# Freshwater fishes found in Pajo-Sto. Domingo River system in Catanduanes Island, Philippines

[1,3,4]Jimmy T. Masagca, [2]Imaculate T. Latorre, [3,4]Mark Lorenz S. Trinidad

[1] Natural Science Department, College of Arts and Sciences, Catanduanes State University, Catanduanes, Philippines; [2] Catanduanes National High School, Department of Education, Virac 4800, Catanduanes, Philippines; [3] Commission on Higher Education (CHED) National Agriculture and Fisheries Extension System (NAFES) funded program on Sustainable Resource Use of Mangroves and Biodiversity Conservation (SURMABIOCON) and CHED - Institutional Development and Innovation Grant (IDIG) for Building a Culture for Publishing Research of Higher Education Institutions Program, CHED K to 12 Transition Program; [4] President's Initiative for the Popularization of Environmental Research & Services (PIPERS) Committee, Catanduanes State University, Catanduanes, Philippines. Corresponding author: J. T. Masagca, jtibarmasagca@gmail.com; jtmasagca@catanduanesstateu.edu.ph

**Abstract**. The topic on freshwater resources on the rivers and lakes in the Philippines is strangely under researched despite its economic and ecological importance. There is very little research on freshwater fish biota in the numerous islands of the archipelago that this paper will remedy this omission. Field works were done from October 2017 to February 2018 to determine the freshwater fish resources found in Pajo-Sto-Domingo (PSD) river system in Virac, Catanduanes Island, Luzon. A total of 12 families (Ambassidae, Anguillidae, Atherinidae, Cichlidae, Cyprinidae, Eleotridae, Gobiidae, Mugilidae, Channidae, Osphronemidae, Sparidae, Terapontidae); 18 genera and 20 species of fish fauna were identified in the study areas, higher than the previous studies. The most speciose families are Cyprinidae, Gobiidae and Mugilidae, with three species each, followed by Ambassidae and Eleotridae with two species each, and then the rest of the families with one species each.
**Key Words**: Catanduanes, diversity, fish abundance, fish fauna, freshwater systems, streams.

**Introduction**. The review of Magbanua et al (2017) provided indications that further research is needed in freshwater systems wherein organisms thriving in rivers and streams have been neglected in the Philippines. From a total of 281 papers reviewed, only 78 papers were on freshwater fish and the rest were on zooplankton (Aquino et al 2008), and algal bloom occurrence in Laguna de Bay lake (Baldia et al 2003). It was Papa & Mamaril (2011) who traced the history of biodiversity and limno-ecological studies on Lake Taal and have recommended the need for more in depth researches about this inland body of water in the Philippines.

Despite the importance of biodiversity in rivers in tropical Asia, this has been neglected compared to its temperate counterpart (Dudgeon 2000a; Dudgeon et al 2006). Recent situations indicate that these aquatic ecosystems have suffered from intense human intervention resulting in habitat loss and degradation and as a consequence many fresh water and estuarine fish species have become heavily endangered (Dudgeon 2000b; Strayer & Dudgeon 2010; Magbanua et al 2017).

In many southeast and east Asian countries like the Philippines and India, river basins receive heavy demand for the economic and industrial uses of fresh water. This is coupled with irreversible changes in natural population by introduction of exotic species and diseases (Pusey et al 2004; De Silva et al 2006; Dudgeon et al 2006). River conservation and management activities in most countries suffer from inadequate knowledge of the constituent biota. Therefore, research is being pursued on river biota to develop conservation planning to protect freshwater biodiversity. This concern was pursued globally by Margules & Pressey (2000), Lipsey & Child (2007), and Kennard et al (2010). As claimed three decades ago, rivers in Asian countries support a rich but barely known biota such as the fish fauna. While they serve significant functions in human populations, tropical rivers remained poorly understood and studied (Kottelat & Whitten 1996).

