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Some Aspects of the Biology of *Sarotherodon melanotheron* and *Tilapia guineensis* inhabiting Mahin Lagoon, Nigeria

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ABSTRACT: Studies on fish biology are important because they help determine the best management strategy to use in order to conserve fish species in their natural habitat. Thus, some aspects of the Biology of *Sarotherodon melanotheron* and *Tilapia guineensis* in the Mahin Lagoon were covered in this study. For the study, 121 fish samples were collected. The sex ratio of *S. melanotheron* (1:1.64) and *T. guineensis* (1:1.36) showed no significant deviation from the expected 1:1. Fecundity ranged from 243 to 1223 in *S. melanotheron* and 156 to 600 in *T. guineensis* with means of 344.39±166.85 and 286.27±114.85 respectively indicating low fecundity in both species. Observed Gonado-Somatic Index (6.40±3.25% for *T. guineensis* and 5.65±3.31% for *S. melanotheron*) suggested the peak of gonad maturity. The regression equation of the length-weight relationship indicated that *S. melanotheron* exhibited negative allometric growth in male (b=1.66, R^2=0.63), female (b=2.80, R^2=0.83) and combined sex (b=2.55, R^2=0.78) while *T. guineensis* exhibited positive allometry in male (b=3.05, R^2=0.97), female (b=3.04, R^2=0.95) and combined sex (b=3.04, R^2=0.96). The condition factor was greater than 2 for both species. This study also revealed that the fecundity of the two species was size dependent. Examination of stomach fullness revealed that 4.2% and 0.0% of *S. melanotheron* and *T. guineensis* had empty stomachs while 20.0% and 3.8% had full stomachs respectively. This study therefore established that the study area was conducive for the fish. Monitoring and regulation of the fisheries is therefore recommended for conservation and management of the study area.

KEYWORDS: Sex ratio; fecundity; Gonado-Somatic Index; length-weight relationship; diet composition

1. Introduction

Nigeria is fortunate to have many water bodies with a wide variety of fish species. These fish species include both fish and shellfish, both of which are widely available. Cichlids are one of the fish species that may be found in freshwater and coastal waters. They are economically significant due to their abundance, year-round availability, affordability, tasty meat, economic importance, and nutritional value [1]. Cichlids enrich the lives of fish farmers and the commercial inland fishing in the majority of the world's nations [2, 3]. According to Offem et al. [4], Andem et al. [3] and Loto et al. [1], *Sarotherodon melanotheron* and *Tilapia guineensis* are known to be the most dominant fish in commercial catches exploited in artisanal fishery of the Mahin lagoon, however, this had not been the case in recent times due to its high exploitation [1, 5].

Many fish species are experiencing population declines, and some have been classified as vulnerable or endangered species. This decline has been ascribed to a number of issues, including overfishing, habitat loss and degradation, pollution, and the introduction of alien and non-native species [6]. According to Kareem et al. [7] about 300 species of freshwater fish are thought to be at risk of going extinct in the next 20 to 30 years, if frequent biological assessment studies are not conducted to enhance proper management procedure. Information on reproductive biology guide fishery managers to detect changes in the condition of fish over time. In developing countries, most of the catch comes from fisheries that are poorly managed, because even the most basic information on the performance of fish stocks is unavailable [9]. Moreover, understanding the reproductive biology of fish is essential for rational utilization of stocks. Therefore, studies on fecundity, sex ratio, breeding season and factors associated with them are needed to protect new recruits and predict recruitment variability in the Mahin lagoon. It is necessary to conduct studies on the biology and associated factors in order to protect new recruits and estimate recruitment variability. Fish reproductive biology is a crucial element in determining the best management strategy to implement in order to conserve species of fish in their ecosystem. The abiotic environment, food availability, predator pressure, and parental fish habitat all affect how they reproduce [8]. The GSI, fecundity, and gonadal histology, in addition to determining the ovary's level of maturity, are the most crucial variables in understanding the reproductive biology of any fish [7]. A reliable predictor of fish gonadal development is the gonado-somatic index, which measures gonad size in relation to fish size.

