Reproductive Biology, Trophodynamics and Stock Structure of Ribbonfish (*Trichiurus lepturus* Linnaeus, 1758) in Tropical Marine Waters of the Bight of Benin

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ABSTRACT

This study was an attempt to understand the exploitation rate and mortality parameters of *Trichiurus lepturus* Linnaeus, 1758 for sustainable exploitation and conservation of this important fish species in Ogun coastal waters, Nigeria. Reproductive biology, trophodynamics and stock structure of the population was assessed from ribbonfish captured with graded gillnets (18, 22, 26, 30, 40, 45, 50, 65, 70, 75, 80 and 90 mm, knot-to-knot). A total of 1,616 individuals of *T. lepturus* were captured and subjected to descriptive and inferential statistical tools. Sex ratio of males: females (0.4:1) was significantly (x^2=32.144; p=0.0007) different from unity. Peak spawning seasons were December and July. Total fecundity ranged between 7,051 and 12,456 eggs·yr^{-1}. In stomach contents, juveniles of ribbonfish dominated the finfish group with an index of relative importance (IRI) value of 42.6%, while Penaeids occurred most in the shellfish group with IRI value of 17.3%. Feeding intensity showed that juveniles fed mostly on prawns and crustaceans while adults fed more on finfishes. *T. lepturus* exhibited positive allometric growth with modal classes of 35-36.9 and 45-46.9 cm; von Bertallanfy model gave an asymptotic-length ($L\infty$) of 69.3 cm. Exploitation rate of *T. lepturus* is 0.73, which indicates that the stock of *T. lepturus* is marginally over-exploited.

Keywords: Fecundity, Feeding-intensity, Fish eggs, Stock-structure

INTRODUCTION

Aquatic resources play an important role in the economic, social, nutritional and aesthetic development of a nation. The uses of these resources, especially fish, for human consumption has increased over the years as a result of the continuous increase in human population. More than half of the world's population depends on fish as their main source of animal protein (FAO, 2010). It is a valuable and nutritious food and an essential source of high quality and cheap animal protein crucial to the diets of man (United Nations, 2004). However, despite the social, economic, nutritional and ecological significance of fish, the state of stocks worldwide is declining at an alarming rate due to a combination of environmental degradation as a result of human activities and poor management of fisheries resources (Jamu and Ayinla, 2003; Akpaniteaku *et al*., 2005).

According to Clark (2006), the non-implementation of the required management policies has led to over-exploitation and eventual collapse of most aquatic ecosystems. A collapse of an aquatic ecosystem can cause several alterations and also contribute a negative effect to the economy of a nation (Dudgeon *et al*., 2006). This ecosystem collapse might inexorably lead to increased poverty

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and lack of opportunities for fisher folk to make a decent livelihood. This calls for an ecological assessment of aquatic resources in order to understand the relationship between different aquatic organisms (Karr *et al*., 2006), and how the population of one affects the others.

Trichiurus lepturus, popularly known as "Ribbonfish" but locally called "Doje", represents an important species of food fish in the coastal communities in Nigeria (Odulate, 2010). This species is confined to a shallow depth zone below 70 m (Ghosh *et al*., 2014). Females of *T. lepturus* spawn more than once in a reproductive season. The females are more abundant, especially among older cohorts (Al-Nahdi *et al*., 2009). They are apex predators, which feed actively on fishes, crustaceans and cephalopods (Ojelade *et al*., 2016).

Hence, trophodynamic interactions (predation and competition), stock structure and reproductive biology of *T. lepturus* will give insight into the composition, distribution, spawning season and food habits of the species before applying appropriate management measures.

At the present time, there is no available information on reproductive biology, food items and feeding habits, nor the stock structure of *T. lepturus* from Ogun marine waters, which represents an important and unique commercial fishing community on the Bight of Benin. This area is also the only zone where coastal marine species can be caught in Ogun State, Nigeria. Hence, the objective of this study was to determine some aspects of the reproductive biology, trophodynamics and stock structure of ribbonfish (*Trichiurus lepturus*) in tropical marine waters of the Bight of Benin.

MATERIALS AND METHODS

Description of the study area

The geographical location chosen for this study is the coastal marine waters of Ogun State, Nigeria. It covers an area of about 6,032 km^2 with a 15-km (Olopade, 2001) coastline off Nigeria along the Bight of Benin (Figure 1). The study area is bounded to the west by Ijebu-East Local Government Area and Lekki Lagoon, to the north and east by Ondo State and to the south by Lagos State and the Bight of Benin. It is predominantly a rural settlement and the indigenes are mainly the south-western habitants of Nigeria (Odulate *et al*., 2012). The area comprises over 50 towns and villages and the Headquarters is at Abigi, at 6°29′N 4°24′E/ 6.483°N 4.4°E with a population of 72,935 (NPC, 2006). Ogun coastal area is situated in the rainforest belt of Nigeria with an annual rainfall of 125-150 cm as reported by Oluwalana (1997). It is characterised by two distinct seasons. The rainy season lasts for eight months (March-October) while the dry season lasts for four months, between November and February. The relative humidity is high year-round, usually above 80% during the wet season and ranges between 60% and 80% during the dry season (Ayansanwo, 2003).

Catch assessment survey

The study was carried out between February 2015 and January 2017. The data were pooled as annual data by estimating their means. Each site was visited monthly for data collection. A graded monofilament gillnet of varying mesh sizes (18, 22, 26, 30, 40, 45, 50, 65, 70, 75, 80 and 90 mm, knot-to-knot) was used to acquire the fish population sample. Three fishing nets were set at a distance of 300 m from the shore in late afternoon (6 PM and 8 PM) and retrieved the following morning (6:00 AM and 8:00 AM). Specimens of *T. lepturus* were sorted out and subjected to further analysis.

