

Aspects of biology of Clupeidae in the New Calabar river, Niger delta, Nigeria

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Abstract

The study examined the aspect of biology of the Clupeidae family in the New Calabar River, sampling was carried out with the assistance of fishermen in the landing sites. A total of 155 individuals of Clupeidae species were recovered, identified and data collected were statistically analysed using descriptive statistics. The result showed that *Sardinella maderensis* was the most abundant species, accounting for 49.03% of the sampled individual followed by *Ilisha africana* (16.77%) and *Pellonula leonensis* (16.13%). Sex ratio reported a male-dominated populations for the majority of species, *Pellonula leonensis* with a male-to-female ratio of 2.57:1 and *Sardinella maderensis* having a ratio of 2.17:1. *Ethmalosa fimbriata* recorded an equal sex ratio 1:1. Hepatosomatic index (HSI) values varied among species, *Ilisha africana* recorded the highest HSI (4.00 ± 0.00). *Ethmalosa fimbriata* and *Sardinella aurita* had identical mean HSI values 3.51 ± 0.01 , while *Pellonula leonensis* recorded the lowest HSI 2.51 ± 0.01 . Therefore there is need for conservation measures during peak spawning seasons to preserve biodiversity and fishery production of Clupridae species in the New Calabar River

Keywords: Hepatosomatic index; Clupeidae; Sex ratios; New Calabar River

1. Introduction

Clupeidae species play multifaceted roles within the ecosystem, serving as both key components of the food web and valuable targets for commercial fisheries, providing sustenance and livelihoods for local communities. Clupeids are among the most important commercial fish species [19]. The New Calabar River, situated within the Niger Delta region of Nigeria, Port-Harcourt specifically, represents a vital aquatic ecosystem characterized by its rich biodiversity and socio-economic importance. The river system supports diverse fish communities, including species from the Clupeidae family, commonly known as herrings, shads, and sardines.

The gonad's relative weight in relation to somatic weight, or total body weight, is measured by the gonadosomatic index (GSI) [14]. According to [16], multiple spawners produce fewer, larger eggs over a longer breeding period, sometimes lasting the entire year. Only a portion of the eggs ripen in the gonad at a single spawning are said to be produced by total spawners, despite the fact that the former are thought to have a higher GSI than the latter [24]. The gonadosomatic index indicates the proportion of fish body weight that is utilized for egg production. The proportion of male to female fish in a population, the prevalence of sex in that population, and the fundamental data required for fish reproduction and stock size estimation are all provided by studies on sex ratios. [4]. The foundation for creating plans and creating regulations for efficient management of fisheries resources is the study of the reproductive biology of various fish species. Gonadosomatic index (GSI) and sex ratio study present a viable way to learn about fish reproductive biology and to guide management and conservation plans. Researchers can learn more about reproductive tactics, population dynamics, and possible dangers to fish populations by examining sex ratios.

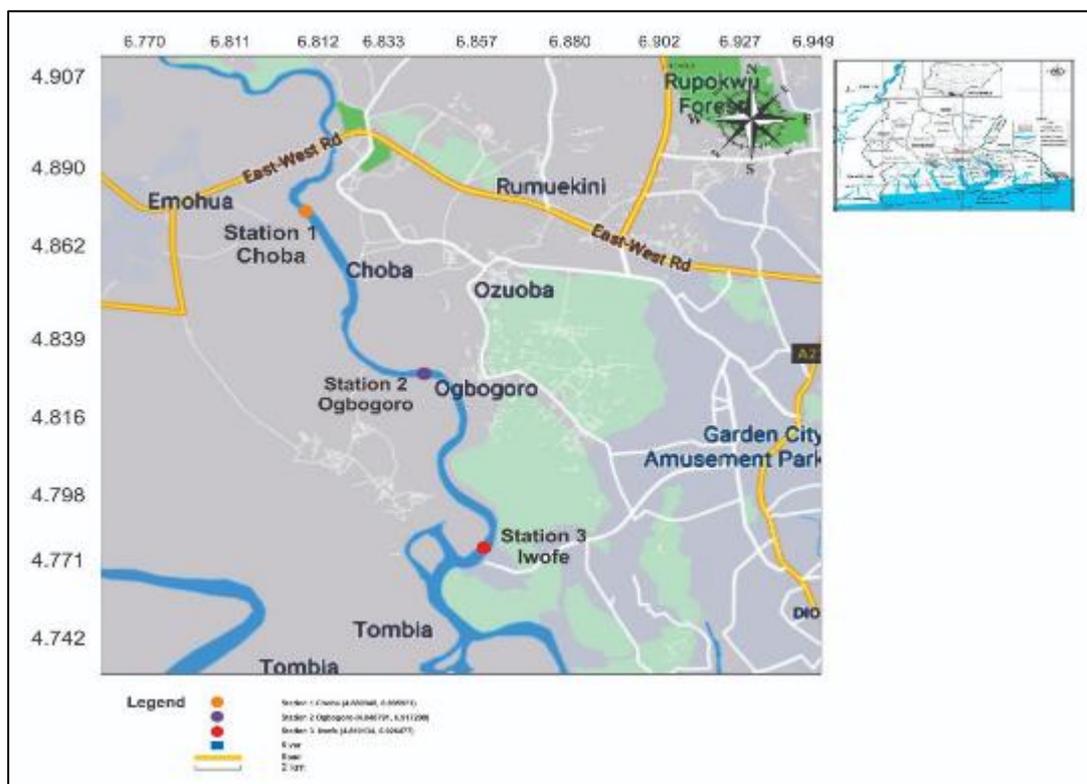
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Gonadosomatic index (GSI) provides crucial information for fisheries management and conservation planning by acting as a trustworthy indicator of gonadal development and spawning seasons. These studies make it possible to identify important reproductive sites, evaluate the health of the population, and put specific conservation measures in place to protect species that are at risk. Additionally, sex ratio and GSI evaluations support wider ecosystem monitoring initiatives by directing proactive conservation efforts and assisting in the detection of early indicators of ecological degradation. In general, our capacity to sustainably manage fish populations and maintain the health and integrity of aquatic ecosystems is improved when sex ratio and GSI studies are incorporated into research and management frameworks.

