

ASPECT OF BIOLOGY OF *Chrysichthys nigrodigitatus* (Lacepede 1802) FROM EPE, LAGOS, AND BADAGRY LAGOONS, SOUTH-WEST NIGERIA.

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Abstract

The morphometric characteristics, length-weight relationship, condition factor, and diet composition of *Chrysichthys nigrodigitatus* from the Badagry, Epe, and Lagos Lagoons were studied from November 2017 to April 2018. The chemical parameters of Epe, Badagry, and Lagos Lagoons showed that pH was 6.60 ± 1.04 , 6.68 ± 0.60 , and 6.85 ± 0.19 respectively, and salinity was 1.66 ± 2.80 ‰, 0.68 ± 0.12 ‰, and 2.72 ± 2.60 ‰ respectively. Total lengths of *Chrysichthys nigrodigitatus* obtained from Epe, Badagry, and Lagos lagoons were 23.7 ± 4.3 cm, 22.7 ± 18.6 cm, and 24.8 ± 4.8 cm respectively. Some morphometric parameters tested against total length revealed a strong positive correlation, except the mouth gape that showed weak positive correlations. The length-weight relationships of *Chrysichthys nigrodigitatus* from the lagoons showed negative allometric growth. The condition factor (K) of the combined sexes of the *Chrysichthys nigrodigitatus* from Epe, Badagry, and Lagos Lagoons was 0.76 ± 0.18 , 0.77 ± 0.18 , and 0.69 ± 0.31 respectively. The condition factor of *Chrysichthys nigrodigitatus* from the three lagoons showed that the values were all less than 1. This reflects poor physiological and environmental conditions; it indicates that the fishes are not healthy and does not do well in the waterbodies. The fish stomach content showed that 32%, 4%, and 17% had empty stomachs from Epe, Badagry, and Lagos lagoons respectively. Items identified from the fish gut from the Lagoons include molluscs, sand grain, fish, shrimp, and some unidentified materials. *Chrysichthys nigrodigitatus* from the three Lagoons are omnivorous. Sand grains observed in the fish stomach indicated that the species is a bottom feeder. This study confirmed that *C. nigrodigitatus* can survive in different habitat with different environmental factors include temperature, food, pollutants, population density, sound, light, and parasites.

Keywords: Frequency, stomach, diet, habitats, plankton, fish.

Introduction

Chrysichthys nigrodigitatus (Lacepede 1802) is a common silver-colored African catfish occurring in Nigeria and several West African countries. It is a highly valuable fish species amongst the indigenous African populations (Akinsanya *et al.*, 2007; Esenowo *et al.* 2017). Ajani (2001) reported the species as a carnivore in Lagos Lagoon; *Chrysichthys* species were omnivorous (Dada and Araoye, 2008), while Ogbeibu and Ezeunara (2005) reported these species as bottom-feeding mesopredators Ikpoba River. The species was considered detritivores because it fed on vegetable debris and associated animal communities Ikpoba River. This was observed by Oboh *et al.* (2003) for Jamieson River, Ogbeibu and Ezeunara (2005) for Ikpoba River. Lawal *et al.* (2010) reported *Chrysichthys nigrodigitatus* as an omnivore feeder and that its flexibility in trophic level gave the fish ecological advantage to feed effectively on different categories of diet based on the availability of the food items. Atobatele and Ugwumba (2011) reported the species as general mesopredators. Esenowo *et al.*

(2017) noted that *C. nigrodigitatus* feed on various food items ranging from plant origin to animal materials with dietary preference classified into eight major groups consisting of Crustaceans, fish parts, detritus, plant parts, undefined, Mollusca, insects, and nematodes from Nwaniba River, Southeast Nigeria.

The growth model in fish generally follows the cube law hence the use of Fulton's Condition Factor or the Isometric Factor. The growth exponent $b = 3$ indicates that the body form maintains a constant proportion to length (Weatherly and Gill, 1987) while when $b \geq$ or ≤ 3 shows an allometric growth pattern, which could be positive when b is greater than 3 or negative when b is less than 3. Pauly (1984) reported that a slope value greater than 3 denotes allometric growth while Pauly and Gayanilo (1997) reported that b values may range from 2.5-3.4 for fish species. Yem *et al.* (2007) reported values of $b = 3.29$ and 2.49 for males and females respectively of *C. nigrodigitatus* in Lake Kainji and concluded that males showed positive allometric growth while females of *C. nigrodigitatus* showed negative

allometric growth. Ofori-Danson *et al.* (2002) reported b value of 3.010 for females of *C. nigrodigitatus* from in Lake Volta. Francis and Elewuo (2012) reported b-values of 1.93-2.09 in the New Calabar River that showed negative allometry. Inyang and Ezenwaji (2004) reported isometric growth (3.109 ± 0.281) in the population of *Chrysichthys sp.* found in Agulu Lake. Similarly, Ecoutin *et al.* (2005) recorded b - value of 3.127 in Gambia and concluded that the fish exhibited isometric growth. Konan *et al.* (2007) reported a, b and r as 0.011, 2.899, and 0.938, respectively, that showed isometric growth and a positive correlation between the length and weight of *C. nigrodigitatus*.

Major causes of death for fishes in the wide are fishing by humans and natural mortality caused by environmental

factors including climatic factors like temperature and rainfall. A new thought has been proposed to include assessment of the risk of overfishing and stock collapse (Ama - Abasi and Uyoh, 2020). The list of these risks are sources of uncertainty inter alia, future environmental conditions, Ama – Abasi and Uyoh (2020), and uncertainty in the variability introduced by effects of variable abiotic factors (Caddy and Mahon, 1995). Fish health can be adversely affected by temperature changes, habitat deterioration and aquatic pollution (Skouras *et al.* 2003). Fish species have attracted considerable interest in studies assessing the biological effects of environmental contaminants (Powers 1989). *C. nigrodigitatus* experiences frequent growth fluctuations due to changes in food consumption, environmental variables like temperature, food, pollutants, population density, sound, light, and parasites and spawning conditions. However, environmental degradation, including oil spillages, pollution and destruction of mangrove swamps have had considerable impacts on the breeding and nursery ground of the fish, particularly in Nigeria (Ndome and Udo, 2018).

The study aimed to investigate the aspect of the biology of *Chrysichthys nigrodigitatus* in relation to environmental factors from Epe, Badagry, and Lagos lagoons, south-west, Nigeria.

Materials and methods

Description of study areas

Lagos lagoon in Nigeria is located between longitudes 3°20' and 3°50'W and latitudes 6°24' and 6°36'N. It is the

largest lagoon system on the West African coast, covering 208 km² (Nwankwo and Onitiri, 1991). The lagoon is an open tidal estuary; it is fed in the north by Ogun River, Majidun, Agoyi, and Ogudu creeks. The southern margin is bounded by Five Cowries and Badagry creek and in the east by Lekki and Epe lagoons. Ogun River remains the major source of water to the lagoon, discharging a large volume of water into the lagoon. The lagoon opens into the Atlantic Ocean via Lagos harbour. It is shallow in-depth and in most places; it is little more than 1.5 metres deep. The lagoon is surrounded by marshy ground which is a permanently white mangrove forest.

Badagry Lagoon lies between latitudes 6°22' and 6°42'N; and longitudes 2°42' and 3°42'E (Agboola and Anetekhai, 2008). Epe Lagoon is situated between latitudes 3°50' – 4°10'N and longitudes 5°30' – 5°40'E. The lagoon lies within the rainforest belt of southern Nigeria which experiences two major seasons, the rainy season concentrated between May and November, and the dry season occurring between December and April. The fish landing sites where the fish were collected 6° 25'53.7''N, 2°53'15.5''E; 6°29'48.7''N, 3°23'22.3''E and 6° 34'58.2''N, 3°59'25.6''E for Badagry Lagoon, Lagos Lagoon and Epe Lagoon respectively. The study areas are indicated on the map in Figure 1.

