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Growth Condition, Length-Weight Relationship and Morphological Diversity of *Sarotherodon melanotheron* and *Tilapia guineensis* inhabiting the Coastal Waters of Ondo State, Nigeria

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ABSTRACT: *Sarotherodon melanotheron* and *Tilapia guineensis* were studied in Mahin Lagoon and Idiogba in the coastal waters of Ondo State to determine their sizes, length-weight relationships, and condition factors. The mean total length and weight for *S. melanotheron* were 13.35±1.66 cm and 48.41±20.89 g in Mahin, and 13.44±1.72 cm and 49.96±20.80 g in Idiogba, respectively. Meanwhile, the values recorded for *T. guineensis* were 16.06±4.83 cm and 104.81±107.94 g in Mahin, and 15.00±3.74 cm and 78.98±81.51 g in Idiogba. This morphological similarity revealed an overlap of data between the populations of the two species in Mahin Lagoon and Idiogba. The regression coefficient (b) of length and weight revealed that *S. melanotheron* exhibited hypoallometry (b=2.55; a=-2.76; R2=0.78) in Mahin and (b=2.31; a=-2.13; R2=0.78) in Idiogba, while *T. guineensis* exhibited hyperallometry (b=3.04; a=-4.06; R2=0.96) in Mahin and (b=3.05; a=-4.11; R2=0.92) in Idiogba. The condition factor was greater than 2 for both species, although it was higher in *T. guineensis* (K=2.53 in Mahin and K=2.34 in Idiogba) than in *S. melanotheron* (K=2.04 in Mahin and K=2.06 in Idiogba). Therefore, this study revealed that both species were very fat and healthy despite anthropogenic activities in the study area.

KEYWORDS: Morphometric characteristics; eco-biology; allometry; pollution; cichlids.

1. Introduction

The African freshwater fish (Cichlids) are over 100 species which includes; *Oreochromis, Sarotherodon and Tilapia*. The species are able to exhibit tropic plasticity based on the environment they inhabit [1] and also serve as an important source of food [2]. They are adaptable to a range of habitats, and the fact that they are omnivores makes them a vital component of fish farming, which places demands on their way of life and ecological needs [2]. Cichlids grow relatively very fast, widely accepted by consumers in the market, able to grow on wide range of artificial and natural feed, couple with high survival ability and efficiency in food conversion [3]. These attributes call for the need to assess their morphometric characteristics for proper monitoring, growth, development and conservation of the fish. *S. melanotheron* and *T.* guineensis are inherently tolerant to unfavourable ecological changes (water volume, food availability and physico-chemistry). Thus, they are abundant in the inland waters of Nigeria.

Morphology (a study of structure and form of organisms) is very essential in biology. It is useful in establishment of evolutionary relationships and also helpful in distinguishing species taxonomically [4]. For a successful fisheries management, studies of morphological variations provide basis for population structure and also helpful for studying environmental induced variations [5]. The susceptibility of fishes to environmental induced morphological variation is higher than any other vertebrates such that the demonstration of population variation between and within species is high [2]. Morphometric parameters reveal high plasticity as a result of changes in environmental conditions such as; presence of predators, water velocity, temperature, food availability (pelagic-benthic feeding continuum) and salinity [6]. Also species traits are more favoured than others in response to the pressures operating within different habitats or habitat units as more suited traits to the prevailing conditions found in one habitat may not be suited to those found in others [7].

Morphometric evaluation of species is important in taxonomic study, particularly in differentiating species from their congeners. It provides the relationship between body parts such as head length, head depth, caudal peduncle length relative to standard length. It is therefore the quickest and straightforward method of species identification. In fish biology, fish sizes are often regarded as being more significant than fish ages because a number of physiological and ecological parameters affect sizes over age. Therefore, morphological studies of fish are important in fisheries management because it allows the ability to estimate the average by establishing a mathematical relationship between the relative well-being of the fish population [8]. Additionally, knowing the morphological traits and growth patterns of fish is crucial for assessing fish stocks because it can improve management, support the conservation and culture of fish species, and allow for future comparisons between populations of the same species [9].

