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Assemblages of Aquatic Fauna in the River Systems of Claver, Surigao del Norte, Philippines

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ABSTRACT

A survey of aquatic fauna in selected river systems of Claver, Surigao del Norte was conducted from 2022 to 2023. This study recorded six taxa of macroinvertebrates with 92 total mean individuals, dominated mostly by Order Hemiptera and Decapoda. Among fishes, eight families were recorded mostly comprising cichlids, siganids and holocentrids. Heavy silt deposits with eroded stream banks characterized their habitat. In turn, this has affected the stream flow rate that ranged from 0.18 to 110.1 m3/sec. Given this scenario, it is imperative to do proactive means of appropriate conservation and management initiatives for the river systems of Surigao del Norte.

***Keywords**:* River system, tropical fauna, siltation, Surigao del Norte

INTRODUCTION

The biodiversity of freshwater ecosystems in the Philippines is threatened by natural calamities exacerbated by changing weather conditions like torrential rains and sudden flash floods. This natural phenomenon is being worsened by uncontrolled anthropogenic disturbances such as pollution generation in various types and magnitudes. Over time and space, these coupled natural and human-induced disturbances could result in habitat loss and degradation causing a decline in species diversity and ecosystem simplification. To this, many fishes and other invertebrate species have become highly vulnerable, particularly to those inhabiting river systems with relatively higher demands of resources (Negi & Mamgain, 2013). Freshwater fishes, along with other freshwater invertebrates, are highly diverse assemblages of macrofauna; however, they are now mostly threatened (Arthington et al., 2016; Liu et al., 2017) by natural and human-induced disturbances. Hence, the status of these macrofaunal assemblages may be true in the Surigao del Norte river systems.

Rivers in the Philippines and Mindanao are mostly biologically threatened based on some studies conducted (Quimpang et al., 2015). However, concerted efforts of all participating agencies, academe, research communities, non-government and government sectors, and other community sectors (Vedra et al., 2013) have already been undertaken. While the lack of initiatives for freshwater faunal studies is currently addressed, some scientists and researchers are now looking into more studies to add more literature to understand the complexities of ecosystems and processes. For instance, the macrobenthos population did not thoroughly change through time and space, thereby potentially determining patterns and dynamics of biodiversity in ecosystems in the river system of Kauswagan, Lanao del Norte (Vedra et al., 2023). In the rivers of Surigao del Norte, those scientific interests are catered to, thereby describing macrofaunal status in terms of composition and habitat conditions, which is because Surigao del Norte's river systems are crucial for biodiversity conservation due to their support of diverse ecosystems and endemic species.

Rivers, such as the Surigao River, provide vital habitats for both aquatic and terrestrial wildlife (Vedra et al., 2022). They sustain mangrove forests, essential for fish breeding and act as buffers against storms and coastal erosion. Additionally, these river systems play a significant role in maintaining water quality and supply for the surrounding communities, supporting human and ecological health (Corpuz et al., 2023). Hence, the study is conducted to connect the adverse impacts of various anthropogenic-based activities undertaken in those river systems that contribute to point and non-point source pollution and, thus, disturb the entire aquatic ecosystem. Wastes generated in river systems may alter their water quality (Bertomen et al., 2015) and eventually affect the inhabiting organisms therein. As such, this study is conceptualized and conducted in various selected Surigao del Norte river systems in Mindanao, Philippines.

OBJECTIVES OF THE STUDY

This study aimed to identify the composition of aquatic fauna along designated collecting stations and suggest recommendations for riverine conservation and management options.

MATERIALS AND METHODS

Habitat Description and Stream Flow Rate

Habitat and substrate conditions were described in each sampling site (Figure 1), which were assumed to be outcomes of the activities undertaken during the sampling period. Habitat description along with biotic survey were conducted at the receiving streams/channels during *habagat* seasons (SE monsoon) from June 16 to 17, 2022, and July 4 to 7, 2023.

