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Ecological and Demographic Characteristics of *Synodontis koensis*, an Endemic Species of the Sassandra River Basin (Côte d'Ivoire)

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Abstract

This study investigated the ecological and demographic characteristics of *Synodontis koensis* (Pellegrin, 1934), an endemic species of the Sassandra River Basin (Côte d'Ivoire), in order to provide baseline data for its conservation and sustainable habitat management. Sampling was conducted from November 2024 to March 2025 at five stations along the N'Zo River, a major tributary of the Sassandra. Physico-chemical parameters of the water (temperature, pH, conductivity, total dissolved solids, and depth) were measured in situ, and a total of 329 individuals were collected for morphometric and weight analyses. Results revealed favorable environmental conditions for aquatic life, with water temperature ranging from 27.3 to 29.5 °C, slightly alkaline pH (7.65–7.95), and low conductivity (51–68 µS/cm). Standard lengths of fish ranged from 35 to 110 mm (mean = 77.48 ± 13.63 mm) and body weights from 2 to 31 g (mean = 11.71 ± 5.73 g), indicating a unimodal size structure dominated by medium-sized classes (60–90 mm). The length–weight relationship followed the model P=aLbP, with b=1.93b = 1.93b=1.93, showing a negative allometric growth pattern (b < 3), meaning that body length increases faster than weight. The condition factor (K) ranged from 1.10 to 9.26 (mean = 2.59 ± 1.57), suggesting good overall physiological condition. These findings indicate that S. koensis inhabits an environment that remains favorable but is increasingly affected by anthropogenic pressures. The study provides essential baseline information to guide conservation strategies and sustainable management of endemic fish populations within the Sassandra Basin.

Keywords: Synodontis Koensis; N'Zo River; Sassandra Basin; Allometric Growth; Condition Factor

1. Introduction

Sustainable management of fishery resources in West Africa relies on a sound understanding of the biological and ecological characteristics of exploited species, particularly those that are endemic [1,2]. In African river basins, and especially in Côte d'Ivoire, increasing anthropogenic pressures such as intensified fishing, deforestation, and agricultural expansion are threatening the long-term viability of fish populations [3,4]. These pressures are further exacerbated by climate change, which alters hydrological regimes and degrades aquatic habitats [5]. Among the major river systems in Côte d'Ivoire, the Sassandra River hosts a rich ichthyofauna, including several endemic species such as *Synodontis koensis* (Pellegrin, 1934), a member of the Mochokidae family [6,7]. This benthic catfish plays a key ecological role in organic matter recycling and occupies a central position in aquatic food webs [8,9]. At the same time, it has considerable socioeconomic importance as a source of income and food for local communities [10,11]. Despite its ecological and economic relevance, *S. koensis* faces multiple threats. Habitat degradation, river fragmentation, and overfishing jeopardize the survival of its populations [12,13]. Consequently, the species is currently listed as Near

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Threatened on the IUCN Red List [13]. The implementation of effective conservation measures, however, requires detailed information on its biology, demography, and ecological interactions [14,31].

Research on the Synodontis genus in Africa has been largely dominated by the works of Gower et al. on taxonomy [15], Lévêque on fisheries biology [16], and Paugy and Lévêque on biogeography [9]. Yet, ecological and demographic parameters of S. koensis remain poorly documented, particularly in the Sassandra River Basin. It is therefore essential to investigate its environmental conditions, population structure, and growth patterns to identify the key parameters influencing its population dynamics and to provide a foundation for sustainable management.

The present study contributes to this objective by assessing the ecological and demographic characteristics of *Synodontis koensis* in the N'Zo River, a major tributary of the Sassandra Basin. Specifically, it aims to (i) analyze the physico-chemical parameters of its habitat, (ii) describe its population structure through size and weight distributions, and (iii) establish the length–weight relationship and condition factor of this endemic and threatened species. This integrative approach is expected to enhance our understanding of *S. koensis* population dynamics within its natural habitat and to provide scientific insights supporting the sustainable management of fishery resources in the Sassandra River Basin.

2. Materials and methods

2.1. Study Area

The study was conducted in the N'Zo River, a major left-bank tributary of the Sassandra River located in southwestern Côte d'Ivoire. The N'Zo Basin covers approximately 4,310 km^2, with a main river course 124 km long and a hydrological regime characterized by alternating high-water (July–October) and low-water (November–June) periods [17]. The region has a sub-equatorial climate, with an annual rainfall exceeding 2,000 mm [18]. Five sampling stations (S1–S5) were selected along the river course based on habitat diversity and accessibility (Figure 1). These sites represent distinct ecological gradients, ranging from upstream headwaters to downstream areas near the Buyo Reservoir.

