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Morphometry and Natural Diets of *Distichodus engycephalus* from Middle Basin of Ogun River, Southwest Nigeria

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ABSTRACT

Morphometry, natural diets, length-weight parameters and condition factor of *Distichodus engycephalus* in middle basin of River Ogun, Southwest Nigeria were investigated. One hundred and fourteen fish were sampled; consisting of eighty-seven males and twenty-seven females. Stomach contents were analyzed, morphometric and meristic characters were also measured. The analyses of data were based on sexes and combined population using descriptive, regression and correlation statistics. Student t-test was employed to detect significant difference (α=0.05) between the mean characters of the sexes. Results showed that *D. engycephalus* is an herbivore; feeding mostly on *Oscillatoria* (45.6%), *Microspora* (43.9%) and *Protococcus* (43.9) by occurrence method. Numerically, the diets composed of *Oscillatoria* (40.0%), *Phormidium* (18.3%) and *Microcystis* (10.3%). The mean total length, weight and condition factor for both sexes were 24.9±0.64 cm, 204.6±16.02 g and 1.09±0.01, respectively. Student t-test statistics revealed that means of the investigated characters were significantly higher ($p<0.05$) in female fish except depth of caudal peduncle (DCP) and number of pelvic rays (PVR). However, no significant difference ($p>0.05$) was detected in the condition factor between the sexes. Observed sex ratio for male: female fish was 1:0.31. The 'b' values of length-weight relationship analysis were 2.90 for male, 2.97 (female) and 0.92 (both sexes) which were not significantly different ($p>0.05$) from 3; indicating isometric growth pattern. Conclusively, *D. engycephalus* in the middle basin of Ogun River is herbivorous and grows isometrically.

Keywords: Characters, combined sexes, growth, herbivorous, isometry, total length

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INTRODUCTION

The decline in inland fish production can be attributed to over-fishing, climate change, lack of management of water bodies and anthropogenic effects such as pollution. To meet the fish demand of the human population, there is need to carry out research on the diets of various wild fish species in order to increase the culturable species through aquaculture. The knowledge of natural diets of fish is important in understanding the growth of the fish in the natural environment and aquaculture. Food studies of fish provides insight into trophic relationship and interactions among species in the aquatic ecosystem. Fish diets influence its growth, well-being, fecundity and migration (Adeyemi et al., 2009). In ecological research, knowledge of diet compositions is essential as it reveals the source of the animal's food on which it depends for growth and development (Ahlbeck et al., 2012).

One of the most commonly used analyses of fisheries data is length-weight relationship (Mendes et al., 2004). Length-weight relationship is often used to estimate weight from length (Sinovcic et al., 2004). Like any other morphometric characters, it can be used for the differentiation of taxonomic unit and the relationship changes with various developmental stages in life (Thomas et al., 2003). It is important in assessing the relative well-being of a fish population (Bolger & Connoly, 1989). Moutopoulos and Stergiou (2002) noted that length-weight relationship was important in estimating population size of a fish stock and growth pattern in fisheries management for rational exploitation and comparative growth studies. It can also be used to determine possible differences between separate unit stocks of the same species (King, 2007). Also, Kulbick et al. (2005) stressed the importance of the length-weight relationship in modelling aquatic ecosystem.

Distichodus engycephalus was observed to be one of the commercially important fish species, especially during the dry season, in Ogun River. *Distichodus engycephalus* is cherished by consumers and has good taste. *Distichodus* is genus in the family Distichodontidae and it is indigenous to tropical Africa (Arawomo, 1982). Among others, Teugels et al. (1992) reported *Distichodus* species as major exploitable fish species and widely distributed in Nigeria, Niger, Sudan, Volta, Chad and Nile basins. Three species, *Distichodus brevipinnis, D. engycephalus* and *D. rostratus*, are common in Nigerian inland waters. Few literature on the length-weight relationship, condition factor and its biology have been published by Berte et al. (2008) and Shinkafi et al. (2013). However, there is paucity of information on its natural diets and morphometry and no study has been published on this fish species in Ogun River.

