Morphometric measurements and phenotypic correlations of the tilapia GIFT after individual selection

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Abstract – This study sought to evaluate the effect of individual selection for body weight on morphometric characteristics of the Nile tilapia (GIFT-Epagri strain), and to determine the phenotypic correlations of these measurements. This study used 325 males and 272 females derived from seven different populations of a breeding program. The following morphometric characteristics were measured: body weight (BW), total length (TL), standard length (SL), corrected length (CL), head length (HL), body height (BH) and body width (BWi). Then, the data were used to determine the following ratios: Fulton's condition factor (K), HL/SL, BH/SL, BWi/SL and CL/SL. Fish selected for body weight showed greater FC and BH/SL when compared to unselected fish. In addition, all correlations between variables were high (above 0.70), indicating that the selection of individuals with higher body weight may provide indirect gains in other desirable characteristics.

Index terms: *Oreochromis niloticus*; individual selection; morphological parameters; phenotypic correlations.

Medidas morfométricas e correlações fenotípicas de tilápia Gift submetidas a seleção individual

Resumo – O objetivo deste estudo foi avaliar o efeito da seleção individual para peso corporal nas medidas morfométricas de tilápia-do-nilo, linhagem GIFT-Epagri, e determinar as correlações fenotípicas destas medidas com o peso do corpo. Foram utilizados 325 machos e 272 fêmeas, derivados de sete diferentes populações do programa de melhoramento. De cada indivíduo foram avaliados os seguintes parâmetros: peso corporal (PC), comprimento total (CT), comprimento padrão (CP), comprimento do tronco (CTr), comprimento da cabeça (CC), altura corporal (AC) e largura corporal (LC). Posteriormente, foram determinadas as seguintes relações: fator de condição de Fulton (FC), CC/CP, AC/CP, LC/CP e CTr/CP. Os indivíduos selecionados para peso corporal das diferentes populações apresentaram maior FC e AC/CP, em relação aos indivíduos não selecionados. Além disso, todas as correlações entre as variáveis analisadas foram altas (acima de 0,70), indicando que na seleção dos indivíduos com maior peso há boa possibilidade de haver ganhos indiretos para outras características desejáveis.

Termos para indexação: *Oreochromis niloticus*; seleção individual; parâmetros morfológicos; correlações fenotípicas.

Nile tilapia (*Oreochromis niloticus* – Linnaeus, 1758) has been highlighted as a fish with excellent potential for freshwater aquaculture. In Brazil, 261,000 tons of this fish has been produced, growing an average of 14.2% per year over the last 10 years (KUBITZA, 2015). However, some problems regarding the quality of fingerlings have arisen, such as low growth rate and non-uniform size. These problems may be associated to the high rate of inbreeding in commercial fish farms, as a result of inappropriate genetic management of the brood stock by hatcheries. To solve this problem, the *Empresa de Pesquisa Agropecuária e Extensão Rural de Santa Catarina* (Epagri – Santa Catarina Agency for Rural Extension and Agricultural Research) started a Development Center of Tilapia in the state of Santa Catarina in 2010, with financial resources from the Ministry of Fishing and Aquaculture (MPA). This project sought to develop a strain better adapted to the conditions of the region. The Epagri center delivers tilapia brood stock with genetic quality and certified origin for hatcheries in the Southern region of Brazil. The most commercially cultivated strain in Santa Catarina is GIFT, which was introduced in the state almost a decade ago and is gaining prominence. So far, producers of fingerlings in Southern Brazil have obtained GIFT tilapia from the *Universidade Estadual de Maringá* (UEM) and from Epagri (BARROSO et al., 2016). However, the morphometric parameters and the influence of the selection process regarding these parameters for Nile tilapia and its strains have been poorly reported. This lack of information may result in indirect selection when traits of interest are strongly correlated with the selected character, resulting in future benefits or problems in the breeding program (TURRA et al., 2010). Given this context, this study sought to evaluate the effect of individual selection for body weight on the morphometric characteristics of Nile tilapia (GIFT *O. niloticus*, Epagri strain) from the Epagri breeding program, as well as to determine the phenotypic correlations of these measurements.

