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LENGTH–WEIGHT RELATIONSHIPS AND BIOLOGICAL ASPECTS FOR 34 FISH SPECIES FROM TRÊS IRMÃOS RESERVOIR, LOWER TIETÊ RIVER BASIN, SP - BRAZIL*

Paula Maria Gênova de Castro Campanha[1]
Anderson Arimura Matsumoto[1]
Midiã Lima Brazão[1]
Lucas Matheus Basilio[1]
Lidía Sumile Maruyama[1]

[1]Instituto de Pesca – IP, Centro de Pesquisa de Recursos Hídricos – CPRH, Secretaria de Agricultura e Abastecimento – SAA-SP, Agência Paulista de Tecnologia dos Agronegócios – APTA, Avenida Francisco Matarazzo, 455, Barra Funda, CEP 05001-970, São Paulo, SP, Brasil. E-mail: paulagc08@gmail.com (corresponding author).

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ABSTRACT

The length-weight relationship of fish species is widely used in fisheries monitoring programs and it is an important tool for proposing stock management measures. The objective of this study was to estimate the growth parameters of 34 species belonging to the fish community captured by experimental fishery in the Três Irmãos reservoir, Tietê river. The biological and ecological characteristics of these species are also presented in order to understand the profile of the present fish community. The fish were collected during ten experimental fishing seasons between October/2015 and February/2018, with quarterly frequency using four types of fishing gear. All fish captured were identified and the total length - TL (cm), standard length - SL (cm) and total weight - TW (g) were measured. The length-weight relationship was established using the linear regression TW vs SL (log-transformed): log (TW) = log (a) + b log (SL), where **a** is the regression curve intercept (coefficient related to body shape) and **b** is the coefficient of regression (exponent indicating the type of growth). A total of 7,319 individuals was identified, comprising five orders: Characiformes (7 Families), Siluriformes (5 Families), Perciformes (1 Family), Cichliformes (1 Family) and Cyprinodontiformes (1 Family). The most abundant species were *Plagioscion squamosissimus* (N=1,513), *Geophagus sveni* (N=1,160), *Serrasalmus maculatus* (N=1,049) and *Metynnis maculatus* (pacu-CD) (N=974), all of them being target species for professional artisanal fishing, with the exception of pacu-CD, which is discarded since it has no commercial interest. From the whole set of analyzes 15 species (44.1%) have positive allometric growth type (3.15≤ b ≤3.59), 14 (41.2%) isometric (2.98≤ b ≤ 3.08), and 5 (14.7%) negative allometric growth (2.7 ≤ b ≤ 2.90). Among the species studied nine reached a maximum length above that of the FishBase: *Cichla piquiti* (TL= 55.4 cm), *Crenicichla haroldoi* (SL= 21.5 cm), *C. jaguarensis* (SL= 23.5 cm), *Cyphocharax nagelii* (TL= 22.9 cm), *Hypostomus ancistroides* (TL= 28.5 cm), *Metynnis maculatus* (TL= 19.5 cm), *Piaractus mesopotamicus* (SL= 60.0 cm), *Roeboides descalvadensis* (SL= 11.3 cm) and *Schizodon borellii* (TL= 40.0 cm).

Key words: morphometric relationship; scientific fishing; growth; biological and ecological characteristics; neotropical reservoir.

RELAÇÃO COMPRIMENTO-PESO E ASPECTOS BIOLÓGICOS DE 34 ESPÉCIES DE PEIXES DO RESERVATÓRIO DE TRÊS IRMÃOS, BACIA DO BAIXO RIO TIETÊ, SP – BRASIL

