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Diversity of ichthyofauna in freshwater system in bega watershed, prosperidad, agusan del sur, Philippines

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Abstract

This study aimed to determine the diversity of the fish species in the freshwater system of Bega watershed, Mabuhay, Prosperidad, Agusan del Sur, Philippines. Sampling was carried out on May 8-14, 2014 using fish net, hand net, spear, and the hook-and-line method. Six species were recorded of which three are endemic, one native, and two are introduced species. Low species diversity and a more or less even distribution were recorded. The most abundant species was the endemic *Dermogenys pusilla*. The canonical correspondence analysis results showed that fish assemblage was affected by dissolved oxygen, pH, water temperature, and water depth.

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Introduction

Some of the globally valuable hotspots for biological diversity and endemism are found in the Philippines but these studies are mostly focused on terrestrial and marine biodiversity (Paller *et al.,* 2010). One of the most affected ecosystems by human activities is the freshwater ecosystem (Dudgeon *et al.,* 2006). Bodies of water are important for life as well as for fisheries, hydrology, and ecotourism (Fischer and Harris, 2003). Inland waters of the Philippines such as rivers, lakes, and waterfalls are known to have very diverse biotic community (Vedra *et al.,* 2013). Rivers are known for their rich aquatic life (Guzman and Capaque, 2014). Locals in the community near the waterfalls or rivers use this water advantage from nature for several applications such as irrigation and domestic purposes (Jomoc *et al.,* 2013; Ecot *et al.,* 2014). Rich biomes of indigenous and exotic species are often found in tropical waterfalls which are dragged down from upstream waterfalls by gravity to settle and inhabit the downstream and river where calm environment is more suitable for living (Gabriel and Benedict, 2011).

Fishes are one of the most important staple items in the diet of many societies and considered valuable in the economy of many countries (Shukla and Singh, 2013; Guzman and Capaque, 2014). Freshwater habitats are one of the richest in terms of biological diversity (Ward and Tockner, 2001). According to Jenkins (2003), it is alarming to know that there is a decrease of freshwater biodiversity and its decline is faster than marine or terrestrial biodiversity. Knowledge of the fish fauna is essential in conservation (Gabriel and Benedict, 2011).

The interaction between population and environment affects the patterns of abundance and distribution trends of organisms as well as its size and flow regime (Tokeshi and Schmid, 2002). It was reported by Camacho *et al.* (2001) that the average annual growth rate of Philippine fisheries in 1987-1997 was 2.2%; the commercial fisheries and aquaculture showed 4.4% and 5.4% annual growth, respectively; while the municipal fisheries decreased by 1.6%.

Alima and Patricio (2010) reported 23 fish species, belonging to 19 genera and 12 families in Tubay, Agusan del Norte, Philippines while most studies in Agusan del Sur, Philippines focuses on the fish diversity in Agusan marsh (Davies, 1993; Hubilla and Kis, 2006; Hubilla *et al.,* 2007). No record is available for the freshwater fish diversity in Prosperidad, Agusan del Sur, Philippines where Bega watershed is situated.

The Bega watershed, composed of waterfalls and river, is located in Mabuhay, Prosperidad, Agusan del Sur, Philippines. Several streams converge into one river from where water cascades over steep cliff which flows into the waterfalls. The local government unit of Agusan del Sur is working on the development of Bega falls to make it a suitable ecological habitat and at the same time a tourist spot. Knowledge on the diversity inventories of inland waters like waterfalls and rivers will provide a higher understanding on the conservation and protection plans (Abell *et al.,* 2008). Hence, assessment on the diversity and abundance of fish species is important in order to have an account on the species present in the selected areas of Bega watershed. This study determined the species composition, richness, relative abundance, conservation status, and diversity indices of ichthyofauna as well as the physico-chemical parameters of the water system in Bega watershed.