The families of tilapia, GIFT strain from UEM, were divided among seven different populations according to their origin. Each genetic group

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(population) consists of fingerlings from the breeding of 40 females and 20 males, and each population was from the previous selective breeding generation of GIFT-Epagri. Fifteen hundred fingerlings of each population, weighing approximately 2 g (45 days after hatching), were randomly chosen and stocked separately in ponds with area of 250 m², aerated using a 3/4 hp pond aerator. The animals were fed a powdered diet containing 40% crude protein until reaching 10 g in weight. Later, they were fed extruded feed containing 32% crude protein. The rearing period occurred from February to September 2015. Approximately 240 days post-hatch the fish were weighed individually for the selection of animals that had the highest body weight (BW) (60 females and 40 males per population). The intensity selection used was approximately 6.9% for males (4.1 to 12.2%) and 10.7% for females (6.4 to 15.4%). In addition, approximately 85 fish from each population (including males and females, both selected and unselected) were sampled to measure the following morphometric parameters: total length (TL), standard length (SL), head length (HL), body height (BH) and body width (BWi). The morphometric measurements followed the method from Oliveira et al. (2014). Moreover, corrected length (CL) was obtained by subtracting SL from HL. Measurements were obtained using a digital balance (0.01g), fish ruler and digital caliper. The data obtained were processed as ratios, with the measurements of head length, body height, body width and corrected length to the standard length, as follows: a) head length/standard length (HL/SL), b) body height/standard length (BH/SL), c) body width/standard length (BWi/SL) and d) corrected length/standard length (CL/SL). Fulton's condition factor (K) was calculated for each animal. The ratios were used to compare the fish selected by body weight to the average weight of the unselected population. The Mann-Whitney test was used for this comparison, with 5% significance. Weight data and morphometric measurements were also assessed using Spearman's rho test to determine the relationship among the variables.

Table 1 shows the morphometric characteristics of the selected male/female fish and of the unselected for body weight. Males and females selected for body weight showed greater factor condition and body height (BH/SL) than unselected animals. Otherwise, morphometric parameters were similar between the selected and unselected animals, both males and females. For both, the largest phenotypic correlations for body weight were those between TL and SL (0.968 and 0.956, respectively, for males and 0.957 and 0.950, respectively, for females). Body height showed the highest correlation with HL (0.940) for males and HL (0.902) and TL (0.902) for females. Female head length also showed high correlation with TL (0.910). In general, all measurements showed high values and positive phenotypic correlations between each other, with correlation coefficients always greater than 0.70 (Table 2).

In this study, body weight selection was used to select fish, males and females, with a greater body height. According to Lundstedt et al. (2008), greater body height results in a greater fillet width and, consequently, in increased carcass yield, i.e., greater fillet yield. Studies on Nile tilapia suggest that body height has moderate heritability, between 0.17 to 0.40 (RUTTEN et al., 2005; CONTI et al., 2014; OLIVEIRA et al., 2014; FERNANDES et al., 2015; REIS NETO et al., 2015). Thus, individual body weight selection for this population is expected to result in fish with greater body height and, consequently, a higher carcass yield. However, further research must be made to better explain these results. Fernandes et al. (2015) observed that the body height is the most suitable morphometric measure for direct selection regarding carcass gain in tilapia 119 days after hatching. In a study by Lundstedt et al. (2008), the authors observed greater body height (BH/SL) in males (0.398) when compared to females (0.331). In this study, males usually showed greater BH/SL than females, but only for body weight selected fish (Table 1), as the BH/SL ration among unselected males and females was numerically equal (0.370). In general, morphometric measurements were similar between males and females. However, Reis Neto et al. (2015) observed that males may respond to body weight selection distinctly from females regarding morphometric characteristics. For females, head length is related to reproductive behavior since females of the *Oreochromis* genus incubate eggs and shelter newly hatched larvae in the mouth. Theoretically, a greater head length would have a larger oral cavity, thus allowing a higher survival rate of the progeny, this would also imply a lower carcass yield (LUNDSTEDT et al., 2008). Head length was monitored in this study for this reason. Body width and corrected length were not changed by selection for body weight ▸