2. Materials and methods

2.1. Study Area

The study was carried out in the New Calabar River of Rivers State, Nigeria which is a partially mixed estuarine river (Figure 1). The climate is tropical, with high rainfall and annual precipitation of 2372 mm range 2000 – 3000 mm [1]. The New Calabar River is a black water type, which takes its rise from Elele-Alimini where it is acidic, fresh and non-tidal [11]. It is joined by a smaller tributary river at Aluu, which takes its rise at Isiokpo. It further empties into some creeks and lagoons bordering the Atlantic Ocean. According to [10], the New Calabar River is regarded as one of the important water resources in the Niger delta region of southern Nigeria, because a lot of communities present around these areas directly depend on the river for their agricultural, recreational and sometimes domestic water supplies. The sampling stations are the middle reaches of the river which empties into the Bonny River. These sampling stations were chosen because they are major landing sites in the river course



Source: [9]

Figure 1 Map of the study area showing the sampling stations

2.2. Sample Collection

Fish samples were collected from three sampling stations along the New Calabar River, they include; Choba, with a distance of 5021.5 meters to Ogbogoro and also with a distance of 3806.86 meters to Iwofe landing sites. Field survey was carried out twice a month with the help of local fishermen using various fishing gears Dugout canoes with paddles were used during the sampling within the river, kept in the ice box and transported to the Fisheries Laboratory, Faculty of Agriculture, University of Port Harcourt, Choba for further analysis.

2.3. Data Collection

Fishes were identified after [2]. Fish specimens were measured for Total Length (TL) and Standard Length (SL) in centimeter (cm) using a measuring board measuring of 30 cm ruler and the body Weights (BW) were measured in grams (g), with electronic sensitive scale weighed to the nearest 0.1 g (model BP 310S). The sampling duration with the fishing gear and methods were approximately the same throughout the period. The abdominal region of the fish was dissected to determine the sex of the fish. Sex of fish was determined through visual and microscopic examination of the gonads

2.4. Data Analysis

The descriptive statistics analysis using Means \pm standard deviation (SD) were calculated for both group. Statistical analysis and Post tests was done using the software Graph-pad Prism 5, at a 5% significance level. Relative species abundance which refers to the relative representative of a species it was determined by dividing the number of species (n) from each catch by the total number of species (N) from the total catch recorded.

Relative species abundance (%) = $(n/N) \times 100$

Sex ratio (Female : Male) was calculated for each fish species and the total samples [5] The proportion of the two sexes relative to one another was used to calculate the sex ratio, which was analysed using Chi – square (χ^2) Test. The weight of the fish and total weight of liver were used to determine hepato-somatic index (HSI).

$$\text{Hepato – somatic index (HSI)} = \frac{\text{Weight of the Liver}}{\text{Weight of the Fish}} \times 100 \dots [15].$$

3. Results

3.1. Clupeidae fish species in the New Calabar River

Table 1 reveals the percentage frequency of Clupeidae species in the New Calabar River. *Sardinella maderensis* recorded the highest frequency of 76 with 49.03 %, followed by *Ilisha africana* with the frequency of 26 and 16.77 %, while *Pellonula leonensis* recorded a frequency of 25 with 16.13 %, *Sardinella aurita* recorded a frequency of 20 with 12.90 %, and the least frequency of 8 with 5.16 % was recorded for *Ethmalosa fimbriata*, respectively.

