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Comparative analysis of *Oreochromis niloticus* and a putative hybrid (Wesafu): A Search for morphometric identity

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Abstract

Oreochromis nilotics is an important aquaculture species worldwide. Members of the tilapiine family hybridize easily in nature. The present study was conducted to examine the morphometric and meristic characteristics of *Oreochromis niloticus from New Calabar River* and a putative hybrid called Wesafu found in Epe Laggon. The study was based on the hypothesis that the tilapia hybrid will possess traits which will be intermediate to those of *O. niloticus*. A total of 24 morphometric measurements and 8 meristic counts were used to generate data which were analyzed using t-test. The total length of Wesafu and *O. niloticus* fish ranged from 7.00 -24.5cm and 12.00 -15.5cm respectively. Our study rejected the hypothesis of mid-values Additionally, the total length and body weight relationship were found to be a straight line in logarithmic scale expressed Log BW = 2.7724 Log TL - 1.6171 and Log BW = 2.8442 Log TL - 1.7114 for both Wesafu and *O. niloticus* respectively. The value of regression co-efficient "b" obtained for the length-weight relationship of Wesafu and *O. niloticus* was 2.7 and 2.8 respectively.

Keywords: Epe lagoon; New Calabar River; Tilapia hybrid; *Oroechromis niloticus*; Morphometric measurement; Meristic characters

1 Introduction

The Nile Tilapia, *Oreochromis niloticus*, is a widespread species in Africa and Middle East. It is naturally distributed in East, Central and West Africa and the Levante area, including Palestine, and Lebanon [1, 2]. In West Africa, the natural distribution covers the basins of the Senegal, Gambia, Volta, Niger, Benue and Chad, with introduced specimens reported from various coastal basins [3]. The species is of great importance in aquaculture, representing perhaps, the second most important species in global aquaculture [4, 5]. This followed some zootechnical characteristics which include fast growth rate, tolerance to diverse environmental conditions, subsistence in low value foods, tolerance to diseases, high fecundity and prolificacy. Because of some of the aforementioned zootechnical characteristics, the Nile tilapia is capable of outcompeting native species in areas where it has been introduced.

The cichlids are generally prolific and particularly known for their ability to hybridize with closely related species [6**],** resulting in high speciation in the wild. For example, hybridization occurred between *Oreochromis niloticus* and *Oreochromis spirulus nigra* introduced into Lkae Lake Bunyoni in Uganda, resulting in the disappearance of the pure species. Hybrids between the two species, *O. spirulus nigra* and *O. leucostictus* were harvested from Lake Naivasha in Kenya [7]. Several other hybrids have in been reported between C. *guineensis* and *C. zilli* [8]). In C6te d'Ivoire, the cases of hybridization of *C. zillii* and *T. guineensis* are numerous [8].

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In recent years, specimen thought to be *Copton guineensis* were discovered in Epe Lagoon, Lagos, Nigeria [9]. The specimen now called Wesafu locally is highly prized, grows very fast and big to 1500g at 414mm in length [10]. The morpholometric and meristic identity of fish species is a primary source of information for taxonomic and evolutionary studies. The *Oreochromis macmchir* and *O. niloticus* hybridized in a natural lake in Madagascar, showing intermediate specimen between the two species [11]. The aim of this study was to assess the characteristic morphometric and meristic indices in *O. niloticus* and a putative tilapiine hybrid (Wesafu) found in Epe Lagoon, Lagos. Our hypothesis is that morphometric traits of the tilapia hybrid, "wesafu" is intermediate of those *O. niloticus*. Therefore, the study will help to further characterize *O. niloticus* and the putative hybrid Wesafu found in Epe, Nigeria. Results will be compared with other works on *Caopton guineensis* and *Copton zilli*. The findings from this study will add to literatures that will help for appropriate identification of the indigenous species in Nigeria.

