ABUNDANCE AND DIVERSITY OF FISHES IN BAYAWAN RIVER, NEGROS ORIENTAL, PHILIPINES

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ABSTRACT

This study aimed to: 1) identify fish species found in Bayawan River; 2) determine fish abundance and species composition in three segments of the river; 3) characterize physico-chemical and hydrological parameters of the river; and 4) correlate fish abundance and diversity with the physico-chemical and hydrological characteristics of Bayawan River. The fishes of Bayawan River in Negros Oriental, central Philippines were assessed for three sampling months (December 2018-February 2019). Abundance and diversity of fishes were quantified in relation to physico-chemical and hydrological parameters. The data were analyzed using Shannon-Wiener Diversity Index (H'), Margalef's Index (species richness), Principal Component Analysis (PCA), and Canonical Correspondence Analysis (CCA). The Shannon-Weiner Diversity Index (H') across sampling months ranged from 2.3-3 showing a relatively diverse ecosystem. However, the number of species decreased from December 2018 to February 2019 (27 to 15 species). Twenty six (92.9%) of the fish species are marine species that spend only part of their life in freshwater while two species (7.1%) are truly freshwater species. Generally, the ichthyofauna consists of 28 species belonging to 20 families and were dominated by families Leiognathidae and Carangidae (14.3%). Most abundant species were *Deveximentum megalolepis* (125), *Eubleekeria jonesi* (107) followed by *Oreochromis niloticus* (48) and the rest were represented by 40 individuals and below. It is recommended that future studies should cover temporal differences, covering the wet and dry season.

Keywords: diversity; fishes; limnology; lotic; Negros Island

KELIMPAHAN DAN KEANEKARAGAMAN IKAN DI SUNGAI BAYAWAN, NEGROS ORIENTAL, FILIPINA

ABSTRAK

Penelititan ini bertujuan untuk: 1) mengidentifikasi spesies ikan yang ditemukan di Sungai Bayawan; 2) menentukan kelimpahan ikan dan komposisi spesies di tiga segmen sungai; 3) mengkarakterisasi parameter fisika-kimia dan hidrologis sungai; dan 4) mengkorelasikan kelimpahan dan keanekaragaman ikan dengan karakteristik fisika-kimia dan hidrologis Sungai Bayawan. Kajian mengenai ikan-ikan di Sungai Bayawan di Provinsi Negros Oriental, Filipina ini dilakukan selama tiga bulan yaitu pada bulan Desember 2018 sampai bulan Februari 2019. Kelimpahan dan keanekaragaman ikan dikuantifikasi dalam kaitannya dengan parameter fisika-kimia dan hidrologi. Data dianalisis menggunakan Shannon-Wiener Diversity Index (H'), Margalef's Index (kekayaan spesies), Principal Component Analysis (PCA), dan Canonical Correspondence Analysis (CCA) Indeks Keragaman Shannon-Weiner (H') selama waktu pengambilan sampel berkisar antara 2,3-3 yang menunjukkan ekosistem yang relatif beragam. Namun, jumlah spesies menurun dari Desember 2018 hingga Februari 2019 (27 menjadi 15 spesies). Dua puluh enam (92,9%) dari spesies ikan adalah spesies laut yang hanya menghabiskan sebagian hidupnya di air tawar sementara dua spesies (7,1%) adalah spesies yang benar-benar air tawar. Umumnya, ichthyofauna terdiri dari 28 spesies yang termasuk dalam 20 famili dan

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didominasi oleh famili Leiognathidae dan Carangidae (14,3%). Spesies yang paling banyak adalah Deveximentum megalolepis (125), Eubleekeria jonesi (107) diikuti oleh Oreochromis niloticus (48) dan sisanya diwakili oleh 40 individu dan di bawahnya. Disarankan bahwa penelitian di kemudian hari harus mencakup perbedaan temporal yang meliputi musim hujan dan kemarau.
Kata kunci: keanekaragaman; ikan; limnologi; lotic; Pulau Negros

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INTRODUCTION

Rivers are lotic (running) bodies of water that served as habitat to a diverse organisms ranging from invertebrates (e.g. mollusks and crustaceans) to vertebrates, including fishes (Dudgeon, 2000; Ward & Tockner, 2001; Fu *et al.*, 2003; Dudgeon *et al.*, 2006; Jayaratne & Surasinghe, 2010). These organisms are important resource for food to local communities, especially for poor rural families, which account for about 17% of protein and 6.7% of total food consumed global globally (FAO, 2016).

Of all primary freshwater species known globally, about 15, 000 species are believed to occupy freshwater and brackish water (Levêque *et al.,* 2007). There are unique species of freshwater fishes that are known to be confined only to isolated rivers and lakes (Paller *et al.*, 2011; Froese & Pauly, 2018) such as cyprinids, gobies, halfbeaks and pipefishes whose status in the freshwater environments is not yet fully known.

There are about 3,325 fish species currently known in the Philippines, 346 of which occur in freshwater systems, 85 species are endemic, and 50 species are introduced either for aquaculture or for aquarium trade (Froese & Pauly, 2018). Majority of the fish species found in Philippine rivers are either marine or estuarine species that spend only part of their lives in freshwater to feed and shelter (Davies, 1999).

A number of studies have been done on the riverine fish fauna of the Philippines, including those in Western and Central Visayas. Pagatban River in Basay, Negros Oriental only had 18 species in the 1980s due to pollution from copper mining operation (Alcala, 1999). More recent surveys conducted in selected river systems such as the Bago River in Negros Occidental documented 55 species, dominated by the Family Gobiidae. Jalaur River in Iloilo, Panay Island had 51 fish species (E. Alcala *et al.*, 2010). The varied number of fish species of these riverine systems could be attributed to differences in water quality as this composition served as ecological indicator of the environment associated with several parameters (Deegan *et al.*,1997; Shields *et al.*, 2000).

Fishes have been used as the central group (focal) of species in many researches on freshwater and brackish water biodiversity (Kottelat & Whitten, 1996). Fish assemblages represent integrative biological indicators of the stability of fisheries, impacts of habitat deterioration and ecosystem productivity and are prominent for their role in food chain, nutrient cycling, and regulation of biological species (Whitfield, 1996; Soto-Galera *et al.*, 1998). The adaptation to physical condition and reciprocal action with other organism determine the allocation of species and their profusion within the area. The variety of habitat affects the structure and composition (Casas *et al.*, 2016), and also entails all necessary physical factors such as temperature, water depth, current, waves and dissolved minerals. In addition, other environmental factors that affect fish biodiversity are global warming, climate change (Buisson *et al.,* 2008), extreme weather, natural and man-made pollution and incursion of exotic fishes (Dudgeon *et al.*, 2006).

