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Research Paper

Morpho-Meristic Characteristics of Local and Exotic Nile Tilapia Strains: Identification of Traits for Genetic Improvement in Local Strains

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ABSTRACT: *Comparative morphology of local and exotic tilapia was carried out using exotic strains (Thai and Swansea) and local strains obtained from Makurdi. The measurable morphometric characters used were Total length (TL), Standard length (SL), Dorsal Fin length (DFL), Anal Fin Length (AFL), Length of Last Dorsal Spine (LDS), Length of Third Anal Spine (LTAS), Pelvic Fin Length (PFL) Pre-Dorsal Distance (PDD), Pectoral Fin Length (PECFL), Pre-Pectoral Fin Length (PPFL), Pre-Orbital Distance (POD), Caudal Peduncle Length (CPL), Pelvic Spine Length (PSL), Pre-Anal Distance (PAD). Lengths were obtained using a ruler and all length measurements were recorded in centimeter (cm) The meristic characters determined are Dorsal fin spines (DFS), Number of dorsal fin spines, Dorsal fin rays (DFR): Number of dorsal fin rays, Anal fin spines (AFS): Number of dorsal fin spines. Makurdi strain had the least value ($p<0.05$) for TL, SL, BH, HL, POD and EHD (11.21, 8.95, 3.41, 3.24, 1.03 and 1.00 cm respectively) compared to the exotic strains that had similar values for the parameters. The Makurdi strain had the least measurements for fin related variables with significant differences ($p<0.05$) occurring between the strains. Spine lengths and distance between fins also differed significantly ($p<0.05$) among the strains with Makurdi strain trailing behind with values of 4.86, 1.00, 1.20, 1.45, and 0.46 cm for DDA, DDC, DCA, LTSA and LFSD respectively. Meristic counts were also significantly lower ($p<0.05$) for Makurdi strain compared to the exotic strains. All the three strains have a strong positive correlation between TL and SL. The Thailand strain had a negative correlation (-0.64) between EHD and TFR while the Swansea strain had negative correlations between AFS and LPEF (-0.46) as well as between DFR and EHD (-0.40). From the foregoing, the Makurdi strain is quite small compared to the exotic strains and will benefit immensely from genetic improvement for profitable aquaculture.*

Keywords: *strain, dorsal fin, spine, pectoral fin, length*

I. INTRODUCTION

All species have linkage through a hierarchical and evolutionary tree that spans several thousands and millions of branches with millions of branches [1]. Each branch itself is a representation of the natural history of a particular species and its pedigree [2]. Speciation is created if there is a blockage of natural gene flow in natural populations either via natural occurrence (barriers created by earthquakes and volcanoes) or artificially created barriers (aquaculture facilities and dams). Under such bottlenecks, two types of speciation will occur: allopatric speciation [3] and sympatric speciation [4]. However, within the sub-populations, genetic diversity creates differences in traits hence the nomenclature of strains.

The stock of Nile tilapia currently under culture worldwide originates from stocks that were received from five countries: Egypt, Sudan, Ivory Coast, Ghana and Uganda [5]. This effectively creates a small founder population with consequent issues of genetic diversity. These founding stocks come from a limited population of wild species [6]. Development of improved strains started as far back as 1960 with introduction of the founding stocks and subsequent distribution of improved strains all over the world [7].

