



Direct and indirect effects of measures and reasons morphometric on the body yield of Nile tilapia, *Oreochromis niloticus*

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ABSTRACT. The study was carried out with the objective of verifying which measures and morphometric ratios are more directly related to the body yield of Nile tilapia, *Oreochromis niloticus*, in two weight classes. Data were analyzed from 257 specimens of tilapia divided into two weight classes: p₁ = 400 to 599 g and p₂ = 600 to 900 g. The morphometric measurements standard length (SL), head length (HL), body height (BH) and body width (BW), and the ratios of these measures (HL / SL, BH / SL, BW / SL, HL / BH, BW / BH, BW / HL) were evaluated. The following body yields were calculated: carcass (RCAR), fillet (RFILE) and head (RCAB). The data were initially submitted to the "stepwise" procedure to eliminate problems of multicollinearity among the morphometric variables, then the correlations between the dependent variables (body yield) and the independent variables (measured and morphometric relationships) were calculated. Later, these correlations were divided into direct and indirect effects through path analysis, and the direct and indirect contributions of each variable measured in percentage terms. The morphometric ratio BW/HL, for both weight classes, was the variable most highly correlated and with the highest direct effect on RFILE and RCAB, showing to be the most important morphometric variable studied for tilapia carcass trait determination.

Keywords: path analysis, evaluation of carcass, animal breeding, morphometry, *Oreochromis niloticus*.

Efeitos diretos e indiretos de medidas morfométricas e razões sobre o rendimento do corpo de tilápia do Nilo, *Oreochromis niloticus*

RESUMO. O estudo foi realizado com o objetivo de verificar quais medidas e razões morfométricas estão mais diretamente relacionadas com os rendimentos corporais da tilápia do Nilo, *Oreochromis niloticus*, em duas classes de peso. Foram analisados os dados de 257 exemplares de tilápia divididos em duas categorias de peso: p₁ = 400 a 599 g e p₂ = 600 a 900 g. As medidas morfométricas comprimento padrão (CP), comprimento da cabeça (CC), altura do corpo (AC) e largura do corpo (LC), e as razões entre estas medidas (CC / CP, AC / CP, LC / CP, LC / CC, LC / AC, CC / AC) foram avaliadas. Os rendimentos corporais calculados foram: carcaça (RCAR), filé (RFILE) e cabeça (RCAB). Os dados foram inicialmente submetidos ao procedimento 'stepwise' para eliminar os problemas de multicolinearidade entre as variáveis morfométricas, em seguida, as correlações entre as variáveis dependentes (rendimentos corporais) e as variáveis independentes (medidas e razões morfométricas) foram calculadas. Posteriormente estas correlações foram desdobradas em efeitos diretos e indiretos por meio de análise de trilha e as contribuições diretas e indiretas de cada variável foram quantificadas percentualmente. A razão morfométrica LC / CC, para ambas as classes de peso, foi a variável mais altamente correlacionada e com o maior efeito direto sobre RFILE e RCAB, mostrando ser a variável morfométrica estudada mais importante para determinação das características de carcaça da tilápia.

Palavras-chave: análise de trilha, avaliação de carcaça, reprodução animal, morfometria, *Oreochromis niloticus*.

Introduction

The Nile tilapia *Oreochromis niloticus* is one of the main species cultivated commercially due to its good growth, its great potential for intensive fish farming, adaptation to different climates, tolerance to different

environmental conditions, full field of cultivation techniques and a meat of excellent quality. Furthermore, the meat of tilapia is

appreciated by the market, primarily as a result of its white color, lack of intramuscular bones and great texture and flavor (BRUMMETT et al., 2004)

The fillet is the presentation of the final product that is most marketed by the fish processing industry, especially when compared to the gutted whole fish or as a main trunk (without head, fins, skin and viscera) (SOUZA et al., 2000). In general, *Oreochromis* sp. has a lower fillet yield when compared to other species (TURRA et al., 2012). According to the authors Freato et al. (2005), Burkert et al. (2008) and Grigorakis et al. (2011), fusiform fish such as *Brycon. orbignyanus* (44.97%), *Pseudoplatystoma* sp. (47.79%), and *Argyrosomus regius* (42.2%), respectively, have relatively high yields, exceeding values found for Silva et al. (2009) (34.18 %) working with tilapia.