The Philippines is considered one of the 17 mega-diverse countries in the world, based on high level of endemism of terrestrial flora and fauna (Mittermeier *et al.*, 1998; Ong *et al.*, 2002). The marine ecosystem of the Philippines is also well-known as the 'epicenter' of the world's marine biodiversity (Carpenter & Springer, 2005; Sanciangco *et al.*, 2013). The biodiversity of freshwater ecosystems (especially riverine systems) of the Philippines, however, remained to be studied in greater details. One such river system is Bayawan River in Negros Oriental. Furthermore, given that any species depend on the physico-chemical, hydrological and biological factors acting in an ecosystem, there is a great need to gather baseline data in Bayawan River since no scientific studies have ever done.

Aside from its importance in terms of biodiversity, Bayawan River has been providing ecological services to Bayawan City and adjacent municipalities in terms of water supply for domestic and agricultural purposes as well as in terms of fishery, .

especially in the lower reaches of the river. This study aims to assess the abundance and diversity of fishes in Bayawan River, Negros Oriental.

Specifically this study aims to: 1) identify fish species found in Bayawan River; 2) determine fish abundance and species composition in three segments of the river; 3) characterize physico-chemical and hydrological parameters of the river; and 4) correlate fish abundance and diversity with the physico-chemical and hydrological characteristics of Bayawan River.

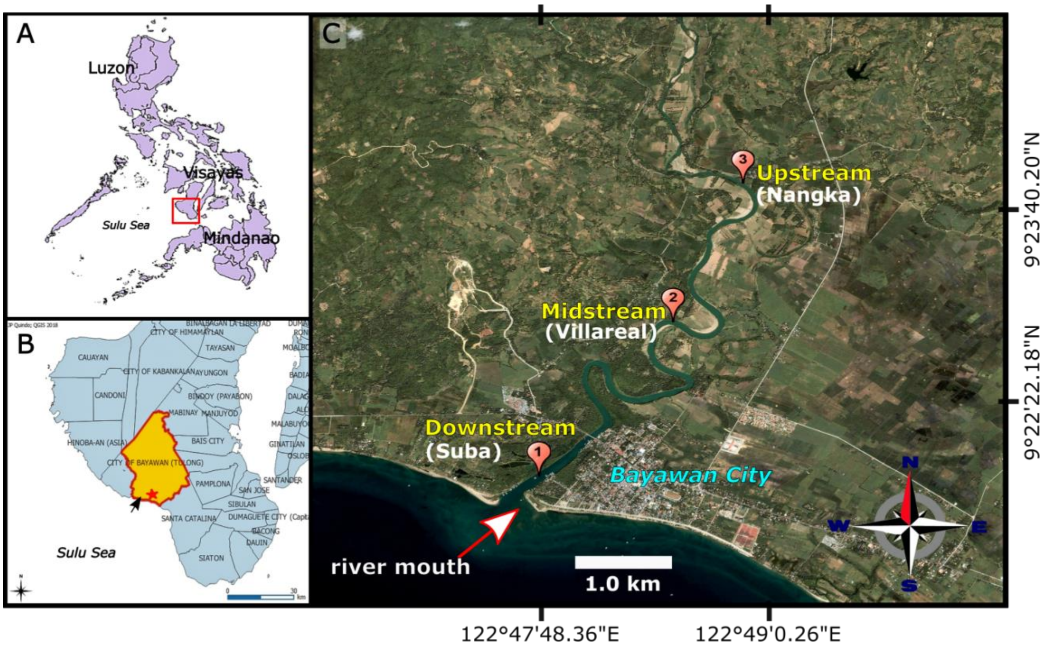

Figure 1. Map showing the location of the southern Negros Oriental (A), Bayawan (B), and the three sampling stations along the Bayawan River (C)

MATERIALS AND METHODS

Description of Sampling Stations

The main channel of Bayawan River is located roughly 0.5 km northwest of Poblacion, Bayawan City, Negros Oriental (Figure 1). This river can be considered a large river, with length extending to about 25 km and width ranging from 30 m to 150 m (near the mouth of the river). The main tributary is found in Barangay Calumbuyan. However, due to security and safety concerns, this site is at present inaccessible.

The study area was divided into three sampling stations with 4-5 kilometers interval. In each station, three replicate sampling stations were established, with about 100m from each other. The three sampling stations are the following: Suba (downstream) in Barangay Suba (9°21'29" N, 122°47'39" E); Villareal (midstream) in Brgy. Villareal (9°36'01" N, 122°83'42" E); and Nangka (upstream) in Brgy. Nangka (9°41'74" N, 122° 82' 66" E).

Suba is influenced by severe disturbance due to ferrying fishing vessels that use this part of the river for navigation on a daily basis. The river bed is predominantly muddy. Flash floods were recorded last 2013 due to Super Typhoon Yolanda (*Haiyan*), resulting to erosion of the river banks.

Villareal has extensive nipa (*Nypa fruticans*) grooves along the river banks as well as canal system (irrigation) along the rice fields at Barangay Villareal and Barangay Poblacion that drains directly towards the river. Riverbed is predominantly muddy.

Nangka has depauperate riparian vegetation cover. Bottom sediments are composed of sand and pebbles.

Table 1. Wenthworth (1992) Grade Scale.

Name		Grade Limits	
		mm	µm
Gravel	Boulder, Cobble, Pebble, Granule	> 256 - 2	
Sand	Very Coarse Sand	2 - 1	2000 - 1000
	Coarse Sand	1 - 0.5	1000 – 500
	Medium Sand	0.5 - .25	500 – 250
	Fine Sand	0.25 - 0.125	250 – 125
	Very Fine Sand	0.125 – 0.062	125 – 62
Mud	Silt, Clay	0.062 - < 0.0039	62 - < 3.9

Physico-chemical and Hydrological Parameters

The following physico-chemical parameters were measured *in situ* during three months sampling period (December 2018 to February 2019). Three readings were made for all the parameters: Sub-surface temperature (°C), *pH*, and *Total Dissolved Solids (ppm)* were measured using *KMOON* portable tri-meter. *Conductivity* (µS/cm) was measured using a hand held pen type EC meter. *Salinity* (ppt) was determined using a handheld (ATC) refractometer. *Turbidity (cm)* was measured using a an improvised Secchi disk that was made from a round can lid that measures 25cm in diameter and was attached to calibrated PVC tube that was also used to measure depth of the water (m).