In the Philippines, recent studies have been done by some institutions putting premium on the biodiversity analysis of some riverine systems. In Negros island a total of 55 species of fish belonging to 33 families were observed (Pacalioga et al 2010). There are also a number of unique species of freshwater fishes that are known to be confined only to isolated rivers and lakes in the country (Herre 1953; Paller et al 2011). These unique species are the gobies, halfbeaks and pipefishes whose status on these freshwater environments is not yet fully known as revealed by Herre (1953) and Butler (2006). Froese & Pauly (2010) stressed that the most diverse group among the freshwater fishes in the Philippines are gobies, with 16 species found only in the country (Froese & Pauly 2010; Eschmeyer 2011). Worth mentioning is the world's only known freshwater sardine, *Sardinella tawilis* occuring only in Taal Lake (Herre 1927; Hargrove 1991). The Philippines is also having a species of rice fish from the family Adrianichthyidae, *Oryzias luzonensis* (Herre & Ablan 1934; Froese & Pauly 2010). Paller et al (2011) assessed the freshwater fish fauna in the watersheds of Mt. Makiling Forest Reserves which updated the list of freshwater fish found in Mt. Makiling. Guzman & Capaque (2014) carried out a study on Bugang River, which is recognized as one of the cleanest rivers in the Philippines and a popular tourist destination in Panay Island for its Malumpati Health Spring and Tourist Resort, however Bugang River's biota is not well known. The study revealed the occurrence of thirty-eight (38) species in the river belonging to thirty (30) genera and twenty (20) families. Eleotridae was the most dominant family, with six species, followed by Gobiidae (four species). The fishes were also ecologically classified based on their origin and tolerance to saltwarer, indicating that majority of the fishes were sporadic visitors. Migratory fishes were also seen representing a minor proportion of the population.

There is a paucity of published work on the freshwater fishes in Catanduanes. However, the works of Masagca (1999), Masagca et al (2016) and an on-going project called *Balik Sigla sa Ilog at Lawa* (BASIL) funded by the Philippine Bureau of Fisheries and Aquatic Resources Regional Office No. 5 profile the river resources and describe semi- and wholly freshwater fishes in the island. There is no serious published study that tackles fish composition of rivers in this island of the Bicol region in Luzon. Thus, this work on a river in Virac, Catanduanes Island.

**Material and Method**. The study site is located in the island province of Catanduanes in Bicol region in Luzon, Philippines lying between 13.5$^o$and 14.1$^o$N latitude stretching to 124$^o$ to 124.5$^o$ E longitude. It is bounded on the east by Maqueda Channel, the Lagonoy Gulf on the south and the Philippine Sea on the north and east. Catanduanes has 38 river systems, Pajo River popularly known as Pajo-Sto. Domingo river is the second largest river of the province in terms of catchment area. It is located at 13$^o$35'30" N latitude and 124$^o$10'01" E longitude in the southwest part of the capital town of Virac that runs through from barangay Dugui San Vicente to barangay (= village) of Pajo. Weather condition in the island is characterized by two seasons – wet and dry. Siltation and turbulence of water on some parts were observed. People living around the area is dependent upon the river for agriculture, quarrying, fishing and domestic use.

Four sampling sites were established in the Pajo-Sto. Domingo river system in Virac, Catanduanes, Philippines. These sampling sites are headstream (HDS), upper midstream (UMS), lower midstream (LMS) and downstream (DWS) areas. These sites were selected based on the distance from the river mouth towards the estuarine-linked Pajo-Sto. Domingo river.

***Sampling methods, preparation and examination of samples***. The four sampling sites were examined and four collection spots were selected randomly. Fish samples were collected four times a month or weekly from November 2017 to February 2018 using gill net, hook and line, scoop net and the use of fish traps made of bamboo. Sampling was carried out during day time and night time. Fish samples were placed in plastic bags, labeled and placed in cooler with cracked ice before transporting to the CSU-CHED NAFES SURMABIOCON laboratory for sorting and processing. Initial identification was done *in situ* and documentation was carried-out by getting photos of the fish specimens.