RESUMO

A relação comprimento-peso das espécies de peixes é bastante utilizada entre os cientistas em programas de monitoramento da pesca, sendo uma ferramenta importante na proposição de medidas de manejo dos estoques. Objetiva-se estimar os parâmetros de crescimento de 34 espécies pertencentes à comunidade de peixes capturada pela pesca experimental no reservatório de Três Irmãos, rio Tietê. As características biológicas e ecológicas das espécies são também apresentadas visando a elaboração do perfil da comunidade. Os peixes foram coletados durante dez campanhas da pesca experimental, entre outubro/2015 a fevereiro/2018, com periodicidade trimestral, usando quatro tipos de aparelhos de pesca. Todos os peixes capturados foram identificados, mensurados em termos de comprimento total – Ct (cm) e comprimento padrão - Cp (cm), e obtido o peso total – Pt (g). A relação foi estabelecida usando a regressão linear Pt vs Cp (log-transformada): log (Pt) = log (a) + b log (Cp), onde **a** é o intercepto da curva de regressão (coeficiente relacionado à forma do corpo) e **b** o coeficiente de regressão (expoente indicando o tipo de crescimento). Foram identificados 7.319 indivíduos, compostos por cinco Ordens: Characiformes (7 Famílias), Siluriformes (5 Famílias), Perciformes (1 Família), Cichliformes (1 Família) e Cyprinodontiformes (1 Família). As espécies mais abundantes foram *Plagioscion squamosissimus* (corvina) (N= 1.513), *Geophagus sveni* (porquinho) (N=1.160), *Serrasalmus maculatus* (piranha/pirambeba) (N=1.049) e *Metynnis maculatus* (pacu-CD) (N=974), espécies alvo da pesca artesanal profissional; com exceção do pacu-CD que é descartado por não ter interesse comercial. Do conjunto analisado, 15 espécies (44.1%) possuem crescimento do tipo alométrico positivo (3,13 ≤ b ≤3,62), 14 (41.2%) isométrico (2,91 ≤ b ≤ 3,08), e 5 (14.7%) alométrico negativo (2,71 ≤ b ≤ 2,94). Do total das espécies, nove alcançaram comprimento máximo acima ao referenciado no FishBase: *Cichla piquiti* (TL= 55.4 cm), *Crenicichla haroldoi* (SL= 21.5 cm), *C. jaguarensis* (SL= 23.5 cm), *Cyphocharax nagelii* (TL= 22.9 cm), *Hypostomus ancistroides* (TL= 28.5 cm), *Metynnis maculatus* (TL= 19.5 cm), *Piaractus mesopotamicus* (SL= 60.0 cm), *Roeboides descalvadensis* (SL= 11.3 cm) e *Schizodon borellii* (TL= 40.0 cm).

Palavras-chave: relação morfométrica; pesca científica; crescimento; características biológicas e ecológicas; reservatório neotropical.

INTRODUCTION

The Length-Weight Relationship (LWR) of fish species is widely used among fisheries scientists in fisheries monitoring programs. It is an important tool for proposing stock management measures since it provides information on the autecology of species (Vazzoler, 1996). Often there is a need to estimate the size of a fish population in a given water body, in order to accomplish sustainable exploitation of the fish resources (Le Cren, 1951; Pauly, 1984; King, 1995; Froese, 2006). In addition, the Length-Weight Relationship can also be used for estimating biomass from fish length frequency data, and as a measure of the length-weight variation of individuals, indicating their condition or well-being (Petrakis and Stergiou, 1995).

Several researches on the monitoring and exploitation of fisheries resources focus on the marine environment (e.g., Beverton and Holt, 1957; Ricker, 1958; Gulland, 1969). In Neotropical freshwater environments, these studies are relatively more frequently in rivers (Bayley, 1981), when compared with reservoirs (Gubiani et al., 2009). In general, there is a shortfall in the knowledge about the Length-Weight Relationship of Neotropical freshwater fishes (Azevedo-Santos et al., 2017). For reservoirs, mainly in Brazil, is clear the needs of new studies in this scope. For instance, for the upper Paraná river, which hold a series of reservoirs (see Agostinho et al., 2008), just a few works were published (e.g., Benedito-Cecílio et al., 1997; Angelini and Agostinho, 2005; Gubiani et al., 2009; Oliva-Paterna et al., 2009; Marques et al., 2016).