Figure 1

Map of the study sites showing the different river stream in Claver, Surigao del Norte

The river flow rate refers to the volume of water passing a point in a fixed period of time (adopted from Rinehart et al., 2013). The assessment of river flow is important because it suggests river discharge measurements, which have essential and direct applications for water management, erosion, and other related services. The determination of the flow rate of each river station was conducted using the supply method (Sverdrup et al., 1942), wherein the cross-sectional area (m2) of the river was measured and multiplied by the average water velocity (m/s). Hence, the flow rate was expressed as *(m3/s) = area (m2) x velocity (m/s)*. The cross-section of the river was obtained using a transect tape to measure river length, while a meter stick was used to measure the depth of the river, as expressed as *Cross section (m2) = length x depth*. River water velocity was measured using an improvised floater, allowing travel allowed to travel from one point to anothe at a standard distance of 10m. Velocity was calculated by dividing the distance covered by the floater and the time it traveled in the distance set as replicated three times. It is expressed as *Average water velocity (m/s) = distance/time*.

Specimen Collection Techniques and Data Management

Specimens captured in various study sites were surveyed and assessed using opportunistic sampling techniques through ocular surveys or visual encounter techniques. To this, all encountered fauna were noted and described, especially among the fish and invertebrate populations. Fish and freshwater macroinvertebrates were observed and collected in 12 different stations established within those river systems considered. During specimen collection, the "kick-net method" was employed, wherein a handheld net sampler measuring 0.5 x 0.25 m2 with a mesh size of 1 mm was used. Three (3) replicate samples were collected for the 12 sampling stations. Outflow stations (i.e., Stations 4, 8, and 10) were wider streams exhibiting the interaction of fresh and seawater. During ebb tide, freshwater fish dominated, while marine fish and organisms inhabited the area during high tide. Most fish samples were collected in these areas. Counts on taxa composition and number of individuals were done using descriptive statistics, and diversity indices were determined using PAST Software.

RESULTS AND DISCUSSIONS

Habitat Description

A total of 12 sampling stations were surveyed and the majority of them showed signs of a disturbed river ecosystem. Siltation was particularly observed at the downstream portion of each stream channel (Stations 2, 4,5,6,8, and 9). Heavy silt deposits were observed and mixed on the stream substrates (Stations 1, 5, 6, and 7). The following were generally observed within the sampling periods conducted: (1) Eroded stream banks were noted while dredging and stream widening were done at Stations 1 and 7 to facilitate water flow on the silted areas; (2) Stations 13, 14, and 15 had clearer waters or less siltation. However, it possessed the same laterite deposits and substrates as the other stations. The distance and different conditions among stations reflect the varying situation among sampling points; and (3) The river mouth in Station 10 is wide and exhibits the interaction of river and sea; during ebb tide, freshwater fish dominated while marine fish and other organisms inhabited said Station during high tide where the fish samples were collected (Table 1).

During the latest filed survey in 2023, a 3-day heavy rains occurred due to the onset of the Habagat (SW monsoon) Season. As such, de-siltation and dredging activities were conducted on most of the monitoring sites. Rain and habitat modification resulted in turbidity and sedimentation on the streams. The majority of the monitoring stations exhibited high turbidity. It silted especially on sites located downstream and within the other sites (Stations 1, 2, 4, 5, 6, 7, 8, 9, and 10) compared to other sites farther (Stations 13, 14, and 15; Table 1).

Table 1

Assessment of habitats on the 12 sampling sites in the river systems of Surigao del Sur

Sites	River/Stream	Environmental/Substrate Conditions		Elevation (m)	
		2022	2023	2022	2023
Station 1	Daku Creek	Silted and dredging are present	Has a very narrow channel and was modified due to previous massive flooding (December 2022). The substrate is composed of boulders and muddy silt, the channel flow was rerouted due to sedimentation.	48	48
Station 2	Taganito River (Upstream)	Silted and shallow	De-siltation/dredging activity was present on the riverbed and widening of riverbanks, the substrate was silted and the water was turbid.	33	33
Station 4	Taganito River (Downstream)	Silted with vegetation present in the banks.	The stream is wide and the water is turbid because sampling was conducted after heavy rain.	24	24
Station 5	Taganito River (Downstream)	Clearer narrow channels	The channel is wide and situated under a bridge. The substrate is rocky and sandy with little laterite deposits.	19	19
Station 6	Daang Suba	Clearer deep stream banks	Water flow from the stream is rapid caused by shallow and rocky substrate. The stream bank is riprapped with artificial meshed rocks.	31	31
Station 7	Daang Suba	Silted and dredging was present	Channel is an immediate outflow of the upper mining area, water is silted and the substrate is predominantly rock and muddy. Delta is formed in the middle of the stream separating 2 narrow channels.	31	31
Station 8	Taganito Estuary	Silt deposits on sandy substrate	Substrate is sandy muddy, construction of bridge was present during the sampling date.	19	19
Station 9	Hayanggabon River (Downstream)	Silt deposits and muddy, mangrove vegetation is present	Has a mangrove nursery where an artificial outflow dam is located. The substrate is predominantly rocky. A thick brown moss covers the rocks.	22	22
Station 10	Hayanggabon River Mouth	Benthic is covered with silt on the wide river mouth	The estuary has a rocky and muddy substrate. De-siltation and dredging were conducted at the stream during the sampling period.	19	19
Station 13	Sensio Creek (Upstream)	Clearer water with silt deposits, vegetation is present within stream banks	Narrow stream with moderate silt to rocky substrate and with laterite deposits. The riverbank is elevated and comprise high vegetation. Station 15 is adjacent to disposal site of mine tailings, overall streams are shallow with clear waters	18	18
Station 14	Sensio Creek (Downstream)			17	17
Station 15	Hayanggabon (Upstream)			n/a	n/a

