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Length-weight relationships for fish fauna from waterbodies in the upper Tapajós river basin of Palito Mountain ridge, Brazilian Amazon region

Kurt Schmid[1,2*], Marcelo Costa Andrade[1,2], Allan Jamesson Silva de Jesus[1,2], Juliana de Souza Araujo[1,2], Paulo Roberto Brasil Santos[4], Tommaso Giarrizzo[1, 2, 3]

1. Universidade Federal do Pará, Cidade Universitária Prof. José Silveira Netto. Laboratório de Biologia Pesqueira e Manejo dos Recursos Aquáticos, Grupo de Ecologia Aquática. Avenida Perimetral, 2651, Terra Firme, 66077830. Belém, PA, Brasil.
2. Programa de Pós-Graduação em Ecologia Aquática e Pesca. Universidade Federal do Pará, Instituto de Ciências Biológicas. Cidade Universitária Prof. José Silveira Netto. Avenida Augusto Corrêa, 1, Guamá, 66075110. Belém, PA, Brasil.
3. Programa de Pós-Graduação em Biodiversidade e Conservação. Universidade Federal do Pará, Faculdade de Ciências Biológicas. Avenida Cel. José Porfírio, 2515, São Sebastião, 68372010. Altamira, PA, Brasil.
4. Universidade Federal do Oeste do Pará, Instituto de Ciências e Tecnologias das Águas. Laboratório de Geoinformação e Investigação Pesqueira. Avenida Mendonça Furtado, 2946, Fátima, 68040050. Santarém, PA, Brasil.
*Autor para correspondência - Email: kurt@ufpa.br

ABSTRACT: Length-weight relationships (LWR) of 14 fish species were estimated from Palito Mountain ridge, upper Tapajós river basin, Brazilian Amazon region. This study represents the first LWR to the small characid *Hemigrammus marginatus*, and additionally provides new maximum record of length and weight for three species.

Keywords: Neotropical freshwater fish fauna; Length-weight relationship; Tapajós river basin; Allometry.

Relações comprimento-peso para a fauna de peixes de corpos d'água da bacia do alto rio Tapajós, Serra do Palito, região da Amazônia brasileira

RESUMO: Relações comprimento-peso (RCP) de 14 espécies de peixes da Serra do Palito, alto rio Tapajós, região amazônica brasileira foram estimadas. Este estudo apresenta a primeira RCP para o pequeno characídeo *Hemigrammus marginatus*, e fornece adicionalmente novos registros máximos de comprimento e peso para três espécies.

Palavras-chave: Peixes de água doce neotropicais, relação peso-comprimento, bacia do rio Tapajós, alometria.

1. Introduction

Length-weight relationships (LWR) of fish species are widely used to estimate weight through given length, and allow comparison between different populations of a same fish species and between different species (FROESE, 2006; GIARRIZZO et al., 2006; JOYEUX et al., 2009). This study reports the LWR for 14 fish species from Palito Mountain ridge, an area that houses tributaries of the Tapajós river basin in Pará State, northern Brazil. The Tapajós river basin is historically known for its water quality decrease since the beginning of gold mining activities in 1980's decade (ROULET et al., 1998; 2001).

2. Materials and Methods

Quarterly field samplings were undertaken between October 2010 and May 2014 in nine sites distributed among small tributaries and headwaters of the Jamanxim and Novo rivers (Tapajós Basin), located in the Palito Mountain ridge area (6°19'21.9"S 55°47'34.5"W) Itaituba city, Jardim do Ouro village, northern Brazil. The fish catch were performed using gillnets (20 m long, 2 m high and 20, 40, 60, 80, 100, 120, 150 and 180 mm mesh size), casting nets (2.7 m high and 3 mm mesh size), and circular sieves (51 cm diameter and 2 mm mesh size). Collected specimens were fixed in 10% formaldehyde solution and preserved in 70% alcohol solution. In laboratory each fish was identified to the lowest possible taxonomic level, measured in standard length (*SL* nearest 0.01 cm) and weighed (*W* nearest 0.001 g).