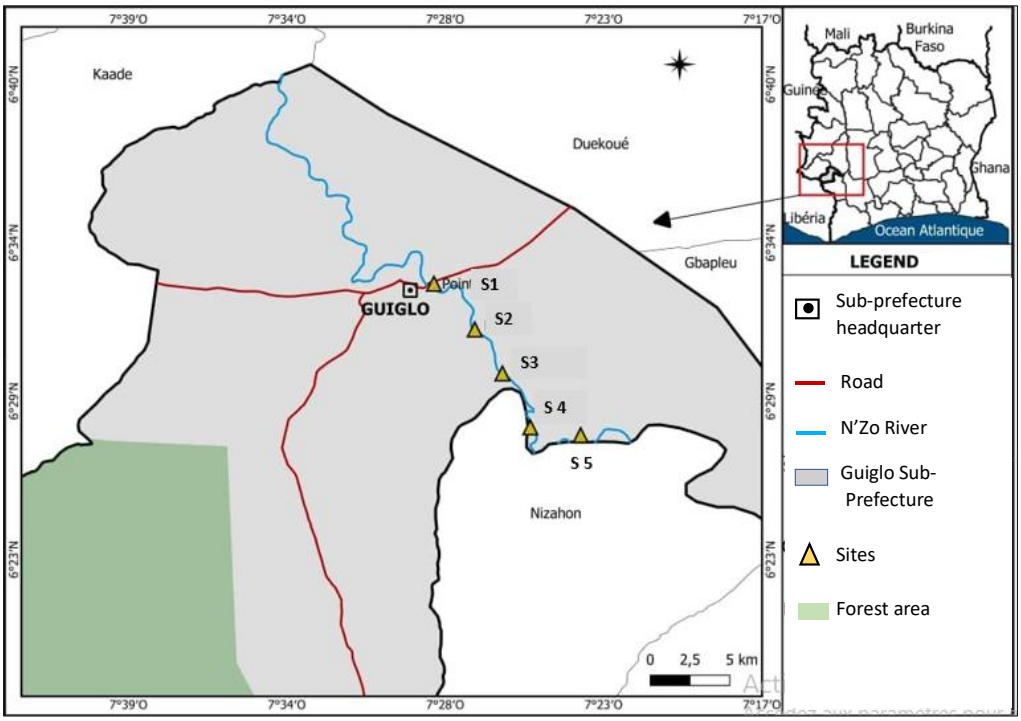


Figure 1 Location of the five sampling sites along the N'Zo River (Côte d'Ivoire).

2.2. Fish Sampling

Specimens of *Synodontis koensis* were collected between November 2024 and March 2025 using artisanal fishing techniques in collaboration with local fishers. Multiple fishing gears were employed, including gillnets, beach seines, hand lines, longlines, traps, and traditional bamboo pots. A total of 329 individuals were captured and analyzed.

Specimens were immediately preserved in ice after capture and later processed in the laboratory for morphometric measurements.

2.2.1. Morphometric and Weight Measurements

For each specimen, standard length (SL, mm) and total length (TL, mm) were measured with an ichthyometer to the nearest 1 mm, while total weight (TW, g) was recorded using a precision balance (Toledo PB810, ± 0.1 g).

2.2.2. Physico-Chemical Parameters of Water

Water quality parameters were measured *in situ* at each of the five sites on a bimonthly basis, between 07:00 and 09:00 a.m. A multiparameter meter (HACH HQ30d) was used to record temperature (°C), pH, conductivity (µS/cm), and total dissolved solids (TDS, ppm). Water depth was measured using a weighted graduated cord.

2.2.3. Size Structure Analysis

Population size structure was described based on frequency distributions of standard length. Length classes were determined according to Sturges' rule [19]. The coefficient of variation (CV) of size was calculated to assess population homogeneity:

- CV < 2 % = highly homogeneous
- 2 % ≤ CV ≤ 30 % = homogeneous
- CV > 30 % = heterogeneous

2.3. Length–Weight Relationship

The length–weight relationship was expressed by the formula: $P = aL^b$

where P is total weight (g), L is standard length (cm), a is the intercept, and b is the allometric coefficient. After logarithmic transformation, linear regression was performed as:

$\log P = \log a + b \log L$

The estimated allometric coefficient (b) was statistically compared to the theoretical value of 3 (isometric growth) using a student's t-test.

