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Length-weight and length-length relationships of four fishes from small streams of the Trombetas River basin, Brazilian Amazon

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ABSTRACT

The length–weight (LWR) and length–length (LLR) relationships were estimated for four fish species of small streams from the Trombetas River basin, Lower Amazon tributary, western of Pará State, Brazil. Fishes were collected using sieves with 70 cm x 40 cm and 1 mm mesh size in December 2018. The *a* parameter ranged from 0.0150 for *Copella nattereri* (Lebiasinidae) to 0.0252 for *Laimosemion dibaphus* (Rivulidae). The allometric coefficient *b* ranged from 2.837 for *Copella nattereri* to 3.263 for *Crenuchus spilurus* (Crenuchidae). The present study reports the first estimates of LWRs for two species, the first LLR_s to four fish species from small streams of Trombetas River basin, and the new record of maximum total length for *Copella nattereri*.

Keywords: Fish biometry; Allometric coefficient; Fish ecology; Amazon basin; Western Pará.

Relações peso-comprimento e comprimento-comprimento de quatro espécies de peixes de pequenos riachos da bacia do Rio Trombetas, Amazônia brasileira

RESUMO

As relações peso-comprimento (LWRs) e comprimento-comprimento (LLRs) foram estimadas para quatro espécies de peixes de igarapés da bacia do Rio Trombetas, afluente do Baixo Amazonas, oeste do estado do Pará, Brasil. Os peixes foram coletados com puça de 70 cm x 40 cm e malha de 1 mm em dezembro de 2018. O parâmetro *a* variou de 0,0150 para *Copella nattereri* (Lebiasinidae) a 0,0252 para *Laimosemion dibaphus* (Rivulidae). O coeficiente alométrico *b* variou de 2,837 para *Copella nattereri* a 3,263 para *Crenuchus spilurus* (Crenuchidae). O presente estudo registra as primeiras estimativas de LWRs para duas espécies, as primeiras LLR_s para as quatro espécies de peixes de igarapés da bacia do Rio Trombetas e o novo registro de comprimento total máximo para *Copella nattereri*.

Palavras-chave: Biometria de peixes, Coeficiente alométrico, Ecologia de peixes, Bacia Amazônica, Oeste do Pará.

Introduction

The fish diversity in small streams of the Amazon is poorly known (MOJICA et al., 2009) even though be the freshwater ecosystem most extensive in the Amazon basin (BEIGHLEY; GUMMADI, 2011). Besides that, Amazonian small streams are very threatened by anthropogenic disturbances, such as the agribusiness expansion and urbanization, while lacking environmental legislation to protect the stream ecosystems and fish communities (LEAL et al., 2018). The length–weight relationships (LWRs) and length–length relationships (LLRs) provide growth models of species in their natural habitat, which contribute to estimates of biomass rate through a given fish length (FROESE et al., 2011). Thus, this study analyzes the LWRs and LLRs of four fish species from different families in small urban streams in the western Pará, Brazilian Amazon.

The Crenuchidae family presents small specimens, less than 10 cm, with a pair of holes in the frontal bones, easily visible in the subfamily Crenuchinae, in which the genus *Crenuchus* is included (BUCKUP, 2003). Most Crenuchidae specimens inhabit streams, rapids and small waterfalls. The *Crenuchus spilurus*, one of the target species of this study, are distributed in the Orinoco and Amazonas rivers basins (BUCKUP, 2003). The individuals of the Lebiasinidae family occur from Costa Rica to Argentina and have cylindrical and elongated body, with relatively large scales. The most of species of this family inhabit streams of clear or black water. The target species in this study, *Copella nattereri* is easily identified by a dark spot present in most of its light-colored scales along its body. This species distribute in the Lower Amazon, Negro River and Upper Orinoco River basins (WEITZMAN; WAITZMAN, 2003).

