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Length-weight relationship of fish species from Central Amazon floodplain

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Abstract

Length-weight relationship (LWR) for 39 freshwater fish species captured in the Catalão Lake, a floodplain area at the confluence of the Amazonas and Negro rivers is presented. LWRs were calculated based on fish sampled over 18 years (1999–2017) using a set of ten gill nets with different mesh sizes, monthly immersed in water for 24-hr with 6-hr interval catches. Measurements were done for standard length (SL – 0.1 cm precision) and total weight (TW – 0.01 g precision). The LWRs were calculated by the linear regression of natural log-transformed SL and TW data: $TW = a \times SL^b$. All statistical analyses were performed with R software. From all species considered, 32 are new LWR records for the international literature as well as for the Amazonian ichythyofauna; additional records expand the known size range for seven species.

KEYWORDS

Amazon, floodplain, LWR

1 | INTRODUCTION

Length-weight relationship (LWR) is likely the most useful tool to estimate indirect growth, body condition, and to understand the life cycle of fishes (Camara, Caramaschi, & Petry, 2011; Froese, 2006). Length and weight are biometrics data easily taken and available in most datasets from monitoring studies. Despite the simplicity, it provides highly useful information for fisheries management and can be used in different applications like the estimation of biomass from length data or comparisons between growth patterns and morphologic differentiation of the same species from different populations (Imorou, Alphonse, Edmond, & Youssouf, 2019; Karachle & Stergiou, 2012).

The Amazon basin shelters a very highly diverse freshwater fish fauna that occupy a wide variety of environments. The middle stretch of the Amazon River sustains very important fishery activities, which targets about 100 species coming from its main channel and associated floodplain environments (Santos, Ferreira, & Zuanon, 2006). Here we present LWRs for 39 fish species based on 18 years of monthly fish sampling in the Catalão Lake, at the confluence of Amazonas and Negro rivers.

2 | MATERIALS AND METHODS

This study was carried out in the Catalão Lake, a floodplain lake at the confluence of the Amazonas and Negro rivers, Amazonas State, Brazil. Samples were obtained monthly between October 1999 and December 2017, using a set of 10 gill nets with different mesh sizes ranging from 30 to 120 mm, immersed in water for 24-hr with 6-hr interval catches (Röpke, Amadio, Winemiller, & Zuanon, 2016). Each fish specimen was measured for standard length (SL – 0.1 cm

TABLE 1 Length–weight relationship parameters for 39 fish species from Catalão Lake, middle Amazonas River

