LENGTH-WEIGHT RELATIONSHIPS OF THE MAIN COMMERCIAL FISH SPECIES OF TUCURUÍ RESERVOIR (TOCANTINS/ARAGUAIA BASIN, BRAZIL)

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ABSTRACT

The Tucuruí reservoir has a great ecological and economic importance, but is lacking in basic information of population biology of fishes, especially length-weight relationship. Of the 20 species analyzed, are presented new records of the length-weight relationship for five species, one have record on gray literature and the remaining 14 have records in other studies which was compared to this study. The information generated by this work can contribute to a better environmental and fisheries management in Neotropical region, especially in Tucuruí reservoir.

Keywords: population biology; artisanal fisheries; dam

RELAÇÃO PESO-COMPRIMENTO DAS PRINCIPAIS ESPÉCIES DE PEIXES COMERCIAIS DO RESERVATÓRIO DE TUCURUÍ (BACIA DO TOCANTINS/ARAGUAIA, BRASIL)

RESUMO

O reservatório de Tucuruí tem uma grande importância econômica e ecológica, mas é carente de informações básicas da biologia populacional de peixes, especialmente relação peso-comprimento. Das 20 espécies analisadas, são apresentados novos registros da relação peso-comprimento para cinco espécies, uma tem registro na literatura cinzenta e as 14 restantes apresentam registros em outros estudos, os quais foram comparados com os dados deste trabalho. A informação gerada por este estudo pode contribuir para um melhor manejo ambiental e pesqueiro na região Neotropical, em especial para o reservatório de Tucuruí.

Palavras chave: biologia populacional; pesca artesanal; barramento

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INTRODUCTION

The Tucuruí reservoir is located at Tocantins/Araguaia basin, state of Pará, in Northern Brazil. Its construction was due to the growing demand for electricity in the country, in particular from mining activities in the region. Besides the environmental, social and economic impacts caused by the damming of the Tocantins river, artisanal fisheries remained as an important livelihood alternative and income generation for local population (CAMARGO and PETRERE-JÚNIOR, 2004).

The artisanal fisheries, both commercial and subsistence, are very important to the economy of the Amazon region, because it is a source of income and protein and is also consumed in other Brazilian regions (ALMEIDA *et al.*, 2006). In Tucuruí, considering the impoundment area, annual catches increased from 452 t before the damming to about 5,000 t in 2001 (JURAS *et al.*, 2004). In 2006, were registered 7,854 artisanal fishermen in the colonies, with about 50,000 people directly dependent on fisheries in the reservoir of Tucuruí (CINTRA *et al.*, 2011).

However, despite their ecological and economic importance, most of the commercial fish species of Tucuruí reservoir and its area of influence lack basic biological data (CINTRA *et al.*, 2013) specifically length–weight relationships which can be used for estimate condition factor, for geographic comparisons of life histories (PETRAKIS and STERGIOU, 1995; GONÇALVES *et al.*, 1997); indirect analysis of growth rate, detecting any changes in shape throughout ontogeny (SPARRE *et al.*, 1989); and interspecific and interpopulation morphometric comparisons of fish species (BOLGER and CONNOLLY, 1989).

In the present study, the parameters of length–weight relationship and length-length relationship are given for 20 main commercial fish species of Tucuruí reservoir and its area of influence.

MATERIAL AND METHODS

The study area comprises the region influenced by the Tucuruí Reservoir, located in the state of Para, Brazil (03°45′03″S; 49°40′03″W). The damming occurred in 1984, flooding an area of 2.830km².

Samples were collected quarterly at eight sites in the reservoir and at six sites downstream the dam, from 2001 to 2010, as part of the environmental monitoring program of Eletronorte, who operates hydroelectric power generation in this reservoir.

Fish collections were performed using standardized monofilament nylon multi-mesh (40–200 mm) gillnets and each specimen was measured for total length (TL), standard length (SL), weighed (WT), and dissected for macroscopic gonad analysis for sexual recognition. Fish species were identified based on reference guides (BRITSKI, 1972; BRITSKI *et al.*, 1988, 1999) and checked against FishBase (http://www.fishbase.org).

Data of 25,523 specimens were analyzed, belonging to 20 species among 115 commercial mentioned by SANTOS *et al.* (1984). The length–weight relationship (LWR) and length-length relationship (LLR) were determined by linear regressions, respectively, $\log WT = \log a + b \log SL$ and $TL = a + b^*SL$, where: a = intercept and b = regression coefficient (FROESE, 2006).