The Rivulidae family is easily recognized because the males are very colorful. Many of these species are annual, living in small freshwater pools formed in the rainy season and that dry afterward (COSTA, 2003). The *Laimosemion dibaphus*, one of the target species of this study, is a species that inhabits clear water streams, with moderate speeds and sandy bottom. This species is distributed in the Amazon River basin (COSTA, 2006). The family Loricariidae is divided into several subfamilies, such as the Hypoptopomatinae, whose species are easy to distinguish because they are mainly herbivorous species with daytime habits (SCHAEFER, 2003). Another target species in this study, *Hypoptopoma gulare* differs from its congeners by having a single paranasal plate that separates the lateral process of the lateral ethmoid from the second infraorbital and nasal organ (AQUINO; SCHAEFER, 2010). This study aims to estimate the LWRs and LLRs of four fish species from four different families described above, commonly found in small streams of the Trombetas River basin, at the Brazilian Amazon.

Material and Methods

Fishes were sampled in three small streams in December 2018 in vicinities of the Oriximiná city (1°45'57"S 55°51'57"W), Pará State, Trombetas River basin, Brazilian Amazon (Figure 1). The fish specimens were collected using

sieve of 70 cm x 40 cm and 1 mm mesh size. Fishes were anesthetized using clove oil, then were preserved in 10% formaldehyde solution and, in laboratory, washed in running water and preserved in 70% alcohol. The specimens were measured in its total and standard lengths (TL and SL, respectively) using digital caliper (0.01 cm accuracy) and weighted in total body mass using eletronic balance (0.001 g).

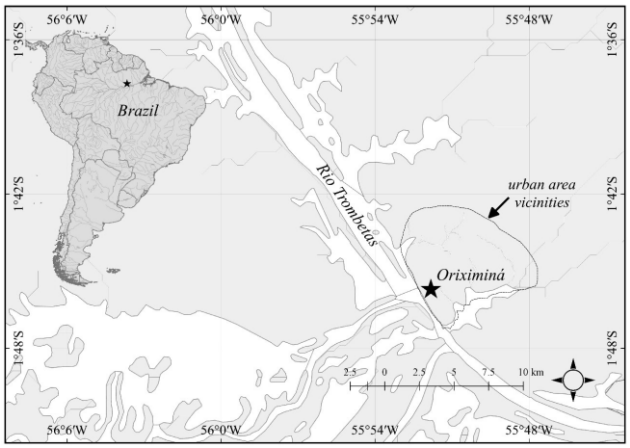

Figure 1. Study area in vicinities of the Oriximiná city, State of Pará, Trombetas River basin, Brazilian Amazon.

The fish species were identified to the lowest taxonomic level according to Géry (1977), Keith et al. (2000), Le Bail et al. (2000), Costa (2006), Aquino and Schaefer (2010). The scientific names, authority and year of description follow Eschmeyer et al. (2019). The length–weight relationships were estimated by growth model equation $W = a*TL^b$ (PAULY, 1984), where W is the weight in grams, a is the intercept, TL is the total length, and b is the allometric coefficient. The Student's t-test was performed to test if the alometric coefficient was statistically different from isometric growth (H_0: b = 3) at significance level of 0.05 (FROESE et al., 2011). The length–length relationships were estimated through linear regression $SL=a+b*TL$ (MARQUES et al., 2016). Prior analysis, outliers were inspected by the dual-plot of the transformed logarithmic-data. All analyses were performed in R (R DEVELOPMENT CORE TEAM, 2019).

Results

Overall, 125 fish specimens belonging to three orders, four families and to four species had the LWR and LLR estimated (Tables 1 and 2, respectively). The parameter a ranged from 0.0150 for *Copella nattereri* (Characiformes) to 0.0252 for *Laimosemion dibaphus* (Cyprinodontiformes), whereas the allometric coefficient b ranged from 2.837 for *C. nattereri* to 3.263 for *Crenuchus spilurus*, both from the order Characiformes. Except for *H. gulare*, the remaining species showed growth different from the isometry (b = 3). The coefficient of determination r^2 were high, ranged from 0.976 for *C. nattereri* to 0.996 for *Hypoptopoma gulare* (Siluriformes) in respect to LWRs (Table 1), and from 0.969 for *L. dibaphus* to 0.996 *H. gulare* in respect to LLRs (Table 2).