The current observation of siltation in the stream/river channels had conformed to the findings of Casatti et al. (2005), such that fish species captured showed a strong correlation to habitat descriptors, which could be due to fine substrates present that, in turn, affect water column-dependent fish species. Siltation also influences the level of dissolved in the water (Rabeni & Smale, 1995), which eventually reduces the physiological response of aquatic inhabitants. Excessive sedimentation and altered flow rates change river channel morphology, leading to increased erosion, altered sediment deposition patterns, and changes in channel structure. These changes affect habitat availability and river stability. Sedimentation smothers benthic habitats, affecting macroinvertebrates and fish species that rely on clear water and stable substrates for spawning and feeding (Dudgeon et al., 2005). Altered flow regimes disrupt migration patterns, breeding cycles, and habitat connectivity. As such, some mitigation initiatives could be done, such as restoration of riparian vegetation, siltation control, and adequate sustainable soil use and practices.

Flow rate

The highest flow rate recorded was observed at Taganito River (Station 4) having a value of 109.23 m3/s because of a relatively big cross-sectional area of 144.95 m2. The Taganito River serves as the main discharge zone of stream systems within the study site, wherein the River stretches upstream from Station 2 to the estuary (Station 8). The mid-downstream Station 5 exhibited a relatively high flow rate of 11.75 m3/s obtained from its cross-sectional area of 14.59 m2; meanwhile, a separate downstream (Hayanggabon River Mouth), the flow rate measured was up at 7.75 m3/s because of a relatively narrower channel area of 60.21 m2. The lowest flow rate was recorded at Sensio Creek, that is, Station 13 and Hayanggabon Upstream (Station 15), with 0.94 and 0.76 m3/s, respectively (Table 2).

Compared to the 2022 data, differences and decreases in the flow rate were observed in the main river systems at Station 4 from 110.1 m3/s to 109.23 m3/s and Station 10 from 11.95 m3/s to 7.75 m3/s. These observed changes might be due to the field sampling period conducted, which was done during the southwest monsoon and with ongoing dredging activities. This, in turn, might affect the stream conditions like differences in cross-sectional area, number of obstructions such as the presence of erosion control mechanisms, and environmental characteristics as tributaries contributing to outflow channels.

In this study, flow rate affects the aquatic inhabitants, like fish, by restricting distribution and life histories along the river system (Kim et al., 2020). Moreover, flow rate influenced the spawning and growth of freshwater fishes (Tsadik & Bart, 2007) and fish sizes and sex (Hockley et al., 2014). Therefore, further studies on hydrological and water quality variables must be conducted to predict the future distribution of aquatic inhabitants because the flow rate of rivers is a critical determinant of riverine hydrology and ecology. It influences channel morphology, sediment transport, water quality, habitat diversity, life cycles of aquatic organisms, nutrient cycling, and floodplain connectivity. Understanding these linkages is essential for effective river management and conservation, particularly in the face of anthropogenic pressures such as dam construction and land use changes.