2 Materials and methods

2.1 Sampling Areas

The specimen were obtained from two locations as shown in Fig. 1. *O. niloticus species* were obtained from fisher-folks operating in New Calabar River. The New Calabar River lies between longitude 006º53´-53º86´E and latitude 04º53´-19º20´N in Choba, Rivers State The putative hybrid, Wesafu was collected from Epe lagoon, Lagos State. The lagoon has a maximum depth of 6m, though a large area of the lagoon is relatively shallow with a minimum depth of 1m, and the vegetation surrounding the lagoon is of the swampy mangrove type. Epe lagoon is sandwiched between two lagoons, the Lekki lagoon (freshwater) in the east and the Lagos lagoon (brackish water) in the west. It is connected to the Atlantic Ocean via the Lagos lagoon year-round [12].

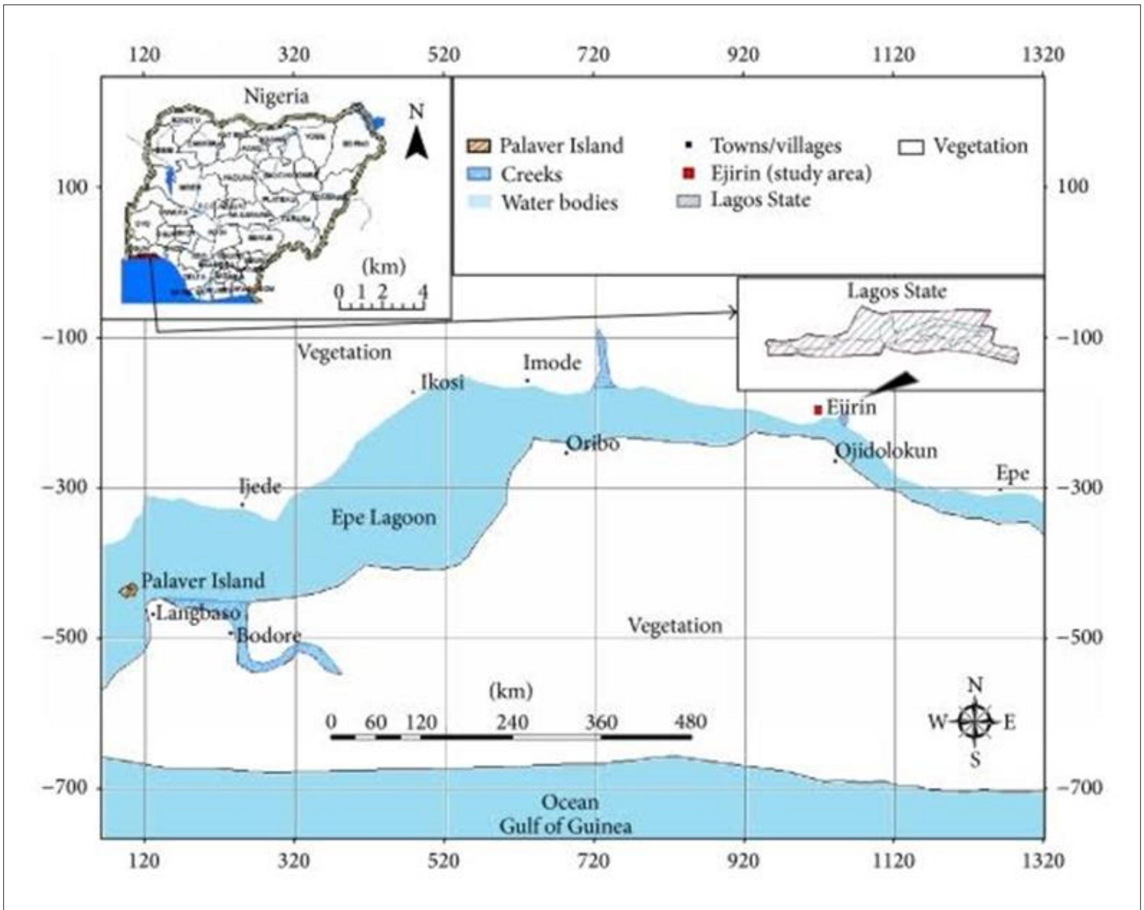

Figure 1 Map showing sampling location of Wesafu in Epe Lagoon, Lagos

One hundred and twenty-nine (129) and 24 specimen of the putative hybrid (Wesafu) and *O. niloticus* were respectively, collected from the Epe lagoon, Lagos and New Calabar River. The samples were obtained from fishermen at the landing sites, frozen before being transportation to Fisheries Laboratory, University of Port Harcourt where the specimen were preserved in 75% ethanol.