***Water quality parameters***. Water quality parameters were determined following Brillante & Masagca (2018, 2019). Water samples used in determining the physico-chemical characteristics of PST river system were collected from the study sites established. Collection of water samples was done twice in November 2017 and February 2018. In December 2017, the collection was done once due to heavy rains and weather disturbances causing rough seas which made it impossible for the researcher to gather the water samples. Physical data collections were made at each study site through the water column using Amphibia 2 Eureka probes Instrument. Seven parameters generated by this gadget were used in determining water quality, namely: temperature, conductivity, turbidity, pH, chlorine, ammonia, and dissolved oxygen. The quality of water was assessed in accordance with the Philippine Department of Environment and Natural Resources (DENR) standards issued in 2016. Simple frequency count and arithmetic mean were used in the analysis of data.

***Fish identification***. Collected samples were identified in the laboratory facilitated by various references such as Migdalski & Fichter (1976), Masuda et al (1984), Conlu (1986), Randall (1995), Matsuura et al (2000), and Carpenter & Niem (1999a, b). After identification, the specimens were fixed with 10% formalin solution and photographed for further analysis and identification (Motomura & Ishikawa 2013). Representative specimens were stored in glass jars and deposited in the Reference Collections of the CHED NAFES Program. Further, all specimens were identified based on the classification system of Nelson (2006) and scientific names were verified using http://www.fishbase.org.

***Analysis of the fish composition***. In some instances, captured fish samples were released after recording of data except for a few individuals which needed to confirm species identifications in the laboratory. The fish diversity indices were calculated following the formula of Shannon & Wiener (Rosenzweig 1995):

$$H' = -\sum_{i=1}^{S} p_i \ln p_i$$

where: H' is the species diversity index, s is the number of species, and pi is the proportion of individuals of each species belonging to the ith species of the total number of individuals.

A data matrix was constructed with presence and absence of fish species for each of the four sampling stations in the downstream (estuarine) and upstream (riverine) areas. Other analyses were carried out by determining biodiversity index parameters, namely: (1) Density = total number of individual of species in all collecting station ÷ the total number of collecting station studied; (2) Relative density = number of individuals of one species ÷ total number of all individuals counted X 100; (3) Frequency = number of collecting station in which the species occurs ÷ total number of collecting station sampled; (4) Relative frequency = frequency of one species ÷ total frequency of all species x 100; (5) Abundance = total number of individual of a species in all collecting station divided total number of collecting station in which species occurs; (6) Relative abundance = the abundance of one species ÷ total all species counted x 100. These formulae were obtained from the American Museum of Natural History (https://www.amnh.org/learn-teach/curriculum-collections/biodiversity-counts/).

**Results and Discussion**. Physico-chemical characteristics of the four sampling areas are shown in Table 1.

Table 1

Summary data for the different physical, chemical and some biological parameters of water samples from the head stream (HDS), upper midstream (UMS), lower downstream (LDS) and downstream (DWS) (Oct 2017 to Feb 2018)

| *Parameters* | *2017* | | | *2018* | | *Mean* |
|---|---|---|---|---|---|---|
| | *Oct* | *Nov* | *Dec* | *Jan* | *Feb* | |
| Temperature | 29.06 | 29.00 | 28.31 | 28.77 | 28.53 | 28.73 |
| pH | 8.125 | 7.99 | 7.91 | 7.754 | 7.785 | 7.91 |
| Sp Cond (uS $cm^{-1}$) | 183.3 | 183.1 | 209.1 | 198.16 | 197.625 | 194.26 |
| Chlorine (mg $L^{-1}$) | 8.175 | 7.3 | 8.05 | 7.52 | 6.6 | 7.53 |
| $NH_4$ (mg $L^{-1}$-N) | 0.2325 | 0.2525 | 0.2375 | 0.204 | 0.1925 | 0.22 |
| $NO_3$ (mg $L^{-1}$-N) | 1.6675 | 1.6925 | 1.745 | 1.64 | 1.6325 | 1.68 |
| Blue-green algae (cells $mL^{-1}$) | 0.8925 | 0.8875 | 1.29 | 1.252 | 1.665 | 1.20 |
| Chlorophyll (ug $L^{-1}$) | 0.325 | 0.3025 | 0.455 | 0.366 | 0.445 | 0.38 |
| HDO (mg $L^{-1}$) | 8.685 | 8.69 | 8.36 | 8.61 | 8.6275 | 8.59 |
| HDO%Sat | 117.95 | 126.7 | 119.5 | 115.74 | 117.25 | 119.43 |
| Turbidity (dig NTU) | 10.90 | 18.67 | 17.89 | 9.702 | 14.0075 | 14.23 |
| pH (Mv) | -53.80 | -53.05 | -53.45 | -55.62 | -53.325 | -53.85 |
| ORP (Mv) | -0.5825 | -0.595 | -0.5675 | -0.58 | -0.4775 | -0.56 |
| Sp Cond (mS $c^{-1}$) | 0.21275 | 0.2065 | 0.24875 | 0.1196 | -0.0855 | 0.14 |