Table 2

Summary of flow rate among sampling stations in the river systems of Surigao del Sur

Stations	Year	1	2	4	5	7	9	10	13	14	15
Area (m^2)	2023	1.39	1.69	144.95	14.59	0.46	0.98	60.21	1.25	1.3	1.26
	2022	0.97	3.05	154.2	5.52	1.79	2.25	90.44	1.39	1.26	2.14
Velocity	2023	1.33	1.002	0.75	0.80	0.98	0.75	0.128	0.75	1.46	0.60
	2022	0.45	0.29	0.71	0.71	1.93	0.18	0.13	0.31	0.14	0.16
Flow Rate(m^3/s)	2023	1.86	1.69	109.23	11.75	0.45	0.74	7.75	0.94	1.9	0.76
	2022	0.44	0.89	110.1	3.94	3.45	0.41	11.95	0.44	0.18	0.34

Freshwater Biota

The latest survey (i.e., July 4-7, 2023) revealed only a total of four (4) macroinvertebrate taxa with 95 individuals recorded during the freshwater biodiversity assessment among the sampling stations. The taxa exhibiting the highest relative density, comprising 74%, are groups of water striders belonging to Order *Hemiptera,* namely *Notonectidae,* and, *Gerridae,* with 38 and 30 individuals, respectively. These species were found on 6 out of 9 monitoring sampling sites. The presence of hemipterans is possible due to their tolerance to organic pollution and oxygen depletion in streams (Cano et al., 2018). Moreover, their abundance in streams is due to their predatory characteristics to other insects and some vertebrate prey (Lytle, 2014). *Sesarmidae* or mud crabs (*Decapoda*) were also observed on three (3) monitoring sites (Stations 4, 9, and 10) comprising 20% of relative density (Fig. 2; Table 3). In this study, decapods might not be adversely impacted by ionic and osmotic homeostasis in those streams (Amado et al., 2006). Likewise, those decapods can be out of the water, and, therefore, refrain from the sublethal effects of pollution and predators (Hobbs & Lodge, 2010).

The 2022 survey revealed six (6) major macroinvertebrate taxa, 89 individuals. *Hemiptera* was the most dominant taxa composed of *Gerridae* (20 individuals) and *Notonectidae* (27 individuals), have a total abundance of 47, respectively. These insects were present in seven sampling stations, mostly at midstream (Fig. 3; Table 3). A few species of *Gastropoda* were recorded and present only at Station 4, which might be due to its tolerant nature given the streams' water and habitat quality conditions.

Generally, the nine (9) stations exhibited relatively low abundance, and with the dominance of certain groups of insects that had tolerated well the quality of streams they are inhabiting as influenced by weather conditions, significant siltation, and disturbance from dredging activities that were present in the area.

Figure 2

Macroinvertebrate taxa recorded in all sampling stations in the river systems of Surigao del Norte, July 4-7, 2023. (A) Coenagerinidae (Odonata), (B) Gerridae (Hemiptera), (C) Notonectidae (Hemiptera), (D) Sesa rmidae (Decapoda), (E) Neritidae Gastropoda)

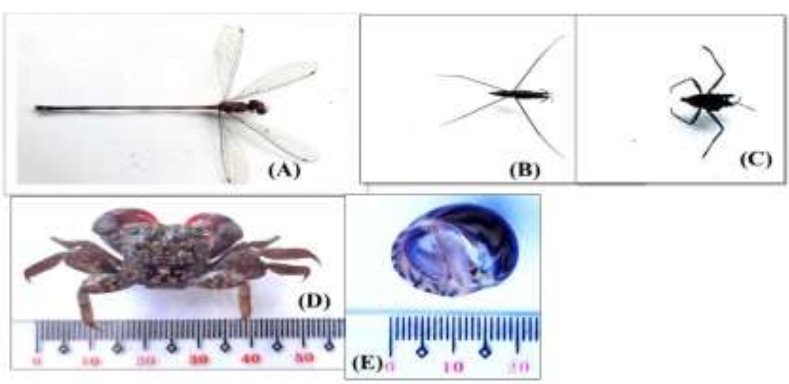
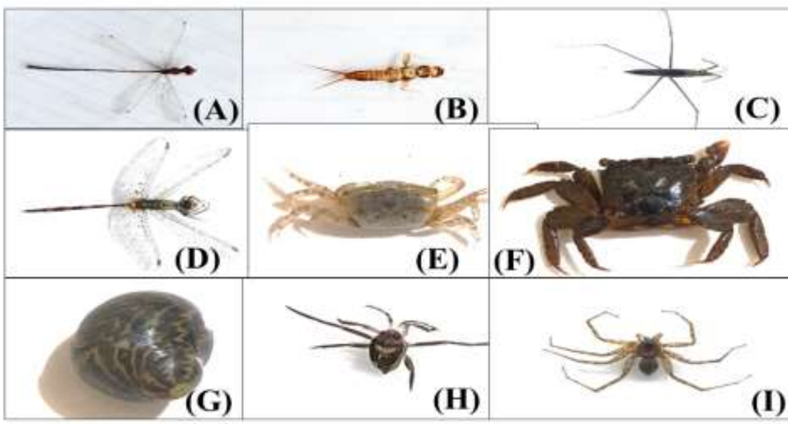


