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Freshwater Fish Assemblages in Palico-Lian River, Batangas, Southern Luzon, Philippines

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ABSTRACT The Palico-Lian River in Batangas, Southern Luzon, Philippines is a designated critical watershed and a major communal fishing ground, yet baseline information on its freshwater fish assemblages remains limited. This study conducted a rapid bioassessment to document species composition, diversity, and associated water quality parameters in the three sampling sites along the studied river continuum. Fish were collected using multiple gear types, and water samples were analyzed following standard procedures. A total of 15 species were recorded, with introduced species (9 taxa) comprising the majority of the assemblages, particularly *Oreochromis niloticus* and *Cyprinus carpio*. Native taxa were more abundant in the downstream section and included secondary freshwater fishes such as gobies (*Glossogobius aureus*), slipmouths (*Leiognathus equula*), and perchlets (*Ambassis interrupta*). Diversity indices varied among sites, with Site 3 exhibiting the highest Shannon diversity (H'=2.377) and evenness (J' = 0.923), while Site 2 showed lower diversity (H' = 1.622) and greater dominance by a few introduced species. Sample-based rarefaction confirmed significantly higher richness at Site 3. Water quality analysis revealed exceedances of ammonia, biological oxygen demand, chloride, and sulfate particularly at the midstream and downstream sites as attributed to nutrient enrichment and saline intrusion. Overall, results indicate a gradient in fish assemblages shaped by both native and introduced species. These findings provide essential baseline data for biomonitoring and conservation management of the Palico-Lian River system.

KEY WORDS Biodiversity; conservation; native ichthyofaunas; rarefaction; water quality.

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INTRODUCTION

The Lian-Palico River, traversing the municipalities of Tuy and Lian in Batangas is a major freshwater system in the Southern Tagalog Region. With an annual runoff volume of approximately 295 million cubic meters and a drainage area of 184 km², it is designated as one of the 140 critical watersheds in the Philippines and one of 23 priority river systems in the Southern Luzon region (Paringit & Uy, 2017). Its hydrological significance is featured by its role in supporting agricultural productivity and domestic water needs in surrounding agro-industrial communities (Briones et al., 2016). Moreover, the river serves as a communal fishing ground for subsistence and is classified under Class C waters which are intended for fishery use, recreational activities, and industrial water supply after treatment.

Despite its ecological and socio-economic importance, recent findings from the Department of Environment and Natural Resources-Ecosystems Research and Development Bureau indicated significant degradation of water quality. The river has been reported to contain coliform and organic pollutant concentrations that exceed the permissible limits for Class C waters, suggesting deteriorating conditions potentially harmful to aquatic biota and human health (Paringit & Uy, 2017). These findings raise concerns regarding the sustained ecological integrity of the river system and the viability of its use for fishery and other ecosystem services.

Despite the Palico-Lian River designation as a critical watershed and its importance to the agro-industrial and subsistence activities of the region, there remains a lack of empirical data on the composition, distribution, and diversity of its ichthyofaunal resources (Garcia et al., 2024). There is a paucity of baseline data on freshwater fish assemblages for Palico-Lian riverine ecosystem and this lack of bioassessment may result to difficulty in assessing the ecological status of the river and the degree of environmental and anthropogenic disturbance on aquatic biodiversity (Corpuz et al., 2015) The absence of socio-ecological data undermines initiative to detect early signs of habitat degradation and to design appropriate conservation and management strategies (Llave et al., 2018; Corpuz & Espaldon, 2023). For these reasons, this study aimed to fill this information gap through a rapid bioassessment of fish diversity and abundance including the evaluation of water quality parameters of Palico-Lian river.

MATERIAL AND METHODS

Study area

The Palico-Lian River (also known as Lian River) originates in the highlands of Nasugbu and Tuy, Batangas, particularly from slopes of Mounts Batulao and Carilao (Batangas, Philippines) and flows toward the coastal municipality of Lian before emptying into the West Philippine Sea (Nasugbu Bay) (Fig. 1). During the study, the landscape use / coverage was predominantly agricultural (sugarcane, grains, and coconut) with interspersed rural residential and small built-up areas. Rural residential and built-up stripped along barangay (village) roads and the municipal center; light industry was present but limited relative to agriculture. The river had a sandy to muddy bottom and the banks in either side are primarily lined by bryophytes, and perennial weeds. A large proportion of inhabitants residing in the riverbanks were engaged in fisheries, farming, and livestock raising.

