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FISH DIVERSITY AND PHYSICO-CHEMICAL CHARACTERISTICS OF THE MINALIN CHANNEL-PAMPANGA RIVER BASIN DURING DRY AND WET SEASON, MINALIN, PAMPANGA, PHILIPPINES

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ABSTRACT

The study was conducted to assess the species composition, abundance and diversity of fish including physico-chemical characteristics of the Minalin Channel-Pampanga River Basin during dry season (February - April 2018) and wet season (July - September 2018). Findings showed that 24 fish species (16 fresh water and 8 marine) where identified representing 16 families (9 fresh water and 7 marine). The most abundant species recorded are *E. hawaiiensis* and *S. melanotheron* during dry season. Likewise, over-all catch of species is more abundant in the dry season. This shows that dry season has higher diversity index compared to wet season. This result could be linked to the seasonality of some species in the fishing area. The seasonality is related to the biology requirements of fishes and external factors that influence these requirements. As to the physico-chemical characteristics of the river, the result of the study showed an abrupt change of salinity from 11.57 ppt in the dry season to 0 ppt in the wet season. This variation could be linked to the drop of temperature and increase of water inputs during wet season. The decrease in temperature observed during wet season could be directly linked to minimal sunlight that reaches the surface and sub-surface layer of the river caused by huge amount of precipitation. This seasonal variation in catch composition and abundance could be a function of seasonal change in habitat condition which affects diversity indices.

INTRODUCTION

Inland water plays significant role in the economy of coastal and riverine communities. These water bodies provide innumerable benefits such as essential protein source and livelihood opportunities. As a coastal province, Pampanga is endowed with numerous interconnected bodies of water that form the basin of Pampanga River. On a biodiversity standpoint, Pampanga River harbors various kinds of fishes and crustaceans. However, little is still known on the composition, abundance and catch diversity in its individual draining channels.

Fish capture is a key element for sustainable growth in riverine areas. However, reports indicated that most of the country's inland waters are already suffering from resource depletion and Minalin Channel is of no exemption. Fishing per se is a major factor that influenced the abundance of fish and productivity of lotic environments (Welcomme *et. al*., 2010). Over the past decades, inland waters' resources drastically change due to human encroachment and climate change (Andrada, 2014). Among the ecological impacts of climate change to inland waters is the reduction of flow rates which affects the dynamics of fish populations (Rytwinski *et. al*., 2017). This problem has been exacerbated by indiscriminate withdrawal for agriculture and domestic use. Thus, remaining fish resources that support the economy of riverine communities are under constant threat of decimation.

The Minalin Channel traversing several barangays of Minalin town is an important fishing ground for its ballooning population. This body of water has not been studied and explored as of date. Therefore, a study on the fish resources in this area is vital and a timely task. Absence of essential data is considered a major constraint in the formulation of appropriate management program. The temporal variation in the catch composition, abundance, and diversity of a certain gear could be used to understand the structure of fish community and its

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prevailing condition. Availability of information could ignite the discussion for the management of its local fishery to prevent further degradation and collapse of its remaining resources.

MATERIALS AND METHODS

The study was conducted at the Minalin Channel, a body of water which is part of the Pampanga River Basin in the Municipality of Minalin, Pampanga. Three sampling stations were established to monitor catch composition and relative abundance during dry (February - April 2018) and wet (July - September 2018) season. Geographical coordinates of each station were determined using a GPS receiver. The coordinates of the stations were plotted using Google Earth 2018. The 1st station is located at latitude 14°58'6"N and longitude 120°40'56"E, the 2nd station is at latitude 14°56'0"N and longitude 120°40'16"E while the 3rd station is at latitude 14°54'18"N and longitude 120°41'36"E.

Three units of *byakus* (hoop net) with identical sizes were installed in the pre-established stations. The gear is made of polyethylene net and characterized by its conical-shaped nettings allowing the filtration of huge volume of water. Setting of the gear was carried out every 15-days interval throughout each season. Setting, hauling, and monitoring of catch composition were made with the aid of a motorized *banca* (Figure 1).