River width (m) was measured using the online software (googlearthpro.com) while *water velocity (m/s)* was determined using the float method and timer (stopwatch). Particularly, an orange fruit was used as an alternative float (Michaud *et al.*, 2005) along a fixed distance (20meters) in each of the sampling sites. The time spent by the float to reach the other end of the known length of the channel was recorded and the procedures repeated at least three times.

To compute the water velocity, length of the section (m) is divided in time (s) as the float took to move through the channel:

$$V = \frac{length(m)}{time(s)}$$

Water discharge (m^3/s) was computed based on the water velocity (m) multiplied by the cross-sectional area (A= width x depth) of the sampling station and by a correction factor (0.8). This correction factor was needed to take into account the different speed in the water column due to different substrate composition.

Bottom sediment samples from each site were collected with an improvised corer (25cc syringe) and were air dried. It was then brought to the laboratory for particle size determination using a series of sieves and classification of sediments was based on Wenthworth scale (Table 1).

Fish Sampling

Fish sampling was dependent on existing indigenous fishing gears and methods. However, to avoid any biases in fish catchment, this study only uses gill net since availability of large fishing gears (e.g. dipnet) in downstream is not accessible to the other stations due to transitions of zone and stressful manipulation of the gear. Overnight immersion of the available gill net was prohibited by the Local Government Unit because Bayawan River served as transportation of large fishing vessels. Gill net was deployed for 15mins and repeated three times for each station. This was done throughout sampling period in all sampling sites. Captured specimens were fixed with 10% formalin for species identification and verification at the laboratory.

Fish identification was done up to the lowest taxon possible, following the taxonomic keys and figures in books and monographs such as Motomura *et al.* (2017), Carpenter & Niem (1999, 2001). The online database such as Fish and Agriculture Organization and FishBase by Froese & Pauly (2018) were also used as reference, especially on the updated nomenclature of each taxon.

Data analysis and Statistical Analysis

Fish species richness of the sampling station was determined using Margalef's 1958 species data index (D_{Mg})= (S-1)/InN. Wherein N is the total number of individuals and S is the number of species recorded.

Fish *diversity* based on number of species and the number of individual in each species was computed using Shannon Diversity Index (H') using the formula:

$$H' = -\Sigma\, p_i \ln(p_i)$$

Where H' = Shannon-Weiner Index, $p_i = n_i/N$
p_i = Proportional abundance of the species i
n_i = Total number of individual of species i
N = Total number of individuals of all species

Table 2. biodiversity scale from Fernando (1998).

Relative values	Shannon-Wiener index (H')
Very High	3.5-4
High	3-3.49
Moderate	2.5-2.99
Low	2-2.49
Very Low	1.99 below

Data were summarized in Microsoft Excel 2010 and using univariate statistics (e.g. mean with standard errors) in PAST v.3 software, described, and presented using basic plots and tables. To determine the influence of the environmental parameters on the abundance of fish (e.g. between stations and sampling months), the multivariate Canonical Correspondence Analysis (CCA) of (Ter Braak, 1986) was used. Otherwise, Principal Component Analysis (PCA) was used through R Studio (v1.1.419). This multivariate analysis was a direct gradient that provides representation on the underlying patterns in the distribution of the measured hysico-chemical and hydrological parameters in Bayawan River (e.g. between sampling sites and the parameters and between sampling months and the parameters).

RESULTS AND DISCUSSION

RESULTS

Physico-chemical Parameters

For three months of sampling period (December 2018 to February 2019), phyisco-chemical characteristics of Bayawan River, Negros Oriental sampling stations were measured as the results are shown on Figure 2.

Subsurface temperature ranged from 26.2-31.5°C (mean: 28.8°C), the lowest temperature was observed December with 26.2°C mainly in Station1 and nearly constant throughout other sampling months in all sampling stations. *Salinity*, on the other hand, ranged from 0.2 to 5.9 ppt (mean: 1.63ppt). Salinity level between sampling sites, downstream obtained the highest salinity level that ranged from 2.2-5.9ppt (mean: 4.4ppt) and nearly persistent on midstream and upstream throughout sampling period. The *pH* level do not vary significantly (6.7-7.1). The highest mean *conductivity* reading was observed in December, ranging from 200-544µS/cm (mean: 324µS/cm) and lowest in February (mean: 146.44±2.6 µS/cm). Conductivity reading particularly in Suba was highest, ranging from 212-544µS/cm (mean: 318.33µS/cm) among other two stations throughout three months. Total dissolved solids (TDS) throughout three sampling months ranged from 44.3-

349.3mg/L (mean: 486mg/L). Across sampling stations, the highest TDS reading was in Suba (mean: 330.1mg/L) and lowest on Nangka (mean: 192.3mg/L).

Hydrological Parameters

Five types of sediments were categorized based on the Wenthworth Grade Scale: medium sand (24%), fine sand (26.7%), silt (54.9%), clay (1.1%) and pebbles or gravel (5.4%). Sediment texture analysis showed that silt dominated in both downstream (55.6%) and midstream (58.7%) while higher percentage of fine sand (50.5%) in the upstream. Meanwhile, clay obtained the least mean percentage composition for three sampling stations: Suba (1.22), Villareal (1.22) and Nangka (0.83) (Figure 3).