MATERIALS AND METHODS

Description of Study Area

Ogun River has coordinates of 3º 28′ E and 8º 41′ N from its source in Oyo State to 3º 25′ E and 6º 35′ N in Lagos where it enters the Lagos Lagoon (Ayoade et al., 2004) and a total surface area of 22.4 km^2 (Oketola et al., 2006) as shown in Figure 1. Two seasons are experienced along the drainage basin of Ogun River, the wet season (April - October) and dry season (November - March). Rocky drainage basin is the major characteristic of the middle basin of Ogun River which is very obvious during the dry season when the water level is low.

Collection of Fish Samples

Samples of *D. engycephalus* were collected every month from December 2015 to May 2016 from artisanal fishermen operating in the middle basin of Ogun River using unselective fishing gears such as cast nets, traps and set gillnets of different mesh sizes. The fish samples were transported immediately to the laboratory for analysis in boxes containing ice cubes.

Laboratory Procedures

In the laboratory, meristic and morphometric measurements were taken and recorded. Individual fish was weighed to the nearest 0.1g using top loading scale (Camry, model: EK5350). The morphometric characters measured were standard length (SL), forked length (FL), total length (TL) and body depth (BD) to the nearest 0.1 cm with the use of a measuring board. Others measurements were eye diameter (EYD), body width (BWD), snout length (SNL), head length (HLT), length of dorsal fin base (LBD), length of anal fin base (LAB), length of base of adipose fin (BAD), length of pelvic fin (LPVF) and length of pectoral fin (LPF) using digital venier calliper to the nearest 0.1 mm. Meristic characters investigated were total number of dorsal spines (DOS),

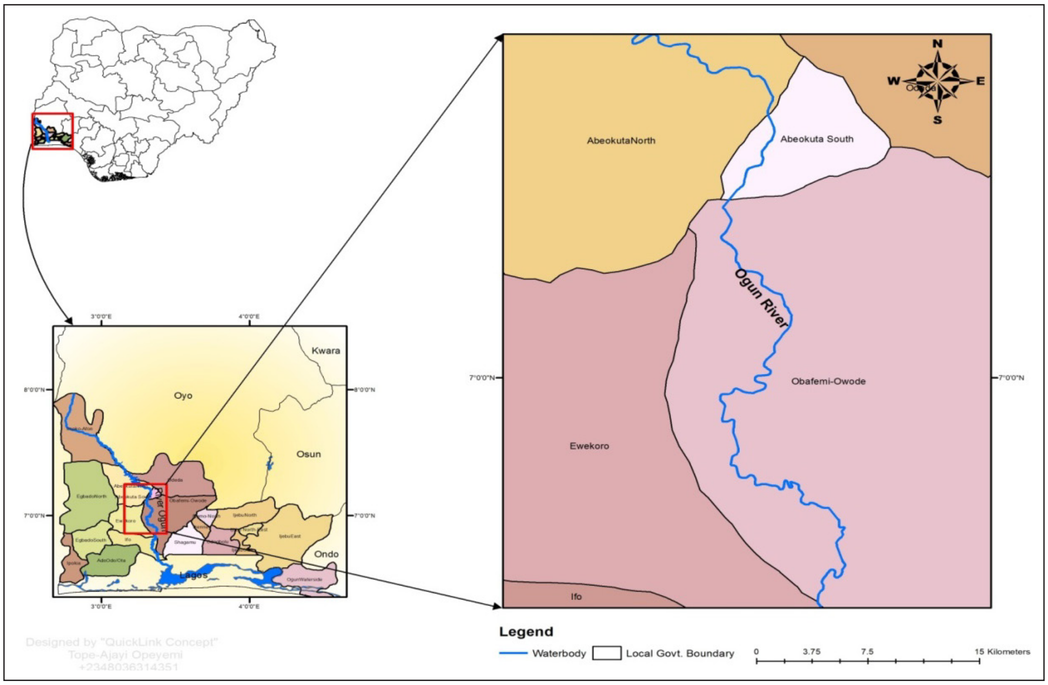

Figure 1. Map of Ogun River, Southwest Nigeria

dorsal rays (DRA), pelvic spines (PEVS), pelvic rays (PVR), pectoral spines (PECS), pectoral rays (PRA), anal spines (ANS) and anal rays (ARA). Individual fish was dissected to examine the sex.