Collection of Fish and Water Samples

Wild fish samples were collected in the three sampling sites using a combination of cast nets, hook-and-line, scoop nets, gill nets, and a 12-backpack electrofishing gear interchangeably operated by local fisherfolks. Each sampling activity lasted approximately 60 minutes and was conducted during daytime (900–1500 h). Collected specimens were placed in Styrofoam boxes containing ice and river water, then immediately transported to Bataan Peninsula State University for further identification. Taxonomic identification of fishes was performed using standard ichthyological references (Froese & Pauly, 2023).

Water samples were obtained from the mid-surface layer of the river using sterile polyethylene bottles. Laboratory analyses were conducted to determine biological oxygen demand, phosphate, fecal coliform, ammonia, chloride, color, oil and grease, nitrate, sulfate, and total dissolved solids (ELARSI Standard and Testing Laboratory, Quezon City, Philippines). *In-situ* monitoring of dissolved oxygen, water temperature, turbidity, and pH were carried out using calibrated hand-held devices.

Data Analyses

Fish faunal biological indices were computed for each sampling site. Species richness was determined by the number of fish species present in each sampling site. The relative abundance for each species was calculated as:

$$\text{Relative abundance} = \left(\frac{a_i}{A}\right)100\%$$

where: a_i is the number of specimens collected in the *i*-th species and A is the total number of species collected in one sampling area during. Diversity index was computed following the Shannon-Weiner diversity index (*H'*):

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

where: s is the number of species; p is the proportion of specimens found in the *i*-th species and