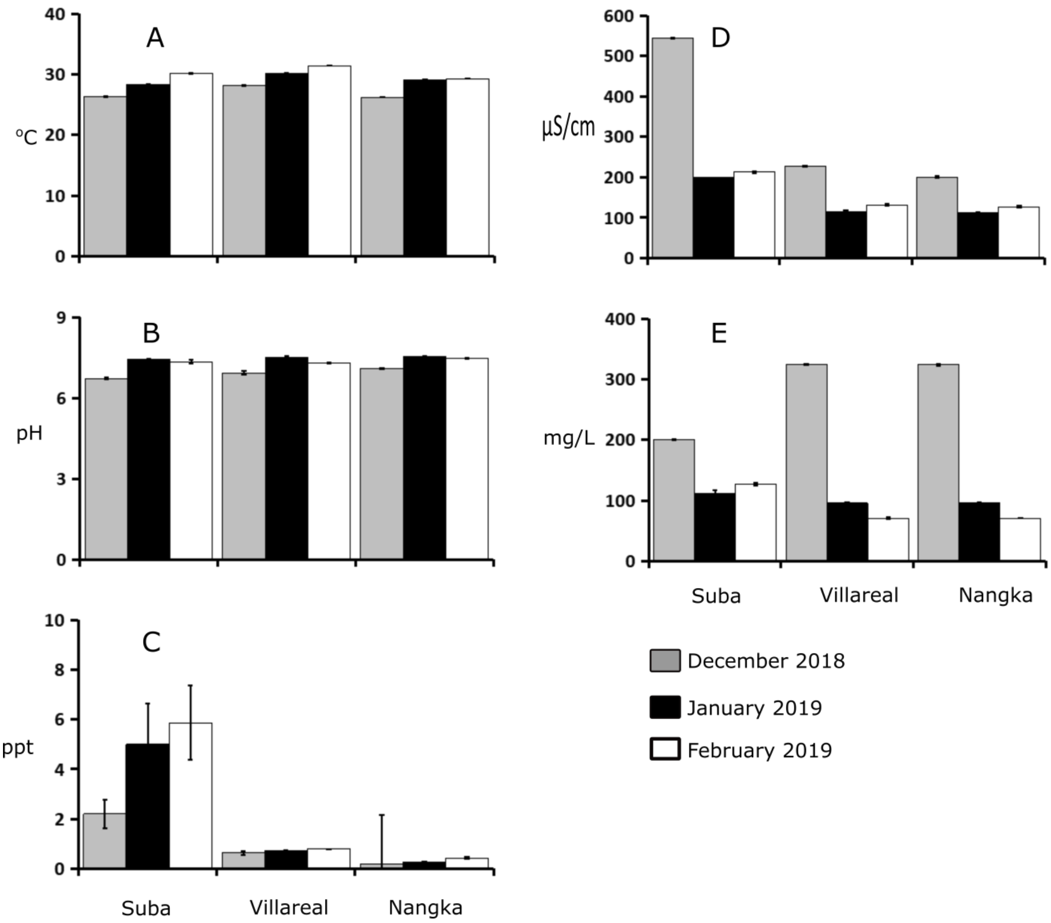

Figure 2. Physico-chemical parameters in the three sampling sites from December 2018 to February 2019 in Bayawan River (A-water sub-surface temperature, B-pH, C-salinity, D-conductivity, and E-total dissolved solids).

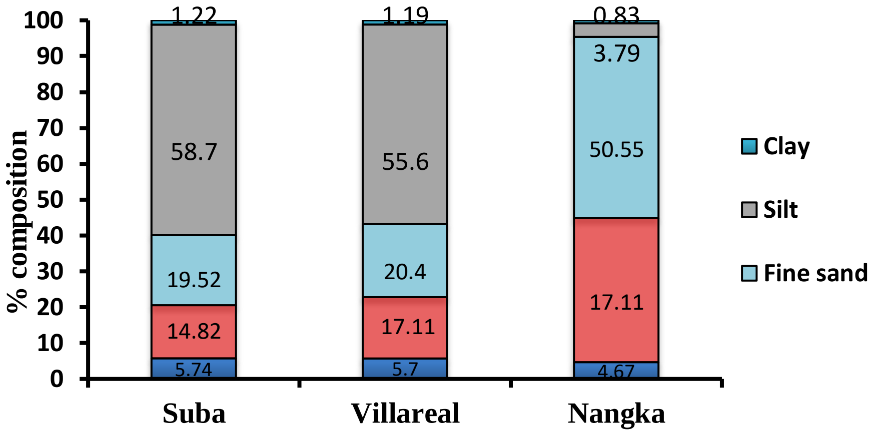

Figure 3. Mean percentage composition for each types of substrate for every station throughout three months sampling period.

Throughout the study, Suba station was found deepest with an average depth of 1.83meters (range: 0.26-2.48m) and shallowest at Nangka (mean: 0.64m). Sampling stations width varied from 51 meters to 126 m. Surface water velocity was observed fastest in Suba and Villareal with an average velocity of 0.1m/s. On the other hand, *volume discharge* was highest at Villareal (21.45 m^3/s) lowest discharge was observed in Nangka. Generally, water transparency reading was found lowest in Villareal (53.44cm) (Figure 4).

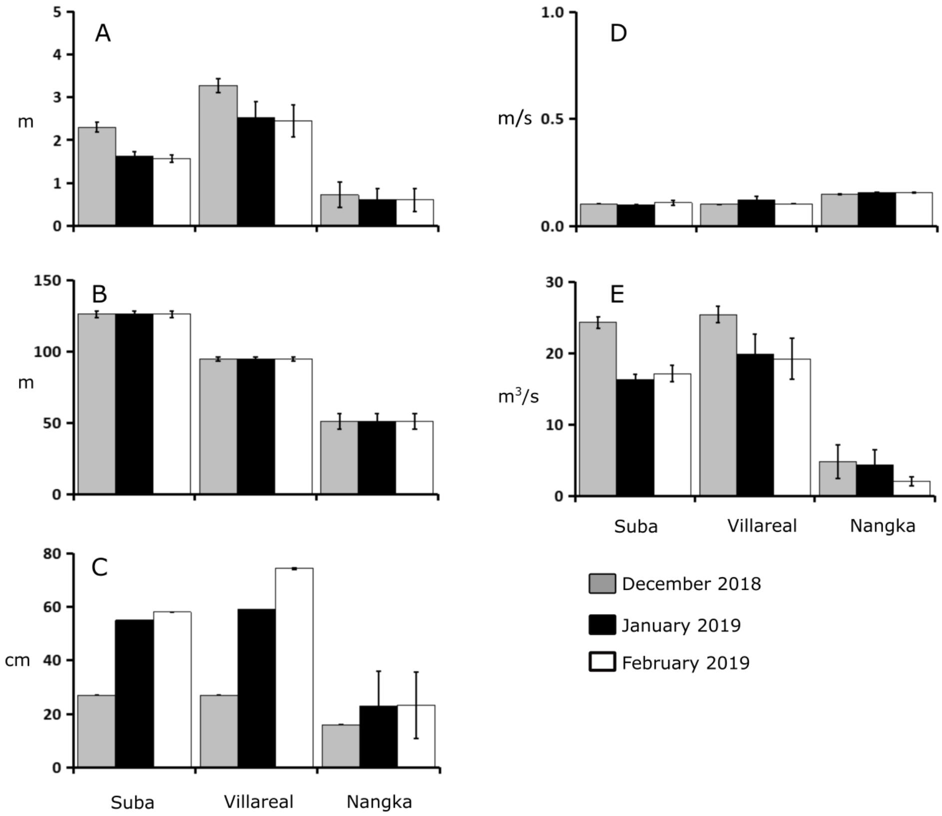

Figure 4. Hydrological measures of Bayawan River, Negros Oriental in three sampling stations. (A) water depth, (B) river width, (C) turbidity, (D) water velocity, and (E) volume discharge.