Altogether, 23 morphometric and eight (7) meristic characters were measured on each specimen. The body weight (g) was measured with mini-digital weighing scale. Other morphometric characters were measured with a metre rule (cm) following traditional and framework measurement according to Fig. 2.

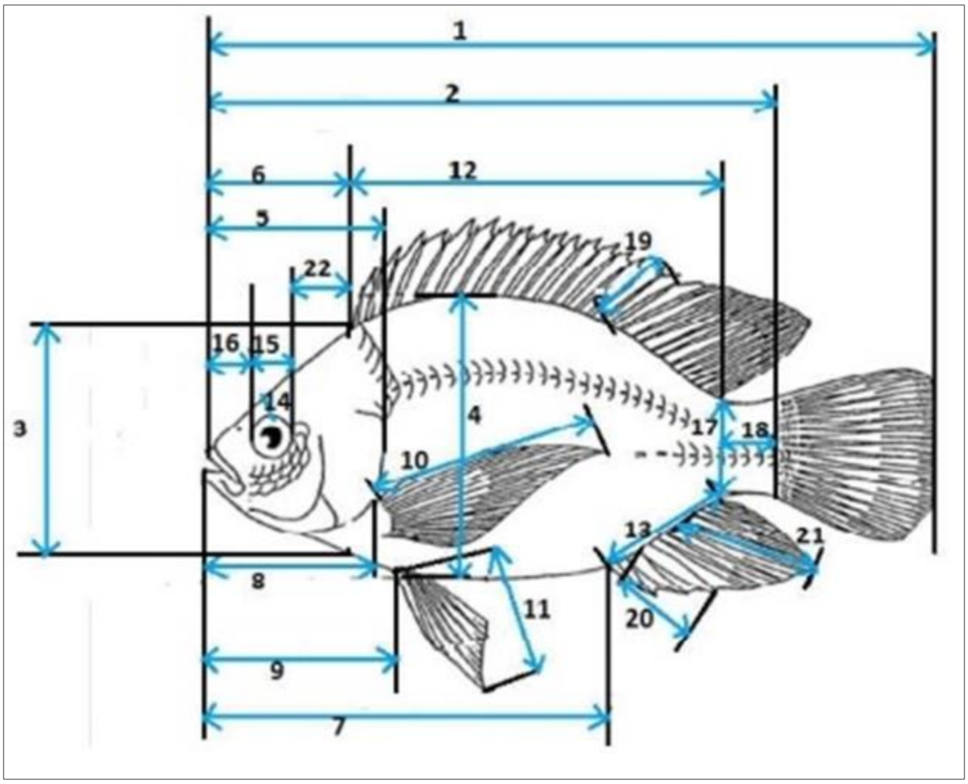

Figure 2 Technical terms and morphological measurements of *O. niloticus* and Wesafu (Adopted from Vreven et al., 1998): 1 – Total length, TL; 2- Standard length, SL; 3 – Head depth, HD; 4 – Body height, BH; 5 – Head length, HL; 6 – Pre-dorsal distance, PDD; 7 - Pre-anal distance, PAD; 8 – Pre-pectoral distance, PPD; 9 – Pre-ventral distance, PVD; 10 – Pectoral fin length, PFL; 11 – Ventral fin length, VFL; 12 –Dorsal base fin length, DFBL; 13 –Anal fin length, AFL; 14 – inter-orbital distance, IOD; 15 – Eye diameter, ED; 16 –Snout length, SnL; 17 –Caudal penduncle length, CPL; 18 – Caudal pendincle depth, CPD; 19 – Greatest dorsal spine length, GDSL; 20 –Third anal spine length, TASL; 21 –Longest anal ray length, LARL; 22 –Post-orbital length, POL