Collection of samples

Fish species were landed at the market by artisanal fishermen (who specifically gave us the location where the fish were caught) using casts nets, drag nets, and set gill nets. Samples of *Chrysichthys nigrodigitatus* were collected from the Makoko market (n=120), Oluwo fish market (Chief market) in Epe area (n=120), and Ojah market in Badagry areas of Lagos state (n=120), between November and April 2018 (6 months). Twenty (20) fish samples were collected monthly from each lagoon for the study. A total of 360 specimens were collected for the study. Samples were stored immediately in an ice- chest after collection and transported to the laboratory for analysis.

Water samples were collected monthly between November and April 2018 at the study stations (Badagry, Lagos, and Lekki Lagoons). Sampling was carried out between 6.30 am and 8.30 am hours on each sampling day. Samples were taken with a Niskin bottle at the depth of 0.5 m below the surface and were taken to the laboratory for chemical analysis. Water pH, salinity, and dissolved oxygen (DO) were measured *in situ* using the HI 9828 pH /ORP/EC/DO multiparameter Instrument (Hanna).

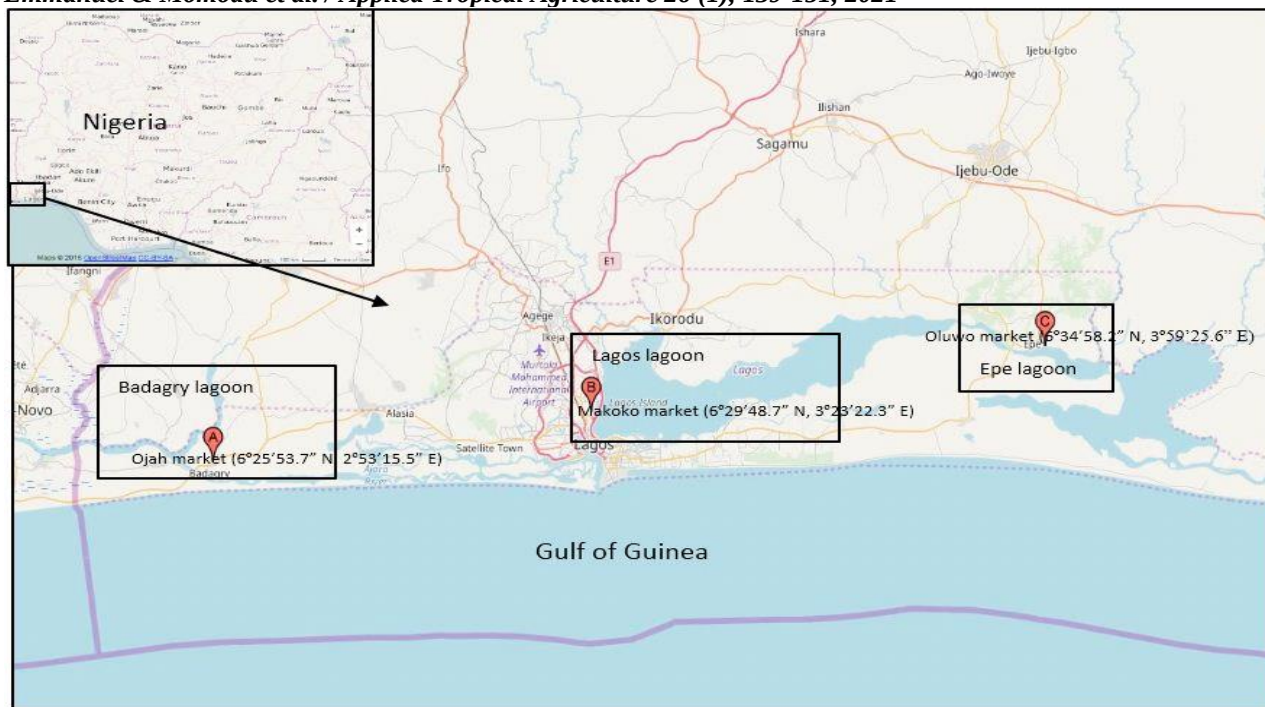


Figure 1: The Study Areas in the Lagos, Epe, and Badagry Lagoons

Laboratory analysis

Identification was carried out using Olaosebikan and Raji (1998). Bodyweight (WGT) was measured with a digital electronic top-loading weighing balance (Camry EK 5055) and recorded to the nearest gram. The standard length (SL), Total length (TL), Fork length (FL), and Head length (HL) were measured in centimeters (cm) using a fish measuring board as described by Olaosebikan and Raji (1998).

Determination of Alkalinity and Hardness of Water

The alkalinity of the water samples was determined by titrating dilute HCl against 50 ml of the water sample using methyl orange as an indicator. Total hardness was determined by titrating the Ca^{2+} and Mg^{2+} present in an aliquot of the sample with Na_2EDTA solution, using $\text{NH}_4\text{Cl-NH}_4\text{OH}$ buffer solution of pH 10 and Eriochrome Black-T as the metal indicator.

Length frequency distribution

The fish were grouped into size classes and the percentage frequency and total length were used for the length-frequency distribution.

Length – Weight Relationship (LWR)

The total length and body weight of fish was used for the Length –Weight Relationship. The L-W relationship was represented by the regression equation described by Pauly (1983).

$$W = aL^b \quad \dots 3$$

Where

W = weight of fish in grams,

L = Total length of fish in centimeter, a = constant / intercept

b = an exponent / gradient.

The above equation (3) and data were transformed into logarithms before the calculations were made. Therefore, equation (3) becomes:

$$\log W = \log a + b \log L \quad \dots 4$$

Stomach Content analysis

Fish stomachs were removed and stored in 70% alcohol. Prey items in stomach contents were sorted under a binocular microscope into their lowest possible taxonomic groups. The state of fullness of each stomach was recorded. Stomach contents analysis was assessed using a combination of Frequency of occurrence (Bowen, 1983) and the numerical method (Lima-Junior and Goitein, 2001). Stomach contents were identified using Mellanby (1979), Jeje, and Fernando (1986).

Frequency of Occurrence Method

This was calculated as reported by (Bowen, 1983)

$$\text{Percentage occurrence of a food item} = \frac{\text{Total number of stomachs with the particular food item}}{\text{Total number of stomachs with food}} \times 100 \quad \dots 1$$

Numerical Method

This was calculated as reported by (Lima-Junior and Goitein, 2001):

$$\text{Percentage number of a food item} = \frac{\text{Total Number of the particular food item}}{\text{Total Number of all food item}} \times 100 \quad \dots 2$$

Condition factor

The condition factor was calculated for males, females, and combined sex as given by (Gomiero and Braga, 2005);

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

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Where K = condition factor, W = the weight of the fish in gram (g), L = the total length of the fish in centimeters (cm).

Statistical analysis

Data generated from this work were subjected to descriptive statistics (mean and standard deviation) and linear regression, using Microsoft Excel, 2016.

RESULTS

Mean chemical parameters of the waters from Epe, Badagry, and Lagos Lagoons.

The pH of the water from Epe, Badagry, and Lagos lagoons showed that Epe lagoon had 6.60 ± 1.04 , Badagry lagoon had 6.68 ± 0.60 , and Lagos lagoons had 6.85 ± 0.19 , total hardness for Epe, Badagry, and Lagos lagoons were 109.33 ± 127.08 mg/l, 70.00 ± 19.18 mg/l, and 452.00 ± 500.19 mg/l respectively, salinity for Epe, Badagry, and Lagos lagoons were 1.66 ± 2.80 ‰, 0.68 ± 0.12 ‰, 2.72 ± 2.60 ‰ respectively, and Dissolved oxygen for Epe, Badagry and Lagos lagoons were 4.46 ± 0.61 mg/l, 4.48 ± 0.50 mg/l, and 3.94 ± 0.34 mg/l respectively. Monthly variation in chemical parameters from Epe, Lagos and Badagry are shown in Figure 2. The mean chemical characteristics of the waters from Epe, Badagry and Lagos lagoons are presented in Table 2.