Evaluation of possible differences of LWRs of males and females was performed by comparing the 95% confidence limits of a and b; if no significant differences were found, the LWR was calculated for males and females together; outliers were removed using a log log-plot (FROESE, 2006).

RESULTS

Fish from 20 species from 15 families and five orders were analyzed in this study. No significant difference was found between males and females, so all species were analyzed grouped regarding sex.

The Table 1 shows that all estimated LWR b values were between 2.443 and 3.112 and the coefficient of determination (r^2) ranged from 0.900 (*Triportheus elongatus*) to 0.982 (*Hypostomus plecostomus*) with 11 of 20 r^2 values (55%) above 0.95.

The coefficient of determination (r^2) of the LLR for all species studied ranged from 0.9401 (*Plagioscion squamosissimus*) to 0.982 (*Hydrolycus scomberoides*) with 18 of 20 r^2 values (90%) greater than 0.95 (Table 2).

Table 1. Taxonomy, estimated parameters of length-weight relationship and descriptive statistics for 20 main commercial fish species, Tucuruí Reservoir, Tocantins/Araguaia Basin, Brazil.

Order	Family	Specie	sex	n	SL (cm)		r^2	*a*	*b*
					min	max			
Characiformes	Acestrorhynchidae	*Acestrorhynchus falcirostris* (Cuvier 1819)	M/F	2,091	10	37	0.928	0.0198 ± 0.0020	2.785 ± 0.033
	Cynodontidae	*Hydrolycus scomberoides* (Cuvier 1819)	M/F	103	14	51	0.972	0.0163 ± 0.0045	2.939 ± 0.099
		Rhaphiodon vulpinus Spix & Agassiz 1829	M/F	1,143	14	47.5	0.907	0.0077 ± 0.0013	2.946 ± 0.055
	Erythrinidae	*Hoplias malabaricus* (Bloch 1794)	M/F	357	9.5	35	0.953	0.0235 ± 0.0045	2.933 ± 0.068
	Prochilodontidae	*Prochilodus nigricans* Spix Agassiz 1829	M/F	762	8	**42**	0.978	0.0315 ± 0.0029	2.950 ± 0.032
	Serrasalmidae	*Pygocentrus nattereri* Kner 1858	M/F	1,575	7.5	30.5	0.973	0.0403 ± 0.0026	3.025 ± 0.025
		Serrasalmus spilopleura Kner 1858	M/F	346	6.5	**31**	0.971	0.0270 ± 0.0037	3.112 ± 0.057
	Triportheidae	*Triportheus elongatus* (Günther 1864)*	M/F	1,150	8	**31**	0.900	0.0667 ± 0.0080	2.443 ± 0.047
Clupeiformes	Engraulidae	*Anchovia surinamensis* (Bleeker 1865)*	M/F	388	6	**22.5**	0.956	0.0507 ± 0.0061	2.474 ± 0.053
	Pristigasteridae	*Pellona castelnaeana* Valenciennes 1847	M/F	433	12	42	0.944	0.0146 ± 0.0029	2.971 ± 0.069
Osteoglossiformes	Osteoglossidae	*Osteoglossum bicirrhosum* (Cuvier 1829)	M/F	159	12	71	0.938	0.0166 ± 0.0057	2.764 ± 0.112
Perciformes	Cichlidae	*Geophagus surinamensis* (Bloch 1791)*	M/F	59	8	22	0.972	0.0568 ± 0.0151	2.743 ± 0.123
	Sciaenidae	*Plagioscion squamosissimus* (Heckel 1840)	M/F	13,850	7	60.5	0.927	0.0368 ± 0.0014	2.768 ± 0.013
Siluriformes	Auchenipteridae	*Ageneiosus inermis* (Linnaeus 1766)	M/F	151	11	45	0.931	0.0156 ± 0.0051	2.944 ± 0.130
	Doradidae	*Megalodoras uranoscopus* (Eigenmann & Eigenmann 1888)	M/F	258	10	52	0.943	0.0279 ± 0.0067	2.911 ± 0.088
		Oxydoras niger (Valenciennes 1821)	M/F	375	15	93	0.977	0.0254 ± 0.0038	2.885 ± 0.045
		Pterodoras granulosus (Valenciennes 1821)	M/F	641	9	51	0.943	0.0224 ± 0.0039	2.983 ± 0.057
	Loricariidae	*Hypostomus plecostomus* (Linnaeus 1758)*	M/F	535	7	35	0.982	0.0865 ± 0.0067	2.572 ± 0.029
		Squaliforma emarginata (Valenciennes 1840)*	M/F	951	9	**41**	0.956	0.0408 ± 0.0043	2.680 ± 0.037
	Pimelodidae	*Pinirampus pirinampu* (Spix & Agassiz 1829)	M/F	196	13	54	0.954	0.0120 ± 0.0032	3.008 ± 0.094