Outliers were identified graphically using log SL vs. log W plots (FROESE; BINOHLAN, 2000) and removed. Length-weight relationships were estimated by linear regression on the transformed equation: $\log W = \log a + b \log SL$ (LE-CREN, 1951; PAULY, 1984), where *W* is body weight (g), *SL* is standard length (cm), *a* is the y-intercept and *b* is the slope of allometric growth (FROESE, 2006). The Student's *t*-test (H_0: $b = 3$) at confidence level of 95% ($\alpha = 0.05$) was used to verify if *b* was significantly different from the isometric value ($b=3$) (SOKAL; ROHLF, 1987; GIARRIZZO et al., 2006). The correlation between *W* and *SL* is certificated by Pearson *r*-squared (r^2). Double logarithmic plotting of each species was tested using ANCOVA to detect different growth stanzas between LWRs (FROESE, 2006). Length of sexual maturity (Lmaturity) was estimated using the life-history tool on the FishBase website (FROESE; PAULY, 2014) based on existing and new maximum length values. Scientific names of fish taxa were checked in Eschmeyer and Fricke (2015).

3. Results

Overall 462 specimens belonging to nine families, 13 genera and 14 species were analyzed for LWR (Tables 1). All LWR's were significant ($P<0.05$) with coefficients of determination r^2 ranging from 0.943 to 0.998 (Table 1). Overall species showed allometric growth of the positive type in LWRs ($b>3$), with the parameter *b* ranging from 3.15 for *Astyanax bimaculatus* and *Myleus schomburgkii* to 3.46 for *Hemigrammus marginatus*. According to the Lmaturity

estimates, most of the analyzed species had exclusively juvenile individuals and only six species were representatives of the two classes (juveniles and adults) (see Table 1) which, although, revealed no significant differences ($p>0.05$) in LWR between juvenile and adult individuals in the analysis of covariance (ANCOVA).

This study presents the first record of LWR to the *Hemigrammus marginatus*, new record of maximum weight for three species (*Hemigrammus marginatus*, *Moenkhausia celibela* and *Pimelodus blochii*) and new maximum length for three species (*Hemiodus vorderwinkleri*, *Moenkhausia celibela* and *Triportheus albus*) (Table 1).

Table 1. Descriptive statistics and length–weight relationship parameters for 14 fish species, Palito Mountain ridge, upper Tapajós River basin, Northern Brazil.