Reproductive biology of collected fish specimens

Sex identification of the specimens was determined by dissecting to reveal the genitals as described by Ama-Abasi (2002); the sex ratios of the sampled fish species were recorded on a monthly basis.

Gonadosomatic Index

Gonadosomatic index (GSI) of the dissected fish specimens was determined by morphometric analysis using the method of Afonso-Dias *et al*. (2005), and was expressed as a percentage of gonad weight (GW) to total body weight (BW) of the specimen, by the following equation:

$$GSI = \left(\frac{GW}{BW}\right) X100$$

Fecundity

The sub-sample method was applied to estimate the fecundity of females of *T. lepturus*. Female specimens were dissected and both ovaries were removed and weighed to the nearest 0.01 g using a Hannna sensitive scale (Model 1106). Three different sections were sampled from the weighed ovaries; 1 g of tissue was taken from the anterior, middle and posterior regions of the ovary, respectively, and examined to determine the average number of eggs per 1 g of ovary after Yelden and Avsar (2000) and Ama-Abasi (2002). Mean of the obtained result was multiplied by the total weight of the gonads to get the absolute fecundity for each fish.

The Relative Fecundity (RF) was determined to express the relationship between the fecundity of each fish specimen in relation to its body weight. This was calculated using the following formula as described by Bagenal (1978):

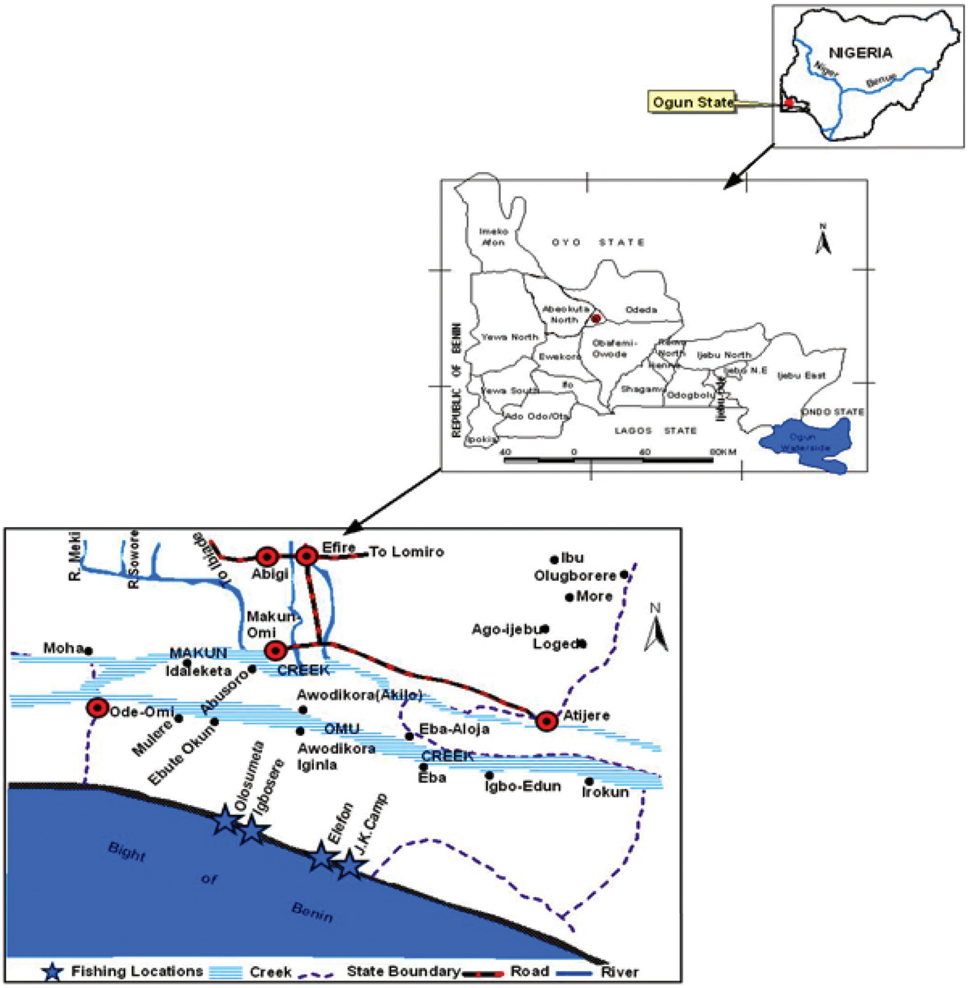

Figure 1. Map of the study area.

$$RF = \frac{Fecundity}{Total\ Weight}\ x100$$

Proportion of ripe gravid females of *T. lepturus* (which was determined by applying slight pressure to the abdomen to reveal presence of eggs) and the estimation of oocyte developmental stages were used to determine the spawning season of the population.

Food and feeding habits of Trichiurus lepturus

Stomachs of all fish specimens without an empty stomach were ventrally dissected to reveal the gut contents, which was preserved by immersing in 4% formaldehyde. The contents of each of the dissected specimens was poured into a Petri dish. The preserved gut contents of *T. lepturus* were analysed using frequency of occurrence, numerical and volumetric methods as described by Hyslop and Ugwumba (Hyslop, 1980; Ugwumba and Ugwumba, 2007).

The feeding intensity of the specimens was assessed based on the volume of food contained in the stomach, and classified as full, ¾ full, ½ full, ¼ full, or empty stomach. Relative importance of various food components in the stomach was calculated by the index of relative importance (IRI) as described in Nunoo *et al*. (2013). This was estimated by incorporating the frequency of occurrence, number, and volume of each food item for effective grading of the individual items. The IRI was computed as given below:

$$IRI = (\%N + \%V) \times \%F$$

where N = number, V = volume and F = frequency of occurrence of prey items in the sampled *T. lepturus*.