According to Indarjo et al. [9], GSI serves as an indicator to pinpoint the precise start of the spawning season and the frequency of spawning of fish species. Fecundity, on the other hand, is a reproductive biology pathway that exhibits variation in the degree of production leading to an increase in the amount of fish captured [8]. For the assessment of commercial potentialities, stock study, life history, particular culture, and fishery management, in-depth and accurate information of fish fecundity is essential [10]. The representation of male and female fish in a population is revealed through studies on sex ratio. It lists the ratio of male to female fish in a population and shows which species of fish are more prevalent in a particular population based on sex. In order to estimate fish population stock size and determine the likelihood of fish reproduction, basic information on the sex ratio is also required [11]. Understanding the status of the fish stock in relation to a chosen point of biological reference can differ depending on how the sex ratio is added to estimations of reproductive potential [12].

Moreover, due to the dwindling nature and the complaint by fishermen on the reduction of the resources over the years, it became obvious to embark on this study to provide information on the current status of this species for proper management and conservation in the Mahin lagoon. Also, despite the enormous potentiality of *Sarotherodon melanotheron* and *Tilapia guineensis*, the study on reproductive biology of these important species in the Mahin Lagoon has not yet been explored. Although a few published studies on their biology are available from other regions of the country [1, 5, 12, 13, 14, 15], no unique information is available with regard to different aspects of these species' reproductive biology. As a result, a detailed investigation of reproductive biology, including sex ratio, gonado-somatic index, fecundity, and stages of gonadal development, was carried out in order to aid in the development of their effective management in the natural environment.

2. Materials and Methods

2.1. Study area.

In the Ilaje Local Government Area of southwestern Nigeria, Mahin Lagoon is situated between Latitude 6.175989 °N and 6.206869 °N and Longitude 4.810944 °E and 4.823770 °E. It is roughly 2.3 km in diameter and 9 km from the Atlantic Ocean. It is well known for being a fishing hotspot. A segment of it serves as a transportation route from Igbokoda to settlements on the coast, and communities are built around it for economic reasons [1]. In light of its proximity to the ocean and the tidal influences that go along with it, Mahin Lagoon represents a diverse and dynamic ecology. A 29 km long river channel that empties into the sea feeds it via the Mahin canal, which is connected to it. The main route for transit from Igbokoda to the coastal settlements used to be along the western flank of the lagoon. Igbokoda to Ugbonla's road system has been improved, which has lessened the area's reliance on water transportation. Algal blooms are typically apparent at the height of the rainy season. The physico-chemical characteristics of this plant matter change as it decomposes, which has an impact on the ecology. This might lead to seasonal movement of species and alter the food chain in the lagoon and its surroundings [15].

2.1. Fish specimen collection and identification.

Monthly samples of fish from the Mahin lagoon in the coastal waters of Ondo State, Nigeria, were taken from February to April 2021. One hundred and twenty-one (121) fish identified as *Sarotherodon melanotheron* and *Tilapia guineensis* according to Adesulu and Sydenham, [16]; Olaosebikan and Raji, [17] were used in this study. 3.5mm mesh size cast netting was used for capturing the fish samples. The samples were brought in an ice chest to the Olusegun Agagu University of Science and Technology's Fisheries and Aquaculture Laboratory in Okitipupa, Nigeria for analysis.

2.2. Determination of Sexes, Sizes, Condition factor, LWR and Gonado-Somatic Index.

The gonads were examined visually and under a microscope to determine the sexes of the fish. The sex ratio was calculated using the proportion of the two sexes in relation to one another [18]. Using a standard measuring board, the total length (measured from the anterior tip of the fish to the most posterior tip of the caudal fin) and standard length (measured from the tip of the mouth to the beginning of the tail) were calculated to the nearest 0.1 cm. According to Loto et al. [1], body weight (the measurement of the total body mass) was also determined using a digital Sartorius top loading weighing balance (Model 1100).

The Length-weight relationship was determined following Ajibare and Loto [5], where weight and length were given as:

$$W = aL^b$$

W stands for weight in grams (g), L for length in centimeters (cm), a for the initial growth index (a constant), and b for the growth coefficient. Constant 'a' denotes the location of the regression line's y-axis intercept, and 'b' denotes the slope of the regression line.

The condition factor (k), which represents the degree of fish wellbeing in their habitat, was calculated using the following equation:

$$K = \frac{100\mathrm{W}}{L^3} \,[5]$$

Where W is the mean weight of each fish species in grams, L is the mean total length of each fish species in centimeters, and K is the condition factor.

