Research Article

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Journal of FisheriesSciences.com
ISSN 1387-234X

2024
Vol.18 No.6:051

Comparative Studies on the Phenotypic Variability among the Population of Nile Tilapia (*Oreochromis niloticus*) Caught from Rivers Taraba and Donga

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Received: May 03, 2024 Manuscript No. IPFS-24-14753; **Editor assigned:** May 08, 2024, PreQC No. IPFS-24-14753 (PQ); **Reviewed:** May 22, 2024, QC No. IPFS-24-14753; **Revised:** December 02, 2024, Manuscript No. IPFS-24-14753 (R); **Published:** December 30, 2024

Citation: Mohammed AM, Obadiah N (2024) Comparative Studies on the Phenotypic Variability among the Population of Nile Tilapia (*Oreochromis niloticus*) Caught from Rivers Taraba and Donga. J Fish Sci, Vol.18 No.6

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. The results revealed significant size-related variation in the fish from the two different water environments. There is significant differences were observed in the 18 phenotypic parameters measured from the two water source and in all of the ten meristic counts 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%). It could be recommended for further studies to compare the morphological characteristics (such as slope, width, depth and sediment composition) of both rivers to identify similarities and differences in their geomorphology.

Keywords: Nile Tilapia; Comparative studies; River Taraba; River Donga; Morphometric mesurement; 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.

Tilapia fish is an indigenous African fish that is widely cultivated especially in Asia and the Middle East. 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.

Tilapia is the second most cultured fish species in the world next to carp. 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. Asmamaw and Tessema posited that, the identification of threats and morphological and/or molecular characterizations come first when conservation is proposed [1].

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. Abd El-Hack et al. 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 [2].

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. 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. Characterization of *O. niloticus* based on morphometric and meristic traits have also been reported in several studies.

These studies report the existence of both genetic and morphometric differences in the cultured *O. niloticus* fish species from similar indigenous fish species in the wild. While the population characteristics (biology, abundance, condition factors and the reproductive biology) of *O. niloticus* seems to be understudy. It is therefore, against this backdrop, that the current study was necessitated [3].

Materials and Methods

Study area

Donga is a local government area in Taraba state, Nigeria. Its headquarters are in the town of Donga. Donga river lies between latitude 7°43'00"N and longitude 10°03'00"E. It has an area of 3,121 km^2 and a population of 209,400 according to 2022 national population projection. The river arises from the Mambila Plateau in eastern Nigeria, forms part of the international border between Nigeria and Cameroon and flows northwest to eventually merge with the Benue river in Nigeria. The Donga watershed is 20,000 square kilo meters (7,700 sq mi) in area. At its peak, near the Benue the river delivers 1,800 cubic meters (64,000 cu ft) of water per second. A lot of fishing activities go on in the river and thus, Hing is an occupation in the area [4].

River Taraba (Tella) is a river in Taraba state, Nigeria, a tributary of the river Benue. River Taraba is the latitude of 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 256 km before entering the river Benue (Figure 1).

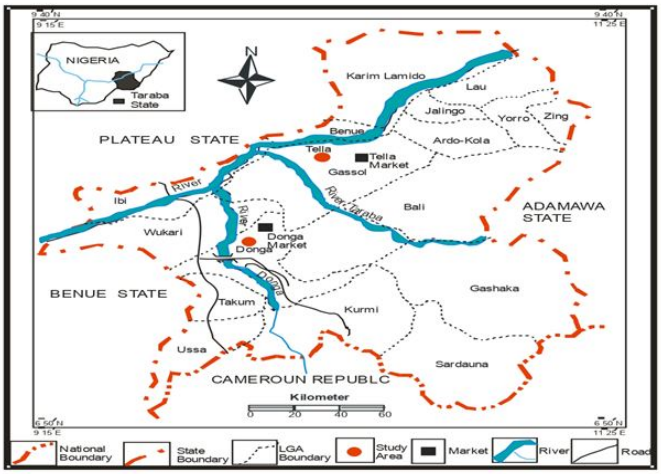

Figure 1: Map of Taraba state showing Tella and Donga market areas (study area).

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. The samples were transported in ice box containing ice block, to the department of biological science laboratory, Federal university Wukari, for; identification, morphometric measurement and meristic count. Fish sample was preserved in a refrigerator throughout the study period in the laboratory. The fish samples were identified using Nigeria fresh water fish pictorial key guide of Olaosebikan and Raji.