The % IRI was estimated according to the methods described in Paul *et al*. (2018), as:

$$\%IRI = \frac{IRI}{\Sigma IRI} \times 100$$

The samples used for stomach analysis were further categorized into three sizes (S1 = ≤42.9 cm, S2 = 43.0-52.9 cm and S3 =≥53.0 cm) as juvenile, post-juvenile and adult using their total length (TL).

Morphometric data for population parameters

Morphometric parameters such as total length (TL, distance from the snout with the mouth closed to tip of the caudal fin) and standard length (SL, distance from the snout to the caudal peduncle) were measured with a measuring board to the nearest 0.1 cm for each of the specimens, while the ungutted body weight (BW) was measured with a Mettler weighing balance (Model 1106) to the nearest 0.01 g.

To study population structure, size frequency was analyzed at a class interval of 2 cm using a histogram to determine the distribution that characterized the fish population.

Length-weight relationship (LWR) of the selected fish species was calculated using the equation: $W = a\ L^b$; where a is the intercept and b is the allometry coefficient, while W (g) and L (cm SL) represent the weight and length of the fish specimens. Parameters a and b were determined via least–squares linear regression (Zar, 1999). In order to check if the value of b was significantly different from 3, the method as described by Sparre and Venema (1992) was used. The value of b gives information on the growth pattern of fish: growth is isometric if $b = 3$, and the growth is allometric if $b \neq 3$ (negatively allometric if $b < 3$ and positively allometric if $b > 3$).

The condition factor, which represents the state of the general well-being of the fish sampled was analysed in relation to size, and this was estimated using Fulton's equation (Le Cren, 1951):

$$K = 100\ W/L^3$$

To estimate growth and mortality parameters, the obtained LW results were subjected to length-frequency analysis in FiSAT II (Version 2.2) to obtain the parameters for the Von Bertalanffy (1938) equation:

$$Lt = L\infty\ [-\exp\ (-K\ (t-t0))]$$

The estimates of L∞ and K were used to compute the growth performance index ϕ' (in terms of length) of the species (Munro and Pauly, 1983; Pauly and Munro, 1984) by the following equation:

$$\phi' = \text{Log10}(K) + 2\text{Log10}(L\infty).$$

The fitting of the best growth curve was based on ELEFAN I (Pauly and David, 1981), which allows the fitted curve through the maximum number of peaks of the length–frequency distribution as described by Abdul *et al*. (2015). The annual instantaneous rate of total mortality, Z, was estimated by linearized length-converted catch curves. Instantaneous natural mortality rates, M, were computed using the empirical equation described in Pauly (1980), and a mean annual surface temperature (T) of 28.6 ºC, as described below:

$$Log10\,(M) = -0.0066 - 0.279\,Log10\,(L\infty) + 0.6543\,Log10\,(K) = 0.463Log\,10\,(T)$$

The instantaneous fishing mortality rate, F, was calculated as Z–M (Sparre and Venema, 1992). The exploitation rate (E) was E = F/Z.

Statistical analysis

The overall sex ratio was tested against 1:1 using chi-square test.

RESULTS

Sex ratio

Females (n=921) dominated the specimens with an overall sex ratio of 1: 1.33 male: female. The sex ratio of the sampled *T. lepturus* varied across the sampling months though, and the obtained mean value was significantly different from 1: 1 (x^2=32.144; p=0.0007) (Table 1).

Spawning season

Gravid females were recorded in all months, with peaks in December-February and June to August (Figure 2). Gonadosomatic Index (GSI) analysis indicated that the gonads of both sexes were available year-round and the spawning season of *T. lepturus* in the study area is not confined to a specific period of the year. GSI varied within

Table 1. Sex ratio of *Trichiurus lepturus* in the tropical marine waters of the Bight of Benin.

Months	Male	Female	Male: Female Ratio
February	51	104	0.3:1
March	80	73	1:0.5
April	55	93	0.4:1
May	56	86	0.4:1
June	67	91	0.4:1
July	71	97	0.4:1
August	65	62	1:0.5
September	47	53	0.4:1
October	48	64	0.6:1
November	75	59	1:0.7
December	43	81	0.5:1
January	37	58	0.4:1
Total	**695**	**921**	**0.4:1**
			(x^2=32.144; p=0.0007)

the months of study, with the highest recorded values in July (2.72±0.75%) and December (2.51±0.63%), while the smallest value (0.91±0.23%) was recorded in March, as presented in Figure 3.

Fecundity

Absolute fecundity of *T. lepturus* (Table 2) varied with individual fish. The fish with the highest fecundity of 12,456 eggs was collected in June with a total length of 60.6 cm, while the fish with the lowest fecundity was collected in November, with a fecundity of 7,051±482 eggs and a TL of 37.9 cm. Relative fecundity ranged between 1,841 ±83 and 2,106±192 eggs·g^{-1}.

Food and feeding habits of Trichiurus lepturus

The food items in the stomachs of *T. lepturus* were made up of finfishes of various sizes as well as shellfish (Figure 4). Juvenile ribbonfish dominated the finfishes in the gut contents, with an IRI value of 42.6%, while Penaeids occurred most frequently in the shrimp group, with an IRI value of 17.3%, as depicted in Figure 5.

Feeding intensity and relative importance

Analysis of food items in relation to body size, as presented in Table 3, depicted that over 40% of the juveniles and post juveniles fed mostly

Table 2. Total length (TL) and some reproductive parameters (RP) of *T. lepturus* sampled from Ogun coastal waters.

TL/RP		
Total length (cm)	Minimum	37.9
	Maximum	67.6
	Mean	62.71±0.52
Gonad weight (g)	Minimum	10.4
	Maximum	17.51
	Mean	13.36±0.34
Fecundity (eggs)	Minimum	7,051
	Maximum	12,456
	Mean	11,156±997
Relative fecundity (eggs)	Minimum	1841±83
	Maximum	2,106±192
	Mean	1985±253

Table 3. Dietary items of *T. lepturus* at different body sizes.

