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Length–length and length–weight relationships for fish fauna from headwaters of Onça Puma Mountain ridge, Amazonian region, Brazil.

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ABSTRACT: Length–length (LLR) and length–weight (LWR) relationships are presented for 19 fish species collected between 2009 and 2011 in small tributaries and headwaters areas of the Tocantins-Araguaia basin, Itacaiúnas drainage, Southwestern Pará, Amazonian, Brazil. This study describes the first reference of LLR for 13 species and LWR for 16 fish species.

Keywords: Allometry, Itacaiúnas, ichthyofauna

RESUMO: Relações comprimento-comprimento e comprimento-peso para a ictiofauna das cabeceiras da Serra Onça Puma, região Amazônica, Brasil. Relações Comprimento-Comprimento (RCC) e Comprimento-Peso (RCP) são apresentadas para 19 espécies de peixes coletadas entre 2009 e 2011 em pequenos tributários de cabeceira da bacia do Toncantins-Araguaia, drenagens do Itacaiúnas, Sudoeste do Estado do Pará, Região Amazônica, Brasil. Este estudo relata a primeira referência de RCC para 13 espécies e de RCP para 16 espécies de peixes.

Palavras-chave: Alometria, Itacaiúnas, ictiofauna

1. Introduction

The Amazon basin with its complex and dynamic environments (e.g. rivers, small streams, beaches, floodplain forests, floodplain lakes) harbors high levels of fish diversity (BARLETTA et al., 2010; MONTANA; WINEMILLER, 2010). The heterogeneity of these habitats has influence on the diversity and also on the structure of the fish assemblages (WINEMILLER, 1990; MONTANA; WINEMILLER, 2010). The ichthyofauna inhabiting the Amazon basin has an important social and economic impact, but there is still little knowledge about the real status of the fishing stocks on this region (BARTHEM; FABRÉ, 2004; BARLETTA et al., 2010). Biological parameters as length–weight (LWR) and length–length (LLR)

relationships are important to convert and compare fishing data with biological characteristic of the species (e.g. pattern of growth) (RUIZ-CAMPOS et al., 2006; GIARRIZZO et al., 2011; PERVAIZ et al., 2012), thereby this data can be helpful for better understanding of the fish communities in the Amazon basin habitats.

This study reports the LLRs and LWRs for 19 fish species, and the first reference of LLR for 13 species and of LWR for 16 species, from the headwater areas at the Onça Puma Mountain ridge, of the Tocantins-Araguaia River basin, Itacaiúnas drainage, Amazonian, Brazil.

2. Material and methods

The field sampling was carried out quarterly between March 2009 and September 2011, in 15 sites distributed in small tributaries and headwater areas of the Cateté River (06°34'S, 051°01'W), located in Onça Puma Mountain ridge, northern Brazil, drainage of the Itacaiúnas River, Tocantins-Araguaia basin.

The fish were sampled with gillnets of nine different mesh sizes (20 to 180 mm stretch mesh size, 20 m long and 2 m high), cast nets (20 mm mesh size and 2.7 m height), and circular sieves (2 mm mesh size and 510 mm diameter). The specimens were fixed in a 10% formalin solution, preserved in 70% alcohol, and deposited in the ichthyological collection of the Grupo de Ecologia Aquática at Universidade Federal do Pará (institutional catalog code GEA available in Table 1). Fish identification was according to specific literature (e.g. GÉRY, 1977; REIS, 1989; KULLANDER; NIJSSEN, 1989; VARI, 1991; PLANQUETTE et al., 1996; ZANATA, 1997; FERREIRA et al., 1998; GARUTTI, 1999; SANTOS et al., 2004; BERTACO; LUCINDA, 2005; HOLLANDA CARVALHO; WEBER, 2005; LUCINDA et al., 2010; BRITSKI; BIRINDELLI, 2013). In laboratory, the fishes were individually measured (standard length *SL*, and total length, *TL*) to the nearest 0.01 cm and weighed (total wet weight, *W*) at a precision of 0.001 g.

Length-length relationships were determined by the method of least squares to fit a simple linear regression model. The LWR were calculated using the equation $W = a\ TL^b$ (PAULY, 1984), and logarithmically transformed into $\log W = \log a + b \log TL$ where W is the weight of the fish (g) and TL is the total length of the fish (cm), a is a constant, and b is the allometric coefficient (FROESE, 2006). The coefficient of determination (Pearson r-squared, r^2) was used as an indicator of quality of the linear regression. In order to check if fish growth (b) was statistically different from isometric growth, a t-test (H_0: b = 3), with $\alpha = 0.05$ was performed (SOKAL; ROHLF, 1987; FROESE et al., 2011).

3. Results and discussion

A total of 966 specimens representing 19 fish species belonging to eight families, and three orders were used for calculation of the LLRs and LWRs. The most diverse family was Characidae (nine species), followed by Cichlidae (three species), and Loricariidae (two species). The five remaining families (Anostomidae, Callichthyidae, Gasteropelecidae and Prochilodontidae) were represented by only one species.

