites that are most important for their protection. One way of defining conservation priorities is initiating assessment and conservation studies of the anurans on untouched areas worldwide (Ambal *et al.*, 2012; Brown *et al.,* 2012; Vasanthi *et al.,* 2014).

A study on the herpetofauna in Mts. Sambilikan, Ararat and Berseba of Diwata range in Agusan del Sur reported 22 species of anurans (Nuñeza *et al.,* 2012). Almeria and Nuñeza (2013) reported 17 species of anurans in the swamp forest of Agusan Marsh. However, there are still no existing records of anuran diversity in Bega watershed. Data gathered in this study can give baseline information on anuran status in Bega Watershed and correspondingly supplement data on the biodiversity status of the whole watershed needed for its Biodiversity Management Plan.

This study primarily aims to determine the species richness, distribution, conservation, and diversity indices, as well as characterize microhabitats or areas essential to anuran population, and identify the existing local threats to anurans within the vicinity of Bega Watershed Barangay Mabuhay, Prosperidad Agusan del Sur.

Materials and methods

Description of the Study Area

The sampling was conducted in Bega Watershed located in the lowland forest of Barangay Mabuhay, Prosperidad, Agusan del Sur on May 8-14, 2014. Four sampling sites were established which all have secondary vegetation type: riparian area of Bega Falls (250 masl; between 08° 69'76.2" N and 125°97'39.1"E), riparian area of Enchanted Falls (267 masl; between 08° 42'09.4" N and 125°58'49.4" E), riparian area of Tiger Falls (321 masl; between 08°70'43.5" N and 125°98'21.1" E), and deciduous forest of Malipaga area (338 masl; between 08° 42' 20.7" N and 125° 54'02.6" E).

Fig. 1. (A) Location of Agusan del Sur in the Philippines (http:/www.maps.google.com, 2014), (B) relative location of Bega watershed of Prosperidad Agusan del Sur showing (C) four sampling sites (http:/www.maphill.com, 2013).

Habitat description was based on the assessment form of Haribon Foundation Inc. (2001). Microhabitat description was based on the work of Ates and Delima (2008). The coordinates of the sampling sites selected were each recorded using a Global Positioning System (GPS) device. A topographical map is shown in Fig. 1. *Sampling Sites*

Sampling site 1 is a riparian area of Bega falls, located 250 meters above sea level (masl) with coordinates of 08° 69'76.2" North latitude and 125°97'39.1"East longitude. The site has a mountainous slope (20-35°) situated in lowland secondary forest. Orchids served as canopy epiphytes. *Musa* sp. and *Ficus* sp. were common in the area while *Pandanus* sp., *Colocasia* sp., rattan, ground orchids and grasses were rarely present. Fallen logs were rarely observed but moss abundance was moderate, usually present on fallen logs and trunks of large trees. Leaf litter cover on ground, composed of loam soil, was present and was about 2.5mm thick. Exposed rocks were abundant and huge boulders were common near the streams with slow moving current. About 1.5 km from the site is a landslide-prone area and a passageway for vehicles.

Sampling site 2 is a riparian area of the Enchanted falls, located at 267 masl with coordinates of North latitude 08° 42'09.4" and 125°58'49.4" East longitude. The site has a flat to undulating slope situated in lowland secondary forest. *Artocarpus* sp. ("Tugop") and *Shorea* spp. ("lauan") were the dominant emergent and canopy trees, respectively. Ferns, mosses and liana are the canopy epiphytes. Giant ferns, *Alocasia* sp., and grasses were the ground plants observed. A rare presence of *Pandanus sp.* was also observed. Leaf litter cover was moderately present on clayish ground which was about 1cm thick. Moss was very abundant in the area, usually found on fallen logs, trunks of trees and abundant rocks near the stream. Along the side of the stream, palms and

Musa sp. (banana) were present while *Ficus* sp. was found to be abundant. Fifteen meters from the site was a degraded area.