Food item	**Body size**					
	≤42.9 cm		**43.0-52.9 cm**		**≥53.0 cm**	
	N	**%**	**N**	**%**	**N**	**%**
Finfish	295	36.41	468	44.9	943	82.5
Shellfish	329	40.67	493	48.8	141	12.3
Undigested Food Materials	187	23.0	65	6.3	59	5.2
Total	**811**	**100**	**1026**	**100**	**1143**	**100**

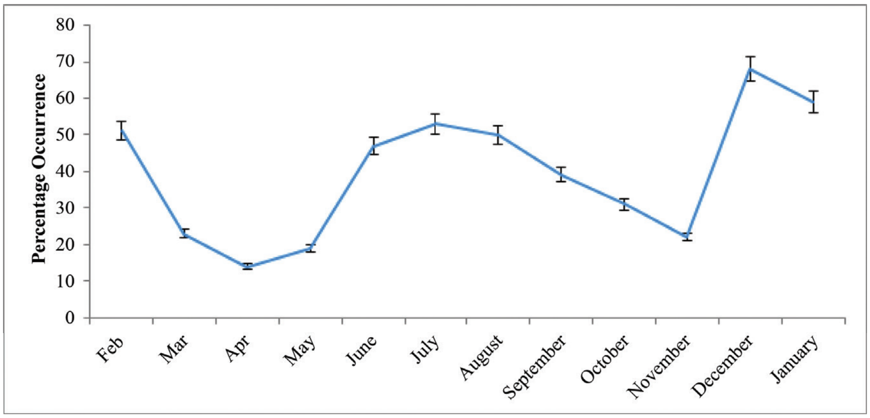

Figure 2. Month-wise percentage occurrence (mean±SD) of mature females of *T. lepturus* in Ogun marine waters.

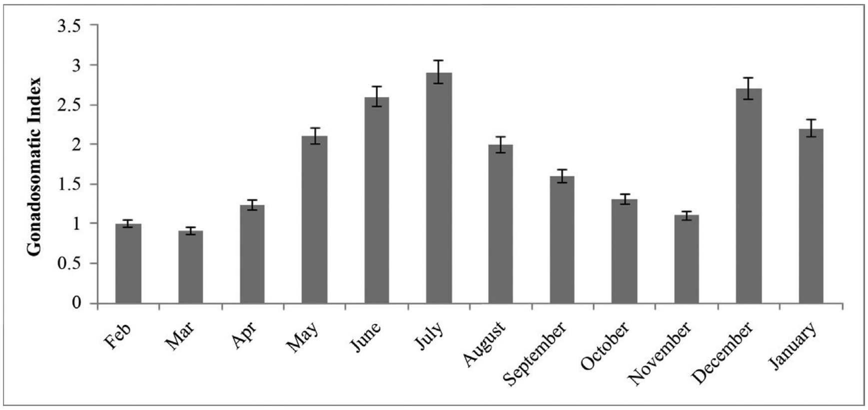

Figure 3. Gonadosomatic index (mean±SD) of females of *T. lepturus* sampled along the Ogun coastline.

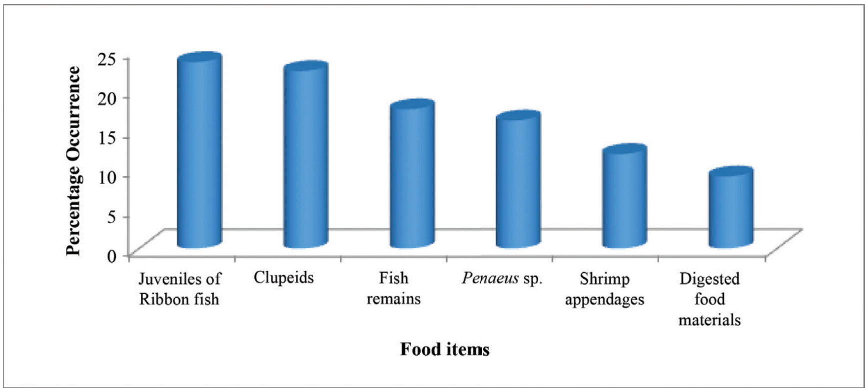

Figure 4. Percentage occurrence of food items in gut contents of *T. lepturus* sampled along the Ogun coastline.

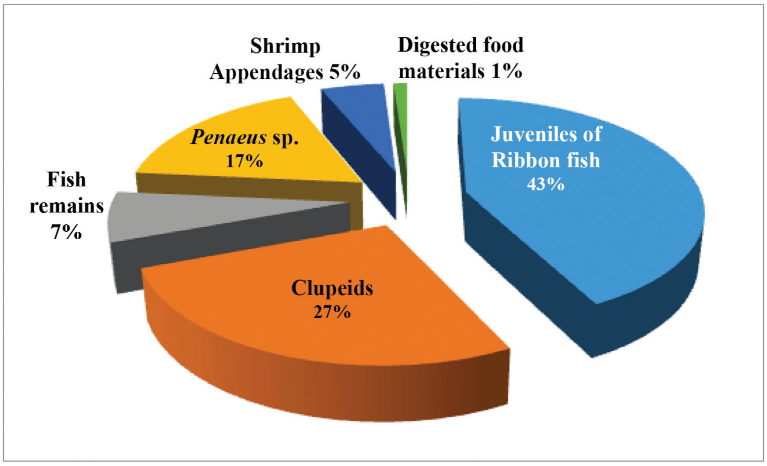

Figure 5. Index of Relative Importance (IRI, %) of food items found in *T. lepturus*.

on shrimps, while most (82.5%) of the adults preferred finfishes. Month-wise intensity of feeding was found to vary throughout the sampling period, with the highest proportion of fish possessing empty stomachs in July, December and January (Figure 6).

