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RESEARCH ARTICLE

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Preliminary evaluation of some aspects of biology of two commercially important fish species in Okrika estuary (Niger-Delta) of Nigeria

ABSTRACT:

Preliminary investigation of length-weight relationship and condition factor of two commercially important fish species, Tilapia, *Sarotherodon melanotheron* and silver catfish, *Chrysichthys nigrodigitatus,* from Okrika estuary was conducted from October 2015 to February 2016. A total of 60 samples (based on financial resources available) of the two fish species were caught by fishermen using various fishing gears. The results obtained showed that the two fish species had negative allometric and isometric growth patterns with the growth exponents, b values of 2.50 and 3.16, respectively. The condition factors, K of both species were 6.6 and 0.44 which indicated that Tilapia was in a good condition while the environment was not favourable for silver catfish. This study was necessary to fill the new knowledge gap and provide baseline and first documented information for management and conservation of the two investigated species in Okrika estuary. This study recommended that further research needs to be conducted because of the sample size of the two fish species collected, and sampling duration (4 months), thereby requires longer and deeper investigations.

KEY WORDS:

tilapia; silver catfish; length-weight relationship; condition factor; Okrika estuary.

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INTRODUCTION:

For decades now, the capture fisheries have been experiencing drastic depleting stock in the world's aquatic ecosystems and efforts are being made to regulate and restore the declining catches (Abu and Agarin, 2016). Nigeria is endowed with abundant aquatic resources in the marine, freshwater and brackish ecosystems (Bolarinwa and Popoola, 2013). The country is blessed with a large hectare (14 million) consisting of reservoirs, lakes, rivers, estuaries, capable of producing over 980,000 metric tonnes of fish annually (FDF, 2007). Statistical surveys have shown that the demand for fish in the country exceeds supply due to ever increasing human population (currently over 150 million) (NPC, 2006; Tsadu *et al*., 2006).

The fish families; *Bagridae, Cichlidae, Mugilidae* and *Clupeidae* occur principally in the Nigerian coastal waters, constitute landings of artisanal fishermen, diets of the populace due to their availability, abundance and wide distribution, and are of great economic and ecological importance in the Okrika estuary and other creeks in the Niger-Delta (Ikomi and Odum, 1998; Ayoade and Ikulala, 2007; Hart and Abowei, 2007; Imam *et al.,* 2010). Cichlids (*Sarotherodon melanotheron*, Ruppell 1852) are important resources of tropical Africa due to their prolific fecundity and reproduction, which enable them to dominate aquatic ecosystems with maturity mean length of 13.2 cm and common length 17.5 cm (Hugg, 1996; Ayoade and Ikulala, 2007). They usually consume aufwuchs, a term used to describe small animals and plants that encrust hard substrates, such as rocks, in aquatic environments also known as periphyton and detritus (Trewavas, 1983), as well as on bivalves and zooplankton (Diouf, 1996). *Chrysichthys nigrodigitatus* (Lacepède 1803) belong**s** to the family *Bagridae* and often inhabit shallow waters. They are highly valued fish species in Asian and African waters as they constitute the major landings of fishermen in these regions. They are omnivores feeding on insects, vegetative materials, bivalves and detritus in the muddy or fine sandy bottom regions of the aquatic environment (Reed *et al.,* 1967; Idodo-Umeh, 2003; Ajah *et al.,* 2006; Abowei and Ezekiel, 2013). Both species are found primarily in brackish ecosystem particularly estuaries and lagoons (Teugels and Thys van den Audenaerde, 2003) and abundant in mangrove areas and do shuttle between fresh and salt waters in native and non-native ranges (Ikomi and Odum, 1998; GSMFC, 2003). *Sarotherodon melanotheron*, the black-chin tilapia, is a pale-coloured cichlid species whose common name is derived from the dark pigmentation usually (but not always) concentrated on the underside of the head (the chin) in adult animals. Melanic pigmentation is usually also present on the posterior edge of the gill (the cleithrum) and on the tips of the soft dorsal rays. Irregular bars, spots or splotches on the body are also typical of this species. The mouth is small and filled with hundreds of very small teeth arranged in 3 - 6 rows (Trewavas, 1983).Sexual dimorphism is very rare in black-chin tilapia (Trewavas, 1983), although the head region of adult males are usually slightly bigger than those of females and some males also have some golden coloration on their opercula.*Sarotherondon melanotheron* is a paternal mouth brooder, and is one of a handful of species showing sex-role reversal, with females as the aggressive and competitive sex and reproduction relying on male choice and discrimination (Balshine-Earn and McAndrew, 1995). As is the case with other cichlids, black-chin tilapia competes with native fishes for breeding grounds (Molnar *et al*., 2008). Spawning season occurs from April to October, coinciding with increasing water temperatures (above 24°C) and favourable conditions for larval development (Faunce, 2000). *Chrysichthys nigrodigitatus* has silvery colour with a white belly and a black adipose and also exhibited a pointed snout slightly longer than or equal to the width of the mouth and the pre-maxillary tooth plate width made 20 - 30% of the head length (Leveque *et al.*, 1992). Meristic characteristics of the species revealed; 8 to 10 soft rays in the pectoral fin, 3 - 7 simple rays and 8 - 12 branched rays in anal fin and 14 to 21 gill rakers on first gill arch.