The gonado-somatic index (GSI) was determined for each gonad as:

$$GSI = \frac{\text{Gonad weight (g)}}{\text{Fish weight (g)}} \, x \, 100 \,[18].$$

2.3. Determination of Stages of Gonadal development.

The gonad development phases (testicles and ovaries) were categorized according to Oso et al., [8] and are shown in Table 1. The number of males and females in each stage of gonadal development were recorded.

Table 1. Classification of stages of Gonadal development.

Stage	Testicular stages	Ovarian stages
Stage I- (Immature)	Small, thin, whitish, a bit asymmetrical	Small, transparent, a bit asymmetrical, somehow cylindrical, free of yolk deposition. Some were elongated, translucent and creamy yellow.
Stage II- (Developing/Maturing)	Whitish, elongated, Vas difference widens but reduced. Quite massive, pale whitish, blood capillaries visible.	Slightly creamy to pale, a bit asymmetrical. The ovaries were rounded and pinkish yellow. They have visible opaque Oocytes. Oviduct much reduced granular appearance. Eggs were clearly seen with unaided eye. Yellow, oviduct further reduced ova still in the follicle.
Stage III- (Matured):	Pale white with hardly any transverse grooves. Viscous fluid flows out from the sliced surface.	Yellow, blood vessels ramifies over the surface.
Stage IV- (Ripe, Running):	More elongated, the outer margins slightly wrinkles, milt expression by a moderate pressure.	Fully developed, deep yellow in colour.
Stage V- (Spent):	No milt expression; testes shrunken, flaccid, and grey.	Ovaries reduced, flaccid, saclike and reddish in color with some residual ova. Very few large ova are dispersed and in a state of reabsorption.

2.4. Estimation of fecundity.

The direct enumeration approach was used to assess fecundity, which is the number of mature eggs in the female prior to the next spawning. The gonad weight was determined before being preserved in Gilson fluid. After being rinsed with water, the preserved gonads were then counted. The eggs were put in a Petri dish, and the number of eggs was counted [9, 14].

2.5. Determination of stomach fullness.

The gut of each individual fish specimen was carefully extracted by opening the fish's abdomen. The stomach was then preserved in 4% formalin for subsequent analysis of the food components. By using the displacement approach, the food volume of each gut was estimated [7]. This was achieved by adding 10ml of distilled water to a glass cylinder with a 50ml capacity. Each stomach was dropped into the glass cylinder of water separately. The amount of food in the intestine was reflected by the amount of water it displaced. The stomachs were categorized as 0% (empty), 25%, 50%, 75%, or 100% (full) according to their fullness [1].

2.6. Statistical analyses.

Statistical Package for Social Scientists (SPSS 20.0) was used to analyze the data. Using chi square analysis, the sex ratio was tested for any variation from the expected 1:1 ratio. Regression analysis was used to examine the connections between fecundity and length and fecundity and weight. Level of significance was selected as $p < 0.05$.

3. Results and Discussion

3.1. Sex ratio, sizes, condition factor and length-weight relationship.

The Sex ratio of *S. melanotheron* (1:1.64) and *T. guineensis* (1:1.36) as revealed in Table 2 shows that despite the numerical abundance of female over male fish in both species, there was no significant difference (P>0.05) in the populations of male and female *S. melanotheron* and *T. guineensis* in the Mahin Lagoon. In this study, there were more females than males. However, the deviation of the observed sex ratio from the predicted 1:1 distribution was not statistically significant (P> 0.05). The sex ratio recorded for *S. melanotheron and T. guineensis* in this study agrees with sex ratios of 1:1.40 for *C. nigrodigitatus* reported by Nzeh and Lawal [19], 1:1.02 Onah [20], 1:0.93 for *C. walkeri* by Oboh and Omoigberale [21] and 1:0.98 for *C. auratus* reported by Al-Nahdi et al. [22]. In all these investigations, almost equal proportions of male and female numbers of these species were observed even though their abundance was in favour of female specimens. Similarly, in the study of *P. jubelini* in Lagos coast, Adebiyi [18] reported a non-significant male dominance over females. The predicted sex ratio of 1:1 may fluctuate from species to species or even within the same population over time due to a variety of factors, including population adaptability, reproductive behavior, food availability, and environmental conditions [18, 19, 20].