The present work has the main objective to estimate the growth parameters of fish species captured by experimental fishery in the Três Irmãos reservoir, low Tietê river basin. The biological and ecological characteristics of these species are also presented in order to understand the profile of the present fish community.

MATERIAL AND METHODS

The Três Irmãos reservoir is located in the Northwest region of the State of São Paulo, between the municipalities of Pereira Barreto and Andradina. Its construction started in 1980, being finished in 1990. With a flooded area of 757,000 ha. is the largest and last reservoir for hydroelectric energy production in Tietê River. It receives contribution from eleven tributaries, among them the Pereira Barreto Channel, an important connection to the São José dos Dourados River, SP (CESP, 1998; Castro et al., 2018) (Figure 1).

The fish samples were obtained from October/2015 to February/2018, quarterly, in sites with three different environments characteristics (lotic, lentic and transition), under the project “Monitoring the aquatic environment of the Três Irmãos Reservoir” supported by Tijoá Participações e Investimentos Company.

The fish were captured using gill nets, with mesh size of 3, 4, 5, 6, 7, 8, 9, 10, 12, 14, 16, 18 and 20 cm between opposing nodes, with stretched mesh, and height ranging from 1.50 to 2.50 meters, 20.00 meters of length each, and total network area of 504.8 m^2.

The net sizes were defined according to the characteristics of the sampled environments (lotic, lentic and intermediate) and the mesh sizes as commonly used by fishermen in the region. The immersion period of the gill-net was 24 hours, with expenditure every 12 hours. To complement the ichthyofauna