Breeding programmes that are aimed at body yield increase present difficulties, since the direct measurement results in sacrifice of the animal and hence in the loss of a potential breeder within the group (CREPALDI et al., 2008; RUTTEN et al., 2004). Thus, an alternative would be the use of body measurements as selection criteria mainly related to the carcass and fillet (SILVA et al., 2009; PONZONI et al., 2007). According Freato et al. (2005), information about the external shape of the fish's body (morphometry) is important to allow an estimation of productivity by reducing costs and increasing profits for both the farmer and for the fish industry itself.

The correlation between the measurements and morphometric ratios with body-associated proceeds was found in several studies (FREATO et al., 2005; DIODATTI et al., 2008; NETO et al., 2012). However, the simple correlation only allows an assessment of the magnitude and direction of the association between the two characters, without providing the necessary information relating to direct and indirect effects of a group of characters in relation to a dependent variable of the greatest importance (LOPES; FRANKE, 2011).

Path analysis is an artifice that researchers have to break the correlation between direct and indirect effects (CRUZ; CARNEIRO, 2003) through a basic variable, such as body yields, and the explanatory variables, such as morphometric measures and ratios, enabling a better understanding of the causes involved in the associations between these traits (NETO et al., 2012).

The present study aimed to evaluate, through path analysis of phenotypic correlations, which

morphometric variables were more directly related to the body yield of Nile tilapia (*O. niloticus*) in two weight classes.

Material and methods

The database used in this study consisted of information on the morphometric measurements, body weights and slaughter yields, of 257 Nile tilapia, male, with a mean weight of 580.41 ± 126.7 grams.

According to Neto et al. (2012), the weight of the animals directly influences the coefficients of correlation between yields of the body and measurements and morphometric ratios, the data were organized into two files depending on the weight class, $p_1 = 400-599$ g, and $p_2 = 600 - 900$ g, (Table 1) and that the analyzes were developed, following exactly the same procedures for the two files.

The following morphometric measurements were evaluated (Figure 1): standard length (SL), measured between the front head extremity and the insertion of the tail fin; head length (HL), measured between the upper and lower edges of the head; body height (BH), measured in front of the first ray of the dorsal fin; and body width (BW), measured at the first ray of the dorsal fin. To complement the measurements above, the following morphometric ratios were calculated: HL / SL , BH / SL , BW / SL , BW / HL , BW / BH , HL / BH .

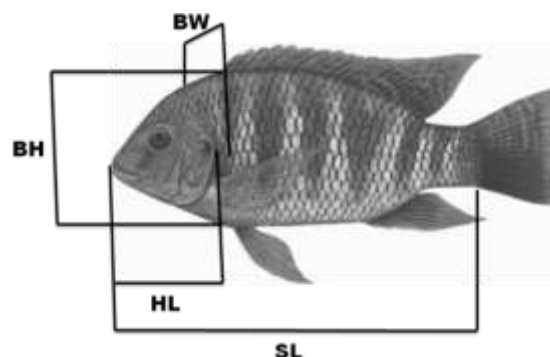


Figure 1. Morphometric measurements of tilapia

To obtain the yields of the body, the animals were eviscerated to weigh the carcass with head (total weight minus the weight of the viscus), and then the skin was removed along with the flakes with the aid of pliers, in the direction 'skull to tail'. After removal of the skin, by cutting in the line after the caudal end of the operculum, the head was separated from the trunk, weighing head. With the

use of a filleting knife, the fillets were removed, without the two lateral ribs of the fish that are present longitudinally along the entire length of the spine and ribs, and subsequently weighed.

