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Comparative studies on the phenotypic variability among the population of Nile tilapia (*Oreochromis niloticus*) caught from rivers Taraba and donga

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Abstract
This study was designed to assess and compare the phenotypic variability among the population of Nile Tilapia (*Oreochromis niloticus*) caught from Rivers, Taraba and Donga. Sixty (60) Nile tilapia **(***Oreochromis niloticus***),** 30 from Tella and 30 from Donga each, were purchased from artisanal fishermen in fish market monthly from July 2023 to October 2023. Descriptive statistics was used to compare the species from the two rivers, Taraba and Donga. The data obtained from the experiment were subjected to t-test at 95% confidence level (p=0.05) with the aid of IBM SPSS version 25. Results obtained present significant different in size-related variation of the fish from the two rivers. Significant difference was observed from the 18 phenotypic attributes measured from the two water source also in all of the ten meristic counts features recorded. A total of 94.4% and 83.3% of morphometric attribute of rivers, Taraba and Donga samples respectively are heterogenous (CV>10%) whereas a total of 80% of meristic attribute in river Taraba samples were heterogenous (CV>10%). The phenotypic variability among the populations of the sample from rivers Taraba and Donga differ suggesting, that their ecological requirements may also differ and should be treated accordingly.

Keywords: Nile tilapia, comparative studies, river Taraba, river donga, morphometric Measurement, meristic count

Introduction
Aquaculture is the world's fastest growing agricultural and food processing sector, and serves a critical role in developing economies through its value chain linkages in promoting food and nutrition security, rural development, and poverty alleviation [1].
Tilapia fish is an indigenous African fish that is widely cultivated especially in Asia and the Middle East [2]. Tilapia is mostly an African Cichlid native to Burkina Faso, Cameroon, Chad, Cole d'Ivoire, Egypt, Gambia, Ghana, Guinea, Liberia, Mali, Niger, Nigeria, Senegal, Sierra Leon, Sudan, Togo, and Uganda. *Oreochromis niloticus* is an important food fish that has been introduced to many different parts of the world by man. In several countries, Nile tilapia has become a problematic invasive species after its introduction [3].
Tilapia is the second most cultured fish species in the world next to carp [4]. It is considered as the ideal fish species for aquaculture mainly due to its rapid growth, high fecundity, ability to resist poor water quality, and good performance under sub-optimal nutritional conditions [5-8] posited that, the identification of threats and morphological and/or molecular characterizations come first when conservation is proposed.
The effect of environmental changes on the growth of Nile tilapia cannot be over emphasized. This is so as, the achievement of the method of farming tilapia relies on various factors which can be difficult to determine the optimal way under certain conditions [9]. identify various factors in environmental changes that can affect the growth of tilapia to include but not limited to; various feed frequencies, various feeding rate, water quality, water temperature, dissolve oxygen concentration, water pH degree, feed and feeding among other.
In the same vein, fish identification studies have been conducted to solve taxonomic uncertainties. A vast majority of tilapia are known for their ability to hybridize as invasive in captivity and within their natural distribution range [10]. In addition, morphometric and meristic methods remain the simplest and most direct way of species identification and can be used as a measure of delineating fish species into strains/ types [11]. Characterization of *O. niloticus* based on morphometric and meristic strains had been reported in several studies.

These studies reported the existence of phenotypic variability among the population of *O. niloticus* fish species from river Taraba and river Donga.

Materials and Methods

Study Area

Donga is a Local Government Area in Taraba State, Nigeria. Its headquarters is Donga town. The coordinates of Donga River lies between Latitude 7°43'00"N and Longitude 10°03'00"E. It has an area of 3,121 km² and a population of 209,400 people according to 2022 National Population Projection.

River Taraba (Tella) is a river in Taraba State, Nigeria, a tributary of the Benue River. The coordinates of River Taraba is between Latitude 8''°34'0"N and the Longitude of 10''°15'0"E. River Taraba takes its source from the high altitude of the Atlantic hills on the Nigeria-Cameroon border in the mid-east part of the state and flows westwards, covering a distance of about 256km before entering the river Benue [12].

