SHORT COMMUNICATION

Length-weight relationship and condition factor for twelve fish species from the Igarapé Fortaleza basin, a small tributary of the Amazonas River estuary

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ABSTRACT

Length and weight data are useful in fisheries management and standard results of fish monitoring programs. Length-weight relationship (LWR) is used for estimating the weight corresponding to a given length, and the condition factor is used to compare the body condition, fatness or health of fish populations. This study aimed to estimate the LWR and the condition factor for 12 freshwater fish species from the Igarapé Fortaleza basin, a tributary of the Amazonas River system in the State of Amapá, eastern Amazon (Brazil). The coefficient of determination, the allometric condition factor and the allometric coefficient varied among species, and were compared with populations elsewhere. In 83.3% of the species, the allometric coefficient remained within the expected range. This was the first record of LWR parameters for *Acestrorhynchus falcirostris*.

KEYWORDS: allometry, Brazil, freshwater fish, growth pattern

Relação peso-comprimento e fator de condição para doze espécies de peixes da bacia do Igarapé Fortaleza, um pequeno tributário do estuário do Rio Amazonas

RESUMO

Os dados de comprimento e peso são úteis na gestão da pesca e resultados padrão dos programas de monitoramento de peixes. A relação peso-comprimento (RPC) é usada para estimar o peso correspondente a um determinado comprimento e o fator de condição é usado para comparar a condição corporal, gordura ou saúde de populações de peixes. O objetivo deste estudo foi estimar a RPC e o fator de condição para 12 espécies de peixes de água doce da bacia do Igarapé Fortaleza, um afluente do sistema do Rio Amazonas no estado do Amapá, na Amazônia oriental brasileira. O coeficiente de determinação, o fator de condição alométrico e o coeficiente alométrico variaram entre espécies, e foram comparados com populações de outras localidades. Para 83,3% das espécies, os valores do coeficiente alométrico estavam dentro da faixa esperada. Este foi o primeiro registro de parâmetros de RPC para *Acestrorhynchus falcirostris*.

PALAVRAS-CHAVE: alometria, Brasil, peixes de água doce, padrão de crescimento

Fish body length and body weight are two useful empirical measures in stock assessment and more generally, in population ecology, community and ecosystem ecology studies (Giarrizzo *et al.* 2015; Baitha *et al.* 2018). Fish growth is generally measured by the increase of length and weight, which are used to determine population development. The length-weight relationship (LWR) is a mathematic model that allows for the conversion of length into weight, and weight into length in stock assessment models, as well as the estimation of biomass from the length frequency distribution. LWR can be used to determine possible differences between separate stock units of a species, provided all units are studied with the same fully standardized sampling methodology (Dieb-Magalhães *et al.* 2015; Freitas *et al.* 2017; Baitha *et al.* 2018). LWR is also used for estimating the condition factor of fish, which is used to compare the health of fish populations. A high condition factor indicates that a fish is heavier than a fish of the same length with a lower condition factor, and thus always refers to a deviation from the average LWR for a population (Le Cren 1951; Froese 2006; Freitas *et al.* 2017). The analysis of LWR and condition factor of fish populations are important tools to support the rational management of fishing resources, and may help in the implementation of public policies (Dieb-

Magalhães *et al.* 2015; Giarrizzo *et al.* 2015; Silva *et al.* 2015; Baitha *et al.* 2018). LWR studies for freshwater fish species from the Amazonas River basin have increased, providing important biological information on fish populations (e.g. Freitas *et al.* 2014; Silva *et al.* 2015; Giarrizzo *et al.* 2015; Cella-Ribeiro *et al.* 2015; Dieb-Magalhães *et al.* 2015; Freitas *et al.* 2017). However, there still are large gaps in the geographical coverage of biological data for many fish widely distributed in the Amazon basin.

The Igarapé Fortaleza basin is a 27.3-km long tributary basin of the Amazonas River estuary in the eastern Amazon in Brazil, in the state of Amapá (municipalities of Santana and Macapá) (Figure 1). The Fortaleza basin has a large extension of floodplain areas, with very peculiar characteristics owed to the combined strong influence of the high rainfall of the Amazon region and the daily tides of the Amazonas River due to the proximity to the Atlantic Ocean (Takyama *et al.* 2004). These areas are important as shelter and feeding grounds for several fish species of different families, including Acestrorhynchidae, Cichlidae, Auchenipteridae, Callichthyidae, Curimatidae, Erythrinidae, Anostomidae and Triportheidae (Takyama *et al.* 2004; Gama and Halboth 2004). In this region, fisheries of several species belonging to these families are among the most important economic activities, and fish stocks are the main food source for many traditional communities. This study aimed to estimate LWR and the allometric condition factor for 12 fish species of different families from Igarapé Fortaleza, for which there is a lack of information on LWR.