The most of the 19 LLR (Table 1) and LWR (Table 2) were highly significant ($P \leq 0.001$), with r^2 ranging between 0.981 and 0.999. In addition, this is the first record of LLR for 13 species and of LWR for 16 species (FROESE; PAULY, 2013). The parameter b of the LWR ranged from 2.4463 to 3.5521 for *Prochilodus nigricans* (Prochilodontidae) and *Poptella compressa* (Characidae), respectively. This result corroborates with the expected range of $2.50 < b > 3.50$, suggested by Froese (2006). In relation to the type of growth, 17 species (89%) showed positive allometry ($b > 3$), and two (11%) negative allometry. Any species showed isometric growth ($b = 3$).

Table 1. Estimated parameters of length–length relationships (LLR) for 19 fish species collected quarterly between of March 2009 and September 2011 in small tributaries of the Itacaiúnas River (Tocantins-Araguaia basin).

Order/Family/Species	Catalog	n	Regression parameters				
			a	*b*	95% CL of *a*	95% CL of *b*	r^2
Characiformes							
Anostomidae							
Leporinus granti Eigenmann, 1912	GEA 1468	11	-0.0757	1.2715	-0.3172 to 0.1658	1.2327 to 1.3103	0.998
Characidae							
Bryconops caudomaculatus (Günther, 1864)	GEA 1471	58	0.2157	1.2010	0.0327 to 0.3988	1.1688 to 1.2332	0.990
Brachychalcinus copei (Steindachner, 1882)	GEA 1472	59	0.5426	1.1817	0.3533 to 0.7319	1.1383 to 1.2252	0.981
Ctenobrycon spilurus (Valenciennes, 1850) ⋆	GEA 1473	116	-0.0194	1.2627	-0.1349 to 0.0961	1.2304 to 1.295	0.981
Jupiaba apenima Zanata, 1997	GEA 1474	15	-0.4511	1.4220	-0.8289 to -0.0733	1.3195 to 1.5245	0.986
Jupiaba polylepis (Günther, 1864)	GEA 1475	61	0.1872	1.2281	0.0424 to 0.3320	1.1838 to 1.2725	0.981
Knodus savannensis Géry, 1961	GEA 1476	92	-0.0359	1.2535	-0.1057 to 0.0338	1.2288 to 1.2781	0.991
Moenkhausia dichroura (Kner, 1858) ⋆	GEA 1477	105	0.1028	1.2614	-0.0255 to 0.2311	1.2356 to 1.2872	0.989
Poptella compressa (Günther, 1864) ⋆	GEA 1478	22	0.019	1.3239	-0.1928 to 0.2308	1.2637 to 1.384	0.991
Steindachnerina pupula Vari, 1991	GEA 1480	59	0.1656	1.2813	-0.0002 to 0.3314	1.2544 to 1.3082	0.994
Erythrinidae							
Hoplias malabaricus (Bloch, 1794) ⋆	GEA 1483	63	0.0398	1.2676	-0.0472 to 0.1268	1.2568 to 1.2785	0.999
Gasteropelecidae							
Thoracocharax stellatus (Kner, 1858)	GEA 1484	59	0.0106	1.2784	-0.1635 to 0.1847	1.2308 to 1.3259	0.981
Prochilodontidae							
Prochilodus nigricans Spix & Agassiz, 1829 ⋆	GEA 1485	27	-1.8859	1.4691	-2.4484 to -1.3234	1.4063 to 1.532	0.989
Perciformes							
Cichlidae							
Aequidens tetramerus (Heckel, 1840)	GEA 1486	64	-0.0931	1.3665	-0.1944 to 0.0082	1.3440 to 1.3889	0.996
Geophagus neambi Lucinda, Lucena & Assis, 2010	GEA 1488	57	0.2151	1.2159	0.0226 to 0.4076	1.1862 to 1.2455	0.992
Retroculus lapidifer (Castelnau, 1855)	GEA 1489	27	0.2220	1.1973	0.0433 to 0.4007	1.1687 to 1.2258	0.997
Siluriformes							
Callichthyidae							
Corydoras aeneus (Gill, 1858)	GEA 1491	28	0.1331	1.2678	-0.0588 to 0.325	1.2078 to 1.3278	0.986
Loricariidae							
Hypostomus ericae Hollanda Carvalho & Weber, 2005	GEA 1493	22	0.0349	1.3253	-0.4312 to 0.5009	1.2768 to 1.3739	0.994
Rineloricaria lanceolata (Günther, 1868)	GEA 1496	21	-0.1230	1.2454	-0.5265 to 0.2805	1.1833 to 1.3075	0.989

n, number of specimens; CL, confidence limits; ⋆, species with length-length relationships estimates only with specimens juveniles, and species in bold have length-length relationships estimates included in FishBase database (FROESE; PAULY, 2013).

Table 2. Descriptive statistic and estimated parameters of length-weight relationships (LWR) for 19 species collected quarterly between March 2009 and September 2011 in small tributaries of the Itacaiúnas River (Tocantins-Araguaia basin).