Sampling site 3 is a riparian area of Tiger falls, located at 321 masl with coordinates of North latitude 08°70'43.5" and 125°98'21.1" East longitude. The site has a flat to undulating slope situated in lowland secondary forest. Ferns and mosses were the canopy epiphytes observed while orchids served as canopy vines. Grasses and a few of *Pandanus* sp. and *Ficus* sp. were present. Rare presence of fallen logs with few moss attachment was observed near the still water. Exposed rocks were found to be abundant in the site.

Sampling site 4 is a deciduous forest located at 338 masl with coordinates of 08° 42' 20.7" North latitude and 125° 54'02.6" East longitude. The site has a flat slope with a secondary vegetation type. *Shorea* spp. (Lauan) was found to be the emergent tree present while "uwayan" served as the canopy tree. Canopy epiphytes observed were the lianas, ferns, and rattan. Understory plants include moderate abundance of *Pandanus* sp. and *Freycinetia* sp., and a rare abundance of *Musa* sp. (banana). Ground cover plants include grasses and sedges, and other ferns. Leaf litter was about ½ inch thick above the ground. Fallen logs were also observed. About 10 m from the site is a slow-moving stream.

Sampling of Amphibians

Amphibians were sampled using the cruising method from around 0900 hours -1100 hours by day and around 1600 hours -2000 hours at night. Several searches were also done in between and beyond these periods to maximize sampling effort resulting to a non-uniform sampling hours for each site. Ninety-nine sampling hours were spent in the field sampling consisting of 42 hours for site 1, 27 hours for site 2, 12 sampling hours for site 3, and 18 hours for site 4.

Morphometrics and significant traits of captured amphibians were recorded and photo documentation was done for each species. Gathered data were then used to identify each sample up to species level with the aid of photographic guides by Alcala and Brown (1998) and Nuñeza (2012). Species identification was verified by Dr. Rafe Brown of University of Kansas, an expert in herpetology. The samples that were readily identified in the field were marked and released. Voucher specimens were kept in the Museum of Natural Sciences, College of Science and Mathematics, MSU-Iligan Institute of Technology, Iligan City. The distribution and conservation status of each species of anuran were checked using 2014 IUCN Red list of Threatened Species and other published references.

Microhabitat Classification

Microhabitat of each amphibian species was noted upon capture. Its characterization was based on the following broad categories made by Ates and Delima (2008).

Type I - *Arboreal microhabitats* referring to those elevated from the ground (5-10m) including branches and stems of plants, leaves and leaf axils.

Type II – *Ground microhabitats* referring to microhabitats directly on the ground (0 – 5 m), or on rotting logs and tree buttresses.

Type III – *Aquatic microhabitats* include streams, rivers, and creeks as well as standing bodies of water.

Statistical Analysis

Data gathered in the sampling period were subjected to different statistical analysis using the Paleontological Statistics (PAST) software. Biodiversity Indices analysis was used for the computation of the species richness, relative abundance, species diversity and species evenness. Endemism was based on the number of endemic species. Principal Correspondence analysis was used for analyzing the data on the distribution of anuran species per site with respect to their microhabitat preferences while Bray-Curtis cluster analysis was used for identifying the similarity of the microhabitat types.

Results and discussion

Species richness, endemism, and biodiversity indices

Thirteen species belonging to six families and 12 genera of anurans were collected from the different sampling sites of Bega Watershed. Seven endemic species were recorded in the area, three of which are of vulnerable status which include *Platymantis guentheri*, *Megophrys stejnegeri* and *Philautus acutirostris*. *P. guentheri* and *P. acutirostris* were both found solely in site 1, riparian area of Bega falls. Meanwhile, *M. stejnegeri* was found in all three sampling sites except in site 3. Table 1 shows the anuran species composition, species richness, relative abundance and endemism in the watershed.

Table 1. Anuran species richness, relative abundance, and endemism in Bega Watershed, Prosperidad, Agusan del Sur.