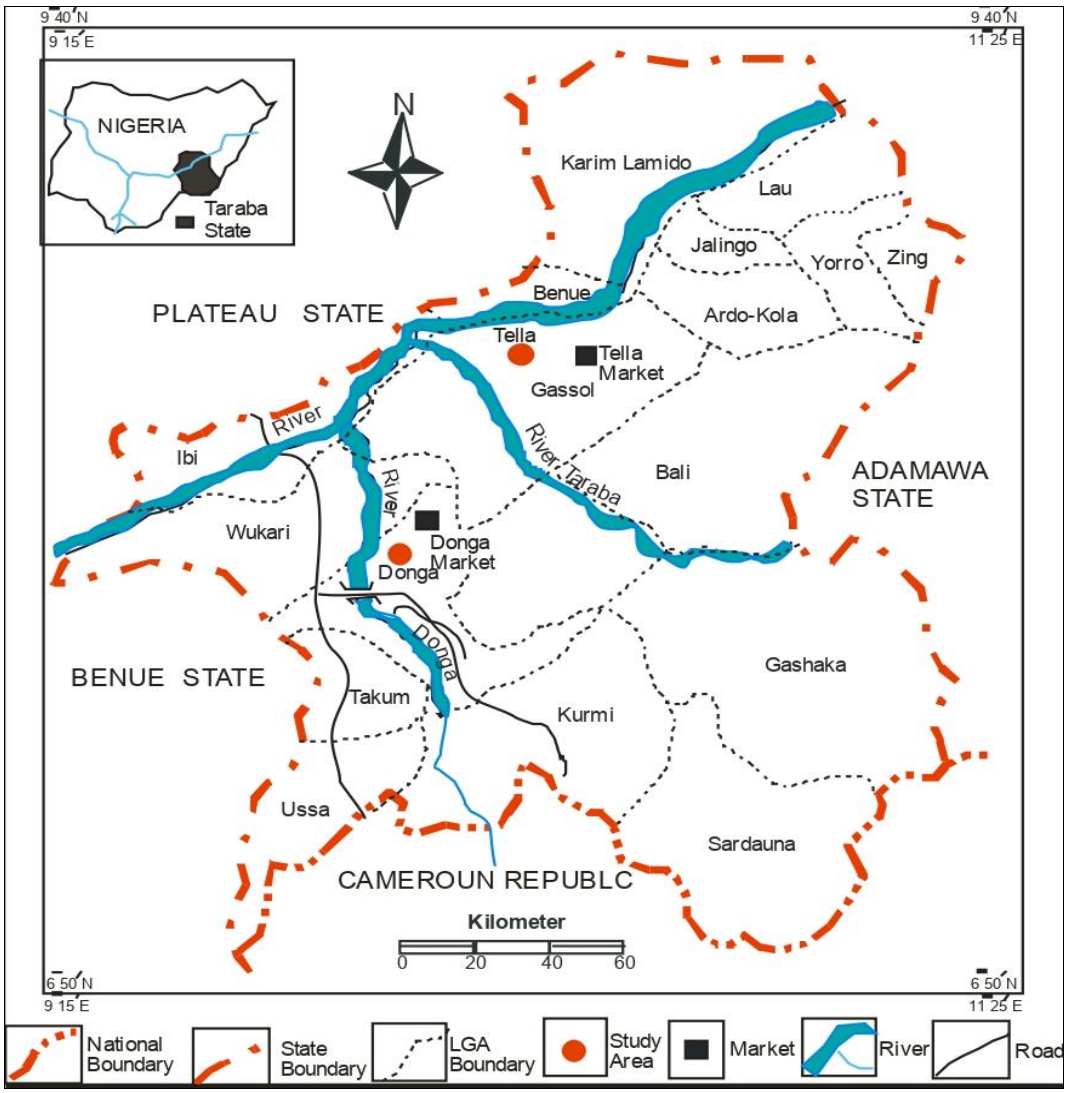

Fig 1: Map of Taraba State Showing Tella and Donga Market Areas (Study area)

Experimental Procedures

A total of sixty (60) Nile tilapia **(***Oreochromis niloticus***)** 30 each, were purchased from artisanal fishermen in the fish market from July 2023 to October 2023 monthly of rivers, Taraba and Donga Local Government Areas of Taraba State. Fish sample were transported in ice-box containing ice block to the Department of Biology Science Laboratory, Federal University Wukari, for; Identification, Morphometric measurement and Meristic count. The sample were preserved in a refrigerator throughout the study period. Sample fish were identified using Nigeria fresh water fish pictorial key guide [13].

