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Functional Feeding Group Composition of Macroinvertebrates As Indicators of Ecosystem Health In Jeddo River, Nigeria

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ABSTRACT
This study assessed the functional feeding group (FFG) composition of Macroinvertebrates in the Jeddo River, Niger Delta, Nigeria, to evaluate their potential as indicators of ecosystem health. Macroinvertebrate samples were collected from three stations along the river using kick sampling and Ekman grab methods and were identified to genus or species level before being classified into functional feeding groups. Physico-chemical parameters, including temperature, pH, dissolved oxygen, nutrients, and salinity, were measured concurrently to assess environmental conditions. Results revealed that predators dominated the macroinvertebrate community, followed by collector-gatherers and grazers, with notable spatial variation across stations. High predator-to-prey ratios and low representation of sensitive functional groups in certain stations indicated ecological stress and potential habitat degradation. The study highlights that FFG analysis, combined with water quality assessments, provides a robust tool for monitoring river health and detecting early signs of environmental disturbance in tropical estuarine systems. These findings provide baseline information essential for sustainable management and conservation of the Jeddo River and similar aquatic ecosystems in the Niger Delta region.

Keywords: Macroinvertebrates, Functional Feeding Groups, River Health, Niger Delta, Ecosystem Monitoring, Estuarine Ecology, Anthropogenic Impacts

INTRODUCTION

Estuarine ecosystems are among the most productive and ecologically important aquatic environments in the world (NOAA Fisheries, 2025). They represent transitional zones where freshwater from rivers mixes with saline water from the sea, creating unique environmental gradients that influence biological diversity and ecosystem functioning. These environments support diverse communities of organisms and provide essential ecosystem services such as nutrient cycling, fisheries production, shoreline protection, and water purification. The ecological condition of aquatic ecosystems is closely associated with water quality characteristics, as changes in physicochemical conditions resulting from natural and anthropogenic activities can significantly influence the structure, distribution, and functioning of aquatic biota (Akawo *et al*., 2025). However, estuarine ecosystems are also highly vulnerable to anthropogenic disturbances including urbanization, industrial effluents, dredging, agricultural runoff, and domestic waste discharge, which can significantly alter water quality and ecological balance (Dalu *et al*., 2022). The ecological integrity of estuarine systems is often assessed using biological indicators that respond to environmental changes (U.S. Environmental Protection Agency [EPA], 2025). Among the most reliable bioindicators are Macroinvertebrates, which are organisms that inhabit the bottom sediments of aquatic ecosystems and are visible to the naked eye. These organisms include insect larvae, crustaceans, mollusks, worms, and other invertebrate groups. Macroinvertebrates are widely used in ecological monitoring because they have relatively long life cycles, limited mobility, and varying levels of tolerance to pollution and environmental stress. As a result, changes in their community structure, diversity, and abundance can provide valuable information about the ecological condition of aquatic environments (Enabulele *and* Olomukoro, 2024).

In estuarine ecosystems, Macroinvertebrates play critical ecological roles in the processing of organic matter, nutrient recycling, and the transfer of energy through food webs. They occupy different trophic levels and contribute significantly to ecosystem functioning by breaking down organic materials and serving as food for higher trophic organisms such as fish and birds. Because of their ecological importance and sensitivity to environmental changes, macroinvertebrate communities are frequently used in biomonitoring programs to evaluate the health and quality of aquatic ecosystems (Ilmi *et al*., 2023).

One important ecological approach for understanding the functional role of macroinvertebrates in aquatic ecosystems is the classification of organisms into functional feeding groups (FFGs). Functional feeding groups categorize organisms based on their feeding mechanisms and the types of food resources they utilize in their habitats. The main functional feeding groups include shredders, scrapers or grazers, gathering collectors, filtering collectors, and predators. Each of these groups contributes differently to the breakdown and processing of organic matter within aquatic systems. The distribution and relative abundance of these feeding groups can therefore provide insight into ecosystem functioning and trophic interactions within a river or estuarine environment (Jitendra *et al*., 2025).