Length-distribution of Trichiurus lepturus

A total of 1,616 *T. lepturus* individuals with length range of 33.4-67.9 cm TL were used for the length-weight relationship analysis. Length frequency distribution of this population for the 24-month sampling period is shown in Figure 7. A bimodal distribution was observed with modal classes of 35.0-36.9 and 45.0-46.9 cm.

Estimates of length-weight relationships (LWR) showed that a strong positive correlation existed between the weight and total length (r^2=0.946) of the *T. lepturus* population in Ogun marine waters. The b-value was 3.08, which was not significantly ($p>0.05$) different from 3, with a corresponding a-value of 0.0101 as shown in Table 4. This result showed that this species increased in weight with a corresponding increase in length. The length frequency distribution with the superimposed growth curve for the sampling months is presented for *T. lepturus* in Figure 8.

Table 4. Length-weight relationship, mortality and population parameters of *T. lepturus* in Ogun marine waters.

Parameter	Value
Number	1,616
Intercept, a	0.0101
Allometry co-efficient, b	3.08±0.011
Regression constant, r^2	0.946
Condition factor, K	1.169286
Linear equation	$Log W = 3.08L - Log 1.62$
Curvilinear equation	$W = 0.0101L^{3.08}$
Asymptotic length, $L\infty$	69.3
Growth curvature, k	0.60
Total mortality, Z (yr^{-1})	3.82
Natural mortality, M (yr^{-1})	1.02
Fishing mortality, F (yr^{-1})	2.80
Exploitation rate, E (yr^{-1})	0.73
Growth Performance Index, ø	3.46

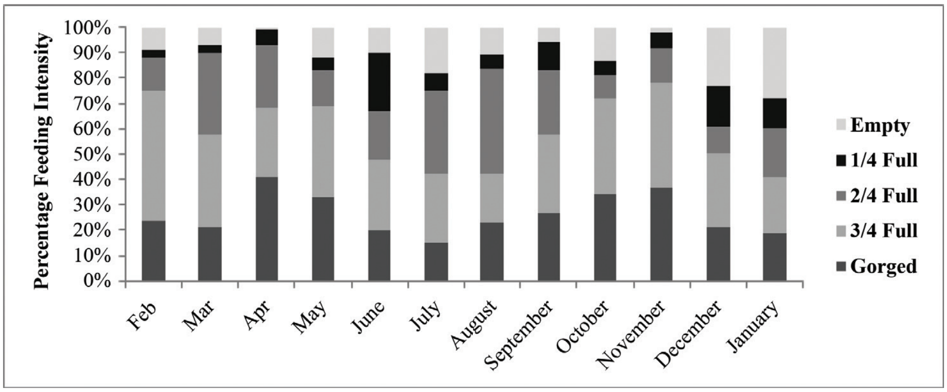

Figure 6. Month-wise feeding intensity of *T. lepturus* in Ogun marine waters.

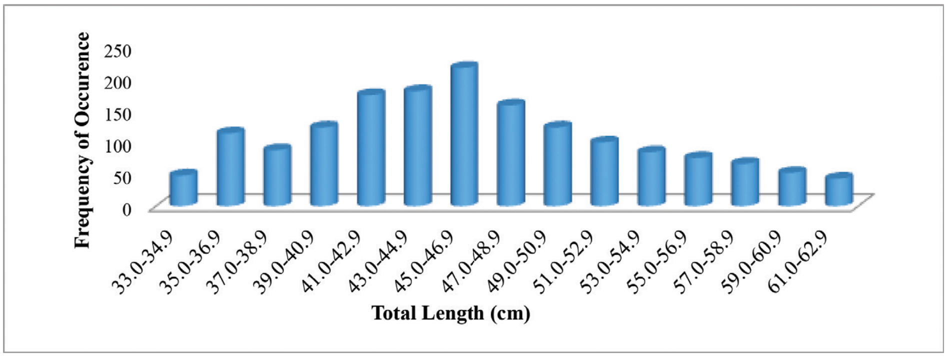

Figure 7. Size structure of *T. lepturus* in Ogun marine waters.

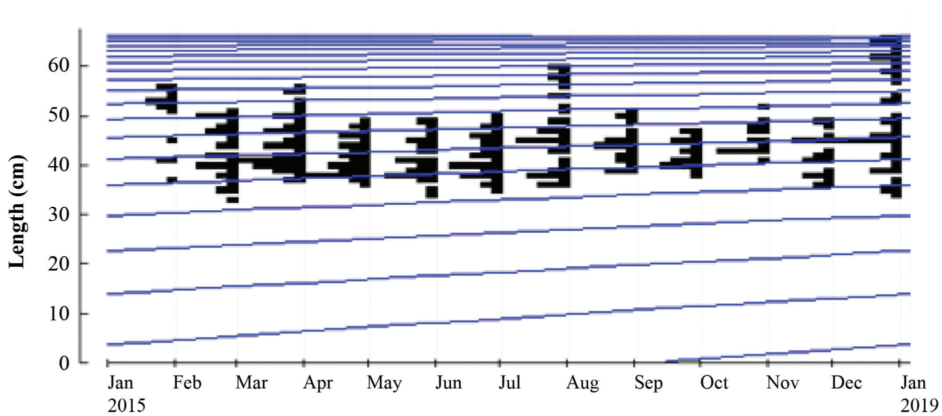

Figure 8. Length frequency distribution output from FiSAT with superimposed growth curves for *T. lepturus* in Ogun marine waters.

Growth and mortality parameters (M, F and Z) of Trichiurus lepturus

The linearized length-converted catch curves for the selected species is presented in Figure 9. The curves enabled the estimation of the total mortality (Z) of 2.53; annual instantaneous fishing mortality rate (F) of 2.52; exploitation rate of 0.73, which reflected an over-exploitation of the fish stock in the study area; and a condition factor (k) of 1.169, as detailed in Table 4. This table further shows the fishing mortality and exploitation rate of 2.80 yr^{-1} and 0.73 yr^{-1}, respectively.