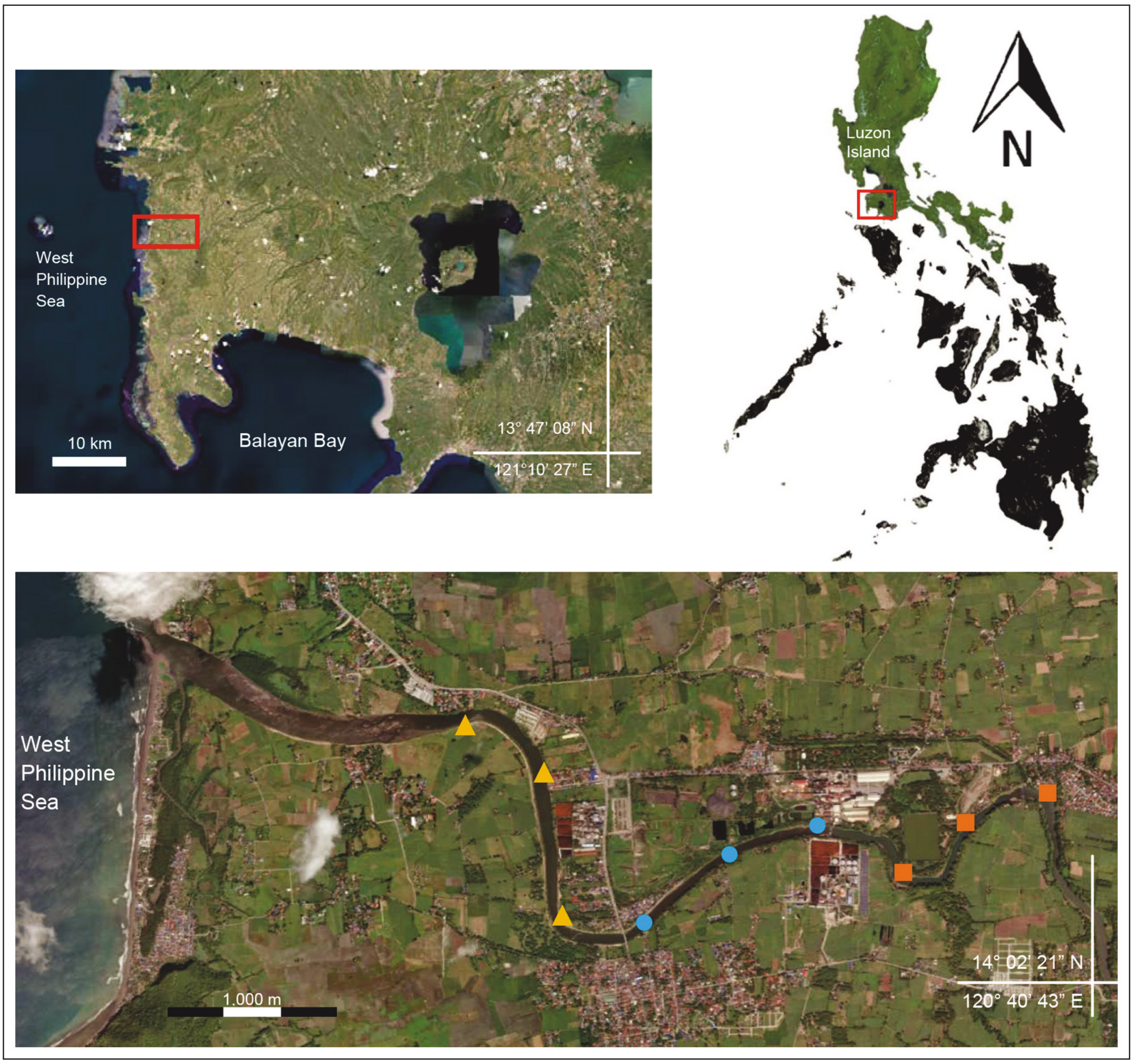

Figure 1. Map of Batangas in Luzon Island, Philippines showing the studied locations.
Sites 1 (■), sites 2 (●), and sites 3 (▲).

ln is the natural logarithm. Evenness (J') was computed following the Shannon's diversity index:

$$J' = \frac{H'}{\ln S}$$

where: S is the total number of species. Species dominance was computed using the Simpson's index formula (λ):

$$\lambda = \sum_{i=1}^{S} \frac{n_i\,(n_i - 1)}{N\,(N-1)}$$

where: s is the number of species, n_i is the number of specimens in the *i*-th species and *N* is the total number of specimens.

To compute the catch per unit effort (CPUE, kg h^{-1}) on an hourly basis, the catch weight or number by the fishing time was normalized:

$$CPUE = \frac{Fish\ Catch\ (kg)}{Fishing\ Effort\ (h)}$$

Sample-based rarefaction from which species richness is to be estimated as a function of number of samples was analyzed using the method of Colwell et al. (2004). In the graphical plot, the standard errors are converted to 95 percent confidence intervals.

RESULTS AND DISCUSSION

Fish composition and abundance

This rapid fish bioassessment recorded at least 15 fish species belonging to twelve families (Table 1; Fig. 2). Fish species composition was largely composed of introduced species (nine species), and predominated by cichlids in terms of fish composition (three species) and abundance (about 80% of the total catch) in all sampling sites. Nile tilapia (*Oreochromis niloticus*) was abundant in the upstream (about 90% by number), whilst Blackchin tilapia (*Sarotherodon melanotheron*) were common in the downstream site (45%). An introduced cyprinid (*Cyprinus carpio*) ranked second to cichlid family. These species, along with other native taxa, constituted an important source of subsistence fisheries for local communities inhabiting the studied river, a pattern consistent with the findings of Corpuz and Espaldon (2023).

The dominant fish communities are primarily dependent on lower trophic organisms such as plankton (Gido & Franssen, 2007; Corpuz et al., 2016). The successful establishment of these species indicates that the river's ecological condition remains capable of sustaining abundant plankton populations, thereby supporting the growth and reproduction of associated fish assemblages. Native fishes with broad salinity tolerance, classified as secondary freshwater species, were particularly abundant in the downstream section. Their presence is indicative of a favorable ecological status of the river system (Karr & Dudley, 1981). Moreover, no physical deformities or signs of disease were observed among the sampled fishes.

