Comparison of the Condition Factor of Five Fish Species of the Araguaia River Basin, Central Brazil

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ABSTRACT:

This study aims to assess the condition factor (K) of five fish species (*Serrasalmus rhombeus*, *Psectrogaster amazonica*, *Loricaria cataphracta*, *Panaque nigrolineatus* and *Squaliforma emarginata*). Samplings were conducted during the low-water period of 2007 and 2008 using gillnets and minnow traps. All equipments were placed along a stretch of 1000 m at 5 pm and retrieved at 7 am. Collected fish were taxonomically identified, weighed (g) and measured (standard length; mm). The fish fitness was assessed by the condition factor ($K=W/L^3$) and compared among groups of tributaries by a Kruskal-Wallis test. From the five species considered, two (*S. emarginata* and *P. amazonica*) displayed significant differences of the condition factor among the groups of tributaries. The highest values of K correspond to fish located in the headwaters, while lowest values are observed in tributaries located in the floodplain.

Keywords: Fitness; *Psectrogaster amazonica*; *Squaliforma emarginata*.

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Biometrics means literally a measure of life (Sokal et al. 1995). Two basic measures in animals, including fish, are weight and length (Santos et al. 2004). The analysis involving a pair of measurements is also useful information, such as the weight-length analysis hereafter called condition factor (Le Cren 1951). This factor assumes that heavier organism, fish in this case, of a determined length are in better condition indicating the general "well-being" or "fitness" of the fish population considered, while fish growth expresses fitness as result of the combination of increase of body length, condition and tissue energy concentration (Bolger & Connolly 1989). These authors also indicates that the fish condition factor was used i) to compare mono-specific populations living under (dis)similar conditions of food density, climate, etc (e. g., Copp 2003; Fafioye & Oluajo (2005); ii) to determine the timing and duration of gonad maturation (e. g. Lizama & Ambrósio 2002; Abowei 2009); iii) as an indicator of nutritional balance changing resulting of severe alterations in feeding activity or food supply (e. g., Zakeyudin et al. 2012).

The condition factor informs about the degree of development of the fish body, health, nutrition, food availability and quality of the environment (Vazzoler 1981), allowing the understanding of the fish life cycle and contributing to adequate fish management and consequently to the maintenance of equilibrium in the ecosystem (Lizama & Ambrósio 2002). The fish condition factor is calculated assuming allometric growth (Braga 1986; Bolger & Connolly 1989), which is valid for most fish species (Le Cren 1951).

The aim of this study is to compare the condition factor of five fish species collected in watercourses of the Araguaia River, Central Brazil. For this purpose, it is used a data set of length and weight values of fish species collected in 13 sampling stations of 11 watercourse grouped in an upstream-downstream gradient along the main channel of the Araguaia River.

Material and Methods

Study Area

The Araguaia River is highly heterogeneous along its course. Two functional sections of this river are present along the west border of Goiás State, Central Brazil the upper and middle section. Accordingly to Aquino et al. (2005), in the former section (from headwaters to Registro do Araguaia city, Goiás), the river runs through a steep landscape with elevations of 1000 m, whereas a floodplain is predominant in the last section (from Registro do Araguaia - Goiás to Conceição do Araguaia – Pará). Brasil (1997) indicates that the rainfall regime of the region has two seasons: low-waters (March - September) and high-waters (November - February).

Samplings were conducted in 13 stations (each 1000 m in length) distributed in 11 tributaries of the Araguaia River (Figure 01), whose physical characteristics are shown in Table 01. The tributaries were grouped into four groups considering their geographical proximity (located in the same sub-basin or in an adjacent sub-basin) along the main channel of the Araguaia River, thus the first group is at the headwaters, while the fourth group is closest to the floodplain (Figure 01).