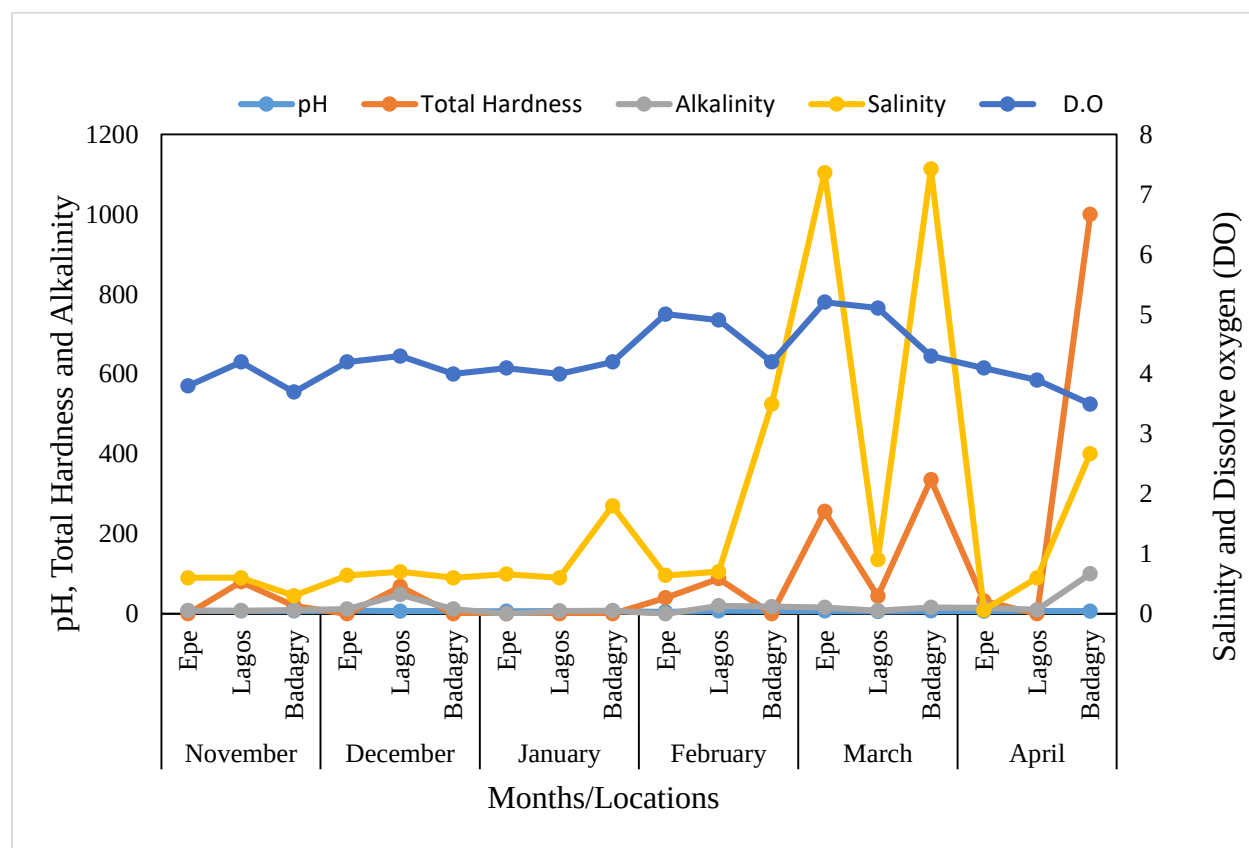


Figure 2: Monthly variation in chemical parameters from Epe, Lagos and Badagry Lagoons

Table 2: Chemical characteristics of the Surface water from Epe, Badagry, and Lagos lagoons

Lagoon		pH	T.H (mg/l)	Salinity (‰)	D.O (mg/l)
Epe lagoon (n=6)	Range	4.80-7.56	32.00-256.00	0.06-7.36	3.80-5.20
	Mean	6.60±1.04	109.33±127.08	1.66±2.80	4.46±0.61
Lagos lagoon (n=6)	Range	5.69-7.49	44.00-88.00	0.60-0.90	3.90-5.10
	Mean	6.68±0.60	70.00±19.18	0.68±0.12	4.48±0.50
Badagry lagoon (n=6)	Range	6.52-7.02	20.00-1000.00	0.30-7.42	3.50-4.30
	Mean	6.85±0.19	452.00±500.19	2.72±2.60	3.94±0.34
Permissible limit (WHO, 2008)		6.5 -8.5	50-150	25 -100	8 - 10
(FEPA, 2003)					

T.H: Total Hardness, D.O: Dissolved Oxygen, n: Number of Months

Length frequency distribution

A total of 120 fish specimens were examined for growth each lagoon studied. The total length ranged from 7.7 to 32.3cm in Epe, 17.0 to 36.5cm in Badagry and 13.5 to 42.9 cm in Lagos Lagoons respectively. In Epe Lagoon, fish in age – group 13.0 to 18.9 (37.5%) had the highest occurrence and lowest occurrence was recorded in age – group 31.0 to 36.9 (8.3%). In

Badagry lagoon, fish in age – group 23.0 to 28.9 (37.5%) had the highest occurrence and lowest occurrence was recorded in 35 - 40.9 (12.5%) age – group. In Lagos Lagoon, fish in age -group 19.0 to 24.9 (33.3%) and the lowest occurrence was recorded in age – group 37.0 to 42.9 (8.3%). Only one age group was recorded in the three lagoons studied (Figures 2 - 4).

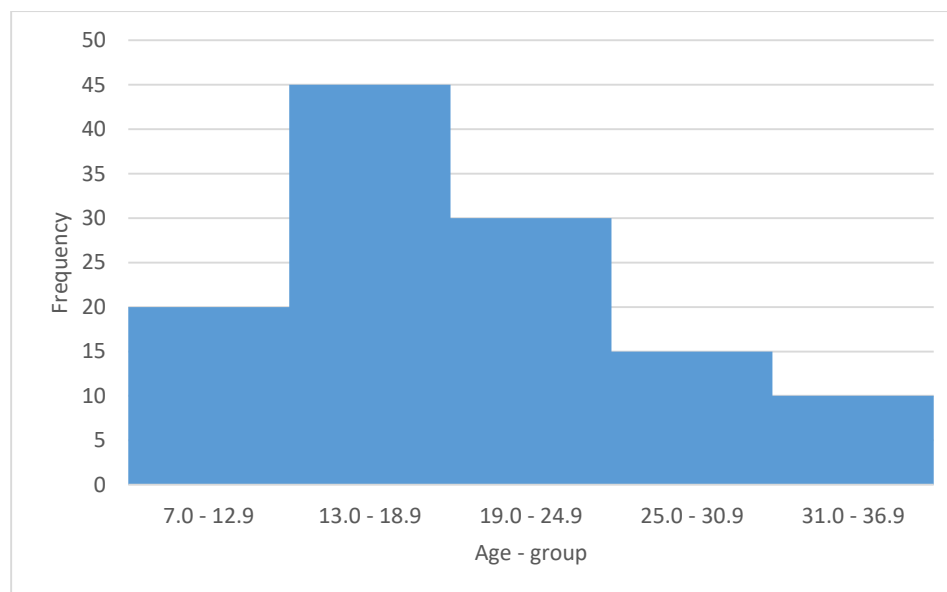


Figure 2: Length – frequency distribution of *Chrysichthys nigrodigitatus* in Epe Lagoon