According to Jega et al. [10] and Indarjo et al. [9], the cause of the deviation from a 1:1 sex ratio is unidentified but it may have been impacted by differences in fish growth between the sexes as well as food availability and abundance. The dominance of females may be due to migration of female specimens to breeding site or may be fishermen are setting their gears close to breeding ground. This situation may not be healthy for fishery conservation where more females are caught out of from their habitat. The non-significant deviation from the expected 1:1 distribution recorded in this study contradicts the report by Kareem et al., [7] who reported that, in African water bodies, males predominate in the population because they typically exhibit greater growth than females.

Table 2. Sex ratio of *S. melanotheron* and *T. guineensis* from Mahin lagoon in the coastal waters of Ondo State, Nigeria.

Species	Female		Male		Combined		Sex Ratio	χ2 Calc.	χ2 Critical	P
	n	%	n	%	n	%				
S. melanotheron	59	62.1	36	37.9	95	100	1:1.64	0.41	3.84	P>0.05
T. guineensis	15	57.7	11	42.3	26	100	1:1.36	0.13	3.84	P>0.05

Moreover, Table 3 presents the sizes of *Sarotherodon melanotheron* and *Tilapia guineensis* collected from Mahin lagoon, Ondo State, Nigeria. The table showed that 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 while that 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±1.48cm and 11.14±1.22 cm with an average of 10.71±1.34 cm while 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 while 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. The table also revealed that the condition factor was greater than 2 for the two species. The table further revealed that the condition factor was higher in *T. guineensis* (K=2.50 for Male; K=2.56 for Female and K=2.53 for combined sex) than *S. melanotheron* (K=2.02 for Male; K=2.04 for Female and K=2.03 for combined sex). The LWR of *S. melanotheron* and *T. guineensis* in Mahin lagoon as presented in Figure 1 revealed that *S. melanotheron* exhibited negative allometric growth in male (b=1.66, R^2=0.63), female (b=2.80, R^2=0.83) and combined sex (b=2.55, R^2=0.78) while *T. guineensis* exhibited positive allometry in male (b=3.05, R^2=0.97), female (b=3.04, R^2=0.95) and combined sex (b=3.04, R^2=0.96) (Figure 2). This shows that *S. melanotheron* becomes more elongated as it grows (b<0.5) while *T. guineensis* becomes less elongated or more roundish as it grows.

Table 3. Length and Weight and Condition Factor of *S. melanotheron* and *T. guineensis* from Mahin lagoon in the coastal waters of Ondo State, Nigeria.

Species	Sex	n	TL (cm)	SL (cm)	FL (cm)	WT (g)	K
S. melanotheron	Male	36	12.96±1.09	10.49±0.85	12.31±1.31	43.93±7.91	2.02
	Female	59	13.58±1.89	10.85±1.55	12.97±1.89	51.14±25.48	2.04
	Combined	95	13.35±1.66	10.71±1.34	12.72±1.72	48.41±20.89	2.03
T. guineensis	Male	11	16.08±4.99	12.81±3.41	15.45±5.07	103.85±109.13	2.50
	Female	15	16.04±4.89	13.05±3.47	15.39±4.97	105.51±110.88	2.56
	Combined	26	16.06±4.83	12.95±3.37	15.41±4.91	104.81±107.94	2.53

This study's investigation of the length-weight relationship revealed that both male and female fish grew allometrically. The values of 'b' demonstrated that the male and female of *S. melanotheron* both displayed negative allometric growth, but the female and male of *T. guineensis* both exhibited positive allometric growth. This indicates that although *T. guineensis* gets stocky or robust as its length increases, S. melanotheron becomes thinner or slender with an increase in length (as described by Loto et al. [1] and Ajibare and Loto [5]. The findings of this study were consistent with information on fish from certain inland waterbodies in Nigeria. Rheman et al. [23] observed that all five fish species collected from a reservoir in Abuja, Nigeria exhibited negative allometric growth while Oso et al. [8] found that three out of their four specimens from Ero dam in Ekiti State, Nigeria, showed negative allometric growth.

The 'K'-values observed in this study were found to be within the range of 2.9 to 4.8 suggested as appropriate for mature freshwater fish [5]. According to the overall mean condition factor, *T. guineensis* was in a better condition than *S. melanotheron*. The sex of the fish, age, stage of maturity, fullness of the gut, type of food consumed, and/or degree of muscle development may have all had an impact on the somewhat higher "K" values that were observed. Variations in the condition factor of several fishes have been reported by Ajibare and Loto [5] and Olawusi-Peters et al. [24] in relation to their feeding rhythm, physico-chemical environmental parameters, and physiological status.