The composition of functional feeding groups is strongly influenced by environmental conditions such as substrate type, organic matter availability, water flow, salinity gradients, and water quality. In estuarine ecosystems, these conditions are particularly dynamic due to tidal fluctuations and the mixing of freshwater and marine inputs. Consequently, any alteration in environmental conditions caused by anthropogenic activities may lead to shifts in the structure and functional organization of macroinvertebrate communities. Pollution and habitat degradation often result in

the dominance of tolerant collector species, while sensitive groups such as shredders and scrapers may decline in abundance. These changes can serve as early warning signals of ecological disturbance and declining ecosystem health (Dalu *et al*., 2022).

Despite the growing application of macroinvertebrate-based biomonitoring worldwide, many estuarine systems in developing countries remain poorly studied in terms of their functional ecological structure. In Nigeria, particularly within the Niger Delta region, estuarine rivers are subjected to various anthropogenic pressures including sand dredging, oil-related activities, industrial discharge, and urban waste inputs. These activities can alter water quality, sediment characteristics, and habitat structure, thereby affecting the composition and ecological roles of Macroinvertebrate communities. However, there is still limited information on the functional feeding group composition of Macroinvertebrates in many estuarine rivers within the region.

The Jeddo River, located in the Niger Delta region of Nigeria, is an estuarine system that supports several human activities such as fishing, transportation, sand mining, and domestic water use. The river also receives inputs from surrounding settlements and industrial areas, which may influence its ecological condition. Such pressures may alter the structure and functional organization of aquatic communities, particularly Macroinvertebrates that live within the river sediments. However, insufficient ecological information exists regarding the trophic structure and functional feeding strategies of macroinvertebrate communities in the Jeddo River. Without such information, it becomes difficult to accurately evaluate the ecological health of the river and detect early signs of environmental degradation.

Therefore, understanding the functional feeding group composition of Macroinvertebrates in the Jeddo River is essential for assessing ecosystem functioning and environmental quality. Functional feeding group analysis provides insights not only into the structure of biological communities but also into the processes governing organic matter decomposition and energy flow in aquatic ecosystems. Consequently, this study aims to examine the functional feeding group composition of Macroinvertebrates in the Jeddo River, Nigeria, and evaluate their potential as indicators of ecosystem health. Specifically, the study aims to identify and classify macroinvertebrates in the Jeddo River into their respective functional feeding groups, determine the distribution and relative abundance of these feeding groups across different sampling stations, and assess how the composition of these functional groups reflects the ecological condition and health status of the estuarine ecosystem. The findings of this study will contribute valuable baseline information for ecological monitoring and sustainable management of estuarine river systems in the Niger Delta region of Nigeria.

MATERIALS AND METHODS

Description of Study Area

The study was conducted at Jeddo River in Okpe, Delta State, Nigeria, (Figure 1) located at approximately 5°35′48″N and 5°42′14″E. Jeddo River is an estuarine river connected to the Warri River, one of the major coastal rivers in the Niger Delta, which eventually drains into the Atlantic Ocean through the Forcados Estuary. The Niger Delta region covers about 70,000 km² and is recognized as one of the largest wetland systems in the world, characterized by mangrove swamps, marshes, tropical rainforest vegetation, and high biodiversity, although this biodiversity is increasingly threatened by anthropogenic activities (Adekola *and* Mitchell, 2011; Edegbene *et al*., 2021).

The area experiences two main seasons: the rainy season (May–October) with frequent rainfall averaging about 20 days per month, and the dry season (November–April) with fewer rainfall days.

Three sampling stations were established along the river. Station 1, located near an abattoir, receives direct discharge of animal waste into the river, leading to nutrient enrichment and the growth of aquatic weeds such as water lettuce (Pistia stratiotes) and water hyacinth (Eichhornia crassipes). Mangrove trees that previously dominated the area have largely been removed, likely due to human development. Station 2, about 1 km from Station 1, contains young mangrove trees (Rhizophora spp.) and economic plants such as oil palm, banana, and cocoyam, while the water surface is heavily covered by invasive water hyacinth. Human activities in this station include small-scale fishing and vegetation clearing. Station 3, located about 2 km away, is an open water area with young mangroves and economic trees but no aquatic weeds, possibly due to water movement and periodic dredging activities carried out to maintain water depth for navigation.