Between October 2017 to February 2018, the range of water temperature was berween 28.31 and 29.06$^{o}$C, with average temperature was at 28.73$^{o}$C. This is warmer than the temperature of Cagayan river in northern Philippines with 28.0$^{o}$C in November 21, 2021 (https://tides4fishing.com/as/philippines/aparri-cagayan-river#_water_temp). Temperature change - either seasonal or daily - is a common phenomenon in aquatic environments. Fish, which are critically important inhabitants of aquatic environments, cannot avoid temperature changes, hence, adaptations, acclimatization, and physiological responses against temperature changes are the only survival techniques of fish (Rahman et al 2021). In Singapore, the warmest water temperature reaches 30.0°C and in coldest in January with an average water temperature 27.4°C, which is lower than the river temperature in Pajo-Sto. Domingo river system from 2017 to 2018. Water temperature can fluctuate diurnally and seasonally, in Asan, India water temperature varied from 20.66 to 25.14°C from December to May (Sofi et al 2018), which is much lower that the present study in Catanduanes Island.

As shown in Table 1, pH is slightly basic at 7.91 in the river under study which is higher at 7.51 in India (Sofi et al 2018). For most freshwater species, a pH range between 6.5 and 9.0 is ideal, but most marine animals typically cannot tolerate as wide range pH as freshwater animals, thus the optimum pH is usually between 7.5 and 8.5 (Boyd & Tucker 1998). The pH is an important parameter in sediment quality monitoring as it governs most of the chemical reactions that take place in soil and water (Sofi et al 2018).

Conductivity reading during the study period from October 2017 to February 2018 was 194.26 uS $cm^{-1}$. Distilled water maintains a conductivity of 0.5-3 us $cm^{-1}$, and inland freshwaters range is 150-500 us $cm^{-1}$ (Behar 1996). River conductivity ranges between 50 and1500 us $cm^{-1}$, and estuaries, salt lakes, and oceans have much higher conductivity levels; and in polluted industrial water may be as high as 10,000 us $cm^{-1}$, but high conductivity alone doesn't tell you whether your aquatic ecosystem is impacted by pollution (USEPA 1996).

The chemical parameters of the water in the four collection sites showed mean values of 7.53 mg $L^{-1}$ for chlorine; 0.22 mg $L^{-1}$ for ammonium, and nitrates ($NO_3$) at 1.68 mg $L^{-1}$. Ammonia is the initial product of the decomposition of nitrogenous organic wastes and respiration, while nitrogenous organic wastes come from uneaten feeds and excretion of fishes (Boyd & Tucker 1998). According to Lawson (1995) high concentrations of ammonia cause an increase in pH and ammonia concentration in the blood of the fish, damaging the gills, the red blood cells, affecting osmoregulation, and reducing the oxygen-carrying capacity of blood.

Other parameters were also determined using the Eureka probes showing the mean values of turbidity at 14.23 dig NTU. The universally accepted unit of measurement of turbidity in water is 'NTU', which is the abbreviation for 'Nephelometric Turbidity Units'. NTU is a measurement of the scattered or reflected light through a sample of the water in an instrument called the Nephelometer (https://www.waterprobes.com/) included in the Eureka probes used in this study at Catanduanes State University. When there is more suspended solids or more turbidity, more light is scattered from the water sample and you get a higher value. So a higher NTU reading means that the water is more turbid. Most water standards like EPA and WHO set the allowable maximum value for NTU at about 0.1 NTU.