Stomach Content Analysis

The degree of fullness were examined and reported as one-quarter (1/4), half (1/2), three-quarter (3/4) and one (1) for one-quarter, half, three-quarter and full stomach respectively. Each stomach was preserved with 4% neutral formalin separately in a labelled specimen bottle. Stomach wall was cut open longitudinally and contents were washed into the petri dish. The contents were analysed using frequency of occurrence and numerical methods according to Chipps and Garvey (2002).

Statistical Analyses

Descriptive and inferential statistics were used for the analysis. Graphs and tables were used to depict the results of the stomach contents. Scatter diagrams was employed to examine the length-weight relationship. Detected outliers were removed according to Froese (2006). Length-weight relationship parameters (a and b) were estimated by linear regression using logarithmic equation:

$$\log W = \log a + b \log L \quad \text{(Sparre \& Venema, 1992; Zar, 1984)} \qquad [1]$$

where W= weight (g), L = total length (cm), a = y-intercept (constant), b = slope of the graph. The length-weight relationship data were analyzed for male, female and both sexes. The b-values for male, female and combined sexes were tested if they were significantly different from 3 which is the isometric growth (Sokal & Rohlf, 1998). A one-way analysis of covariance (ANCOVA) was conducted to compare the regression slopes of the sexes whilst controlling for the effect of total length. The logarithm transformations of weight and total length were used in this wise. Levene's test and normality checks were carried out and the assumptions met. The condition factors (K) for male, female and combined sexes were calculated using the formula:

$$K = 100 \times [W/(L^3)] \qquad [2]$$

according to Bagenal and Tesch (1978), where K = condition factor, W = weight (g), L = total length (cm). Student t-test was used to test the null hypothesis (H_o) that the means of the investigated parameters of male and female fish are homogeneous ($\alpha = 0.05$). Correlation statistics was used to reveal the relationship among the investigated morphometric characters.

RESULTS AND DISCUSSION

In the study, a total of one hundred and fourteen (114) specimens were sampled consisting of eighty-seven males and twenty-seven females. The degree of stomach fullness ranged from 9% (empty) to 39% (full stomach) as shown in Figure 2. *Oscillatoria* (45.6%), *Protococcus* (43.9%), *Microspora* (43.9%) and *Nitzschia* (30.7%) were dominant natural diets by occurrence while the least comprised *Chroccocus*, *Asterocystis*, *Oocystis*, *Pinnularia*, *Docidium*, *Hydrodictyon*, *Scenedesmus*, *Coelosphaerium* with one percent each. This method depicts how often a particular food item was consumed but provides no information on the relative importance of the food to the overall diet. Numerical analysis showed that main diets were *Oscillatoria* (39.0%), *Phormidium* (18.3%) and *Microcystis* (10.3%) as depicted in Table 1. Figure 3 shows the categories of natural diets consumed by *D. engycephalus* in the middle basin of Ogun River, Nigeria. The main food category by occurrence was Chlorophyceae (47%), followed by Baccillariophyceae (18%) and Myxophyceae (13%) while numerical method revealed Myxophyceae (69%), Chlorophyceae (15%) and Bacillariophyceae (9%) as most preferred diets (Figure 4). Diets analysis showed that *D. engycephalus* in Ogun River is herbivorous; occupying low trophic level converting low energy substances to higher ones in the food chain. This observation supported Arawomo (1982) who reported that *D. engycephalus*, *D. brevipinnis* and *D. rostratus*, which were similar species in the same genus, in Kainji Lake were herbivores. Ahlbeck et al. (2012) stated that diet compositions revealed prey-predator relationships and potential competitors which contributed to the understanding of the population dynamics and functioning of ecosystem structure. Stomach contents in fishes reveal the role of the species in the integration and interaction of ecological components in the aquatic system which, among others, enhance ecosystem based management. However, location of sample, time of sampling in the year, characteristics of the habitat are factors that can influence the diet composition.