Taxon (Common Name)	*Sampling sites 1	2	3	4	TOTAL
		Ceratobatrachidae			
Platymantis dorsalis[PE] (Common Forest Frog)	2 (3.39)	0 --	0 --	0 --	2 (1.83)
Platymantis guentheri[PE, V] (Guenther's Forest Frog)	1 (1.69)	0 --	0 --	0 --	1 (0.92)
		Dicroglossidae			
Fejervarya cancrivora (Asian Brackish Tree Frog)	1 (1.69)	0 --	0 --	0 --	1 (0.92)
Limnonectes magnus (Giant Philippine Frog)	2 (3.39)	10 (32.26)	0 --	2 (16.67)	14 (12.84)
Occidozyga laevis (Puddle Frog)	1 (1.69)	0 --	0 --	7 (58.33)	8 (7.34)
		Megophryidae			
Leptobrachium lumadorum[MFE] (Hasselt's Toad)	1 (1.69)	1 (3.23)	1 (14.29)	0 --	3 (2.75)
Megophrys stejnegeri[ME, V] (Mindanao Horned Forest Frog)	6 (10.17)	1 (3.23)	0 --	1 (8.33)	8 (7.34)
		Microhylidae			
Kalophyrnus pleurostigma (Black-Spotted Narrow Mouthed Frog)	9 (15.25)	1 (3.23)	0 --	1 (8.33)	11 (10.10)
		Ranidae			
Sanguirana albotuberculata[PE] (*Hylarana everetti*) (Cabilian Frog)	6 (10.17)	0 --	0 --	0 --	6 (5.50)
Hylarana grandocula[PE] (Big-Eyed Frog)	17 (28.81)	9 (29.03)	2 (28.57)	1 (8.33)	29 (26.61)
Staurois natator (Rock Frog)	7 (11.86)	9 (29.03)	3 (42.86)	0 --	19 (17.43)
		Rhacophoridae			
Polypedates leucomystax (Common Tree Frog)	5 (8.47)	0 --	1 (14.29)	0 --	6 (5.50)
Philautus acutirostris[PE, V] (Pointed-Snouted Tree Frog)	1 (1.69)	0 --	0 --	0 --	1 (0.92)
Total # of individuals	59	31	7	12	109
Total # of species	13	6	4	5	13
Total # of endemic species	7	3	2	2	7
Relative abundance	54.13	28.44	6.42	11.01	
Endemism	53.85	50	50	40	53.85

Legend: *1 = Riparian area of Bega Falls; 2 = Riparian area of Enchanted Falls; 3 = Riparian area of Tiger Falls; 4 = Deciduous Forest of Malipaga area; PE - Philippine Endemic; ME - Mindanao Island Endemic; MFE - Mindanao Faunal Endemic; V - Vulnerable; () relative abundance.

Among the four sampling sites, site 1 had the highest value of species richness comprising all 13 species in the area. Site 2 (R=6) had higher record compared to site 4 (R=5). Results of faunal inventories of several mountains (Diesmos *et al.,* 2002b; Nuñeza *et al.,* 2010; Siler *et al.,* 2011) reveal a decreasing trend in amphibian richness with increasing elevation. Meanwhile, site 3 (R=4) had the lowest species richness because this area, although not as elevated as site 4, was farther compared to other sites.

Table 2. Species diversity and evenness of anurans recorded in Bega Watershed.

	*Sampling Sites				Total
	1	**2**	**3**	**4**	
Species Diversity (H')	2.147	1.415	1.277	1.234	2.156
Species Evenness (E)	0.6561	0.6864	0.8965	0.6872	0.6642

*1 = Riparian area of Bega Falls; 2 = Riparian area of Enchanted Falls; 3 = Riparian area of Tiger Falls; 4 = Deciduous Forest of Malipaga area.

Across sampling sites, *H. grandocula* (26.61%) was the most abundant species while *P. guentheri, F. cancrivora* and *P. acutirostris* were the least abundant (0.92%). In sampling site 1, *Hylarana grandocula* was found to be the most abundant (28.91%). Individuals of *H. grandocula* were generally observed in locations having water structures where they were seen hiding in rock crevices and in the holes of fallen logs. The presence of *H. grandocula* in the area is supported by the existing records where it was found to inhabit undisturbed and disturbed streams and rivers in lowland forests and it breeds and lays its eggs in mountain streams. The tadpoles develop in water (IUCN, 2014). In the same site, *Kalophrynus pleurostigma* was next to *H. grandocula* in terms of abundance (15.25%). Some individuals of this species were seen sitting on leaf litter of the forest floor while others were found mating in small pools of rain water which is the place where it usually lays its eggs (IUCN, 2014). *Limnonectes magnus* (32.26%) along with *H. grandocula* (29.03%) and *Staurois natator* (29.03%) were found to be abundant in site 2 as water structures such as small springs, streams as well as ponds and ditches were common in this site. These species are typical forest aquatic frogs at low vegetation according to Alcala and Brown (1998).