Materials and methods

Study Area

The study was conducted in Bega Falls, Enchanted Falls, Tiger Falls and Malipaga River in Bega watershed, Purok 5 Mabuhay, Prosperidad, Agusan del Sur in the southern part of the Philippines (Fig. 1) on May 8- 14, 2014. Bega Falls (Site 1) is located at an elevation of 225 – 288 masl with grid coordinates of 8°69' North latitude and 125°97' East longitude. Enchanted Falls (Site 2) is at 8°70' North latitude and 125°98' East longitude in an elevation of 278 masl.

Tiger Falls (Site 3) is at an elevation of 330 masl located at 8° 71' North latitude and 125°99' East longitude. Malipaga River (Site 4) is located at an elevation of 338 masl with coordinates of 8° 71' North latitude and 125°99' East longitude.

Fig. 1. The Philippine map (A) (http://en.wikipedia.org, 2015) showing the sampli area, Prosperidad, Agusan del Sur (B) (B) (http://en.wikipedia.org, 2014).

Fish Sampling

Various sampling techniques and gears were employed in the collection of fish such as fish nets, hand nets, and the hook-and-line method. Local fishing gear such as spear was also used for opportunistic sampling.

Physico –chemical Properties of the Water

The water temperature, pH, dissolved oxygen, and water depth were measured in every site using laboratory thermometer, pH meter, dissolved oxygen meter, and steel tape, respectively. Total suspended solids (TSS), substrate composition, and current velocity were also assessed in each study site.

Preservation and Identification of the Specimens Ten to 15 representatives per species were fixed in 10% formalin. After a week, the specimens were transferred to 70% ethyl alcohol. Fish samples were identified using FishBase 2014 database (Froese and Pauly, 2014) and confirmed by Dr. Gorospe of MSU-Naawan.

Data analysis

Species diversity, species richness, dominance, and evenness were computed using PAST: Paleontological Statistics Software Package version 2.17 (Hammer, 2012). Canonical Correspondence Analysis (CCA) and individual rarefaction were done using the same software.

Results and discussion

Species Diversity, Species Richness, Relative Abundance, Dominance, Evenness

Six species from five genera belonging to five families were recorded from the four study sites of Bega watershed (Table 1). Site 1 had the highest number of species (n=6). The remaining sites had the same species richness (n=5). One native species, *Sicyopterus micrurus* commonly called Clinging Goby, which comprised 30.9% of the total specimens collected was found in all the study sites. *Channa striata*, an introduced species, also called Striped Snakehead was observed in all sampling sites while another introduced species, *Oreochromis niloticus* locally known as "tilapia", was found only in Bega Falls. Each introduced species had a relative abundance of 0.77%. Three endemic species,

Barbodes sp. locally known as "pait", *Dermogenys* sp. commonly called halfbeak and *Dermogenys pusilla* or the Wrestling halfbeak constitute 28.2%, 5.2%, and 34.2% of the total number of specimens collected, respectively.

Introduced, native, and endemic species inhabiting the same area were noted because the presence of introduced species poses a risk to the stability of native and endemic species (Paller *et al.,* 2010). Striped snakehead (*C. striata)* and Nile tilapia (*O. niloticus*) are introduced species that are known to compete with food source and space and prey on the eggs and fries of native and endemic species. However, *O. niloticus* was found only in the downstream of Bega Falls.

Table 1. Freshwater fish species composition in Bega Watershed, Prosperidad, Agusan del Sur and their distribution status, conservation status, relative abundance, and biodiversity indices.