Table 1 Percentage composition and frequency of Clupeidae fish species in the New Calabar River

| Species | Frequency | Percentage (%) |
|------------------------------|-----------|----------------|
| <i>Pellonula Leonensis</i> | 25 | 16.13 |
| <i>Ethmalosa fimbriata</i> | 8 | 5.16 |
| <i>Ilisha africana</i> | 26 | 16.77 |
| <i>Sardinella maderensis</i> | 76 | 49.03 |
| <i>Sardinella aurita</i> | 20 | 12.90 |
| Total | 155 | 100 |

The table 2 below shows the sex ratio of Clupeidae species in the New Calabar River. *Pellonula leonensis* recorded the highest ratio, of 72% males and 28% females, with 2.57:1 male-to-female ratio. Followed by the species of *Sardinella maderensis* with 68.42% males and 31.58% females, having a ratio of 2.17:1, *Ilisha africana* recorded a percentage of 65.38% males and 34.62% females, with a ratio of 1.89:1. *Sardinella aurita* also recorded a percentage of 55% males and 45% females, with a ratio of 1.22:1, while *Ethmalosa fimbriata* recorded the least percentage of 50% males to 50% females with an equal sex ratio of 1:1.

Table 2 Sex ratio of Clupeidae fish species in the New Calabar River

| Species | Male | Female | Ratio (M:F) |
|------------------------------|------------|------------|-------------|
| <i>Pellonula Leonensis</i> | 18 (72) | 7 (28) | 2.57:1 |
| <i>Ethmalosa fimbriata</i> | 4 (50) | 4 (50) | 1:1 |
| <i>Ilisha aficana</i> | 17 (65.38) | 9 (34.62) | 1.89:1 |
| <i>Sardinella maderensis</i> | 52 (68.42) | 24 (31.58) | 2.17:1 |
| <i>Sardinella aurita</i> | 11 (55) | 9 (45) | 1.22:1 |

Table 2 below shows the sex ratio of Clupeidae species in the New Calabar River. *Pellonula leonensis* recorded the highest ratio, of 72% males and 28% females, with a 2.57:1 male-to-female ratio. Followed by the species of *Sardinella maderensis* with 68.42% males and 31.58% females, having a ratio of 2.17:1, *Ilisha africana* recorded a percentage of 65.38% males and 34.62% females, with a ratio of 1.89:1. *Sardinella aurita* also recorded a percentage of 55% males and 45% females with a ratio of 1.22:1, while *Ethmalosa fimbriata* recorded the least percentage of 50% males to 50% females with an equal sex ratio of 1:1.

Table 3 below shows the variation of the mean weight of liver and egg sack of Clupeidae species in the New Calabar River. *Ilisha africana* species recorded the highest mean weight of liver with 1.64±0.51 g, and weight of egg sack mean value of 1.55±0.00 g, followed by *Sardinella aurita* with 1.45±0.23 g and weight of egg sack mean value of 1.35±0.30 g while *Pellonula Leonensis* recorded the lowest mean weight of liver with 0.79±0.01 g, and no mean values for weight of egg sack was recorded.

Table 3 Weight of liver and egg sack of Clupeidae fish species in the New Calabar River

| Species | N | Weight of liver (g) | | Weight of egg sack (g) | |
|------------------------------|----|---------------------|-----------|------------------------|-----------|
| | | Range | Mean | Range | Mean |
| <i>Pellonula Leonensis</i> | 25 | 0.78 - 0.8 | 0.79±0.01 | - | - |
| <i>Ethmalosa fimbriata</i> | 8 | 1.19 - 1.51 | 1.35±0.23 | - | 1.00±0.00 |
| <i>Ilisha africana</i> | 26 | 1.28 - 2.00 | 1.64±0.51 | 1.55 - 1.55 | 1.55±0.00 |
| <i>Sardinella maderensis</i> | 76 | 1.1 - 1.35 | 1.20±0.11 | 1.23 - 1.26 | 1.25±0.02 |
| <i>Sardinella aurita</i> | 20 | 1.3 - 1.72 | 1.45±0.23 | 1.14 - 1.56 | 1.35±0.30 |