Sampling Protocols

The fish were collected during the low-waters of 2007 (September) and 2008 (May - August). It was used four sets of gillnets (mesh 3, 5, 7, 10, 12 and 14 cm between knots) and five minnow-traps, they all were placed at 17:00 pm and retrieved at 7:00 am. Samples were collected once in every sampling station. Collected fish were formalized, placed in identified plastic bags and conserved in formaldehyde 10%. In laboratory, fish was identified using taxonomic keys of Planquette et al. (1996), Santos et al. (2004) and Melo et al. (2005), weighed with a balance (OHAUS; 0,1 g) and measured (standard length; 0,1 mm) with an ichthyometer. Specimens of each species were sending to the Laboratory of Ichthyology of the Pontifícia Universidade Católica de Rio Grande do Sul for confirmation of taxonomical identification.

Two species of characins, the redeye piranha *Serrasalmus rhombeus* (Linnaeus 1766) and the toothless characin *Psectrogaster amazonica* (Eigenmann & Eigenmann, 1889) and three armored catfish *Loricaria cataphracta* (Linnaeus 1758), the royal panaque *Panaque nigrolineatus* (Peters 1877) and *Squaliforma emarginata* (Valenciennes 1840) were selected for analyses of the condition factor, since they were present at least in three of the four groups of tributaries considered.

Analysis of Data

The condition factor (K) for each species was calculated using the formula $K = W/L^3$; where: W = total weight; L = standard length; 3 = value of b considering for fish that has an isometric growth (Vazzoler 1981).

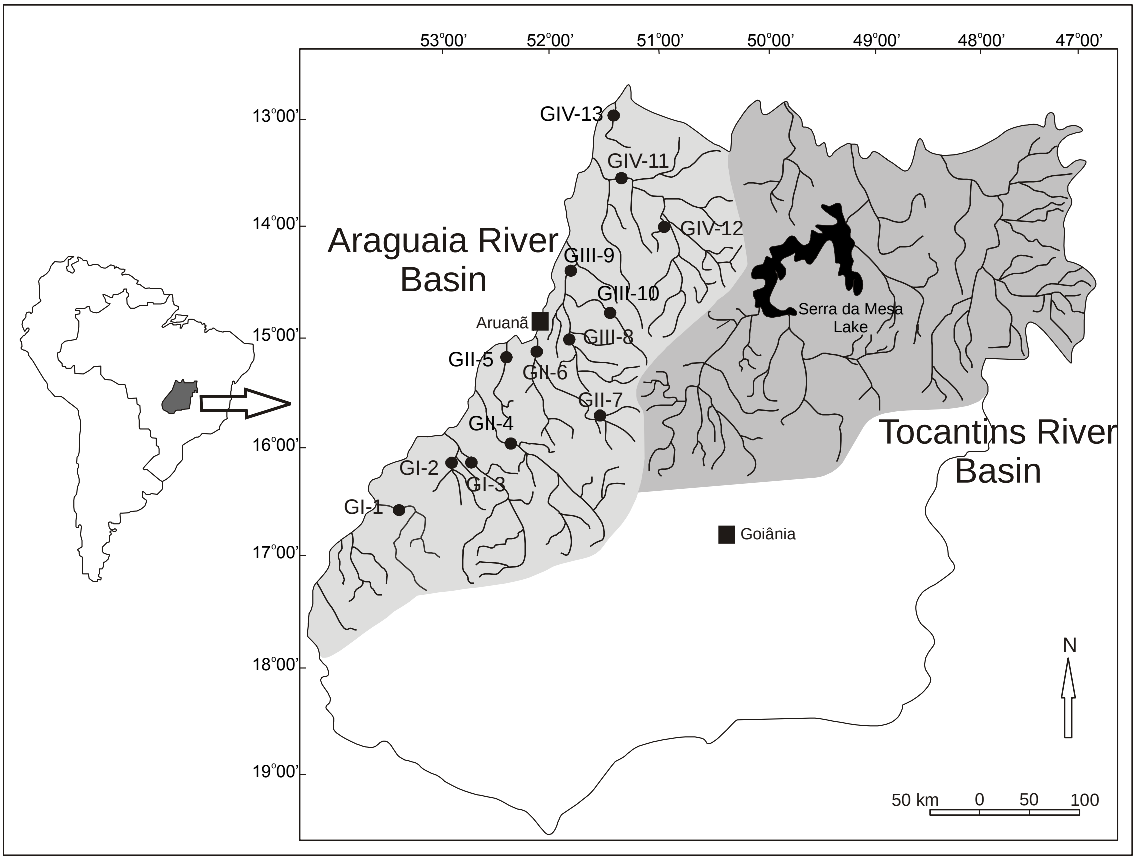
The condition factor values obtained for each species was compared per group of tributaries using the Kruskal-Wallis test followed by a *post hoc* analyses of median test ($p<0.05$ in both cases). For species displaying significant differences a second Kruskal-Wallis test followed by a median test was performed separately on weight and length data by group of tributaries aiming to verify the influence of young individuals on calculation of condition factor.

