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Diversity of Clupeidae (Cuvier, 1816) in the New Calabar River, Rivers State, Nigeria

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ABSTRACT: The study examined the diversity of Clupeidae species in the New Calabar River, Rivers State, Nigeria. Fish samples were collected monthly between May and October 2024 with the assistance of fishermen using various fishing gear. A total of 155 individuals belonging to the Clupeidae family were recovered and identified. Several ecological indices were applied to analyze species abundance and diversity. Five species were recorded: *Pellonula leonensis*, *Ethmalosa fimbriata*, *Ilisha africana*, *Sardinella maderensis*, and *Sardinella aurita*. The most abundant species was *Sardinella maderensis* (49.03%), followed by *Ilisha africana* (16.77%), while *Ethmalosa fimbriata* showed the lowest abundance (5.16%). The Simpson's index peaked in September (0.73) and was lowest in August (0.08). Dominance was highest in August (0.92) and lowest in September (0.27). The Shannon-Wiener index reached its highest value in September (1.45), indicating a highly diverse community, and the lowest in August (0.19). The evenness index was highest in October (0.91) and lowest in August (0.61). Margalef's index was highest in September (1.91) and lowest in August (0.31), suggesting reduced richness and fewer species relative to the number of individuals during that month. The diversity indices indicate that the family Clupeidae is fairly distributed in the study area. It is therefore recommended that further research be conducted to provide a comprehensive understanding of the biology and ecology of Clupeidae in the New Calabar River.

KEYWORDS: Distribution; abundance; New Calabar River; Clupieds

1. Introduction

The Niger Delta region is rich in natural resources and is one of the most prominent areas in Nigeria, endowed with numerous water bodies. These water bodies comprise both freshwater and marine ecosystems, which are abundantly inhabited by a diverse array of fish species [1]. Biodiversity refers to the variety of organisms or the variability among living organisms in the world [2]. Hundreds of thousands of the Earth's species have become extinct in the last fifty (50) years due to the destruction of their natural habitats, leading to significant depletion of various populations [3]. The Niger Delta consists of mangrove swamps and riparian forests, which have come under threat over the past six decades as a result of environmental pollution

stemming from oil exploration and dredging. Globally, river systems face major threats from human activities such as pollution, overharvesting of biotic resources, destruction of supporting riparian and floodplain ecosystems, and the alteration and regulation of natural flow regimes [4]. Overfishing is another significant factor contributing to the loss of aquatic biodiversity in the region [5]. Understanding the status of the ecosystem is essential for the development and implementation of effective conservation and management measures [6].

The Clupeidae family exemplifies remarkable taxonomic and genetic diversity within both marine and freshwater ecosystems. Species richness within this family is extensive, with approximately 200 recognized species distributed across multiple genera, reflecting notable evolutionary adaptation and ecological versatility. Research by [7] has comprehensively documented the global distribution of clupeid species, highlighting their presence in tropical, subtropical, and temperate marine and freshwater environments. Clupeidae populations function as sensitive ecological indicators, offering critical insights into the health and conditions of aquatic ecosystems. Their physiological responses, distribution patterns, and population dynamics make them excellent bio-monitoring species capable of detecting even minor environmental changes. The diversity within the Clupeidae family goes beyond basic classification, encompassing significant ecological and morphological variations. Ranging from brackish estuarine systems to marine pelagic zones, different species exhibit unique adaptations to specific environmental conditions. To ensure the sustainable use of fisheries resources, it is essential to consistently monitor and assess fish composition, abundance, and diversity.

2. Materials and Methods

2.1.Description of the study area.

The New Calabar River is a partially mixed estuarine system located between longitude 7°16′ E and latitude 4°25′ N in Choba, Rivers State, Nigeria. The region experiences a tropical climate characterized by high rainfall, with an average annual precipitation of approximately 2,372 mm, ranging between 2,000 and 3,000 mm [8]. The climate is divided into two main seasons: a wet season (April to September/October) and a dry season (October/November to March). The mean annual relative humidity is 86%, varying from 66% to 96%, while the average annual temperature is 25°C, with recorded values ranging from 22 °C to 32 °C. The New Calabar River is a vital water resource within the Niger Delta region of southern Nigeria, traversing several communities including Iwofe, Ogbakiri, Ogbogoro, Choba, and Aluu. It is bordered by residential areas, oil companies, abattoirs, manufacturing facilities, and a variety of transportation activities, all of which significantly influence the ecological dynamics of the river.