Body yields of each product were calculated as the percentage of body weight (whole fish): carcass yield (RCAR), carcass weight / slaughter weight, head yield (RCAB), head weight / slaughter weight, and fillet yield (RFILE), fillet weight / body weight.

Because the weight of animals can influence the correlation coefficients between body yield, measurements and morphometric ratios, organized our data into two files depending on the weight class, p1 = 400 – 599 g, and p2 = 600 – 900 g, (Table 1), and developed analyses which followed exactly the same procedures for the two files.

Table 1. Morphometric measures and body yield for each body-weight class of Nile tilapia, *Oreochromis niloticus*, with number of animals (n), mean (x), standard deviations (s), maximum (Max) and minimum (Min).

Variables	n	x	s	Máx	Min
Weight class p1 (400 to 599 g)					
SL	136	23.54	1.68	27.60	20.80
HL	136	7.25	0.62	8.50	6.00
BH	136	9.09	0.60	10.70	7.58
BW	136	3.98	0.30	4.89	3.40
RCAR	136	80.13	3.14	85.08	72.71
RFILE	136	35.53	3.89	42.67	26.84
RCAB	136	23.94	5.43	37.43	15.75
Weight class p2 (600 to 900 g)					
SL	121	26.18	1.31	32.00	24.00
HL	121	8.14	0.37	9.10	7.28
BH	121	10.27	1.02	19.75	8.60
BW	121	4.30	0.26	4.90	3.66
RCAR	121	80.98	2.46	85.50	72.99
RFILE	121	36.22	3.51	41.39	26.89
RCAB	121	23.95	4.75	33.08	17.35

SL: standard length; HL: head length; BH: body height; BW: body width; RCAR: carcass yield; RFILE: fillet yield; RCAB: head yield; n: number of animals; x: mean; s: standard deviations; Max: maximum data value, Min: minimum data value.

For this study, body incomes were considered as dependent variables, whereas measures and morphometric ratios were considered as independent variables.

Initially, a multiple linear regression analysis was done using the stepwise procedure. In order to eliminate possible problems, multicollinearity and the Akaike information criterion (AIC) were used to define the independent variables included in the path analysis of each dependent variable in the study (COIMBRA et al., 2005; CHARNET, et al., 2008). This is necessary because the estimated path coefficients (direct and indirect effects) are obtained by regression equations, i.e. from the solution of the equation $X'X\beta = X'Y$; therefore, it is necessary to obtain the direct effects, ensuring that the matrix X is well conditioned, as

multicollinearity problems can cause it to be unique, resulting in unreliability of the least squares estimates (CRUZ; CARNEIRO, 2003).

Having established the independent variables for each dependent variable, we proceeded to identify, by Cook's Distance, and disposal of influential points. Soon after, the correlations between the independent and dependent variables were calculated using Pearson's linear correlation coefficient and, subsequently, we applied the 'student' test to assess the significance of the correlations (CHARNET et al., 2008). Then, the correlations were deployed in direct and indirect effects through path analysis (CRUZ; CARNEIRO, 2003) and the direct and indirect contributions of each variable were quantified in percentages (NETO et al. 2012). Statistical analyses were performed using the software 'R' version 2.13.2 for Windows.

To interpret the results, the criteria adopted by Neto et al. (2012) (adapted from LOURES et al., 2001) were considered, with four possible situations: a) a particular independent variable (x) shows a significant correlation and high direct effect with the dependent variable (y), indicating that by determining variation in y; b) the independent variable has a significant and direct effect on 'y low', indicating that their effects mainly occur indirectly through other variables, and an analysis with other independent variables can result in great benefits for effect estimates, but should not be used in isolation; c) the variable (x) has no significant correlation with y, but its direct effect is high, indicating that its use is of little utility in the determination of the effects of independent variables on y; d) the independent variable has low values of both the direct effect and correlation with y, indicating it to be of little use to the estimates.