Fish species composition and abundance

A total of 670 fish specimens representing 28 species belonging to 20 families was sampled for three months from Bayawan River, Negros Oriental. Figure 6 provides a summary of different families and the number of species quantified under each family. From this graph, it was shown that families Carangidae and Leiognathidae had four species each; Lutjanidae and Mugilidae had only two species each and the remaining 16 families with a single species each. Fish catch for three months (December 2018-February 2019) shows a decreasing trend except for *D. megalolepis* and *U. molucensis.* Some species were absent throughout the following months (Figure 5). Generally, the most abundant species were *D. megalolepis* with 125 individuals; *E. jonesi* with 107 individuals and followed by *O. niloticus* with 48 individuals and the rest are of less 40 individuals (Table 3). In contrast, *G. polyuranodon* and *C. batrachus* were found once throughout the entire sampling. For three months, the site with highest species was in Suba (downstream) corresponding to 572 individuals. Nevertheless, Villareal was least represented compared to Nangka. Between months, December 2018 was found to be the most productive month with 303 individuals corresponding to 27 species, lower in January 2019 with only 24 species and lowest in February 2019 with 15 species (Table 3).

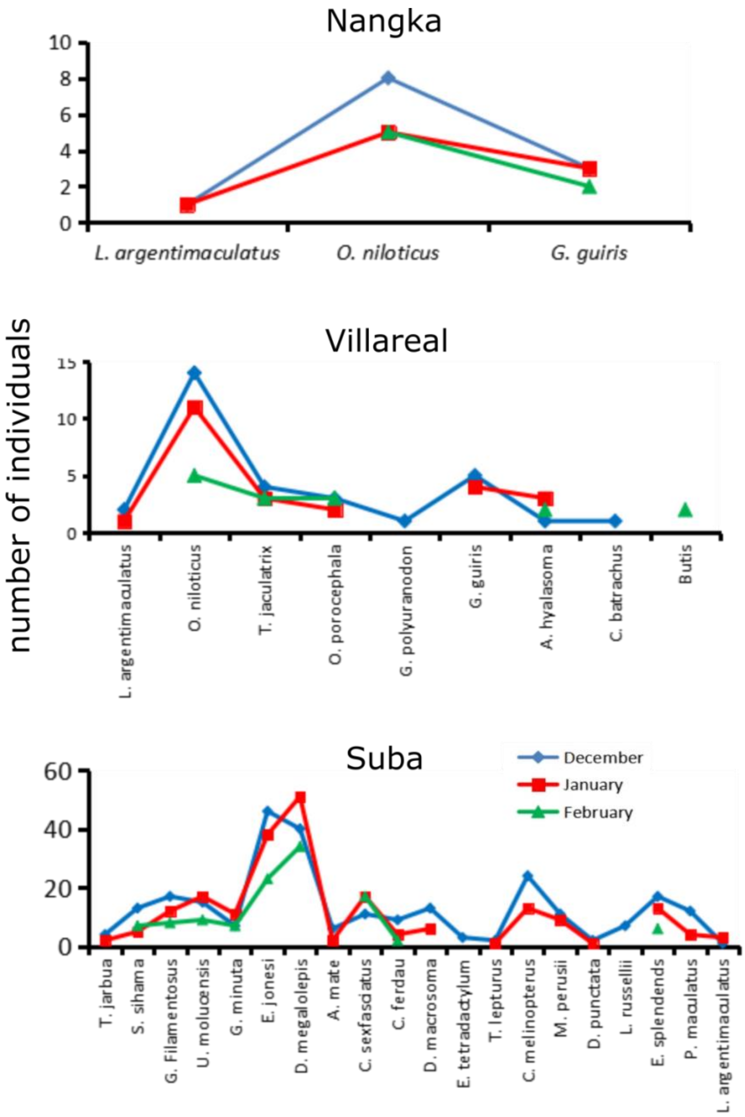

Figure 5. Abundance of fish species in every station.