Figure 3

Macroinvertebrate taxa recorded in all sampling stations in the river systems of Surigao del Norte, June 16-17, 2022: (A) Coenagrionidae (Odonata), (B) Leuctridae (Plecoptera), (C) Gerridae (Hemiptera), (D) Aeshnidae (Odonata), (E) Potamidae (Decapoda), (F) Sesarmidae (Decapoda), (G) Neritidae (Gastropoda), (H) Notonectidae (Hemiptera), (I) Pisauridae (Heterapoda)



Macroinvertebrates are indispensable to the health and functioning of river ecosystems. Their roles in indicating water quality, supporting food webs, cycling nutrients, structuring habitats, acting as ecosystem engineers, and processing pollutants underscore their ecological importance. Conservation and monitoring of macroinvertebrate communities are essential for maintaining riverine biodiversity and ecosystem services. Macroinvertebrates are widely used as bioindicators of water quality. Different species have varying tolerances to pollutants, making their presence or absence indicative of a river's overall health. For example, the presence of pollution-sensitive species like mayflies, stoneflies, and caddisflies suggests good water quality, while the dominance of tolerant species like worms and certain types of midges indicates poor water quality (Vedra et al., 2022).

Fish species

The fish specimens documented on selected monitoring sites were captured by locals who also provided information such as local names. There were only a few comprising three (3) species of fish belonging to 3 families recorded from Station 4 (downstream), Station 13 and Station 15 (upstream), and midstream

(Figure 4, Table 4), namely freshwater carp/minnow Cyperinidae sp. from the upstream, Cardinal Fish Apogon lateralis, and Emperor Fish Lethrinus sp. from the downstream. More species were observed during the last monitoring on the last 2022, where Tilapia and Rabbitfish are found on the midstream, and species on the river mouth consists of Squirrel Fish, Crescent Grunter, and Blackfin Scad which migrates to brackish water in between flood and ebb tides (Figure 4, Table 4). All of the fish species recorded are regarded as commercially important and well-priced in the market. The few species documented could be attributed to disturbance brought by dredging activities throughout the streams during the sampling period.

Table 3

Total number of individuals (ind. m-2) of macroinvertebrates recorded in all sampling stations in the river systems of Surigao del Sur

Taxa	Year	S1	S2	S4	S5	S6	S7	S8	S9	S10	S13	S14	S15	Total Density	Relative Density
Decapoda	2023	0	0	2	0	0	0	0	6	11	0	0	0	19	20.00
	2022	0	0	0	1	0	0	0	6	0	0	0	0	19	21.35
Gastropoda	2023	0	0	4	0	0	0	0	0	0	0	0	0	4	4.21
	2022	0	0	4	0	0	0	0	0	0	0	0	0	4	4.49
Hemiptera	2023	14	6	0	10	0	0	0	0	0	20	16	4	70	73.68
	2022	0	8	0	10	0	3	0	6	0	3	14	5	47	52.81
Heterapoda	2023	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00
	2022	1	6	0	0	0	1	0	0	0	0	0	0	8	8.99
Odonata	2023	0	2	0	0	0	0	0	0	0	0	0	0	2	2.11
	2022	0	0	0	0	0	0	0	2	0	4	0	2	8	8.99
Plecoptera	2023	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00
	2022	0	0	0	3	0	0	0	0	0	0	0	0	3	3.37
Total no. of Individuals	2023	14	8	6	10	0	0	0	6	11	20	16	4	95	100
	2022	1	14	4	14	0	4	0	14	0	7	14	7	89	100
Mean	2023	3.5	2	1.5	2.5	0	0	0	1.5	2.75	5	4	1	9.5	
	2022	0.11	1.56	0.44	1.56	0.00	0.44	0.00	1.56	0.00	0.78	1.56	0.78	8.9	
SD	2023	6.06	2.45	1.66	4.33	0.00	0.00	0.00	2.60	4.76	8.66	6.93	1.73		
	2022	0.33	3.13	1.33	3.32	0.00	1.01	0.00	2.60	0.00	1.56	4.67	1.72		
Total no. of taxa	2023	1	2	2	1	0	0	0	1	1	1	1	1		
	2022	1	2	1	3	0	0	0	3	1	2	1	2		