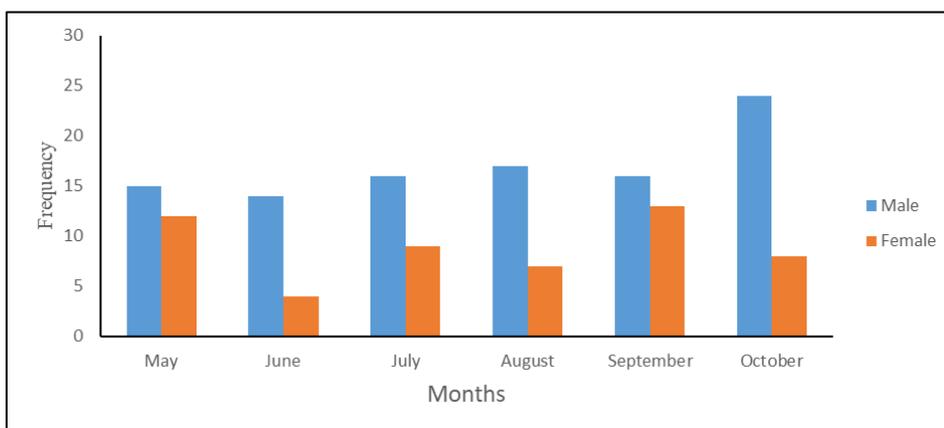


Figure 2 Frequency across months (male and female) of Clupeidae fish species in the New Calabar River

Figure 2 above shows the monthly frequency distribution of male and female Clupeidae fish species in the study area. The month of October recorded the highest frequency of males, followed by the month of August, while the months of July and September recorded the same frequency, and the least was recorded in the month of June for male clupidae species. The female species recorded the highest frequency in the month of September, followed by the month of May while the least frequency was recorded in the month of June, respectively.

Table 4 below shows the hepatosomatic index (HSI) values of Clupeidae fish species in the New Calabar River. *Ilisha africana* recorded the highest mean index of 4.00 ± 0.00 , followed by *Ethmalosa fimbriata* and *Sardinella aurita*, which recorded the same mean index value of 3.51 ± 0.01 , which shows there is no significant difference between the two species ($p < 0.05$). *Sardinella maderensis* recorded an index mean value of 2.92 ± 0.20 , while *Pellonula leonensis* recorded the least mean index value of 2.51 ± 0.01 . All species except *Ethmalosa fimbriata* and *Sardinella aurita* showed significant differences across the Clupidae species ($p < 0.05$).

Table 4 Hepatosomatic index (HSI, %) of Clupidae fish species in the New Calabar River

| Species | Body Weight (g) | HSI (%) |
|------------------------------|-------------------|-------------------|
| <i>Pellonula Leonensis</i> | 31.50 ± 0.71 | 2.51 ± 0.01^d |
| <i>Ethmalosa fimbriata</i> | 38.50 ± 6.36 | 3.51 ± 0.01^b |
| <i>Ilisha africana</i> | 41.00 ± 12.73 | 4.00 ± 0.00^a |
| <i>Sardinella maderensis</i> | 41.33 ± 3.44 | 2.92 ± 0.20^c |
| <i>Sardinella aurita</i> | 41.33 ± 6.66 | 3.51 ± 0.01^b |

Means with different superscript along same column are significantly different ($p < 0.05$)

4. Discussion

The biological characteristics of Clupeidae fish species in the New Calabar River were analyzed through several parameters, including species distribution, sex ratio, and hepatosomatic index (HSI). The results from Table 1 indicate that *Sardinella maderensis* is the most abundant species, accounting for almost 50% of the total Clupeidae population, followed by *Ilisha africana* and *Pellonula leonensis*. This dominance of *Sardinella maderensis* agrees with the findings of [3] in Lagos Lagoon, where similar trends in species abundance were reported. This species' dominance may be attributed to its adaptability to a wide range of environmental conditions, including the relatively brackish waters of the New Calabar River.

Sex ratio in this study showed that most of the species reported exhibited a relatively higher male-based ratio, with *Pellonula leonensis* species recording a ratio of 2.57:1, followed by *Sardinella maderensis* (2.17:1) and *Ilisha africana* (1.89:1). *Ethmalosa fimbriata* recorded a balanced male-to-female ratio (1:1). Male-biased sex ratios are commonly observed in many fish species, particularly those exhibiting early sexual maturity and high reproductive output, such as the Clupeidae family according to [22]. The results from Table 1 indicate that *Sardinella maderensis* is the most abundant species, accounting for almost 50% of the total Clupeidae population, followed by *Ilisha africana* and *Pellonula leonensis*. This dominance of *Sardinella maderensis* agrees with the findings of [3] in Lagos Lagoon, where similar trends in species abundance were reported. This species' dominance may be attributed to its adaptability to a wide range of environmental conditions, including the relatively brackish waters of the New Calabar River.