2.1.1. Sample and data collection.

Sampling was conducted twice monthly between May and October 2024. Fish specimens were collected from three stations—Choba, Ogbogoro, and Iwofe landing sites—along the New Calabar River. Collection was carried out with the assistance of local fishermen using various types of fishing gear during neap tide, to ensure uniformity in sampling conditions. The fish samples were immediately preserved in ice containers and subsequently transported to the laboratory for further analysis. Species identification was performed following the methods

described in references [10–12]. Each fish specimen was measured to the nearest centimeter using a measuring board and weighed to the nearest 0.1 gram using a top-loading Sartorius balance.

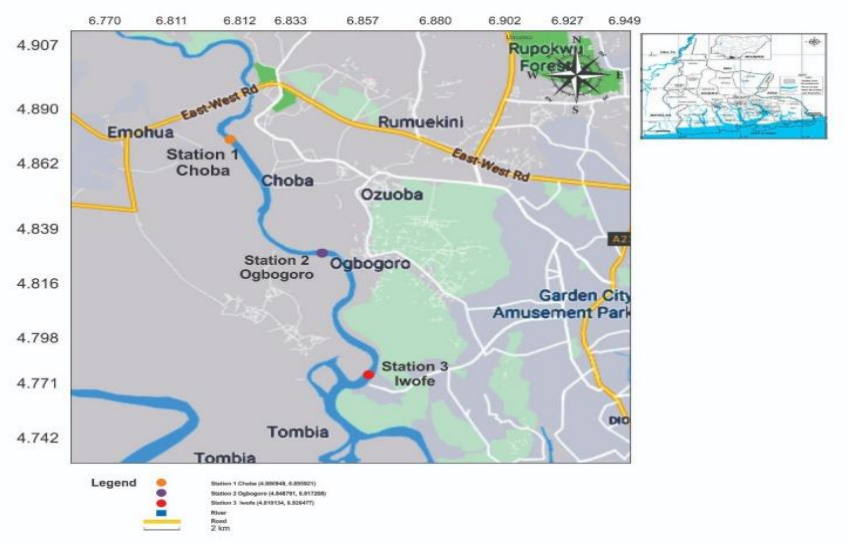

Figure 1. Map of the study area.

2.1.2. Data analysis.

A number of ecological indices were used to describe the diversity of Clupeidae species in the New Calabar River:

- Relative Species Abundance (%) = (n/N) × 100

  This refers to the proportion of each species in the total catch. It was determined by dividing the number of individuals of a given species (n) by the total number of individuals (N) recorded, and multiplying the result by 100.

- Simpson's Index (d) = ∑n(n - 1) / N(N - 1)

  Where *n* is the number of individuals of a particular species, *d* is the diversity index, and *N* is the total number of individuals in the sample.

- Simpson's Index of Diversity = (1 – d)

- Simpson's Reciprocal Index = (1 / d)

- Shannon-Wiener Index (H′) = –∑Pi ln Pi [13]

- Where *Pi* is the proportion of the total number of individuals occurring in species *i*, *n* is the number of individuals of a species, and *N* is the total number of individuals across all species.

- Pielou's Evenness Index (J) = H′ / ln S [14]

  Where *H′* is the Shannon-Wiener diversity index and *S* is the total number of species (species richness).

These diversity indices were applied to compare the different sampling stations and to provide a comprehensive understanding of the distribution and relative abundance of Clupeidae species in the study area.

3. Results and Discussion

The physico-chemical parameters of the three sampled stations in the New Calabar River are presented in Table 1. The results revealed that there was no significant difference ($p > 0.05$) in the pH values of the water samples across the three stations. The mean pH ranged from 6.43 ± 0.32 at Ogbogoro to 6.88 ± 0.33 at Choba. The highest mean temperature value of 29.31 ± 0.99 °C was recorded at Iwofe, while the lowest value of 26.61 ± 0.92 °C was observed at Choba. Dissolved oxygen (DO) levels ranged from 3.78 ± 0.37 mg/l at Choba to 5.54 mg/l at Iwofe. Salinity values ranged from 3.78 ± 0.37 ppt at Choba to 14.46 ± 1.56 ppt at Iwofe. Both dissolved oxygen and salinity showed statistically significant differences ($p < 0.05$) across the three sampling stations.