Method of data collection

Eighteen morphometric and ten meristic attributes were characterized. Morphometric measurements were taken in all the collected fish samples and measured to the nearest 0.01 cm, transparent ruler. All morphometric length measurements were taken between identical points along the anterior to the posterior axis of the fish, whereas body depths were taken between perpendicularly between the identified points taken at the first dorsal ray and at the caudal peduncle. Landmarks showing measured character in Figure 2 below.

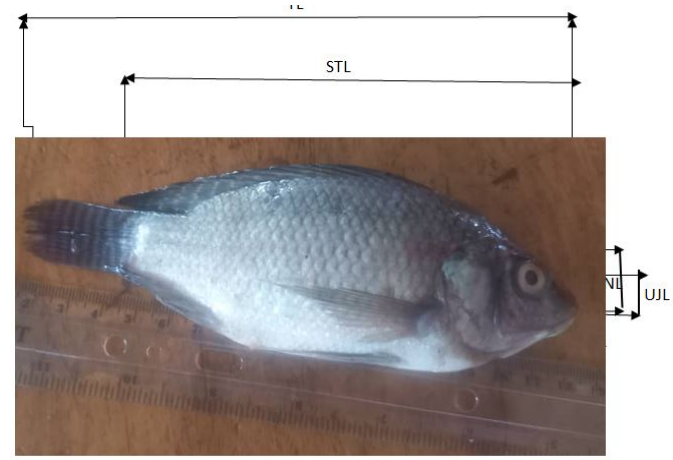

Figure 2: Landmarks showing measured characters.

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.), 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), (Length of Longest Anal Spine) LLAS, (Length of Anal Rays) LAR.

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) Scales Around the Caudal Peduncle, (SACP), on the body of the fish.

Data analysis

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. Descriptive statistics was used to compare the species from the two rivers, Taraba and Donga.

Results

Phenotypic descriptors of morphometric character of Nile Tilapia (*Oreochromis niloticus*) caught from rivers, Taraba and Donga

The mean value of the morphometric characters in Table 1 of river Taraba, fish samples 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 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 high (5.69 cm) body depth was 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.

Table 1: Phenotypic descriptors of the morphometric measurement of Nile Tilapia (*Oreochromis niloticus)* caught from rivers, Taraba and Donga.

Location	River Taraba				Donga				
Phenotype (cm)	**Min**	**Max**	**Mean ± SD**	**CV%**	**Min**	**Max**	**Mean ± SD**	**CV%**	**t-value**
BD	3.7	7.5	5.51 ± 1.07	19.41	3	7.3	5.63 ± 0.87	15.28	-0.7
CPD	2	3.4	2.76 ±0.37	13.4	1.5	3.2	2.71 ± 0.35	12.91	0.44
CPL	1.9	3.7	2.86 ± 0.55	19.23	2.2	3.4	2.85 ± 0.30	11.62	0.05
PRDL	3.9	7	5.38 ± 0.82	15.23	4.2	6.4	5.33 ± 0.30	11.63	0.25
STL	9.2	18	12.74 ± 2.42	18.99	9.8	19	12.90 ± 1.99	15.42	-0.27
TL	11.3	21.2	15.49 ± 2.74	17.68	11.3	20.2	14.76 ± 2.25	15.24	1.11
ED	1.7	2.8	2.02 ± 0.21	10.37	1.7	2.3	2.09 ± 0.13	6.22	-1.58
LDB	4.5	10.6	7.69 ± 1.52	19.76	6.1	9.9	7.64 ± 0.96	12.56	0.16
HDB	1.2	8	1.88 ± 1.39	73.93	1.5	4.3	2.00 ± 0.89	44.5	-0.39
HL	1.3	6.3	4.65 ± 1.15	24.73	2.2	6	4.66 ± 1.08	23.17	-0.03
LLDSP	2.3	4.6	2.90 ± 0.44	15.17	2	4.6	3.13 ± 0.65	20.76	-1.64
LPF	2.4	7.2	4.93 ± 1.36	27.58	3.5	7	5.08 ± 0.87	17.12	-0.49
LPVF	2.8	5.7	4.27 ± 0.72	16.86	2.3	14.3	4.60 ± 2.02	43.91	-0.85
SNL	2	3.5	2.69 ± 0.34	12.63	2.2	5	2.85 ± 0.56	19.64	-1.38
UJL	1.8	3.3	2.26 ± 0.40	17.46	1.8	2.8	2.31 ± 0.25	10.82	-0.49
LJL	1.7	3	2.28 ± 0.37	16.22	1.7	3	2.29 ± 0.23	10.04	-0.08
LLAS	2	4.9	3.35 ± 0.61	18.2	1.5	4	2.72 ± 0.62	22.79	3.93
LAR	2	5.4	3.17 ± 0.88	27.76	2.2	4.9	3.52 ± 0.67	19.03	-1.7