Figure 1 Hauling of catch

Fishes caught during each period of sampling were identified using fishbase electronic publication (Froese and Pauly, 2013) and illustration of market fishes in the Philippines by Broad (2003). Abundance of the catch was determined through counting of individuals from each species and summing up the individual counts.

Catch composition of the gear in the study area was presented in a tabular form indicating the presence and absence of each species during dry and wet season. The relative abundance of fishes was estimated using:

$$RA\ (\%) = \frac{fi}{F} \times 100$$

where: fi is the frequency of each species into total number of individuals and F is the total number of individuals in the catch. On the other hand, differences in the abundance per species and total catch were examined examined using T-test with the aid of SPSS ver. 22.

Descriptive indices of catch diversity were also determined such as Margalef's Index of richness ((Ma= S - 1/lnN where S is the number of species and N is the total number of individuals), Shannon-Weinner Diversity index (H' = - ∑ pi ln pi wherepi is the proportion of individuals found in each specie), Simpson's Index of Dominance (D= $1/\sum pi^2$ where pi is the proportion of individuals found in each species), and Pielous Evennes Index (J' = H' / ln S where S is the total number of species and H' is the diversity value). Index calculations were based on pooled seasonal data.

RESULTS AND DISCUSSIONS

Catch Composition

Catch composition in Minalin Channel-Pampanga River Basin in both seasons is presented in Table 1. Assessment of catch composition during dry season revealed a total of 17 species of fishes belonging to 14 families while 19 species of fishes belonging to 12 families were present during wet season. Looking further at the details, majority of the fishes occurs throughout the year with few having seasonal occurrence. Most of the fishes identified are freshwater in origin (9 families) and have the capability to thrive even in brackish water environment while 7 families are sporadic visitors from marine waters (Appendix A). Species identified in this study are common in tropical waters, but some are not reported by Quiazon *et. al*. (2012) regarding freshwater fishes of Region 3. The result is almost similar with the findings of Gonzales (2017) on the *ichthyofaunal* diversity of Pasac River, Sasmuan, Pampanga.

As to seasonal distribution, it can be seen that family *Cichlidae* has the highest representation during dry season with three common species namely *S. melanotheron*, *O. niloticus*, and *O. mossambicus* (Table 1). However, it is interesting that the three species are also present during wet season. This indicates that seasonal variation is not a major factor that restricts the presence and biological activities of these species in the area. On the other hand, catch composition during wet season is dominated by family *Cyprinidae* which is composed of three species namely *C. idella, C. carpio*, and *H. nobilis* and family Cichlidae with the same species occurred in the dry season which corresponds to the findings of Rosario *et. al*. (2012) and Villanueva (2013). Surprisingly, one of the species belonging to Cyprinidae, *B. binotatus* occurred during dry season (non-existent in the wet season)which attest to the findings of Jenkins *et. al*. (2015) that the fish (medium to large) exclusively inhabits freshwater and stagnant water bodies including lotic waters with minimal flow. The presence of this fish in dry season could be attributed to the minimal volume of water receives by the river from upper-level tributaries that made the river sluggish which suffice its habitat requirement.

As to other species, the presence of *M. cyprinoides*, *A. chacunda and M. cephalus* could be attributed to the increase of salinity level during dry season and could also be linked to their absence during wet season due to non-salinity cause by tremendous volume of freshwater received by the river. The said species are considered marine in origin with migratory behavior (Froese and Pauly, 2013) that could be linked mainly to food and reproductive requirements. However, it is surprising that a freshwater eel (*Anguilla* sp.) is present during dry season in which there was marked increase in salinity. According to Froese and Pauly (2013), *Anguilla* eels are diadromous in which they require marine water during spawning, but this species occur only once during the sampling and may imply that catch is only due to chance. On the other hand, the absence of *Neogobius* sp., *Mesogobius* sp., *C. idella, C. carpio, H. nobilis* and *T. pectoralis* during dry season implies their narrow tolerance in seasonal changes. Contrastingly, other marine-originated fishes (*A. manilensis, E. hawaiensis, Sardinella sp.* and *C. chanoos*) and freshwater-originated fishes (*S. melanotheron, O. niloticus, O. mossambicus, G. giuris, L. plumbeus*, *H. plecostomus*, *C. striata* and *C. batrachus*) were present in both seasons, which indicates that environmental condition of the study sites are still in the tolerable range.