2.4. Condition Factor

The condition factor (K) was calculated for each individual to evaluate its physiological state:

$$K = (TW/SL3) \times 100$$

Where TW is total weight (g) and SL is standard length (cm). Spatial and temporal variations in K were analyzed to assess individual well-being in relation to site and sampling period.

2.5. Statistical Analyses

Data were analyzed using STATISTICA 7.1. Normality of distributions was verified using the Shapiro–Wilk test. Inter-station differences were assessed with the Kruskal–Wallis test ($p < 0.05$). The correlation coefficient (r) and determination coefficient (r^2) were calculated to evaluate the strength and reliability of the length–weight relationships.

3. Results

3.1. Physico-Chemical Parameters of the Water

The physico-chemical parameters measured at the five sites of the N'Zo River are presented in Table 1. Water temperature fluctuated between 27.3 °C (site S2) and 29.5 °C (site S5). Statistical analysis (Kruskal–Wallis test) revealed no significant differences among stations (p > 0.05). The pH ranged from 7.65 (site S2) to 7.95 (site S1), indicating slightly alkaline water. These variations were not significant (Kruskal–Wallis, p > 0.05).

The concentration of total dissolved solids (TDS) varied between 24 ppm (sites S3, S4, and S5) and 32 ppm (site S1), with no significant differences among sites (Kruskal–Wallis, $p > 0.05$). Likewise, electrical conductivity fluctuated from 51 µS/cm (sites S3, S4, and S5) to 68 µS/cm (site S1), again with no significant differences (Kruskal–Wallis, $p > 0.05$).

In contrast, water depth showed marked variability among sites, ranging from 371 cm (site S1) to 875 cm (site S3). Unlike the other parameters, these variations were statistically significant (Kruskal–Wallis, $p < 0.05$).

Table 1 Physico-chemical parameters measured (mean ± standard deviation) at the five sampling sites of the N'Zo River.

Sites	Temperature (°C)	pH	TDS (ppm)	Conductivity (µS/cm)	Depth (cm)
S1	27,8 ± 0,4	7,95 ± 0,05	32,0 ± 2,1	68,0 ± 3,2	371 ± 25
S2	27,3 ± 0,6	7,65 ± 0,07	28,0 ± 1,8	60,0 ± 2,7	500 ± 30
S3	28,5 ± 0,5	7,80 ± 0,04	24,0 ± 1,5	51,0 ± 2,0	875 ± 40
S4	28,7 ± 0,3	7,85 ± 0,06	24,0 ± 1,7	51,0 ± 1,9	820 ± 35
S5	29,5 ± 0,5	7,90 ± 0,05	24,0 ± 1,6	51,0 ± 2,1	790 ± 28

3.2. Population structure

A total of 329 individuals of *Synodontis koensis* were collected from the five sampling sites of the N'Zo River between November 2024 and March 2025 (Table 2). Standard lengths of specimens ranged from 35 mm to 110 mm, with a mean of 77.48 ± 13.63 mm. Individual body weights ranged from 2 g to 31 g, with an average of 11.71 ± 5.73 g.