Results and discussion

The morphometric measurements and ratios that contribute most to the variation in body yields were different for each class of slaughter weight (Table 2), which confirms the influence of weight on body measurements of fish in several studies (SHIBATTA; HOFFMANN, 2005; SANTOS et al., 2006; AYALA-PEREZ et al., 2008; SAHU et al., 2012). The coefficients of determination adjusted for the analysis models were relatively high (Table 2), except for the model-obtained RCAR in class p2 ($r^2 = 0.22$), which demonstrates the importance of morphometric measures and ratios in determining income carcass, head and

fillet of tilapia. Contradictory results were obtained by Diodatti et al. (2008) when working with tilapia which had coefficients of determination adjusted for very low income prediction equations in terms of body measurements and morphometric ratios.

Table 2. Morphometric variables included in the analysis models to track body income tilapia in two weight classes, and their adjusted coefficients of determination (r^2).

Yields body	Morphometric Variables	R^2 aj.
Weight class p1 (400 to 599 g)		
RCAR	SL,HL,BH,BW, HL / SL,BW / SL,BW / BH,HL / BH	0.67
RCAB	HL,BH,BW,BH / SL,BW / SL,BW / HL	0.74
RFILE	BH,BH / SL,BW / SL,BW / HL,HL / BH	0.74
Weight class p2 (600 to 900 g)		
RCAR	SL,HL,BW,BH / SL,BW / HL,BW / BH,HL / BH	0.22
RCAB	SL,HL,BH,BW / HL,HL/BH	0.70
RFILE	SL,HL, BH/SL,BW/HL,HL/BH	0.62

SL: standard length; HL: head length; BH: body height; BW: body width; RCAR: carcass yield; RFILE: fillet yield; RCAB: head yield.

The correlations between measurements and morphometric ratios with carcass yield (RCAR) were higher in fish slaughtered in class p1 (Table 3), with the highest values observed for standard length (-0.65) and head length (-0.40). The direct effect of SL accounted 63.04% of its correlation with RCAR since HL, with the second highest correlation coefficient, showed a large percentage of indirect effects (60.56%) in their correlation, mainly by SL (Table 4). These results reaffirm the importance of standard length in identifying animals with better carcass tilapia weighing between 400 and 600 g, indicating that fish with lower standard lengths in this weight range have a higher carcass yield.

Table 3. Amounts and percentages of direct and indirect effects of the morphometric measures and ratios on the carcass yield of Nile tilapia *Oreochromis niloticus* in different weight class.

Variables	Direct		Indirect		Correlation
	Effect	%	Effect	%	
Weight class p1 (400 to 599 g)					
SL	-1.571	63.04	0.921	36.96	-0.65 **
HL	0.746	39.44	-1.146	60.56	-0.40 **
BH	-0.368	90.54	0.038	9.46	-0.33 **
BW	0.603	40.31	-0.893	59.69	-0.29 **
HL / SL	0.183	88.55	-0.023	11.45	0.16 ns
BH / SL	-0.824	41.04	1.184	58.96	0.36 **
BW / BH	-0.733	50.00	0.733	50.00	0.00 ns
HL / BH	-0.362	79.68	0.092	20.32	-0.27 **
Weight class p2 (600 to 900 g)					
SL	-0.469	62.67	0.279	37.33	-0.19 ns
HL	0.553	56.65	-0.423	43.35	0.13 ns
BW	-0.172	75.13	-0.057	24.87	-0.23 ns
BH / SL	-0.194	31.41	0.424	68.59	0.23 ns
BW / HL	0.309	46.97	-0.349	53.03	-0.04 ns

Table 4. Estimates of the direct and indirect effects, obtained by path analysis, between morphometric measurements and ratios and carcass yield of Nile tilapia, *Oreochromis niloticus*, in different weight classes.