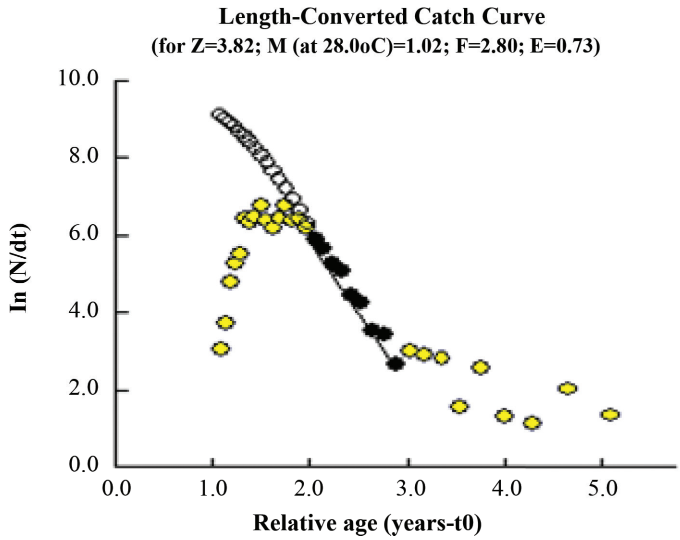

Figure 9. Length-converted catch curve of *T. lepturus* in Ogun marine waters, where N is the number of fish in each length class, dt is the time needed for the fish to grow through.

DISCUSSION

Most of the *T. lepturus* specimens used for the research were females (60%). The observed domination of females of *T. lepturus* in this study at most times during the sampling period is a pattern consistent with that reported by Udo *et al*. (2014), off Qua Iboe Estuary in Nigeria, where the sex proportion favors females. The recorded dominance by females in most months as observed in this study has similarly been observed in ribbonfish by several other authors (Abdussamad *et al*., 2006; Bittar and Di-Beneditto, 2009; Ghosh *et al*., 2014), which could be a mechanism for adapting to ecological changes, habitat preference or population control. The breeding season of *T. lepturus* is variable (Yan *et al*., 2012), and breeding can be seasonal (Chiou *et al*., 2006) or occur throughout the year (Martins and Haimovici, 2000; Al-Nahdi *et al*., 2009).

The spawning season peaked in the wet months, while a prolonged spawning season spanning throughout the year was observed in the study area, which corroborates the findings of Al-Nahdi *et al*. (2009) and Ghosh *et al*. (2014). Peak spawning periods indicated by the GSI in July and December is in general conformity with the percentage occurrence of maturity stages in different months. This recorded peak period could be attributed to a high water volume coupled with enhancement in food abundance during the wet season of the sampling period (Olukolajo and Oluwaseun, 2008).

The fecundity and relative fecundity observed in this study is lower compared to the values reported by Abdussamad *et al*. (2006) for the east coast of India. Differences between this study and the earlier one might be due to the different sampling periods and environmental differences.

However, Ekanem *et al*. (2004) pointed out that high fecundity was a compensation mechanism for coastal fish species, as they did not show adequate parental care for their young. Thus, it allowed for eggs and fry that might be lost due to high mortality arising from environmental perturbation and predation (Offem *et al*., 2008).

The relatively low proportion of empty stomachs of *T. lepturus* observed in this study could be attributed to a high level of food abundance in the coastal environment where the study was carried out, coupled with the variation in the time of capture of the sampled species (Abdussamad *et al*., 2006). This observed trend of feeding intensity is similar to the findings of Udo *et al*. (2014) who also recorded a low level of empty stomachs for the same species in Qua Iboe, Nigeria. This study shows that *T. lepturus* is a voracious carnivore. The observed trend of prey items in this study is similar to the feeding pattern reported by Al-Nahdi *et al*. (2009) in their study on *Trichiurus margitrates*. Feeding intensity varied within the sampling months, probably due to differences in productivity and trophic enrichment caused by fluctuations in coastal waves. This observed trend corroborates the findings of Odulate (2010), who stated that the coastal tides of Ogun marine waters fluctuated with respect to environmental influence and season. Food item analysis with respect to body size depicted that juveniles fed mostly on prawns while adults preferred finfishes. This observed size-wise variation in food item is in line with the assertion of Udo *et al*. (2014) and Brewton *et al*. (2016). Ontogenetic switches in feeding habits are a general phenomenon among fish and it results from increase in body and mouth size, which permits the fish to capture a broader range of prey sizes and types (Bittar and Di-Beneditto, 2009). Feeding intensity varied between juveniles, post-juveniles and adult-sized *T. lepturus*; this could be attributed to the fact that as fish grows in size and age, several morphological changes occur in the form of increase in mouth size and improvement in locomotion ability, which alters their prey catching efficiency (Ghosh *et al*., 2014).

Monthly catch of *T. lepturus* varied throughout the sampling period, with a total of 1,616 individuals. This high catch within 24 months corroborates the report of Odulate, (2010) who also recorded a relatively high proportion of ribbonfish in the same study area. However, Abdussamad *et al*. (2006) reported the availability of this species in water at depths of between 25 and 75 m, with an abundance of 917 individuals. The mean length obtained in this study was significantly higher compared to the report of Morato *et al*. (2001). Abundance of food resulting from seasonal coastal waves, coupled with the graded gillnet used, could be the reason for the varying class length observed during the sampling (Ojelade *et al*., 2016). The length- weight relationship indicated that *T. lepturus* exhibited positive allometric growth in Ogun marine waters of the Bight of Benin; a similar pattern of allometric growth was also recorded by Ghosh *et al*. (2014) in his study on *Trichiurus margitrates*. However, the findings of this study are contrary to the report of Udo *et al*. (2014) who recorded an isometric growth pattern for the same species in the coastal waters of Qua-Iboe. The condition factor obtained shows that *T. lepturus* individuals are in a good physiological state.