Length-weight relationship (LWR) indicates the average weight of fish at a given length by making use of the mathematical equation to show relationship between the two (Beyer, 1987). Fish can attain either isometric or allometric growth (Sakar *et al.,* 2013). Isometric growth indicates that both length and weight of the fish are increasing at the same rate. Allometric growth can be either positive or negative. Positive allometric implies that the fish becomes stouter or deeper-bodied as its length increases. Negative allometric implies the fish becomes slender as its length increases. Condition factor (CF) is an estimation of general well-being of fish (Oribhabor *et al.,* 2011) and is based on the hypothesis or assumption that heavier fish are in better condition than the lighter ones (Bagenal, 1978; Ogamba *et al.,* 2014). The condition factor of one or greater than one indicates the good condition of fish while the one less than 1 shows bad condition (Abobi, 2015). Condition factor can be influenced by season, sex, type of food organism consumed by fish, age of fish, amount of fat reserved, and environmental conditions (Bagenal, 1978; Anene, 2005; Abowei, 2009).

Length-weight relationship and condition factor are important tools in fisheries biology, management and stock assessment to draw up yield equations, estimate standing stock biomass, their well-being (health status), compare ontogeny of fish population and growth pattern studies of fish spatially and temporally, understand their life cycles and span, construct ecosystem modelling and can be used as index to assess the status of the aquatic environment where the fish live (Le Cren, 1951; Beverton and Holt, 1957; Petrakis and Stergiou, 1995; Idodo-Umeh, 2002; Montopoulos and Stergiou, 2002; Anene, 2005; Fafioye and Oluajo, 2005; Imam *et al*., 2010; Lawson *et al*., 2013; Ogamba *et al*., 2014). Abobi and Ekau (2013) reported that Length-weight relationship and condition factor are important to fishery industry as they help to predict the best length and weight and time suited to harvest a particular species of fish. Many studies on LWR and CF analyses have been conducted for some fish species in the Niger-Delta (King, 1996; Ikomi and Odum, 1998; Anene, 2005; Abowei, 2009; Ezekiel and Abowei, 2014).

Because of the high demands for catfish and tilapia in Nigeria, the natural stocks have been depleted. Over 230 species of fish have been reported from Nigerian inland and coastal waters (Ita, 1993). Estuaries are among the most productive ecosystems in the world as they are biogeochemically active and endowed with abundant and diverse ecologically and commercially important fish resources (Primavera, 1998). The population ofmany of these recorded species in estuary is on the decline, with some falling under threatened orendangered species. Fish have been recognized as the most threatened, among all vertebrates worldwide (Bruton, 1995). The number of freshwater and estuarine fishes that will become extinct within the next 20-30 years is estimated at 300 species (Stiassny, 1981), making conservation practices seen as a priority throughout the world. Many factors have been attributed to this; over-fishing, habitat loss and degradation, pollution, introduction of exotic and non-native species (Edgar *et al.,* 2000; Ayotunde and Ada, 2013). These local disturbances could lead to a reduction or massive loss of fisheries production in the coastal waters (Sloterdijk *et al*., 2017). Estuaries have been classified as one of the most degraded ecosystems in the world. Rivers, mangroves and estuaries are the direct recipients of most of the anthropogenic wastes; industrial, agricultural, domestic and municipal which could have serious effects on the biological components (Li *et al*., 2000; Unnikrishnan and Nair, 2004; Dhanakumar *et al*., 2015; Abreu *et al.,* 2016). Okrika estuary is positioned and receives refinery waste-effluents directly and also gas flaring indiscriminately discharged from Port-Harcourt Refining Company (PHRC) in addition to other activities carried out along its course which include oil bunkering, domestic sewage, refuse and waste disposal, waste incineration, fishing, transportation, etc (Akinrotimi *et al*., 2015; Anejionu *et al.,* 2015; Uzoma and Mgbemena, 2015).