The presence of fish in the stream still indicates their relative tolerance to various disturbances in their habitat and food sources. Some of these species were associated with good physical habitat conditions. They were considered good water column swimmers (Casatti, 2002), depending on adequate habitat volume, which decreases with severe siltation (Castro & Casatti, 1997). However, some species were negatively affected by siltation due to the embeddedness of the rocky substrate (Fugi et al., 1996). Through substrate changes, siltation could benefit some species, specifically those adapted to sandy bottoms, but in the case no fish species were captured. Reduction of the water column caused by siltation negatively affects water oxygenation, and only species with behavioral or physiological strategies can support these changes. For instance, the presence of cichlids (tilapia) is noted in the streams studied. This species is considered to have expressive phenotypic plasticity, including swimming strategies for living in hypoxic waters (Casatti et al., 2003) and hypoxia tolerant (Chapman et al., 1995; Araújo and Garutti, 2003; Shibatta and Bennemann, 2003). Freshwater fishes are integral to the functioning and health of river ecosystems. Their roles in trophic dynamics, nutrient cycling, habitat modification, prey-predator relationships, and biodiversity maintenance underscore their ecological importance (Corpus et al., 2023). Additionally, they serve as bioindicators of ecosystem health and hold significant cultural and economic value. Fish communities are often used as bioindicators to assess the health of river ecosystems. Changes in fish diversity, abundance, and species composition can indicate alterations in water quality, habitat degradation, and the impacts of pollution and other environmental stressors (Vedra et al., 2023).

Figure 4

Fish species recorded in all sampling stations in the river systems of Claver, Surigao del Norte, July 4-7, 2023: (A) Cyperinidae sp. (juvenile), (B) Apogon lateralis, (C) Lethrinus sp., while (D) Oreochromis aureus, (E) Oreochromis niloticus, (F) Siganus guttatus, (G) Siganus jarvus, (H) Halocentrus sp., (J) Terapon jarboa, and (K) Alepes melanoptera were recorded on June 17, 2022

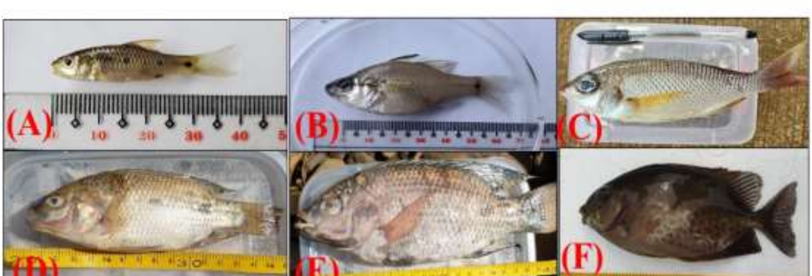


Figure 4 continued

Table 4

Fish recorded in selected sampling stations in the river systems of Surigao del Sur

Date	Family	Scientific name	Common name	Local name
2023	Cyprinidae	*Cyprinidae* sp.	Carp/Minnow	Pait-pait
	Apogonidae	*Apogon lateralis*	Cardinal Fish	Ibis
	Lethrinidae	*Lethrinus* sp.	Emperor Fish	Katambak
2022	Cichlidae	*Oreochromis aureus*	Tilapia	Tilapia
	Cichlidae	*Oreochromis niloticus*	Tilapia	Tialapia
	Siganidae	*Siganus guttatus*	Orange-dotted Rabbitfish	Kitong
	Siganidae	*Siganus jarvus*	Rabbitfish	Danngit
	Holocentridae	*Halocentrus* sp.	Squirrel fish	Baga-baga
	Holocentridae	*Sargocentrus* sp.	Squirrel fish	Baga-baga
	Terapontidae	*Terapon jarboa*	Crescent grunter	Bugaong
	Carangidae	*Alepes melanoptera*	Black fin scad	Lapis

CONCLUSIONS

The river systems in Surigao del Sur played a significant role in harboring various faunal species like various taxa of macroinvertebrates and fishes, although threatened by siltation. Less abundant individuals and dominance of certain faunal groups might have some implications for aquatic ecosystem simplification. The majority of fishes were of commercial importance, and therefore, the demand potential implications for resource conservation and management.