Table 01. Physical Characteristics of the Sampling Stations Located in the Tributaries of the Araguaia River Basin, Central Brazil.

Tributary	Altitude (m)	Width (m)	Depth (m)	Riparian vegetation	River substrate	Anthropogenic activity
Do Peixe River	413	80	0.92	Shrubs, trees	Leaf, sand	Pasture
Piranhas River	333	60	2.5	Shrubs , trees	Leaf, sand	Pasture, culture
Caiapó River	349	101	1.7	Shrubs , trees	Rocks, sand	Pasture
Claro River	302	68	2.4	Interrupted	Sand	Pasture
Água Limpa River	267	7	0.4	Shrubs	Rocks	Pasture
Vermelho River A	-	79	3.75	Shrubs, trees	Sand, clay	Pasture
Vermelho River B	305	31	5.9	Shrubs, trees	Rocks , sand	Pasture
Do Peixe River A	238	85	0.9	Shrubs, trees	Sand, clay	-
Do Peixe River B	262	27	1.15	Shrubs, trees	Sand, gravel	Pasture
Tesouras River	296	20	0.45	Shrubs, trees	Leaf, sand	-
Crixás-Mirim River	244	20	0.5	Shrubs, trees	Leaf, sand	-
Dos Bois River	519	13	0.65	Shrubs, trees	Leaf, sand	Pasture
Verde River	214	18	2.9	Shrubs, trees	Leaf, sand	-

Source: Authors.

Figure 01. Sampling Stations (Black Circles) in the Tributaries of the Araguaia River in Goiás State, Central Brazil.



Codes names identify the group of tributaries (GI, GII, GIII, GIV) followed by a number that corresponds to the name of the tributary (1=Do Peixe River, 2=Piranhas River, 3=Caiapó River, 4=Claro River, 5= Água Limpa River, 6=Vermelho River A, 7=Vermelho River B, 8=Do Peixe River A, 9=Do Peixe River B, 10=Tesouras River, 11=Crixás-Mirim River, 12=Dos Bois River, 13=Verde River). Black squares=main city.

Source: Authors.

Results and Discussion

Two species *P. amazonica* and *S. emarginata* displayed significant differences for K values among the groups of tributaries considered. For both species the general trend is a decrease of K values from upstream to downstream, more specifically the former species K values decrease from group II to III, while for the second species the K value decrease from group I to III (Table 02).

Table 02. Results of the Kruskal-Wallis and *post hoc* test for the Condition Factor (K) of Five Species Considered.