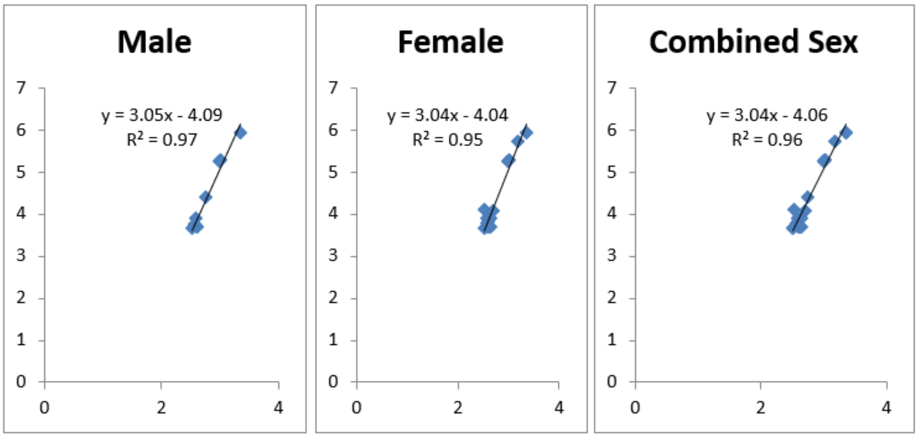

Figure 1. Length-Weight Relationship of *T. guineensis* from Mahin lagoon in the coastal waters of Ondo State, Nigeria.

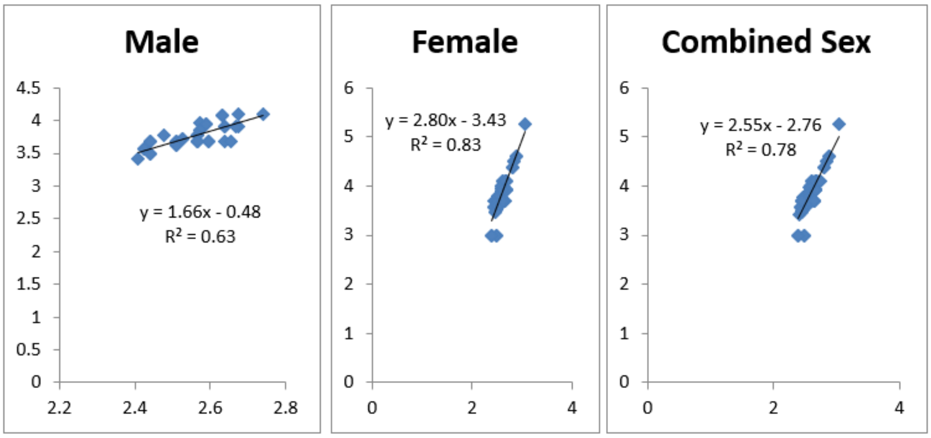

Figure 2. Length-Weight Relationship of *S. melanotheron* from Mahin lagoon in the coastal waters of Ondo State, Nigeria.

3.2. Fecundity, gonado-somatic index (GSI) and gonad maturity.

The average no of eggs for *S. melanotheron* and *T. guineensis* was 344.39±166.85 and 286.27±114.85 respectively. The results also revealed that the eggs ranged from 243 to 1223 in *S. melanotheron* while it ranged from 156 to 600 in *T. guineensis.* The fecundity range obtained in this study revealed that *T. guineensis* (286.27±114.85 eggs) and *S. melanotheron* (39±166.85 eggs) are low-fecundity fish (when contrasted to other high-fecundity fish that lay millions of eggs). This finding is consistent with that of Oboh and Omoigberale [21], who found that *T. nilotica*, with body lengths between 11.0 and 32.0 cm, had a fecundity range of 300 to 2800 eggs. Disparities in the fecundity recorded could be attributed to some biological and environmental factors. According to Adebiyi [18], location, individual fish species, and egg size all affected fecundity, size, and condition factor. Indarjo *et al*. [9] claim that a fish's fecundity is influenced by the river's fertility and that rivers with more nutrients tend to have more fecund fish. This agrees with Oboh and Omoigberale [21] who stated that the low fecundity recorded in their study area was because it was oligotrophic. However, Vicentini and Araujo [11] reported that fecundity varies annually and undergoes long term changes even within a stock. This corroborates with those of other researchers where fecundity per total length is higher than fecundity per body weight [4, 10].