Taxon	DS*	CS	Sampling Sites				
		(IUCN, 2014)	Site 1 (Bega Falls) 225 – 288 masl	Site 2 (Enchanted Falls) 278 masl	Site 3 (Tiger Falls) 330 masl	Site 4 (Malipaga River) 338 masl	Pooled Data
Family Channidae	I	LC	1	2	1	1	5 (0.77%)
Channa striata							
Family Cichlidae	I	LC	5	0	0	0	5 (0.77%)
Oreochromis niloticus							
Family Cyprinidae	E	LC	82	60	24	17	183 (28.2%)
Barbodes sp.							
Family Gobiidae							
Sicyopterus micrurus	N	DD	92	70	23	16	201 (30.9%)
Family Zenarchopteridae							34 (5.2%)
Dermogenys sp.	E	LC	11	9	7	7	222 (34.2%)
Dermogenys pusilla	E	LC	39	59	67	57	
Total number of individuals			230	200	122	98	650
Species Richness (n)			6	5	5	5	6
Total Relative Abundance (%)			35.4%	30.77%	18.8%	15.08%	100%
Species Diversity (H')			1.29	1.27	1.17	1.15	-
Simpson's Dominance Index			0.681	0.698	0.621	0.599	-
Shannon Evenness Index			0.60	0.72	0.64	0.63	-

Legend: *Fish distribution status and currently accepted species name based on FishBase (2014); Numbers indicate the number of individuals while the numbers in parentheses indicate the relative abundance of species; DS – Distribution Status; I – Introduced; N – Native; E- Endemic; CS – Conservation Status; LC – Least Concern; DD – Data Deficient.

Diversity index was found to be low in all sites. The distribution of freshwater fish assemblages showed that *Sicyopterus micrurus* slightly dominates Sites 1 and 2 while *Dermogenys pusilla* dominates Site 3 and 4. Also, results showed more or less even distribution which indicates that fish species thriving in the watershed are fairly distributed (Begon *et al.,* 1996; Paller *et al.,* 2013).

Welcomme (1985) and Bayley and Li (1994) reported that species richness increases from upstream to downstream in a riverine system. The same result was obtained in this study where the highest species richness and abundance was found in Site 1 which is the downstream region in Bega watershed. The high species richness in this area is attributed to the logs, algae, rocks and wide area which serve as food sources, refuge from predators, and protection from current (Angermeier and Karr, 1984).

Physico – chemical parameters

The mean values of the physico-chemical parameters of the four study sites are shown in Table 2. The water temperature ranged from 25°C – 26.5°C which

according to the study of Boyd (1979) and Keremah *et al.* (2014) is good for freshwater fish production. Temperature plays a critical role in determining the spatial shifts in species distribution (Rahel *et al.,* 1996; Whitfield *et al.,* 2014). The average values of dissolved oxygen (DO) are within the standard value (5.0-8.0 g/L) for freshwater, which indicates the high level productivity of living things in the area (Environmental Protection Agency, 2012; Department of Environment and Natural Resources, 1990). One of the most important factors that affects most aquatic species is dissolved oxygen (DO). Fish metabolism is limited by DO and it also determines growth and activity levels of juvenile fish (Keremah *et al.,* 2014).

Table 2. Mean value of physico-chemical parameters of Bega watershed of Mabuhay, Prosperidad, Agusan del Sur.

SITE	Water Temperature (°C)	DO (mg L^{-1})	pH	TSS (mg L^{-1})	Substrate composition	Water depth (m)	Current velocity (m s^{-1})
1 (Bega Falls)	26.5	6.66	7.1	30	Rocky	2.3	0.13
2 (Enchanted Falls)	26	8.2	7.8	28	Rocky	3.1	0.124
3 (Tiger Falls)	25	7.84	7.3	38	Rocky, sand and fine gravel, silt	0.8	0.28
4 (Malipaga River)	25	7.51	7.3	43	Sand, fine gravel, silt	0.5	0.117

The average pH values of the sites were within the optimal range (pH 6.5 – 9.0) for most freshwater fishes to live (Tarazona and Munoz, 1995; Department of Environment and Natural Resources, 1990). Metabolism and physiological processes of fish are known to be affected by water pH (Indian Council of Agricultural Research, 2006). Total suspended solids (TSS) are one of the significant factors that affect the water clarity (Kemker, 2014). The TSS readings (28-43mg/L) in this study were a little higher than the water quality criteria (25mg/L) set by the Department of Environment and Natural Resources (DENR) for watersheds. The slightly higher TSS at Tiger Falls (38 mg/L) and Malipaga River (43 mg/L) could be attributed to the substrate composition. The sediments from the mountain are carried by the run-off water and were deposited at the two sites. Rocks, sand, fine gravel, and silt were the type of substrate found in the study sites. This can be attributed to soil erosion, siltation and small-scale mining activities along the riversides.