Family	Species	*N*	SL (cm)		TW (g)		*a* (CI)	*b* (CI)	r^2
			Min	Max	Min	Max			
Acestrorhynchidae	*Acestrorhynchus abbreviatus* (Cope 1878)	38	12	30	22.7	310.3	0.0341 (0.0218–0.0536)	2.7285 (2.5665–2.8905)	.97
Anostomidae	*Leporinus amazonicus* Santos & Zuanon 2008	42	10	25.3	17.11	304.4	0.0160 (0.0112–0.0227)	3.0487 (2.9229–3.1744)	.98
Auchenipteridae	*Ageneiosus dentatus* Kner 1858	50	16.8	22.9	46.02	122.77	0.0109 (0.0589–0.0202)	3.0027 (2.7946–3.2108)	.95
	Ageneiosus lineatus Ribeiro, Rapp Py-Daniel & Walsh 2017	16	9	12.9	14.9	38.95	0.0735 (0.0343–0.1575)	2.4338 (2.1148–2.7528)	.95
	Auchenipterichthys coracoideus (Eigenmann & Allen 1942)	1970	6.1	19.2	4.53	113.9	0.0390 (0.0341–0.0447)	2.7205 (2.6581–2.7829)	.80*
	Auchenipterus britskii Ferraris & Vari 1999	536	9.5	15.7	13.4	62.2	0.0258 (0.0213–0.0313)	2.7929 (2.7166–2.8692)	.91*
	Trachelyopterus porosus (Eigenmann & Eigenmann 1888)	738	2.7	18.2	0.56	186.4	0.0282 (0.0041–0.0330)	2.9993 (2.9353–3.0633)	.92*
	Tympanopleura rondoni (Miranda Ribeiro 1914)	138	8.5	17.4	9.87	104.67	0.0058 (0.0037–0.0091)	3.4514 (3.2706–3.6322)	.91*
	Tympanopleura piperata Eigenmann 1912	10	7.5	9.5	6.9	15.8	0.0110 (0.0034–0.0360)	3.1936 (2.6431–3.7441)	.96
Callichthyidae	*Dianema longibarbis* Cope 1872	21	7.2	9.8	11	25.8	0.0328 (0.0169–0.0638)	2.9798 (2.6594–3.3003)	.95
Chalceidae	*Chalceus erythrurus* (Cope 1870)	189	8.2	20.2	11.81	201.81	0.0155 (0.0131–0.0182)	3.1472 (3.0847–3.2097)	.98
Cichlidae	*Acaronia nassa* (Heckel 1840)	27	5.5	16	8.7	189.9	0.0590 (0.0433–0.0804)	2.9163 (2.7894–3.0431)	.99
	Astronotus ocellatus (Agassiz 1831)	36	9.5	19.8	49.3	387.6	0.0475 (0.0284–0.0796)	2.9951 (2.8056–3.1847)	.97
	Cichla monoculus Spix & Agassiz 1831	341	2.3	33.8	0.25	874.8	0.0174 (0.0166–0.0182)	3.0921 (3.0748–3.1094)	.99
	Cichlasoma amazonarum Kullander 1983	55	2.5	13.5	0.7	115.9	0.0379 (0.0329–0.0437)	3.2267 (3.1413–3.3121)	.99
	Crenicichla inpa Ploeg 1991	13	3.1	18.4	0.57	126.9	0.0147 (0.0103–0.0210)	3.1112 (2.9664–3.2559)	.99
	Heros efasciatus Heckel 1840	96	5.8	14.2	8.7	141.5	0.0685 (0.0518–0.0907)	2.9450 (2.8236–3.0663)	.96
	Heros notatus (Jardine 1843)	49	7.4	13	23.29	138.32	0.0521 (0.0387–0.0701)	3.0639 (2.9389–3.1890)	.98
	Hypselecara temporalis (Günther 1862)	11	6.7	14	16.9	173.15	0.0440 (0.0347–0.0559)	3.1222 (3.0232–3.2213)	.99
	Satanoperca acuticeps (Heckel 1840)	41	7.6	13.5	15.6	74.9	0.0528 (0.0378–0.0739)	2.8156 (2.6734–2.9578)	.98
Curimatidae	*Curimatella meyeri* (Steindachner 1882)	625	6.8	18.4	10.2	171.9	0.0266 (0.0240–0.0296)	3.0235 (2.9833–3.0636)	.97
	Cyphocharax plumbeus (Eigenmann & Eigenmann 1889)	13	6.9	13	8.72	60	0.0168 (0.0075–0.0379)	3.1612 (2.7956–3.5268)	.97
	Steindachnerina leucisca (Günther 1868)	39	8.7	14.8	15.8	76.7	0.0286 (0.0181–0.0453)	2.9316 (2.7432–3.1200)	.96
Doradidae	*Anadoras grypus* (Cope 1872)	359	8	14.6	11.89	82.4	0.0680 (0.0534–0.0865)	2.6337 (2.5359–2.7315)	.89*
	Nemadoras elongatus (Boulenger 1898)	14	6.2	13	8.67	34.6	0.3244 (0.1538–0.6847)	1.8514 (1.5328–2.1700)	.93*
	Nemadoras hemipeltis (Eigenmann 1925)	104	9	14	12.5	52	0.0214 (0.0134–0.0341)	2.9178 (2.7267–3.1090)	.90*
	Opsodoras stuebelii (Steindachner 1882)	22	10.1	15.2	19	70.5	0.0129 (0.0060–0.0278)	3.1868 (2.8890–3.4847)	.96
	Ossancora punctata (Kner 1855)	361	6.2	11.3	6.36	36.4	0.0251 (0.0201–0.0314)	3.0184 (2.9203–3.1166)	.91*

