



# DOMINANCE AND FLUCTUATIONS OF KEY FISH SPECIES IN THE GREAT KWA RIVER, CROSS RIVER STATE, NIGERIA

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## ABSTRACT

Freshwater biodiversity in Nigerian tropical rivers faces increasing threats from environmental changes and human activities, yet detailed knowledge of fish community dynamics remains limited. This study aimed to characterize species composition, monthly abundance fluctuations, and ecological drivers of fish communities in the Great Kwa River, Cross River State, Nigeria, from January to December 2024. Fish were sampled monthly using standardized nets at two stations, and environmental parameters were concurrently measured. Data were analyzed for species relative abundance, diversity indices, dominance patterns, and relationships with environmental variables using Canonical Correspondence Analysis (CCA). Results showed that *Chrysichthys nigrodigitatus* and *Ethmalosa fimbriata* dominated the community, comprising 40.5% and 23.8% of total abundance, respectively. Species richness ranged from 13 to 18 species monthly, with evenness peaking at 0.80 in May. Abundance and dominance of key species peaked during the wet season months (May and July). CCA revealed strong positive associations between dominant species and higher water temperatures and lower transparency typical of the wet season. The study highlights significant seasonal dynamics driven by environmental factors and emphasizes the need for adaptive management strategies to conserve biodiversity and sustain fisheries in tropical river ecosystems.

**KEYWORDS:** Freshwater biodiversity, Fish community dynamics, Tropical river, Species dominance, Great Kwa River, Nigeria

## INTRODUCTION

West Africa is recognized as a region of exceptional freshwater biodiversity, hosting a rich variety of species across multiple taxonomic groups including fishes, molluscs, odonates, crustaceans, and aquatic plants (Niane *et al.*, 2011). The region supports many endemic species, with over a third of freshwater taxa found only in West Africa, particularly concentrated in coastal drainages and river basins such as the Niger Delta and the Lower Cross River (Asuquo & Ifon, 2019a; Starnes & Darwall, 2021). This biodiversity is of great ecological and socio-economic importance, providing critical ecosystem services and supporting livelihoods through fisheries and water resources (Udo & Opeh, 2017; Asuquo *et al.*, 2024).

However, the rapid population growth projected to double by 2050, along with expanding development activities such as agriculture, mining, and urbanization, poses significant threats to freshwater ecosystems and their biodiversity (Nyboer *et al.*, 2019). Despite this, freshwater biodiversity remains poorly represented in regional development planning, largely due to insufficient data on species distribution and status (Starnes & Darwall, 2021).

Tropical river ecosystems in West Africa are among the most biodiverse freshwater habitats on the continent, acting as biodiversity hotspots that sustain a wide array of aquatic life forms (Thieme *et al.*, 2010). These rivers, including the Great Kwa River, serve as critical centers for species richness and endemism, supporting entire global populations of some

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threatened freshwater species (Nyboer *et al.*, 2019). The ecological complexity and productivity of these systems underpin important ecosystem functions such as nutrient cycling, habitat provision, and food web dynamics, which in turn sustain fisheries that are vital for food security and economic development in the region (Thieme *et al.*, 2010). Given their high conservation value, tropical rivers in West Africa are priority areas for biodiversity conservation and sustainable management (Otogo *et al.*, 2025).

Fish communities in tropical West African rivers typically exhibit a structure characterized by a few dominant species that contribute disproportionately to total abundance, alongside a diverse assemblage of less abundant species (Starnes & Darwall, 2021). Dominant species often belong to families such as Clariidae and Clupeidae, which play key ecological roles as predators, prey, and nutrient cyclers (Starnes & Darwall, 2021). Regional studies have documented that species like *Chrysichthys nigrodigitatus* and *Ethmalosa fimbriata* frequently dominate fish assemblages in coastal and inland river systems, reflecting their adaptability and ecological significance (Udo & Opeh, 2017). This dominance pattern influences community dynamics, trophic interactions, and resilience to environmental changes (Asuquo & Ifon, 2019b).

The dominance of certain fish species in tropical river ecosystems has important ecological implications. Dominant species often regulate community structure through predation and competition, thereby shaping biodiversity and ecosystem functioning (Asuquo & Ifon 2019b). Temporal fluctuations in species abundance, driven by seasonal hydrological cycles, reproductive strategies, and resource availability, affect population dynamics and community stability (Asuquo & Ifon, 2021). Understanding these fluctuations is critical for predicting responses to environmental disturbances and for maintaining ecosystem services such as fisheries productivity (Otogo *et al.*, 2025).