Aquatic pollution brings about undesirable changes in the environment, which could interfere with and affectthe biological components of anecosystem along with some socio-economic and ecological implications (Muyodi *et al.*, 2011; Chilaka *et al*., 2014). *Tilapia* and *Chrysichthys*species are the two dominant fish populations in Okrika estuary based on the observed landings of the fishermen. They provide livelihood (employment and income generation) and a cheap source of protein to the populace inhabiting this eco-region. There is no published research conducted on the biology or ecology aspects of the fish species in this aforementioned ecosystem. This study will provide first documented and baseline information and help in the decision-making process for effective management and conservation of the stocks concerned.

This study aimed at length-weight relationship and condition factor analyses of two commercial fish species (*Sarotherodon melanotheron* and *Chrysichthys nigrodigitatus*) in Okrika creeks.

Research Questions:

1.) What kind of growth patterns do *Sarotherodon melanotheron* and *Chrysichthys nigrodigitatus* exhibit in the Okrika estuary ecosystem?

2.) Are the fish in good condition in the ecosystem despite pollution from anthropogenic sources?

MATERIAL AND METHODS:

Description of the study area:

The study area:

lies between latitudes 4° 44’ 00” to 4° 46’ 10” N and longitudes 7° 5’ 15” to 7° 6’ 15” with an area of 905.2 sq.km. It is located in Okrika Local Government Area of Rivers State with a population of over 150,000 (NPC, 2006). Okrika estuary has an average length of 21km and lies in the north bank of the Bonny River with a distance of about 56km from the Bight of Benin in Eastern part of the Niger-Delta. It serves as a collecting basin for the effluents generated from both Port-Harcourt Oil Refining Company, industrial and domestic sources because along its banks are found mechanic workshops, oil-bunkering, sand mining, sewage and refuse, etc (Ogunola *et al*., 2017). It is a mangrove environment characterised by regular salt water inundation as a result of tidal action and flooding and extensive sandy bottom and mud-flat. The tidal amplitude ranges between 1.5 – 2 m in normal tide. It originates from Marine Base and runs through Okari and crosses the Mainland to Ekerekana Ama and other creeks such as Sandfilled/Mainland Bridge (Ogoloma). It is characterized by tropical climate with alternating wet (March to October) and dry (November to February) seasons. Based on the Nigerian Meteorological (NIMET) data, the area is associated with warm temperature ranging from 26^0 to 34^0C, annual bimodal rainfall of 2300 - 4000 cubic metres and distinct relative humidity and evaporation. It is ecologically endowed with vast biodiversity; fish, mollusc, crustaceans, crabs, *Rhizophora mangle, Laguncularia racemosa, Avicennia africana* (Fig. 1).

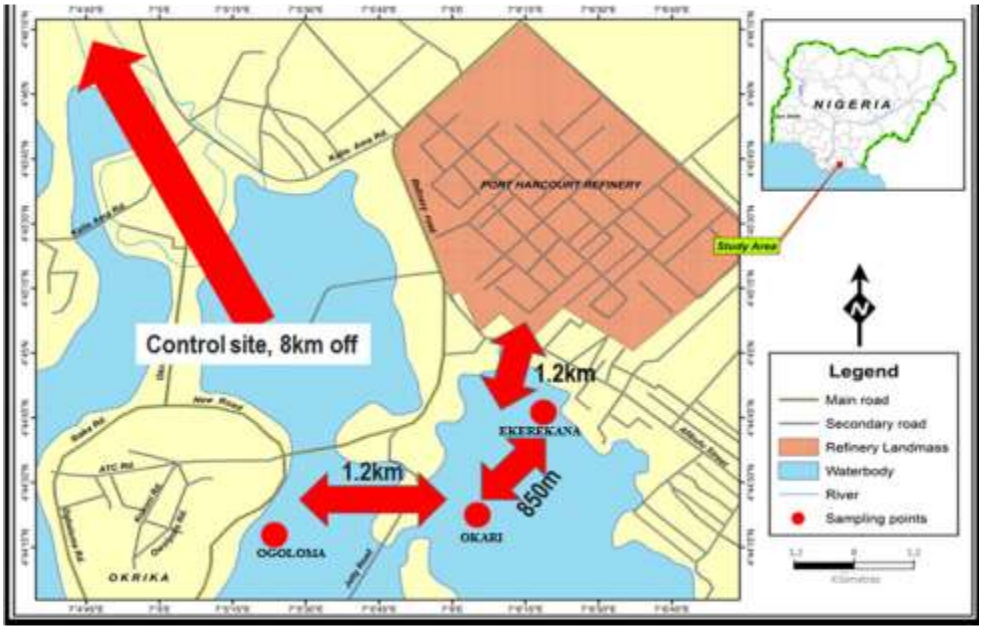

Fig. 1. Map of Okrika estuary showing the sampling stations

Experimental design:

Three experimental sampling sites along the estuary course were utilized for data collection. Each site is about 1 – 2 km from the other. The respective sampling sites were represented as Ekerekana (EKR), Okari (OKR) and Ogoloma (OGL). These sites were chosen because they are the fishing and landing grounds of fishermen and also their proximity to the refinery discharge point and in addition to other activities such as domestic waste and sewage disposal, oil-bunkering and transportation carried out along its course. Sampling was done in October/November 2015 and January/February 2016 which represent the peak of both the wet and dry seasons, respectively.

Fish = 3 Sites, * 2 Species, * 5 Replicates, *2 Seasons = 60 Samples

Fish collection, preservation and identification:

The fish samples were collected directly from each sampling site by employing two fishermen who captured the fish species with different gears of beach-seine, cast net or gill-net of various mesh sizes. Sampling was done in accordance with the techniques used by other published literatures (Anene, 1998; Ndimele *et al.,* 2010). Silver catfish (*Chrysichthys nigrodigitatus*) and Black-chin Tilapia (*Sarotherodon melanotheron*) were sampled from each sampling site based on their abundance, availability, economic importance, mostly eaten by the populace (market survey) and feeding habits. A total of sixty samples were taken due to limited financial resources available. They were transported to the laboratory in ice cold chest to arrest microbial action prior to analysis (Ndimele *et al.,* 2010). In the laboratory, they were identified to the specie level using fish catalogue of FAO (FAO, 1990; Schneider, 1990). Their morphometrics of standard lengths and total lengths (TL) were measured using graduated plastic measuring board and body weight (BW) using sensitive scale balance (Kern 440 - 35A model). All lengths and weights were measured in centimetres and grams, respectively.

Data analysis:

Length-weight relationship (LWR):

The raw data of total length (TL) and body weight (BW) of the fish collected were used to compute the length-weight relationship with the formula;

$W = aL^b$ ...(1) (Le Cren, 1951; Ricker, 1973)

where W = body weight, L = total length, a = intercept on the length axis, b = slope or regression coefficient which usually ranges from 2 to 4.

Equation (1) is log transformed to give a linear relationship;

$\text{Log } W = \text{Log } a + b \text{ Log } L$ ..(2) (Le Cren, 1951; Koutrakis and Tsikliras, 2003)

When Log W is plotted against Log L, the regression coefficient or growth exponent, b, and intercept, a are obtained.

For each species, the growth exponent (b) was compared to 3 using student's t-test to ascertain whether species grow isometrically or not (Sokal and Rohlf, 1987). This was achieved by using the formula and statistical link;

$t_s = b - 3 / s_b$... (Zar, 1984; Morey *et al.,* 2003)

http://www.socscistatistics.com/pvalues/tdistribution.aspx

t_s = student's t-test, b = slope, s_b = standard error of the slope. The b value of 3 was chosen for comparison and a standard because it indicates that the fish grows isometrically.

Condition factor:

This was computed for each species with Fulton's equation;

$K = 100 \times W / L^b$……….(Pauly, 1983)

whereK = condition factor, W = body weight, L = total length, b = compiled growth exponents.

Statistical analysis:

The data obtained from the morphometric analysis were subjected to statistical analysis using R-Studio Version 0.98.1083 (2009 - 2014) and excel spread-sheet. Analysis of variance (ANOVA) was used to test whether the calculated regression line was significant (Ogbeibu *et al*., 2005). All statistical analyses were considered at significant level of 5% ($p < 0.05$).

RESULTS:

Length-weight relationships:

A total of 60 samples (30 each) of Tilapia (*Sarotherodon melanotheron*) and silver catfish (*Chrysichthys nigrodigitatus*) were measured for their biometrics from October 2015 to February 2016. The body weights and total lengths of *Sarotherodon melanotheron*and and *Chrysichthys nigrodigitatus* sampled ranged from 7.76 – 125 g (mean value of 56.32 ± 6.06), 52.77 – 177.94 g (mean value of 94.89 ± 7.76) and 7.3 – 18.6 cm (14.65 ± 0.68), 20 – 27.5 cm (23.23 ± 0.59), respectively (Table 1).

Table 1. Morphometrics, Length-weight relationships and Condition Factors of the two fish species from the study area.