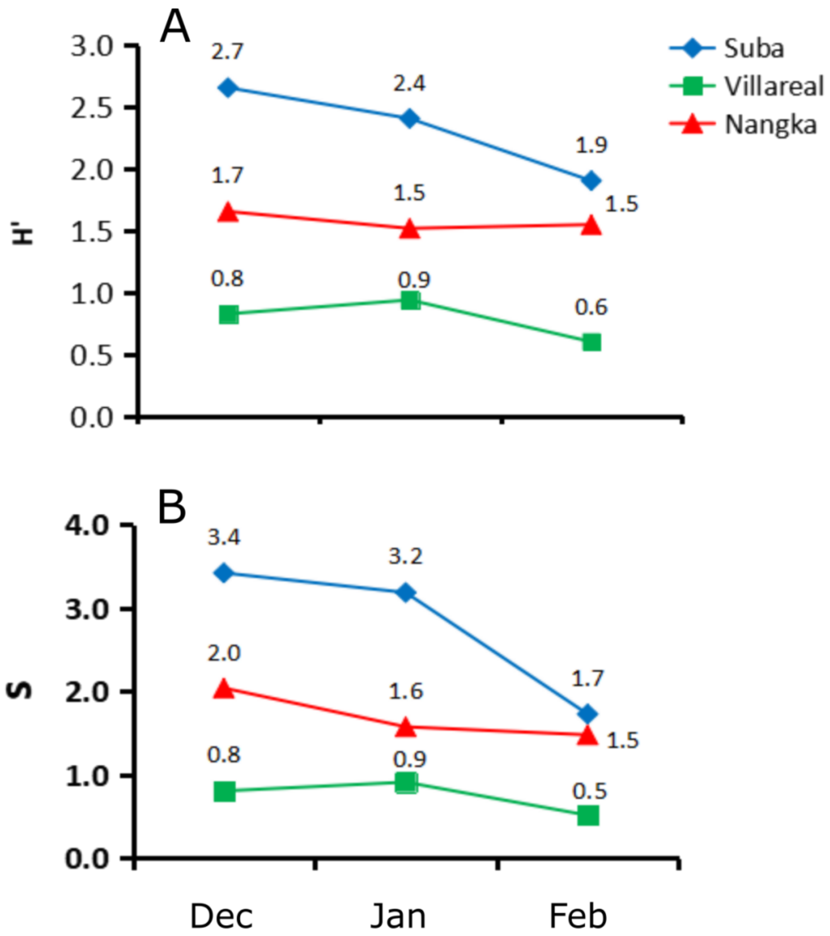

Figure 6. Diversity indeces (A-Shannon-Weiner H' index; B-Margelef's species richness) values of species for every month of sampling in Bayawan River, Negros Oriental.

Diversity

Using the Shannon-Weiner Index, the diversity of each sampling station throughout sampling period was calculated. Generally, Bayawan River, Negros Oriental H'value ranged from 0.6-2.7 (mean: H' =2.65). Highest H' value obtained was on Suba during the month of December 2018 (H'= 2.7) and decreases towards the following months. Meanwhile, Nangka was found less diverse throughout three sampling period wherein H' value ranged only from 0.6-0.8. Furthermore, a total of 28 fish species were recorded in the study. Between sampling months, fish species richness varied from 15-27 species. Highest number of species recorded was on December 2018 with 27 species. Towards following months, species quantified decreases. Using Margalef's data index, species richness was calculated which generally shows a decreasing trend in all sampling stations throughout three months (Figure 6).

Multivariate Analysis

Principal Component Analysis (PCA)

The PCA between nine parameters and sampling stations detected two components; PC1 accounts 46.5% (explained var) and PC2 29.1% (explained var). Based on the preloading pH, velocity, temperature, turbidity, and TDS are positively correlated to Component 2 whereas water depth, river width and conductivity are negatively correlated to Component 1. Moreover, Station1 was partly influenced by water width, water depth, turbidity and TDS and most of the environmental parameters greatly influenced Station2. In behalf of station3, the result has not shown any influential factors (Figure 7).

Table 3. List of fish species sampled in each station (S1-Suba; S2-Villareal; S3-Nangka) from December 2018 to February 2019.

Species	Dec 2018			Jan 2019			Feb 2019		
	S1	S2	S3	S1	S2	S3	S1	S2	S3
Atule mate	6	---	---	2	---	---	---	---	---
Butis sp.	---	---	---	---	---	---	---	---	2
Carnx sexfasciatus	11	---	---	17	---	---	7	---	---
Carangoides ferdau	9	---	---	4	---	---	2	---	---
Chelon melinopterus	24	---	---	13	---	---	---	---	---
Clarias batrachus	---	---	1	---	---	---	---	---	---
Decapterus macrosoma	13	---	---	6	---	---	---	---	---
Drepane punctata	2	---	---	1	---	---	---	---	---
Deveximentum megalolepis	40	---	---	51	---	---	34	---	---
Eleutheronema tetradactylum	3	---	---	---	---	---	---	---	---
Eubleekeria jonesi	46	---	---	38	---	---	23	---	---
Eubleekeria splendens	17	---	---	13	---	---	6	---	---
Gazza minuta	7	---	---	11	---	---	7	---	---
Gerres filamentosus	17	---	---	12	---	---	8		
Glossogobius guirus	---	3	5	---	3	4	---	2	---
Gymnothorax polyuranodon	---	---	1	---	---	---	---	---	---
Lutjanus russelli	7	---	---	---	---	---	---	---	---
Moolgarda perusii	11	---	---	9	---		---	---	---
Ophiocara porocephala	---	---	3	---	---	2	---	---	3
Oreochromis niloticus	---	8	14	---	5	11	---	5	5
Pomadasys maculatus	12	---	---	4		---	---	---	---
Sillago sihama	13	---	---	5	---	---	7	---	---
Taxotes jaculatrix	---	---	4		---	3	---	---	3
Terapon jarbua	4	---	---	2	---	---	---	---	---
Trichiurus lepturus	2	---	---	1	---	---	---	---	---
Lutjanus argentimaculatus	1	1	2	3	1	1	---	---	---
Upeneus molucensis	15	---	---	17	---	---	9	---	---
Yarica halasoma	---		1	---	---	3	---	---	2

Base on the result of the PCA between sampling months and nine environmental parameters, it detected two principal components; PC1 which explained 37% variance and PC2 which explained 30.1% variance. According to the result, environmental parameters such as conductivity, water discharge, water depth, river width were negatively correlated and pH was positively correlated to PC2 whereas salinity, TDS, turbidity, velocity were negatively correlated to PC1. Base on the findings, only conductivity influences the month of December. On the other hand, the months January and February were greatly influenced by salinity, TDS, turbidity, pH, and velocity (Figure 8).

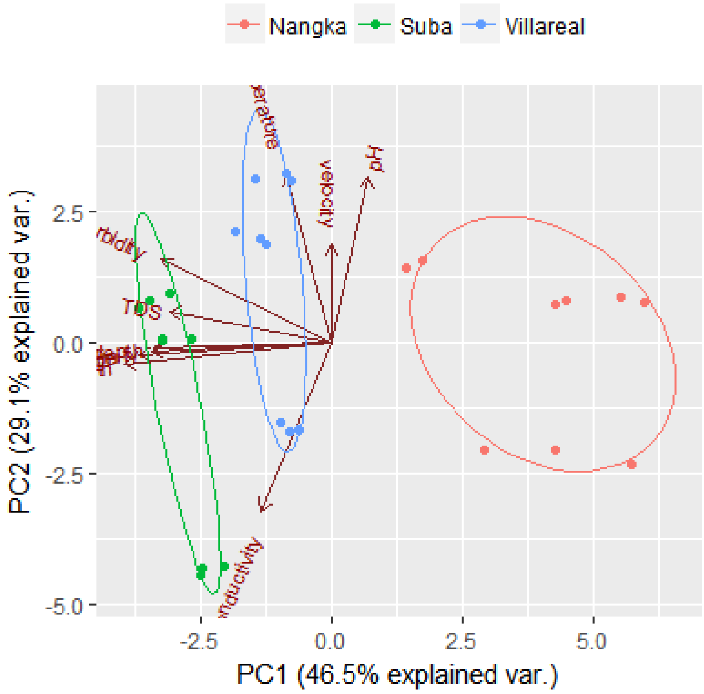

Figure 7. Principal Component Analysis showing the relationship between nine environmental parameters and the sampling stations.