Order/Family/Species	N	SL (cm)		W (g)		WL Regression parameters				
		Min	Max	Min	Max	*a*	95% CL (*a*)	*b*	95% CL (*b*)	r^2
Characiformes										
Characidae										
Astyanax bimaculatus (Linnaeus 1758)	106	1.89	9.33	0.13	26.73	0.0216	0.0187 - 0.0249	3.15	3.05 - 3.25	0.974
***Hemigrammus marginatus* Ellis 1911**	33	1.2	3.3	0.02	**0.71**	0.0105	0.0087 - 0.0125	3.46	3.27 - 3.66	0.977
*Moenkhausia celibela** Marinho & Langeani 2010	32	1.16	4.83	0.02	**2.37**	0.0138	0.0118 - 0.0162	3.2	3.00 - 3.39	0.974
*Tetragonopterus chalceus** Spix & Agassiz 1829	21	4	9.8	1.35	26.46	0.0106	0.0074 - 0.0152	3.45	3.28 - 3.63	0.989
Erythrinidae										
Hoplias malabaricus (Bloch 1794)	34	2.1	21.6	0.12	183.7	0.0096	0.0073 - 0.0125	3.31	3.17 - 3.44	0.987
Hemiodontidae										
Hemiodus argenteus Pellegrin 1909	18	1.98	14.34	0.05	61.2	0.0103	0.0059 - 0.0178	3.27	3.00 - 3.55	0.975
*Hemiodus vorderwinkleri** (Géry 1964)	21	7.1	**11.6**	6.27	33.14	0.0087	0.0055 - 0.0138	3.37	3.16 - 3.57	0.985
Prochilodontidae										
*Prochilodus nigricans** Spix & Agassiz 1829	23	7.29	24.89	9.3	561.6	0.0187	0.0145 - 0.0241	3.17	3.07 - 3.27	0.995
Serrasalmidae										
Myleus schomburgkii (Jardine 1841)	20	4.72	13.23	5.29	119.9	0.0363	0.0266 - 0.0495	3.15	2.99 - 3.30	0.990
Serrasalmus rhombeus (Linnaeus 1766)	32	4.39	31.96	2.02	1428	0.0151	0.0134 - 0.0171	3.29	3.23 - 3.35	0.998
Triportheidae										
*Triportheus albus** Cope 1872	15	6.59	**17.32**	4.57	113.8	0.0073	0.0042 - 0.0127	3.37	3.16 - 3.59	0.988
Perciformes										
Cichlidae										
Aequidens tetramerus (Heckel 1840)	46	1.5	9.4	0.11	49.94	0.0314	0.0273 - 0.0362	3.31	3.21 - 3.40	0.991
Siluroformes										
Auchenipteridae										
*Ageneiosus ucayalensis** Castelnau 1855	50	10.8	20.8	12.57	96.53	0.0045	0.0024 - 0.0086	3.26	3.03 - 3.49	0.943
Pimelodidae										
Pimelodus blochii (Valenciennes 1840)	11	7.46	19.27	6.42	**141.5**	0.0083	0.0062 - 0.0111	3.31	3.19 - 3.43	0.998

N, sample size; SL, standard length; W, weight; *a* and *b*, parameters of the relationship; CL, confidence limits; r^2, Pearson *r*-squared for log–log regression (all relationships significant at $P < 0.05$); species name in bold is a new LWR record. New records of maximum length and maximum weight in bold. * Fish species which are representatives of the two classes (juveniles and adults).

4. Discussion

The data presented in this study were reliable to express the LWR's with approximately 90% of fit (r^2-values) higher than 0.97. Values of *b* fell within the expected range of $2.50 < b > 3.50$ (FROESE, 2006). Due to smaller samples sizes (< 20 individuals) LWR's should be treated with caution for *Triportheus albus* and *Pimelodus blochii*. Growth type did not differ significantly between juvenile and adult individuals for those 6 species in the present study, but the allometry results for six species showed distinct growth type found in previous research (FROESE; PAULY, 2014; GIARRIZZO et al., 2011, 2015; OLIVEIRA et al., 2013) based on LWR done with TL. We assume that the use of standard length for LWR regressions, which revealed lower data variation and thus greater statistical robustness than TL for our fish samples, is a possible explanation for such differences. Furthermore, even with a smaller sample size, our data included a greater range of length for *M. celibela*. For instance, *M. celibela* was evidenced by Giarrizzo et al. (2015) as negative allometry ($b=2.82$), but studied exclusively juvenile individuals (< Lmaturity), whereas in the present study were included both, juvenile and adult fish, and found positive allometric growth ($b=3.2$) for the species. Further, Oliveira et al. (2013) present negative allometry for *Prochilodus nigricans* with individuals between 9.13 and 18.54 cm TL, whilst our study found positive allometric growth for this species, using specimens ranging from 9.47 to 29.42 cm TL. Finally, Benedito-Cecilio et al. (1997) according to Fisbase database (FROESE; PAULY, 2014), detected negative allometric growth ($b=2.88$) for *Astyanax bimaculatus* on LWR based on standard lengths ranging from 5.4 to 13.6 cm SL. On the other hand, including also smaller individuals in our analysis (1.89 to 9.33 cm SL), we detected positive allometric growth ($b=3.15$) for *A. bimaculatus*. The presented results are of great value to the knowledge of the fish fauna from Palito Mountain range, due to both, representing an area already impacted by prospecting and mining activities, and to serve as a comparative basis for future studies on the biology of the species.

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