Total length of the specimens (both sexes) ranged between 12.3 and 40.3 cm with a mean of 24.9±0.64 cm and mean weight (204.6±16.02 g) varied between 26.0 and 791.0 g (Table 2). It was observed that total length and weight of female species of *D. engycephalus* in Ogun River were significantly higher ($p<0.05$) than that of male fish. The maximum total length observed in this study was higher than

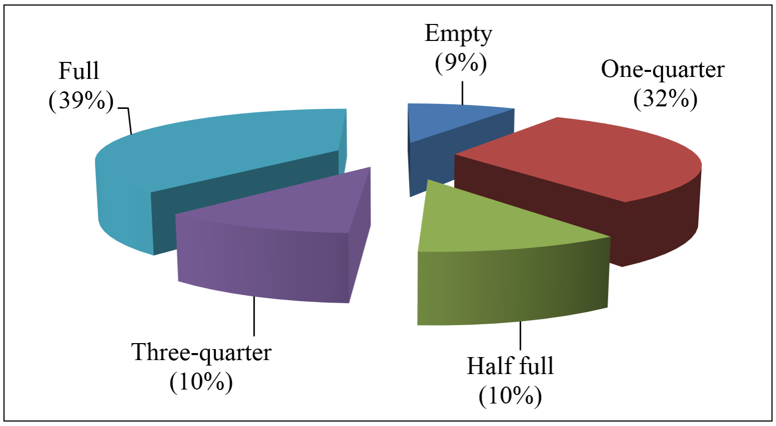

Figure 2. Stomach fullness of *Distichodus engycephalus* from middle basin of Ogun River, Southwest Nigeria

Table 1
Stomach content of Distichodus engycephalus *from middle basin of Ogun River, Southwest Nigeria*

Organism			Percentage	
	Occurrence method	Numeric method	Occurrence	Numeric
Bacillariophyceae	**11**	**27952**	**17.74**	**8.53**
Campylodiscus	6	10	5.263	0.003
Cyclotella	11	86	9.649	0.026
Cymbella	20	20	17.544	0.006
Diatoma	13	13	11.404	0.004
Gomphonema	12	12	10.526	0.004
Gyrosigma	5	2598	4.386	0.793
Navicula	4	4	3.509	0.001
Nitzschia	35	6035	30.702	1.842
Pinnularia	1	1	0.877	0.000
Synedra	15	22	13.158	0.007
Tabellaria	23	19151	20.175	5.846
Chlorophyceae	**29**	**50883**	**46.77**	**15.53**
Ankistrodesmus	3	3	2.632	0.001
Botryoccoccus	3	18	2.632	0.005
Bulbochaeta	4	4	3.509	0.001
Chaetophora	14	425	12.281	0.130
Characium	2	2	1.754	0.001
Chlorella	2	2	1.754	0.001
Cladophora	3	17	2.632	0.005
Closterium	15	161	13.158	0.049
Clucigenia	2	201	1.754	0.061
Coelastrum	5	5	4.386	0.002
Docidium	1	1	0.877	0.0003
Enteromorpha	6	79	5.263	0.024
Genicularia	23	23	20.175	0.007
Gonatozygon	16	3942	14.035	1.203
Hydrodictyon	1	1	0.877	0.000
Kirchneriella	5	380	4.386	0.116
Micrasteria	2	25	1.754	0.008
Microspora	50	14322	43.860	4.372
Mougeotia	2	1704	1.754	0.520
Oocystis	1	2	0.877	0.001
Protococcus	50	24660	43.860	7.528
Scenedesmus	1	1	0.877	0.000
Spirogyra	32	1132	28.070	0.346
Staurastrum	2	2	1.754	0.001
Stigeoclonium	3	11	2.632	0.003
Tetraspora	11	11	9.649	0.003