Staurois natator (42.86%) and *Hylarana grandocula* (28.57%) were also found to be abundant in site 3, riparian area of Tiger falls. Habitat preference of anurans is aquatic areas such as this site. Also *S. natator* appeared to be very abundant in this undisturbed site since it is said to inhabit clean, clear mountain streams (Alcala and Brown, 1998). Consequently, *O. laevis* (58.33%) was very abundant in site 4, which is a deciduous forest, where puddles formed by rain water were abundant. This species was commonly observed to thrive in such habitat according to Alcala and Brown (1998).

The difference in the relative abundance of each species among the sites sampled shows the effect of variation in habitat tolerance of each species, hence also associated with the availability of specific habitat to thrive in. Alcala and Brown (1998) stated that high moisture content is common in anuran habitats since they need water to replace that which was lost through their thin, permeable skin and to provide the environment for reproduction. Thus, only few species tolerated dry conditions for limited period of time. Moreover, water bodies and other moist locations such as rivers, streams, and pools are used by aquatic amphibians undergoing indirect development or complete metamorphosis specifically those species laying eggs (Kardong 1995). And since the sampling area was a watershed, aquatic species were naturally abundant. Consequently, highest abundance of anurans in the area was recorded in site 1 (54.13%). It was noted that more bodies of water were found in this area.

Ecological studies demonstrate a propensity of amphibians toward a fine scale isolation and distribution, making this group appropriate model organisms to identify sub-centers of endemism (Diesmos and Brown, 2009). In terms of endemism, Bega Watershed holds a relatively high endemism (53.85%). Of the 13 species collected in the vicinity of the sampling area, seven are endemic. Mindanao Island endemic *M. stejnegeri* is a forest floor dweller of montane and lowland forest which breeds in mountain streams. Three of the seven endemic species are of vulnerable status.

Table 3. Distribution of anurans in the four sampling sites of Bega Watershed.

Species	*Sampling Sites			
	1	2	3	4
F. cancrivora	+	-	-	-
H. grandocula	+	+	+	+
K. pleurostigma	+	+	-	+
L. lumadorum	+	+	+	-
L. magnus	+	+	-	+
M. stejnegeri	+	+	-	+
O. laevis	+	-	-	+
P. acutirostris	+	-	-	-
P. dorsalis	+	-	-	-
P. guentheri	+	-	-	-
P. leucomystax	+	-	+	-
S. albotuberculata	+	-	-	-
S. natator	+	+	+	-
Total No. of Species	13	6	4	5

*Sampling sites: 1, riparian area of Bega falls; 2, riparian area of Enchanted falls; 3, riparian area of Tiger falls; 4, deciduous forest of Malipaga area.

Sampling site 1 recorded the highest endemism (53.85%) while sampling site 4 recorded the least endemism (40%). Although sampling sites in Bega watershed were not necessarily found in high elevations, which supposedly cater higher endemism due to higher isolating mechanism, they still shelter a valuable number of endemic species. Site 1, a riparian area which had a mountainous slope and comprised the highest number of bodies of water among four sites showed a different pattern of anuran endemism compared with that of the study of Diesmos (2000) on the Philippine frogs. Endemic species in this site, represented almost all the six anuran families found in the area except for the family Dicroglossidae and Microhylidae. Sites 2 and 3 also have relatively high endemism (50%) despite their flat to undulating slope. *L. lumadorum* and *H. grandocula* were the two endemic species found in both sites. These species are said to occur in a wide range from lowland to montane forests, streams, ponds, and tree holes (Alcala *et al.,* 2012). Despite being the last in rank in terms of endemism, site 4 still harnessed a moderate level of endemism (40%). In fact, the Mindanao island endemic, *M. stejnegeri* was found in this site. This species thrives in site 4 because this site has thick leaf-litter on its forest floor where *M. stejnegeri* was usually found (Alcala *et al.,* 2012).