The asymptotic length and growth performance indices of *T. lepturus* as observed in this study indicate a proportional increase in the length and corresponding weight of this species; this corroborates the reports of Al-Nahdi *et al*. (2009), who reported similar trends of growth parameters for *T. lepturus* from the Arabian sea coast, but differs from the report of Abdul *et al*. (2015), who recorded lower values of growth parameters for Elops lacerta in the Ogun River. However, this variation in growth parameters could be due to factors related to ecosystem and biological phenomena such as maturity stages, feeding behaviour, and competition for food (Morato *et al*., 2001; Ekanem *et al*., 2004; Al-Nahdi, 2009).

The exploitation rate of 0.72 in this study, which is higher than the 0.50 sustainable exploitation margin, is an indication of an over-exploitation of the stock of ribbonfish in the study area, and shows that the population of *T. lepturus* is under threat of over-exploitation.

CONCLUSION

Some aspects of reproductive biology and stock structure of *Trichiurus lepturus* in the tropical marine waters of the Bight of Benin were studied. Females of *T. lepturus* dominated the population structure with a high fecundity rate, and peaks of spawning were in December and July. *T. lepturus* is a voracious carnivore with a positive allometric growth and asymptotic length of 69.5 cm. Condition factor of *T. lepturus* showed that individuals in this population were in good physiological condition. However, the exploitation rate of the species in Ogun coastal waters shows that it is almost over-exploited. Immediate management actions such as size-limit regulation, time-limit regulation, and protection of breeding or nursery areas are considered necessary for sustainable exploitation and conservation of this important fish species.

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LITERATURE CITED

Abdul, W.O., I.T. Omoniyi, E.O. Adekoya, O.S. Daniel and O.S. Olowe. 2015. Some stock parameters of *Elops lacerta* during estuarine phase of life history. **Ife Journal of Science** 17(2): 323–334.

Abdussamad, E.M., P.N.R. Nair and P. Achayya. 2006. The ribbonfish fishery and stock assessment of *Trichiurus lepturus* Linnaeus off Kakinada, east coast of India. **Journal of the Marine Biological Association of India** 48(2006): 41–45.

Afonso-Dias, I., C. Reis and P. Andrade. 2005. Reproductive aspects of *Microchirus azevia* (Risso, 1810) (Pisces: Soleidae) from the south coast of Portugal. **Scientia Marina** 69: 275–283.

Akpaniteaku, R.C, M. Weimin and Y. Xinhua. 2005. Evaluation of the contribution of fisheries and aquaculture to food security in developing countries. **NAGA.** 28: 28–32.

Al-Nahdi, A., A. Al-Marzouqi, E. Al-Rasadi and J.C. Groeneveld. 2009. The size composition, reproductive biology, age and growth of largehead cutlassfish *Trichiurus lepturus* Linnaeus from the Arabian Sea coast of Oman. **Indian Journal of Fisheries** 56: 73–79.

Ama-Abasi, D.E. 2002. **Aspects of population biology of bonga, *Ethmalosa fimbriata* (Bowdich, 1825) (Clupeidae) in Cross River Estuary, Nigeria.** Ph.D. thesis, University of Calabar, Calabar. 179 pp.

Ayansanwo, T.O. 2003. **Fisheries development in Nigeria with special reference to Ogun State.** OGADEP, Idi-Aba, Abeokuta. 30 pp.

Bagenal, T.B. 1978. **Aspects of fish fecundity.** In: Methods of assessment of ecology of freshwater fish production (ed. S.D. Gerking), pp. 75–101. Blackwell Scientific Publication, Oxford, UK.

Bittar, V.T. and A.P.M. Di-Beneditto. 2009. Diet and potential feeding overlap between *Trichiurus lepturus* (Osteichthyes: Perciformes) and *Pontoporia blainvillei* (Mammilia: Cetacea) in northern Rio de Janeiro, Brazil. **Zoologia** 26: 374–378.

Brewton, R.A., B. Matthew, J. Ajemian, C. Peter, Y. Gregory and W. Stunz. 2016. Feeding ecology of dolphinfish in the Western Gulf of Mexico. **Transactions of the American Fisheries Society** 145(4): 839–853.

Chiou, D., C.Y. Chen, C.M. Wang and C.T. Chen. 2006. Food and feeding habits of ribbonfish *Trichiurus lepturus* in coastal waters of south-western Taiwan. **Fisheries Science** 72: 373–381.

Clark, C.W. 2006. **The worldwide crisis in fisheries.** Cambridge University Press. Cambridge, UK. 217 pp.

Dudgeon, D., A.H. Arthington, M.O. Gessner, Z.I. Kawabata, D.J. Knowler, C. Leveque, R.J. Naiman, A.H. Prier-Richard, D. Soto and M.J. Stiassny. 2006. Freshwater diversity: importance, threats, status and conservation challenges. **Biological Review** 81: 163–182.

Ekanem, S.B., A. Marilyn-Joan. and M.M. Ekere. 2004. Studies on some reproductive aspects of *Pseudotolithus elongatus* in the Cross River estuary, Nigeria. **Scientia Marina** 68(2): 265–271.

Food and Agriculture Organization of the United Nation (FAO). 2010. **Ecosystem approach to aquaculture.** FAO technical guidelines for responsible fisheries No. 5, Suppl. 4. Rome. 53 pp.

Ghosh, S., M.V. Hanumantha Rao, P. Rohit, K. Rammohan and G. Maheswarudu. 2014. Reproductive biology, trophodynamics and stock structure of ribbonfish *Trichiurus lepturus* from northern Arabian Sea and northern Bay of Bengal. **Indian Journal of Geo-marine Science** 43(5): 755–771.

Hyslop, E.P. 1980. Stomach content analysis: a review of methods and their application. **Journal of Fish Biology** 17: 41–429.