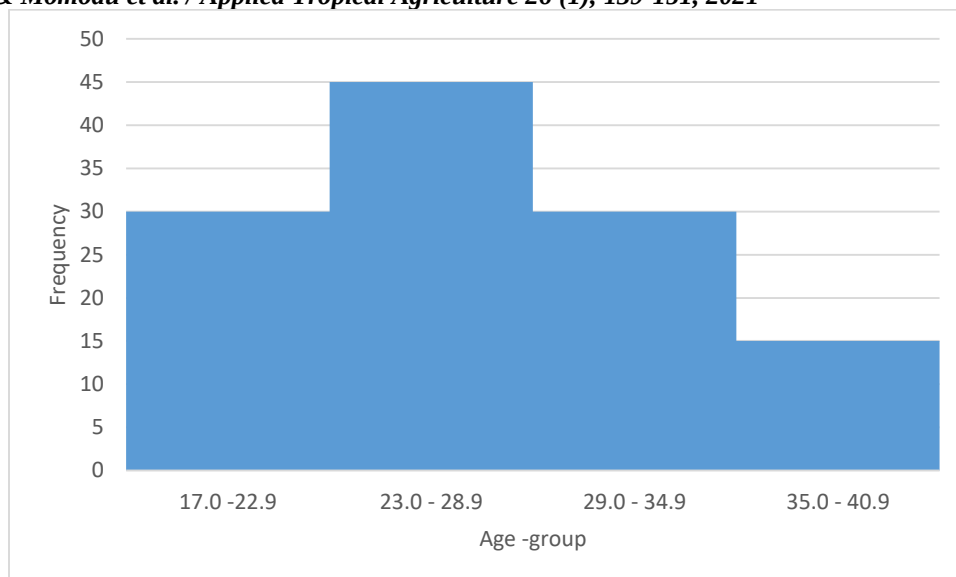


Figure 3: Length – frequency distribution of *Chrysichthys nigrodigitatus* in Badagry Lagoon

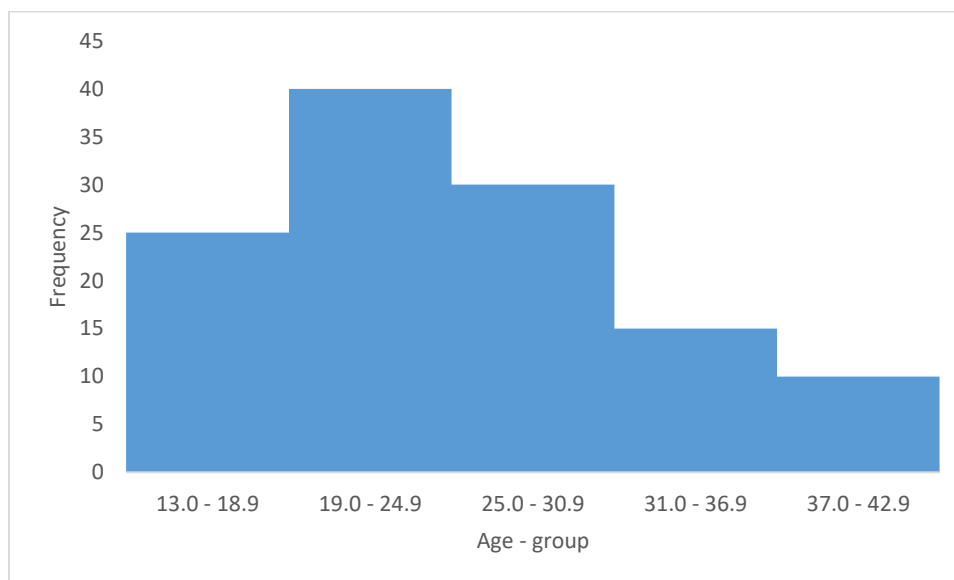


Figure 3: Length – frequency distribution of *Chrysichthys nigrodigitatus* in Lagos Lagoon

MORPHOMETRICS CHARACTERISTICS OF *Chrysichthys nigrodigitatus* FROM EPE, BADAGRY, AND LAGOS LAGOONS.

The total lengths of *Chrysichthys nigrodigitatus* obtained from Epe, Badagry, and Lagos lagoons were

23.7±4.3 cm 22.7±18.6 cm, and 24.8±4.8 respectively, the standard lengths were 17.4±2.9 cm, 16.8±2.2 cm, and 18.1±3.6 cm. The details of the morphological characteristics of *Chrysichthys nigrodigitatus* from Epe, Badagry, and lagoons are presented in Table 3.

Table 3: The morphological characteristics of *Chrysichthys nigrodigitatus* from Epe, Badagry and Lagos lagoons.

Lagoon		TL (cm)	SL (cm)	FL (cm)	MG (cm)	WGT (g)
Epe lagoon (n=120)	Range	7.7-32.3	6.0-22.5	13.5-24.5	1.5-4.0	20.0-230.0
	Mean	23.7±4.3	17.4±2.9	18.9±3.3	2.5±0.5	108.4±55.2
Badagry lagoon (n=120)	Range	17.0-36.5	12.3-23.5	14.2-25.1	1.5-3.5	36.0-197
	Mean	22.7±18.6	16.8±2.2	18.5±2.4	2.4±0.5	92.2±34.9
Lagos lagoon (n=120)	Range	13.5-42.9	10.3-31.0	11.3-34.2	1.3-4.5	26.0-258.0
	Mean	24.8±4.8	18.1±3.6	19.6±3.9	2.4±0.6	107.5±56.3

Note: TL: Total Length, SL: Standard Length, FL: Fork Length, MG: Mouth Gape, WGT: Weight, n: Sample size

Monthly variation in the length of *Chrysichthys nigrodigitatus* from Epe, Badagry, and Lagos Lagoons.

The monthly observation of the lengths of *Chrysichthys nigrodigitatus* from Epe, Badagry, and Lagos lagoons showed that, in Epe Lagoon, the

highest total length was recorded in November (28.6 cm) and the least was recorded in April (19.7 cm). The monthly variation in the length of *Chrysichthys nigrodigitatus* from Epe, Badagry, and Lagos lagoons is presented in Table 4.

Table 4: Monthly variation in the length of *Chrysichthys nigrodigitatus* from Epe, Badagry, and Lagos lagoons.

Lagoon	Statistics	Nov. (n=20)	Dec. (n=20)	Jan. (n=20)	Feb. (n=20)	Mar. (n=20)	Apr. (n=20)
Epe lagoon	Range	25.6-32.3	18.5-29.5	21.5-29.0	18.0-29.5	7.7-31.1	17.5-24.9
	Mean	28.6±1.6	22.6±3.2	25.2±2.4	23.9±3.0	21.9±5.9	19.7±1.6
Badagry lagoon	Range	23.0-36.5	17.0-32.3	20.5-26.5	21.1-29.5	18.2-24.5	17.8-25.8
	Mean	26.4±3.3	20.8±3.9	22.7±1.7	24.4±2.2	20.8±2.1	21.0±2.0
Lagos lagoon	Range	18.5-42.9	13.5-35.7	21.0-35.5	13.5-29.2	19.5-28.5	22.4-30.0
	Mean	24.34±6.6	27.8±5.3	26.0±3.2	20.9±4.1	24.7±3.2	25.2±2.1

The correlation coefficient of the morphometric parameters of *Chrysichthys nigrodigitatus* from Epe, Badagry, and Lagos lagoons.

All parameters tested against total length revealed a strong positive correlation, except the mouth gape

from all the three lagoons that showed weak positive correlations. The coefficient of determination of morphometric parameters *Chrysichthys nigrodigitatus* from Epe, Badagry, and Lagos lagoons is presented in Table 5.

Table 5: Coefficient of determination of morphometric parameters *Chrysichthys nigrodigitatus* from Epe, Badagry and Lagos lagoons

Lagoon	Parameters	Regression Equation	Coefficient of Determination 'r ² '
Epe lagoon	Standard length (Y) on Total length (X)	y=0.7323x+0.2336	0.6239
	Fork length (Y) on Total length (X)	y=0.7258x+0.2783	0.6404
	Mouth Gape (Y) on Total length (X)	y=0.5264x-0.3363	0.2759
	Weight (Y) on Total length (X)	y=2.2477x-1.0936	0.7107
Badagry lagoon	Standard length (Y) on Total length (X)	y=0.8136x+0.1223	0.8125
	Fork length (Y) on Total length (X)	y=0.8409x+0.1355	0.6334
	Mouth Gape (Y) on Total length (X)	y=0.4148x+0.1822	0.1046
	Weight (Y) on Total length (X)	y=2.1914x-1.0264	0.6831
Lagos lagoon	Standard length (Y) on Total length (X)	y=0.9984x-0.1358	0.9187
	Fork length (Y) on Total length (X)	y=0.6829x+0.3525	0.6850
	Mouth Gape (Y) on Total length (X)	y=1.0494x-1.0844	0.1429
	Weight (Y) on Total length (X)	y=2.2026x-1.0838	0.6175

Length-weight relationship of *Chrysichthys nigrodigitatus* from Epe, Badagry, and Lagos lagoons.