Method of Data Collection

Eighteen morphometric and ten meristic attributes were characterized. The morphometric measurements was taken for all the collected samples and measured to the nearest 0.01cm, with transparent ruler. All morphometric length measurements were taken between identical points along the anterior to the posterior axis of the sample fish whereas body depths was taken perpendicularly between the identified points taken at the first dorsal ray and at the caudal peduncle. The Landmarks measured 18 characters in figure 2 shows below.

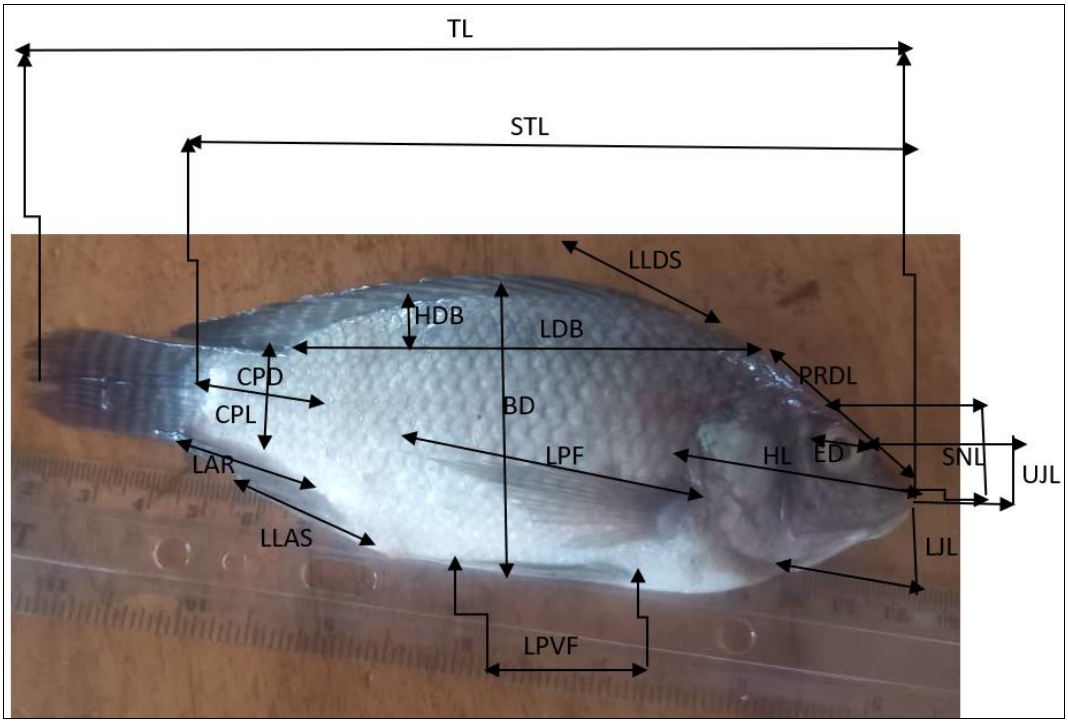

Fig 2: Landmarks showing measured characters

Morphometric Measurement

Morphometric characters were measured using measuring board and transparent Ruler with 0.1 cm accuracy. The following morphometric parameters were recorded: BD (Body Depth.), CPD (Caudal Pendula Depth.), CPL (Caudal Pendula Length), PRDL (Pre Dorsal Length), STL (Standard Length), TL (Total Length), ED (Eye Diameter), LDB (Length of Dorsal Base), HDB (Height of Dorsal Base), HL (Head Length), LLDSP (Length of Longest Dorsal Spin), LPF (Length of Pectoral Fin), LPVF (Length of Pelvic Fin), SNL (Snout Length), UJL (Upper Jaw Length), LJL (Lower Jaw Length), LLAS (Length of Longest Anal Spine) and LAR (Length of Anal Rays).