The dissolved oxygen (DO) reading was known to be 8.59 mg $L^{-1}$ or HDO% saturation at 119.43. Blue green algae population was estimated at 1.20 cells $mL^{-1}$ and chlorophyll was 0.38 ug $L^{-1}$. Blue-green algae (= cyanobacteria) occur naturally in lakes, rivers and ponds (Stone & Bress 2007). According to WHO (1999), these microscopic organisms are components of the aquatic food chain. Moreover, in ordinary circumstances, cyanobacteria do not cause harm, but in warmer water temperatures and high nutrient concentrations causing rapid increase in abundance (Oberholster et al 2004; Bláha et al 2009).

After having discussed these physico-chemical parameters for this estuarine-linked river in Catanduanes island, it can be stressed that rivers are important in maintaining the balance of the ecosystem and are also a main source of water for humans and animals. Rivers also play an important role in assimilating or carrying away industrial or municipal wastewater, run-off from agriculture area, sewage from urban areas, and any other anthropogenic factors (Nurul-Ruhayu et al 2015). Thus, they are said to be vulnerable to pollution as the river systems are connected to the other coastal wetlands and the terrestrial systems having potential sources of materials.

Pajo-Sto. Domingo river system is a shallow and narrow river system compared to the larger systems in the Philippines. This river system crosses the municipality of Virac and ends in the estuarine river area of Palnab with some mangrove areas (Masagca 1999). There is a sort of a high degree of homogeneity that may exist for various physical, chemical parameters and biological features such as blue green algae describing primary production in shallow steams or rivers. This is manifested by the lack of variability in the water temperature, pH readings and to some extent the DO obtained in the course of the study

***Different taxa of fishes found in four sampling areas****.* During the data collection, a total of 20 species belonging to 18 genera and 12 families of fishes were obtained. Table 2 presents the different fish families, genera and species obtained from four sampling stations.

Table 2

Summary of the families, genera and species of fishes from Santo Domingo River

| *Family* | *Genus* | *Species* | *Local name in the Philippines* |
|---|---|---|---|
| Ambassidae | *Ambassis* | *A. interrupta* | Langaray |
| | | *A. gymnocephalus* | Langaray |
| Anguillidae | *Anguilla* | *A. japonica* | Kasili |
| Atherinidae | *Atherinomorus* | *Atherinomorus* sp. | Guno |
| Cichlidae | *Oreochromis* | *O. niloticus* | Tilapia |
| Cyprinidae | *Cyprinus* | *C. carpio* | Karpa |
| | *Cyclocheilichthys* | *C. armatus* | Karpa |
| | *Barbodes* | *Barbodes* sp. | Karpa |
| Eleotridae | *Eleotris* | *E. fusca* | Biya |
| | *Giuris* | *G. margaritacea* | Bungog |
| Gobiidae | *Awaous* | *A. ocellaris* | Biya |
| | | *A. melanocephalus* | Biya |
| | *Gobius* | *G. paganellus* | Biya |
| Mugilidae | *Crenimugil* | *C. seheli* | Balanak |
| | *Planiliza* | *P. melinoptera* | Baranak |
| | *Mugil* | *M. cephalus* | Balanak |
| Channidae | *Channa* | *C. striata* | Haluan |
| Osphronemidae | *Osphronemus* | *O. goramy* | Gurami |
| Sparidae | *Acanthopagrus* | *A. berda* | Berda |
| Terapontidae | *Leiopotherapon* | *L. plumbeus* | Silver therapon |

***Composition and abundance of freshwater fishes in Pajo-Sto. Domingo river.*** Based on the number of species in each family and genus, the most speciose (number of species) families are Cyprinidae, Gobiidae and Mugilidae, with three species each, followed by Ambassidae and Eleotridae with two species each, and then the rest of the families with one species each.

Table 3 presents the frequency of individual fishes caught in Pajo-Sto. Domingo River where the most abundant species was *C. seheli* (Mugilidae) with 16.04% abundance, followed by *O. niloticus* with abundance of 13.21% (frequency of 14 fish samples) and *P. melinoptera* (Mugilidae) with the abundance of 11.32% while the species *A. monocephalus*, *A. berda* and *L. plumbeus* got the lowest frequencies.