Effect	Weight class p1 (400 to 599 g)
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BW / BH	-0.162	58.07	-0.117	41.93	-0.28 *
HL / BH	-0.193	44.27	0.243	55.73	0.05 ns

SL: standard length; HL: head length; BH: body height; BW: body width. *(p = 0.05); **(p = 0.01); ns (not significant).

For class weight p2, the ratio BW/BH is the only variable morphometric with significant correlation with the RCAR; however, this is low and negative (-0.28) and, furthermore, the direct effect of BW/BH was accountable for less than 60% of this correlation, primarily due to indirect effect via BW (-0.122) (Table 3 and Table 4). Correlation coefficients were low compared to those for fish weight class p1, indicating that the morphometric variables studied contribute very little to the variation in heavier tilapia carcasses. This implies that there may be one or more morphometric variables not measured in this study, requiring evaluation for their effects on RCAR.

Diodatti et al. (2008), working with some tilapia strains, found a significant correlation coefficient between morphometric measurements and carcass yield measured at the point of insertion of the anal fin. Moreover, Freato et al. (2005) reported that the height of the body, making the insertion of the pectoral fin was the most important measure for determining the yield of the carcass of *Brycon orbignyanus*. In round fish such as pacu (*Piaractus mesopotamicus*) and tambaqui (*Colossoma macropomum*), Neto et al. (2012) noted, in a study in path analysis, the ratio of the length of head and body height can be used in the assessment of RCAR.

The ratio of the width of the body by head length (BW / HL) had the highest correlation coefficients, -0.75 and -0.82 (Table 5), respectively, in classes p1 and p2 with the head yield (RCAB). Besides high correlation with RCAB, BW / HL also showed high percentages of direct effects, both in class p1 (83.14%) and p2 (84.24%), with the path coefficients of -0.624 (Class p1) and -0.691 (Class p2) proving to be a key variable yield for the body (Tables 5 and 6). This indicates those tilapias which are wider at the head and dorsal region and of shorter length will result in a lower yield of fish head.

Such information is quite significant to the industry, especially since the head is considered a residue of fish processing and, therefore, of no economic value.

	SL	HL	BH	BW	HL / SL	BH / SL	BW / BH	HL / BH
Direct	-1.571	0.747	-0.369	0.603	0.184	-0.824	-0.733	-0.362
Indirect by SL	---	0.597	-0.206	0.247	0.007	0.445	0.066	-0.236
Indirect by HL	-1.256	---	-0.287	0.241	0.114	0.091	0.213	-0.261
Indirect by BH	-0.879	0.582	---	0.199	0.105	-0.313	0.389	-0.043
Indirect by BW	-0.644	0.299	-0.122	---	0.024	0.099	-0.455	-0.094
Indirect by HL / SL	-0.062	0.463	-0.210	0.078	---	-0.437	0.271	-0.127
Indirect by BH / SL	0.848	-0.082	-0.140	-0.072	0.097	---	0.315	0.217
Indirect by BW / BH	0.141	-0.217	0.195	0.374	-0.068	0.354	---	-0.047
Indirect by HL / BH	-1.021	0.538	-0.044	0.157	0.064	0.494	-0.095	---
Effect	Weight class p2 (600 to 900 g)							
	SL	HL	BW	BH / SL	BW / HL	BW / BH	HL / BH	
Direct	-0.470	0.554	-0.173	-0.194	0.310	-0.163	-0.193	
Indirect by SL	---	0.210	-0.066	0.113	0.050	-0.020	-0.008	
Indirect by HL	-0.179	---	-0.029	-0.035	-0.136	0.042	-0.087	
Indirect by BW	-0.179	0.094	---	0.016	0.108	-0.122	0.025	
Indirect by BH / SL	0.272	0.100	0.014	---	-0.118	0.075	0.081	
Indirect by BW / HL	-0.075	-0.244	-0.060	0.074	---	-0.083	0.039	
Indirect by BW / BH	-0.056	-0.144	-0.130	0.089	0.158	---	-0.035	
Indirect by HL / BH	-0.019	0.249	0.022	0.082	-0.062	-0.029	---	

SL: standard length; HL: head length; BH: body height; BW: body width.