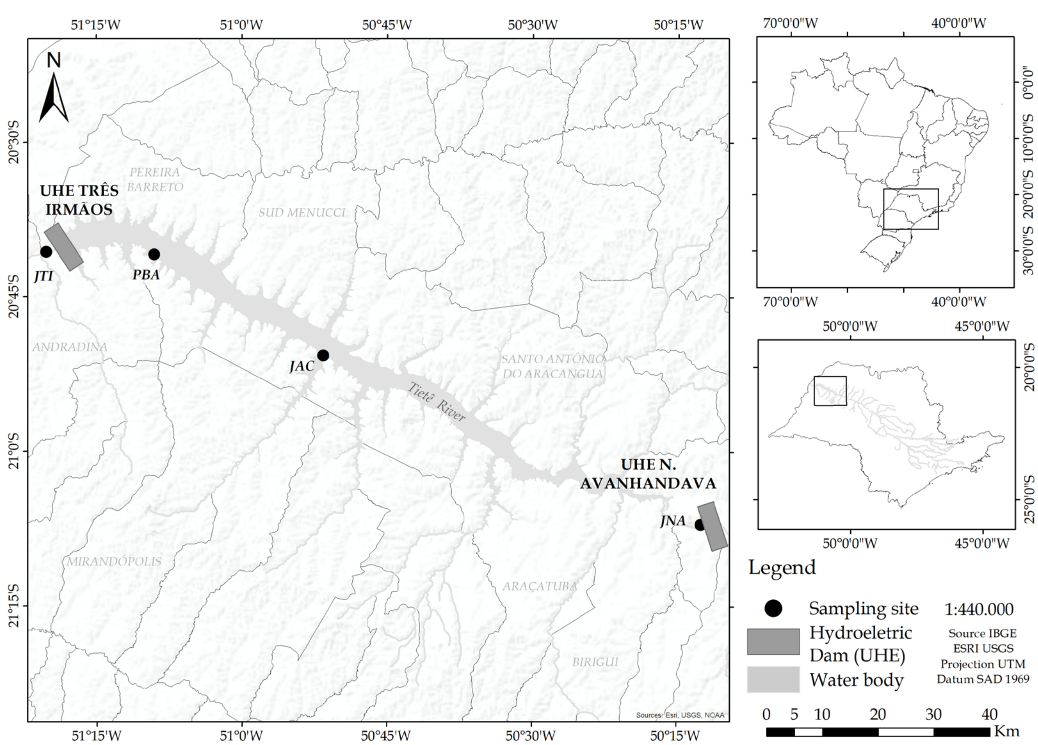

Figure 1. Map of the studied region, with emphasis on the Três Irmãos reservoir, in the lower Tietê river basin, São Paulo, with its down and upstream dam, neighboring municipalities, and sampling site: JNA- downstream from the Nova Avanhandava dam; JAC- Jacaré Stream; PBA- Pereira Barreto; JTI- downstream of the Três Irmãos dam.

survey of the region, the fishing with rod (line and hook), casting net and sieve, were also used.

The identification of the captured individuals was based on Bristski et al. (1986; 1999), Buckup et al. (2007), Graça and Pavanelli (2007).

The fishes were classified by mesh size, identified at the lowest possible level, their total length (TL) and standard length (SL) measured with an ictiometer (scale in millimeters), and the total weight (TW) of each specimen obtained from an electronic weighing-machine with a minimum of 1g scale. Measurements and weighing of all species collected were carried out with the specimens preserved in natura. Two specimens of each species (vouchers) were deposited in a scientific or didactic collection at the Laboratory of Ecology and Continental Fisheries (LabEcoPesca) of the Fisheries Institute, in São Paulo, Brazil.

For the length-weight relationship (LWR) was applied the potential equation TW = a * SLb, where TW is the total weight, SL the standard length, a the factor related to the degree of fattening of the individuals and b (ø) the coefficient of related to the shape of individuals' growth.

The values of **a** and **b** were estimated by the least squares method (predictive model), after logarithmic transformation of the following equation: log (TW) = log (a) + b * log (SL), where a is the curve intercept (coefficient related to body shape) and b the regression coefficient (exponent indicative of growth type). The coefficient of determination r^2 was used as an indicator of the linear regression fit quality (Zar, 1984). Prior to regression analysis, log10-log10 plots of TW and SL were used to detect and exclude outliers (Froese, 2006).

The species growth was considered isometric when the value of b = 3 and allometric when this value was lower or higher than 3 (b <3 <b or b <3, b> 3). Student's t-test was used to verify if the parameter b was significantly different than expected or from the theoretical value (b = 3, p <0.05). Thus, ts = (b-3) / sb (Zar, 1984), where ts-Student t test; b = slope, sb = slope standard error. Where sW = variance of body weight (g), sL = variance of standard length, n = sample size. All statistical analyzes were considered significant at the 5% level (p <0.05).

For the origin identification of the species, the classification contained in Langeani et al. (2007) was followed. For the categorization of size, we used the classification of Vazzoler et al. (1997), according to the description: size G > = 40 cm of total length (TL); size M > 20 and < 40 cm of TL. The values of TL were transformed to SL by the simple linear regression equation for each species analyzed: SL = a + bTL. In order to classify the trophic structure of the fish community present in the Três Irmãos reservoir, the studies of Vazzoler et al. (1997), Graça e Pavanelli (2007), and Langeani and Rêgo (2014) were considered.

For the analysis of the reproductive strategies, we based the criterion adopted in the studies carried out in the Alto Paraná basin and summarized by Vazzoler (1996), Vazzoler et al. (1997) and Suzuki, et al. (2004). The length of first sexual maturation (L50%) of the analyzed species was obtained based on published works for the neotropical region (Table 2).

The present work, inserted in the project (SGP nº 1305) "*Diagnosis of the fish fauna of the Três Irmãos reservoir, lower Tietê river basin*", was approved by the Institutional Ethics Committee (CEEAIP) under No. 08/2016.