Fish Diversity

Overall, the Palico-Lian River exhibited a relatively high diversity index ($H' = 1.97 \pm 0.38$) (Table 2), which exceeded the reported diversity scores from rivers along the west of Luzon Island, Philippines (Romero et al., 2016; Roque et al., 2019; Corpuz et al., 2024). In comparison, the adjacent Pansipit River, a major river system in Batangas, recorded a higher diversity index ranging from 2.17 to 3.05 (Corpuz et al., 2016).

The H' values varied among the sampling sites: Site 3 (2.377) showed the highest diversity, followed by Site 1 (1.903), and Site 2 (1.622). The high diversity scores correspond to both high richness and more equitable distribution of specimens across species (Krebs, 1999). The Equitability Index (*J*) conforms this gradient, where Site 3 had the highest evenness (0.923), suggesting a balanced community structure, while Site 2 (0.833) reflected moderate dominance by fewer species. This was corroborated by the Dominance Index that was lowest in Site 3 (0.104), and highest in Site 2 (0.247) indicating that a few species (likely introduced fish species) were disproportionately abundant. Consistent with the findings of Garcia et al. (2006), the present study demonstrated that fish assemblage dominance was driven by introduced fish taxa. Moreover, these findings align with Corpuz et al. (2015, 2025), who observed that higher diversity and evenness are found in upstream or vegetated river sections, while sites closer to human activity or aquaculture inputs exhibit low diversity and higher dominance by non-native species. Similarly, Roque and his colleagues (2022) emphasized the importance of water quality and habitat heterogeneity in shaping fish community structure in riverine environment.

Site 1 recorded the highest CPUE (4.53 kg h^{-1}), indicating greater fish biomass that was primarily attributed to the presence of larger-bodied introduced species. These species are widely utilized in aquaculture and are highly valued as food fish (e.g. tilapia, catfish, and carps), which underscores considerable contribution to the observed biomass.

Native and introduced fish species

Figure 3 illustrates the relative abundance of native (black bars) and introduced (grey hatched bars) fish species in the three sampling sites. A clear gradient in species composition and relative abundance was observed along the river continuum. In the upper reaches (Site 1), native species, predominated by catfish were relatively higher compared to introduced species. Toward the river mouth (Site 3), closer to the sea, native fish species became dominant comprising the majority of the fish assemblages. These native assemblages were largely composed of secondary freshwater fishes such as