The underlisted meristic traits were counted: dorsal fin spines count (DFS), dorsal fin rays count (DFR), pectoral fin rays count (PeFR), ventral fin spines count (VFS), caudal fin rays count (CFR), anal fin spines count (AFS) and anal fin rays count (AFR).

2.2 Data Analysis

The raw data generated was analyzed using Past3.6 to determine range, means and standard error. The t-test was used to compare the means of morphological data between *O. niloticus* and the putative hybrid. The method described by [13] was followed to minimize the effect of size by transforming morphometric characters to allometric ratio. All the characters were assumed as Y and showed a positive correlation with the total length (x) using the regression formula (Y = a + bx), whereas the value of a and b for various Y are given in Table 1

The coefficient of variation (CV) was calculated as: % CV = (standard deviation / mean) × 100 [14]. When% CV ≤ 10%, the population is very homogeneous; CV> 10% the population is heterogeneous. It makes it possible to evaluate the variations of a character within the populations.

2.3 Length-weight relationship

The length-weight relationships of the fish were evaluated. This was obtained from the relationship:

W = aLb ( ), Where W = body weight (g); L = Total length of species (cm); a = intercept and b = slope

The linear regression was obtained by a logarithm transformation according to the formula:

Log10W = log a + b log10L

2.4 Condition factor

The condition factor (K) of the species was estimated using the Fulton's condition factor relationship;

$$K = 100W / L3$$

Where K = condition factor W = Weight of species (g)

L = Total length of species (cm). The mean total length and weight of each species was used for the analysis. The use of condition is extensively common in fisheries research in a morphometric condition index.

3 Results

Specimen of the putative hybrid, Wesafu weighing more than 300gms were excluded in the study, resulting in a combined total of 153 specimens of tilapia (*O. niloticus* and Wesafu) obtained from different locations.

3.1 Morphometric characteristics of Wesafu and *Oreochromis niloticus*

The range, mean and standard error of the morphometric characteristics for the putative tilapia hybrid, (Wesafu) and *O. niloticus* are presented in Table 1. The total body weight and total length were in the range of 5.5 g - 265.1g and 7.7cm - 24.5cm, respectively in the putative tilapia hybrid while *O. niloticus*, it was 21.00g - 52.50g and 4.5 cm - 15.5cm respectively. The mean value of the body weight in the hybrid (Wesafu) was 26.86±4.04 and was observed to be lower than the mean value of the body weight in *O. niloticus*. The degree of variation was significant ($p<0.05$).The head depth, pre-anal distance, anal fin length, longest length and gape were not significantly different between the populations ($p> 0.05$). Other morphometric traits examined showed substantial evidence for unequal means ($p< 0.05$). The coefficients of determination adjusted for the analysis models were relatively high except for CPD, AFL, POL and gape in *O. niloticus* and the putative hybrid where the R^2 were less than 0.5.

Descriptive analysis of *O. niloticus* population showed that ten (10) – SL, HD, HL, DFL, PFL, BDH, Pre-dorsal length, pre-ventral length, pre-pectoral length and dorsal spine length of the morphometric variables showed low variability (CV< 10%) implying homogeneity in those characters. However, all the metric characters measured in the putative hybrid showed CV greater than 10, the population being highly heterogenous. To estimate the importance of morphometric measurements for identification or classification of the two species, univariate analysis of the morphometric traits measured expressed as ratios relative to the standard length of each individual was run. With the exception of POL, Longest length, Greatest dorsal spine length, and third anal fin length, all other variables measured showed substantial evidence of differences between the putative hybrid and *O. niloticus*.