Table 1 *(continue)*

Organism	Occurrence method	Numeric method	Percentage Occurrence	Percentage Numeric
Ulothrix	2	2	1.754	0.001
Volvox	2	2	1.754	0.001
Zygnema	4	3745	3.509	1.143
Cyanophyceae	**4**	**14943**	**6.45**	**4.56**
Calothrix	2	2	1.754	0.001
Coelosphaerium	1	1	0.877	0.000
Nostoc	2	2	1.412	0.001
Spirulina	11	14938	9.649	4.560
Insecta	**1**	**6**	**1.61**	**0.18**
Insects	6	6	5.263	0.002
Myxophyceae	**8**	**227216**	**12.9**	**69.36**
Anabaena	19	1030	16.667	0.314
Aphanizomenon	2	6	1.754	0.002
Chroococus	1	51	0.877	0.016
Glococapsa	22	4449	19.298	1.358
Mycrocystis	31	33933	27.193	10.358
Oscillatoria	52	127724	45.614	38.988
Phormidium	33	59992	28.947	18.313
Tolypotrix	6	31	5.263	0.009
Rodophycea	**4**	**5063**	**6.45**	**1.55**
Asterocystis	1	20	0.877	0.006
Batrachospermum	4	5028	3.509	1.535
Lamenea	3	8	2.632	0.002
Phorphyridium	3	7	2.632	0.002
Xanthophycae	**2**	**17**	**3.22**	**0.005**
Ophiocytium	3	3	2.632	0.001
Vaucheria	2	14	1.754	0.004
Nematoda	**1**	**184**	**1.61**	**0.06**
Nematode worm	22	184	19.298	0.056
Others	**2**	**1332**	**3.22**	**0.41**
Plant parts	33	1283	28.947	0.392
Fish Scales	16	49	14.035	0.015

those reported for *D. engycephalus* in Anambra River, Nigeria (Nwani & Ude, 2005) and Yapei Stretch of White Volta, Ghana (Abobi, 2015). However, Shinkafi et al. (2013) and Abowei (2010) reported maximum total length of 46.2 cm and 54.0 cm for *D. rostratus* in River Rima and lower Nun River, Nigeria respectively. Mean weight of 218.3 g, 332.0 g and 227.0 g were documented for male *D. engycephalus*, *D. brevipinnis and D. rostratus* and 213.7g, 218.3 g and 23.0 g for female respectively

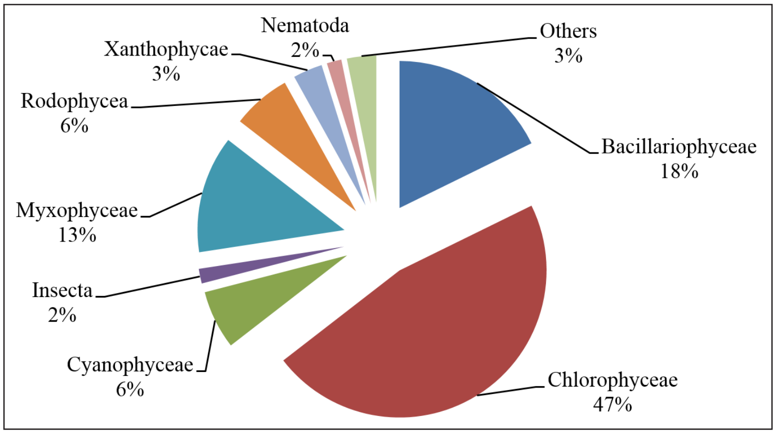

Figure 3. Categories of stomach content (occurrence method) of *Distichodus engycephalus* from middle basin of Ogun River, Southwest Nigeria

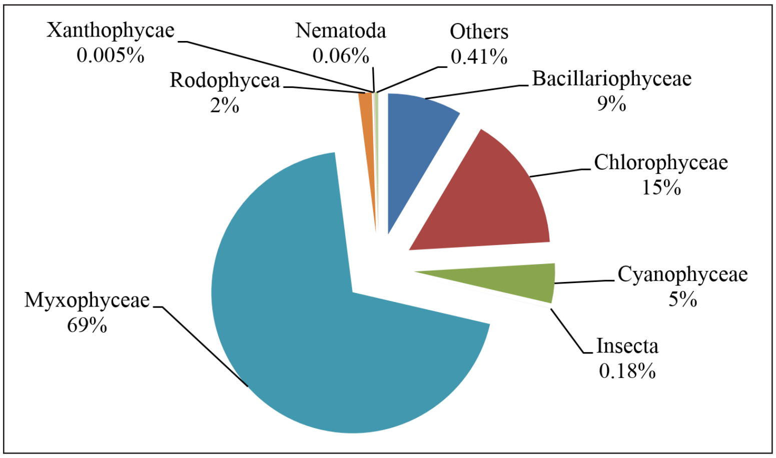

Figure 4. Categories of stomach content (numerical method) of *Distichodus engycephalus* from middle basin of Ogun River, Southwest Nigeria