Meristic Counts

The meristic counts were carried out by counting the number of Dorsal Fin Spines (DFS), Dorsal Soft Ray (DSR), Anal Spines (AS), Anal Gill Rays (AGR), Total Pectoral Rays (TPR), Scale Along the Lateral Line (SCALL), Scale Above the Lateral line (SCALL), Scale Below the Lateral Line (SBLL), Scale Below the Dorsal Fin (SBDF) and Scales Around the Caudal Peduncle (SACP) all on the body of the fish.

Data Analysis

The data obtained from the experiment were subjected to t-test for comparison at 95% level of confidence (p=0.05) with the aid of IBM SPSS version 25. Descriptive statistics was used to calculate minimum, maximum and mean of the species from two rivers Taraba and Donga.

Results

Phenotypic descriptors of morphometric character of Nile tilapia (*Oreochromis niloticus*) caught from rivers Taraba and donga.

(Table 1) showed mean value of the morphometric characters of river Taraba, the fish sample value varied from 1.88±1.39 in HBD to 15.49±2.74 in TL while that of Donga varied from 2.00±0.89 in HBD to 14.76±2.25 in TL. The coefficient of variability (CV) of river Taraba fish sample varied from 10.37% in ED to 73.93% in HBD while Donga fish sample varied from 6.22% in ED to 43.91 in LPVF. The highest (5.69cm) body depth was recorded from (*O. niloticus)* of Donga. There was significant difference (p<0.05) between the body depth value of (*O. niloticus*) caught from River Taraba compared to those caught from Donga. The highest (15.49cm) Total length was recorded from *O. niloticus* of river Taraba. There is significant difference (p<0.05) between the total length value of *O. niloticus* caught from Donga compared to those caught from river Taraba. A total of 94.4% and 83.3% of morphometric attributes of rivers Taraba and Donga sample were heterogenous (CV>10%). The heterogenous attributes of river Taraba are BD, CPD, CPL, PRDL, ST, TL, LDB, HDB, HL, LLDSP, LPF, LPVF, SNL, UJL, LJL, LLAS, and LAR, whereas Donga sample are BD, CPL, CPD, PRDL, STL, TL, LDB, HDB, HL, LLDSP, LPF, LPVF, SNL, LLAS and LAR. The lowest (2.71cm) caudal pendula depth value of *O. niloticus* was recorded in Donga. There was no significant difference (p>0.05) between the caudal pendula depth value of *O. niloticus* caught from Donga compared to those caught from river Taraba.

Table 1: Showed mean value of the morphometric characters of river Taraba

Location	River Taraba				Donga				
Phenotype (cm)	**Min**	**Max**	**Mean±SD**	**CV%**	**Min.**	**Max.**	**Mean±SD**	**CV%**	**t- value**
BW(g)	8.70	158.80	47.70±38.16	80.00	24.10	113.20	56.20±21.50	38.25	-2.26
BD	3.70	7.50	5.51±1.07	19.41	3.00	7.30	5.63±0.87	15.28	-0.70
CPD	2.00	3.40	2.76±0.37	13.40	1.50	3.20	2.71±0.35	12.91	0.44
CPL	1.90	3.70	2.86±0.55	19.23	2.20	3.40	2.85±0.30	11.62	0.05
PRDL	3.90	7.00	5.38±0.82	15.23	4.20	6.40	5.33±0.30	11.63	0.25
STL	9.20	18.00	12.74±2.42	18.99	9.80	19.00	12.90±1.99	15.42	-0.27
TL	11.30	21.20	15.49±2.74	17.68	11.30	20.20	14.76±2.25	15.24	1.11
ED	1.70	2.80	2.02±0.21	10.37	1.70	2.30	2.09±0.13	6.22	-1.58
LDB	4.50	10.60	7.69±1.52	19.76	6.10	9.90	7.64±0.96	12.56	0.16
HDB	1.20	8.00	1.88±1.39	73.93	1.50	4.30	2.00±0.89	44.5	-0.39
HL	1.30	6.30	4.65±1.15	24.73	2.20	6.00	4.66±1.08	23.17	-0.03
LLDSP	2.30	4.60	2.90±0.44	15.17	2.00	4.60	3.13±0.65	20.76	-1.64
LPF	2.40	7.20	4.93±1.36	27.58	3.50	7.00	5.08±0.87	17.12	-0.49
LPVF	2.80	5.70	4.27±0.72	16.86	2.30	14.30	4.60±2.02	43.91	-0.85
SNL	2.00	3.50	2.69±0.34	12.63	2.20	5.00	2.85±0.56	19.64	-1.38
UJL	1.80	3.30	2.26±0.40	17.46	1.80	2.80	2.31±0.25	10.82	-0.49
LJL	1.70	3.00	2.28±0.37	16.22	1.70	3.00	2.29±0.23	10.04	-0.08
LLAS	2.00	4.90	3.35±0.61	18.2	1.50	4.00	2.72±0.62	22.79	3.93
LAR	2.00	5.40	3.17±0.88	27.76	2.20	4.90	3.52±0.67	19.03	-1.70