The study was conducted monthly from March 2012 to December 2014. Samples of each fish species (juveniles and adults) (Table 1) were collected using gillnets (15 m long and 1.5 m deep) with different mesh sizes (10, 15, 20, 25, 30, 35 and 40 mm between knots). Fish were sampled at six points in the southeastern sector of the Fortaleza basin (Figure 1). Mean duration of net exposure at each sampling point was six hours. All fish were transported in boxes with ice to the Laboratory of Aquaculture and Fishery at Embrapa Amapá, in Macapá, state of Amapá. In the laboratory, fish were measured for total length (cm) and body weight (g) for determination of LWR and the allometric condition factor. The study was authorized by the Ethics Committee on Animal Use of Embrapa Amapá (protocol # 004 - CEUA/CPAFAP) and by ICMBio (SISBIO license # 23276-1).

LWR was calculated using the equation $W = aTL_t^b$, where W is the total weight (in g) and TL is the total length (in cm), while a is constant and b is the allometric coefficient. The values a and b were estimated by linear regression of the transformed equation: $\log W = \log a + b \log TL$, using the software Statistica, v. 7.0. Additionally, 95% confidence limits (CL) of the b coefficient and the coefficient of determination (R^2) of the LWR were estimated for each species. Outliers were graphically identified and removed (Froese and Binohlan 2000). Type of growth was determined through a t-test where: H_0: $b = 3$ (isometric growth) and H_1: $b \neq 3$ (allometric growth) (Zar 2010). The allometric condition factor (K_a was calculated according to equation $K_a = W/L_t^b$ (Le Cren 1951).

Table 1. Total body length and weight, length-weight relationship (LWR) parameters and allometric condition factor for samples of 12 fish species collected in the Igarapé Fortaleza basin, state of Amapá (Brazil) from March 2012 to December 2014.

| Order/Family/Species | N | Total length (cm) | | Body weight (g) | | LWR parameters | | | Cond factor |
		Min	Max	Min	Max	a (95% CL)	b (95% CL)	R^2	K_a
CHARACIFORMES									
Acestrorhynchidae									
Acestrorhynchus falcirostris Cuvier, 1819	33	12.5	28.5	16.0	156.0	0.015 (0.005-0.045)	2.757 (2.405-3.106)	0.892	0.839 ± 0.071
Triportheidae									
Triportheus angulatus Spix & Agassiz, 1829	31	14.0	20.5	20.0	78.0	0.006 (0.0008-0.047)	3.136 (2.419-3.852)	0.734	0.867 ± 0.052
Curimatidae									
Curimata cyprinoides Linnaeus, 1766	65	6.6	15.0	3.8	44.6	0.020 (0.014-0.028)	2.848 (2.699-2.996)	0.959	1.155 ± 0.062
Erythrinidae									
Hoplias malabaricus Bloch, 1794	67	12.0	32.5	16.0	412.0	0.013 (0.007-0.021)	2.962 (2.805-3.118)	0.956	0.860 ± 0.060
Anostomidae									
Leporinus friderici Bloch, 1794	50	10.0	25.5	14.0	240.0	0.022 (0.016-0.031)	2.827 (2.711-2.943)	0.980	1.069 ± 0.070
CICHLIFORMES									
Cichlidae									
Chaetobranchus flavescens Heckel, 1840	39	9.5	24.0	22.0	248.0	0.051 (0.029-0.088)	2.647 (2.443-2.850)	0.949	1.211 ± 0.112
Pterophyllum scalare Schultze, 1823	42	5.5	10.5	2.0	22.0	0.027 (0.013-0.056)	2.795 (2.418-3.172)	0.848	1.249 ± 0.161
Aequidens tetramerus Heckel, 1840	92	10.0	19.2	21.7	157.0	0.084 (0.043-0.163)	2.487 (2.238-2.737)	0.813	1.269 ± 0.081
SILURIFORMES									
Auchenipteridae									
Ageneiosus ucayalensis Castelnau, 1855	24	14.0	35.5	20.0	260.0	0.026 (0.008-0.083)	2.518 (2.139-2.896)	0.851	0.874 ± 0.054
Auchenipterus nuchalis Spix & Agassiz, 1829	27	14.0	21.0	28.0	80.0	0.055 (0.012-0.251)	2.331 (1.797-2.865)	0.763	0.997 ± 0.037
Trachelyopterus galeatus Linnaeus, 1766	37	7.5	14.5	4.0	52.0	0.003 (0.001-0.006)	3.579 (3.303-3.856)	0.951	1.085 ± 0.083
Callichthyidae									
Callichthys callichthys Linnaeus, 1758	38	15.5	21.0	58.0	140.0	0.040 (0.008-0.203)	2.709 (2.143-3.275)	0.723	1.102 ± 0.041