Table 1 Catch composition in Minalin Channel-Pampanga River Basin in both seasons.

Family	Species	Dry Season	Wet Season
Freshwater Fishes			
Cichlidae	*Sarotherodon melanotheron*	+	+
	Oreochromis niloticus	+	+
	Oreochromis mossambicus	+	+
Gobiidae	*Glossogobius giuris*	+	+
	Neogobius sp.	-	+
	Mesogobius sp.	-	+
Theraponidae	*Leiopotherapon plumbeus*	+	+
Loricariidae	*Hypostomus Plecostomus*	+	+
Channidae	*Channa striata*	+	+
Anguillidae	*Anguilla sp.*	+	-
Cyprinidae	*Barbodes binotatus*	+	-
	Ctenophangyrodon idella	-	+
	Cyprinos carpio	-	+
	Hypophthalmichthys nobilis	-	+
Osphronemidae	*Trichogaster pectoralis*	-	+
Clariidae	*Clarias batrachus*	+	+
Marine Fishes			
Elopidae	*Elops hawaiensis*	+	+
Megalopidae	*Megalops cyprinoides*	+	-
Ariidae	*Arius manilensis*	+	+
Clupeidae	*Anodontostoma chacunda*	+	-
	Sardinella sp.	+	+
Mugilidae	*Mugil cephalus*	+	-
Chanidae	*Chanos chanos*	+	+
Apogonidae	*Ambassis sp.*	-	+
	Species Richness	**17**	**19**

Note: (+) present; (-) absent

In general, there were 16 families representing 24 species. Comparing the richness of the two seasons, the result indicates only little variation on the number of species caught during dry and wet seasons (Table 1). However, as to the occurrence, significant disparity was observed. This result could be linked to the seasonality of some species in the fishing area. This seasonality is related to the biology requirements of fishes and external factors that influence these requirements. Variation in fish assemblages is strongly influenced by biological factors of individual species (Idelberger and Greenwood, 2005).

Catch Abundance

The catch abundance of a certain gear is directly related to the abundance of fishes in their habitat. The result on catch monitoring during dry and wet seasons is presented in Table 2. Result revealed that *E. hawaiiensis* and *S. melanotheron* are the most abundant species during dry season. The movement of *E. hawaiiensis* can be linked to its migratory behavior. The recorded abundance of the fish during dry season is a manifestation of its recruitment to the area. A younger individual penetrate freshwater bodies but does not travel far inland (Levesque, 2015). Its abundance in the catch can be also attributed to the schooling behavior of the fish in open water which made the individuals more vulnerable to capture. Almost all individuals caught during dry season are still in juvenile stage. On the other hand, *S. melanotheron, G. giuris* and *L. plumbeus* also showed great number of individuals. These species are considered euryhaline in nature and with greater economic value compared to *E. hawaiiensis*.

In terms of abundance based on pooled data, it shows that there is significant difference between dry and wet season ($p<0.05$) as shown in Table 2. Result revealed that catch is more abundant in the dry season compared to wet season. The result of the study is in conformity to the findings in Gerado and Dirma Rivers in Ethiopia (Tessema and Mohammed, 2016). According to Kolding (1985), water level can directly influence abundance of fish. Also variation in food sources, habitat condition, fishing pressure, life history and behavior of fishes can affect catch abundance of a certain gear. The result implies that catch in terms of individual frequency is abundant during dry season. This result could be linked to the rise in salinity during this season which gives opportunity to some species originated from marine water to thrive in the inner portion of the river. However, catch abundance in terms of individual frequency does not reflect catch biomass due to variations of individual sizes.

Table 2 Catch abundance in Minalin Channel-Pampanga River Basin in both seasons.