Table 3

Summary of the frequency rank as to frequency of occurrence of fishes caught during the collection periods according to families, genus and species of fishes from an ELRIS: Pajo-Santo Domingo in Virac, Catanduanes

| *Family* | *Freq* | *%* | *Rank* | *Genus* | *Species* | *Freq* | *%* | *Rank* |
|---|---|---|---|---|---|---|---|---|
| Ambassidae | 3 | 2.83 | 6 | *Ambassis* | *A. interrupta* | 2 | 1.88 | 10 |
| | | | | | *A. gymnocephalus* | 1 | 0.94 | 11 |
| Anguillidae | 3 | 2.83 | 7 | *Anguilla* | *A. japonica* | 3 | 2.83 | 9 |
| Atherinidae | 2 | 1.88 | 8 | *Atherinomuros* | *Atherinomorus* sp. | 2 | 1.88 | 10 |
| Cichlidae | 14 | 13.21 | 4 | *Oreochromis* | *O. niloticus* | 14 | 13.21 | 2 |
| Cyprinidae | 6 | 5.66 | 6 | *Cyprinus* | *C. carpio* | 2 | 1.88 | 10 |
| | | | | *Cyclocheilichthys* | *C. armatus* | 2 | 1.88 | 10 |
| | | | | *Barbodes* | *Barbodes* sp. | 2 | 1.88 | 10 |
| Eleotridae | 15 | 14.15 | 2 | *Eleotris* | *E. fusca* | 5 | 4.71 | 7 |
| | | | | *Giuris* | *G. margaritacea* | 10 | 9.43 | 8 |
| Gobiidae | 10 | 9.43 | 3 | *Awaous* | *A. ocellaris* | 4 | 3.77 | 8 |
| | | | | | *A. monocephalus* | 2 | 1.88 | 10 |
| | | | | *Gobius* | *G. paganellus* | 4 | 3.77 | 8 |
| Mugilidae | 37 | 34.90 | 1 | *Crenimugil* | *C. seheli* | 17 | 16.04 | 1 |
| | | | | *Planiliza* | *P. melinoptera* | 12 | 11.32 | 3 |
| | | | | *Mugil* | *M. cephalus* | 8 | 7.55 | 4 |
| Channidae | 8 | 7.55 | 5 | *Channa* | *C. striata* | 8 | 7.55 | 4 |
| Osphronemidae | 6 | 5.66 | 6 | *Osphronemus* | *O. gorami* | 6 | 5.66 | 5 |
| Sparidae | 1 | 0.94 | 9 | *Acanthopagrus* | *A. berda* | 1 | 0.94 | 11 |
| Terapontidae | 1 | 0.94 | 9 | *Leiopotherapon* | *L. plumbeus* | 1 | 0.94 | 11 |
| Total: | 106 | 100.00 | | | Total: | 106 | 100.00 | |

**Conclusions**. A total of 12 families, 18 genera and 20 species of fish fauna were identified in the study areas higher than the previous studies. From the total of 106 individual fish obtained from the study areas, the most speciose are the families Mugilidae, Gobiidae and Eleotridae. Although the findings of the study reveal normal ranges of the water quality, other parameters such as *E. coli*, sediment analysis and pesticide residues can be carried out in the future. Moreover, a thorough analysis of the domestic wastes can be done in the future.

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**Conflict of interest**. The authors declare that there is no conflict of interest.

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Authors:
Jimmy T. Masagca, Natural Science Department, College of Arts & Sciences, Catanduanes State University, Virac 4800, Catanduanes, Philippines; e-mail: jtibarmasagca@gmail.com; jtmasagca@catanduanesstateu.edu.ph
Imaculate T. Latorre, Catanduanes National High School, Department of Education, Virac 4800, Catanduanes, Philippines, e-mail: imaculate.latorre@gmail.com
Mark Lorenz S. Trinidad, CHED-NAFES SURMABIOCON Project and CHED-IDIG Building the Culture of Research and Publishing BCPRO Program, Commission on Higher Education K to 12 Transition Program Institutional and Development and Innovation Grant Program, Philippnes; e-mail: tmarklorenz@gmail.com

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