Species	Group	n	K Median	K Min.	K Max.	Kruskal-Wallis test Statistics	Kruskal-Wallis test p	Multiple comparisons p values				
Loricaria cataphracta	I	-	-	-	-		0.6338	-	-	-	-	-
	II	2	0.000006	0.000006	0.000006	H (2, N=13) = 0.9120879						
	III	3	0.000005	0.000005	0.000006							
	IV	8	0.000005	0.000004	0.000006							
Panaque nigrolineatus	I	4	0.000042	0.000041	0.000044		0.1651	-	-	-	-	-
	II	-	-	-	-	H (2, N=16) = 3.602941						
	III	6	0.000043	0.00004	0.000049							
	IV	6	0.000044	0.000042	0.000048							
Psectrogaster amazonica	I	-	-	-	-		**0.0035**	Group	II	III	IV	
	II	6	0.000032	0.000028	0.000034	H (2, N=26) = 11.33789		II	-			
	III	5	0.000033	0.000031	0.000034			III	0,850639	-		
	IV	15	0.000029	0.000027	0.000031			IV	0,132675	**0.005077**	-	
Serrasalmus rhombeus	I	5	0.000032	0.000026	0.000038		0.0597	-	-	-	-	-
	II	2	0.000037	0.000036	0.000038	H (3, N=21) = 7.418811						
	III	3	0.000037	0.000035	0.000042							
	IV	11	0.000031	0.000003	0.000037							
Squaliforma emarginata	I	2	0.000023	0.000021	0.000025		**0.0037**	Group	I	II	III	IV
	II	10	0.000015	0.000012	0.00002	H (3, N=46) = 13.46605		I	-			
	III	30	0.000018	0.000014	0.000023			II	**0.019495**	-		
	IV	4	0.000017	0.000011	0.00002			III	0.633154	**0.015881**	-	
								IV	0.28716	1	1	-

Significant values (p<0.05) are in bold.

Source: Authors.

The differences observed seem to be related to the different responses of fish population to food availability in consequence of the regional seasonal period. Sampling collects in this study were conducted during the low-waters season, in which there is a severe alteration of food supply resulting, in part, of a shortage of allochthonous input of organic nutrients from riparian vegetation (Junk et al. 1989; Pusey & Arthington 2003) and an increase of predation and competition for resources (Magoulick & Kobza 2003). Severe alteration of food supply is known to influence on condition factor (Bolger & Connolly 1989). These authors also indicate that condition factor is sensitive to gonad maturation. Some tropical fish, including those of the Araguaia River, perform seasonal reproductive migration at the end of the low-water period (Sivasundar et al. 2001), as is the case of *P. amazonica* (Fernandes 1997; Agostinho et al. 2007). Along the previous period that precede migration (May –

September), gonad maturation is in course; this seems to be the case for *P. amazonica* in this study. However, non-migrant fishes, such is the case of *S. emarginata* (Melo et al. 2012); also have their reproductive period at the end of the low-water period.

The analysis of weight and length of the species with significant differences in the condition factor among the groups of tributaries indicates that from the two species only *P. amazonica* displayed non influence of the juvenile fish on the condition factor calculated using the regression coefficient b=3 (Table 03).

Table 03. Results of the Kruskal-Wallis and *post hoc* test for the Condition Factor (K) of Five Species Considered.