RECOMMENDATIONS

Henceforth, it is imperative to determine the anthropogenic activities and appropriate interventions such as restoration of riparian vegetation, siltation control, and adequate sustainable soil use and practices to protect the inhabiting faunal species in those river systems through enhanced concerted efforts of all sectors involved. Moreover, further comprehensive studies involving correlations of various biophysical factors and anthropogenic-based interventions done in the riverine systems must be undertaken.

LITERATURE CITED

Amado, E. M., Freire, C.A. and Souza, M.M. (2006). Osmoregulation and tissue water regulation in the freshwater red crab Dilocarcinus pagei (Crustacea, Decapoda), and the effect of waterborne inorganic lead. *Aquatic Toxicology 79(1), 1-8*. https://doi.org/10.1016/j.aquatox.2006.04.003.

Arthington, A. H., Dulvy, N. K., Gladstone, W., & Winfield, I. J. (2016). Fish conservation in freshwater and marine realms: status, threats and management. *Aquatic Conservation: Marine and Freshwater Ecosystems, 26*(5), 838-857. https://doi.org/10.1002/aqc.2712

Bertomen, W. K., Roa, E. C., Tubio, E. G., Vedra, S. A., & Dela Peña, G. D. (2017). Water Quality of Sawaga River, Malaybalay City, Bukidnon, Philippines. *International Journal of Science and Research, 6*(7), 1090–1095. https://doi.org/10.21275/art20175318

Cano, J., Rodríguez, A., Simpson, H., Tabah, E. N., Gómez, J. F., & Pullan, R. L. (2018). Modelling the spatial distribution of aquatic insects (Order Hemiptera) potentially involved in the transmission of Mycobacterium ulcerans in Africa. *Parasites & vectors, 11*, 1-16. https://doi.org/10.1186/s13071-018-3066-3

Casatti, L., Langeani, F., Silva, A. M., & Castro, R. M. C. (2006). Stream fish, water and habitat quality in a pasture dominated basin, southeastern Brazil. *Brazilian Journal of Biology, 66*(2b), 681–696. https://doi.org/10.1590/s1519-69842006000400012

Casatti, L. (2002). Alimentação dos peixes em um riacho do Parque Estadual Morro do Diabo, bacia do Alto Rio Paraná, sudeste do Brasil. *Biota Neopropica/Biota Neotropica, 2*(2), 1–14. https://doi.org/10.1590/s1676-06032002000200012

Casatti, L., Mendes, H. F., & Ferreira, K. M. (2003). Aquatic macrophytes as feeding site for small fishes in the Rosana Reservoir, Paranapanema River, Southeastern Brazil. *Brazilian Journal of Biology, 63*, 213-222. https://doi.org/10.1590/s1519-69842003000200006

Castro, R. M. (1997). The fish fauna from a small forest stream of the upper Paraná River basin, southeastern Brazil. *Ichthyo. Expl. Freshwaters, 7,* 337-352. https://cir.nii.ac.jp/crid/1571135649712278912

Chapman, L. J., Kaufman, L. S., Chapman, C. A., & McKenzie, F. E. (1995). Hypoxia tolerance in twelve species of East African cichlids: potential for low oxygen refugia in Lake Victoria. *Conservation biology,* 1274-1287. https://doi.org/10.1046/j.1523-1739.1995.9051262.x-i1

Corpuz, Mark Nell. (2023). Length-Weight Relationship and Relative Condition Factor of Fishes in Talisay and Bagac River Systems, Bataan, Philippines. *International Journal of Latest Engineering Science, 6*(4). http://dx.doi.org/10.51386/25816659/ijles-v6i4p102

De Araujo, R. B., & Garutti, V. (2003). Ecology of a stream from upper Paraná River basin inhabited by Aspidoras fuscoguttatus Nijssen & Isbrüker, 1976 (Siluriformes, Callichthyidae). *Brazilian Journal of Biology, 63*(3), 363–372. https://doi.org/10.1590/s1519-69842003000300002

Dudgeon, D. A.H. Arthington, M.O. Gessner, Z.I. Kawabata, D.J. Knowler, C. Lévêque, R.J. Naiman, A.H.Prieur-Richard, D. Soto, M.L. J. Stiassny and C.A. Sullivan. (2005). Freshwater biodiversity: importance, threats, status and conservation challenges. *Biological Reviews , Volume 81(2): 163 – 182.* https://doi.org/10.1017/S1464793105006950.