Table 1. Length-weight relationships of four fish species collected in December 2018 in three small streams of the Trombetas River basin.

Order	Family	Species	N	Total length (cm)	Weight (g)	WL Regression parameters		
				Min-Max	Min-Max	a (95% CL)	b (95% CL)	r^2
Characiformes	Crenuchidae	*Crenuchus spilurus* Günther 1863	44	2.3-4.7	0.10-1.0	0.0169 (0.0153-0.0187)	3.263 (3.151-3.375)	0.988
Characiformes	Lebiasinidae	*Copella nattereri* (Steindachner 1876) †, ‡	31	1.7-6.4	0.04-1.14	0.0150 (0.0124-0.0181)	2.837 (2.671-3.002)	0.976
Cyprinodontiformes	Rivulidae	*Laimosemion dibaphus* (Myers 1927)	38	1.4-3.4	0.02-0.44	0.0252 (0.0233-0.0273)	2.876 (2.750-2.998)	0.984
Siluriformes	Loricariidae	*Hypoptopoma gulare* Cope 1878 †	12	2.5-10.9	0.08-9.96	0.0179 (0.0143-0.0225)	3.079 (2.950-3.200)	0.996

N, sample size; a and b, parameters of the length-weight relationships, CL, confidence limits; r^2, Pearson r-squared for log–log regression (all relationships significant at P < 0.0001); †, novel length–weight relationships; ‡, new maximum length recorded.

Table 2. Length-length relationships of four fish species collected in December 2018 in three small streams of the Trombetas River basin.

Order	Family	Species	LL Regression parameters		
			a (95% CL)	b (95% CL)	r^2
Characiformes	Crenuchidae	*Crenuchus spilurus* Günther 1863	0.8419 (0.7994-0.8866)	0.92748 (0.8826-0.9723)	0.976
Characiformes	Lebiasinidae	*Copella nattereri* (Steindachner 1876)	0.8635 (0.7997-0.9324)	0.92558 (0.8707-0.9805)	0.975
Cyprinodontiformes	Rivulidae	*Laimosemion dibaphus* (Myers 1927)	0.7039 (0.6636-0.7465)	1.1148 (1.0479-1.1817)	0.969
Siluriformes	Loricariidae	*Hypoptopoma gulare* Cope 1878	0.8073 (0.7438-0.8762)	0.9731 (0.9338-1.0124)	0.996

a and b, parameters of the length-length relationships, CL, confidence limits; r^2, Pearson r-squared for log–log regression (all length–length relationships are novel to science, and were significant at P < 0.0001).

Discussion

All coefficient of allometry fits within the expected range from 2.5 to 3.5 as found for most fish species (FROESE, 2006), where *C. spilurus* presented positive allometry (b > 3), *H. gulare* isometry (b = 3), and the *C. nattereri* and *L. dibaphus* negative allometry (b < 3). In spite of the species *C. nattereri* and *L. dibaphus* had limits estimated of the allometric coefficient slightly below of the expected by the Bayesian estimates suggested by Froese et al. (2014) for their respective families, in general, the limits of the four LWRs fits with the expected. In the analysis were not used tiny specimens such as larvae for the estimates, which could contribute to shrinkage effects, but these subtle differences were likely influenced by this effect after formalin fixation (XIONG et al., 2007). We reinforce Andrade et al. (2018), and Freitas et al. (2019) that further studies of LWR should be carried out to evaluate possible shrinkage effects resulting from fixation process. Therefore, our study presented reliable LWRs and LLRs as growth model of the four fish species (r^2 > 0.95), as well as highly significance (P < 0.0001). The study showed new LWRs for *C. nattereri* and *H. gulare*, as well as the new maximum length for the first species mentioned, and the first estimates of the LLRs of these four fish species (FROESE; PAULY, 2019).

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