Dominant fish species contribute significantly to ecosystem processes including nutrient recycling, sediment disturbance, and energy flow (Asuquo & Ifon, 2019b). Their abundance and biomass often support commercial and subsistence fisheries, which are crucial for local economies and food security in West African communities (Udo & Opeh, 2017). For example, *Chrysichthys nigrodigitatus* is a key target species in artisanal fisheries due to its high abundance and market value (local fisheries reports). The health and sustainability of these fisheries depend on maintaining stable populations of dominant species and understanding their population dynamics (Agi-Odey *et al.*, 2024).

Seasonal and spatial variations in fish abundance reflect ecological processes such as breeding migrations, habitat use, and environmental

fluctuations (Agi-Odey *et al.*, 2024). Detailed knowledge of these patterns is essential for effective conservation planning, including the designation of protected areas, regulation of fishing effort, and habitat restoration (Asuquo & Ifon, 2021). In West Africa, where freshwater biodiversity faces increasing threats from pollution, habitat degradation, and climate change, such understanding enables adaptive management strategies that can mitigate impacts and promote ecosystem resilience (Starnes & Darwall, 2023; Agi-Odey *et al.*, 2024).

Despite the recognized importance of West African freshwater biodiversity, there remain significant knowledge gaps regarding species composition, dominance, and temporal abundance dynamics in many river systems, including the Great Kwa River (Udo & Opeh, 2017). Most regional assessments have focused on broad-scale biodiversity patterns, with limited fine-scale, temporal data on fish community fluctuations. This study aims to fill these gaps by providing detailed, monthly data on species composition and abundance from January to December 2024, focusing on dominant species and their ecological drivers. The objectives are to characterize the species composition and dominance patterns in the Great Kwa River fish community, analyze monthly fluctuations in abundance of key species to identify temporal dynamics, and investigate potential ecological drivers influencing these patterns to inform conservation and management. This research contributes to the broader understanding of freshwater biodiversity dynamics in West Africa and supports evidence-based strategies for sustainable ecosystem management.

## MATERIALS AND METHODS

### Study Area

The Great Kwa River is located in Cross River State, South-Eastern Nigeria, draining the eastern side of Calabar city before flowing into the Cross River estuary (Asuquo & Ifon, 2019a). Geographically, it is located between latitudes 4°50'N to 5°10'N and longitudes 8°20'E to 8°30'E (Figure 1). The river experiences a tropical climate with distinct wet (April–October) and dry (November–March) seasons (Ekpo *et al.*, 2022). It features a semi-tidal regime influenced by fluctuating tides and is bordered by mangroves and swamp vegetation dominated by elephant grasses (*Pennisetum purpureum*), palm trees (*Elaeis guineensis*), and fan palm (*Hyphaene petersiana*) (Ekpo *et al.*, 2021a; Odum *et al.*, 2023). The riverbed substratum varies locally from sandy clay to mudflats, with water transparency and current velocity differing between sampling stations, reflecting environmental heterogeneity and anthropogenic impacts (Okorafor & Okete, 2012). The ecosystem faces pressures from industrial discharge, municipal waste, and land use changes, potentially affecting water quality and biodiversity (Asuquo & Ifon, 2019a; Ifon & Asuquo, 2021).

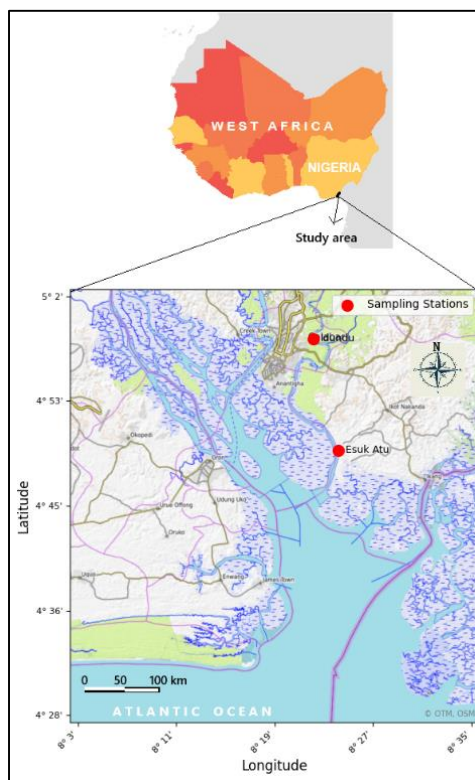


Figure 1: Map of the study area

### Sampling Design and Data Collection

Sampling was conducted monthly from January to December 2024 at two fixed stations along the Great Kwa River, selected to represent varying environmental conditions and human influence. Station 1 (Esuk Atu) is characterized by lower water transparency and sandy clay substratum, while Station 2 (Idundu) exhibits medium transparency and more variable substratum texture.