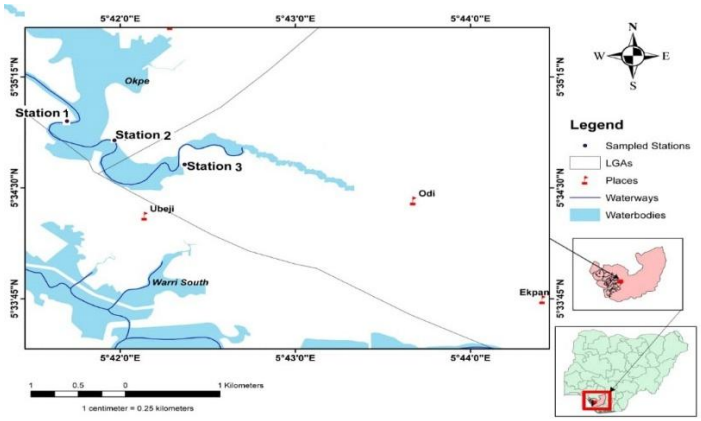

Figure 1: Map of Jeddo River in Okpe Local Government Area of Delta State, Nigeria. Developed Using Google Maps (2024)

Determination of Physico-Chemical Parameters

Physico-chemical parameters of the Jeddo River were determined through both in-situ measurements and laboratory analyses. At each sampling station, some parameters were measured directly in the field, while others were collected in 5-liter containers and transported in an ice chest to the Dennis

Osadebay University laboratory for further analysis. Dissolved oxygen (DO) was determined using the modified Winkler's method (American Public Health Association [APHA], 2017), where water samples were fixed with manganese sulphate and alkaline iodide-azide solutions to form a precipitate, later dissolved with sulphuric acid and titrated with sodium thiosulphate. Biochemical Oxygen Demand (BOD_5) was determined following APHA (1998) procedures by measuring the difference between the initial dissolved oxygen and the dissolved oxygen after five days of incubation in the dark.

Other basic water quality parameters were measured using standard field instruments. pH was determined using a calibrated portable Hanna HI98107 pH meter, while air and water temperatures were measured using a calibrated mercury-in-glass thermometer. Electrical conductivity was measured using a Hanna Instruments HI98303 conductivity meter after calibration with a standard potassium chloride (KCl) solution, and the probe was carefully inserted into the water sample to obtain readings in microsiemens per centimeter (µS/cm). Salinity was also measured using a digital salinity meter, with the probe immersed in the sample and readings recorded in parts per thousand after proper calibration and stabilization.

Nutrient concentrations in the water were analyzed using laboratory spectrophotometric methods (American Public Health Association [APHA], 2017). Nitrate concentration was determined using the ultraviolet spectrophotometric method, where the optical density of the treated sample was measured at 220 nm and compared with a prepared standard curve. Sulphate concentration was measured using the turbidimetric method, where barium chloride was added to form barium sulphate precipitate and turbidity readings were obtained with a photometer. Phosphate was determined using the stannous chloride method, where reagents produced a blue color whose intensity was measured with a spectrophotometer at 690 nm and compared with a phosphate calibration curve to determine concentration.

Sampling of Macroinvertebrates

Macroinvertebrate samples was collected between 07.00hrs – 12.00hrs, alternating from upstream (station 1 to station 3) and downstream to upstream (station 3 to station 1), on every other sampling day, using the "Kick sampling technique" and an Ecrkman grab.

Kick Sampling Technique

The modified "Kick sampling technique" described by Kellogg (1984) was used to sample Macroinvertebrates. The kick net, with a mesh size of 154 µm, was placed downstream of the collector, with the flat side of the "D-shaped" frame resting on the substrate or stream bed. The collector walked forward while the net stood behind, and the substrate and littoral macrophytes were disturbed by kicking. The water current carried the dislodged animals into the standing net. Sampling was extended only along the area adjacent to the stream bank, because this region is known to have aquatic macrophytes that support macroinvertebrate fauna.