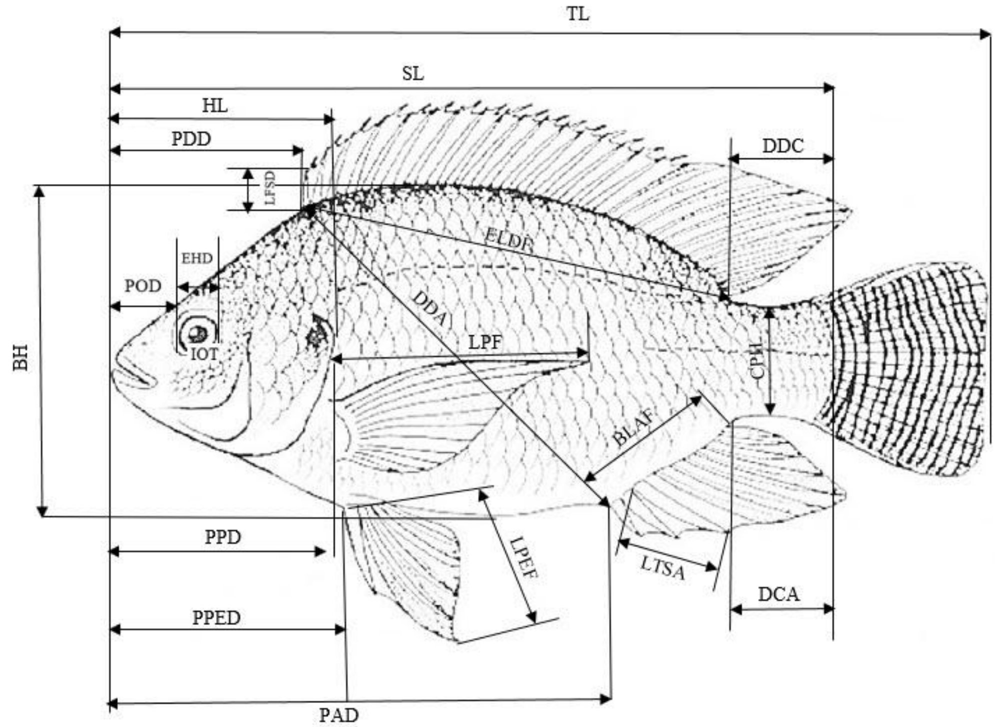
A good number of the populations under culture today are highly inbred considering the small founder stock and the prolific nature of the species [8]. According to Peterman and Phelps [9], dress out percentage of improved Ivory Coast strain of Nile tilapia was better than that of a less domesticated strain. The impact of domestication has often been linked to reduction in genetic diversity [10]. When this is coupled with the fact that the domesticated stocks outperform the less domesticated stocks, it creates a need for improvement of the less domesticated stocks to meet the economic trait that is used to judge them. Individuals that become well adapted to the hatchery environment and give superior performance are usually selected as broodstock for the next generation with subsequent adaptations to the culture environment by the generations that are produced being better than the earlier one [11]. With the domestication of tilapia, selection for growth and survival are common [12]. Caution is needed in selective breeding considering the effect of pleiotropic genes [13]. Khaw, et al. [14] have shown that there is an inverse correlation between selection for improved weight and increased aggressiveness in GIFT tilapia. This is premised on the fact that high coefficients of variation for weight automatically translate to a scenario of dominance and aggressive behaviour. Thus, the main objective of this study was to quantify the morphometric and meristic characteristics of two improved strains and a local strain of Nile Tilapia and determine their variation.

II. MATERIALS AND METHODS

This study was conducted on two strains of exotic tilapia (Thailand strain, n=30; Swansea strain, n=30) raised in concrete tanks in Makurdi (7°47'7.3104"N; 8°34'49.0872"E) while the local strain (n=28) was obtained from earthen ponds in Makurdi as well (7°45'4.1904"N; 8°37'42.6576"E). All samples were collected from cohorts that were one year old.

Morphometric And Meristic Study

The following morphometric measurements (Figure 1) were taken, according to the methods of Boussou, et al. [15]: (1) Total length (TL), Standard length (SL), Body height (BH), Head length (HL), Preorbital distance (POD), Eye horizontal diameter (EHD), Interorbital thickness (IOT), Pre-dorsal fin distance (PDD), Pre-anal distance (PAD), Pre-pectoral distance (PPD), Pre-pelvic distance (PPED), Base length of dorsal fin (BLDF), Base length of anal fin (BLAF), Length of pectoral fin (LPF), Length of pelvic fin (LPEF), Caudal peduncle height (CPH), Distance between dorsal and anal fin (DDA), Distance between dorsal and caudal fin (DDC), Distance between caudal and anal fin (DCA), Length of the third spine of the anal fin (LTSA) and Length of the first spine of the dorsal fin (LFSD). Meristic counts, following Boussou et al. (2010) were: Dorsal fin ray count (DFR), Dorsal fin spine count (DFS), Anal fin rays (AFR), Anal fin spines (AFS), Ventral fin spines (VFS) and Number of superior lateral line scales (SLL). Total weight of each specimen was taken using an electronic weighing scale (Generic Chinese model 10kg, 1g accuracy) while lengths were taken using a stainless steel metre ruler. Measurements were taken after fish were anaesthetized using clove oil (1ppm). Upon completion of measurements, each specimen was allowed to recover in fresh aerated water in a 60L bowl for 10 minutes before being returned to the tank.



Key: TL = Total length, SL = Standard length , BH = Body height, HL = Head length, POD = Preorbital distance, EHD = Eye horizontal diameter, IOT = Interorbital thickness, PDD = Pre-dorsal fin distance, PAD =

Pre-anal distance, PPD =Pre-pectoral distance, PPED = Pre-pelvic distance, BLDF = Base length of dorsal fin, BLAF = Base length of anal fin, LPF = Length of pectoral fin, LPEF = Length of pelvic fin, CPH = Caudal peduncle height, DDA = Distance between dorsal and anal fin, DDC = Distance between dorsal and caudal fin, DCA = Distance between caudal and anal fin, LTSA = Length of the third spine of the anal fin, LFSD = Length of the first spine of the dorsal fin.