Table 1 Variation of metric and equation of relationships for the morphometric characteristics of Wesafu and *O.niloticus*

Traits	Putative tilapia hybrid (Wesafu), N= 129				*Y=a+bx*	CV%	*O. niloticus*, N=24				Y=a+bx	CV%
	Min	Max	X±Se	% Tl			Min	Max	X±Se	% Tl		
W	5.5	265.1	26.86±4.04				21.3	51.7	32.88±1.76			
TL	7.7	24.5	10.66±0.31		3.52±0.12	32.94	4.5	15.5	13.13±0.44			16.28
SL	5.8	18.5	8.07±0.22	75.71	Y=1.0029x+0.11637	31.03	8.5	11	10.06±0.16	76.62	Y=0.61471x+0.4945	7.79
HL	2.5	8.5	2.71±0.12	33.02	Y=0.84196x+0.5695	39.11	3.5	4.5	3.49±0.05	30.08	Y=0.2794x+0.94238	7.34
HD	2.2	6.2	2.87±0.05	27.67	Y=0.96539x+0.5721	29.56	3	4.1	3.95±0.05	26.66	Y=0.8652x+0.63997	7.98
BH	2.3	8.8	3.70±0.12	34.71	Y=0.85344x+0.54484	37.94	3.4	4.5	3.95±0.06	26.66	Y=0.70006x+0.69203	7.92
PDD	2.5	7.5	3.28±0.10	30.77	Y=0.89007x+0.5689	34.93	3.5	5	4.26±0.83	32.44	Y=0.4277x+0.84077	9.59
PAD	3	15.5	6.41±0.19	60.13	Y=0.92448x+0.2809	33.18	4.2	8.8	7.36±0.18	56.05	Y=0.22192x+0.9175	12.49
PPD	2	6	2.83±0.08	26.55	Y=0.93366x+0.6029	30.45	3	4	3.44±0.05	26.20	Y=0.89608x+0.6294	8.33
PVD	2.3	7.5	3.39±0.09	31.80	Y=0.96815x+0.5131	31.46	3.5	4.3	3.94±0.06	30.01	Y=0.71414x+0.6850	8.27
PPFL	1.4	8.5	2.90±0.13	27.20	Y=0.48544x+0.8077	51.45	3.4	4.7	3.96±0.07	30.16	Y=0.43811x+0.8431	9.33
VFL	1.2	8.5	2.38±0.11	22.33	Y=0.52641x+0.8347	53.52	2.2	3.7	3.04±0.08	23.15	Y=-0.19166x+1.201	13.25
DFBL	3.5	11.5	4.64±0.14	43.53	Y=0.68527x+0.5674	34.12	4.7	6.3	5.47±0.09	41.66	Y=0.22394x+0.9441	8.39
AFL	0.9	5.3	1.55±0.09	14.54	Y=0.50618x+0.9336	67.94	1.2	2	2.46±0.80	18.74	Y=-.052205x+1.123	98.86
IOD	0.4	1.5	0.59±0.02	5.53	Y=0.65251x+1.1738	38.84	0.8	1	0.95±0.02	7.24	Y=0.21451x+1.1971	15.32
ED	0.7	1.6	0.87±0.02	8.16	Y=1.0042x+1.0833	23.48	0.5	0.7	0.54±0.02	4.11	Y=0.1107x+1.1121	12.07
Snout	0.5	2.0	0.92±0.02	8.6	Y=0.5544x+1.0925	47.97	0.7	1.3	0.96±0.03	7.31	Y=-0.13088x+1.105	18.70
CPL	1.0	3.7	1.51±0.05	14.17	Y=0.85132x+0.8755	37.54	1.3	2	1.72±0.04	13.10	Y=0.29605x+1.0405	11.98
CPD	0.2	2.0	0.92±0.12	8.63	Y=0.57986x+1.0432	28.84	0.6	1.3	1.07±0.03	8.15	Y=0.1356x+1.1058	16.97
GDSL	0.7	3.3	1.19±0.05	11.16	Y=0.63278x+0.9816	43.62	1.2	1.7	1.45±0.28	11.04	Y=0.34993x+1.0529	9.72
TASL	0.8	3	1.17±0.04	10.98	Y=0.9081x+0.96616	34.93	1	2.5	1.45±0.06	11.04	Y=0077186x+1.1079	23.19
LaRL	1.0	5.0	1.85±0.07	17.35	Y=0.72161x+0.8387	43.08	1.4	2.7	2.20±0.68	16.76	Y=0.49701x+1.0124	15.28
POL	1.2	4.2	1.75±0.06	16.32	Y=0.86573x+0.8181	36.19	1.7	3.8	2.20±0.09	16.75	Y=0.088716x+1.079	21.82
Gape	0.7	1.6	0.90±0.04	8.44	Y=0.15339+1.0268	90.23	0.6	1.6	1.08±0.05	8.23	Y=0.0038512x+1.109	31.62