Family	Species	Mean BWt (g)	Mean TL (cm)	a	b	Type of growth	r	p-value of r	K	t-value
Cichlidae	*Sarotherodon melanotheron*	56.32 ± 6.06	14.65 ± 0.68	- 2.73	2.50	- A	0.95	2.2×10^{-16} ***	6.60	- 4.54
Bagridae	*Chrysichthys nigrodigitatus*	94.89 ± 7.76	23.23 ± 0.59	- 5.43	3.16	I	0.90	2.3×10^{-15} ***	0.44	0.80

BWt = body weight, TL = total length, a = intercept of the regression, b = slope of the regression (growth exponent), -A = negative allometric growth, I = isometric growth, r = correlation coefficient of length weight relationship, p-value of r = significance of correlation, K= Condition Factor, t-value = absolute value of t-test parameter to compare calculated slope to 3. ***$p<0.001$.

The results of the regression statistics for Length-weight relationships for the two species showed the regression slopes or growth coefficients, b, of values 2.50 and 3.16 for *S. melanotheron* and *C. nigrodigitatus*, respectively (Table 1). Based on the results of the t-test, the growth exponents, b of *S. melanotheron* was significantly different ($p < 0.05$) from 3 but that of *C. nigrodigitatus* showed no significant difference ($p > 0.05$) (Table 1). High power of statistical test (1 – ß error prob) = 0.82, using small effect size of 0.1 and sample-size of 30 each on G*Power 3.1.9.2 version, was obtained when tested with student's t-test to ascertain if the species grew isometrically or not.This indicated that *S. Melanotheron* exhibited a negative allometric growth pattern while *C. Nigrodigitatus* exhibited an isometric growth pattern (Table 1). The Length-weight regression equations for the two species were found to be; Log BWt = - 2.73 + 2.50 Log TL and Log BWt = -5.43 + 3.16 Log TL, respectively. Their correlation coefficient was found to be 0.95 and 0.90 for *S. melanotheron* and *C. nigrodigitatus*, respectively, with highly significant regression values ($p < 0.001$) (Table 1). The scatter plots or regression graphs of the total length and body weight relationships of the two species are shown in figures 2 & 3. These reflect the exponential growth in weight with increasing length.

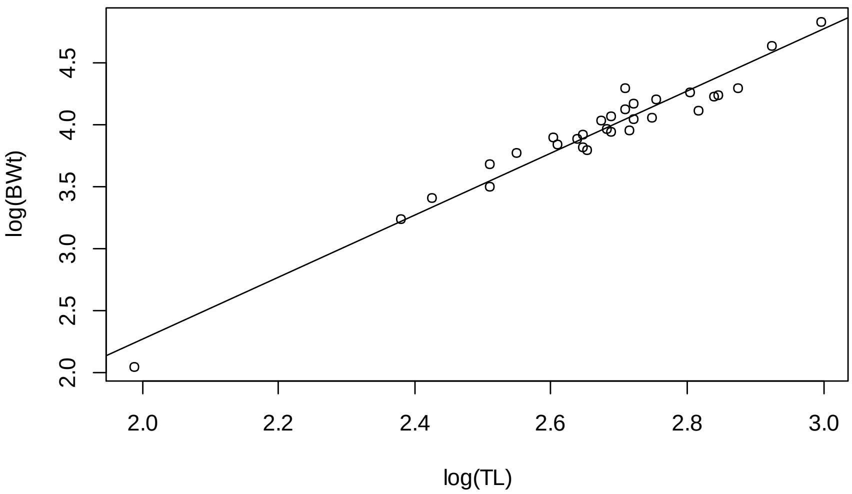

Fig. 2. Length-weight relationship of Tilapia (*Sarotherodon melanotheron*)

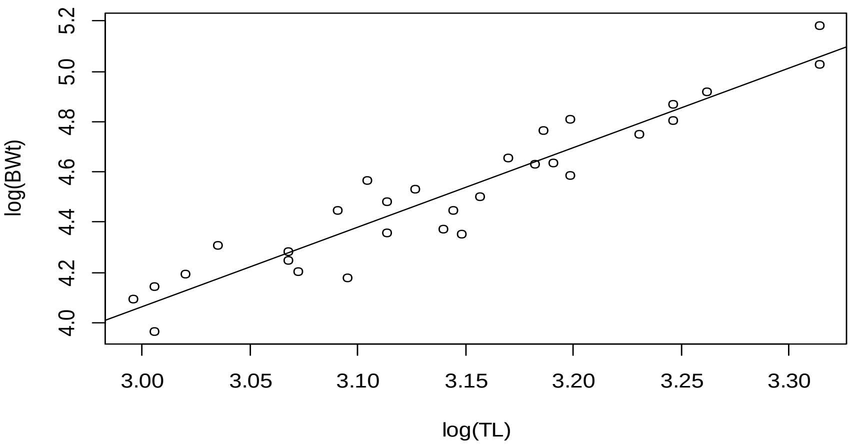

Fig. 3. Length-weight relationship of silver catfish (*Chrysichthys nigrodigitatus*)

Condition factors (k):

The mean K values of *S. melanotheron* and *C. Nigrodigitatus* for the sampling period in the study area was found to be 6.60 and 0.45, respectively.