Statistical Analysis

The data were classified into three categories based on the location and proximity to prominent body structures as: 1). Body and head related morphometric variables, 2). Fin related morphometric variables and 3). Spine length and fin distance related morphometric variables. One-way analysis of variance (ANOVA) was performed on the morphometric and meristic characters to test the variation for each trait among the Swansea, Thai and local tilapia fish population. Pearson's square correlation was used to determine the relationship between the morphometric and meristic data of each strain. All analyses were carried out using R version 3.4.3 [16].

III. RESULTS

Body and head related morphometric variables of *Oreochromis* sp. of three different origins

A significant difference ($p<0.05$) was observed in body and head related morphometric measurement of the three strains. The Makurdi strain had lower values for TL, SL, BH, HL, EHD, and IOD respectively (Table 1).

Table 1: Body and Head related morphometric variables of *Oreochromis* sp. of three different origins

Origin	TL	SL	BH	HL	POD	EHD	IOT
Makurdi	11.21 ± 0.33^{a}	8.95 ± 0.26^{a}	3.41 ± 0.11^{a}	3.24 ± 0.10^{a}	1.03 ± 0.02	1.00 ± 0.01^{a}	0.36 ± 0.01^{ab}
Swansea	17.52 ± 0.69^{b}	13.99 ± 0.51^{b}	5.38 ± 0.23^{b}	5.15 ± 0.20^{b}	2.73 ± 1.01	1.21 ± 0.04^{c}	0.40 ± 0.01^{b}
Thai	17.46 ± 0.18^{b}	14.14 ± 0.13^{b}	5.60 ± 0.04^{b}	5.18 ± 0.04^{b}	1.90 ± 0.03	1.10 ± 0.02^{b}	0.35 ± 0.01^{a}
p-value	$<2.0\times10^{-16}$	$<2.0\times10^{-16}$	$<2.0\times10^{-16}$	$<2.0\times10^{-16}$	0.143	2.30×10^{-7}	0.005

Means in the same column with different superscripts differ significantly ($p<0.05$)

KEY: TL = Total length, SL= Standard length, BH = Body height, HL = Head length, POD = Preorbital distance, EHD = Eye horizontal diameter, IOT = Interorbital thickness

Fin related morphometric variables of *Oreochromis* sp. of three different origins

There was a significance difference ($p<0.05$) in fin related morphometric measurements of the three strains of tilapia investigated. Lower values were identified with the Makurdi strain for PDD, PAD, PPD, PPED, BLAF, LPF, LPEF, and CPH respectively (Table 2).

Table 2: Fin related morphometric variables of *Oreochromis* sp. of three different origins

Variables	**Origin**			**p-value**
	Makurdi	**Swansea**	**Thai**	
PDD	3.37 ± 0.10^{a}	5.22 ± 0.17^{b}	5.04 ± 0.08^{b}	2.00×10^{-16}
PAD	6.19 ± 0.17^{a}	9.20 ± 0.30^{b}	9.49 ± 0.06^{b}	2.00×10^{-16}
PPD	3.39 ± 0.10^{a}	5.38 ± 0.17^{b}	5.30 ± 0.06^{b}	2.00×10^{-16}
PPED	3.71 ± 0.11^{a}	5.87 ± 0.21^{b}	5.88 ± 0.07^{b}	2.00×10^{-16}
BLDF	4.94 ± 0.16^{a}	7.87 ± 0.30^{b}	8.01 ± 0.10^{b}	2.00×10^{-16}
BLAF	1.60 ± 0.06^{a}	2.69 ± 0.12^{b}	2.57 ± 0.07^{b}	1.59×10^{-13}

Means in the same row followed by different superscripts differ significantly ($p<0.05$)

Key: PDD = Pre-dorsal fin distance, PAD = Pre-anal distance, PPD =Pre-pectoral distance, PPED = Pre-pelvic distance, BLDF = Base length of dorsal fin, BLAF = Base length of anal fin, LPF = Length of pectoral fin, LPEF = Length of pelvic fin, CPH = Caudal peduncle height.

Spine length and fin distance related morphometric variables of *Oreochromis* sp. of three different origins

Spine length and fin distance related morphometric measurements differed significantly ($p<0.05$) among the strains. The Makurdi strain had lower values which for DDA, DDC, DCA, LTSA and LFSD respectively (Table 3).