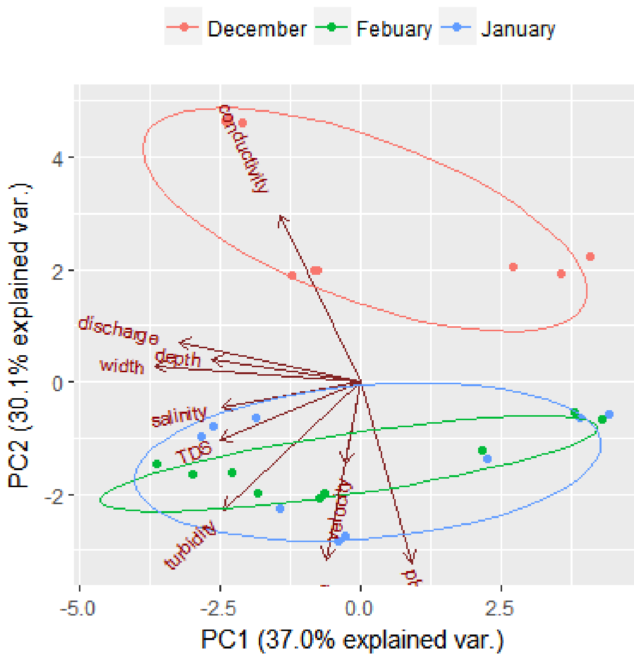

Figure 8. Principal Component Analysis between sampling months and nine environmental parameters.

Canonical Correspondence Analysis (CCA)

CCA was used to determine the relationship of 10 parameters to species abundance. Based on the CCA plot, Axis 1 explained 83.8% of the variation in the abundance of the seven species, whereas Axis 2 explained 16.2% of the observed variation. However, an eigenvalue of 0.033 in Axis 1 indicate low gradient and much more on Axis 2 which is 0.006. It can be seen that of the 10 influential parameters, 2 of which are positively correlated with Axis 1; medium sand and fine sand. On the other hand, silt and clay are negatively correlated with Axis 1. Axis 2 are positively correlated with most of the physic-chemical parameters; salinity, temperature, pH, TDS, and turbidity whereas conductivity is negatively correlated with Axis 2. *D. megalolepis*, *E. jonesi* and *O. niloticus* were the most abundant during the study. This infer that species having a score 1.05 in Axis 2 was influenced by salinity, temperature, turbidity, pH and TDS. Likewise, species with scores of 0.02 and 0.26 were influenced by conductivity (Figure 9; Table 4).

Table 4. Eigenvalues and scores of Axis 1 and Axis 2 in Canonical Correspondence Analysis.

	Axis 1	Axis 2
Eigenvalues	0.033026	0.006364
%variance	83.840000	16.160000
D. megalolepis	-0.652550	1.050050
E. jonesi	0.0223450	-1.063760
G.Filamentosus	1.6530400	0.533677
C. sexfasciatus	-1.4475800	0.245735
U. molucensis	-0.6392800	-0.103210
O. niloticus	0.2613200	-1.574200
E. splendens	2.2330600	1.032320
Salinity(ppt)	-0.1986500	0.942102
pH	-0.6244900	0.684807
EC(µS)	0.3958520	-0.853060
Temperature(?C)	-0.1512500	0.957147
Turbidity(cm)	-0.2556000	0.920885
TDS(mg/l)	-0.3201100	0.892554
Medium sand	0.4779180	0.937192
Fine sand	0.5269400	0.915914
Silt	-0.5052800	-0.925770
Clay	-0.4787400	-0.936870

DISCUSSION

Physico-chemical and Hydrological Parameters

The data presented in this study should be considered only as preliminary and can be used as baseline information for future studies. This study provided baseline data on physico-chemical (e.g. temperature, TDS, etc) as well as hydrological information (water velocity, discharge) needed to draw some become vulnerable to damage (Balek, 1983; Carumbana, 2002). Although the month of December 2018 had the lowest temperature which coincides with an increased fish abundance, long-term observations are still needed.

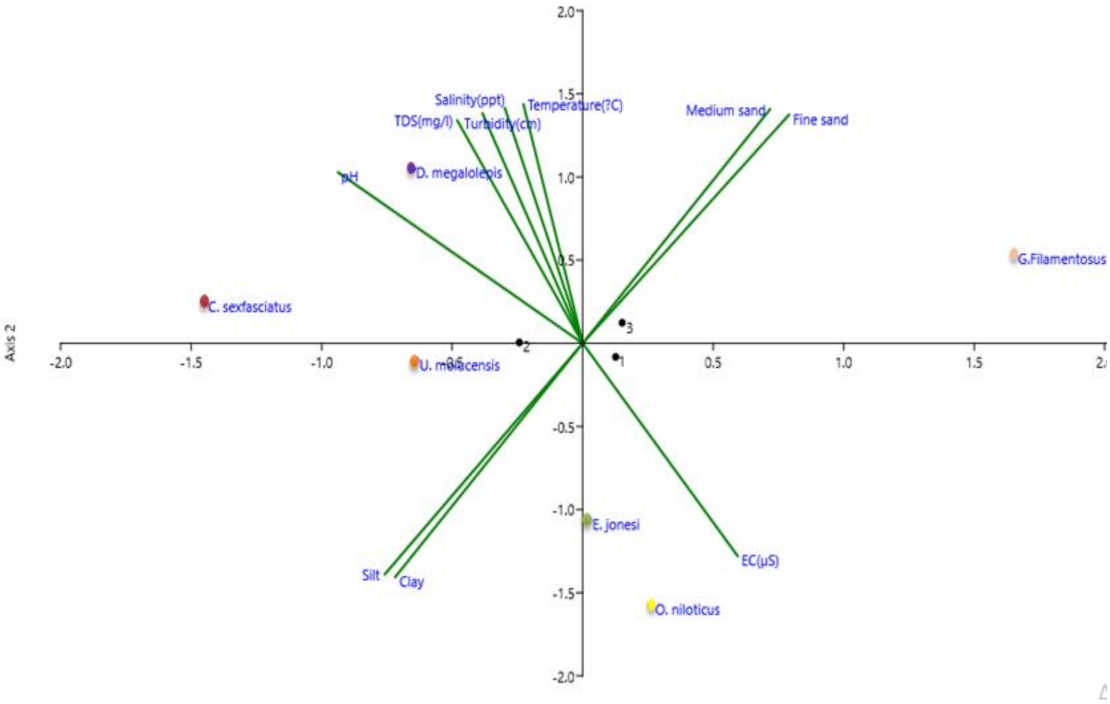

Figure 9. Canonical Correspondence Analysis (CCA) showing the relationship between parameters and species.