Table 2
Morphometry of Distichodus engycephalus *from middle basin of Ogun River, Southwest Nigeria*

	Male			Female			Both sexes		
	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean
WT	26.0	722.0	143.8±12.13	67.0	791.0	400.5±34.75	26.0	791.0	204.6±16.02
SL	10.0	32.8	17.9±0.44	14.8	32.8	25.8±0.87	10.0	32.8	19.8±0.50
FL	11.0	33.9	19.3±0.45	15.5	36.2	27.9±1.00	11.0	36.2	21.4±0.54
TL	12.3	39.1	22.5±0.55	18.5	40.3	32.7±1.11	12.3	40.3	24.9±0.64
BD	3.1	10.5	5.8±0.15	4.5	11.2	8.4±0.31	3.1	11.2	6.4±0.17
SNL	4.7	17.9	10.0±0.28	8.4	20.5	15.1±0.53	4.7	20.5	11.2±0.31
EYD	6.6	12.8	9.8±0.12	9.2	15.0	11.3±0.22	6.6	15.0	10.2±0.12
HLT	7.4	63.2	33.4±0.97	32.9	69.0	51.4±1.57	7.4	69.0	37.6±1.10

Table 2 *(continue)*

	Male			Female			Both sexes		
	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean
LBD	24.2	69.4	40.6±0.97	32.9	76.1	59.1±2.08	24.2	76.1	44.9±1.15
LPF	6.3	49.3	28.2±0.98	12.8	54.8	42.0±1.78	6.3	54.8	31.5±1.01
LPVF	19.4	53.7	31.1±0.79	25.6	53.3	44.8±1.48	19.4	53.7	34.3±0.88
LAB	6.3	42.6	19.7±0.70	15.7	44.3	28.7±1.16	6.3	44.3	21.9±0.70
BAD	4.4	21.8	8.8±0.37	5.8	25.2	12.3±0.67	4.4	25.2	9.6±0.35
DCP*	5.7	35.5	17.9±0.65	7.6	39.3	16.9±1.25	5.7	39.3	17.7±0.58
DRA	19.0	24.0		21.0	24.0		19.0	24.0	
PRA	12.0	20.0		10.0	20.0		10.0	20.0	
PVR*	7.0	10.0		9.0	17.0		7.0	17.0	
ARA	5.0	13.0		11.0	13.0		5.0	13.0	
K*	0.87	1.75	1.09±0.01	0.89	1.24	1.06±0.02	0.87	1.75	1.09±0.01

* No significant difference in the values between the sexes at 0.05 level
Legend:
Weight (WT), standard length (SL), forked length (FL), total length (TL), body depth (BD), snout length (SNL), eye diameter (EYD), head length (HLT), length of dorsal fin base (LBD), length of pectoral fin (LPF), length of pelvic fin (LPVF), length of anal fin base (LAB), length of base of adipose fin (BAD), depth of caudal peduncle (DCP), dorsal rays (DRA), pectoral rays (PRA), pelvic rays (PVR), anal rays (ARA) and condition factor (K)

in Anambra River, Nigeria (Nwani & Ude, 2005). Food availability and good water quality are synergist to healthy fish growth and maximum size a fish can attain. Time of sampling, sex and reproductive stage of the sampled fish might also be contributing factors to the differences observed.