Furthermore, this ratio could be an important morphometric value, after a study evaluating genetic improvement programs for tilapia as an indirect selection criterion aiming fish with lower head yield.

Diodatti et al. (2008), working with RCAB tilapia, found the highest correlation coefficient (-0.481) for the width and length standard differed from the results of this work. Freato et al. (2005) and Neto et al. (2012) observed in piracanjuba round fish that the morphometric ratio, HL / SL is the most important, and the greater this ratio, the higher the yield of head.

Table 5. Amounts and percentages of direct and indirect effects of the morphometric measures and ratios on the head yield of Nile tilapia *Oreochromis niloticus* in different weight class.

Variables	Direct		Indirect		Correlation
	Effect	%	Effect	%	
Weight class p1 (400 to 599 g)					
HL	0.345	75.06	0.114	24.94	0.46 **
BH	1.078	63.94	-0.608	36.06	0.47 **
BW	-1.329	46.50	1.529	53.50	0.20 *
BH / SL	-0.977	40.14	1.457	59.86	0.48 **
BW / SL	1.776	52.98	-1.576	47.02	0.20 *
BW / HL	-0.623	83.14	-0.126	16.86	-0.75 **
Weight class p2 (600 to 900 g)					
SL	-0.107	71.85	-0.042	28.15	-0.15 ns
HL	-0.430	31.86	0.920	68.14	0.49 **
BH	0.652	72.89	-0.242	27.11	0.41 **
BW / HL	-0.690	84.24	-0.129	15.76	-0.82 **
HL / BH	0.489	58.34	-0.349	41.66	0.14 ns

SL: standard length; HL: head length; BH: body height; BW: body width. *(p = 0.05); **(p = 0.01); ns (not significant).

Table 6. Estimates of the direct and indirect effects, obtained by path analysis, between morphometric measurements and ratios and head yield of Nile tilapia, *Oreochromis niloticus*, in different weight classes.

Effect	Weight class p1 (400 to 599 g)					
	HL	BW	BH / SL	BW / SL	BW / HL	
Direct	0.345	1.078	-1.329	-0.978	1.776	-0.624
Indirect by HL	---	0.819	-0.518	0.108	-0.693	0.399
Indirect by BH	0.262	---	-0.399	-0.401	-0.426	0.355

Indirect by BW	0.135	0.323	---	0.166	0.924	-0.019
Indirect by BH / SL	-0.038	0.442	0.226	---	0.622	0.206
Indirect by BW / SL	-0.135	-0.259	-0.691	-0.342	---	-0.150
Indirect by BW / HL	-0.221	-0.615	-0.040	0.323	0.426	---

Effect	Weight class p2 (600 to 900 g)					
	SL	HL	BH	BW / HL	HL / BH	
Direct	-0.108	-0.430	0.653	-0.691	0.490	
Indirect by SL	---	-0.146	0.189	-0.124	0.039	
Indirect by HL	-0.037	---	0.392	0.311	0.255	
Indirect by BH	-0.031	-0.258	---	0.228	-0.181	
Indirect by BW / HL	-0.019	0.194	-0.215	---	-0.088	
Indirect by HL / BH	-0.009	-0.224	-0.241	0.124	---	

SL: standard length; HL: head length; BH: body height; BW: body width.

The fillet yield also had the highest correlation coefficients with the ratio BW / HL, being 0.74 and 0.78 in the p1 class in class p2, respectively (Table 7), and the percentages of the direct effects of this variable were also high with RFILE in both class p1 (77.63%) and class p2 (95.78%) (Table 7). Other variables might be important for class P1, such as the height of the body (BH) and the ratio BH / SL, which showed significant correlation coefficients of -0.5 to RFILE; however, the percentages under the direct effects were primarily due the indirect effects via BW / HL (0.069 to 0.094 BH and BH / SL) (Tables 7 and 8), confirming the importance of body length and the width ratio of the head to determine the fillet yield.