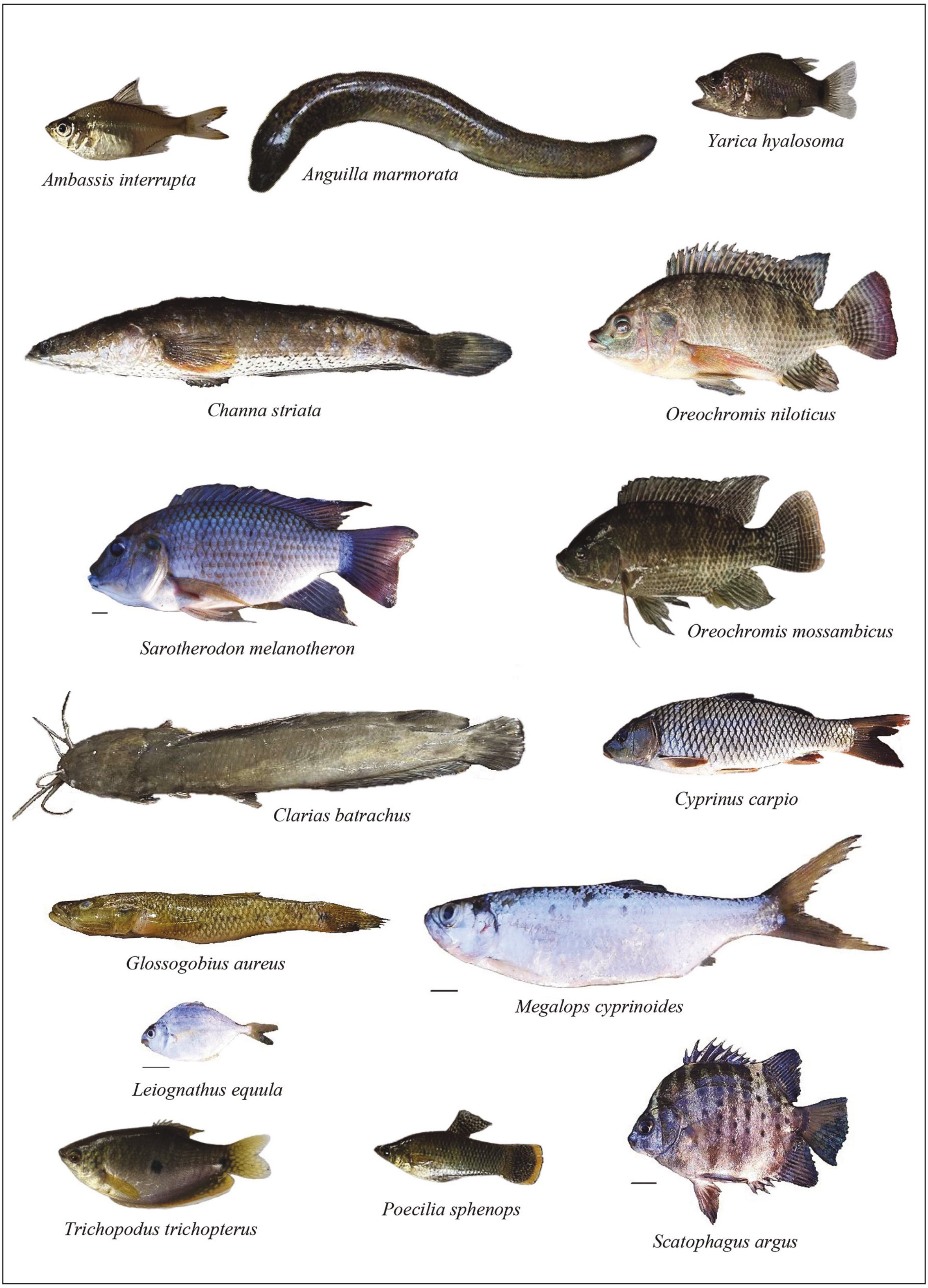

Figure 2. Photos of representative fish samples collected from Palico-Lian River Systems, Batangas, Philippines.

gobies, slipmouths, and perchlets (in order of importance). The dominance of these taxa in similar riverine and estuarine habitats has also been reported in previous studies (Paller et al., 2011; Corpuz et al., 2013, 2025).

Rarefaction

Figure 4 presents sample-based rarefaction curves of species richness (Taxa S) in the three studied sites and normalized by sample size. Site 3 consistently exhibited the highest expected richness across all sampling intensities reaching an asymptote of approximately 14 species. This indicates both greater diversity and evenness. While yielding the greatest specimen count (52 specimens) in Site 1, it plateaus at only 9 species which suggested dominance by a few abundant taxa. Site 2 had the lowest richness, plateauing around 7 species with the least sampling effort (30 specimens), indicating a more homogeneous community. The 95 percent confidence intervals diverge notably at higher sample sizes, particularly between Site 3 and the other two. This analysis supports that Site 3 is ecologically richer and may potentially by less impacted by anthropogenic pressures, whereas Sites 1 and 2 may be under environmental stress or largely dominated by introduced species (Goteli et al., 2001; Meijer et al., 2024).