Fugi, R., Hahn, N.S. & Agostinho, A.A. Feeding styles of five species of bottom-feeding fishes of the high Paraná river. *Environ Biol Fish 46*, 297–307 (1996). https://doi.org/10.1007/BF00005006

Hobbs, H. H., & Lodge, D. M. (2010). *Decapoda. In Ecology and classification of North American freshwater invertebrates* (pp. 901-967). Academic Press.

Hockley, F. A., Wilson, C. A. M. E., Brew, A., & Cable, J. (2014). Fish responses to flow velocity and turbulence in relation to size, sex and parasite load. *Journal of the Royal Society Interface, 11*(91). https://doi.org/10.1098/rsif.2013.0814

Kim, Z., Shim, T., Koo, Y., Seo, D., Kim, Y., Hwang, S. and Jung, J. (2020). Predicting the Impact of Climate Change on Freshwater Fish Distribution by Incorporating Water Flow Rate and Quality Variables. *Sustainability, 12(23), 10001.* https://doi.org/10.3390/su122310001.

Liu, X., Hu, X., Ao, X., Wu, X., & Ouyang, S. (2018). Community characteristics of aquatic organisms and management implications after construction of Shihutang Dam in the Gangjiang River, China. *Lake and Reservoir Management, 34*(1), 42-57. https://doi.org/10.1080/10402381.2017.1373716

Lytle, D. A. (2015). Order Hemiptera. In *Thorp and Covich's freshwater invertebrates* (pp. 951-963). Academic Press. https://doi.org/10.1016/B978-0-12-385026-3.00037-1.

Negi, R., & Mamgain, S. (2013). Species diversity, abundance and distribution of fish community and conservation status of Tons River of Uttarakhand State, India. *Journal of Fisheries and Aquatic Science, 8*(5), 617–626. https://doi.org/10.3923/jfas.2013.617.626

Quimpang, V. T., Opiso, E. M., Cudal, M. C., Coquilla, K. L., Buot, G. A., Forten, R. R. C., Bruno, A. G. T., & Amoroso, V. B. (2015). Assessment and monitoring of fish species in the mountain streams and Lake of Mindanao LTER sites. *Asian Journal of Biodiversity, 6*(1). https://doi.org/10.7828/ajob.v6i1.697

Rabeni, C. F., & Smale, M. A. (1995). Effects of siltation on stream fishes and the potential mitigating role of the buffering riparian zone. *Hydrobiologia, 303,* 211-219. https://doi.org/10.1007/bf00034058

Shibatta, O. A., & Bennemann, S. T. (2003). Plasticidade alimentar em Rivulus pictus Costa (Osteichthtyes, Cyprinodontiformes, Rivulidae) de uma pequena lagoa em Brasília, Distrito Federal, Brasil. *Revista Brasileira de Zoologia, 20,* 615-618. https://doi.org/10.1590/s0101-81752003000400009

Sverdrup, H. U., Johnson, M. W., & Fleming, R. H. (1942). *The Oceans: Their physics, chemistry, and general biology* (Vol. 1087, No. 8). New York: Prentice-Hall.

Tsadik, G. G., & Bart, A. N. (2007). Effects of feeding, stocking density and water-flow rate on fecundity, spawning frequency and egg quality of Nile tilapia, Oreochromis niloticus (L.). *Aquaculture, 272*(1-4), 380-388. https://doi.org/10.1016/j.aquaculture.2007.08.040

Vedra, S.A., Ocampo, P.P., de Lara, A.V., Rebancos, C.M., Pacardo, E.P. and Briones, N.D. (2013). Indigenous goby population and conservation efforts of the communities along Mandulog River System, Iligan City, Northern Mindanao, Philippines. *Journal of Environmental Science and Management 16(2):11-18.* https://doi.org/10.47125/jesam/2013_2/02

Vedra, S.A., R.F.Q. Padilla and R.J. Vicente. (2022). Macrobenthic Assemblages in the Riverine Systems in Kauswagan, Lanao del Norte, Philippines. *Biodiversity Journal, 2023, 14 (1): 167–171.* https://doi.org/10.31396/Biodiv.Jour.2023.14.1.167.171.

Vedra, S. A., Padilla, R. F. Q., & Vicente, R. J. (2022). Indigenous fishes inhabiting the Talabaan river system of Naawan, Misamis Oriental, Northern Mindanao, Philippines. *International Journal of Fisheries and Aquatic Studies, 10*(4), 23–27. https://doi.org/10.22271/fish.2022.v10.i4a.2700

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