According to Goldman and Horne (1983), pH is considered as an indicator of overall productivity and diversity of one habitat due to the fact it affect dissolved oxygen concentration which is a prime factor of fishes. Water acidity or alkalinity is dependent on the amount of rainfall, water current, total dissolved solids (Carumbana, 2002) and the parent materials of soil. Primarily, most stream pH ranges from 6.5-8.5 which is suitable level for species diversity (Balek, 1983) which seemingly coincide to the pH of Bayawan River. The slight acidity of the river in December particularly in Suba may be caused by leaching of some ions (e.g. calcium, magnesium, potassium, sodium and ammonium), waste materials and decay of organic matter from the riverbanks and the upper reaches of the river that were drained towards the river mouth. Apparently, basicity of the river might be caused by outrage of irrigation system, anthropogenic activities (e.g. washing clothes) and siltation and weathering of rock which is rich in lime (e.g. limestone pH=9.9) capable of neutralizing the water and thereby allowing freshwater species to live and be more productive. Hence, pH value <5.0 greatly reduced fish abundance.

The amount and type of dissolved substances serve as food and nutrients for aquatic organisms which entails productivity, hence the diversity and abundance of organisms. Mean TDS value in this study throughout the three sampling months was 1460.7 mg/L which is relatively high and possibly attributed by some household and agricultural run offs (Pacalioga *et al.*, 2010). Between stations, Suba had the highest TDS value (330mg/L) throughout sampling period , probably because it is in the lower reaches of the river. Suba and Villareal were predominantly silty and more turbid throughout the three months sampling. High level of turbidity of the habitat results on low productivity and less diversity which in fact coincides to the observations in this study.

Water depth significantly varies from downstream to upstream. Suba station, for example, was found to be the deepest since it serve as the mouth of the river reach which receive most likely all the loads from the tributaries. Relatively, downstream is directly connected to marine environment which respectively allow fish species to enter river reach to breed and spawn and to feed since nutrient level in river is high compared to marine which is well assimilated. In addition, as water depth increases, it may also increase the width due to erosion of riverbanks (Pacalioga *et al.*, 2016). Bayawan River width might have received high influence impact during the typhoon Yolanda (*Haiyan)* way back 2013. Due to the widened mouth, it would neither drain a larger volume of water nor allows entry of water during high tide that would likely influence profusion of species (Pacalioga *et al.*, 2016).

The result of the multivariate PCA between environmental parameters and sampling months demonstrate that hydrological parameters were not associated partly to the sampling months but with physico-chemical parameters. The month of December was associated with conductivity probably because this month is considered as the end of the span of wet season which may be caused by the dilution of inorganic compounds in upper reaches of the river and drained in the downstream station (Pacalioga *et al.*, 2010). PCA have also shown a strong correlation between the physico-chemical and hydrological parameters between sampling stations. The middle and downstream stations were also affected by anthropogenic activities. Suba, for example, serves as transportation of fishing and cargo vessels that leads to assortment of sediments in the bottom and is prone to erosion of riverbanks during high tide, which might explain the increased turbidity of the water. Total dissolved solids were higher in downstream station since heavy loads of dissolved materials from the upper reaches of the river are drained directly in the downstream (Linaugo *et al.*, 2010). Water flow in the downstream portion of the river is expected since this station was also the deepest among three stations (Golez, 2010).

Fish Species Composition and Abundance

For three months of sampling period (December 2018-February 2019), 28 species belonging to 20 families have been recorded. Of which, about 92.9% of the fish species in Bayawan River are marine species and classified as catadromous individual or those species that spawn on marine ecosystem but spend half of their life in freshwater, particularly during juvenile stage (Carumbana, 2002). With exception to *O. niloticus* and *C. batrachus*, a true freshwater species which spawn mainly in freshwater yet able to adapt salinity of at least 25ppt as it reach their adult stage but prefer freshwater to maximize their size (Carumbana, 2002). Furthermore, *G. polyuranodon*, a rare species of the family Muraenidae (Herre, 1923) was documented in the upstream station of the river. *G. polyuranodon* is a catadromous species of marine eel, wherein juveniles have the ability to migrate 240km from the lower reach of the river to the upper reaches (Ebner et al., 2011; Tsukamoto et al., 2014).

The high number of individuals in Suba was partly due to influx of marine fish species (Allen, 1992; Davies 1999; Motomura 2017). Studies have shown that abundance and diversity of fish species tend to decrease with distance of the river from the sea (Welcomme, 1985; Carumbana, 2002).

The other aspect not covered by this study include the timing of spawning of river fishes. According to (Carumbana, 2002), breeding and spawning migration of catadromous species happens on August to February.

The result of CCA showed that the presence of some species was related to a range of particular physico-chemical parameters. Most abundant species in the study were the *D. megalolepis, E. jonesi,* and *O. niloticus.* Species under the family Leiognathidae are the most diverse in areas near mangroves and estuaries. They also inhabit muddy substrates (Motomura *et al.*, 2017).

CONCLUSIONS

In this pilot study, 28 fish species belonging to 20 families were identified throughout the sampling period in Bayawan River, Negros Oriental, Philippines. The predominant species primarily belong to families Leiognathidae and Carangidae. Majority of the fishes recorded are marine species that spend part of their life cycle in freshwater. Moreover, the biology of *G. polyuranodon,* a rare species, needs to be studied in greater details. Apart from environmental variables that may influence the abundance and diversity of fish, this study supported the notion that the number of individuals decreases as distance of the sampling site from the marine environment increases.

RECOMMENDATION

For future studies, vital physico-chemical parameters (dissolved oxygen, nutrient and chemical concentration) should be included which are greatly influential to the composition and distribution of species. The duration of the study should also be increased to cover temporal variation, particularly the on species composition between wet and dry season.

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