Table 2 shows moderate over-all anuran species diversity (H'=2.156) and evenness (E=0.6642). Site 1 which is a riparian area of Bega Falls had the highest diversity (H'=2.147) among the four sites in the area despite being disturbed. Accordingly, anurans prefer riparian area with prominent water body structures (Relox *et al.,* 2009). Sampling sites 2 (H'=1.415), 3 (H'=1.277), and 4 (H'=1.234), on the other hand, still had moderate species diversity.

Table 4. Microhabitat preferences of Anurans in Bega Watershed.

Species	Microhabitat Types		
	I	II	III
F. cancrivora			1.
H. grandocula[C]		2.	3.
K. pleurostigma[C]		4.	5.
L. lumadorum		6.	
L. magnus			7.
M. stejnegeri		8.	
O. laevis			9.
P. acutirostris	1.		
P. dorsalis		2.	
P. guentheri	3.		
P. leucomystax	4.		
S. albotuberculata			5.
S. natator			6.
Total	3	5	7

7. Present in the microhabitat type; [C] - Combination of microhabitat types; I – elevated from the ground (5-10m) including branches and stems of plants, leaves and leaf axils; II – directly on the ground (0 – 5 m), or on rotting logs and tree buttresses.; III – streams, rivers, and creeks as well as standing bodies of water.

Evenness values depict how equally distributed the individuals of a species are in a community, with values near 1.0 indicating well distributed species (Molles, 1999). Site 3 showed the highest and nearest value to 1.0 (E=0.8965) while site 1 had the lowest (E=0.6561). Nevertheless, despite having the least evenness value, site 1 still garnered a moderate species distribution since the value is greater than 0.5. These differences in evenness are results of variation in the communities' geographical and physical factors (Bryant, 2002) since distribution of organisms involves selection of habitats that provide the resources required for the survival of individuals of a particular species (Zug, 1993).

Habitat preferences

The sampling sites showed differences in the presence of anuran species. The species collected per sampling site are presented in Table 3. Of the three sites situated in a lowland secondary forest, site 1, the riparian area of Bega falls showed the highest number of species present (R=13), followed by site 2, riparian area of Enchanted falls (R=6) and finally Site 3, riparian area of Tiger falls (R=4). While site 4, a deciduous forest in Malipaga area ranked second to the last in terms of species richness (R=5).

Site 1, riparian area of Bega falls situated in lowland secondary forest, is observably a complex site which comprises microhabitats that are favorable to anuran species. Accordingly, a complex environment provides more room for organisms of smaller body size, including frogs, as refuges for the species (Bryant, 2002). Canopy epiphytes, leaf litters and huge boulders which are said to be hiding places of several anurans were common in the site. Moreover, despite the recorded disturbances, site 1 remained functionally stable due to the possible regeneration which is a natural ability of an ecosystem to recover as reported by Sinha and Heaney (2006). Meanwhile, site 3, a riparian area of Tiger falls, had the lowest distribution of species due to its higher elevation and steep undulating slope which had probably limited the dispersion of anurans in the area. This result in site 3 can be associated with the results of faunal inventories of several mountains (Diesmos *et al.,* 2002b; Nuñeza *et al.*, 2010; Siler *et al.*, 2011) which reveal a decreasing trend in amphibian richness with increasing elevation.