Species	Dry Season (Feb- Apr)		Wet Season (Jul-Sep)		Test of Significance	
	Fi	RA	Fi	RA	T	p
Freshwater Fishes						
Sarotherodon melanotheron	843	13.83	316	27.65	2.47	0.013*
Oreochromis niloticus	200	3.28	206	18.02	0.24	0.405
Oreochromis mossambicus	144	2.36	51	4.46	1.81	0.047*
Glossogobius giuris	892	14.63	88	7.70	1.98	0.037*
Neogobius sp.	0	0.00	7	0.61	1.34	0.103
Mesogobius sp.	0	0.00	71	6.21	2.49	0.015*
Leiopotherapon plumbeus	601	9.86	105	9.19	2.13	0.028*
Hypophthalmichthys nobilis	0	0.00	84	7.35	2.79	0.009*
Channa striata	8	0.13	21	1.84	2.07	0.025*
Anguilla sp.	1	0.02	0	0.00	1.00	0.169
Barbodes binotatus	18	0.30	0	0.00	2.37	0.019*
Ctenophangyrodon idella	0	0.00	55	4.81	2.58	0.013*
Cyprinos carpio	0	0.00	3	0.26	1.00	0.169
Trichogaster pectoralis	0	0.00	1	0.09	1.00	0.169
Clarias batrachus	1	0.02	9	0.79	1.66	0.061
Marine Fishes						
Elops hawaiensis	2883	47.29	15	1.31	3.57	0.002*
Megalops cyprinoides	22	0.36	0	0.00	2.22	0.024*
Arius manilensis	350	5.74	8	0.52	2.26	0.022*
Anodontostoma chacunda	1	0.02	0	0.00	1.00	0.169
Sardinella sp.	2	0.03	1	0.09	0.59	0.279
Mugil cephalus	39	0.64	0	0.00	4.66	0.000*
Chanos chanos	40	0.66	83	7.26	3.16	0.003*
Hypostomus Plecostomus	52	0.85	18	1.57	3.44	0.002*
Ambassis sp.	0	0.00	3	0.26	1.00	0.169
Total catch (F)	6,097	100.00	1,145	100.00	5.40	0.033*

Catch Diversity

Descriptive indices of catch diversity are presented in Table 3. Margalef's index showed very high values in both seasons. However, looking deeper to the result can be seen a slight variation. Higher value was recorded in the wet season which could be linked to the richness during this season as to pooled data. Margalef's index has no limit value and depends on the number of species present in a community. This index is commonly used to compare species richness in sampling sites (Kocatas, 1992), however, can be used also to determine variation in temporal comparisons.

In terms of Shannon-Weinner Index, dry and wet seasons recorded 1.661 and 1.598, respectively. This shows that dry season has higher diversity index compared to wet season. The Shannon-Weinner index commonly varies from 0 to 3.5. According to Nath and Patra (2015), values greater than one (1) indicates favorable environment for fish survival. The result may imply that the condition of the environment where the sampling gears were installed in both seasons suited to the physiological requirement of fish. The diversity and distribution of fish is a function of biotic and abiotic factors (Paul and Meyer, 2001).

With respect to Simpson's index of dominance, lower values recorded in both seasons suggesting the dominance is shared by small number of species. This result can be directly linked to the abundance of only few species in both seasons. This index ranges from 0 to 1, in which the closer to 0 exhibits low diversity and stressful environment (Dash, 2003). Based from the result, wet season recorded higher index of dominance compared to dry season. This means that greater number of fish species shows dominance during wet season.

As to Pielou's evenness index, greater value was noted in the dry season. However, both seasons recorded values not closer to one (1) suggesting that fishes are not evenly distributed in the catch. This result could be linked to the dominance of some species.

Table 3 Descriptive Indices of catch diversity.