Table 3: Spine Length and Fin Distance Related Morphometric Variables of *Oreochromis* sp. of Three Different Origins

Origin	DDA	DDC	DCA	LTSA	LFSD
Makurdi	4.86±0.14[a]	1.00±0.03[a]	1.20±0.05[a]	1.45±0.07[a]	0.46±0.01[a]
Swansea	7.72±0.31[b]	1.75±0.07[b]	1.85±0.09[b]	2.13±0.09[b]	0.55±0.03[b]
Thai	8.39±0.32[b]	1.65±0.02[b]	1.96±0.02[b]	2.16±0.05[b]	0.49±0.01[a]
p-value	5.02×10^{-14}	2.00×10^{-16}	7.44×10^{-14}	5.95×10^{-11}	0.001

Means in the same column followed by different superscripts differ significantly ($p<0.05$)

Key: *DDA* = Distance between dorsal and anal fin, *DDC* = Distance between dorsal and caudal fin, *DCA* = Distance between caudal and anal fin, *LTSA* = Length of the third spine of the anal fin, *LFSD* = Length of the first spine of the dorsal fin

Meristic counts of *Oreochromis* sp. of three different origins

A significant difference ($p<0.05$) was observed in mean meristic count of the three strains of tilapia investigated. The Makurdi strain had lower meristic features than the other strains (Table 4).

Table 4: Mean Meristic counts of *Oreochromis* spp. of three different origins

Origin	DFR	DFS	AFR	AFS	SLL
Makurdi	11.32±0.15[a]	16.61±0.14	8.14±0.18[a]	3.00±0.00	20.96±0.36[a]
Swansea	12.23±0.13[b]	16.63±0.11	9.20±0.07[b]	2.97±0.03	22.67±0.44[b]
Thai	12.47±0.10[b]	16.57±0.09	9.00±0.00[b]	3.00±0.00	22.27±0.22[b]
p-value	2.26×10^{-8}	0.917	2.20×10^{-9}	0.385	0.003

Means in the same column followed by different superscripts differ significantly ($p<0.05$)

Key: DFR = Dorsal fin rays, DFS = Dorsal fin spines, AFR = Anal fin rays, AFS = Anal fin spines, SLL = Number of superior lateral line scales.

Correlation of morphometric and meristic characteristics of *Oreochromis* spp.

Considering the Thailand strain (Figure 2), the strongest positive correlation is between SL and TL which is 0.92 while the strongest negative correlation is between EHD and DFR (-0.64). For the Swansea strain, (Figure 3), the strongest positive correlation is also between SL and TL as well as TL and PAD: 0.99 and 0.98 respectively. There were Negative significant correlations between AFS and LPEF as well as DFR and EHD: -0.46 and -0.4 respectively. Within the Makurdi strain, (Figure 4), there is a strong positive Correlation between AD and TL; TL and SL; BH and TL; DDA and BH. No negative correlation was found.