DISCUSSION:

Length-weight relationships:

The correlation coefficients (r) for LWR were very high (≥ 90) for *S. Melanotheron* and *C. nigrodigitatus* which indicate their strong correlation and increase in length with increase in weight. This agreed with earlier studies involving fishes from different aquatic ecosystems (Laléyé, 2006). The values of growth exponent, b obtained for the two species are within the limits or range of 2 and 4 reported for most fish (Tesch, 1971). The growth pattern of *S. melanotheron* (b = 2.50) was found to be negative allometric which indicates that as the length of the fish increased, it became lighter, thinner or less plumpy or simply put, it shows poor growth of length and weight (Anderson and Gutreuter, 1983; King, 1996; Wootton, 1998). The fish did not grow symmetrically as they became thinner with increase in length (Tesch, 1971; King, 1996). The growth pattern of *C. nigrodigitatus*was found to be isometric (b = 3.16) which indicates that the fish increased proportionately in length and weight or at the same rate (Lawson *et al*., 2010). This also means that the fish became robust as its length increased and would command a good yield, landing size and high market price for the fishermen. This isometric growth pattern indicates that the fish will not change its shape as it grows. Le Cren (1951) and Fagbenro *et al.* (1991) stated that conformance with the cube law (isometric growth, b = 3) was rare in the majority of fish species and this was not true for *C. nigrodigitatus* in this study because there was no deviation (p > 0.05 of 3.16) from the cube law (b = 3) when tested with student's t-test. This value was within those (2 - 4) mostly reported for tropical freshwater fish species (Tesch, 1971; Thomas *et al.,* 2003). This is also in agreement with Carlander (1969) and Gayannilo and Pauly (1997) who postulated that exponent b normally falls between 2.5 and 3.5 for most tropical fish species.

When LWR of a single fish species is compared with other literatures, there is possibility of finding a wide variation in parameter estimates due to some intrinsic/biological and sampling related factors (Ricker, 1975). Ricker (1973), Bagenal (1978), Sikoki *et al.* (1998), Abowei (2006), Obasohan *et al.* (2012) and Uneke (2015) reported that factors such as food abundance, sampling season, sex, fishing pressure, genetic make-up, habitat quality and suitability, individual metabolism and environmental degradation could influence or cause variation of growth exponent. By comparing the values of growth exponents, b of the two species with the literatures from other regions, *C. nigrodigitatus*has almost the same value (isometry) with 2.98, 3.00, 3.02, 3.21, and 3.04 obtained from River Nile (Egypt), River Benin (Niger-Delta), Epe Lagoon, Amassoma floodplains and Cross River in the Niger-Delta but higher value than 1.58, 2.13,1.99, 2.14, 2.24, and 1.78-2.27, negative allometry, obtained in Lower Reaches of Ebonyi River (South-East), Asejire andErelu Lakes, New Calabar and Nwaniba Rivers (Niger-Delta) and Ibeshe Lagoon, Lagos and lower value to 3.85 (positive allometry) in Lagos Lagoon (Ikomi and Odum, 1998; Fafioye and Oluajo, 2005; Taiwo and Aransiola, 2003; Offem *et al*., 2008; Abowei and Ezekiel, 2013; Bolarinwa and Popoola, 2013; Ragheb, 2014; Kareem and Orisasona, 2015; Uneke, 2015; Abu and Agarin, 2016; Kuton and Akinsanya, 2016; Olanrewaju *et al*., 2016; Esenowo *et al*., 2017). This indicates that the fish exhibits isometric growth because the growth exponent, b is not significantly different from 3 and could be as a result of abundant food resources, genetic make-up, etc (Bagenal, 1978; Khaironizam and Norma-Rashid, 2000). The observed growth pattern (isometric) in this study could be linked to feeding behaviour or intensity of the species which is determined by the abundance of food or prey items and the low or absence of competitors and predators. During rainy season, flooding exists, water level rises, food resources become abundant and fish density is at its lowest favouring intensive feeding (Welcomme, 2001). When predator density is low, prey species like *C. Nigrodigitatus* will be less attentive and increase their time for foraging (Bayley, 1988; Belk, 1993). Fish generally forage to maximize growth rate rather than growth efficiency. The weight of fish increases when they utilise food items available for growth (Kamaruddin *et al*., 2012). Growth is also seasonal, being fastest during the flood or high-water season (Bayley, 1988). The rapid growth during the high-water period generally corresponds to periods when food resources are abundant (as a result of flood promoting primary and secondary productions and bringing in large quantities of allocthonous food inputs into the system), temperature is at its highest (moderate) and density (competition) is at its lowest (Welcomme 1985 & 2001; Junk *et al.,* 1989; Quarcoopome, 2016). This isometric growth pattern of *C. nigrodigitatus* is an indication of high level of phyto-zooplankton, detritus, worm, insect, mollusc, crustacean and fish prey (such as tilapia) resources in the ecosystem (Ikusemiju and Olaniyan, 1977). Another reason could also be attributed to environmental factor, such as temperature, which plays a significant role in metabolism. The metabolic rate of the fish is enhanced at moderate temperature (28 - 30°C) to activate digestive enzymatic activities that can facilitate their growth and attain maximum size within a given period of time. This temperature range is recommended for fish growth in the tropics (Boyd, 1979; Bhatnagar and Singh, 2010). This is evidenced in the findings of Obire *et al.* (2008), Emuedo *et al*. (2014), and Makinde *et al.* (2015) who recorded a temperature range of 28.5 - 29.88°C in the creek.