Sample Processing

Samples were preserved directly without sorting in 70% ethanol. The debris and associated macroinvertebrate organisms from each sample were stained with Rose Bengal, a stain that binds to animal tissues, and transported to the laboratory of the Department of Animal and Environmental Biology, Delta State University, Abraka. The stained samples were processed using the flotation technique as described by Arimoro (2010). This technique involved submerging the samples in a sodium chloride solution (12.2 g/L in filtered river water) with a specific gravity higher than that of the macroinvertebrate organisms. The invertebrates floated to the surface, where they were easily collected using forceps.

Statistical Analysis

With the aid of PAST statistical software, Principal component analysis (PCA), was applied to physical (air and water temperature) and chemical (conductivity, pH, alkalinity, dissolved oxygen, sulphate, nitrates, and total phosphorus) and macroinvertebrate abundance to evaluate the variations which exist between the various sampling stations in Jeddo river. A One-way ANOVA was applied to physicochemical parameters to determine any variations between the various stations. The Turkey's pairwise analysis was used to determine the points of these variations, if present. Microsoft Excel 2010 was used to plot simple line graphs and bar charts showing the fluctuations in the values of measured parameters.

Functional Feeding Groups of Macroinvertebrates

In the laboratory, the macroinvertebrate samples was identified to genus or species levels, counted, and assigned into functional feeding groups using the identification keys of Cummins *et al.* (2005). The functional feeding group ratios was used to calculate ecosystem attributes.

i. Autotrophy/ Heterotrophy (P/R) Index = $Scrapers / Shredders + Total\ Collectors$
ii. Substrate Stability Index = $Scrapers + Filtering\ Collectors/Shredders + Gathering\ Collectors$
iii. Predator Index = $Predator / Scrapers + Shredders + Total\ Collectors$

Where,

Predators = Organisms that feed on other organisms or consumers.

Scrapers = They consume benthic algae and associated materials.

Shredders= These consume leaf litter or other coarse particulate organic matter (CPOM).

Collectors= They collect fine particulate organic matter (FPOM) from the stream bottom and dissolved organic matter from the water column using a variety of filtering structures.

RESULTS AND DISUSSION

Environmental Parameters

Table 1 presents the mean values and standard deviations of physico-chemical parameters measured across the three sampling stations in Jeddo River, together with the F-values, p-values, and recommended WHO/NSDWQ limits for drinking water. The results show that air temperature and water temperature were relatively similar across the stations, with mean water temperatures ranging from 28.14°C to 28.88°C, which fall within the acceptable limit of ≤40°C. The pH values at Stations 1 and 2 were slightly acidic (around 6.0), while Station 3 recorded a higher alkaline mean value. Electrical conductivity ranged from 107.85 to 143.94 µS/cm, remaining far below the WHO permissible limit of 1000 µS/cm, indicating relatively low ionic concentration in the river water. Salinity values also varied slightly among stations, reflecting the estuarine nature of the river.

Other water quality indicators such as dissolved oxygen (DO), biochemical oxygen demand (BOD), and nutrient concentrations showed moderate variations among stations. Dissolved oxygen values ranged from 5.43 to 5.95 mg/L, slightly above the recommended minimum of 5 mg/L, suggesting that the river water can still support aquatic life.

BOD values were relatively low (2.12–2.70 mg/L), indicating moderate organic pollution levels and remaining below the standard limit of 5 mg/L. Nutrients such as nitrates, sulphates, and phosphates were generally within acceptable limits, although sulphate levels slightly exceeded the recommended guideline in some cases. Statistical analysis showed that most parameters did not differ significantly among stations ($p > 0.05$), except for conductivity and turbidity, which showed noticeable variation, possibly reflecting differences in local environmental conditions and human activities at the sampling sites.