Descriptive Indices	Dry Season	Wet Season
Margalef's Index (Ma)	16.882	18.858
Shannon-Weinner Diversity index (H')	1.661	1.598
Simpson's Index of Dominance (D)	0.362	0.392
Pielous Evennes Index (J)	0.586	0.543

The values obtained only represent the diversity of catch using *byakus* and can't be used to indicate the diversity of the fish community as a whole in the body of water. According to Magurran (2004), diversity of fishes in a certain area is strongly affected by sampling methods. Although the gear used in this study is not target specific, the gear still represents certain level of error in sampling.

Physico-Chemical Characteristics

The results indicated in Table 4 showed no significant difference ($p>0.05$) on the water depth and dissolved oxygen (DO). Moreover, temperature and salinity bared significant variation ($p<0.05$). The pH of the area where the experimental gear was installed did not show any change along the course of the study. Comparable values obtained for water depth may be attributed to the connection of the study site to other minor rivers and creeks that directly drained to Manila Bay. In spite of the huge amount of rainfall and run-off receives during wet season, water level is still comparable to dry season because of the constant volume of water flowing towards other water bodies and eventually ended up into the sea.

As to temperature, the decrease observed during wet season could be directly linked to minimal sunlight that reaches the surface and sub-surface layer of the river caused by huge amount of precipitation, which corresponds to the findings of Abowei (2009); the discovery in Ghat River and Moi-Vaal Network, South Africa (Naseema *et. al*., 2013; Manyatshe *et. al*., 2016); and by Vijayakumar *et. al*. (2014), who reported similar results as to the seasonal temperature of Thengaithittu estuary. This water quality parameter is a major factor that controls the metabolic rate, distribution, and biological activities of organisms (Jayakumar *et. al*., 2009). The temperature observed in the two seasons is within the range, which accord to the findings of Albaster and Lloyd (1980).

In terms of DO, only a slight change was noted which brought an insignificant result, which was not in accordance to the findings of Braide *et. al*. (2004), Naseema *et. al*. (2013) and Manyatshe *et. al*. (2016) showing lowest level of DO during dry season and summer periods. The result of the previous studies was directly linked to the rise in temperature during dry season that lessens the oxygen-holding capacity of the water. This disparity could be linked to the amount of vegetation, area covered, and anthropogenic activities within the range of their study and the present one. Comparable values obtained from this study can be attributed to the primary use of the river as a mode of transportation and fishing area. The movement of various floating crafts that causes disturbance and diffusion of atmospheric oxygen on water surface despite of higher degree of temperature observed during dry season. The level of DO during dry season is within the optimal range of 5.0-9.0 mg/l (Offem *et. al*., 2011). On the other hand, the DO concentration during wet season fell below this range. However, the value obtained in both seasons is within the recommended threshold levels (3.0-5.0 mg/l) of the parameter to support biological components of estuarine areas (Vijayakumar *et. al*., 2014).

With regard to pH, there was no change observed in all sampling periods for dry and wet seasons. This result could be linked to the method used in assessing the pH of water. Colorimetric method is only sufficient to provide rough estimate (Higgins, 2014). However, pH in both seasons is slightly alkaline. This result is congruent with the findings of Manyatshe *et. al*. (2011) for pH during wet and dry season in Moi-Vaal Network in South Africa and with Aquino *et. al*. (2016) and Gonzales (2017) for man-made and natural bodies of water with no consideration on seasonal bounds. The level of pH could be related to the constant movement of water in which it carries organic matter towards the coastal areas. In general, the pH of the river is within the range (6.5-9.0) reported by Offem *et. al*. (2011) for natural waters in which not directly harmful to aquatic life. Moreover, pH of water is an important parameter that influences other components of water quality.

Salinity is regarded a parameter that affects the abundance of organisms in estuaries (Marshall and Elliot, 1998). This parameter also fluctuates in wide variations as a result of various interacting factors such as rainfall, river discharge and tide. The study site is considered an estuary because of seasonal entry of saline water from Manila Bay via connecting channels. The result of the study showed an abrupt change of salinity from 11.57 ppt in the dry season to 0 ppt in the wet season. This variation could be linked to the drop of temperature and increase of water inputs during wet season which conform to the findings of Vijayakumar *et. al*. (2014). However, disparity was noted on the report of Idelberger and Greenwood (2005) with maximum salinity of Mayakka and Peace Rivers between May and June while the minimum was between August and November. The result on salinity variation may imply that catch composition and abundance may differ as also described by Flannery *et. al*. (2002) for tidal rivers.