An essential and effective component of managing fisheries resources is having information of population metrics like length-weight relationships. It is impossible to overstate the significance of length-weight relationships in fish biology since they help calculate the average weight of fishes, distinguish between different unit stocks of the same species, and gauge the health of individual fishes. This is beneficial for modeling aquatic ecosystems as well as comparative growth studies for fisheries management since it offers important information on fish habitats [6]. Moreover, according to Omotayo et al., [10], condition factor gives the understanding of the fishes' life cycle as it contributes to the maintenance of the ecosystem equilibrium and proper management of the fish species. Ajibare et al, [11] stated that in the study of the biology of fish species, condition factor serves as an indicator of health by reflecting interactions between abiotic and biotic elements in the physiological circumstances of fish.

Several studies of fish morphological diversity in different water bodies have been published, particularly in Nigeria on *Sarotherodon melanotheron* in Ologe Lagoon, Lagos by Ndimele et al. [12], *Ethmalosa fimbriata* in Cross River estuary by George et al. [13], *Synodontis schall* in River Benue, Makurdi by Akombo et al. [14]. Others include [15–18] and others. However, there is paucity of information on the morphological diversities of *Cichlids* in the coast of Ondo state, Nigeria. Thus, detailed knowledge on the population structure of these commercially exploited species is very important and more essential is the knowledge application on fisheries management. This study therefore determined the morphological diversities (sizes), length-weight relationship and condition factor of *Sarotherodon melanotheron* and *Tilapia guineensis* collected from Mahin lagoon and Idiogba creek.

2. Materials and Methods

2.1. Study area.

This study was conducted in the equatorial evergreen swamp forest of Ilaje Local Government Area (L.G.A.) in Ondo State, Nigeria, situated at the extreme southern part of the state. Ilaje L.G.A. shares boundaries with Okitipupa Local Government Area in the North, the Atlantic Ocean in the South, Ijebu Waterside Local Government Area (Ogun State) in the West, and Delta state in the East. The area is positioned within the equatorial evergreen swamp forest [6]. In the Ilaje L.G.A of Ondo State, Nigeria, the coastal waters of Mahin Lagoon (06°11'6.798''N 04°49'14.286''E) and Idiogba Creek (06°05'N 04°47'E) were selected due to their accessibility, large fishing operations, and various anthropogenic activities such as farming, transportation, and discharges. Both locations boast rich biodiversity, including a diverse assemblage of fish, shellfish (shrimps, crabs, lobster, gastropods, and cephalopods), reptiles, and other living organisms [6].

2.2. Collections and identification of fish.

Samples of fish identified as Sarotherodon melanotheron and Tilapia guineensis, following the classification by Olaosebikan and Raji [19], were randomly collected monthly from Mahin Lagoon and Idiogba Creek in the coastal waters of Ondo State, Nigeria, spanning from February to April 2021. Cast nets with a mesh size of 3.5mm were employed for fish collection, and the samples were promptly transported in an ice chest to the Olusegun Agagu University of Science and Technology's Fisheries and Aquaculture Laboratory in Okitipupa, Nigeria, for further analysis.

2.3. Sample measurement.

The total length (the distance from the frontal tip of the fish to the most posterior end of the caudal fin), standard length (from the tip of the mouth to the base of the tail), and fork length (the distance from the tip of the snout to the central point of the fork of the caudal fin) of the fish were measured using a standard measuring board, recorded to the nearest 0.1 cm. Additionally, body weight (the estimate of total body mass) was determined using a computerized weighing balance (Model 1100), recorded to the nearest 0.01g [4].

2.4. Data analysis.

Morphometric data, including weight, standard length, fork length, and total length, were subjected to multivariate analysis of variance using SPSS 20.0. The relationship between length and weight was established through linear regression, following the methodology outlined by Indarjo et al. [20], where length and weight were expressed as:

$$W = aL^b$$

and was logarithmically transformed into:

$$logW = loga + blogL$$

In this equation, W = weight (g), L = length (cm), a = constant (the point at which the regression line intersects the y-axis), and b = slope (the growth coefficient).

The condition factor (K) was calculated according to the formula:

$$K = \frac{100W}{L^3}$$ [11].