The length-weight relationships of *Chrysichthys nigrodigitatus* from Epe, Badagry, and Lagos lagoons showed that the *Chrysichthys nigrodigitatus* from the

three lagoons exhibited a negative allometric growth ($b < 3$) and a strong positive correlation ($r > 0.5$) as shown in Figures 2, 3, and 4 respectively.

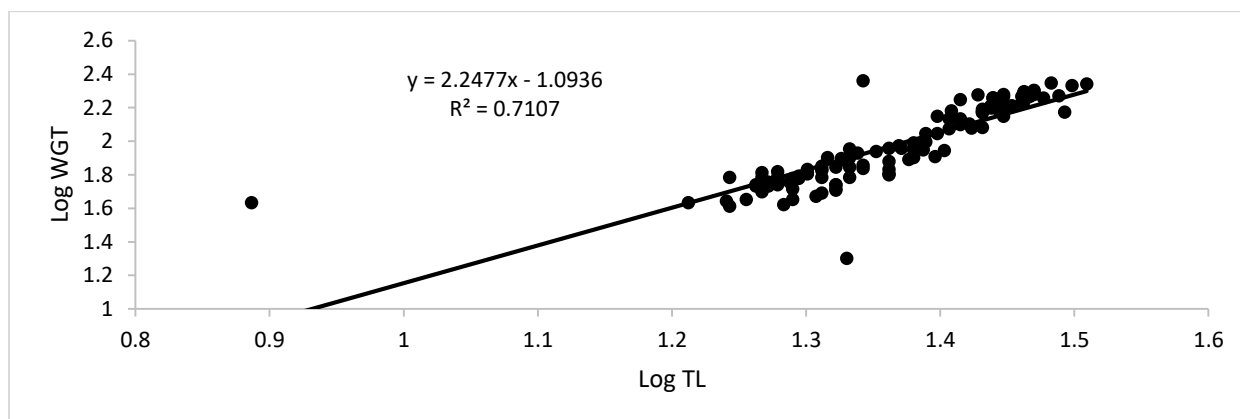


Figure 2: Length-weight relationship of *Chrysichthys nigrodigitatus* from Epe lagoon

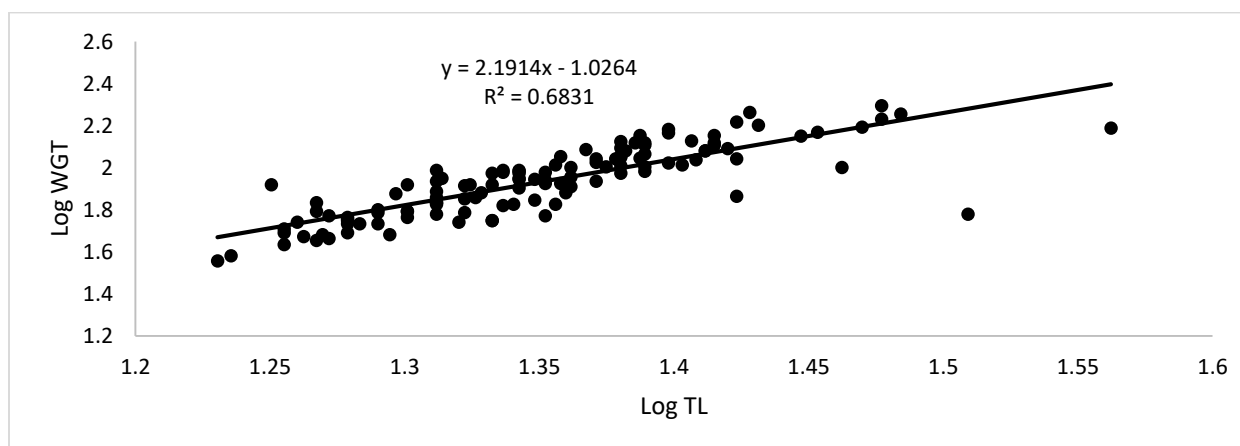


Figure 3: Length-weight relationship of *Chrysichthys nigrodigitatus* from Badagry lagoon

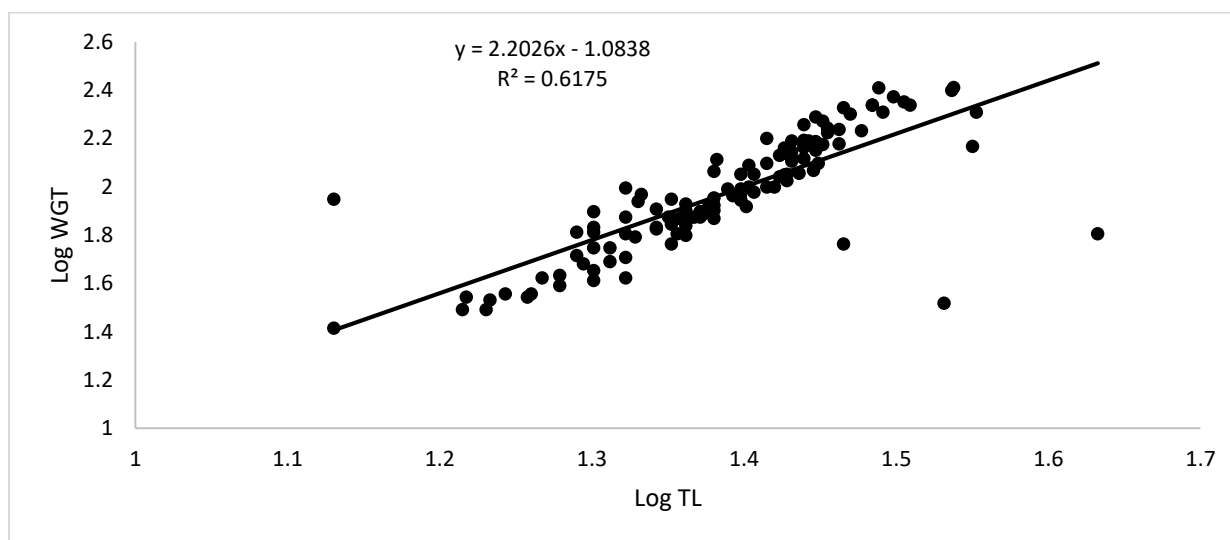


Figure 4: Length-weight relationship of *Chrysichthys nigrodigitatus* from Lagos lagoon

Condition factor of *Chrysichthys nigrodigitatus* from Epe, Badagry, and Lagos lagoons.

The condition factor (k) of the combined, female and male sexes of the *Chrysichthys nigrodigitatus* from Epe, Badagry, and Lagos lagoons showed that Epe lagoon had 0.76 ± 0.18 , 0.78 ± 0.12 , and 0.75 ± 0.21

respectively, Badagry lagoon had 0.77 ± 0.18 , 0.80 ± 0.16 , and 0.76 ± 0.18 , and Lagos lagoon had 0.69 ± 0.31 , 0.66 ± 0.16 , and 0.74 ± 0.46 respectively. Badagry lagoon had the highest condition factor (0.77 ± 0.18) while Lagos lagoon had the least condition factor (0.69 ± 0.31) (Table 6).

Table 6: Condition factor of *Chrysichthys nigrodigitatus* from Epe, Badagry and Lagos lagoons.