Where: Min=minimum, Max=maximum; X=mean, SE= Standard error

3.2 Meristic characteristics of Wesafu and *O.niloticus*

The range, mean, standard error, median and mode of the meristic characteristics for the putative hybrid, Weasfu and *O. niloticus* are presented in Table 2. In case of dorsal fin spines (14-17), dorsal fin soft rays (12-16), pectoral fin soft rays (12-16), pelvic fin spines (1), and caudal fin rays (14-21) in *O. niloticus*. The same measurements were recorded respectively as 16-18, 11-15, 12-15, 1 and 11-19 in the putative hybrid. Non-significant differences were observed in the pectoral fin and anal fin spine and ventral fin spines of the two species (p>0.05). The most frequent number of DFR, PeFR, AFR, DFS and CFR were respectively 15, 15, 9, 16 and 18, for *O. niloticus* and 16, 14, 14, 13 and 17 for Wesafu.

Table 2 Variations in meristic characteristics of hybrid and *O. niloticus* from Epe Lagoon, Lagos

Traits	*O. niloticus* (24)					Putattive hybrid (129)					
	Min	Max	X±SE	Median	Mode	Min	Max	X±SE	Median	Mode	Sig
DFR	12	16	13.94±0.12	14	15	16	18	16.54±0.15	16	16	***
PeFR	12	16	13.87±0.10	14	15	12	15	13.79±0.21	13	14	NS
AFR	9	11	9.56±0.05	10	9	8	19	14.04±0.53	14	14	***
AFS	3	3	3.0±0.00	3.00	3	3	3	3.00±0.00	3	3	NS
VFS	1	1	1±0.00	1.00	1	1	1	1±0.00	1	1	NS
DFS	14	17	15.82±0.06	16	16	11	15	13.17±0.23	13	13	***
CFR	14	21	17.81±0.15	18	15	11	19	16.63±0.31	17	17	***

Where, MIN= minimum, MAX= maximum, X= mean, SE= standard error, SD= standard deviation, Sig= Significance difference, *** = p<0.001, NS=No significant difference

3.3 Length-weight relationship and condition factor of species

The regression coefficient, coefficient of determination, correlation coefficient and condition factor of *O. niloticus* and the putative hybrid are shown in Table 3 and Fig. 3 and 4. The result showed that the hybrid (Wesafu) and *O. niloticus* exhibited negative allometric growth pattern of 2.77 and 2.84. While the Fulton Condition Factor of Wesafu and *O. niloticus* were 1.98 and 1.01 respectively. The Fulton condition factor of Wesafu was higher than *O. niloticus*.

Table 3. Correlation and condition factor of *Oreochromis niloticus* and wesafu

Location	A	b	r^2	K
Hybrid	0.0242	2.7724	0.7264	1.9824
O. niloticus	0.0194	2.8442	0.8615	1.0069

Where a = intercept, b = slope, r^2 = coefficient of determination, K = condition factor.