Where W is average weight of each fish species (in grams), L is average total length of each fish species in centimeters. The observed condition factor (K) was divided into five categories: extremely thin (K=0.01-0.50), thin (K=0.51- 0.99), ideal (K=1.0), fat (K=1.01-1.50), and very fat (K>1.50) according to Indarjo et al. [20].

3. Results and Discussion

3.1. Sizes and morphological diversity.

The sizes of *Sarotherodon melanotheron* and *Tilapia guineensis* collected from Mahin Lagoon, Ondo State, Nigeria, as presented in Table 1, indicate that the total length (TL) of examined S. melanotheron ranged between 13.00±1.81 cm and 14.00±1.51 cm, with an average of 13.35±1.66 cm. Meanwhile, the TL of *Tilapia guineensis* ranged between 14.96±3.81 cm and 16.81±5.73 cm, with a mean of 16.06±4.83 cm. The Standard Length (SL) for *Sarotherodon melanotheron* ranged between 10.48±1.48 cm and 11.14±1.22 cm, with an average of 10.71±1.34 cm. On the other hand, the SL of *T. guineensis* ranged between 12.29±3.20 cm and 13.38±3.83 cm, with an average of 12.95±3.37 cm. Similarly, the fork length (FL) of *S. melanotheron* ranged between 12.31±1.89 cm and 13.50±1.49 cm, with a mean of 12.72±1.72 cm, while that of *T. guineensis* ranged between 14.35±3.99 cm and 16.05±5.87 cm, with an average of 15.41±4.91 cm. The weight of *S. melanotheron* ranged between 47.49±16.06 g and 49.49±26.90 g, with an average of 48.41±20.89 g. In comparison, the weight of *T. guineensis* ranged between 82.78±93.25 g and 122.24±124.29 g, with a mean of 104.81±107.94 g.

Similarly, the sizes of *S. melanotheron* and *T. guineensis* collected from Idiogba Creek (Table 2) showed that the total length (TL) of *S. melanotheron* ranged between 12.86±1.81 cm and 14.44±0.73 cm, with an average of 13.44±1.72 cm, while that of *T. guineensis* ranged between 13.88±1.13 cm and 15.68±4.63 cm, with an average mean of 15.00±3.74 cm. The standard length (SL) of *S. melanotheron* ranged from 10.39±1.47 cm to 11.36±0.81 cm, with an average of 10.81±1.42 cm, while that of *T. guineensis* ranged between 11.58±1.54 cm and 12.91±3.10 cm, with an average of 12.37±2.63 cm. The fork length (FL) of *S. melanotheron* ranged between 12.21±1.93 cm and 13.92±0.66 cm, with a mean of 12.83±4.68 cm, while that of *T. guineensis* ranged between 13.37±1.32 cm and 15.02±4.68 cm, with a mean of 14.31±3.82 cm. The weight of *S. melanotheron* ranged between 49.14±26.56 g and 51.00±18.42 g, with a mean of 49.96±20.80 g, while the weight of *T. guineensis* ranged between 52.08±15.74 g and 94.23±1.02 g, with an average of 78.98±81.51 g.

The monthly fluctuations in the size of the fish species identified in this research may be related to their habitat's environmental conditions and other factors. Morphological variability in fish serves as an important adaptive strategy for populations encountering inconsistent ecological variables [10]. According to Kara et al. [21], morphological differences rather than genetic differences may be explained by environmental conditions and fish interactions within a habitat. Environmental variability can be used to identify abiotic component variations such as substrate, competition, salinity, food availability, physico-chemical features, water habitat substrate, predations, and water velocity that operate as selective pressures.

The overlap of data between populations of *S. melanotheron* and *T. guineensis* from Mahin Lagoon and Idiogba Creek implies that these populations are somewhat similar morphologically. This finding aligns with the report of Khayyami et al., [22], who studied the morphological variability of two separate populations of *Liza klunzingeri* in the North-Eastern Persian Gulf using principal component analysis (PCA) and univalent analysis of variance. The report reveals that migrations among stocks are limited by geographic variations. Fish populations inhabiting various ecosystems, as reported by Suneetha [23], maintain morphological heterogeneity. Castosmids, Characids, and Cichlids, as reported by Oladimeji and Olaosebikan [4], are characterized by extremely large body shape variations. Oso et al. [24] reported high morphological diversity of Cichlids in Africa. Variations in other environmental parameters and morphology increase with increasing geographical distance [25]. Therefore, the similarity in the sizes/morphometric data of *S. melanotheron* and *T. guineensis* in Mahin Lagoon and Idiogba Creek reveals that the environmental and biotic factors influencing both stations and species (such as interactions, dietary preferences, or habitat choices) are somewhat similar.