N = sample size; Min = minimum; Max = maximum; a = intercept; b = slope; R^2 = coefficient of determination of the length-weight relationship; 95% CL = 95% confidence interval; K_a = allometric condition factor.
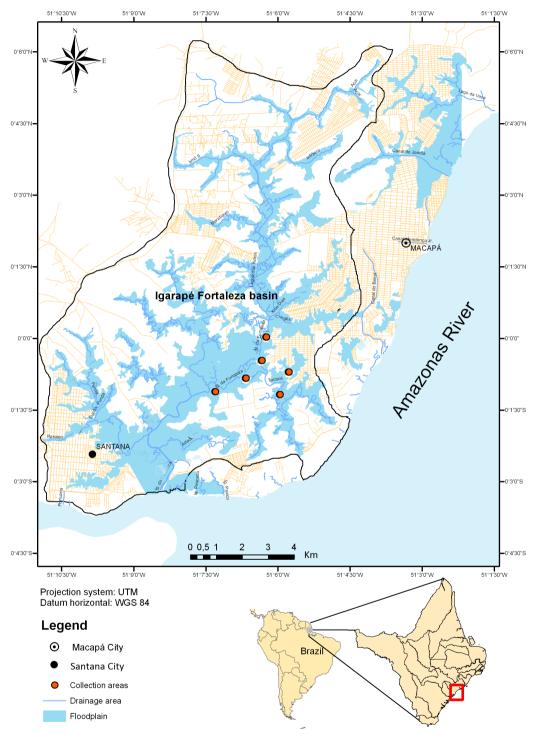
Figure 1. Map of the Amazonas River tributary basin of Igarapé Fortaleza, in the state of Amapá, in northern Brazil (small maps). Red dots indicate the fish sampling sites. This figure is in color in the electronic version.

Mean K_a ranged from 0.839 for *Acestrorhynchus falcirostris* to 1.211 for *Chaetobranchus flavescens*. The *b* coefficient ranged from 2.331 for *Auchenipterus nuchalis* to 3.579 for *Trachelyopterus galeatus*. The R^2 of the LWR ranged from 0.723 for *Callichthys callichthys* to 0.980 for *Leporinus friderici* (Table 1). K_a was variable among species, probably reflecting recent feeding conditions, as well as physiological and/or reproductive state of the fish, as the proportions of males and females in the sample were different for each species (Le Cren 1951). *Trachelyopterus galeatus* and *Triportheus angulatus* showed

positive allometric growth, while the remaining species showed negative allometric growth. Except for *Aequidens tetramerus* and *A. nuchalis*, which presented a *b* coefficient below 2.5, and *T. galeatus* with *b* above 3.5, the remaining species presented *b* within the expected range of 2.5 – 3.5 (Froese 2006).

LWR parameters are available for various fish species at FishBase (www.fishbase.org), a global information system on fish (Froese and Pauly 2019). This is the first report of LWR for *A. falcirostris*. We found some contrasting values for the estimated parameters for the other species in other parts of their distribution range. Froese and Pauly (2019) inform mean *b* coefficients of 3.180 for *A. tetramerus* in the Xingu River, 2.760 to 3.180 for *C. callichthys* and *Curimata cyprinoides* in the Tucuruí reservoir (Tocantins River.), 2.483 for *C. flavescens* and 3.071 for *T. galeatus* in the Madeira River, 2.807 for *Pterophyllum scalare* in the Matapi River in Brazil, 2.897 to 3.090 for *T. angulatus* and 2.655 to 3.130 for *L. friderici* from diverse localities in Brazil and French Guiana, 2.720 to 3.305 for *Hoplias malabaricus* from Brazil, Portugal, Peru, Argentina, Colombia and French Guiana, 2.755 to 3.055 for *Ageneiosus ucayalensis* and 2.750 to 3.136 for *A. nuchalis* from Brazil. The *b* coefficient in our samples fell within the 95% confidence interval for the species (Table 1), except for *A. tetramerus*, *L. friderici*, *A. ucayalensis* and *A. nuchalis*.

These lower *b* values for *A. tetramerus* and *A. nuchalis* and higher values for *T. galeatus* may be due to various factors. The growth type of fish species can be changeable, depending on the season, food availability, population, sex or physiology (Silva *et al.* 2015; Giarrizzo *et al.* 2015; Cella-Ribeiro *et al.* 2015; Dieb-Magalhães *et al.* 2015; Freitas *et al.* 2017). Therefore, more data, from a larger sample size, are needed to confirm these extreme growth pattern values.

No data for Igarapé Fortaleza are available in FishBase, therefore ours are likely the first LWR estimates for fish in the Fortaleza basin, contributing to the knowledge on the biology of fish stocks and efforts to achieve sustainable fishery in the basin. Furthermore, our results contribute to the improvement of fishery exploitation models in the Amazon.

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