Table 1: A Summary of the Results of the Physico-Chemical Parameters of the Sampled Stations, Showing Sample Means ± Standard Deviation, F-Value, P-Value, and Standard Limits of these Parameters in Drinking Water

Water Parameter	Station 1 Mean±SD	Station 2 Mean±SD	Station 3 Mean±SD	F-value	P-value	WHO/NSDWQ /SON
Air Temperature (^{0}C)	30.94±0.49 (27.00-34.50)	30.00±0.37 (27.32-33.00)	31.51±0.46 (28.00-34.90)	2.98	0.2397	Not Listed
Water Temperature (^{0}C)	28.52±0.34 (26.00-33.10)	28.14±0.29 (26.00-30.10)	28.88±0.52 (21.00-33.50)	0.88	0.0962	≤40
pH	6.08±0.21 (3.39-7.28)	6.02±0.20 (3.51-7.45)	9.15±2.35 (3.63-63.00)	1.71	0.1900	6.5-8.5
Conductivity (µS/cm)	107.85±7.86 (35.90-200.00)	128.62±24.28 (43.20-516.00)	143.94±23.56 (4.00-516.00)	0.82	0.0365	1000
Salinity (mg/L)	23.46±4.44 (1.00-66.00)	19.91±4.22 (0.00-57.00)	31.16±5.34 (2.00-80.00)	1.50	0.4357	
Turbidity	5.50±0.71 (0.06-11.30)	-4.57±3.89 (-70.00-8.50)	28.66±6.57 (0.08-101.20)	14.80	0.0018	
D.O. (mg/L)	5.75±0.69 (2.90-17.00)	5.43±0.52 (2.40-12.00)	5.95±0.64 (2.60-16.40)	0.19	0.8287	5
B.O.D (mg/L)	2.12±0.18 (0.80-4.00)	2.70±0.39 (0.90-8.40)	2.52±0.30 (1.00-5.80)	0.28	0.7513	5
Nitrates (mg/L)	1.24±0.12 (0.44-2.53)	1.16±0.15 (0.05-3.00)	1.52±0.18 (0.22-3.20)	1.56	0.4206	50
Sulphates (mg/L)	102.02±9.24 (20.00-181.20)	103.83±9.20 (30.50-198.00)	94.90±10.20 (0.16-180.80)	0.24	0.4738	100
Phosphates (mg/L)	0.31±0.04 (0.02-0.82)	2.95±1.88 (0.02-35.00)	0.39±0.06 (0.05-1.20)	1.92	0.2213	5

Macroinvertebrates Functional Feeding Groups (FFG) in Jeddo River

The macroinvertebrate community of the Jeddo river was categorized into three distinct functional groups; collector/gatherers, predators and Grazers, (Table. 2). The macroinvertebrate community was dominated by the predators with 923 individuals, from 16 different families. The sub-dominant group was the Collector-gatherers with 134 individuals from 3 families, while the third and least FFG were the Grazers, with 18 individuals, from two families only. The predators were gotten from the following families; *Chironomidae, Tabanidae, Dytiscidae, Nauciridae, Hydrophilidae, Pisauridae, Gerridae, Atyidae, Desmoearidae, Araeolamidae, Dorilaimidae, Coenagrionidae, Petaluminidae, Libellulidae, Curculionidae* and *Palaemonidae.* The Grazers were represented by the familes, *Corbiculidae* and *Cerithidae* Collector-gatherers were contributed by the different families; *Chironomidae, Naididae* and *Lubricidae.* As shown in Table 2; the predators were most dominant, with 168, 620 and 135 individuals in stations 1, 2 and 3, respectively. The Collectors followed with 60 individuals in station 1, 59 individuals in station 2 and 15 in station 3. The Grazers came last with 4 individuals in station 1, 14 in station 2 and none in station 3.