Table 1. Sizes (lengths and weight) of *S. melanotheron* and *T. guineensis* from Mahin lagoon in the coastal waters of Ondo State, Nigeria.

Species	Month	Number of Sampled Fish	Total Length (cm)	Standard Length (cm)	Fork Length (cm)	Weight (g)
S. melanotheron	February	37	13.29±1.50	10.69±1.22	12.64±1.54	47.49±16.06
	March	36	13.00±1.81	10.48±1.48	12.31±1.89	49.49±26.90
	April	22	14.00±1.51	11.14±1.22	13.50±1.49	48.18±17.36
	Mean	**95**	**13.35±1.66**	**10.71±1.34**	**12.72±1.72**	**48.41±20.89**
T. guineensis	February	8	16.81±5.73	13.38±3.83	16.05±5.87	122.24±124.29
	March	8	14.96±3.81	12.29±3.20	14.35±3.99	82.78±93.25
	April	10	16.33±5.14	13.13±3.41	15.75±5.14	108.50±113.43
	Mean	**26**	**16.06±4.83**	**12.95±3.37**	**15.41±4.91**	**104.81±107.94**

Table 2. Sizes (lengths and weight) of *S. melanotheron* and *T. guineensis* from Idiogba creek in the coastal waters of Ondo State, Nigeria.

Species	Month	Number of Sampled Fish	Total Length (cm)	Standard Length (cm)	Fork Length (cm)	Weight (g)
S. melanotheron	February	32	13.63±1.75	11.03±1.49	13.02±1.83	51.00±18.42
	March	41	12.86±1.81	10.39±1.47	12.21±1.93	49.14±25.56
	April	18	14.44±0.73	11.36±0.81	13.92±0.66	50.00±11.38
	Mean	**91**	**13.44±1.72**	**10.81±1.42**	**12.83±1.82**	**49.96±20.80**
T. guineensis	February	5	14.56±3.35	11.90±2.43	13.60±3.53	71.58±69.01
	March	6	13.88±1.13	11.58±1.54	13.37±1.32	52.08±15.74
	April	13	15.68±4.63	12.91±3.10	15.02±4.68	94.23±102
	Mean	**24**	**15.00±3.74**	**12.37±2.63**	**14.31±3.82**	**78.98±81.51**

3.2. Length-weight relationship and growth condition.

The length-weight relationship and condition factor of *S. melanotheron* and *T. guineensis* from Mahin lagoon and Idiogba creek in the coastal waters of Ondo State, Nigeria is presented in Table 3. The regression coefficient (*b*) of length and weight was *b*=2.55; *a*=-2.76; R^2=0.78 (in Mahin lagoon) and *b*=2.31; *a*=-2.13; R^2=0.78 (in Idiogba creek) while the values computed for *T. guineensis* was *b*=3.04; *a*=-4.06; R^2=0.96 (in Mahin lagoon) and *b*=3.05; *a*=-4.11; R^2=0.92 (in Idiogba creek). The values of the fish's allometry coefficient (b) agreed with other research in terms of hypoallometric growth [22, 4]. According to Ajibare et al. [11], in isometric growth (b = 3), all fish dimensions expand at the same rate while the fish becomes substantially slimmer when the b value is less than 3.0 (hypoallometric), and if it becomes plump, the b value would be more than 3.0 (hyperallometric).