Table 1. Physico chemical parameters in the New Calabar River.

Parameters	Choba	Ogbogoro	Iwofe
pH	6.88 ± 0.33^a	6.43 ± 0.32^a	6.67 ± 0.47^a
Temperature	26.61 ± 0.92^a	28.68 ± 0.62^b	29.31 ± 0.99^b
Dissolved Oxygen	3.78 ± 0.37^a	4.37 ± 0.30^b	5.54 ± 0.29^c
Salinity	12.41 ± 1.25^a	13.86 ± 1.60^b	14.46 ± 1.56^c

Means with different superscripts along same row are significantly different ($p<0.05$).

Table 2 presents the composition of the Clupeidae family recovered from the study area. A total of five (5) species—*Pellonula leonensis*, *Ethmalosa fimbriata*, *Ilisha africana*, *Sardinella maderensis*, and *Sardinella aurita*—were identified. The species exhibited variations in abundance across the sampling months, with the highest total catch recorded in September, during which all five species were present. The catch was dominated by *Sardinella maderensis*, which was recorded throughout the sampling period, followed by *Pellonula leonensis* and *Ilisha africana*. Of the five species, *Ethmalosa fimbriata* was the least represented, being recorded only in May and September. *Sardinella maderensis* showed the highest percentage composition across all months, with peak abundance in May and June, and the lowest in August. *Ilisha africana* was not recorded in May, June, and July, but showed the highest percentage composition (93.85%) in August and the lowest (10.34%) in October. *Pellonula leonensis* recorded its highest percentage composition in October and the lowest in September. *Sardinella aurita* was fairly distributed with low abundance across the sampling months, peaking in September. Meanwhile, *Ethmalosa fimbriata* had its lowest percentage composition in September.

Table 2. Percentage composition of Clupeidae fish species in the New Calabar River.

Species	May	June	July	August	September	October
Pellonula Leonensis	0	27.78	24	0	6.9	37.5
Ethmalosa fimbriata	18.52	0	0	0	10.34	0
Ilisha aficana	0	0	0	95.83	10.34	0
Sardinella maderensis	74.07	61.11	64	4.17	41.38	50
Sardinella aurita	7.41	11.11	12	0	31.03	12.5
Total	**100**	**100**	**100**	**100**	**100**	**100**

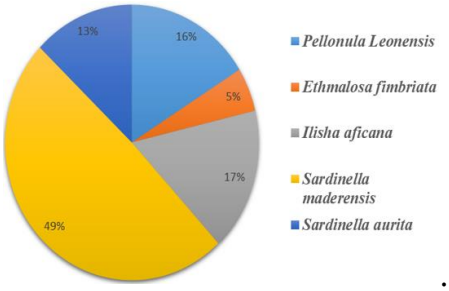

Figure 2. Abundance of Clupeidae species in New Calabar River.

Figure 2 illustrates the species abundance of Clupeidae in the New Calabar River. *Sardinella maderensis* was the most abundant species, accounting for 49.03% of the total catch, followed by *Ilisha africana* (16.77%), *Pellonula leonensis* (16.13%), *Sardinella aurita* (12.9%), and the least abundant species, *Ethmalosa fimbriata* (5.16%). Table 3 presents the diversity indices for Clupeidae. The highest number of taxa (5 species) was recorded in September, while the lowest (2 species) was observed in August. The highest individual count (32) occurred in October, whereas the lowest (18) was recorded in June. Species dominance was highest in August and lowest in September. Simpson's index, which indicates species diversity, reached its highest value in September and its lowest in August. Similarly, the Shannon-Wiener Index (H) recorded the highest value in September, indicating a more diverse community, and the lowest in August, reflecting reduced diversity.

Table 3. Diversity of Clupeidae fish species in the New Calabar River.