The regression coefficients (b-values) obtained in this study depicted that male (2.90), female (2.97) and both sexes (0.92) of *D. engycephalus* had isometric growth since the values were not statistically different from 3 (Figures 5, 6 and 7). High values of co-efficient of determination (R^2) were obtained for male (0.97), female (0.98) and both sexes (0.98). The isometric growth pattern and condition factor reported in this study supported the results of Nwani (2006) on *D. engycephalus* from Anambra River. In similar study, Shinkafi et al. (2013) reported b-values of 2.29 (male), 2.48 (female) and 2.46 (both sexes) for *D. rostratus* in River Rima while in lower Nun River it was 2.76 for both sexes (Abowei, 2010). Result of condition factor ranged from 0.87-1.75 with a mean of 1.09±0.01 for both sexes. The condition factor (K) was not significantly higher (p>0.05) in male than female fish. This result was similar to that reported by Shinkafi et al. (2013) in River Rima. However, lower condition factor (0.98) was documented by Abowei (2010) for *D. rostratus* in lower Nun River. In River Anambra, condition factor for *D. rostratus, D. brevipinnis* and *D. engycephalus* were 1.12, 1.06, and 0.94 respectively (Nwani, 2006). This implied that aquatic ecosystem of Ogun River provided favourable aquatic environment that promoted good well-being of *D.* engycephalus. The observed sex ratio of male: female was 1:0.31 in favour of male production in the river system. Berte et al. (2008) reported sex ratio of 1:1.60 for *D. rostratus* in Bandama River, Ivory Coast.

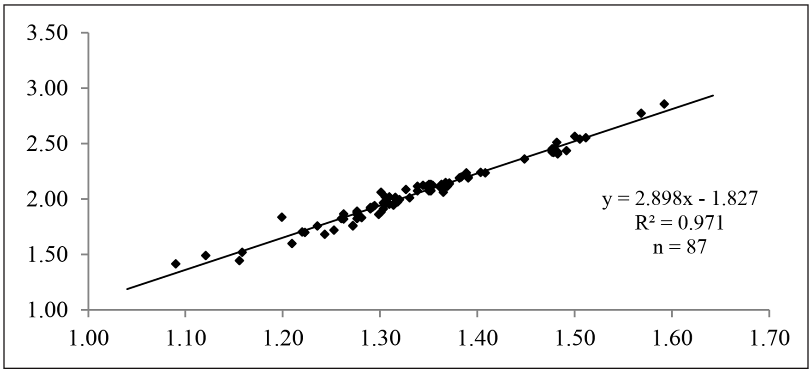

Figure 5. Length-weight relationship of male *Distichodus engycephalus* from middle basin of Ogun River, Southwest Nigeria

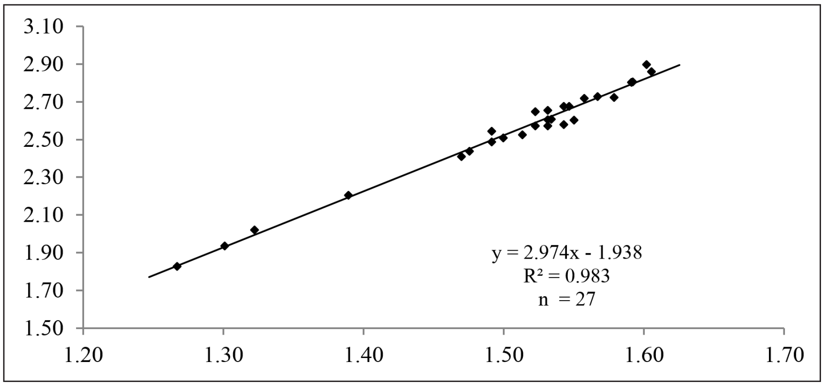

Figure 6. Length-weight relationship of female *Distichodus engycephalus* from middle basin of Ogun River, Southwest Nigeria