The study's sex ratio revealed that the majority of the reported species displayed a comparatively higher male-to-female ratio, with the *Pellonula leonensis* species recording a ratio of 2.57:1, followed by *Sardinella maderensis* (2.17:1) and *Ilisha africana* (1.89:1). *Ethmalosa fimbriata* recorded a balanced male-to-female ratio (1:1). Male-biased sex ratios are commonly observed in many fish species, particularly those exhibiting early sexual maturity and high reproductive output, such as the Clupeidae family, according to [22]. In contrast, [8] and [13] noted a female-dominated population in Senegalese and Tunisian waters, respectively. The differences in the size-specific sex ratio were also reported for Libyan waters [21] and were related to sexual differences in growth, mortality, or energetic cost of reproduction. It was also reported that females generally dominated the higher length classes in the northern Aegean, Algerian [7] and Tunisian waters [13], while differences in the size-specific sex ratios have been reported for other Mediterranean marine fishes [21]. The ratios in *Pellonula leonensis* and *Sardinella maderensis* may be attributed to differential growth rates and early maturation, as reported by [18], who stated that males mature faster or are more prevalent in a population due to their higher reproductive success. However, the equal ratio in *Ethmalosa fimbriata* suggests a more

balanced reproductive strategy in this species, possibly due to its specific ecological requirements and reproductive biology.

Their distribution is largely influenced by temperature, salinity, and food availability. [20]. The results from this study showed that the month of October recorded the highest frequency of males, followed by the month of August, and the least was recorded in the month of June for male clupeidae species. The female species recorded the highest frequency in the month of September, followed by the month of May, while the least frequency was recorded in the month of June. This distribution is in agreement with the findings of [17], who reported that fluctuation in male and female across months was documented for species such as *Sardinella aurita*, where males are more abundant during certain times of the year due to higher migration or spawning behavior. Such patterns may be influenced by factors like water temperature, food abundance, and reproductive cycles, which affect the growth and distribution of the fish population [6]. The distribution of males to female species observed in the study may be as a result of male species migration possible for the purpose of spawning activities in the study area.

Hepatosomatic index is the main indicator of metabolic activity in animals [23]. The hepato-somatic index (HSI) is a bio-indicator of contaminant exposure, so it is used in fisheries science as an indicator of energy reserves in the liver. It is the ratio of liver weight to body weight. In this study, the HSI showed significant differences in liver development relative to body weight among the species. *Ilisha africana* with the highest of 4.00, higher as compared to other fish species recorded. [12] reported that fish with higher HSI values often display better nutritional and reproductive health, particularly when they are in good condition and well-fed. In contrast, *Pellonula leonensis* has the lowest HSI (2.51), indicating a relatively smaller liver size compared to body weight. This could reflect poor health or suboptimal environmental conditions, according to [17]. This finding is in agreement with the findings of the study on lower reproductive capacity observed in *Pellonula leonensis* species. *Sardinella aurita* and *Ethmalosa fimbriata* recorded values of (3.51), indicating a more balanced allocation of energy towards both liver and weight development. This is reflective of their ability to thrive in the river system and produce offspring successfully, though they do not exhibit the same high metabolic investment as seen in *Ilisha africana*. The variations in HSI suggest that the species in the New Calabar River have adapted differently to the ecological conditions, such as food availability, water temperature, and habitat structure.

5. Conclusion

The findings indicate that *Sardinella maderensis* is the most abundant species, followed by *Ilisha africana* and *Pellonula leonensis*, which reflects its adaptability to varying environmental conditions. The sex ratio data revealed a male-dominated species distribution across the species recovered as a result of migration patterns and spawning behaviour. The species, *Ilisha africana*, had the highest value for hepatosomatic index, indicating superior metabolic and reproductive health. These findings provide valuable insights on the aspect of the biology of Clupeidae fish with a broader understanding of fish populations in riverine ecosystems and a foundation for future ecological studies and fisheries management in the New Calabar River.

Compliance with ethical standards

Acknowledgments

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Disclosure of conflict of interest

The authors declare that there is no conflict of interest.

Statement of ethical approval

For this type of study, formal consent is not required.

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