Jamu, D.M and A.O. Ayinla. 2003. Potential for the development of agriculture in Africa. **NAGA** 26(3): 9–13

Karr, D., A.V. Nagarthana, T.V. Ramachandra and S.C. Dey. 2006. Fish diversity and conservation aspects in an aquatic ecosystem in north eastern India. **Zoos' Print Journal** 21: 2308–2315.

Le Cren, E.D. 1951. The length-weight relationship and seasonal cycle in gonad weight and condition in the perch *Perca fluviatilis*. **Journal of Animal Ecology** 20(2): 201–219.

Martins, A.S. and M. Haimovici. 2000. Reproduction of the cutlassfish *Trichiurus lepturus* in the southern Brazil subtropical convergence ecosystem. **Scientia Marina** 64: 97–105.

Morato, T., P. Afanso and P. Lourhino. 2001. Length-weight relationship for 21 coastal fish species of the Azores, North Eastern Atlantic. **Fisheries Research** 50 (3): 297–302.

Munro, J.L. and D. Pauly. 1983. A simple method for comparing the growth of fishes and invertebrates. **ICLARM Fishbyte** 1(1): 5–6.

National Population Commission (NPC). 2006. **Nigeria national census: population distribution by sex, state, LGAs and senatorial district abuja: 2006 Census priority tables (vol. 3).** https://scholar.google.com/scholar_lookup?title=Population+distribution+by+sex,+state,+LGAs+and+senatorial+districts:2006+census+priority+tables&publication_year=2006&. Cited 7 Jan 2019.

Nunoo, F.K., E.E. Sossoukpe, A. Adite and F.D. Fiogbe. 2013. Food habits of two species of *Pseudotolithus* (sciaenidae) off benin (west africa) nearshore waters and implications for management. International **Journal for Fisheries and Aquaculture** 5(6): 142–151.

Odulate, D.O. 2010. **Diversity and growth parameters of fish population in a part of Gulf of Guinea in Ogun State, Nigeria.** Ph.D thesis, Federal University of Agriculture, Abeokuta. 136 pp.

Odulate, D.O., F.O.A. George and A.A. Idowu. 2012. Role of women in fisheries in coastal wetland areas of Ogun State, Southwest Nigeria. **Journal of Agricultural Science and Environment** 12(1): 74–82

Offem, B.O., Y. Akegbejo-Samsons and I.T. Omoniyi. 2008. Reproductive aspects of common freshwater fishes in the Cross River, Nigeria. **Journal of Animal and Plant Sciences** 18(4): 130–138.

Ojelade, O.C., I. Abdulraheem, D.O. Odulate, F.I. Adeosun, M.I. Akaeze and A.K. Sanusi. 2016. Ecological assessment of fish biodiversity in relation to hydrological variables in Ogun coastal water, Ogun State, Nigeria. **Journal of Aquatic Sciences** 31: 129–141.

Olopade, A. 2001. **Biodiversity and conservation of marine fish beels of the coastal wetlands of Ogun State, Nigeria.** Ph.D Thesis, University of Ibadan, Ibadan. 205 pp.

Olukolajo, S.O. and K.A. Oluwaseun. 2008. Seasonal variation in the distribution and fish species diversity of a tropical lagoon in South-West Nigeria. **Journal of Fisheries and Aquatic Science** 3: 375–383.

Oluwalana. 1997. An economic Analysis of the existing teak and Gmelina plantation in Ogun state, Nigeria. **The Nigerian Journal of Forestry** 27(3): 40–47.

Pauly, D. 1980. **A selection of simple methods for the assessment of tropical fish stocks.** FAO Fisheries Technical Paper No. 234. 54 pp.

Pauly, D. and N. David. 1981. ELEFAN I, a BASIC program for the objective extraction of growth parameters from length frequency data. **Meeresforsch** 28(4): 205–211.

Pauly, D. and J.L. Munro. 1984. Once more on growth comparisons in fishes and invertebrates. **ICLARM Fishbytes** 2(1): 20–21.

Paul, M., S. Hajisamae, S. Pradit, P. Perngmark and R. Islam. 2018. Trophic ecology of eight sympatric nemipterid fishes (Nemipteridae) in the lower part of the South China Sea. **Turkish Journal of Fisheries and Aquatic Sciences** 18: 277–287

Sparre, P. and S.C. Venema. 1992. **Introduction to tropical fish stock assessment.** Part 1 manual. FAO Fisheries Technical Paper No 306 (1), Rev. 1. FAO, Rome. 376 pp.

Udo, M.T., G.P. Ayua1, M.M. Akpan, S.I. Umana and A.I. Isangedighi. 2014. Abundance, condition factor, food and feeding habits of the solefish *Cynoglossus senegalensis* in the cross river estuary, Nigeria. **Nigerian Journal of Agriculture, Food and Environment** 10(3): 43–48

Ugwumba, A.A. and O.A. Ugwumba. 2007. **Food and feeding ecology of fishes in Nigeria.** Jodetan Ventures. Ibadan. 70 pp.

United Nations. 2004. **Global action for women towards sustainable and equitable development.** http://www.un-documents.net/a21-24.htm. Cited 7 Jan 2019.

Von Bertalanffy, L. 1938. A quantitative theory of organic growth (inquiries on growth laws. II). **Human Biology** 10: 181–213.

Yan, Y., J. Chen, H. Lu, G. Hou and J. Lai. 2012. Feeding habits and ontogenetic diet shifts of hairtail *Trichiurus margarites*, in the Beibu Gulf of the south China Sea. **Acta Ecologica Sinica** 32(1): 18–25.

Yeldan, H. and O. Avsar. 2000. A preliminary study on the reproduction of the rabbit fish *Siganus rivulatus* (Forsskal. 1775) in the north eastern Mediterranean. **Turkish Journal of Zoology** 24: 173–182.

Zar, J.H. 1999. **Biostatistical analysis,** 4th Edition. Prentice–Hall, Englewood Cliffs, New Jersey. 662 pp.