Family	Species	Common Name/ Local name	Origin of species	Sampling sites		
				1	2	3
AMBASSIDAE	*Ambassis interrupta* (Bleeker, 1853)	Long-spined glass perchlet / Langaray	Native			+
ANGUILLIDAE	*Anguilla marmorata* (Quoy et Gaimard, 1824)	Giant mottled eel / Igat, palos, kasili	Native	+		+
APOGONIDAE	*Yarica hyalosoma* (Bleeker, 1852)	Humpbacked cardinalfish / Dangat	Native			+
CHANNIDAE	*Channa striata* (Bloch 1793)	Striped snakehead / Dalag, bulig	Introduced	+	+	+
CICHLIDAE	*Oreochromis niloticus* (Linnaeus, 1758)	Nile tilapia / Tilapya, pla-pla	Introduced	+	+	+
CICHLIDAE	*Sarotherodon melanotheron* (Rüppell, 1852)	Blackchin tilapia / Arroyo, gloria	Introduced	+	+	+
CICHLIDAE	*Oreochromis mossambicus* (Peters, 1852)	Mozambique tilapia / Native tilapia	Introduced			+
CLARIIDAE	*Clarias batrachus* (Linnaeus, 1758)	Philippine catfish / Pantat, hito, paltat	Introduced	+	+	
CYPRINIDAE	*Cyprinus carpio* (Linnaeus, 1758)	Common carp / Karpa	Introduced	+	+	+
GOBIIDAE	*Glossogobius aureus* (Akihito et Meguro, 1975)	Golden tank goby / Bia	Native	+	+	+
MUGILIDAE	*Megalops cyprinoides* (Broussonet, 1782)	Indo-Pacific tarpon / Bulan-bulan	Native			+
LEIOGNATHIDAE	*Leiognathus equula* (Forsskål, 1775)	Slipmouth, ponyfish / Sap-sap	Native			+
OSPHRONOMIDAE	*Trichopodus trichopterus* (Pallas, 1770)	Three spot gourami / Gurami	Introduced	+		
POECILIDAE	*Poecilia sphenops* (Valenciennes, 1846)	Molly / Kataba	Introduced	+	+	+
SCATOPHAGIDAE	*Scatophagus argus* (Linnaeus, 1766)	Spotted scat / Katang, kitang	Native			+

Table 1. Fish species (seriation of presence and absence) collected from Palico-Lian River, Batangas, Philippines.

	Site 1	Site 2	Site 3
Species Richness / Taxa	9	7	13
Fish abundance / fish specimens	52	31	48
Shannon-Weiner diversity index (H’)	1.903	1.622	2.377
Dominance index (λ)	0.185	0.247	0.104
Shannon Evenness Index (J’)	0.866	0.833	0.923
CPUE kg h-1	4.53	3.12	3.78

Table 2. Biodiversity indices of the three sampling sites in Palico-Lian River, Batangas, Philippines.

Water Quality Parameters	Site 1	Site 2	Site 3	Reporting Limit*
Color, TCU	5	5	5	75
Ammonia as NH3-N, mg L-1	< 0.007	1.72	2.12	0.05
Biological Oxygen Demand, mg L-1	10	13	10	7
Chloride, mg L-1	9	3,704	6,482	350
Nitrate as N, mg L-1	0.938	1.03	0.813	7
Oil and grease, mg L-1	< 1	1	< 1	2
Phosphate as P, mg L-1	0.131	0.055	0.040	0.5
Sulfate (SO4), mg L-1	7.8	301.8	623.6	275
Total suspended solids, mg L-1	< 2	< 2	< 2	80
Thermotolerant Coliform, MPN 100 mL-1	2.0	4.5	2.0	200
Temperature, °C	28.7	28.6	28.6	25–31
Dissolve Oxygen, mg L-1	6.54	6.67	5.47	5
pH	8.42	7.14	7.85	6.5–9

Table 3. Results of water quality analysis in Palico-Lian River, Batangas. *DENR DAO No. 2016-08 (DENR 2016).

Water quality parameters

Table 3 summarizes the physicochemical and microbiological parameters measured across three sampling sites, with corresponding reporting limits for water quality standards. Most parameters were within acceptable ranges; however, several exceeded the threshold values.