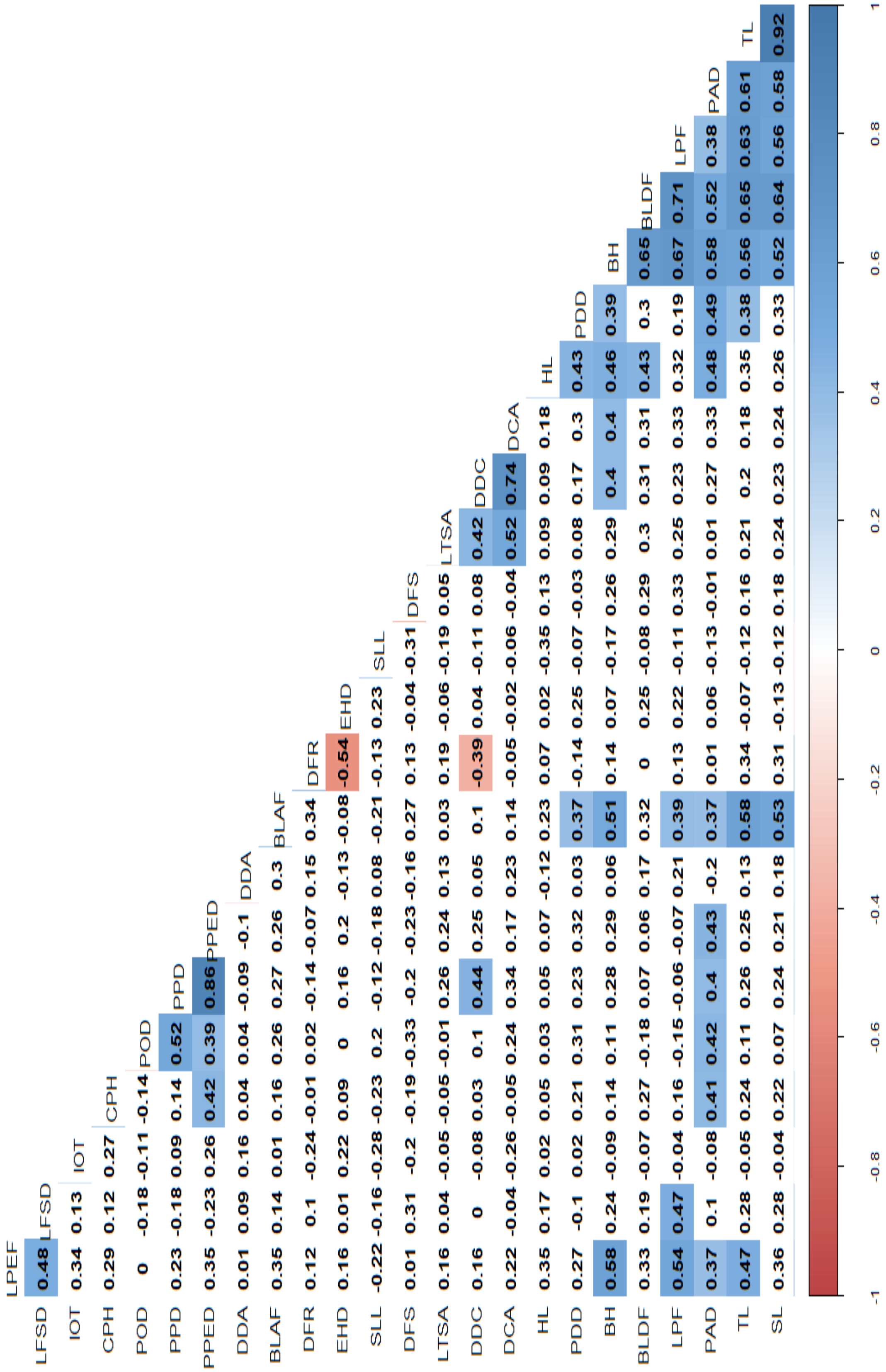


Figure 2: Correlation matrix plot of morphometric and meristic characteristics of Oreochromis sp. (Thailand strain) (Significant (p<0.05) correlations are shaded accordingly)