According to Loto et al. [1], *S. melanotheron* exhibit different reproductive strategies in different ecosystems. One of the reproductive strategies for the survival of these species in Mahin lagoon could be early sexual maturity or precocious reproductive habit evidenced by the observed small sizes at maturity. Since, fecundity varies as a result of different adaptations to environmental habitat, the observed fecundity may be due to the effect of environmental factors such as pollution, fishing pressure and siltation in the lagoon. Moreover, according to Rheman et al. [23], fluctuation in fecundity may be due to differential abundance of food, whilst wide fluctuations are usually attributed to differential feeding success. Therefore, fish stock, nutritional status, demographic characteristics like size, age, and sex, environmental circumstances, and the availability of space and food are only a few of the variables that may be responsible for the observed fecundity [18, 21].

Moreover, the gonado-somatic index (GSI) for male and female *S. melanotheron* was 1.34±0.83 and 5.65±3.31 respectively while the values recorded for combined sex was 4.02±3.38 (Table 4). The table further revealed that the GSI recorded for male *T. guineensis* was 1.01±0.77 while values recorded for female and combined sex were 6.40±3.25 and 4.16±3.65 respectively. In this study, both males and females of *S. melanotheron* and *T. guineensis* had high gonado-somatic indices which suggested the spawning period of both species [18, 22]. Also, the observed GSI is an indication of the peak of gonad maturity. Similar findings were reported by Offem et al. [4] and Idodo – Umeh [2] who noted that flood, among other things, provides enlarged habitat and readily available food resources to enable the survival of the large number of young fishes produced [20–22]. According to Kareem et al. [7], several species of fish exhibit poor somatic condition during the spawning season, which may be a sign that gonad development is limiting somatic growth. High gonado-somatic indices observed in both male and female fish indicate that the study time may have been the two species' spawning season, which fell during the rainy season.

Table 4. Fecundity of *S. melanotheron* and *T. guineensis* from Mahin lagoon in the coastal waters of Ondo State, Nigeria.

Species	Range	No of Eggs	Weight of Gonad (g)			GSI		
			Female	Male	Combined	Female	Male	Combined
S. melanotheron	Minimum	243	0.65	0.04	0.04	1.08	0.08	0.08
	Maximum	1223	10.05	0.96	10.05	20.1	2.85	20.1
	Mean	344.39±166.85	2.68±1.85	0.59±0.35	1.89±1.79	5.65±3.31	1.34±0.83	4.02±3.38
T. guineensis	Minimum	156	3.26	0.04	0.04	1.04	0.05	0.05
	Maximum	600	4.23	0.80	4.23	9.92	2.06	9.92
	Mean	286.27±114.85	3.69±0.32	0.57±0.25	2.37±1.60	6.40±3.25	1.10±0.77	4.16±3.65

The stages of gonad maturity as presented in Table 5 revealed that no fish with immature gonad was captured in this study. However, 3.4% and 5.6% of the female and male *S. melanotheron* were spent while 20.0% and 9.1% of female and male *T. guineensis* were spent. The table shows that 16.8%, 42.1% and 36.8% of *S. melanotheron* were classified as maturing, matured and ripe respectively. Furthermore, for *T. guineensis*, 15.4%, 38.5% and 30.8% were categorized as maturing, matured and ripe respectively. This revealed that the bulk of the samples were in their spawning period. Thus, except for the immature stage, all stages of gonadal development in male and female fish were seen in this study. The results of Adebiyi [18] in the Lagos coast for both male and female *P. jubelini* were consistent with this finding. In a similar vein, independent investigations by Al-Nahdi et al. [22] and Fehri-Bedoui and Gharbi [25] noted immature, resting, maturing, mature, spawning, and spent stages of gonad development. The percentage of fish weight utilised for egg production at the maturation stage is indicated by the gonado-somatic index [8].

Table 5. Stage of Gonad Maturity of *S. melanotheron* and *T. guineensis* from Mahin lagoon in the coastal waters of Ondo State, Nigeria.