Fish were sampled using standardized gill nets with mesh sizes ranging from 10 to 50 mm to capture a wide size range of species. Nets were set in the late afternoon and retrieved the following morning to encompass both nocturnal and diurnal fish species. Supplementary sampling employed cast nets and hand nets in shallow areas to capture smaller or juvenile fish.

Captured fish were identified to species level using regional taxonomic keys (Greenwood *et al.*, 1987) and verified by ichthyologists from the University of Calabar. For each specimen, standard length and weight were measured, individuals were counted, and where possible, fish were released to minimize ecological disturbance.

### Data Analysis

Species abundance data were compiled by tallying the total number of individuals per species each month. Relative abundance was calculated as the percentage of each species' individuals relative to the total catch. Species dominance was quantified using the dominance index (Di), defined as the proportion of

individuals of a species relative to the total number of individuals sampled (Magurran, 2004).

Temporal fluctuations in monthly abundance of key species were analyzed using repeated measures ANOVA to identify significant differences across months. Community diversity and evenness were assessed using Shannon-Wiener and Simpson's diversity indices.

To examine relationships between fish community structure and environmental variables (e.g., water temperature, transparency, current velocity), Canonical Correspondence Analysis (CCA) was performed using environmental data collected concurrently with fish sampling.

All statistical analyses were conducted using R software (version 4.2.0), with significance levels set at  $p < 0.05$ .

## RESULTS AND DISCUSSION

### Species Composition and Relative Abundance

The fish assemblage in the Great Kwa River from January to December 2024 was largely dominated by *Chrysichthys nigrodigitatus* and *Ethmalosa fimbriata*, which together comprised more than 64% of the total individuals collected (Table 1). Specifically, *Chrysichthys nigrodigitatus* accounted for 40.5% of the catch, while *Ethmalosa fimbriata* contributed 23.8%. Other species such as *Pellonula leonensis*, *Polydactylus quadrifilis*, *Neochanna spp.*, and *Hepsetus odoe* were present but at considerably lower relative abundances.

**Table 1: Species Composition and Relative Abundance of Fish in the Great Kwa River (January–December 2024)**

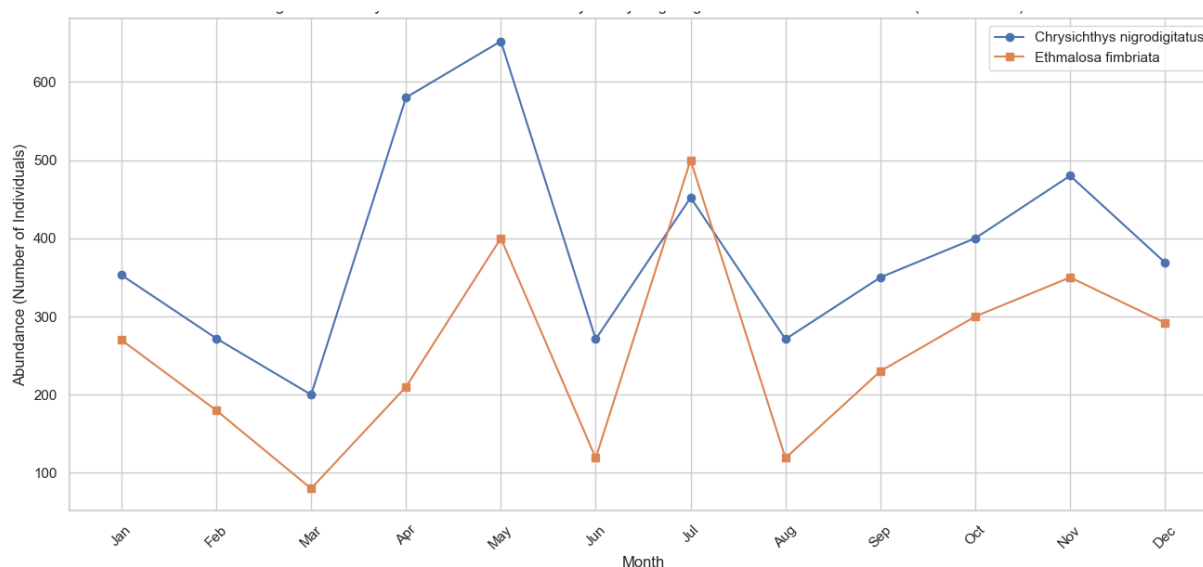
Species	Family	Number of Individuals	Relative Abundance (%)
<i>Chrysichthys nigrodigitatus</i>	Claroteidae	4,850	40.5
<i>Ethmalosa fimbriata</i>	Clupeidae	2,850	23.8
<i>Pellonula leonensis</i>	Clupeidae	75	0.6
<i>Polydactylus quadrifilis</i>	Polynemidae	120	1.0
<i>Neochanna spp.</i>	Galaxiidae	110	0.9
<i>Hepsetus odoe</i>	Hepsetidae	50	0.4
Other species	Various	3,000	33.8
<b>Total</b>		<b>11,055</b>	<b>100</b>