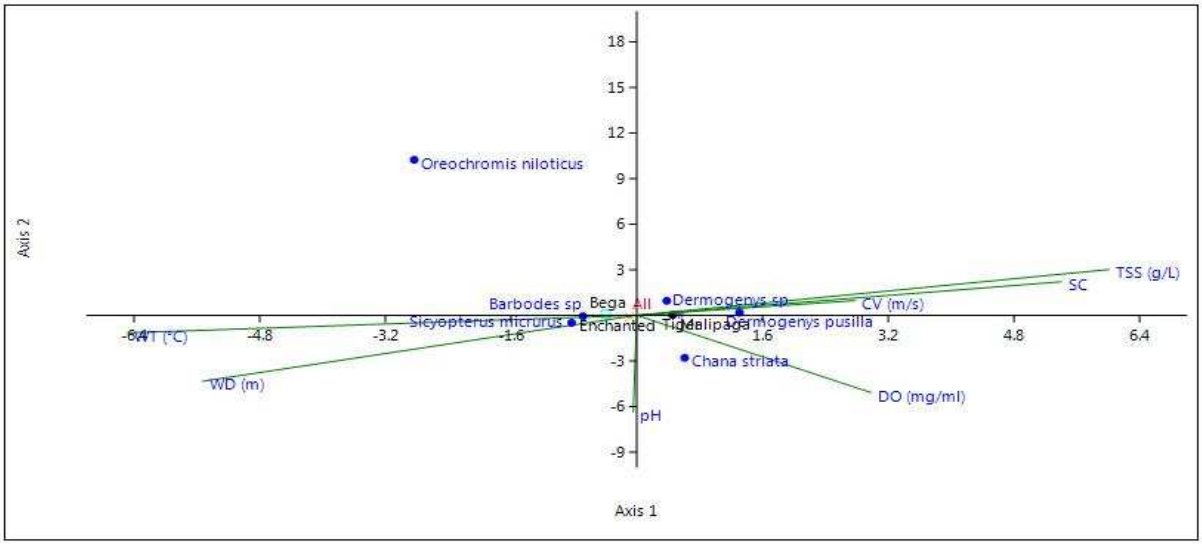

Fig. 2. The Canonical correspondence analyses (CCA) diagram showing the correlation between fish species and environmental variables.

The results showed that most of the physico-chemical parameters are within the standard water quality for fresh water surface according to Department of Environment and Natural Resources (1990) administrative order no. 34 (water quality criteria). This implies that the watershed has good physico–chemical attributes for good fish production. The physico-chemical factors prevailing in the sampling sites are the prime determiners of the abundance, diversity, and optimum growth of the biotic system (Ehiagbonare and Ogundiran, 2010).