Lagoon	Sex	Sample size	Range	Mean
Epe Lagoon	Female	48	0.50-1.14	0.78 ± 0.12
	Male	72	0.20-2.16	0.75 ± 0.21
	Combined	120	0.20-2.16	0.76 ± 0.18
Badagry Lagoon	Female	46	0.41-1.47	0.80 ± 0.16
	Male	74	0.00-1.13	0.76 ± 0.18
	Combined	120	0.00-1.47	0.77 ± 0.18
Lagos Lagoon	Female	75	0.08-1.07	0.66 ± 0.16
	Male	45	0.45-3.62	0.74 ± 0.46
	Combined	120	0.08-3.62	0.69 ± 0.31

Stomach fullness classification of *Chrysichthys nigrodigitatus* from Epe, Badagry, and Lagos lagoons.

Observation of the stomach content of *Chrysichthys nigrodigitatus* from Epe lagoon showed that 32% had an empty stomach, 48% had a quarter-full stomach, 5% had a half-full stomach, 10% had a three-quarter-full stomach, and 5% had a full stomach. For Badagry lagoon, 4% had an empty stomach, 67% had a quarter-full stomach, 13% had a half-full stomach, 7% had a three-quarter-full stomach, and 9% had a full stomach. For Lagos lagoon, 17% had an empty stomach, 49% had a quarter-full stomach, 27% had a half-full stomach, 4% had a three-quarter-full stomach, and 3% had a full stomach. The classification of the fullness of the stomach of *Chrysichthys nigrodigitatus* from Epe, Badagry, and Lagos lagoons are presented in Figures 5, 6, and 7 respectively.

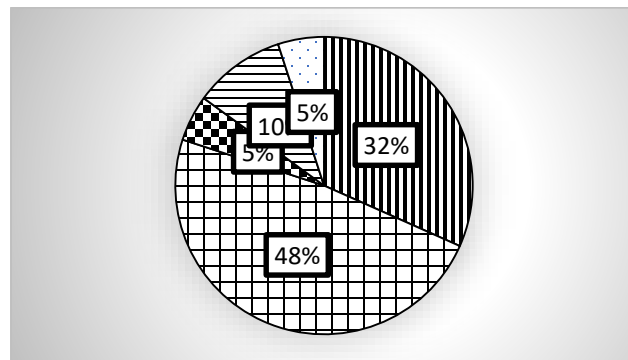


Figure 5: Stomach fullness classification of *Chrysichthys nigrodigitatus* from Epe Lagoon.

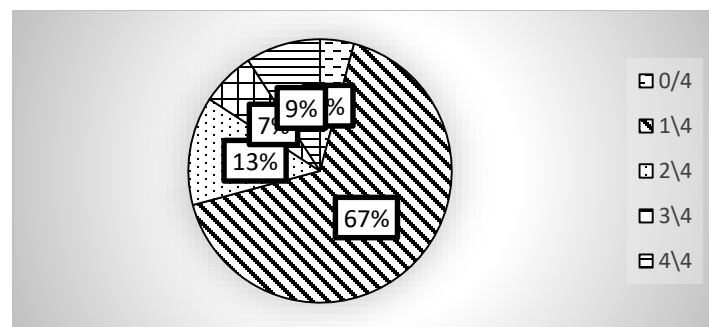


Figure 6: Stomach fullness classification of *Chrysichthys nigrodigitatus* from Badagry Lagoons.

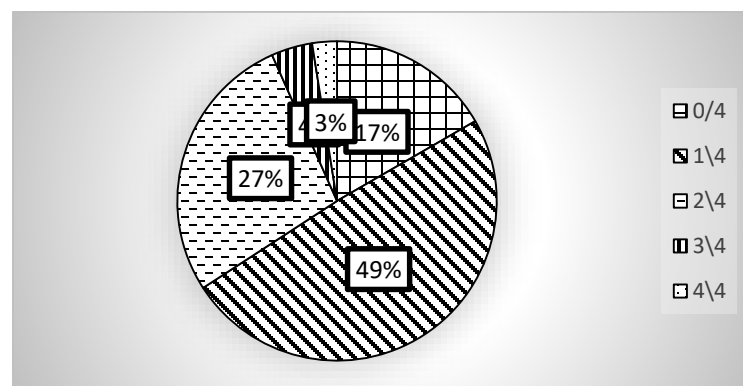


Figure 7: Stomach fullness classification of *Chrysichthys nigrodigitatus* from Lagos Lagoon

Stomach composition of *Chrysichthys nigrodigitatus* from Epe, Badagry, and Lagos Lagoons.

Items identified from the stomach of *Chrysichthys nigrodigitatus* from Epe lagoon include molluscs, sand grain, fish, and some unidentified materials. In

Badagry lagoon, mollusc, sand grain, fish, shrimp, and some unidentified materials were sorted from the stomach of *Chrysichthys nigrodigitatus*, likewise in Lagos lagoon, mollusc, sand grain, fish, shrimp, and some unidentified materials were also sorted from the stomach of *Chrysichthys nigrodigitatus* (Table 7).

Table 7: Stomach composition of *Chrysichthys nigrodigitatus* from Epe, Badagry, and Lagos lagoons.

	Epe lagoon		Badagry lagoon		Lagos lagoon	
	F	N	F	N	F	N
Mollusc	90.24	96.11	92.17	98.12	68.75	96.68
Sand grain	15.85	1.88	5.217	1.06	36.46	1.31
Fish	4.878	0.53	9.56	0.24	7.29	1.92
Shrimp			3.48	0.57	3.12	0.09
Unidentified	17.07		18.26		10.41	
Plankton		Abundance		Abundance		Abundance
<i>Coscinodiscus p.</i>		110500		173750		132750
<i>Bactenastrum sp.</i>		6000		23250		24500
<i>Detonula sp</i>		18250		69500		41750
<i>Eucampia zoodiacus</i>		79750		136750		86000
<i>Licmophora sp</i>		5000		56000		24750
<i>Gleocapsa sp.</i>		2250		5000		4250
<i>Microcystis sp</i>		-		1750		4000
<i>Anabaena circinalis</i>		108000		108000		131250
<i>Rhizosolemia sp</i>		-		15250		10000
<i>Amylax sp</i>		8750		2000		12000
<i>Hemiculars sp</i>		6000		5000		24500
<i>Entomoneis sp.</i>		-		4000		-
<i>Hemialus sp.</i>		6000		3750		11750
<i>Oscilatona sp.</i>		250		6750		-
<i>Asteromphalus sp.</i>		12250		19250		8000
<i>Ceratualima sp</i>		1250		-		3500
<i>Odontella sp.</i>		2250		-		-
<i>Cylindrocera sp</i>		9500		-		-
<i>Skeletonema sp.</i>		500		-		-
<i>Lioloma sp.</i>		-		-		2250

F: Frequency of occurrence N: Numerical abundance

Discussion

The chemical properties of lagoon waters showed that the range of values of pH (6.60 ± 1.04 - 6.85 ± 0.19) and dissolved oxygen (3.94 ± 0.34 - 4.48 ± 0.50) recorded in the three sampling sites were within the range (pH 6.5-9.5 and D.O 3.0-5.0 mg L⁻¹) recommended by the Federal Environmental Protection Agency (FEPA, 2003). However, total hardness (109.33 ± 127.08 and 452.00 ± 500.19 mg/L of Epe lagoon and Badagry lagoon respectively) were above the values (total hardness 0-75 mg L⁻¹) recommended by FEPA (2003). The high values of total hardness recorded may be associated with the dredging activities in the lagoons. Hardness of the aquatic medium increases due to leaching of sedimentary rock, containing sources of divalent cations, such as limestone and gypsum (Boyd 1979). Water hardness has been shown to have a direct effect on the swelling of newly

fertilized eggs, which is speculated as an important process during the early development of the teleost egg (Spade and Bristow, 1999). In general, calcium is of greater importance than magnesium in the management of water for aquaculture as it is required for the water hardening of newly fertilized freshwater fish egg and calcification of larval skeletal structure. Calcium also influences the membrane permeability which is essential for successful embryonic development (Whitaker, 2006). Observations made by Bhatnagar *et al.*, (2004) revealed that a hardness of 75-150 mg l⁻¹ is optimum for pisciculture, over >300 mg l⁻¹ of CaCO₃ is lethal to the fishes and hardness under 20 mg l⁻¹ causes stress to fishes due to unavailability of nutrients in water. So, the higher water hardness values recorded in this study may be danger if it is continuously entering the water body without putting a stop.