Parameters	May	June	July	August	September	October
Number of Taxa	3	3	3	2	5	3
Number of Individuals	27	18	25	24	29	32
Dominance (C)	0.57	0.43	0.46	0.92**	0.27*	0.39
Simpson's index (D)	0.43	0.57	0.54	0.08*	0.73**	0.61
Shannon-Wiener (H)	0.76	0.96	0.92	0.19*	1.45	1.01**

*Lowest calculated value ** Highest calculated value.

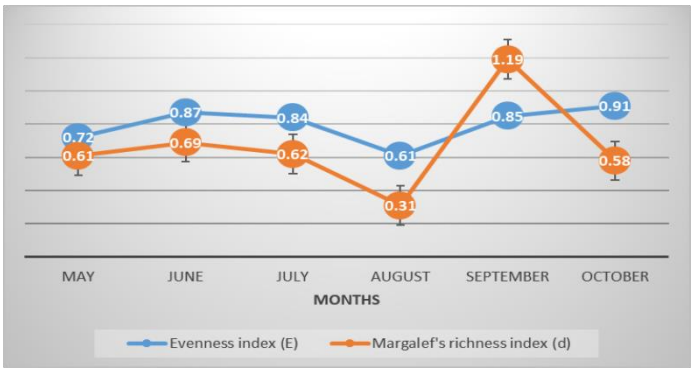

Figure 3. Evenness and Margalefs richness in the New Calabar River.

Figure 3 illustrates the Evenness Index (E), with the highest evenness recorded in October (0.91), indicating a more balanced distribution of species. In contrast, the lowest evenness was observed in August (0.61), suggesting a dominance by fewer species. Margalef's Richness Index (d) showed the highest value in September (1.19), reflecting greater species richness, while the lowest value was recorded in August (0.31), indicating lower richness. Table 5 presents the similarity coefficient across sampling months. A very strong similarity coefficient

(0.996*) was observed between the months of June and July. Additionally, October exhibited a strong similarity with both June and July, which was statistically significant ($p > 0.05$).

Table 5. Similarity coefficient of pairs of sampling months of Clupeidae species in the New Calabar River.

Months	May	June	July	August	September
June	0.816				
July	0.856	0.996*			
August	-0.320	-0.401	-0.385		
September	0.779	0.679	0.730	-0.322	
October	0.635	0.96*	0.934*	-0.465	0.515

* Significantly different ($p>0.05$)

The results of this study showed that five species from the family Clupeidae were recorded in the New Calabar River: *Sardinella maderensis*, *Sardinella aurita*, *Pellonula leonensis*, *Ilisha africana*, and *Ethmalosa fimbriata*. This contrasts with the findings of [15], who reported only three species from the Malabar Coast of Kerala. However, the findings align with [16] and [4], who each recorded three species using gill nets and cast nets, respectively, confirming the presence of Clupeidae in the New Calabar River. These species are typically coastal marine fishes, as reported by [7], but they are known to migrate into freshwater for various ecological purposes [17]. The limited number of species observed in previous studies may be attributed to the use of single fishing gears (e.g., gill nets), whereas this study employed a variety of fishing methods, leading to a broader catch. Among the five species, *Sardinella maderensis* was the most abundant, followed by *Ilisha africana*, *Pellonula leonensis*, and *Sardinella aurita*, with *Ethmalosa fimbriata* being the least abundant. This finding agrees with [16], who also observed *Sardinella* as the dominant species. The high abundance of *Sardinella maderensis* may result from its biological traits, such as high fecundity, high survival rates, and strong competitive ability [18].

Monthly species representation revealed variability in species richness, with the highest diversity observed in September and the lowest in August. This variation may reflect differences in sampling effort, fishing methods, or seasonal abundance, as also noted by [19]. For instance, [4] reported only two Clupeidae species (*S. maderensis* and *E. fimbriata*) and described the New Calabar River as a mixed estuary—a classification supported by the physico-chemical results of this study. The New Calabar River, a tributary of the River Niger that discharges into the Atlantic Ocean, supports migratory behavior in fish species. Such migratory patterns highlight the need for a nuanced approach to fisheries management, particularly for Clupeidae. The absence or rarity of some species may indicate a declining trend in fish biodiversity. Diversity indices, which offer more insights than simple species counts, were employed to assess community structure and ecological stability [20]. Species diversity is influenced by ecological interactions such as competition, predation, and succession, all of which affect species evenness [21]. According to Shannon-Wiener index classifications, a diversity value below 1 indicates instability, 1–3 reflects moderate stability, and values above 3 represent a highly stable ecosystem [22]. In this study, diversity indices—including Simpson's Index (D), Dominance (C), Shannon-Wiener Index (H), Evenness Index (E), and Margalef's Richness Index (d)—were calculated monthly. These indicators reflect the health of the ecosystem, with lower diversity suggesting environmental stress [23]. The low dominance values recorded may be attributed to anthropogenic influences such as dredging, industrial discharge, and seasonal environmental fluctuations.