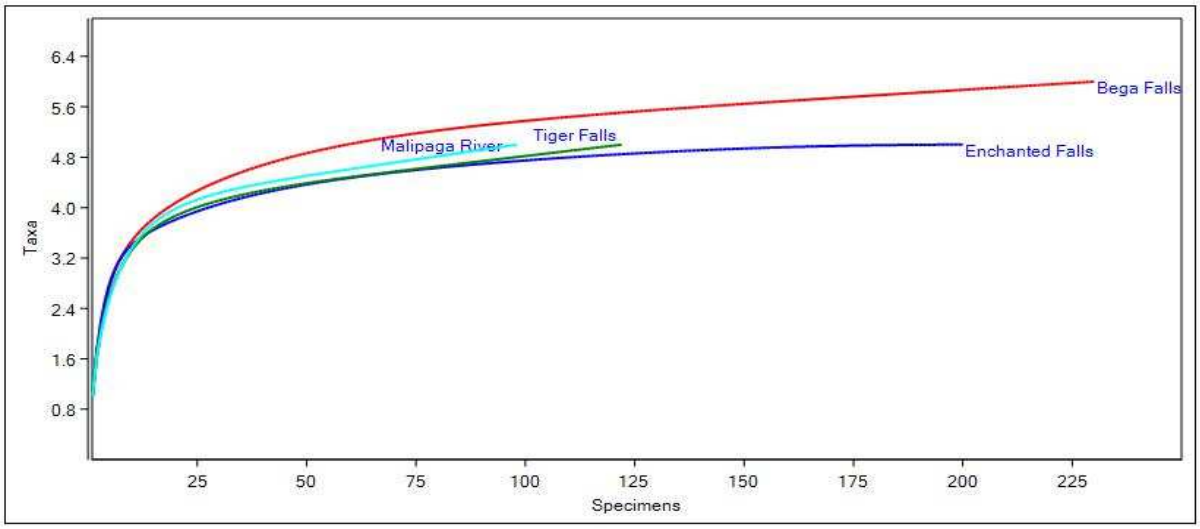

Fig. 3. A graph showing the species accumulation curve of each site using Individual Rarefaction analysis.

Canonical Correspondence Analysis

Fig. 2 shows the correlation between species composition and environmental factors in the sampling sites. It was observed that a decreasing water temperature and water depth favored the dominance of *S. micrurus* in Bega Falls (Site 1) and Enchanted Falls (Site 2). *Sicyopterus* sp. is known to thrive in shallow and relatively cool waters (Tweedley *et al.,* 2013). On the other hand, species of the genus *Dermogenys* were negatively correlated with decreasing dissolved oxygen. *C. striata* which thrives more in Tiger Falls and Malipaga River was negatively correlated with decreasing pH and dissolved oxygen. Results also showed that *O. niloticus* and *C. striata* can thrive in low DO and pH, an unfavorable environment for native and endemic species. Although introduced species in the watershed occur in low number at present, they still pose a great risk for native and endemic species in the future. Environmental factors (Rahel *et al.,* 1996), human interventions (Paller *et al.,* 2010), pollution (Jiraungkoorskul *et al.,* 2007; Rani *et al.,* 2011), and introduction of invasive species (Guerrero, 2002; Paller *et al.,* 2010) account for the major threats to freshwater fish diversity.

Individual Rarefaction

Bega Falls (Site 1) had the highest curve as shown in Fig. 3. It had the highest species abundance and richness. This adheres to the report of Pires *et al.* (1999) that the density and biomass of fish are greater in downstream rivers and sites. On the other hand, Tiger Falls and Malipaga River had short curves. This means that more sampling efforts in these sites would likely result in additional species (Smith and Jones, 2005). Angermeier and Smogor (1995) reported that in order to reach asymptote and to acquire more species, additional sampling effort is needed.

Species accumulation curve is helpful in comparing the richness of the species collected in different sites (Willot, 2001). It was observed in this study that the number of captured fish was greatly affected by varying sampling time and effort, anthropogenic

disturbance, and weather that account for varying lengths in curves. According to Guerrero (2002), pollution, anthropological destruction, habitat loss, and invasive species are the reasons to the country's diminishing freshwater fish diversity.

Conclusion

Low species diversity was recorded in Bega watershed, however, distribution was more or less even. Most of the physico-chemical parameters were within the range of water quality standards. The presence of introduced species poses risk to the population of endemic and native species since they are known to thrive in unfavorable environmental conditions which are disadvantageous to the endemic and native fish species in the area.

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