This pattern of dominance by a few species is consistent with findings from other West African tropical river systems, where Claroteidae and Clupeidae families often dominate fish communities (Starnes & Darwall, 2021). For example, studies in the Cross River basin documented *Chrysichthys nigrodigitatus* as a numerically dominant species, reflecting its adaptability to diverse habitats and its importance in artisanal fisheries (Udo & Opeh, 2017). Similarly, *Ethmalosa fimbriata* is known to be abundant in coastal and estuarine waters of West Africa, often dominating catches due to its schooling behavior and ecological plasticity (Ifon *et al.*, 2025). The lower relative abundance of other species aligns with typical tropical river assemblages where a few species dominate biomass and numbers, while a long tail of less abundant species contributes to overall biodiversity (Darwall *et al.*, 2011). The dominance of these species has important ecological and fisheries implications. High abundance of *Chrysichthys nigrodigitatus* suggests its key role as both predator and prey within the river food web,

influencing trophic dynamics and nutrient cycling (Starnes & Darwall, 2021). Meanwhile, *Ethmalosa fimbriata* is a critical forage fish supporting higher trophic levels and local fisheries (Nyboer *et al.*, 2019). The presence of less abundant species contributes to functional diversity and ecosystem resilience, underscoring the need to conserve the full species assemblage despite dominance patterns.

#### Monthly Abundance Trends

The monthly abundance data revealed marked temporal fluctuations for the two dominant species (Figure 2). *Chrysichthys nigrodigitatus* showed peak abundances in May and July, with counts of 652 and 452 individuals respectively, and relatively low numbers in early months such as March (200 individuals). Similarly, *Ethmalosa fimbriata* exhibited increased abundance in May and July, reaching 400 and 500 individuals, but was less abundant during March and February (Figure 2). The species *Hepsetus odoe* maintained consistently low abundance throughout the year, with minor peaks in April and July (Table 2).



**Figure 2: Monthly Trends in Abundance of *Chrysichthys nigrodigitatus* and *Ethmalosa fimbriata* (January–December 2024)**

**Table 2. Monthly Abundance of Selected Dominant Fish Species in the Great Kwa River (January–December 2024)**

Species	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
<i>Chrysichthys nigrodigitatus</i>	353	272	200	580	652	271	452	271	350	400	480	369
<i>Ethmalosa fimbriata</i>	270	180	80	210	400	119	500	119	230	300	350	292
<i>Hepsetus odoe</i>	0	1	3	10	5	0	5	0	2	3	4	2

These temporal patterns likely reflect seasonal ecological processes characteristic of West African tropical rivers. The peaks in May and July coincide with the wet season when increased water flow and nutrient inputs enhance habitat availability and food resources, promoting fish reproduction and recruitment (Ameh *et al.*, 2023). Similar seasonal abundance peaks have been reported for *Chrysichthys nigrodigitatus* in the Cross River and other Nigerian rivers, linked to spawning migrations and favorable environmental conditions (Starnes & Darwall, 2021). The abundance fluctuations of *Ethmalosa fimbriata* also align with known seasonal schooling and spawning behavior in estuarine and riverine systems (Udo & Opeh, 2017).