RESULTS

In total, 7,319 individuals were studied, composed of five Orders: Characiformes (7 Families), Siluriformes (5 Families), Perciformes (1 Family), Cichliformes (1 Family) and Cyprinodontiformes (1 Family) (Table 1). The most abundant species were *Plagioscion squamosissimus* (N = 1,513), *Geophagus sveni* (N = 1,160), *Serrasalmus maculatus* (N = 1,049) and *Metynnis maculatus* (pacu-CD) (N = 974), which are target species of professional artisanal fishing, with the exception of pacu-CD that it is discarded in the catch-net fisheries. Nine species reached maximum length above that referenced in FishBase (Froese and Pauly, 2017): *Cichla piquiti* TL = 55.4 cm/ TL = 48.0 cm (Fishbase); *Crenicichla haroldoi* SL = 21.5/SL = 9.8 cm (Fishbase); *C. jaguarensis* SL = 23.5 cm/SL = 14.8 cm (Fishbase); *Cyphocharax nagelii* TL = 22.9 cm/TL = 19.0 cm (Fishbase); *Hypostomus ancistroides* TL =28.5 cm/TL = 21.0 cm (Fishbase); *Metynnis maculatus* TL = 19.5 cm/TL = 18.0 cm (Fishbase); *Roeboides descalvadensis* SL = 11.3 cm/SL = 8.9 cm (Fishbase); *Piaractus mesopotamicus* SL = 60.0 cm/SL = 40.5 cm (Fishbase) and *Schizodon borellii* TL = 38.4 cm/TL = 40.0 cm (Fishbase) (Table 1).

The specimens sampled ranged from 1.00 cm SL (0.02 TW), for *Poecilia reticulata* to 60.7 cm SL (70.0 cm TL) (4,940.0 g TW) for *Plagioscion squamossisimus* (Table 1). The growth parameter (b) of the length-weight relationship (LWR) ranged between 2.71 and 3.62 (Table 2; Figure 2). The species exhibited both allometry (b <3 and b> 3) and isometry (b = 3) growth types. The test t Student showed that b (ranging from 2.71 - 2.94) (p <0.05) was significantly lower than the theoretical value of 3, indicating negative allometric growth for five (5) species (Table 2). Student's t test showed that b (ranging from 3.13 - 3.62) indicated positive allometric growth (b> 3.0; p <0.05) for 15 species (Table 2). However, the test t exhibited isometric growth (b ranging from 2.91 - 3.08) (p> 3), with no significant difference from the theoretical value of 3 (Table 2; Figure 2). In this research, overall growth parameter, r^2 values were positive and highly correlated with r^2> 0.85 between fish stander length and body weight measurements (P <0.05) with $r^2 \geq 0.90$ in thirty-two (32) different species, being the smallest value (r^2 = 0.86) for *Apareiodon affinis* and *S. nasutus* (r^2 = 0.89) (Table 2).

The Table 3 summarizes the biological, ecological and behavioral information of the species, based on data obtained by different studies and researches for the Upper Paraná basin, for the Três Irmãos reservoir located in the low sub-basin Tietê river, SP (Vazzoler et al., 1997; Suzuki et al., 2004; Graça e Pavanelli, 2007; Langeani et al., 2007; Langeani and Rêgo, 2014).

Table 1. Total length (cm), standard length (cm) and total weight (g) characteristics for 34 species caught in Três Irmãos reservoir, during October/2015 and February/2018. Data marked in gray indicate values higher than those available in the revised literature.