Variations in fish size (length-frequency) indicated that the fish population ranged from immature specimens to fully matured ones. Although the population was more of smaller sizes than of adult species. The length frequency distribution of *C. nigrodigitatus* showed that the fish exhibited unimodal distribution in Epe, Badagry and Lagos Lagoons. The frequency distribution study is one of the methods used for determining age of fishes. This method has been successfully used by Fagade and Olaniyan (1972) cited by Emmanuel and Ross (2019) to age the Bonga fish (*Ethmalosa fimbriata*) in which three age groups were reported off the Lagos coast and by Kusemiju (1976) who reported several modes in *Chrysichthys walkeri* in Lekki Lagoon.

The mean total length of *Chrysichthys nigrodigitatus* observed in the three lagoons is between 22-25 cm (23.7±4.3 cm, 22.7±18.6 cm, 24.8±4.8 cm). This is an indication that the species in the lagoons have been over-exploited. Innocent (2008) reported that the mean total length of *Chrysichthys nigrodigitatus* observed in Jebba lake, Nigeria was 30.50±4.58 cm. Francis and Elewuo (2012) who used a trap to catch *Chrysichthys nigrodigitatus* in New Calabar River, Nigeria, stated that a minimum of 18 cm and a maximum of 95 cm was recorded, whereas, in this study, where fish samples were obtained from fishmongers, 25 cm was the highest mean length recorded. The difference could be because of the source of the fish samples. This can also be related to the condition of the fish in the lagoons as the condition factor of the fish in the three lagoons indicated that the fish was not doing well. Monthly variation of the total length of the species from the three lagoons showed that for Epe lagoon, the length had a decreasing order of Nov.>Jan.>Feb.>Dec.>Mar.>Apr., for Badagry lagoon, the decreasing order was Nov.>Feb.>Jan.>Apr.>Dec.=Mar., and for Lagos lagoon, the decreasing order was Dec.>Jan.>Apr.>Mar.> Nov.> Feb. This is an indication that bigger sizes of *Chrysichthys nigrodigitatus* move most in these lagoons in November and December, and could be because of the salinity (less than 1‰) fluctuation property of the lagoon. Olaosebikan and Raji (1998) reported that *Chrysichthys nigrodigitatus* is a freshwater species, therefore, November being an early stage of the dry season might be why bigger sizes of *Chrysichthys nigrodigitatus* were associated with intense rainfall in the month during this study.

The coefficient of determination (r^2) of the relation between the morphometric parameters with the total length of *Chrysichthys nigrodigitatus* from the three lagoons showed that all have a strong positive correlation ($0.5 < x \leq 1$) except for the mouth gape that

showed a weak positive correlation ($0 > x < 0.5$). This is an indication that an increase in total length brings about an increase in standard length, fork length, and weight, but no significant change to the mouth gape. Previous studies have not established these predictive characteristics for various morphometric parameters except for length and weight relationship. Taiwo and Aransiola (2003) also observed a strong positive correlation between the length and weight of both *Chrysichthys nigrodigitatus* and *Chrysichthys walkeri*. It is expected that the same species of same size group in future studies should have very similar characteristics. The wide difference from these facts will suggest that the species are not the same.

The length-weight relationships of *Chrysichthys nigrodigitatus* from Epe, Badagry, and Lagos lagoons showed that the *Chrysichthys nigrodigitatus* from the three lagoons exhibited a negative allometric growth and a strong positive correlation. This implies that the fishes become fatter as they increase in weight (Riedel et al., 2007). This result agrees with the study of Francis and Elewuo (2012) who also reported that *Chrysichthys nigrodigitatus* exhibited a negative allometric growth pattern. Francis and Elewuo (2012) also reported that *Chrysichthys nigrodigitatus* exhibited a strong positive correlation between length and weight.

The condition factor of *Chrysichthys nigrodigitatus* from the three lagoons showed that the values were all less than 1. This reflects poor physiological and environmental conditions; it indicates that the fishes are not healthy and does not faring well in the water. Francis and Elewuo (2012) reported that *Chrysichthys nigrodigitatus* had K values that were greater than 1. The low condition factor observed in this study may be due to the quality of the prey items available to the species in their habitats. According to Bolger and Connolly (1989), condition factor values of 1 and above indicates that the fishes are healthy and fare well in the water, and values of less than 1 did not reflect good physiological and environmental conditions. Condition factor increases with sexual maturity (Thomas et al., 2003).

Observation of the stomach content of the *Chrysichthys nigrodigitatus* showed that in Epe lagoon 32% had empty stomach; in Badagry lagoon, 4% had empty stomach; and in Lagos lagoon, 17% had an empty stomach. This is an indication that the habitats of the species, especially Badagry lagoon, are not devoid of prey items.

Items identified from the gut of *Chrysichthys nigrodigitatus* from Epe, Badagry, and Lagos lagoons include mollusc, sand grain, fish, shrimp, and some unidentified materials. The morphology of *Chrysichthys nigrodigitatus* is adapted for bottom-feeding although stomach contents may prove otherwise as the variety of food items contained in the stomach often reflect the ability of the fishes to obtain food from different locations Atobatele and Ugwumba

(2011). However, Idodo-Umeh (2003) stated that morphological features couldn't limit *Chrysichthys* as exclusive bottom feeders, as stomach content indicates food items from different locations. The wide food spectrum of *C. nigrodigitatus* is an indication of flexibility in trophic level, which gives the fish ecological advantage to feed effectively on different categories of diet based on the availability of the food items (Warren, 1993). A wide range of plankton organisms was observed in the gut of *Chrysichthys nigrodigitatus* from Epe, Badagry, and Lagos lagoons. Considering the volume of the macro content of the guts, it may be inappropriate to conclude that *Chrysichthys nigrodigitatus* feed on these plankton as food since plankton are ubiquitous (Ser-Giacomi et al., 2018). Fish feed in the water and the plankton found in the stomach of the species in this study might have gotten there while feeding their target macro-organisms. Plankton identified in the gut of the fish could rather describe the status of eutrophication in their habitats and the predominant species of plankton in the habitats.

Conclusion

Based on the findings of this study, *Chrysichthys nigrodigitatus* from Epe, Badagry, and Lagos lagoons fed on both animal and plant materials and can therefore be said to be omnivorous. A previous study claimed that *Chrysichthys nigrodigitatus* are omnivorous (Kuton and Akinsanya, 2016), but no macrophyte was observed in the stomach content during this study. This could be because the plant materials had decayed into unidentified materials in the stomach of the fish by the action of digestive enzymes between the period of catch and laboratory analysis. The sand grain observed in the stomach is an indication the species spend some time, if not all, feeding at the benthic region of the water column. This study confirmed that *C. nigrodigitatus* can survive in different habitat with different environmental factors include temperature, food, pollutants, population density, sound, light, and parasites.

References

Agboola, J.I., and M.A. Anetekhai, (2008). Length-weight relationships of some fresh and brackish water fishes in Badagry creek, Nigeria. *J. Applied Ichthyol.* **24**: 623-625.

Ajani, E.K. (2001). Effects of biotic and abiotic components of the habitat on fish productivity in Lagos Lagoon, Nigeria. Ph.D. Thesis, University of Ibadan, Ibadan, Nigeria.

Akinsanya, B., Otubanjo, O.A., and Ibidapo, C.A. (2007). Helminth bioload of *Chrysichthys nigrodigitatus* (Lacepede 1802) from Lekki Lagoon, Lagos Nigeria. *Turkish Journal of Fisheries and Aquatic Science* **7**: 83-87.