** Represents the first report of length-weight relationship to the species; new maximum size data in bold according to FishBase data (http://www.fishbase.org); a and b refers to the equation W = a SL b, in g and cm; a and b presented as estimated values 95% confidence limits; parameters were estimated for grouped sexes and indicated by M/F.*

Table 2. Results of linear regression relating total length (TL) and standard length (SL) for 20 main commercial fish species, Tucuruí Reservoir, Tocantins/Araguaia Basin, Brazil.

Order	Family	Specie	*a*	*b*	r^2
Characiformes	Acestrorhynchidae	*Acestrorhynchus falcirostris* (Cuvier 1819)	1.4217	1.0871	0.9602
	Cynodontidae	*Hydrolycus scomberoides* (Cuvier 1819)	0.4833	1.094	0.9892
		Rhaphiodon vulpinus Spix & Agassiz 1829	1.4758	1.0412	0.9405
	Erythrinidae	*Hoplias malabaricus* (Bloch 1794)	1.8455	1.0952	0.9515
	Prochilodontidae	*Prochilodus nigricans* Spix Agassiz 1829	1.8122	1.0904	0.9874
	Serrasalmidae	*Pygocentrus nattereri* Kner 1858	0.7052	1.1247	0.9815
		Serrasalmus spilopleura Kner 1858	0.0351	1.1623	0.9811
	Triportheidae	*Triportheus elongatus* (Günther 1864)	1.7347	1.0607	0.9592
Clupeiformes	Engraulidae	*Anchovia surinamensis* (Bleeker 1865)	0.6284	1.1234	0.9869
	Pristigasteridae	*Pellona castelnaeana* Valenciennes 1847	0.4771	1.159	0.9771
Osteoglossiformes	Osteoglossidae	*Osteoglossum bicirrhosum* (Cuvier 1829)	2.7683	0.9953	0.9882
Perciformes	Cichlidae	*Geophagus surinamensis*(Bloch 1791)	1.3003	1.0786	0.9595
	Sciaenidae	*Plagioscion squamosissimus* (Heckel 1840)	1.7736	1.0965	0.9401
Siluriformes	Auchenipteridae	*Ageneiosus inermis* (Linnaeus 1766)	1.981	1.0575	0.9736
	Doradidae	*Megalodoras uranoscopus* (Eigenmann & Eigenmann 1888)	2.1649	1.1011	0.9719
		Oxydoras niger (Valenciennes 1821)	1.0265	1.1104	0.9872
		Pterodoras granulosus (Valenciennes 1821)	3.2685	1.0538	0.9628
	Loricariidae	*Hypostomus plecostomus* (Linnaeus 1758)	0.9208	1.1687	0.9812
		Squaliforma emarginata (Valenciennes 1840)	0.8107	1.2216	0.961
	Pimelodidae	*Pinirampus pirinampu* (Spix & Agassiz 1829)	3.9667	1.0196	0.966

*a e b are the parameters of equation TL = a + b*SL, in cm.*

DISCUSSION

Type of growth in fish (parameter *b* of LWR) normally tends to isometry, in the majority of species, fall between 2.5 and 3.5 (FROESE, 2006). Only *Triportheus elongatus* and *Anchovia surinamensis* had estimated values for *b* outside of this range (2.443 e 2.474, respectively), probably because of its peculiar, elongated shape.

According to FROESE and PAULY (2004) of these 20 species, 14 has been studied in other Brazilian regions, eight of them in the subtropical Itaipu reservoir (BENEDITO-CECILIO *et al.*, 1997), six of Lower Amazon region (RUFFINO and ISAAC, 1995) and 12 of Madeira River (CELLA-RIBEIRO *et al.*, 2015), with three species in common between them.