The growth constant '*b*' estimated for *S. melanotheron* and *T. guineensis* in Mahin lagoon and Idiogba was not equal to 3, indicating that the growth pattern in both species was not isometric but rather allometric and, therefore, growth was not dimensional. Hyperallometric growth patterns (b>3), which indicate that fish get heavier as they grow longer, were computed for *T. guineensis* (b=3.04 in Mahin and b=3.05 in Idiogba), while hypoallometric growth (b<3) was computed for *S. melanotheron* in Mahin (*b*= 2.55) and Idiogba (*b*=2.31) which indicates that the body becomes more rotund as it increases in length. Moreover, variances in sample size, fish ages, as well as ecological and other environmental factors such as food availability and competition within food chains, among other things, may contribute to or have an influence on the observed growth patterns [11].

Table 3. Length-weight relationship and condition factor of *S. melanotheron* and *T. guineensis* from Mahin lagoon and Idiogba creek in the coastal waters of Ondo State, Nigeria.

Species	Month	*a*		*b*		R^2		K	
		Mahin	**Idiogba**	**Mahin**	**Idiogba**	**Mahin**	**Idiogba**	**Mahin**	**Idiogba**
S. melanotheron	February	-3.20	-3.12	2.72	2.69	0.81	0.85	2.02	2.02
	March	-2.92	-2.61	2.64	2.53	0.94	0.93	2.25	2.31
	April	-4.00	-5.23	2.97	3.42	0.79	0.62	1.75	1.66
	Mean	**-2.76**	**-2.13**	**2.55**	**2.31**	**0.78**	**0.78**	**2.04**	**2.06**
T. guineensis	February	-3.96	-5.04	3.01	3.41	0.97	0.98	2.57	2.32
	March	-4.61	-4.69	3.25	3.28	0.99	0.94	2.47	1.95
	April	-3.91	-3.86	2.98	2.96	0.92	0.9	2.49	2.45
	Mean	**-4.06**	**-4.11**	**3.04**	**3.05**	**0.96**	**0.92**	**2.53**	**2.34**

a = Regression constant (the point at which the regression line intersects the y-axis), and *b* = Regression slope (the growth coefficient).

Table 2 also revealed that the condition factor was greater than 2 for the two species in both stations throughout this study. The table further revealed that the condition factor was higher in *T. guineensis* (K=2.53 in Mahin and K=2.34 in Idiogba) than *S. melanotheron* (K=2.04 in Mahin and K=2.06 in Idiogba). Condition factor (K) is predicated on the notion that fish with a certain length and more weight are in better physical condition. The mean K for *S. melanotheron* was 2.04 and 2.06 in Mahin and Idiogba respectively while the mean K for *T. guineensis* was 2.53 (in Mahin) and 2.34 (in Idiogba). When the condition factor value is high, it is perceived that the fish has improved condition, and the opposite is true when the value is low. K=1 represents the middle point between the organism's slender and robust states. If K is more than 1, the organism's robustness is better and the fish is stout [24]. Oso et al. [24] and Ajibare et al. [11] reported that a variety of factors, including variations in weight, stress, stage of maturity, age, food availability, feeding activity/degree of nourishment, sex, gonadal activity, season, water quality parameters, and other environmental factors, could be responsible for the condition factors. The negligible variations in K values obtained for the two species at both stations might therefore be attributed to these environmental elements. The condition indices consequently revealed that the two fish species were very fat (K>1.5), in normal and healthy condition [20].

4. Conclusions

This study determined that populations of *S. melanotheron* and *T. guineensis* in Mahin Lagoon and Idiogba shared similar morphologies based on morphometric characteristics. *S. melanotheron* exhibited hypoallometric growth in both locations, while *T. guineensis* displayed hyperallometric growth in the study area. Additionally, the calculated K values for both species indicated that the fish samples in Mahin and Idiogba were in good health, being notably well-nourished. The observed monthly fluctuations in the fish species' sizes may have been influenced by various factors. To ensure the sustainability of the water bodies, a thorough analysis of physico-chemical and biological water quality indicators, along with other factors affecting the coastal waters of Ondo State, Nigeria, may be necessary. Furthermore, it is strongly recommended to conduct additional research on other aspects of the biology of these species, as well as other relevant species, to contribute to the proper management and conservation of fisheries. A holistic approach to understanding the ecological dynamics and factors impacting these populations will be essential for effective long-term conservation strategies

Statement and Declarations

Data Availability

This article includes all of the data that was generated or analyzed during the course of this research.

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Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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