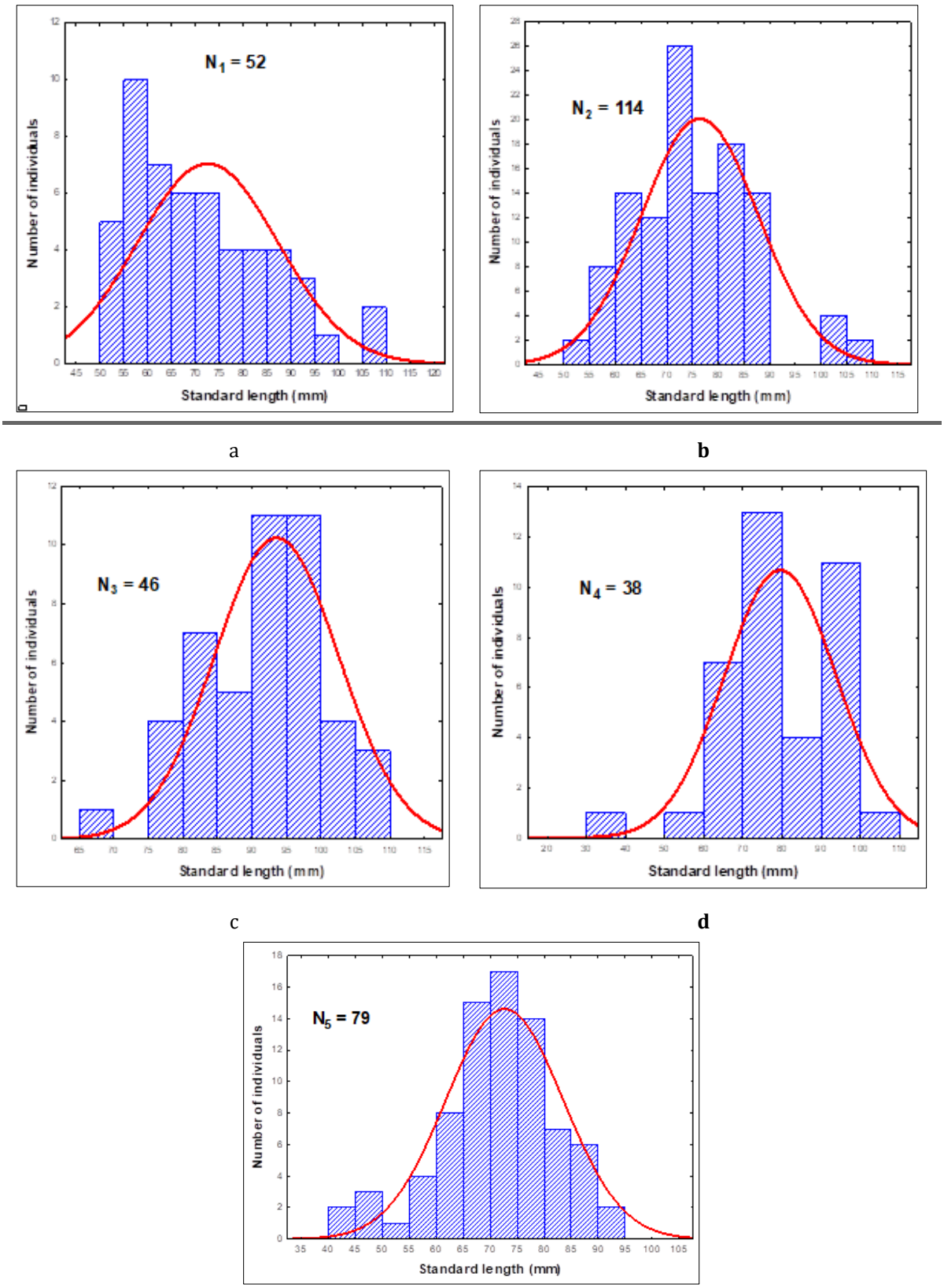
The frequency distribution by length class revealed a unimodal structure dominated by the 70–80 mm class (Figure 2). The majority of individuals (93.31 %) fell within the 60–90 mm range. The calculated coefficient of variation (CV = 17.59 %) for the total sample indicates a relatively homogeneous population in terms of size. Analysis by site revealed notable differences in demographic composition

- Site S1: Individuals between 50 mm and 75 mm represented 65.39 % of the total catch.
- Site S2: 79.82 % of fish measured between 65 mm and 90 mm.
- Site S3: 76.08 % of specimens belonged to the 80–105 mm class, reflecting a higher proportion of large individuals.
- Site S4: Dominant size classes ranged from 70 mm to 100 mm, accounting for 73.68 % of the catch.
- Site S5: Fish between 60 mm and 85 mm constituted 61.25 % of the sampled population.

These data indicate that, although the overall population is relatively homogeneous and dominated by medium-sized classes, certain spatial differences exist—particularly the predominance of smaller individuals at site S1 and larger ones at site S3.

Table 2 Demographic parameters of fish collected from the N'Zo River.

Sites		S1	S2	S3	S4	S5	T
Standard Length (mm)	Min	52	55	70	35	42	35
	Max	110	109	110	103	95	110
	Mean ± SD	72,42±14,69	76,25±11,34	93,41±8,96	79,23±14,17	72,46±10,78	77,48±13,63
Weight (g)	Min	5	5	9	2	2	2
	Max	21	23	31	26	18	31
	Mean ± SD	13,57±5,15	10,07±4,10	19,15±5,66	11,89±5,72	8,43±3,55	11,71±5,73
Number of individuals (N)		52	114	46	38	79	329



Site 1; b) Site2; c) Site 3; d) Site 4; e) Site 5; N: Number of individuals

Figure 2 Frequency distribution of fish captured at each sampling site from November 2024 to March 2025.