Previous studies, such as [4], also reported uneven species distribution due to gear selectivity, with cast nets capturing fewer species. In contrast, [24] recorded three evenly distributed species using gill nets. Our study highlighted variations in richness, evenness, and dominance across months. September showed the highest diversity (H = 1.45), while August showed the lowest (H = 0.19) due to the dominance of *Ilisha africana*, potentially influenced by seasonal or anthropogenic factors. Evenness was highest in October (0.91), suggesting balanced species distribution, whereas August had the lowest (0.61), reflecting dominance by a single species. The Shannon-Wiener Index values above one in September and October indicate moderate ecological stability during these months, while values below one in earlier months suggest instability, likely due to industrial activities. This is in contrast with [25], who reported higher species richness in the New Calabar River—possibly due to longer sampling periods or different methodologies. Factors like gear type, fish behavior, and avoidance responses may all impact catch composition and species representation.

Similarity coefficient indices were also evaluated to assess temporal changes. June and July had a very strong similarity (0.996*), with October also showing strong similarity to both June and July ($p < 0.05$). Typically, fish communities in riverine systems exhibit seasonal trends of increasing diversity and abundance, often related to spawning migrations or salinity preferences [26], [27]. In this study, fish diversity increased from August to October, possibly indicating seasonal recruitment. The observed patterns may also reflect cumulative impacts of habitat degradation and human activities such as sand mining and industrial discharges, as noted in earlier reports [28], [29]. These activities negatively affect water quality and fish health [30], and crude oil pollution is a significant factor contributing to reduced fish catches. Stress-induced changes in community structure lead to declining species diversity and abundance. The significant similarity across some months might also be influenced by the rainy season, which typically affects hydrology and fish distribution. These findings suggest ongoing fishery decline and potential stock depletion of Clupeidae in the Niger Delta region. Overfishing, particularly of juveniles, limits population recovery and poses a threat to the long-term viability of the fish community [31].

4. Conclusion

The study provided scientific findings regarding the Clupeidae family in the New Calabar River, which plays a critical role in providing habitat for Clupeidae species such as *Sardinella maderensis, Sardinella aurita, Pellonula leonensis, Ilisha africana*, and *Ethmalosa fimbriata. Sardinella maderensis* was the most abundant species recorded in the results of this study, followed by *Ilisha africana, Pellonula leonensis,* and *Sardinella aurita,* while *Ethmalosa fimbriata* was the least abundant. The diversity indices revealed that the biological dynamics of Clupeidae were not stable during the rainy season, which was attributed to industrial activities in the study area, underlining the importance of sustainable fisheries management through mesh regulations, which would allow for proper recruitment while accounting for the factors that influence species abundance and diversity. It is therefore recommended that further research be conducted on the food and feeding habits, as well as stock assessment studies, to provide a comprehensive examination of the biology and ecology of Clupeidae in the New Calabar River.

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Author Contribution

Conceptualization: Henry Eyina Dienye, Olaniyi Alaba Olopade. Methodology: Henry Eyina Dienye, Olaniyi Alaba Olopade; Data Collection: Henry Eyina Dienye, Pretty Sunday. Data Analysis: Henry Eyina Dienye. Writing: Henry Eyina Dienye. Supervision: Henry Eyina Dienye, Olaniyi Alaba Olopade. Funding: Henry Eyina Dienye, Olaniyi Alaba Olopade.

Competing Interest

The authors declare that they have no conflicts of interest related to the publication of this research paper. No financial, personal or professional relationships influenced this research work.

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