Order															
Characiformes			**Total lenght (cm)**					**Standard lenght (cm)**				**Total body weight (g)**			
Family															
Acestrorhynchidae															
Species	**Common name**	**N**	**Mean**	**±SE**	**min**	**max**	**N**	**Mean**	**±SE**	**min**	**max**	**Mean**	**±SE**	**min**	**max**
Acestrorhynchus lacustris	Peixe-cachorro	65	22.50	2.46	17.00	26.60	71	19.70	2.37	14.00	24.00	116.13	42.64	20.00	205.00
Anostomidae															
Leporinus friderici	Piau-três-pintas/ Piava	86	31.86	4.67	20.60	40.30	95	25.85	3.57	16.90	33.00	463.37	197.99	100.00	1,050.00
Schizodon borellii	Piava-catinguda/ Chimboré	32	25.37	3.62	20.90	**38.50**	32	21.60	3.14	18.10	34.00	254.06	206.24	120.00	1,255.00
Schizodon nasutus	Taquara	41	28.58	3.69	20.40	35.50	46	24.30	2.78	18.60	30.20	279.00	95.74	130.00	440.00
Characidae															
Astyanax lacustris[1]	Lambari-do-rabo-amarelo	28	12.79	1.59	7.40	14.90	29	10.60	1.46	6.10	12.80	35.90	13.68	5.75	65.00
*Cynopotamus kincaidi**	Saicanga	51	10.00	4.62	2.70	16.00	57	8.75	3.85	2.20	13.50	21.31	16.46	0.20	50.00
Hyphessobrycon eques	Mato-grosso	28	3.14	0.57	1.50	3.73	39	2.61	0.38	1.30	3.13	0.53	0.18	0.04	0.84
*Metynnis maculatus**	Pacu-cd	807	14.23	2.24	2.70	**19.50**	974	11.90	1.95	2.30	16.40	82.22	34.07	0.53	205.00
Piaractus mesopotamicus[2]	Pacu-guaçu/ Pacu-caranha	10	36.25	12.42	22.00	64.50	11	31.09	11.25	18.00	**60.00**	1,653.64	2,461.87	235.00	8,885.00
*Roeboides descalvadensis**	Dentudo/ Saicanga	130	8.71	1.40	3.67	12.80	145	7.33	1.16	3.10	**11.30**	6.95	3.03	0.44	23.40
Serrasalmus maculatus	Piranha/ Pirambeba	1,038	17.55	4.66	1.98	29.60	1,049	15.02	4.20	1.69	26.50	167.51	133.50	0.17	685.00
Serrasalmus marginatus	Piranha-branca	123	17.47	3.97	6.90	28.40	125	14.86	3.57	5.80	25.50	132.64	99.96	5.00	575.00
Curimatidae															
Cyphocharax nagelii	Saguiru	15	19.48	3.13	11,6	**22,90**	18	15.79	3.50	8.90	19.50	102.93	52.59	15.00	190.00
Erythrinidae															
Hoplias malabaricus	Traíra/Lobó	283	26.17	8.76	3.07	42.30	302	22.05	7.16	2.56	35.90	257.49	146.57	0.25	920.00
Parodontidae															
Apareiodon affinis	Canivete/Durinho	166	14.37	0.98	11.50	16.70	155	12.53	0.78	10.0	15.10	37.52	9.28	15.00	75.00
Prochilodontidae															
Prochilodus lineatus	Curimbatá	48	40.48	10.62	22.50	57.40	55	34.57	9.06	20.20	51.00	1,488.55	1,138.13	200.00	4,470.00
Cyprinodontiformes															
Poeciliidae															
*Poecilia reticulata**	Lebiste/Guppy	19	2.14	0.52	1.30	3.20	20	1.73	0.44	1.00	2.62	0.12	0.10	0.02	0.34
Cichliformes															
Cichlidae															
*Astronotus crassipinnis**	Apaiari/Oscar	31	13.95	9.26	2.80	26.70	31	11.00	7.26	2.20	21.70	153.25	150.99	0.46	495.00
*Cichla kelberi**	Tucunaré-amarelo	248	27.11	6.70	4.40	39.60	251	22.79	5.79	3.71	35.50	354.84	224.02	0.86	1,235.00
*Cichla piquiti**	Tucunaré-azul	100	30.10	8.07	14.00	**55.40**	100	25.94	7.04	11.50	49.50	522.82	495.96	35.00	3,180.00
*Coptodon rendalli***	Tilápia-africana/ Tilápia-rendalli	27	16.74	7.39	6.50	29.20	30	14.83	6.72	5.30	25.90	214.40	196.19	5.56	690.00