Order/Family/Species	n	TL (cm)		W (g)		Regression parameters					T-test	Growth type
		Min	Max	Min	Max	*a*	*b*	95% CL of *a*	95% CL of *b*	r^2		
Characiformes												
Anostomidae												
Leporinus granti Eigenmann, 1912	11	2.80	15.13	0.21	67.31	0.0066	3.3377	0.0047 to 0.0092	3.1648 to 3.5106	0.995	0.0008	+ allometry
Characidae												
Bryconops caudomaculatus (Günther, 1864)	58	2.63	9.54	0.11	8.42	0.0055	3.2395	0.0064 to 0.0047	3.3190 to 3.1599	0.992	0.0000	+ allometry
Brachychalcinus copei (Steindachner, 1882)	59	3.75	8.29	0.58	9.87	0.0064	3.4766	0.0055 to 0.0075	3.3891 to 3.5642	0.991	0.0000	+ allometry
Ctenobrycon spilurus (Valenciennes, 1850) ⋆	116	1.98	6.01	0.04	1.79	0.0053	3.2533	0.0046 to 0.0060	3.1638 to 3.3428	0.98	0.0000	+ allometry
Jupiaba apenima Zanata, 1997	15	2.09	5.86	0.06	2.15	0.0055	3.3493	0.0039 to 0.0076	3.1333 to 3.5652	0.989	0.0020	+ allometry
Jupiaba polylepis (Günther, 1864)	61	1.83	5.75	0.04	2.01	0.0045	3.5149	0.0038 to 0.0054	3.3880 to 3.6417	0.981	0.0000	+ allometry
Knodus savannensis Géry, 1961	92	1.44	5.96	0.02	2.50	0.0038	3.5290	0.0034 to 0.0044	3.5219 to 3.7360	0.981	0.0000	+ allometry
Moenkhausia dichroura (Kner, 1858) ⋆	105	3.42	8.87	0.30	6.87	0.0046	3.3611	0.0040 to 0.0053	3.2862 to 3.4360	0.987	0.0000	+ allometry
Poptella compressa (Günther, 1864) ⋆	22	4.38	5.14	0.87	1.55	0.0043	3.5521	0.004 to 0.0047	3.5411 to 3.6431	0.999	0.0000	+ allometry
Steindachnerina pupula Vari, 1991	59	3.54	16.77	0.34	65.34	0.0053	3.3554	0.0042 to 0.0067	3.2360 to 3.4747	0.982	0.0000	+ allometry
Erythrinidae												
Hoplias malabaricus (Bloch, 1794) ⋆	63	1.15	27.96	0.01	241.00	0.0059	3.1711	0.0051 to 0.0069	3.0888 to 3.2535	0.990	0.0001	+ allometry
Gasteropelecidae												
Thoracocharax stellatus (Kner, 1858)	59	3.51	6.81	0.50	5.80	0.0065	3.5324	0.0054 to 0.0078	3.4105 to 3.6543	0.983	0.0000	+ allometry
Prochilodontidae												
Prochilodus nigricans Spix & Agassiz, 1829 ⋆	27	9.13	18.54	12.41	66.00	0.0514	2.4463	0.0398 to 0.0665	2.3400 to 2.5526	0.989	0.0000	- allometry
Perciformes												
Cichlidae												
Aequidens tetramerus (Heckel, 1840)	64	1.41	11.35	0.01	41.60	0.0086	3.5025	0.0071 to 0.0105	3.3849 to 3.6201	0.983	0.0000	+ allometry
Geophagus neambi Lucinda, Lucena & Assis, 2010	57	2.73	15.70	0.14	78.51	0.0069	3.3782	0.0059 to 0.0081	3.2987 to 3.4576	0.992	0.0000	+ allometry
Retroculus lapidifer (Castelnau, 1855)	27	1.78	18.21	0.06	89.50	0.0078	3.2507	0.0066 to 0.0092	3.1565 to 3.3449	0.995	0.0000	+ allometry
Siluriformes												
Callichthyidae												
Corydoras aeneus (Gill, 1858) ⋆	28	1.75	5.72	0.07	4.06	0.0099	3.4938	0.0082 to 0.0120	3.3521 to 3.6354	0.990	0.0000	+ allometry
Loricariidae												
Hypostomus ericae Hollanda Carvalho & Weber, 2005	22	5.26	24.03	2.53	158.30	0.0275	2.7062	0.0193 to 0.0393	2.5555 to 2.8568	0.986	0.0003	- allometry
Loricaria lata Eigenmann & Eigenmann, 1889	24	1.99	19.30	0.01	22.41	0.0013	3.3152	0.0009 to 0.0018	3.1592 to 3.4712	0.989	0.0002	+ allometry

n, number of specimens; TL, total length; W, weight; CL, Confidence limits; ⋆, species with length-length relationships estimates only with specimens juveniles, and species in bold have length-length relationships estimates included in FishBase database (FROESE; PAULY, 2013).

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