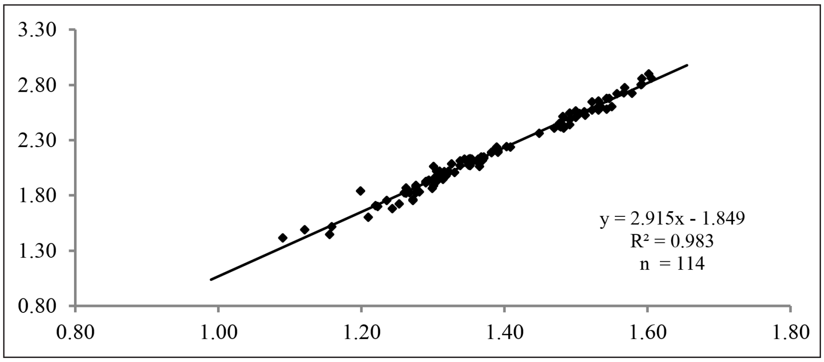

Figure 7. Length-weight relationship of *Distichodus engycephalus* (both sexes) from middle basin of Ogun River, Southwest Nigeria

Results of ANCOVA showed that there was significant difference in regression slopes of the sexes {$F(1, 111) = 0.01$} while adjusting for total length at 0.05 level, hence there is regression homogeneity between the sexes. Significant difference was observed in the investigated characters between male and female fish except in DCP and PVR. Student-test revealed that WT, SL, TL, BD, SNL, EYD, HLT, LDB, LPF, LPVF, LAB, BAD, DRA, PRA and ARA were significantly higher ($p<0.05$) in female than male fish. Countable characters are important in describing fish in that they may vary among and within the same species because they can be influenced by environmental factors especially at early stage of development. High positive correlations were observed in SL/TL (0.99), SL/FL (0.97) and FL/TL (0.98) as shown in Table 3. These results were expected as SL is part of the measurement of FL and TL. However, high correlations existed in TL/LPVF (0.98), SL/LPVF (0.97), SL/LBD (0.97), TL/LBD (0.97) and TL/WT (0.96). Zebe et al. (2010) documented TL/WT of 0.98 for *D. antonii* in Congo River. Least correlation value was obtained in DCP/HLT and DCP/LPF with 0.04 each. Generally, DCP had low relationship with the morphometric characters. The highest value (0.40) was observed in DCP/EYD.

Table 3
Correlation matrix of Distichodus engycephalus *from middle basin of Ogun River, Southwest Nigeria*

	WT	SL	FL	TL	BD	SNL	EYD	HLT	LDB	LPF	LPVF	LAB	BAD	DCP
WT	1													
SL	0.96	1												
FL	0.95	0.97	1											
TL	0.96	0.99	0.98	1										
BD	0.94	0.95	0.95	0.96	1									
SNL	0.90	0.93	0.92	0.94	0.90	1								
EYD	0.76	0.81	0.81	0.82	0.81	0.77	1							
HLT	0.90	0.92	0.93	0.92	0.88	0.91	0.75	1						
LBD	0.94	0.97	0.96	0.97	0.94	0.93	0.82	0.91	1					
LPF	0.77	0.74	0.82	0.79	0.77	0.77	0.63	0.80	0.78	1				
LPVF	0.94	0.97	0.95	0.98	0.94	0.93	0.79	0.92	0.96	0.80	1			
LAB	0.82	0.89	0.80	0.85	0.82	0.80	0.71	0.77	0.82	0.44	0.84	1		
BAD	0.62	0.71	0.59	0.66	0.60	0.59	0.53	0.56	0.63	0.13	0.63	0.86	1	
DCP	0.28	0.32	0.28	0.31	0.35	0.14	0.40	0.04	0.31	0.04	0.26	0.36	0.38	1

Weight (WT), standard length (SL), forked length (FL), total length (TL), body depth (BD), snout length (SNL), eye diameter (EYD), head length (HLT), length of dorsal fin base (LBD), length of pectoral fin (LPF), length of pelvic fin (LPVF), length of anal fin base (LAB), length of base of adipose fin (BAD) and depth of caudal peduncle (DCP)

CONCLUSION

It can be concluded that *D. engycephalus* in the middle basin of Ogun River is herbivorous, feeding mainly on Oscillatoria, Protococcus and Phormidium. The fish (male, female and both sexes) depicted isomerism in their growth pattern in the river system. The lotic environment of the river supported better growth performance of female fish. There were morphological differences between male and female fish which could be used to sex them, since they do not possess external reproductive features to differentiate the sexes. The study provides essential information needed for further studies on population dynamics and management of this fish species in aquatic ecological environments to ensure sustainable fish production.

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