Note: 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 high (15.49 cm) total length was of *O. niloticus* recorded in river Taraba. There is significant difference ($p<0.05$) between the total length values of *O. niloticus* caught from Donga compare to those caught from river Taraba. A total of 94.4% and 83.3% of morphometric attribute of rivers, Taraba and Donga samples respectively are heterogenous (CV>10%). The heterogenous attribute of river Taraba are BD, CPD, CPL, PRDL, ST, TL, LDB, HDB, HL, LLDSP, LPF, LPVF, SNL, UJL, LJL, LLAS and LAR, while that of Donga samples are BD, CPL, CPD, PRDL, STL, TL, LDB, HDB, HL, LLDSP, LPF, LPVF, SNL, LLAS, LAR. The lowest caudal pendula depth value of *O. niloticus* was (2.71 cm) recorded in Donga. There was no significant difference ($p>0.05$) between the caudal pendula depth values of *O. niloticus* caught from Donga compare to those caught from river Taraba.

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 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. Coefficient of variability of river Taraba sample varied from 10.37% in ED to 73.93 in HDB while that of Donga samples varied from 6.22 cm in ED to 44.5 HDB. A total of 80% of meristic attribute in river Taraba samples were heterogenous (CV>10%), while 90% of Donga samples were heterogenous (CV>10%).

Table 2: Phenotypic descriptors of the meristic count of Nile Tilapia (*Oreochromis niloticus*) caught from rivers Taraba and Donga.

Location	River Taraba				Donga				
Phenotype	**Min**	**Max**	**Mean ± S.D**	**CV%**	**Min**	**Max**	**Mean ± S.D**	**CV%**	**t-value**
DFS	13	18	16.63 ± 1.12	6.73	15	18	16.26 ± 0.73	4.48	2.5
DSR	9	13	11.96 ± 0.88	7.35	11	13	12.10 ± 0.48	13.96	2..53
AR	3	7	3.13 ± 0.73	23.32	3	10	3.63 ± 1.93	53.16	3.02
ASR	7	12	8.66 ± 1.29	14.89	3	12	9.13 ± 2.33	25.52	1.62
TPR	9	22	12.03 ± 2.14	17.89	10	14	12.33 ± 0.92	27.46	2.02
SCALL	18	49	30.10 ± 7.70	25.58	20	38	27.90 ± 4.65	16.66	4.45
SCABLL	24	57	36.36 ± 7.16	19.69	21	44	33.83 ± 4.94	14.6	2.76
SBLL	10	54	37.66 ± 8.56	22.72	13	50	34.70 ± 9.86	28.41	2.22
SBDF	9	22	13.23 ± 3.09	23.35	7	53	14.86 ± 9.37	63.05	3.29
SACP	29	81	53.53 ± 13.04	224.36	31	78	51.76 ± 10.74	20.74	1.06

Note: 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

[illegible] Donga

[illegible]

The result also showed a very high value of the coefficient of variation (between 23% and 38%) of body weight among the fish samples of the three populations. From their result, body weight (W) showed a very high value of the coefficient of variation (between 23% and 38%). There was a significant difference (p<0.05) in weight among the fish samples collected from the three water bodies. Samples from Lake Koka displayed a higher mean value (11.3258 ± 2.62520 gm). 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%. Their result further revealed all the coefficients of variation of different morphometric characters were significantly different (p<0.05) between populations [6].

[illegible]

[illegible]

The coefficient of variability of river Taraba sample varied from 10.37% in ED to 73.93 in HDB while that of Donga samples varied from 6.22 cm in ED to 44.5 HDB. The study of Olufeagaba et al. recorded signi icant di erence (p<0.05) in nine out of fourteen body related parameters and six out of eight head related parameters, also there is significant di erences (p<0.05) in all meristic count of the four cichlids assessed from Lake Kainji. The findings demonstrated that, in comparison to fish sample from River Taraba, the Nile Tilapia from the Donga River had a considerably greater body size and deeper body form. The population from Donga had the high (56.21 g) mean body weight, while River Taraba recorded (47.70 g) mean body weight. According to Yakubu and Okunsebor the 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 [10].

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 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. 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 recommended that for Nile Tilapia farming program the River Donga side should be preferred based on sizes and biomass.

Competing Interest

The authors declare that they have no known competing financial interest or personal relationships that could have appeared to influence the work reported in this article.

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