For *S. melanotheron*, negative allometric pattern ($b < 3$) obtained in this study is similar to findings observed in Ogun estuary, Ogudu creek, Lakes Nokoué and Ahémé, Ologe Lagoon and Asejire Lake (Abdul *et al.,* 2010; Ndimele *et al*., 2010; Niyonkuru and Laléyé, 2012; Lawson *et al.,* 2013; Olanrewaju *et al.*, 2016) but in contrast to isometric growth ($b = 3$) obtained from Eleiyele Lake, Ibadan and Buguma creek in the Niger-Delta (Ayoade and Ikulala, 2007; Oribhabor *et al.,* 2009). In addition to this, several authors have also reported negative allometric growth for *S. melanotheron* (Soyinka and Ayo-Olalusi, 2009; Imam *et al.,* 2010; Soyinka and Ebigbo, 2012). This negative allometric growth pattern could be attributed to low food items for this species in the ecosystem or reduction of their body size to escape predation or high fishing mortality or intensity and adverse effects of oil pollution on their growth (Law, 2000; Chilaka *et al*., 2014). Since *S. melanotheron* is planktivorous and showed negative allometry, it is therefore possible that this is an indication of high competition (intra-specific) for available phyto and zooplankton resources in the ecosystem which could have affected their growth due to limited nourishments available to individuals.

Condition factors:

The condition factor of *S. melanotheron* ranged from 5.35 – 8.40 (mean value of 6.6) while for *C. nigrodigitatus* was 0.37 – 0.53 (mean value of 0.44) (Table 1). *S. melanotheron* was found to be in very good condition ($K > 1$) as against the observation in *C. nigrodigitatus* probably due to their genetic makeup or because they have developed a self-regulatory metabolic mechanism to cope and thrive well in the refinery waste polluted creeks of Okrika (Anene, 2005; Franco-Lopez *et al*., 2010). Similar pattern ($K > 1$) was obtained for this species in Lake Eleiyele, Ibadan, Ntak Inyam Stream (Niger-Delta) and Lake Nokoué and Ahémé (Ayoade and Ikulala, 2007; Onuoha *et al.,* 2010; Niyonkuru and Laléyé, 2012).