Table 2: Composition and Abundance of Functional Feeding Groups in Jeddo River

Functional Feeding Groups	Family	Species	Station 1	Station 2	Station 3	Total
Gathering collectors	Naididae	Pristina aequiseta	0	14	2	16
	Lubricidae	E. eugeniea	10	14	4	28
	Chironimidae	Chironomus sp	50	31	9	90
Sub-total			60	59	15	134
Predator	Chironimidae	Pentaneura sp	12	7	4	23
	Tabanidae	Tabunus sp	10	2	0	12
	Dystiscidae	Dysticus sp	17	89	26	132
	Curculionidae	Neochetia sp	0	155	28	183
	Hydrophihilae	Hydrophilus sp	18	125	32	175
	Libellulidae	Anax junias	8	0	0	8
		Pachydiplax longipennis	8	0	0	8
	Megapoda gronidae	Ischnura sp	4	0	0	4
	Coenagrionidae	Pseudagrion sp	8	5	3	16

Functional Feeding Groups	Family	Species	Station 1	Station 2	Station 3	Total
	Naucoridae	Naucoris obscuratus	16	52	6	74
		Ilyocoris cimicoides	4	15	7	26
		Ranatra sp	7	14	2	23
	Gerridae	Geris lacustris	8	18	4	30
	Atyidae	Caridina africana	2	15	5	22
	Desmoearidae	D. trispinosa	7	12	4	23
	Palaemonidae	M. macrobrachion	0	10	2	12
	Pisauridae	Thalassius sp	11	59	3	73
		Dolomedes sp.	12	10	2	24
	Araeolaimidae	Rhabdolaimus sp	6	12	2	20
	Dorylaimidae	Dorylaimus sp	10	20	5	35
Sub-total			168	620	135	923
Grazers	Corbiculidae	Corbicula fluminea	4	12	0	16
	Cerithiidae	Cerithium spp.	0	2	0	2
Sub-total			4	14	0	18
			232	693	150	1075

Table 3, presents the ecological surrogate ratios of the various functional feeding groups of macro invertebrate in Jeddo River. The ratio of production to respiration, as well as that for Substrate stability indexes were the same. The values were highest in stations 2 (0.24), followed by station 1 with a value of 0.07, while it was zero in station 3 for both indices. The top-down ratio or predator to prey ratio was higher than 0.2 at the three sampled stations. The values recorded were; 2.63, 8.49 and 9.0, for stations 1, 2 and 3 respectively

Table 3: Ecological Surrogate Ratio of Aquatic Macroinvertebrate Functional Feeding Groups in Jeddo River

Ecological Surrogate	Station 1	Station 2	Station 3
Predator Index	2.63	8.49	9
Autotrophy/Heterotrophy	0.07	0.24	0
Stability Index	0.07	0.24	0

Discussion

The macroinvertebrate assemblage in the Jeddo River was categorized into three major Functional Feeding Groups (FFGs): predators, collector-gatherers, and grazers. The composition of the community revealed a clear dominance of predators, which comprised 923 individuals representing 16 distinct families. This group was followed by the collector-gatherers, which accounted for 134 individuals from three families, while the grazers were the least represented group, with only 18 individuals drawn from two families. The pronounced dominance of predatory macroinvertebrates has important ecological implications for the structure and functioning of the Jeddo River ecosystem.

A predator-heavy assemblage often reflects altered energy flow pathways, where secondary consumers exert strong top-down control on lower trophic levels. This can suppress the abundance of herbivorous and detritivorous taxa, potentially limiting organic matter processing and primary production within the system. Such a trophic imbalance is frequently associated with environmental stressors that reduce habitat suitability for more sensitive functional groups, thereby favoring resilient and opportunistic predators. The high dominance of predatory macroinvertebrates is consistent with observations in comparable tropical freshwater systems where environmental stress, moderate habitat complexity, and prey availability favor predator survival and recruitment (Arimoro and Ikomi, 2008; Barman and Gupta, 2016).

Predators in this study were distributed across a broad taxonomic range, including families such as Chironomidae, Tabanidae, Dytiscidae, Naucoridae, Hydrophilidae, Pisauridae, Gerridae, Atyidae, and Libellulidae, among others. This diversity reflects the adaptive success of predator taxa in exploiting a variety of prey and occupying diverse microhabitats within the river system.