Ama-Abasi, D. and Uyoh, E. A. (2020). Ecology and population dynamics of silver catfish,

Chrysichthys nigrodigitatus (Siluriformes: claroteidae), of the Cross River, Nigeria. *Global Journal of Agricultural Sciences* **19**: 71-82

Atobatele, O.E., and Ugwumba, O.A. (2011). Condition factor and diet of *Chrysichthys nigrodigitatus* and *Chrysichthys auratus* (Siluriformes: Bagridae) from Aiba Reservoir, Iwo, Nigeria. *Revista de Biología Tropical.* **59**(3): 1233-1244

Bhatnagar, A., Jana, S.N., Garg, S.K., Patra, B.C., Singh, G., Barman, U.K. (2004). Water quality management in aquaculture. Course Manual of summer school on development of sustainable aquaculture technology in fresh and saline waters, CCS Haryana Agricultural, Hisar (India), 203- 210.

Bolger, T., and Connolly, P.L. (1989). The selection of suitable indices for the measurement and analysis of fish condition. *Journal of Fish Biology*, **34**(2): 171-182.

Bowen, S.H. (1983). Quantitative description of the diet. In: Nielsen LA, Johnson DL, (Eds). *Fisheries Techniques*. Maryland: American Fisheries Society.

Dada, J.O., and Araoye, P. A. (2008). Some aspects of the biology of *Chrysichthys nigrodigitatus* (Pisces: Siluroidae) in Asa Lake, Ilorin, Nigeria. *Nigerian Journal of Fisheries.* **5**(1): 73-84

Ecoutin, J. M., Albert, J. J., and Trape, S. (2005). Length-weight relationships for fish populations of a relatively undisturbed tropical estuary, Gambia. *Fisheries Research*, **73**:347-351

Ekanem, S. B. (2003). The biology and culture of catfish *Chrysichthys nigrodigitatus*. *Journal of Sustainable Tropical Agriculture Research.* **10**:1-7

Esenowo, I. K., Ugwumba, A. A. A., Umoh, I. I. and Andem, A. B. (2017). Aspects of the Biology of Silver Catfish (*Chrysichthys nigrodigitatus*) in Nwaniba River, Southeast Nigeria. *Asian Journal of Biology* **3**(1): 1-9

FEPA., (2003). Guidelines and standards for environmental pollution control in Nigeria. Federal Environmental Protection Agency, pp: 238.

Francis, A., and Elewuo, U. (2012). Aspects of the biology of trap caught *Chrysichthys nigrodigitatus* (Lacepede: 1803) from the New Calabar River, Nigeria. *International Journal of Fisheries and Aquaculture*, **4**(6): 99-104

Gomiero, L. M., and de Souza Braga, F. M. (2005). The condition factor of fishes from two river basins in São Paulo state, Southeast of Brazil. *Acta Scientiarum: Biological Sciences* **73**-78.

Jeje, C.Y. and Fernando, C.H. (1986). A practical guide to the identification of Nigerian zooplankton (Cladocera, Copepoda, and

- Rotifera) Kainji Lake. Research Institute, Niger, Nigeria. 142pp.
- Kuton, M.P., and Akinsanya, B. (2016). Food and feeding habits of *Chrysichthys nigrodigitatus* (Lacepede, 1803) and evaluation physicochemical parameters in the Lagos Lagoon, Nigeria. *Egyptian Journal of Experimental Biology (Zoology)*, **12**(1): 73 – 79
- Lawal, M. O., Sangoleye, O. J., and Seriki, B. M. (2010). Morphometry and diet of *Chrysichthys nigrodigitatus* (Lacepede, 1803) in Epe Lagoon, Nigeria. *African Journal of Biotechnology*. **9**(64): 7955-7960
- Lima-Junior, S. E., and Goitein, R. (2001). A new method for the analysis of fish stomach contents. *Acta scientiarum*. **23**(2): 421-424.
- Mellanby, H. (1979). Animal Life in Freshwater. A guide to Freshwater Invertebrates. Chapman and Hall Ltd. Distributed in the U.S.A. by Halsted Press. A Division of John Wiley and Sons, Inc., New York. 308.
- Nerbrand, C., Svärdsudd, K., Ek, J., and Tibblin, G. (1992). Cardiovascular mortality and morbidity in seven counties in Sweden in relation to water hardness and geological settings. The project: Myocardial infarction in mid-Sweden. *Eur Heart J*. **13**:721–727.
- Nwankwo, D.I., and Onitiri, O.I. (1992). Periphyton (Aufuschs) community on submerged aquatic macrophytes in Epe Lagoon, Nigeria. *Journal of Agricultural Science and Technology*, **3**: 153 – 141.
- Offem, B.O., Akegbejo-Samsons, Y. and Omoniyi, I.T. (2008). Diet, size, and reproductive biology of the silver catfish, *Chrysichthys nigrodigitatus* (Siluriformes: Bagridae) in the Cross River, Nigeria. *Rev. Biol. Trop*. **56**: 1785-1799.
- Ogbeibu, A. E., and Ezeunara, P. U. (2005). Studies on the food composition and feeding pattern of fish communities in the Ikpoba River, Southern in part of Nigeria. *Journal of Aquatic Sciences*. **20**(2): 17-129.
- Olaosebikan, B., and Raji, A. (1998). A field guide to Nigerian freshwater. Federal college of fresh water fishes, New Bussa, Niger State. Nigeria. 106pp.
- Pauly, D. (1983). Some simple methods for the assessment of tropical fish stocks. *FAO Fish Tech. Pap.* **234**: 52.
- Pauly, D. and Gayanilo, F. C. (1997). FAO - ICLARM stock assessment tools (FiSAT) reference manual. Food and Agriculture Organization computerized information series - Fisheries No.8, Rome, FAO. 262p.
- Powers, D.A. (1989). Fish as model systems. *Science* **246**: 352–358.
- Ser-Giacomi, E., Zinger, L., Malviya, S., De Vargas, C., Karsenti, E., Bowler, C., and De Monte, S. (2018). Ubiquitous abundance distribution of non-dominant plankton across the global ocean. *Nature ecology and evolution*, **2**: 1243-1249.
- Skouras, A., Broeg, K., Dizer, H., Von Westernhagen, H., Hansen, P., Steinhagen, D. (2003). The use of innate immune responses as biomarkers in a programme of integrated biological effects monitoring on flounder (*Platichthys flesus*) from the southern North Sea. *Helgoland Marine Research*. **57**: 190–198
- Spade S, Bristow B. (1999). Effects of increasing water hardness on egg diameter and hatch rates of striped bass eggs. *North American Journal of Aquaculture*. **61**:263-265.
- Taiwo, I.O., and Aransiola, M.O. (2003). *Length weight relationship, condition factors, and fecundity of Chrysichthys nigrodigitatus and Chrysichthys walkeri in Asejire Lake*. In: 16th Annual Conference of the Fisheries Society of Nigeria (FISON), 4-9 November 2001, Maiduguri, Nigeria, pp. 277-281
- Thomas, J., Venu, S., and Kurub, B. M. (2003). Length-weight relationship of some deep-sea fish inhabiting the continental slope beyond 250m depth along the west coast of India. *NAGA, ICLARM Quarterly*, **26**(2): 17 - 21.
- Warren, W.G. (1993). Changes in the within-survey spatial temporal structure of the northern cod (*Gadus morhua*) population. *Canadian Journal of Fisheries and Aquatic Science*, **54**(1):139-148.
- Weatherley, A. H., and Gill, H. S. (1987). *The Biology of Fish Growth*. Academic Press, London. 443pp.
- Whitaker M. (2006). Calcium at fertilization and in early development. *Physiological reviews*. **86**:25-88.
- Yem, I.Y., Bankole, N.O., and Olowosegun, O. M. (2009). The length-weight relationship and Condition Factor of *Chrysichthys nigrodigitatus* (Lacepede, 1803) from KainjiLake, Nigeria. *Journal of Research in Agriculture Science* **4**(4): 20-22.