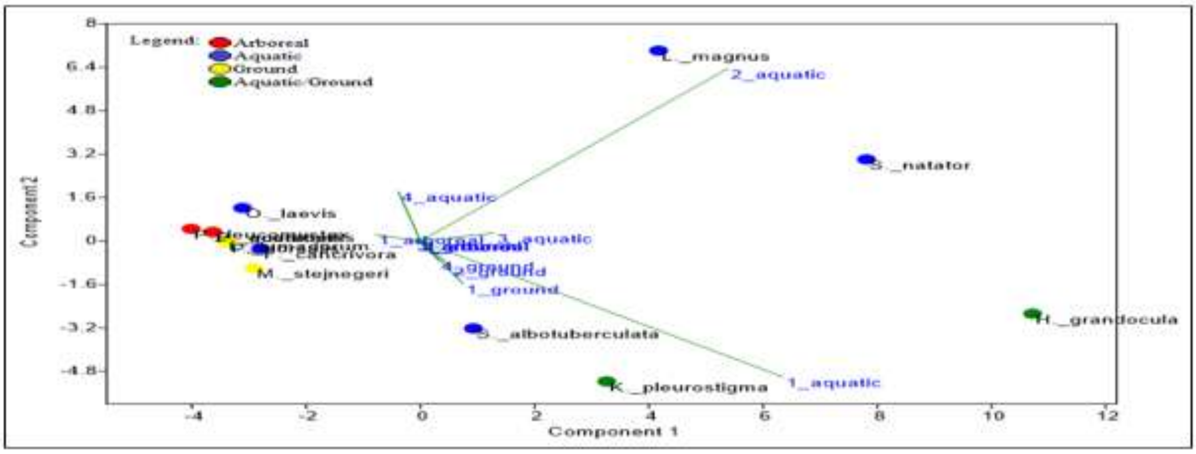

Fig. 7. Scatter plot of anuran distribution in Bega watershed.

Three types of anuran microhabitats were characterized by Ates and Delima (2008). Results on the microhabitat preferences of the species encountered in the area are shown in Table 4. Among the 13 species of anurans, five (38.46%) species thrive solely in type III microhabitat. This indicates that majority of the encountered anurans in Bega Watershed are water-dwelling or aquatic species. Aquatic anurans are those that spend the greater part of their lives in water or within its vicinity such as in streams, rivers, and creeks as well as standing bodies of water (Alcala and Brown, 1998). Observed water-dweller species include: *F. cancrivora, L. magnus, O. laevis, S. albotuberculata* and *S. natator.*

Other anuran species were found in this study to inhabit elevated substrata such as branches and stems of plants, leaves, and leaf axils, which are usually 5-10m above the ground. Ates and Delima (2008) refer to this type of habitat as arboreal habitat. This type I microhabitat is inhabited by *P. guentheri, P. leucomystax* and *P. acutirostris* indicating that these are arboreal species (Siler *et al.,* 2009; Mohammad *et al.,* 2013; Araujo-Filho *et al.,* 2014). For those species which prefer thriving directly on the ground (0 – 5 m), or on rotting logs and tree buttresses, they were found in type II microhabitat. Species which were found in this microhabitat type include: *P. dorsalis, L. lumadorum,* and *M. stejnegeri.* These species are usually found on forest floor stratum (IUCN, 2014).

There were also species such as *K. pleurostigma* and *H. grandocula* which preferred two microhabitat types. Both species were found in types II and III microhabitat in the area. This pattern of having several microhabitat preference is associated with organization of the microhabitats based on their function. As explained by Diesmos (2000), frogs retreat to different sites to carry diverse behavioral activities that can be supported by their structure. Selected breeding site may or may not be the same microhabitat preferred by frogs as calling site.

However, assessment on microhabitat at different periods of the year in this area is still suggested so it may help increase the discovery of species dependent on certain microhabitats.

Scatter plot of the principal component analysis on the distribution of the anuran species in the different microhabitat types per site in the Bega watershed is shown in Fig. 7. Species are generally distributed across the sampling sites but some species were found to be unique in site 1, riparian area of Bega falls. Jongsma *et al.,* (2014) reported that riparian zones harbor amphibian assemblages distinct from other habitat types, including rare and endangered species. Arboreal species which include *P. guentheri* and *P. acutirostris* were observed only in site 1 possibly due to their habitat preference which is highly present in this site where canopy epiphytes are common. Presence of *F. cancrivora* and *S. albotuberculata* in the same site is explained by the abundance of water structures in the area since these species are recorded to be aquatic species in the IUCN (2014). Although the leaf litter is not as much in site 1, the forest floor stratum is still a favorable microhabitat for *P. dorsalis*.