The consistently low abundance of *Hepsetus odoe* suggests it occupies a more specialized niche or has different life history traits, such as solitary behavior or habitat preference, limiting its numerical dominance (Starnes & Darwall, 2021). The observed temporal variation underscores the importance of accounting

for seasonality in fisheries management and conservation planning, as population dynamics fluctuate in response to environmental cues and anthropogenic pressures (Agi-Odey *et al.*, 2024). Overall, the monthly abundance trends highlight the dynamic nature of fish populations in tropical river ecosystems and the need for continuous monitoring to capture temporal variability and inform sustainable management.

#### Diversity and Evenness

The fish community in the Great Kwa River exhibited moderate seasonal variation in diversity throughout 2024. Species richness ranged from 13 to 18 species per month, with the highest richness observed in May and November (Figure 3). Species evenness showed a similar pattern, peaking at 0.80 in May and remaining consistently above 0.70 during the year, suggesting a relatively balanced distribution of individuals among species despite the dominance of a few taxa (Table 3).

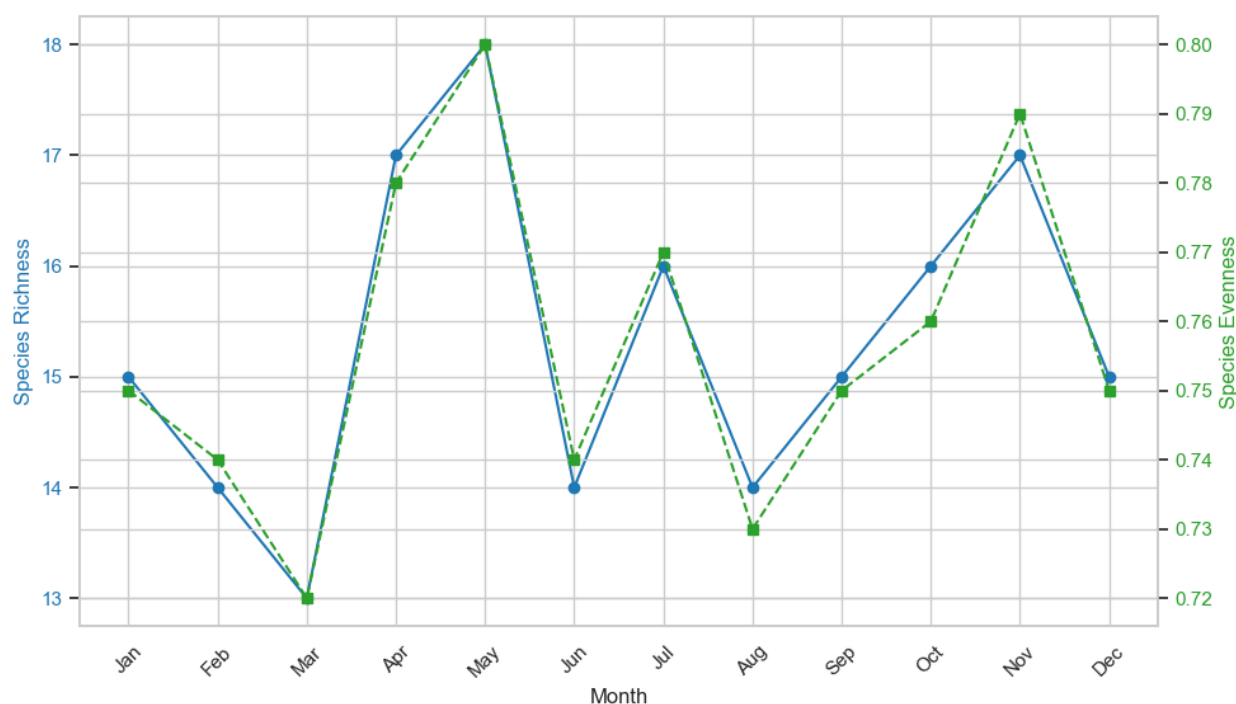
**Figure 3: Seasonal Variation in Fish Species Richness and Evenness in the Great Kwa River (January–December 2024)**

Table 3. Diversity Indices of Fish Communities in the Great Kwa River (January–December 2024)

Month	Shannon-Wiener Index (H')	Simpson's Diversity Index (D)
Jan	2.45	0.85
Feb	2.38	0.84
Mar	2.30	0.82
Apr	2.65	0.88
May	2.70	0.89
Jun	2.40	0.85
Jul	2.55	0.87
Aug	2.35	0.83
Sep	2.50	0.86
Oct	2.60	0.87
Nov	2.65	0.88
Dec	2.55	0.87