Table 3 shows that there are differences in the *b* values between this study and the Itaipu reservoir, Lower Amazon and Madeira River studies. Normally the differences in LWR parameters between different studies are related to different environmental and biological factors (TORRES *et al.*, 2012), spatial variation (SPARRE *et al.*, 1989), due to the influence of water quality or food availability on fish growth (MOMMSEN, 1998), photoperiodism and water temperature (SCHULTZ and CONOVER, 1997), and also to the characteristics of the sampling, e.g., size ranges, number of individuals sampled, etc. (TORRES *et al.*, 2012).

Regarding the study of RUFFINO and ISAAC (1995) and CELLA-RIBEIRO *et al.*, 2015 the main difference is that sampling took place in the confluence of Tapajós and Amazon rivers, stretches without influence of damming at that time (1992 and 1993). The damming modifies the biology and composition of fish fauna (AGOSTINHO *et al.*, 2007).

The present study presented LWR records for five species that are new to scientific literature, one have been previously published in gray literature and also maximum lengths for five species were reported. This absence of registers suggests that there is a lack of scientific information about the population biology of neotropical fishes, specially LWR. To do reliable analysis of LWR is necessary a considerable sampling number of specimens and a wide range of size classes, this requisites are achieve by a

huge sampling effort, mainly in species who occurrence is low, usually fish ecological studies not have an enough sampling effort for this type of study.

Table 3. Number of specimens (n), standard length ranges (SL range) and *b* values for those species compared between this study and Itaipu Reservoir (BENEDITO-CECILIO *et al*., 1997), Lower Amazon region (RUFFINO AND ISAAC, 1995) and Madeira River (CELLA-RIBEIRO *et al*., 2015).

Species	This study			Itaipu reservoir			Lower Amazon			Madeira River		
	N	SL Range	b	N	SL Range	b	N	SL Range	b	N	SL Range	b
Acestrorhynchus falcirostris (Cuvier 1819)	2091	10.0-37.0	2.79							735	10.0-45.0	3.17+
Hydrolycus scomberoides (Cuvier 1819)	103	14.0-51.0	2.94							212	12.0-46.7	3.28+
Rhaphiodon vulpinus Spix & Agassiz 1829	1143	14.0-47.5	2.95	1420	13.9-64.0	3.23+				600	20.5-55.8	3.15+
Hoplias malabaricus (Bloch 1794)	357	9.5-35.0	2.93	604	9.6-48.6	3.12+	308	23.0-50.0	2.99=	314	10.9-40.3	3.16+
Prochilodus nigricans Spix Agassiz 1829	762	8.0-42.0	2.95				1144	21.0-42.0	3.18+	639	7.2-38.2	2.93=
Pygocentrus nattereri Kner 1858	1575	7.5-30.5	3.03	41	24.0-33.3	3.23+	376	11.0-25.0	3.13+	822	7.0-21.4	3.13+
Serrasalmus spilopleura Kner 1858	346	6.5-31.0	3.11	122	5.1-25.0	3.34+				129	5.2-19.3	3.13=
Pellona castelnaeana Valenciennes 1847	433	12.0-42.0	2.97				1116	25.0-75.0	3.21+	280	8.7-60.9	3.12+
Osteoglossum bicirrhosum (Cuvier 1829)	159	12.0-71.0	2.76				591	37.0-74.0	3.27+			
Plagioscion squamosissimus (Heckel 1840)	13850	7.0-60.5	2.77	7200	6.8-47.9	3.09+	500	11.0-68.0	3.15+	178	12.9-42.5	2.86-
Ageneiosus inermis (Linnaeus 1766)	151	11.0-45.0	2.94	32	17.5-53.2	2.98=				206	12.7-45.0	2.97=
Oxydoras niger (Valenciennes 1821)	375	15.0-93.0	2.89							73	14.5-57.0	2.95=
Pterodoras granulosus (Valenciennes 1821)	641	9.0-51.0	2.98	1651	5.1-53.2	2.88-				21	14.6-43.0	2.74-
Pinirampus pirinampu (Spix & Agassiz 1829)	196	13.0-54.0	3.01	466	14.9-77.4	3.18+						

+ represents higher, - lower and = similar values of b than this study.

Therefore, this study brings important information about the population biology of several species of commercial interest, contributes to better fisheries management and environmental conservation in the Neotropical region, especially in the Tucuruí reservoir region, supplementing GARCIA-AYALA *et al.* (2014) who analyzed 29 fish species of Tucuruí reservoir news for literature.

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