Table 4 Show the water quality characteristic between wet and dry season 2018.

Parameter	Mean		T-value	p
	Dry	Wet		
Water Depth (ft)	18.21	20.90	-3.21	0.08
Temperature (°C)	28.70	26.83	11.96	0.01*
Dissolved Oxygen (mg/L)	5.96	4.88	1.54	0.26
pH	7.6	7.6	-	-
Salinity (ppt)	11.57	0.00	13.16	0.00*

* - Significantly different at 5% level

CONCLUSION

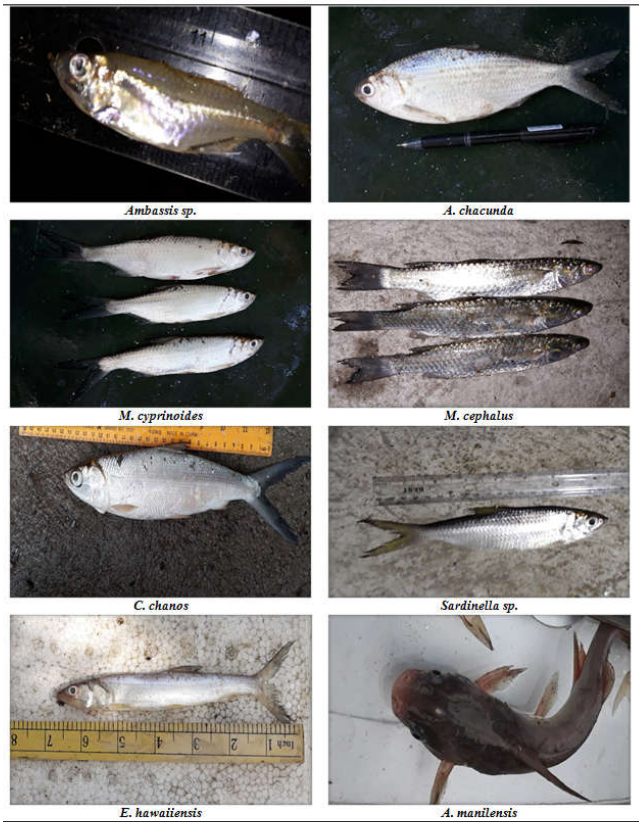
Based on the assessment, 24 species (16 fresh water fishes and 8 marine fishes) where identified representing 16 families (9 fresh water fishes and 7 marine fishes) of the Minalin Channel-Pampanga River Basin during dry and wet season, however abundance varied seasonally. Result revealed that *E. hawaiiensis* and *S. melanotheron* are the most abundant species during dry season. Furthermore, result showed that over-all catch of species is more abundant in the dry season as compared to wet season. Comparing the richness in the two seasons, the result indicates only little variation on the number of species caught during dry and wet seasons. However, as to the occurrence, significant disparity was observed. This shows that dry season had higher diversity index compared to wet season. This result could be linked to the seasonality of some species in the fishing area. This seasonality is related to the biology requirements of fishes and external factors that influence these requirements.

As to the physico-chemical characteristics of the river, temperature and salinity bared significant variation. The study site is considered an estuary because of seasonal entry of saline water from Manila Bay via connecting channels. The result of the study showed an abrupt change of salinity from 11.57 ppt in the dry season to 0 ppt in the wet season. This variation could be linked to the drop of temperature and increase of water inputs during wet season. The decrease in temperature observed during wet season could be directly linked to minimal sunlight that reaches the surface and sub-surface layer of the river caused by huge amount of precipitation. This seasonal variation in catch composition and abundance could be a function of seasonal change in habitat condition. Also, this fluctuation affects diversity indices.

Appendix A. Diversity of freshwater and marine fishes of the Minalin Channel-Pampanga River Basin.

A. Freshwater Fishes

Marine Fishes



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