Keys: BD (Body Depth.), CPD (Caudal Pendula Depth.), CPI (Caudal Pendula Length), PRDL (Pre Dorsal Length), STL (Standard Length), TL (Total Length), ED (Eye Diameter), LDB (Length of Dorsal Base), HDB (Height of Dorsal Base), HL (Head Length), LLDSP (Length of Longest Dorsal Spin), LPF (Length of Pectoral Fin), LPVF (Length of Pelvic Fin), SNL (Snout Length), UJL (Upper Jaw Length), LJL (Lower Jaw Length), LLAS (Length of Longest Anal Spine), LAR (Length of Anal Rays).

The meristic count character of Nile tilapia (*Oreochromis niloticus*) caught from rivers Taraba and donga

Table 2 in respect to the meristic attribute, the mean value varied from 3.13±0.73 in AR to 53.53±13.04 in SACP of river Taraba samples while mean value of the donga fish samples varied from 3.63±1.93 in AR to 51.76±10.74 in SACP. The coefficient of variability of river Taraba samples varied from 10.37% in ED to 73.93 in HDB while Donga samples varied from 6.22cm in ED to 44.5 HDB. A total of 80% of meristic attributes in river Taraba samples were heterogenous (CV>10%) whereas 90% of Donga samples were heterogenous (CV>10%).

Table 2: Respect to the meristic attribute, the mean value varied from

Location	River Taraba				Donga				t- value
Phenotype	**Min**	**Max**	**Mean ±S.D**	**CV%**	**Min**	**Max**	**Mean ±S.D**	**CV%**	
DFS	13.00	18.00	16.63±1.12	6.73	15.00	18.00	16.26±0.73	4.48	2.50
DSR	9.00	13.00	11.96±0.88	7.35	11.00	13.00	12.10±0.48	13.96	2..53
AR	3.00	7.00	3.13±0.73	23.32	3.00	10.00	3.63±1.93	53.16	3.02
ASR	7.00	12.00	8.66±1.29	14.89	3.00	12.00	9.13±2.33	25.52	1.62
TPR	9.00	22.00	12.03±2.14	17.89	10.00	14.00	12.33±0.92	27.46	2.02
SCALL	18.00	49.00	30.10±7.70	25.58	20.00	38.00	27.90±4.65	16.66	4.45
SCABLL	24.00	57.00	36.36±7.16	19.69	21.00	44.00	33.83±4.94	14.60	2.76
SBLL	10.00	54.00	37.66±8.56	22.72	13.00	50.00	34.70±9.86	28.41	2.22
SBDF	9.00	22.00	13.23±3.09	23.35	7.00	53.00	14.86±9.37	63.05	3.29
SACP	29.00	81.00	53.53±13.04	224.36	31.00	78.00	51.76±10.74	20.74	1.06

Keys: DFS (Dorsal Fin Spines), DSR (Dorsal Spines Rays), AR (Anal Rays), ASR (Anal Ray Spines), TPR (Total Pictorial Rays), SCALL (Scale Along Lateral Line), SCABLL (Scale Around the Lateral Line), SBLL (Scale Below the Lateral Line), SBDF (Scale Below the Dorsal Fin), SACP (Scale Around the Caudal Peduncle.