Table 7. Amounts and percentages of direct and indirect effects of the morphometric measures and ratios on the fillet yield of Nile tilapia *Oreochromis niloticus* in different weight class.

Variables	Direct		Indirect		Correlation
	Effect	%	Effect	%	
Weight class p1 (400 to 599 g)					
BH	-0.122	24.58	-0.377	75.42	-0.50**
BH / SL	-0.284	56.97	-0.215	43.03	-0.50**
BW / SL	-0.378	71.80	0.148	28.20	-0.23**
BW / HL	0.574	77.63	0.165	22.37	0.74 **
HL / BH	-0.249	73.59	0.089	26.41	-0.16 ns
Weight class p2 (600 to 900 g)					
SL	0.587	58.46	-0.417	41.54	0.17 ns
HL	-0.590	73.73	0.210	26.27	-0.38 **
BH / SL	0.570	37.50	-0.950	62.50	-0.38 **
BW / HL	0.747	95.78	0.032	4.22	0.78 **

HL / BH	0.492	43.39	-0.642	56.61	-0.15 ns
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SL: standard length; HL: head length; BH: body height; BW: body width. *(p = 0.05); **(p = 0.01); ns (not significant).

Generally, the variable morphometric BW / HL was the most determining factor for the variation of yield and fillet head; however, the correlations are given in opposite directions, namely wider and shorter heads have higher yields of fillet and lower yields of head and, therefore, are more desirable.

Table 8. Estimates of the direct and indirect effects, obtained by path analysis, between morphometric measurements and ratios and fillet yield of Nile tilapia, *Oreochromis niloticus*, in different weight classes.

Effects	Weight class p1 (400 to 599 g)				
	BH	BH / SL	BW / SL	BW / HL	HL / BH
Direct	-0.123	-0.285	-0.379	0.574	-0.250
Indirect by BH	---	-0.122	0.080	-0.322	-0.012
Indirect by BH / SL	-0.053	---	-0.125	-0.190	0.152
Indirect by BW / SL	0.026	-0.094	---	0.132	0.085
Indirect by BW / HL	0.069	0.094	-0.087	---	0.090
Indirect by HL / BH	-0.006	0.174	0.129	-0.207	---
Effects	Weight class p2 (600 to 900 g)				
	SL	HL	BH / SL	BW / HL	HL / BH
Direct	0.587	-0.590	0.570	0.747	0.493
Indirect by SL	---	-0.218	-0.331	0.112	0.020
Indirect by HL	0.217	---	0.103	-0.336	0.227
Indirect by BH / SL	-0.341	-0.106	---	-0.291	-0.212
Indirect by BW / HL	0.088	0.266	-0.222	---	-0.099
Indirect by HL / BH	0.023	-0.272	-0.245	-0.149	---

SL: standard length; HL: head length; BH: body height; BW: body width.

Freto et al. (2005), working with piracanjuba *Brycon orbignyanus* reported that fusiform fish, in other words, longer and plump, have higher incomes and housing fillet.

Results similar to the present study were observed by Neto et al. (2012), who evaluated round fish, in which morphometric ratio BW / HL showed high correlation coefficients and high percentages of direct effect on the prime yield body (rib, fillet and fillet with rib), in other words, the wider and shorter the length of the fish heads, the better its carcass characteristics are.

The morphometric measurements and ratios could be used for assessing body yields of Nile tilapia and, therefore, should be subjected to character studies that provide genetic information necessary for these variables to be applied in breeding programs aimed at optimizing the carcass characteristics of this fish.

Conclusion

The ratio between the width and length of the body is the head morphometric most important variable for determining carcass characteristics of Nile tilapia, because it is strongly associated with head and fillet yield. Regardless of weight class evaluated.

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