Species	Classification	Female		Male		Combined	
		n	%	n	%	n	%
S. melanotheron	Immature	0	0.0	0	0.0	0	0.0
	Maturing	11	18.6	5	13.9	16	16.8
	Matured	25	42.4	15	41.7	40	42.1
	Ripe	21	35.6	14	38.9	35	36.8
	Spent	2	3.4	2	5.6	4	4.2
T. guineensis	Immature	0	0.0	0	0.0	0	0.0
	Maturing	2	13.3	2	18.2	4	15.4
	Matured	8	53.3	2	18.2	10	38.5
	Ripe	2	13.3	6	54.6	8	30.8
	Spent	3	20.0	1	9.1	4	15.4

3.3. Degree of the fullness of stomach.

The degree of the fullness of stomach of *S. melanotheron* and *T. guineensis* as presented in Table 6 revealed that 4.2% and 20.0% of *S. melanotheron* were having empty and full stomach respectively. However, there was no sample of *T. guineensis* with empty stomach while only 3.8% had full stomach. The table further revealed that 53.8% and 26.9% of *T. guineensis* had 75%full and 50%full stomach respectively. This revealed that there was adequate food in the study area. The result obtained in this study showed that no *T. guineensis* and 4.2% of *S. melanotheron* had empty stomach. The reason for this may be due to the fact that the food items in their stomach may have been digested or regurgitated as the fish struggled for escape in the nets [1]. This agrees with the observations of Adebiyi [18], Kareem et al. [7], Jega et al. [10] and Indarjo et al. [9]. Oso et al. [8] recommended that cast netting (as used in this study) should be used for study of food and feeding habits because, specimens caught with cast net had lesser amount of empty stomach. The percentage of occurrence of empty stomach was very low and this revealed that food is available for fish species in the lagoon. It could therefore be said that the lagoon was rich in natural foods. Thus, Mahin lagoon can support a very good fish production if proper management is implemented.

Table 6. Stomach Fullness of *S. melanotheron* and *T. guineensis* from Mahin lagoon in the coastal waters of Ondo State, Nigeria.

Species	Classification	Female		Male		Combined	
		n	%	n	%	n	%
S. melanotheron	Empty	3	5.1	1	2.8	4	4.2
	25% Full	10	16.9	4	11.1	14	14.7
	50% Full	9	15.3	5	13.9	14	14.7
	75% Full	26	44.1	18	50.0	44	46.3
	100% Full	11	18.6	8	22.2	19	20.0
T. guineensis	Empty	0	0.0	0	0.0	0	0.0
	25% Full	1	6.7	3	27.3	4	15.4
	50% Full	3	20.0	4	36.4	7	26.9
	75% Full	10	66.7	4	36.4	14	53.8
	100% Full	1	6.7	0	0.0	1	3.8

3.4. Relationship between fecundity and body weight, total length, weight of gonad, and GSI.

Positive correlations were found between fecundity and both body length and weight (Figures 3 and 4). The relationship, however, showed that a fish's weight was more crucial to reproduction than its length. Similar observation was reported by Onah, [20] and Al-Nahdi et al., [22] This is an indication that small fishes have better and excellent condition than their larger counter part especially gravid fish. This might be as a result of smaller fish being more successful at obtaining food than bigger, gravid fish. This is consistent with the findings of Rheman et al. [23] who suggests that big fish have more energy and a larger body cavity for the development of eggs. Moderate relationship was established between fecundity and body weight (R^2=0.27), total length (R^2=0.22), gonad weight (R^2=0.05) and GSI (R^2=0.31) of *T. guineensis* (Figure 3). The relationship of fecundity with body weight (R^2=0.07), total length (R^2=0.02), gonad weight (R^2=0.00) and GSI (R^2=0.01) of *S. melanotheron* showed low relationships (Figure 4). These findings agree with the observations of Offem et al [4] who reported that fecundity is size dependent because their study revealed that the larger the fish, the higher its number of eggs and this may be due to more available visceral volume for holding the eggs [26].