(Continues)

TABLE 1 (Continued)

Family	Species	N	SL (cm)		TW (g)		*a* (CI)	*b* (CI)	r^2
			Min	Max	Min	Max			
Engraulidae	*Lycengraulis figueiredoi* Loeb & Alcântara 2013	136	8.6	17.1	7.8	61.3	0.0237 (0.0162–0.0347)	2.7608 (2.6150–2.9065)	.91*
Loricariidae	*Ancistrus dolichopterus* Kner 1854	61	5.6	14.5	4.86	120.2	0.0166 (0.0125–0.0220)	3.3232 (3.2000–3.4464)	.98
	Dekeyseria amazonica Rapp Py-Daniel 1985	284	8.2	17.4	7.54	89.6	0.0113 (0.0092–0.0140)	3.1554 (3.0760–3.2348)	.96
	Loricariichthys acutus (Valenciennes 1840)	52	9.3	28	3.87	91.6	0.0047 (0.0032–0.0069)	3.0269 (2.9002–3.1536)	.98
	Loricariichthys maculatus (Bloch 1794)	48	15.3	26.3	22.53	130.6	0.0045 (0.0020–0.0101)	3.1327 (2.8756–3.3899)	.93*
	Loricariichthys nudirostris (Kner 1853)	11	17	23.5	21.52	89.64	0.0001 (0.0000–0.0001)	4.4086 (3.7517–5.0655)	.96
	Pterygoplichthys pardalis (Castelnau 1855)	422	1.4	34.8	0.04	655.3	0.0201 (0.0191–0.0212)	3.0053 (2.9861–3.0244)	.99
Pristigasteridae	*Pristigaster cayana* Cuvier 1829	81	6.2	10.4	4.4	28	0.0117 (0.0081–0.0170)	3.2808 (3.1088–3.4528)	.95
Rhamphichthyidae	*Rhamphichthys pantherinus* Castelnau 1855	49	31.2	55	38.7	350	0.0002 (0.0001–0.0008)	3.5137 (3.1780–3.8495)	.90*
Sciaenidae	*Plagioscion montei* Soares & Casatti 2000	150	12	25	25.5	286.94	0.0174 (0.0125–0.0243)	3.0317 (2.9181–3.1453)	.95
Serrasalmidae	*Metynnis argenteus* Ahl 1923	11	6.8	13.7	19	153	0.0575 (0.0292–0.1132)	2.9630 (2.6734–3.2526)	.98

Note: N, number of specimens used in the LWR; *a*, regression intercept; *b*, regression slope; CI, confidence interval; SL, standard length; TW, total weight; r^2, coefficient of determination; Min, lowest value; Max, highest value.

*Tentative parameters due to $r^2 < .95$.

precision) and total weight (TW – 0.01 g precision). The fish survey was authorized by IBAMA – Brazilian Institute of the Environment and Renewable Natural Resources (license #101932) and INPA Animal Ethics Committee CEUA (protocol #051/2015).

The LWRs were calculated by the linear regression of natural log-transformed TW and SL data: $TW = a \times SL^b$ (Froese, 2006). The intercept (*a*), slope (*b*), the 95% confidence limits for *a* and *b* and the coefficient of determination (r^2) were estimated. Before the determination of the coefficients, length-weight plots were conducted for outliers' detection, which were excluded from the analyses (Froese, 2006). Species with specimens' numbers as low as 10 were included if there was a good fit for LWRs ($r^2 \geq .95$). All statistical analyses were performed with R software (RDevelopment Core Team; www.r-project.org).