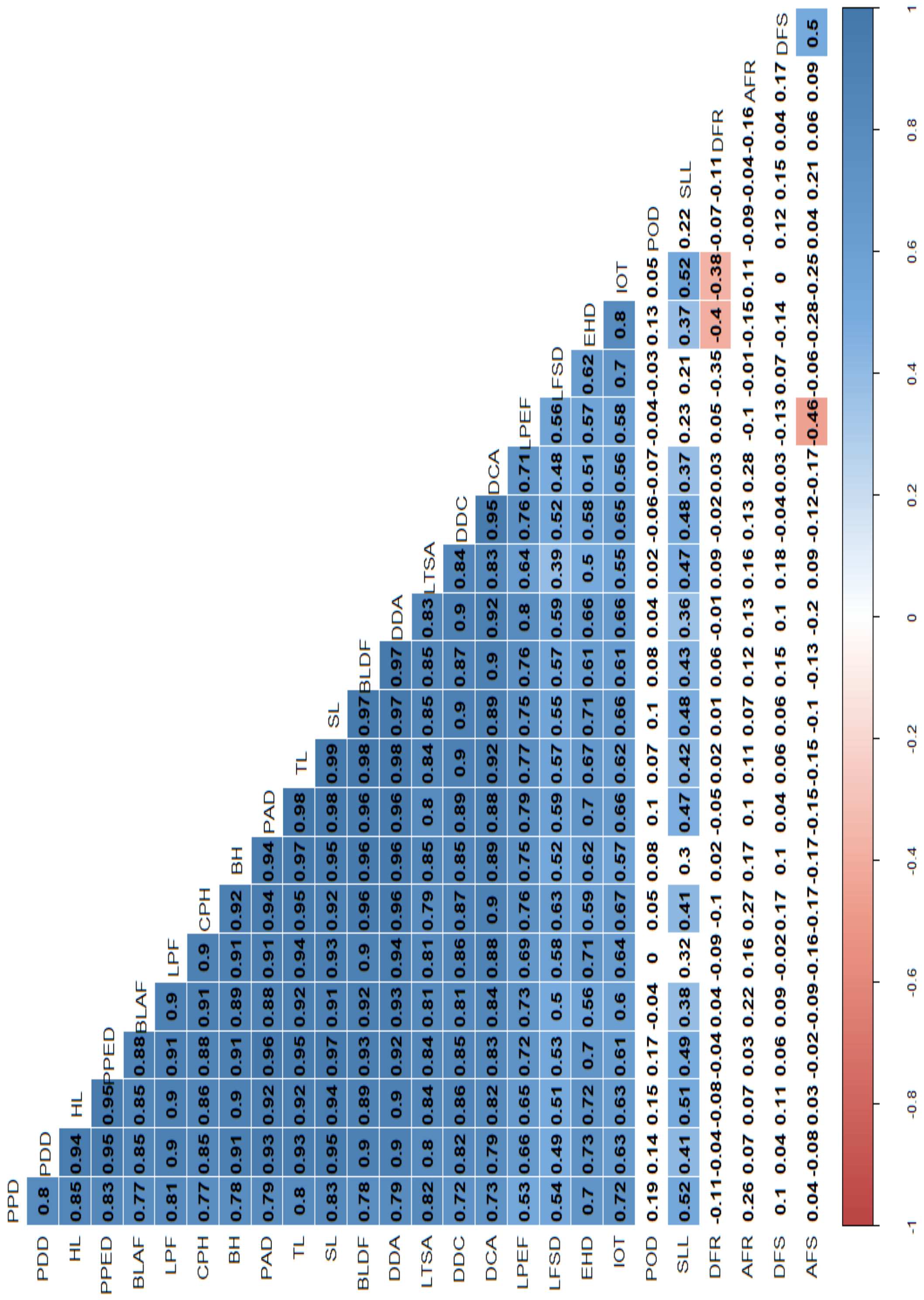


Figure 3: Correlation matrix plot of morphometric and meristic characteristics of Oreochromis sp. (Swansea strain) [Significant (p<0.05) correlations are shaded accordingly]

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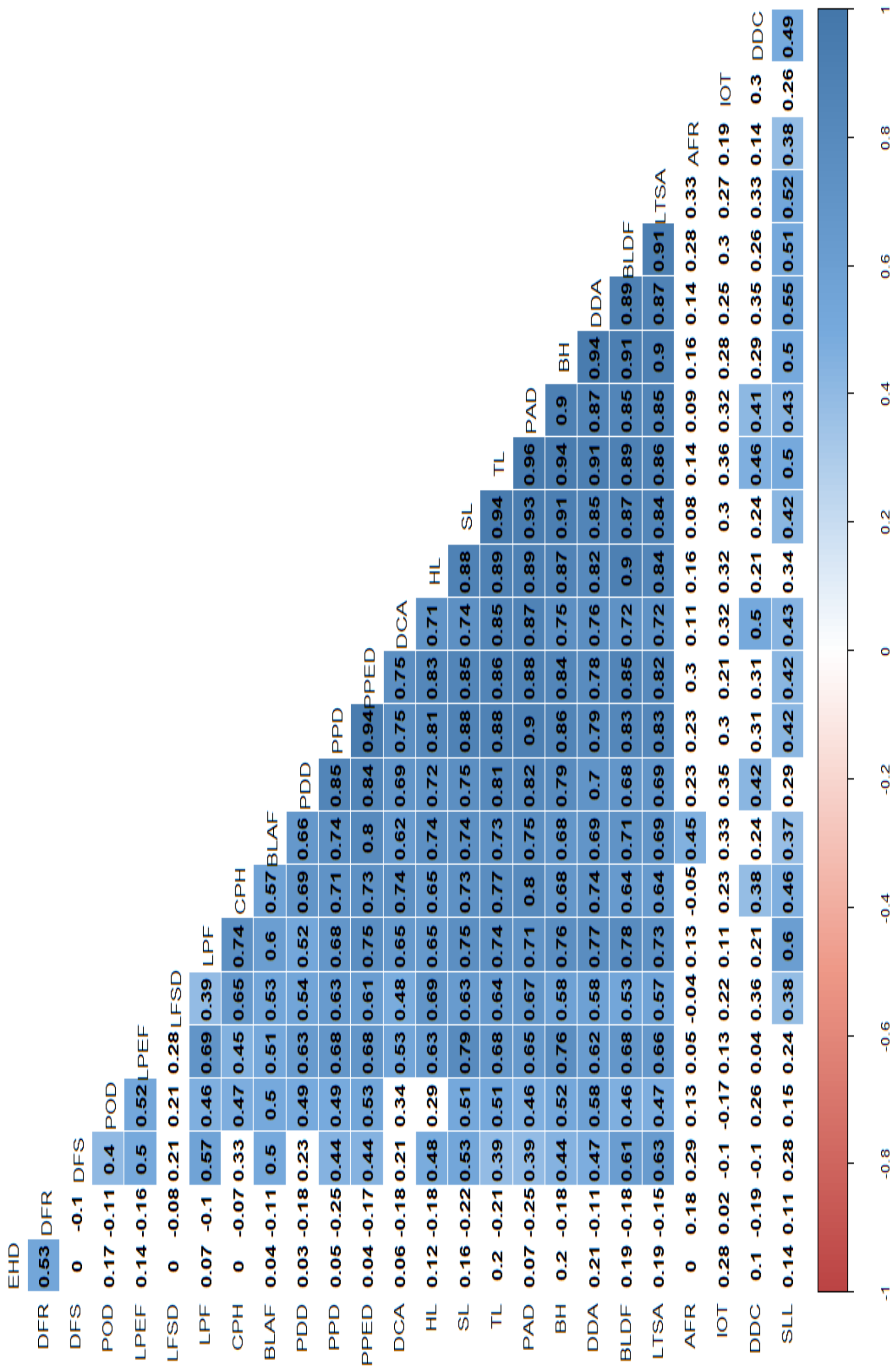