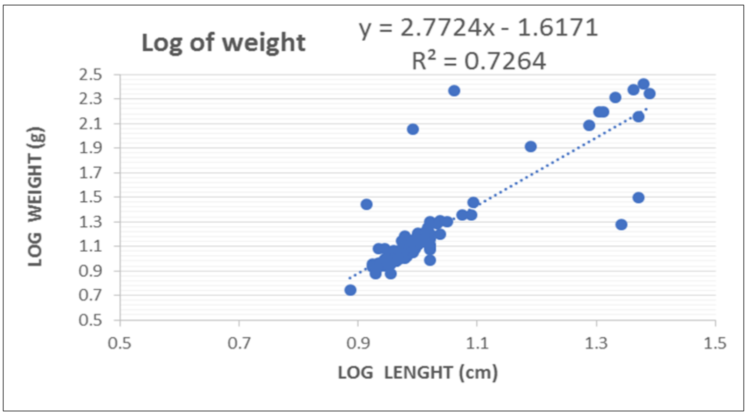

Figure 3 Length weight relationship for Wesafu

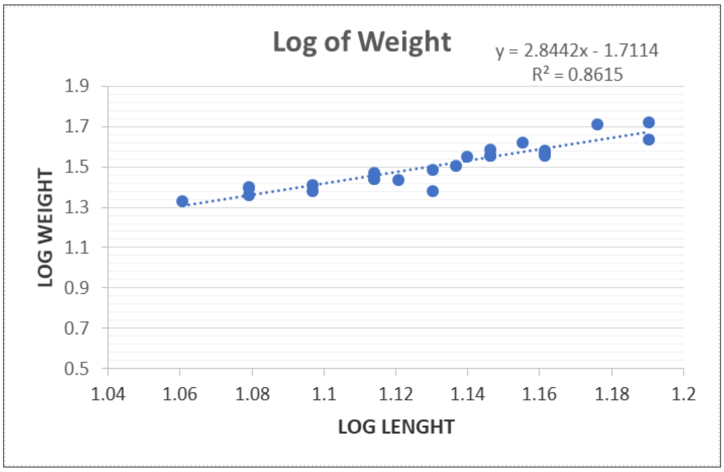

Figure 4 Length weight relationship for *O. niloticus*

4 Discussion

It is generally complex and difficult to differentiate among many cichlids. This is because of high level of similarity due perhaps to the production of fertile hybrids from inter-specific spawning [15]. However, samples analyzed in this study present a range of metric and meristic characters which fits into some specific range reported for *Oreochromis niloticus* and *Copton guineensis* (16, 17, 18, 19, 20]. The present morphometric analysis of an 'ecotype' tilapia hybrid called 'Wesafu' and *O. niloticus* from Epe Lagoon and New Calabr Rivers, respctvely revealed high variability between the two and the morphometric measurements in Wesafu were not intermediate contrary to expectations. The analysis clearly showed distinct morphological differences between *O. niloticus* and "Weasfu", which nullifies the hypothesis that the morphometric traits of Weasfu would be some-how intermediate of *O. niloticus*.

The morphological characteristics studied in this study have made it possible, based on the morphometric characters, to compare Wesafu and *O. niloticus* populations. The eye diameter observed in *O. niloticus* and the putative hybrid agrees with the range obtained by [18, 21, 22], The eye diameter in this study is different from those of other cichlids – *Coptodon guineensis* (1.2cm) and *Sarotherodon galilaeus* (1.2cm) reported by [21]. In the opinion of [23], eye diameter is heritable within species because it is subject to selection. Therefore, the eye diameter can serve as a basis of differentiating this putative hybrid from other tilapine species found in the lagoon. The mean values obtained in this study for AFL, HL, BD and CPL fits within the range reported for *Copton zilli* by [24]. The mean values of most morphometric measurements in the putative hybrid were higher than that of the *O. niloticus* except in PDD, POL, LaRL, IOD, VFL, and PPFL. The morphological variability might be attributed to species morpho-genetic difference and environmental conditions.