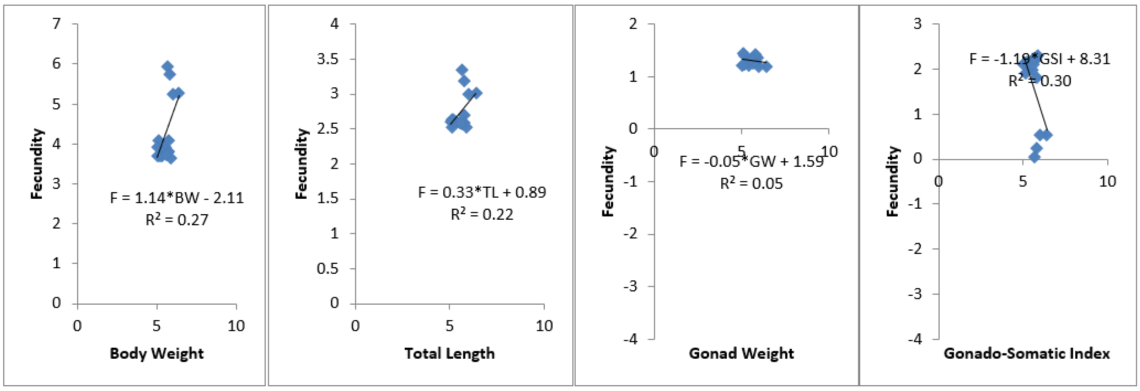

Figure 3. Relationship between fecundity and body weight, total length, weight of gonad, and GSI of *T. guineensis* from Mahin lagoon in the coastal waters of Ondo State, Nigeria.

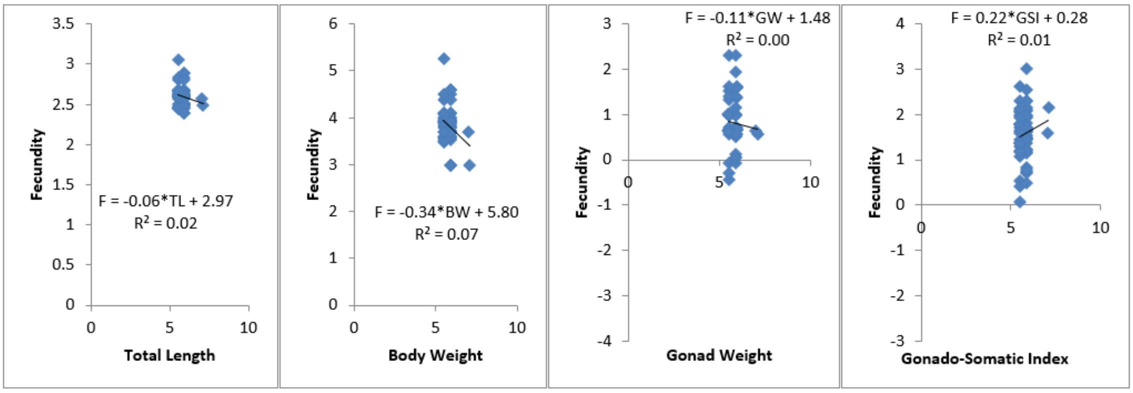

Figure 4. Relationship between fecundity and body weight, total length, weight of gonad, and GSI of *S. melanotheron* from Mahin lagoon in the coastal waters of Ondo State, Nigeria.

4. Conclusions

This study offers some fundamental details on the reproductive biology of *T. guineensis* and *S. melanotheron* in Mahin lagoon, Nigeria, including sex ratio, gonadosomatic index, gonadal development, stomach fullness, and fecundity. The overall sex ratio was calculated as 1:1.36 and 1:1.64 (male:female) with mean Gonado-somatic index of 4.16±3.65 and 4.02±3.38 for *T. guineensis* and *S. melanotheron* respectively. The timing and volume of recruitments as well as population dynamics can be determined using knowledge of the fecundity of *T. guineensis* and *S. melanotheron*. It is hoped that the current findings would add to the scant knowledge of *T. guineensis* and *S. melanotheron*'s reproductive biology in Nigerian water bodies and be helpful in the management and conservation of this significant commercial fish species. Furthermore, the results of this study will help fishery biologists and managers regulate the exploitation of young individuals and maintain sustainable management (such as responsible fishing practices, avoidance of overfishing, reduction of bycatch, targeting specific species at different seasons, etc.) of this population in Mahin lagoon. By advancing the understanding of the reproductive biology of fish in a lagoon, this work has thereby made a significant contribution to the body of knowledge needed for fisheries management. Further research areas for investigation include the food and feeding habits, effects of anthropogenic, environmental and climatic factors on the reproductive biology as well as the effect of fishing gears on the survival of the species.

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Competing Interest

The author declares that there is no competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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