3 | RESULTS

A total of 39 species representing 14 families of six orders are considered in this study. The LWR parameters of the species and the related statistics are shown in Table 1, presenting the standard length and weight ranges as well as the equation parameters "a" (intercept) and "b" (slope) of the LWR regressions. Despite the high r^2 value obtained for *Cichla monoculus* the estimates should be considered with care, once size range is restricted to small fish. The LWR estimates for 11 species, marked with (*) in Table 1, should be considered as tentative because of the relatively low value (<0.95) for the coefficient of determination despite the careful checks for outliers.

4 | DISCUSSION

This study provides new LWR records for 32 fish species from the Central Amazonian river-floodplain system, which represent an important increase in the scientific information available for fishes from the region (Bevilaqua & Soares, 2010; Dieb-Magalhães, Florentino, & Soares, 2015; Matos et al., 2019; Prestes, Soares, Silva, & Bittencourt, 2010; Sousa, Soares, & Prestes, 2013), as well as for the international literature. From all records presented here, LWR estimates for *Cichla monoculus* and *Pterygoplichthys pardalis* can be found at FishBase, however, we opted to keep these two species in the study because the published record for the first species was based on three specimens only, and for the second, refers to an introduced population in the Philippines (Jumawan & Seroney, 2017), as opposed to our findings that are based on natural populations (Ferraris-Jr, 2007). Our study also considers another seven species which LWR estimates have already been published elsewhere, however, we decided to present the information here because they bring new records on the maximum length, were based on a larger number of specimens and showed better size range: *Heros efasciatus* (Sampaio, Aguiar-Santos, Anjos, Freitas, & Siqueira-Souza, 2019), *Curimatella meyeri* (Matos et al., 2019), *Cichlasoma amazonarum* (Sampaio et al., 2019), *Acestrorhynchus abbreviatus*, *Anadoras grypus*, *Chalceus erythrurus, and Pterygoplichthys pardalis* (the four species on Chuctayal, Capitani, Faustino, & Castro, 2017).

Besides the LWR estimates for the 39 species presented here (Table 1), there are three undescribed species with a good size range and distribution that is worth mentioning due to the high degree of certainty that each one of them represents one taxonomic unity (Cella-Ribeiro, Hauser, Nogueira, Doria, & Torrente-Vilara, 2015; Queiroz et al., 2013): *Serrasalmus* sp. n. "2n58" (SL = 5.8–17.5, $r^2 = .98$, $a = 0.014(0.012–0.015)$, $b = 3.342(3.293–3.392)$), *Hemiodus* sp. n."rabo de fogo" (SL = 2.3–22.7, $r^2 = .96$, $a = 0.018(0.017–0.019)$, $b = 2.925(2.906–2944)$), and *Anodus* sp. (SL = 12.1–24.8, $r^2 = .93$, $a = 0.009(0.006–0.012)$, $b = 3.156(3.043–3.269)$).

The undescribed species *Hemiodus* sp. n. "rabo de fogo" has already been registered by Cella-Ribeiro et al. (2015), however, here we present a wider size range and much lower *b* value, 2.836, against $b = 3.543$ for the same species from Madeira River. Since fishes were captured using similar standardized methods in both environments, this result may reflect different environmental characteristics (Cella-Ribeiro et al., 2015), as the two regions (Madeira River and Amazonas floodplain), are physiographically distinct. The LWR estimates for the other two undescribed species *Serrasalmus* sp. n. "2n58" and *Anodus* sp. constitute new records for the scientific literature. Froese's study (2014) provided the estimation of LWR parameters for practically all known fish species available at FishBase using Bayesian analysis, however, as the author pointed out, no specific LWR studies using a set of collected data from natural populations are available for most species, which is provided here.

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CONFLICT OF INTEREST

The authors declare no conflict of interest.

DATA AVAILABILITY STATEMENT

Data are available only on personal request to the authors.

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