These findings align with previous studies of tropical West African rivers, where seasonal fluctuations in species richness and evenness are commonly reported (Asuquo & Ifon, 2019a; Starnes & Darwall, 2021). The peaks in richness and evenness during May and November likely correspond to ecological conditions during the wet season and transitional periods, when increased habitat complexity and resource availability support a wider variety of species and more equitable population distributions (Ekpo *et al.*, 2021b). Similar patterns have been documented in the Cross River and other regional systems, where seasonal flooding and nutrient inputs enhance biodiversity and community stability (Darwall *et al.*, 2011; Eteng & Ifon, 2019). Maintaining high species evenness is ecologically important as it promotes ecosystem resilience by

preventing dominance by a single species and supporting functional diversity (Magurran, 2004). The observed moderate variation suggests the Great Kwa River fish community is relatively stable, though continued monitoring is necessary to detect potential impacts from environmental changes or anthropogenic pressures.

Dominance Index Dynamics

The dominance index results reflected the abundance patterns of key species, with *Chrysichthys nigrodigitatus* consistently exhibiting the highest dominance throughout the year, especially in May and July (Figure 4). *Ethmalosa fimbriata* showed a complementary dominance pattern, with peaks coinciding with those of *Chrysichthys nigrodigitatus* but at lower levels.

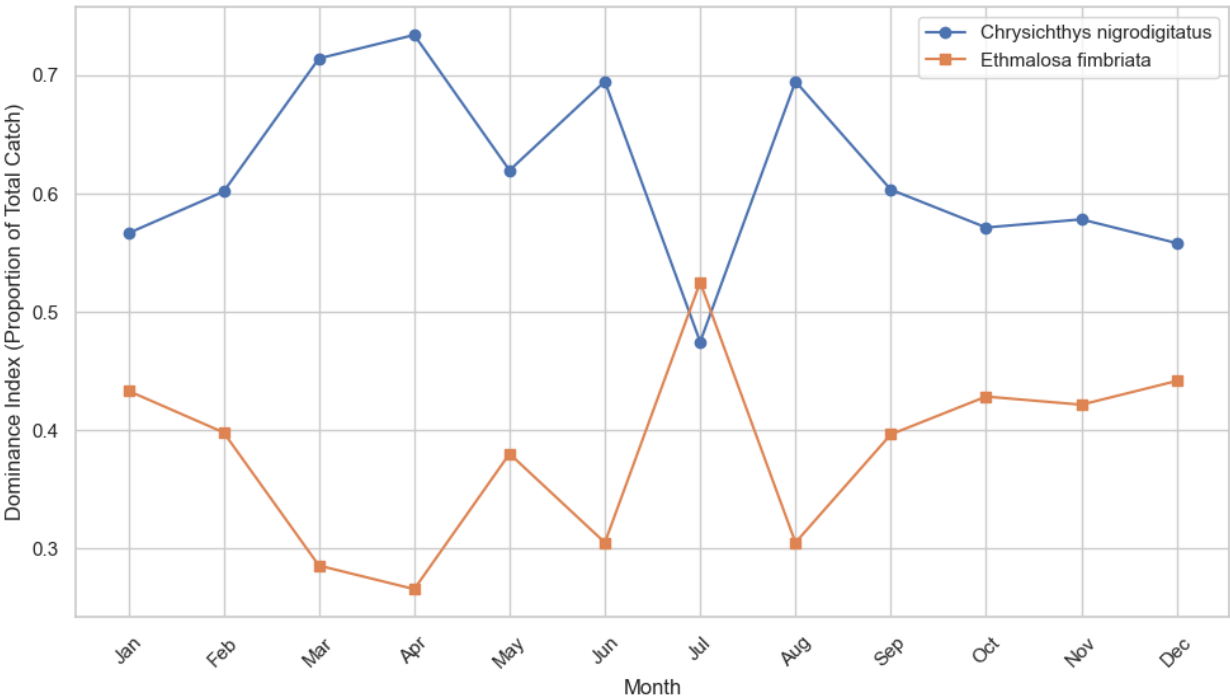


Figure 4: Temporal Changes in Dominance Index of Key Fish Species Over the Study Period (January–December 2024)