Table 1. Morphometric characteristics of male and female Nile tilapia, GIFT-Epagri strain, selected individually for body weight

Group	K	HL/SL	BH/SL	BWi/SL	CL/SL
Selected males	2.01±0.15^{A}	0.318±0.014	0.388±0.020^{A}	0.175±0.010	0.682±0.014
Unselected males	1.94±0.15^{B}	0.315±0.018	0.370±0.029^{B}	0.175±0.010	0.685±0.018
***p*–value**	0.0001	0.4382	0.0001	0.5820	0.2535
Selected females	2.09±0.17^{A}	0.321±0.015	0.379±0.021^{A}	0.181±0.009	0.679±0.015
Unselected females	2.03±0.17^{B}	0.322±0.021	0.370±0.025^{B}	0.181±0.011	0.678±0.020
***p*–value**	0.0008	0.9271	0.0023	0.7052	0.4047

*Different letters indicate statistical differences in the Mann–Whitney test at 5% significance level. K – Fulton's condition factor, HL – Head length, BH – Body height, BWi – Body width, CL – Corrected length, SL – Standard length.

Table 2. Phenotypic correlations between morphometric measurements and body weight of males (above diagonal) and females (below diagonal) of Nile tilapia, GIFT-Epagri strain

	BW	TL	SL	HL	BH	BWi	CL
BW	–	0.968	0.956	0.887	0.893	0.900	0.915
TL	0.957	–	0.961	0.902	0.886	0.870	0.917
SL	0.950	0.966	–	0.892	0.886	0.858	0.976
HL	0.892	0.910	0.889	–	0.940	0.749	0.778
BH	0.908	0.902	0.878	0.902	–	0.751	0.794
BW	0.859	0.822	0.829	0.729	0.725	–	0.844
CL	0.898	0.913	0.969	0.761	0.790	0.814	–

BW – Body weight, TL – Total length, SL – Standard length, HL – Head length, BH – Body height, BWi – Body width, CL – Corrected length.

in this study. Some studies reported a relationship of these features with fillet yield (RUTTEN et al. 2005; LUNDSTEDT et al., 2008), showing the importance of monitoring these parameters.

Studies correlating selected variables, such as body weight, with morphometric measurements are important to determine possible indirect selections in genetic breeding programs, intended or not. Conti et al. (2014) observed that, due to the impossibility of performing body weight selection on a farm, using body width selection led to a good genetic gain for body weight. In addition to a high positive correlation with other desired variables, body width has high heritability. In this study, the variables that showed higher correlation with body weight were total length and standard length. The correlations between all variables were high and positive, corroborating the results of other studies (RUTTEN et al., 2005; OLIVEIRA et al., 2014). Nowadays, one of the main applications for tilapia production is fillet production, based on its higher value when compared to other fish products. Researchers have observed that several morphometric measurements show significant and positive correlations with Nile tilapia fillet yield. As already mentioned, Fernandes et al. (2015) observed that body height 119 days post-hatch and corrected length 231 days post-hatch showed the highest correlations with fillet yield, although body weight also showed good results. In the studies by Melo et al. (2013) and Rutten et al. (2005), the characteristic with the highest correlation with fillet yield was body width. However, in Rutten et al. (2005), the authors found that the genetic gain for fillet yield and fillet weight would be increased by selecting for body weight rather than body width based on a more accurate selection for body weight. Thus, selection for body weight is the most appropriate alternative for gains in fillet yield and fillet weight (RUTTEN et al., 2005).

Individual selection shows high genetic gain between generations; however, such selection can rapidly deplete population variability and hinder the selection for more than one or two traits (OLIVEIRA et al., 2014). Therefore, studies like this help in decision-making related to improving breeding programs, in addition to developing a better understanding of the consequences of the selection process. Therefore, selection according to geographic region and environmental conditions will result in fish better adapted to one place. Through this study, we determined that selection for body weight of animals with greater height did not harm the other morphometric characteristics. Furthermore, the correlations between the analyzed variables showed high and positive values, indicating the possibility of using indirect selection for some desired characteristics.

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