Furthermore, the predominance of predators may indicate a system experiencing moderate ecological imbalance, where simplified food webs and reduced functional redundancy make the ecosystem more vulnerable to additional disturbances. The low representation of grazers and collector-gatherers suggests limited periphyton grazing and organic matter breakdown, processes that are essential for maintaining nutrient cycling and overall ecosystem resilience.

Consequently, the dominance of predatory taxa in the Jeddo River underscores the need for closer evaluation of habitat quality and anthropogenic influences that may be shaping the functional structure of its macroinvertebrate community. Collector-gatherers, comprising families such as Chironomidae, Naididae, and Lubricidae, were the subdominant group. These taxa typically feed on fine particulate organic matter (FPOM) and are often abundant in systems with moderate organic enrichment and relatively stable sediment substrates (Cummins and Klug, 1979). Their presence in all stations, albeit in lower numbers, suggests a level of sediment deposition sufficient to support their feeding strategy but not dominant enough to overshadow predatory taxa.

Grazers, represented only by the families Corbiculidae and Cerithiidae, showed the least abundance, with just 18 individuals across the study. Their low numbers, particularly the complete absence in Station 3, may be attributed to limited periphytic algae or macrophyte surfaces necessary for their feeding. This pattern may also reflect localized disturbances or substrate instability, which may have hindered the establishment of grazer populations. Spatial distribution of the FFGs varied across the three sampling stations. Predators

were most abundant in Station 2 (620 individuals), followed by Station 1 (168 individuals) and Station 3 (135 individuals), mirroring the overall macroinvertebrate abundance trend. Collector-gatherers also showed their highest count in Station 1 (60 individuals), with a marginal decrease in Station 2 (59 individuals), and the lowest count in Station 3 (15 individuals).

The grazers were recorded in Station 1 (4 individuals) and Station 2 (14 individuals), but were entirely absent in Station 3. This spatial variation may be influenced by factors such as organic matter availability, substrate composition, aquatic vegetation, and the degree of anthropogenic impact in each station. Ecological surrogate ratios further reveal insights into the functional structure and ecological health of the Jeddo River. The Production to Respiration (P/R) ratio and Substrate Stability Index were highest in Station 2 (0.24), followed by Station 1 (0.07), and zero in Station 3. These values indicate relatively higher ecosystem functioning and stability in Station 2, likely due to favorable physicochemical conditions and habitat complexity. The absence of these indices in Station 3 suggests poor substrate stability and reduced primary productivity or degraded habitat structure, which could explain the lower grazer and collector abundance observed there.

The Top-Down Control ratio (Predator/Prey) exceeded 0.2 in all stations, with values of 2.63, 8.49, and 9.0 in Stations 1, 2, and 3, respectively. These high values indicate strong predatory pressure across all stations, particularly in Stations 2 and 3. Elevated predator-to-prey ratios, as observed here, are often indicative of stressed or simplified systems where predator species dominate due to lower prey diversity or abundance, or due to increased habitat fragmentation.

CONCLUSION

The study has demonstrated that the composition and distribution of Macroinvertebrates, particularly their functional feeding groups, are reliable indicators of riverine ecosystem health. Variation in physico-chemical parameters across the sampled stations directly influenced the abundance and diversity of these macroinvertebrates, with stations subjected to higher anthropogenic pressures exhibiting reduced species richness and altered functional group composition. Collector-gatherers and shredders dominated relatively unpolluted areas, whereas pollution-tolerant taxa became more prevalent in impacted sections, highlighting the sensitivity of macroinvertebrate communities to environmental stressors.

Overall, the findings underscore the importance of using a combination of biological and physicochemical assessments for monitoring freshwater systems. The established relationships between macroinvertebrate functional groups and water quality parameters provide a practical framework for ongoing biomonitoring and conservation strategies. Therefore, maintaining habitat integrity and controlling pollutant inputs are essential for sustaining biodiversity and ecological function in tropical river systems.

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