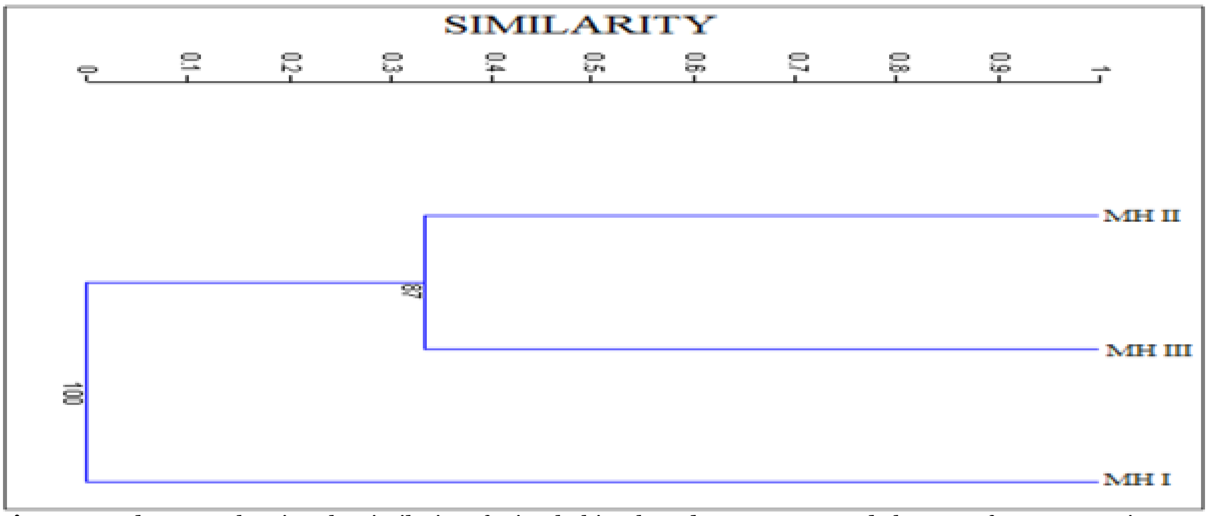

Fig. 8. Dendrogram showing the similarity of microhabitat based on presence and absence of anuran species.

Bray-Curtis index of similarity for the three microhabitats revealed types II and III to be the most similar with regards to their species composition (BC=0.33) which was followed by type I (BC=0). The relationship between these sites is shown in Fig. 8.

Type II and type III microhabitats are shared by two species: *K. pleurostigma* and *H. grandocula*. These two anurans are considered as both ground and aquatic species. Accordingly, they utilize one microhabitat type as either breeding, calling or oviposition site and at the same time they make use of another type of microhabitat as a diurnal site where they hide from predators or against the sun's rays (Alcala and Brown, 1998; Diesmos, 2000). *K. pleurostigma* is a terrestrial frog observed to inhabit forest floors (type II) but is said to lay eggs in small rain puddles in forest (Alcala and Brown, 1998), a characteristic of type III microhabitat. *H. grandocula* on the other hand, is recorded to inhabit disturbed and undisturbed streams and rivers (IUCN, 2014) as observed in the area. Some individuals however, were found on leaf litters of forest floors, above fallen logs and in a tree hole. This suggests that Bega watershed is rich in plant and tree species as well as water structures that could shelter frog species dependent on microhabitat types II and III.

Consequently, microhabitat type I was the most dissimilar among the three types. Three species of anuran were observed in this microhabitat which include *P. guentheri, P. leucomystax* and *P. acutirostris*. These species are said to be arboreal as observed in the area where individuals were found on stems and leaves of low vegetation (Alcala and Brown, 1998).

Threats to the Anuran Fauna in Bega Watershed

Among the 13 species encountered in the area, only *L. magnus* was observed to be locally popular as food because of its meat. IUCN (2014) listed this species to be nearly threatened. All other species face the grave threat of habitat loss due to slash and burn activity and disturbances caused by frequent visitors, who mostly leave their trashes in the area. Although the local government has already created rules and regulation to conserve Bega Watershed, proper implementation and public awareness are still needed.

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Conclusion

Bega watershed hosts a diverse number of anuran species including a high number of endemic species with several already under the threatened category. Sampling site 1, a riparian area situated in lowland secondary forest contained more endemic and threatened species showing the importance of a complex habitat having both water body structures and a forested area.

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