On the other hand, *C. nigrodigitatus* was not in good condition ($K < 1$) probably because their genetic makeup could not cope or live in a highly polluted environment (inability to regulate or metabolise the effluents or pollutants (Biswas, 1993; Atobatele and Ugwumba, 2011; Ayotunde and Ada, 2013; Abu and Agarin, 2016). Poor water quality parameters could also have contributed to the observed data. Obire *et al.* (2008), Marcus (2011) and Emuedo *et al*. (2014) reported a dissolved oxygen concentration of 3.73 - 4.9 mg/L, temperature, 27.2°C and pH of 5.23 in the creek. These values are outside the recommended values of > 5.0 mg/L, 28 - 30°C and 6.5 - 8.5, suitable for the growth of tropical fish species (Boyd, 1979; Bhatnagar *et al*., 2004; Bhatnagar and Singh, 2010). Most importantly, another reason might be because the sampling period might have coincided with their late primary peak (October) or early secondary peak (January) of spawning i.e gonadal development, as they have been reported to spawn all year round (Ajang *et al*., 2013). The condition of the fish tends to be poor during their spawning period. Similar pattern of $K < 1$ was obtained for this species in Badagry Lagoon, Warri and Imo Rivers (Ezenwa *et al*., 1986), Epe Lagoon (Fafioye and Oluajo, 2005), Cross River in Niger-Delta (Offem *et al.,* 2008), River Niger (Nwachi, 2016) and Nwaniba River (Esenowo *et al.,* 2017) but different patterns of $K > 1$ (1.21, 1.34, 1.67, and 2.9) and $K = 1$ was obtained for *C. nigrodigitatus* in Rivers Ebonyi, New Calabar, Niger, Beninand Amassoma creek in the Niger-Delta (Ikomi and Odum, 1998; Abowei and Ezekiel, 2013; Uneke, 2015; Abu and Agarin, 2016; Nwachi, 2016).

Conclusions and recommendation:

This study provided information on the LWRs and condition factors (biology) of two major important fish species, Tilapia (*Sarotherodon melanotheron*) and silver catfish (*Chrysichthys nigrodigitatus*) in Okrika creeks which is the first documented report of its kind and would serve as a reference point for future research.

From the findings of this study, there were highly significant correlations ($p < 0.05$) for the LWRs of both species. *Chrysichthys nigrodigitatus* exhibited isometric growth but were not in good condition in the study area as their mean K value is far less than 1. This suggests the condition of the estuary is unfavourable (habitat degradation) to them as the waterbody receives effluents from a nearby crude oil refining company. The isometric growth pattern indicates a good landing size and market price from their sales, resulting in high return for the fisherfolks involved. This is similar to the finding of Fafioye and Oluajo (2005) who reported isometric growth and $K < 1$ for this species in Epe Lagoon. This species is gaining attention as a potential aquaculture candidatein West Africa, therefore, needs maximum conservation, especially for its early life stages from the wild (Ajayi, 1972; Ezenwa, 1982; Kuton and Akinsanya, 2016).

On the other hand, *Sarotherodon melanotheron* exhibited negative allometric growth but were in good condition as their mean K value far exceeded 1. This could be probably because they have developed a self- regulatory metabolic mechanism or become genetically modified to cope and adapt in such an unfriendly environmental condition (Bagenal, 1978). Their negative allometric growth could be as a result of malnourishment through competition for available food items, age, abundance of predators, environmental degradation from oil pollution, etc (Henderson, 2005; Adeyemi, 2010; Obasohan *et al.,* 2012). This agrees with the findings of Soyinka and Ayo-Olalusi (2009) and Atama *et al.* (2013) who reported negative allometric growth and $K > 1$ for tilapia (*Tilapia mariae,* a related species) in Ologe Lagoon and Anambra River, respectively. Their negative allometry would not favour a good landing size and command a reasonable market price from their sales for the fishermen, thereby resulting in economic loss. From the ecological point of view, the good condition of *S. melanotheron* could have favoured the reproduction, proliferation and abundance of this species, which have benefited the growth (isometry) of *C. nigrodigitatus* along the food chain as the former serves as prey items for the latter. Tilapia species have been found and widely reported in the gut contents of *C. Nigrodigitatus* (Sandon and Tayid, 1953; Ikusemiju and Olaniyan, 1977; Nwadiaro and Okorie, 1985; Ajah *et al*., 2006; Ekpo *et al*., 2014; Kuton and Akinsanya, 2016). Further studies need to be carried out to complement the results of this study because of the sampling duration (4 months) and sample size. This is necessary to justify and validate the outcomes. This study did not investigate and confirm (due to time and financial constraints) the evidence and absence of water quality parameters, food and feeding parameters and chemical pollution (contaminants) of the estuary which could have been flushed out of the aquatic basin by flood after raining.

In conclusion, the brackish ecosystem of Okrika creeks produced two fish species of isometric and negative allometric growth patterns with different K values of good and bad conditions. Therefore, measures must be taken by the Nigerian government, refinery companies and all stakeholders to reduce pollution impact on the aquatic ecosystem.

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This research did not involve human participants.

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All authors have agreed to publish this article for the use of scientific communities and the general public at large.

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The data and materials used are available with the first author and online.

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All authors contributed significantly to sample collections, data analyses, write up, insights and comments.

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