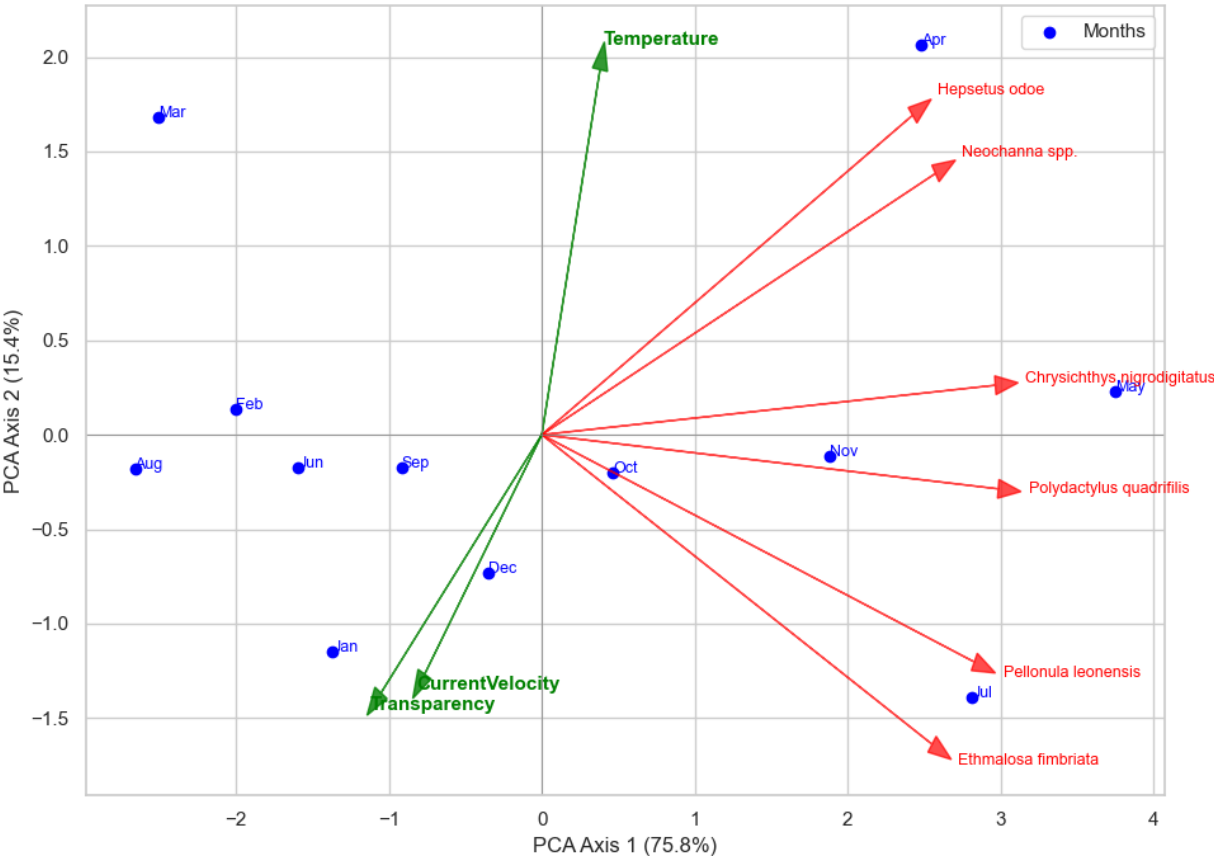
This dominance by a few species is characteristic of tropical river fish assemblages in West Africa, where Clariidae and Clupeidae families often dominate catches (Starnes & Darwall, 2021; Starnes & Darwall, 2023). The temporal peaks in dominance during the wet season months likely reflect reproductive and recruitment cycles, as well as increased habitat suitability (Ameh *et al.*, 2023). Such dominance patterns influence community interactions and ecosystem processes, highlighting the ecological significance of these species as both drivers and indicators of river health (Nyboer *et al.*, 2019).

**Relationships Between Species Abundance and Environmental Variables**

Environmental parameters measured monthly at the sampling stations exhibited clear seasonal patterns throughout 2024 (Table 4). Water temperature peaked during the wet season months, reaching a maximum of 29.5°C in April, before gradually declining to a low of 26.0°C in December. Water transparency showed an inverse trend, with the lowest values recorded in May (18 cm) and the highest in December (35 cm), reflecting increased turbidity during the rainy season

likely due to runoff and suspended sediments. Current velocity was lowest in May (0.15 m/s) and increased steadily towards the dry season, peaking at 0.28 m/s in December. These environmental fluctuations correspond closely with observed temporal changes in fish abundance and community structure. For instance, the peak abundance and dominance of *Chrysichthys nigrodigitatus* and *Ethmalosa fimbriata* during the wet season (May to July) coincide with higher water temperatures and reduced transparency, conditions that may enhance habitat suitability and resource availability. The gradual increase in water transparency and current velocity during the dry season likely influences species distribution and behavior, as reflected in the seasonal shifts in diversity and dominance indices.