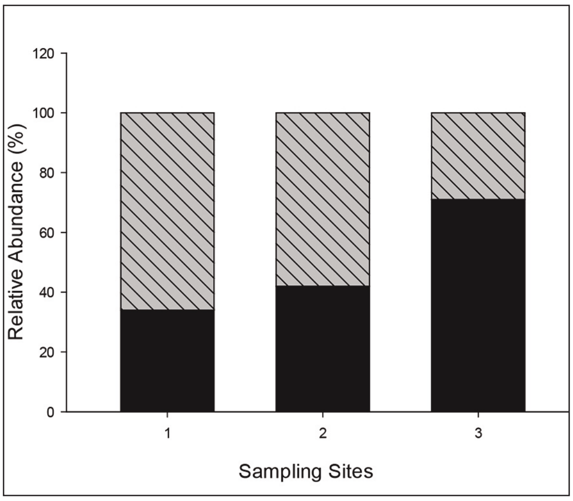

Figure 3. Stacked bar of percent representation in abundances of native (black bars) and introduced (grey hatched bars) fish assemblages from the three sampling sites of Palico-Lian river System, Batangas, Philippines.

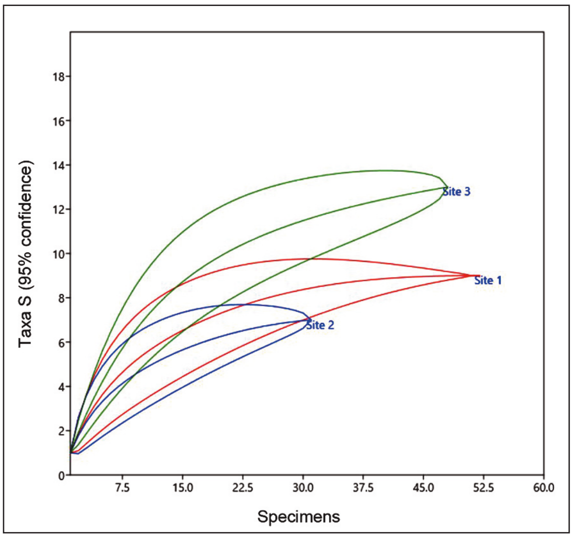

Figure 4. Sample-based rarefaction and accumulation curves of three sampling sites of Palico-Lian river System, Batangas, Philippines.

At Site 2 and Site 3, ammonia (NH_3-N) concentrations (1.72 and 2.12 mg L^{-1}, respectively) were far above the reporting limit (0.05 mg L^{-1}), indicating significant nutrient enrichment that may originate from agricultural runoff, aquaculture effluents, or domestic discharges. Elevated biological oxygen demand (BOD) values were observed at all sites (10–13 mg L^{-1}) compared to the reporting limit (7 mg L^{-1}), suggesting high levels of biodegradable organic matter and increased microbial activity. The most critical exceedances were recorded for chloride and sulfate, particularly at Site 2 (3,704 and 301.8 mg L^{-1}, respectively) and Site 3 (6,482 and 623.6 mg L^{-1}, respectively), which were markedly above their limits (350 and 275 mg L^{-1}, respectively). Such elevated ionic concentrations are indicative of strong saline intrusion or contamination from anthropogenic sources, consistent with downstream and estuarine influence.

Other hydrological parameters including nitrate, phosphate, oil and grease, total suspended solids, thermotolerant coliforms, temperature, dissolved oxygen, and pH, remained within their respective reporting limits. Notably, dissolved oxygen values (5.47–6.67 mg L^{-1}) were above the minimum requirement (5 mg L^{-1}), indicating that despite organic loading, oxygen levels were sufficient to support aquatic life.

CONCLUSIONS

The Palico-Lian River supports a relatively diverse fish assemblages, with conspicuous ecological gradient where upstream reaches are dominated by introduced species, whereas downstream sites harbor more diverse fish assemblages of native secondary freshwater fishes. This has important implications for river conservation, as it underscores the need for targeted restoration and protection strategies in more degraded sections of the river. To sustain the ecological integrity of the river, it is necessary to implement stricter regulation and monitoring of agricultural, aquaculture, and domestic effluents and institutionalize long-term biomonitoring programs using fish assemblage metrics and water quality parameters to guide adaptive management and conservation planning.

The results support the use of fish assemblage metrics in river biomonitoring studies to assess and guide conservation efforts. The decline in the relative abundance of sensitive species across sites highlights the necessity for continued ecological assessment to inform adaptive management and safeguard the river's biodiversity and ecological functions.

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