Figure 4: Correlation matrix plot of morphometric and meristic characteristics of Oreochromis sp. (Makurdi strain) [Significant (p<0.05) correlations are shaded accordingly]

IV. DISCUSSION

Differences in morphometric characteristics of Nile tilapia has been reported by various authors. The difference observed in the various morphometric characteristics in the present study also lends credence to the use of morphometric characteristics for strain differentiation [17]. Within Nigeria, Fagbuaro [18] successfully delineated three clades of *Tilapia zilli* within three Dams in South-Western Nigeria using differences observed in head length, total length, standard length, pre-pelvic distance and body weight. Similarly, differences in standard length, pre-anal fin length, body depth, peduncle depth and pre-pelvic fin length have been reported for the Guinean tilapia *Coptodon guinensis* in two locations within the Niger Delta region of Nigeria [19]. In a study of morphological differences between wild and cultured *Cichlasoma festae* in Ecuador, González, et al. [20] reported that 21 morphometric traits differed among the two populations including total length, standard length, head length, body depth, dorsal fin length among others with the cultured strain exceeding the wild strain in several characteristics. The current report of morphometric characteristics of exotic and local strains of *O. nioloticus* is similar to the report of González, et al. [20] given the fact that the local strain of *O. niloticus* used for this research was obtained from the wild. The local strain of *O. niloticus* is a wild strain and its morphometric characteristics lag behind those of the exotic strains that have adapted to culture conditions over several generations and have also benefited from selective breeding.

Meristic counts as observed in the present study fall within the range reported by Chuhila [21] for *O niloticus* in Kenya. The mean values of Dorsal Fin Rays (DFR) ranged from 11 to 12 in the present study while a similar range of 10 to 13 was reported by Chuhila [21]. The three strains evaluated in the present study had a mean Dorsal Fin Spine count of about 16 hence the count falls in the range of 15 to 19 that was reported for the same species in Kenya (Chuhila 2015). Species differences seem to account for the wide margin in DFR between *O. niloticus* as reported presently and *C. festae* as reported by González, et al. [20]. These authors reported an average of 27 DFR in *C. festae* as against the highest value of 12 in the present report. In addition, Anal Fin Ray (AFR) count in the present study (8 to 9) is lower compared to the report for *C. festae* (13) by González, et al. [20].

Correlations between morphometric characteristics showed that Total length and Standard length were strongly correlated for the three strains, a situation that has also been reported for *O. niloticus* in Thailand [22]. Medium correlations ($r \geq 0.5$) have been reported by González, et al. [20] for body weight, total length, standard length, pre-ventral length in *C. festae* as against high correlations (≥ 0.8) recorded for such traits in the present study. Base Length of Dorsal Fin (BLDF) showed a high positive correlation with PPD, PDD, HL, PPED, BLAF, LPF, CPH, BH, PAD, TL and SL in the Swansea strain while it (BLDF) was highly correlated with DFS, POD, LPEF, LFSD, LPF, CPH, BLAF, PDD, PPED, DCA, HL, SL, TL, PAD, BH and DDA in the Makurdi strain. Dorsal Fin Ray Count (DFR) was negatively correlated with Eye Horizontal Diameter (EHD) in both Thai and Swansea strains and Distance between Dorsal and Caudal Fin (DDC) in the Thai strain as well as Inter-Orbital Distance (IOT) in the Swansea strain. In A similar report on correlation [21] showed that post orbit length, anal fin base length and dorsal fin base lengths were highly positively correlated while dorsal spine length, pectoral fin length and anal spine length were negatively correlated.

In conclusion, in terms of body and head related morphometric traits, the local *Oreochromis* sp. (Makurdi strain) is the smallest in size while the exotic *Oreochromis* sp. (Swansea and Thailand strains) appear to have the same body measurement but larger than the local strain. No negative correlations between economic related morphometric characteristics or traits were observed. This implies that the phenotypic expression of these phenotypes does not show any sign of pleiotropic effects that are negative.

REFERENCES

[1] C. H. Graham and P. V. A. Fine, "Phylogenetic beta diversity: linking ecological and evolutionary processes across space in time," *Ecology letters,* vol. 11, no. 12, pp. 1265-1277, 2008.

[2] D. A. Morrison, "Genealogies: Pedigrees and phylogenies are reticulating networks not just divergent trees," *Evolutionary biology,* vol. 43, no. 4, pp. 456-473, 2016.

[3] C. J. Hoskin, M. Higgie, K. R. McDonald, and C. Moritz, "Reinforcement drives rapid allopatric speciation," *Nature,* vol. 437, no. 7063, pp. 1353-1356, 2005.

[4] R. K. Butlin, J. Galindo, and J. W. Grahame, "Sympatric, parapatric or allopatric: the most important way to classify speciation?," *Philosophical Transactions of the Royal Society B: Biological Sciences,* vol. 363, no. 1506, pp. 2997-3007, 2008.