3.3. Length–Weight Relationship and Condition Factor (K)

The study of the relationship between body length and weight in *Synodontis koensis* from the N'Zo River revealed significant results in terms of allometric growth (Figure 3). The coefficient of determination (r^2) was estimated at 0.50, indicating that length explains approximately 50 % of the observed variability in body weight.

The regression equation was expressed as

Log P = log a+b log L

where a = −2.61 and b = 1.93.

A Student's t-test was applied to assess the significance of the difference between the observed b value and the theoretical value of 3 (isometric growth). The test indicated that b was significantly different from 3 ($p < 0.05$), confirming that the growth of *S. koensis* in this river deviates from isometric growth.

This species thus exhibits negative allometric growth, meaning that increases in length exceed increases in weight as individuals develop.

Regarding the condition factor (K), which assesses the physiological state of individuals, values ranged from 1.101 to 9.259, with a mean of 2.59 ± 1.57. These data, presented in Table 3, reflect the general physical condition of the specimens and indicate significant variability likely linked to environmental or physiological factors.

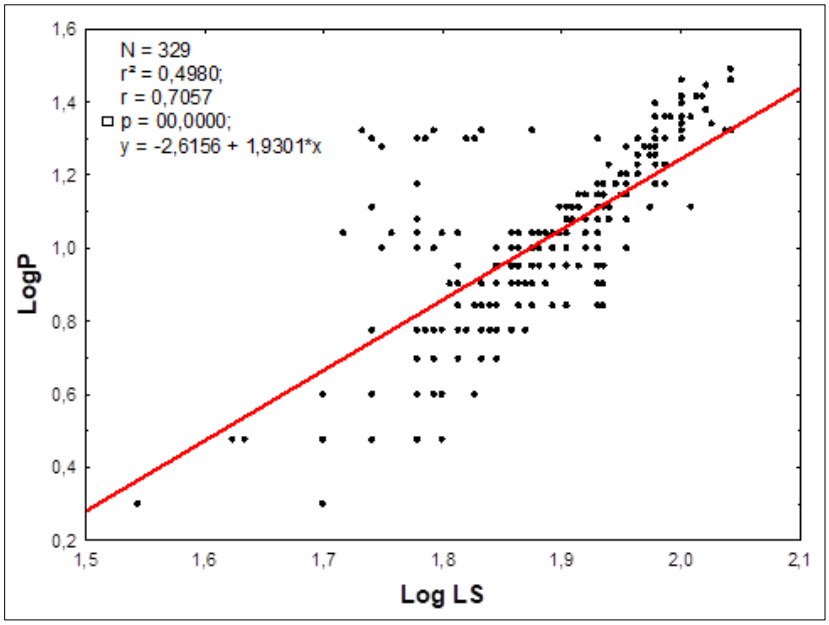


Figure 3 Length–weight relationship of Synodontis koensis in the N'Zo River (November 2024 – March 2025).

Table 3 Parameters of the length–weight relationship and condition factor for Synodontis koensis in the N'Zo River (N = 329).

Species (N = 329)	r^2	*b*	Student's t-test	Growth type	Condition factor		
					Min	Max	Mean ± SD
Synodontis koensis	0.50	1.93	-3.6295891	A-(negative allometric)	1.101	9.259	2.59±1.57

4. Discussion

The study conducted on Synodontis koensis in the N'Zo River provides a comprehensive understanding of the ecological and demographic dynamics of an endemic and threatened species whose survival depends closely on the quality of

aquatic habitats within the Sassandra Basin. The physico-chemical parameters recorded indicate that the N'Zo River offers favorable conditions for aquatic life, with water temperatures ranging from 27 to 29 °C, slightly alkaline pH (7.65–7.95), and moderate conductivity (51–68 $\mu S \cdot cm^{-1}$), which are typical characteristics of tropical forest rivers that remain relatively undisturbed [22,33]. These results demonstrate hydrological and chemical stability, which promotes the growth and reproduction of benthic fish species such as Synodontis koensis [9]. The absence of significant differences between sampling sites for most parameters, except depth, reflects a relatively homogeneous ecological environment and suggests that population variability is more likely driven by biological factors than by abiotic constraints. Nevertheless, the marked variation in water depth among sites may influence the spatial distribution of individuals, as deeper areas may serve as refuges or preferred growth habitats for adults [20,21].