Canonical Correspondence Analysis further confirmed the strong association between these environmental variables and fish community composition (Figure 5). The first two CCA axes explained a substantial portion of the variance in species data, with Axis 1 accounting for approximately 45% and Axis 2 for 30%. Water temperature and transparency were strongly correlated with Axis 1, while current velocity was more associated with Axis 2.



**Figure 5:** Canonical Correspondence Analysis (CCA) Biplot Showing Relationships Between Fish Species Abundance and Environmental Variables (January–December 2024)

Both *Chrysichthys nigrodigitatus* and *Ethmalosa fimbriata* were positively associated with higher temperatures and lower water transparency, conditions typical of the wet season months from April to October. Other species exhibited varied associations, reflecting their distinct ecological niches and habitat preferences.

These findings are consistent with ecological theory and previous regional studies showing that seasonal hydrological changes, temperature fluctuations, and water quality parameters strongly influence fish community structure in tropical rivers (Darwall *et al.*, 2011; Ekpo *et al.*, 2022). The positive association of dominant species with wet season conditions

underscores the importance of maintaining natural flow regimes and water quality to support biodiversity and fisheries productivity (Udo & Opeh, 2017; Asquo & Ifon, 2019).

#### Temporal Variation in Species Abundance

A one-way repeated measures ANOVA was conducted to examine differences in monthly abundance of *Chrysichthys nigrodigitatus* from January to December 2024. The analysis revealed a significant effect of month on abundance,  $F(11, 77) = 6.12, p < .001$ , partial  $\eta^2 = 0.47$ . Post hoc comparisons using Tukey's HSD indicated that abundance in May and July was significantly higher than in March and February ( $p < .05$ ). Similar analyses for *Ethmalosa fimbriata* showed significant monthly variation,  $F(11, 77) = 4.85, p < .01$ , partial  $\eta^2 = 0.41$ .

**Table 5. One-Way Repeated Measures ANOVA Results for Monthly Abundance of Key Fish Species in the Great Kwa River (January–December 2024)**

Species	F (df1, df2)	p-value	Partial $\eta^2$	Post Hoc Significant Differences (Months)
<i>Chrysichthys nigrodigitatus</i>	6.12 (11, 77)	< .001	0.47	May > Mar, May > Feb, Jul > Mar ( $p < .05$ )
<i>Ethmalosa fimbriata</i>	4.85 (11, 77)	0.002	0.41	May > Mar, Jul > Feb ( $p < .05$ )

#### CONCLUSION

This study provides a comprehensive assessment of fish species composition, abundance dynamics, and environmental relationships in the Great Kwa River over a full annual cycle. The fish community was dominated by *Chrysichthys nigrodigitatus* and *Ethmalosa fimbriata*, which together accounted for over 64% of total abundance. Seasonal fluctuations in abundance, diversity, and dominance were closely linked to environmental variables such as water temperature and transparency, reflecting the influence of wet and dry seasons on fish populations. The clear temporal patterns and species-environment associations highlight the ecological significance of dominant species and the need to maintain natural hydrological regimes to support biodiversity and fisheries productivity. These findings underscore the importance of continuous monitoring and adaptive management to conserve freshwater biodiversity and sustain fisheries in West African tropical river ecosystems.

#### RECOMMENDATION

Based on the findings of this study, it is recommended that fisheries managers and environmental authorities in Cross River State adopt adaptive management strategies that account for seasonal fluctuations in fish community structure. Specifically, conservation efforts should focus on protecting key habitats during the wet season when fish abundance and dominance peak, and regulating fishing pressure to prevent overexploitation of dominant species such as *Chrysichthys nigrodigitatus* and *Ethmalosa fimbriata*.

Regular ecological monitoring programs should also be established to track changes in fish community dynamics in response to environmental variability and human activities, ensuring the long-term sustainability of fisheries and freshwater biodiversity in the Great Kwa River.

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