Type	Species	Group	n	Median	Min.	Max.	Kruskal-Wallis test		Multiple comparisons p values				
							Statistics	p					
A	***Loricaria cataphracta***	I	-	-	-	-		-	-	-	-	-	-
		II	2	30.445	21.52	39.37	-						
		III	3	15.78	6.44	74.47							
		IV	8	14.475	8.19	59.56							
	Panaque nigrolineatus	I	4	552.925	175.53	947.35		-	-	-	-	-	-
		II	-	-	-	-	-						
		III	6	372.305	196.82	453.56							
		IV	6	464.275	181.35	852.4							
	Psectrogaster amazonica	I	-	-	-	-		0.1401	-	-	-	-	-
		II	6	76.05	56.8	91.27	H (2, N=26) = 3.930484						
		III	5	64.12	57.24	69.18							
		IV	15	63.02	49.51	91.48							
	Serrasalmus rhombeus	I	5	76.44	60.24	568.42		-	-	-	-	-	-
		II	2	230.2	90.65	369.75	-						
		III	3	113.69	52.67	347.64							
		IV	11	134.61	4.9	275.41							
	Squaliforma emarginata	I	2	15.405	15.39	15.42		**0.0001**	Group	I	II	III	IV
		II	10	400.995	128.44	890.52	H (3, N=46) = 21.99038		I	-			
		III	30	97.74	46.14	349.68			II	**0.001603**	-		
		IV	4	90.12	68.24	108.82			III	0.303297	**0.000794**	-	
									IV	1	**0.019267**	1	-
B	***Loricaria cataphracta***	I	-	-	-	-		-	-	-	-	-	-
		II	2	171.5	156	187	-						
		III	3	145	106	230							
		IV	8	145.5	116	215							
	Panaque nigrolineatus	I	4	235.5	159	285		-	-	-	-	-	-
		II	-	-	-	-	-						
		III	6	206.5	159	220							
		IV	6	218	160	269							
	Psectrogaster amazonica	I	-	-	-	-		0.0654	-	-	-	-	-
		II	6	133	126	141	H (2, N=26) = 5.455080						
		III	5	124	120	130							
		IV	15	130	118	143							
	Serrasalmus rhombeus	I	5	141	128	250		-	-	-	-	-	-
		II	2	174.5	136	213	-						
		III	3	145	115	202							
		IV	11	163	58	195							
	Squaliforma emarginata	I	2	87.5	85	90		0.0001		I	II	III	IV
		II	10	297	185	426	H (3, N=46) = 20.43509		I	-			
		III	30	179	134	289			II	**0.001966**	-		
		IV	4	182.5	155	190			III	0.32307	**0.001002**	-	
									IV	0.744698	0.085124	1	-

Significant values ($p<0.05$) are in bold.

Source: Authors.

Under these conditions (presence of juveniles in the case of *S. emarginata*), it would be necessary to calculate the specific regression coefficient for the species. However, this require a large number of individuals (Rocha et al. 2005), which is difficult to obtain in natural environments as is the case of this study. On the other hand, Vazzoler & Vazzoler (1965) apud Lizama & Ambrósio (2002) found higher values of K for juveniles than for adults of the herring *Sardinella auritia* suggesting that there is not constancy between the condition factor and length of mature fish during a one-year period. This could explain partly of the results for *S. emarginata*.

The absence of significant differences for *S. rhombeus*, *L. cataphracta* and *P. nigrolineatus* may be due to small sample size in some tributaries (Table 02), which directly affect the condition factor (Vazzoler 1996).

In conclusion, this study indicates that from the five species considered two, the toothless characin *P. amazonica* and the armored catfish *S. emarginata* displayed significant differences of the condition factor among the groups of tributaries of the Araguaia River along the upstream-downstream gradient considered. The condition factor seems to be influenced by the presence of juvenile's fish in the case of *S. emarginata*.

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Comparação do Fator de Condição de Cinco Espécies de Peixes da Bacia do Rio Araguaia, Brasil Central

RESUMO:

Este estudo objetiva avaliar o fator de condição (K) de cinco espécies de peixes (*Serrasalmus rhombeus*, *Psectrogaster amazonica, Loricaria cataphracta*, *Panaque nigrolineatus* e *Squaliforma emarginata*). As coletas foram realizadas utilizando-se quatro jogos de redes de malhar e cinco armadilhas, os quais foram colocados ao longo de um trecho de 1000 m das 17:00 às 7:00. Os peixes coletados foram identificados taxonomicamente, pesados (g) e medidos (comprimento standard; mm). A condição física dos peixes foi calculada pelo fator de condição ($K=W/L^3$) e comparada por grupo de cursos de água utilizando um teste de Kruskal-Wallis. Das cinco espécies consideradas *S. emarginata* e *P. amazonica* mostraram diferenças na condição física por grupo de cursos de água. Os maiores valores de K de ambas as espécies correspondem aos espécimes localizados em cursos de água de cabeceira, enquanto que baixos valores são encontrados em peixes dos cursos de água na planície.

Palavras chave: Condição Física; *Psectrogaster amazonica*; *Squaliforma emarginata*.

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