Even in *O. niloticus* from different populations significant morphological differences were detected across range of environmental gradients [25] due to genetic differentiations, food composition, depth, stocking density, farming method (pond or cage), habitats, and water quality [26, 27]. Of all the morphometric traits examined in *O. oreochromis* 10 of them – SL, HD, HL, DFL, PFL, BDH, Pre-dorsal length, pre-ventral length, pre-pectoral length and dorsal spine length of the morphometric, variables showed low variability (CV< 10%) implying homogeneity in those characters. The large variations in parameters as reflected in Wesafu (CV≤10%) demonstrates that the population is heterogeneous and characters may not be stable. Among these most discriminating parameters are those in which both showed remarkably high variation (CV≤10) including the interorbital diameter which could be considered as a key ecological trait related to fish habitat [23],

The Wesafu further showed greater morphological ratios (Table 1). This is in agreement with Ramli et al. [13] who reported the trend in hybrid *O. niloticus*. The HL and HD in this study were smaller than obtained in *O. niloticus* and this according to Melo et al. ((2013) [28] suggested that small head size resulted in higher yield of fillet instead of body ratio. Heterogeneity was observed in all meristic traits of the species except for Dorsal fin spines and Ventral fin spines.

4.1 Length-weight relationship and Condition factor

The characteristic feature of length-weight relationship exponent - b was used to determine the growth pattern in this study. According to [29] the value of b is an exponent indicating an isometric growth when equal to 3 and indicating an allometric growth when significantly different from 3. In *O. niloticus* and Wesafu, the species exhibited a negative allometric growth with a "b" value of 2.8 and 2.7 respectively. It implies that the species becomes slender as it increases in length [30] which is consistent with earlier studies on *O. niloticus* [31, 32, 33]

The Condition factor, K, is also a useful index for assessing the capacity of the environment to provide adequate nourishment and protection to the fish. The K values obtained in both cases was more than 1 which indicates that the fish was healthy and biologically active. Hence, K values suggest that the Epe Laggon provided a more favorable ambient environment for growth for Wesafu when compared with NCR for *O. niloticus*. The NCR represented a polluted environment from hydrocarbon resulting illegal oil exploration and refining activities which would undoubtedly affect condition of fish. Generally, the condition factor confirms that the Wesafu grows bigger than other tilapiine species found in natural waters.

5 Conclusion and recommendation

The knowledge of the existence of these variations is important since analysis of phenotypic variations is a basis for identifying stocks as well as evaluating population structure which can also help researchers to practice selective breeding. In conclusion, this study has revealed the morphological differences between *O. niloticus* and a putative tilapia hybrid, Wesafu found in Epe Lagoon. The study focused on metric and meristic characterization of *O. niloticus* from New Calabar River, Rivers State and a putative hybrid, Wesafu obtained from the Epe lagoon, Lagos. This morphological data could be helpful for taxonomy, fisheries and biology of the species. However, in-depth genetic characterization studies are needful, by the use of mitochondrial DNA polymorphism analysis (a practical tool for studying the spatial structure of subpopulations within a species), genetic differentiation between closely related species, or by the use of other tools, such as the micro satellite markers, to validate or invalidate the results obtained. Such studies are needed because the species evolves rapidly.

The morphological architecture and the extent of morphological variations of populations can differ considerably and can largely be explained by current climatic events. Therefore, the continuous and progressive evaluation of morphometric and meristic changes occurring over to time could help our general knowledge of how natural and anthropogenic forces shape morphometric diversification and this will be fundamental for developing successful management and conservation strategies and to identify species and populations with potential for aquacultural purposes.

Compliance with ethical standards

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Disclosure of conflict of interest

No conflict of interest to be disclosed.

Statement of informed consent

This study was conducted in compliance with international research standards and informed consent was obtained from all individual participants included in the study

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