[5] A. E. Eknath and G. Hulata, "Use and exchange of genetic resources of Nile tilapia (Oreochromis niloticus)," *Reviews in Aquaculture,* vol. 1, no. 3-4, pp. 197-213, 2009, doi: 10.1111/j.1753-5131.2009.01017.x.

[6] M. Moses *et al.*, "Characterizing the genetic structure of introduced Nile tilapia (Oreochromis niloticus) strains in Tanzania using double digest RAD sequencing," *Aquaculture International,* vol. 28, no. 2, pp. 477-492, 2020.

[7] ADB, *An Impact Evaluation of the Development of Genetically Improved Farmed Tilapia and Their Dissemination in Selected Countries*. Asian Development Bank Operations Evaluation, Department, 2005.

[8] Y. Fessehaye, *Natural Mating in Nile Tilapia (Oreochromis Niloticus L.): Implications for Reproductive Success, Inbreeding and Cannibalism*. Wageningen University and Research, 2006.

[9] M. A. Peterman and R. P. Phelps, "Fillet yields from four strains of Nile Tilapia (Oreochromis niloticus) and a Red variety," *Journal of Applied Aquaculture,* vol. 24, no. 4, pp. 342-348, 2012.

[10] R. E. Brummett and R. Ponzoni, "Genetic quality of domesticated African tilapia populations," *Journal of Fish Biology,* vol. 65, pp. 315-315, 2004.

[11] H. C. Karisa, *Selection for Growth of Nile Tilapia (Oreochromis Niloticus L.) in Low-input Environments*. Ponsen et Looijen, 2006.

[12] N. H. Ninh, N. P. Thoa, W. Knibb, and N. H. Nguyen, "Selection for enhanced growth performance of Nile tilapia (Oreochromis niloticus) in brackish water (15–20ppt) in Vietnam," *Aquaculture,* vol. 428, pp. 1-6, 2014/05/20/ 2014, doi: http://dx.doi.org/10.1016/j.aquaculture.2014.02.024.

[13] S. Papakostas *et al.*, "Gene pleiotropy constrains gene expression changes in fish adapted to different thermal conditions," *Nature Communications,* vol. 5, no. 1, pp. 1-9, 2014.

[14] H. L. Khaw, R. W. Ponzoni, H. Y. Yee, M. A. bin Aziz, and P. Bijma, "Genetic and non-genetic indirect effects for harvest weight in the GIFT strain of Nile tilapia (Oreochromis niloticus)," *Aquaculture,* vol. 450, pp. 154-161, 2016.

[15] C. K. Boussou *et al.*, "Morphometric analysis of populations of Chromidotilapia guntheri (Sauvage, 1882) (Cichlidae, perciformes) in four coastal rivers of Côte d'Ivoire (West Africa)," *Pan-American Journal of Aquatic Sciences,* vol. 5, no. 3, pp. 387-400, 2010.

[16] *R: A language and environment for statistical computing*. (2017). R Foundation for Statistical Computing, Vienna, Austria. [Online]. Available: https://www.R-project.org/

[17] V. Espinosa-Lemus, J. L. Arredondo-Figueroa, and I. Barriga-Sosa, "Morphometric and genetic characterization of tilapia (Cichlidae-Tilapiini) stocks for effective fisheries management in two mexican reservoirs," *Hidrobiologica,* vol. 19, no. 2, pp. 95-107, 2009.

[18] O. Fagbuaro, "Morphometric characteristics and meristic traits of Tilapia Zillii from three major dams of a southwestern state, Nigeria," 2015.

[19] O. A. Olopade, H. E. Dienye, B. Jimba, and N. A. Bamidele, "Observations on the Morphometric and Meristic Characters of Guinean Tilapia, Coptodon guineensis (Günther, 1892)(Family: Cichlidae) from the Buguma Creek and the New Calabar River in Nigeria," *Jordan Journal of Biological Sciences,* vol. 11, no. 3, 2018.

[20] M. A. González, J. M. Rodriguez, E. Angón, A. Martínez, A. Garcia, and F. Peña, "Characterization of morphological and meristic traits and their variations between two different populations (wild and cultured) of Cichlasoma festae, a species native to tropical Ecuadorian rivers," *Archives Animal Breeding,* vol. 59, no. 4, pp. 435-444, 2016.

[21] Y. Chuhila, "Assessment of changes in genetic diversity of Nile Tilapia, oreochromis niloticus (linnaeus, 1758), of lake Baringo, Kenya," 2015.

[22] P. Kosai, P. Sathavorasmith, K. Jiraungkoorskul, and W. Jiraungkoorskul, "Morphometric characters of Nile tilapia (Oreochromis niloticus) in Thailand," *Walailak Journal of Science and Technology (WJST),* vol. 11, no. 10, pp. 857-863, 2014.