From a demographic standpoint, the unimodal structure observed in S. koensis populations indicates a relatively stable population with balanced recruitment. The dominance of medium size classes (60–90 mm) and the relatively low coefficient of variation (17.6%) reveal a homogeneous population structure, well established in the ecosystem and probably reproducing regularly. A similar demographic pattern has been observed in related species within the Niger Basin [29], suggesting that the N'Zo River ecosystem still functions effectively despite increasing human pressures. However, the site-specific size variations observed—smaller individuals upstream and larger ones downstream—illustrate spatial organization linked to hydromorphological conditions and the availability of food resources [8,6]. This spatial distribution pattern is consistent with the River Continuum Concept proposed by Vannote et al. [32], which states that the composition and structure of aquatic communities vary along the longitudinal gradient of the river according to changes in depth, current velocity, and organic matter input.

The analysis of the length–weight relationship revealed a negative allometric growth pattern, with an allometric coefficient b = 1.93 significantly lower than the theoretical value of 3. This indicates that S. koensis grows more in length than in weight, suggesting an energy allocation strategy favoring linear growth over biomass accumulation. Such a growth strategy is common among fish species inhabiting environments where food availability fluctuates seasonally [25,26]. Similar findings were reported by Kabré and Illé [30] in Lake Buyo and by Iorchor et al. [29] for Synodontis schall in the Lower Benue River, Nigeria, supporting the idea that species of the genus Synodontis display a high degree of ecological plasticity. The observed growth pattern may also result from selective fishing pressure targeting larger individuals, a phenomenon frequently noted in West African artisanal fisheries [31,12]. The condition factor (K), which ranged from 1.10 to 9.26 (mean = 2.59 ± 1.57), confirms the good adaptation of S. koensis to its environment. Values above 2 generally indicate good physiological condition and favorable environmental conditions [26,27]. However, the inter-individual variability observed suggests local fluctuations in food resource availability or reproductive cycles. The highest K values, recorded at the deepest sites, point to more productive habitats offering better access to benthic organic matter, which is the main trophic source for this species [28]. These results corroborate the findings of Bremmer et al. [5] and Traoré and Koné [4], who emphasized the importance of maintaining habitat quality to sustain healthy fish populations.

Overall, the N'Zo River remains a functional ecosystem capable of supporting this endemic species. However, the predominance of medium-sized individuals and the scarcity of larger specimens suggest a non-negligible fishing pressure that could, in the medium term, affect population renewal. This observation aligns with the broader issue of sustainable fishery management in West Africa, where deforestation, agricultural expansion, and overfishing collectively undermine the resilience of endemic species [3,1].

5. Conclusion

The present study on *Synodontis koensis* in the N'Zo River provides new insights into the ecology and population dynamics of an endemic species from the Sassandra Basin that remains poorly documented despite its ecological and socioeconomic importance. The recorded environmental conditions—temperatures ranging from 27.3 to 29.5 °C, slightly alkaline pH (7.65–7.95), and low electrical conductivity (51–68 µS/cm)—indicate a generally healthy aquatic environment capable of supporting a balanced fish population.

Among the 329 individuals collected, standard lengths ranged from 35 to 110 mm, with a mean total weight of 11.71 ± 5.73 g. This pattern reflects a homogeneous demographic structure dominated by medium-sized classes (60–90 mm). The length–weight relationship revealed an allometric coefficient ($b = 1.93$) significantly lower than 3, indicating negative allometric growth, where increases in body length predominate over weight gain. The condition factor (K), which ranged from 1.10 to 9.26 (mean = 2.59 ± 1.57), suggests an overall good physiological state of the population, although local variations may reflect environmental heterogeneity or reproductive cycles.

Overall, these findings demonstrate that *S. koensis* thrives in an ecosystem that remains relatively functional and favorable for its development, but that is increasingly vulnerable to anthropogenic pressures. The predominance of medium-sized individuals and the relative scarcity of larger fish point to potential fishing impacts that may affect long-term population sustainability.

The data obtained from this study provide a solid scientific basis for developing sustainable management strategies for the Sassandra Basin, particularly in terms of habitat conservation, regulation of fishing effort, and long-term ecological monitoring of *S. koensis* populations. As an indicator of benthic ecosystem health, this species represents a valuable biological model for assessing the resilience of aquatic environments in Côte d'Ivoire and throughout West Africa.

Compliance with ethical standards

Disclosure of conflict of interest

No conflict of interest to be disclosed.

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