Discussion

Comparison of the findings of Nile tilapia *(Oreochromis niloticus)* from rivers Taraba and donga

[14] Reported that among the morphometric characters; weight (W), TL, and PAL showed higher value in all the fish sample populations. The age of fish was not considered in the analysis as there was a high similarity in total length and standard length. The coefficient of variability was less than 4%, which indicated that the age of the sampled fish were very similar. There was no significant difference (p>0.05) between morphometric attributes between males and females in all the sampled populations, so the effect of sex was not considered further in the analysis.

High value of coefficient of variation (between 23% and 38%) of body weight among the fish sample of the three populations were recorded. There was a significant difference (p<0.05) in body weight among the fish samples collected from the three water bodies. The highest (11.3258±2.62520gm) mean value from Lake Koka was displayed. The ratio of POL/SL also showed a high value (22%) of coefficients of variation. Moreover, ratios of ED/SL and CH/SL showed roughly a coefficient of variation between 10 and 15%. All other morphometric characters showed a coefficient of variation lower than 10%. The results from the study further revealed all the coefficients of variation of different morphometric

characters were significantly different (p<0.05) between populations.

(Table 1) showed the mean value of the morphometric characters of river Taraba fish samples varied from 1.88±1.39 in HBD to 15.49±2.74 in TL 12.74±2.42 in STL while that of Donga varied from 2.00±0.89 in HBD to 14.76±2.25 in TL to 12.90±1.99 in STL. The coefficient of variability (CV) of river Taraba fish samples varied from 10.37% in ED to 73.93% in HBD, while that of Donga fish samples varied from 6.22% in ED to 43.91 in LPVF. The highest body depth was (5.69cm) of (*Oreochromis niloticus)* recorded in Donga. There was significant difference (p<0.05) between the body depth values of (*Oreochromis niloticus*) caught from River Taraba compared to those caught from Donga.

[15] Reported similar result of highest mean for standard-length value (18.98±2.161) of *O. niloticus* population from Victoria followed by Kyoga (18.68±3.19) while Rwabirundo (15.69±0.76) had the least mean standard-length value [16]. Reported significant differences (p<0.05) in all morphometric parameters and in three out of five meristic counts from Kainji Lake. Table 2 in respect to the meristic attributes the mean value varied from 3.13±0.73 in AR to 53.53±13.04 in SACP in river Taraba fish samples while the mean value of the Donga fish samples varied from 3.63±1.93 in AR to 51.76±10.74 in SACP.

The Coefficient of variability of river Taraba sample varied from 10.37% in ED to 73.93 in HDB while Donga samples varied from 6.22cm in ED to 44.5 HDB. The study of [17] recorded significant differences (p<0.05) in all meristic counts of the four cichlids assessed from Kainji Lake. This findings demonstrated that, in comparison to fish sample from River Taraba, the Nile tilapia from Donga River had a considerably greater body size and deeper body form. The populations from Donga had the highest (56.21g) mean body weight, while River Taraba recorded highest (47.70g) mean body weight. According to [2] size of fish is more important than its age, mainly because several factors in taxonomy, ecology, and physiology are more size-dependent than age-dependent. The greater size of the body in the Nile Tilapia from the Donga River may be related to variations in environmental conditions such as food supply, water temperature, or pressure from predators.

Conclusion

The study found that the Nile Tilapia from the Donga River had larger bodies and deeper forms compared to those from the river Taraba. The Nile tilapia population from Donga had the high standard-length value and the high body weight, indicating that size is more important than age in taxonomy, ecology, and physiology. Previous studies [18-19] have shown that Nile Tilapia is able to modify their body size in response to environmental factors such as the availability of food and the pressure from predators. Nile Tilapia may have evolved more deeply set bodies to better grasp these prey items when food supplies [20].

The phenotypes of the populations from rivers Taraba and Donga differ suggesting, that their ecological requirements may also differ and they should be treated accordingly. In this study, morphometric and meristic features were used as they still remain reliable tools to characterize fish species. Tilapia from the Donga River had a considerably greater body size and deeper body form, as they had the high mean standard-length and body weight value. This might have occurred as a result of environmental fluctuations. It could be suggested that for Nile tilapia farming program the River Donga side should be preferred based on sizes and biomass.

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