Crenicichla haroldoi	Joaninha/Patrona/ Boca-de-véia	86	15.95	5.96	2.40	26.00	94	13.57	5.11	2.03	**21.50**	67.94	46.40	0.18	210.00
Crenicichla jaguarensis	Boca-de-véia/ Joaninha/Patrona	23	17.66	4.10	7.28	26.40	23	15.28	3.69	6.15	**23.50**	115.54	92.39	4.90	390.00
*Geophagus sveni** [3]	Porquinho	1,116	16.63	3.77	7.00	26.00	1,160	13.70	3.12	5.80	20.50	100.19	66.02	4.90	360.00
*Oreochromis niloticus***	Tilápia-do-nilo	38	9.62	9.10	1.30	36.70	46	10.21	9.70	1.00	33.40	215.67	422.35	0.03	1,815.00
*Satanoperca pappaterra**	Zoiudo/Caroço-de-manga	224	18.43	3.67	3.33	24.20	256	14.99	3.09	2.62	20.00	130.88	55.95	0.57	260.00
Perciformes															
Sciaenidae															
*Plagioscion squamosissimus**	Corvina/Pescada-do-piauí	1,192	24.71	4.75	8.20	70.00	1,513	20.63	4.11	6.80	60.70	198.59	218.78	10.69	4,940.00
Siluriformes															
Callichthyidae															
Hoplosternum littorale	Caborja	47	19.04	1.83	13.40	23.40	49	16.16	1.61	11.20	19.50	159.31	45.60	51.20	275.00
Doradidae															
*Ossancora eigenmanni** [4]	Mandi-serra	63	9.23	0.94	7.60	11.10	59	7.76	0.83	6.50	9.40	13.48	5.83	5.00	25.00
Heptapteridae															
Rhamdia quelen	Jundiá	18	24.42	4.19	16.20	30.80	23	21.93	3.75	14.10	28.40	185.00	86.33	45.00	340.00
Loricariidae															
Hypostomus ancistroides	Cascudinho	57	21.96	2.96	15.40	**28.50**	57	16.83	2.44	11.50	22.60	133.31	50.64	43.70	260.00
Loricariichthys platymetopon	Cascudo-chinelo	193	27.41	3.48	16.10	34.50	193	24.06	3.31	13.80	30.50	128.50	49.71	20.00	245.00
Pterygoplichthys ambrosettii [5]	Cascudo-pantaneiro	196	33.53	7.26	18.00	52.20	196	28.15	6.55	13.00	46.60	555.61	331.34	70.00	1,705.00
Pimelodidae															
Pimelodus maculatus	Mandi-guaçu	15	27.28	4.62	19.00	35.10	15	22.56	3.55	15.80	27.50	263.67	121.50	80.00	495.00
	Total	**6,664**					**7,319**								

* Allochthonous species; ** Exotic species (non-native species)
[1] *Astyanax altiparane* (old name), currently valid name *Astyanax lacustris* (Lucena and Soares, 2016)
[2] *Piaractus mesopotamicus* - Constant on the Red List of native species for the state of São Paulo (SMA-SP, 2018): Decree Nº 63.853, November 27, 2018
[3] *Geophagus proximus* (old name), currently valid name *Geophagus sveni* (Ota et al. 2018)
[4] *Oxydora eigenmanni* (old name), currently valid name *Ossancora eigenmanni* (Birindelli and Sabaj Pérez, 2011)
[5] *Pterygoplichthys anisitsi* (old name), currently valid name *Pterygoplichthys ambrosettii* (Ota et al. 2018)

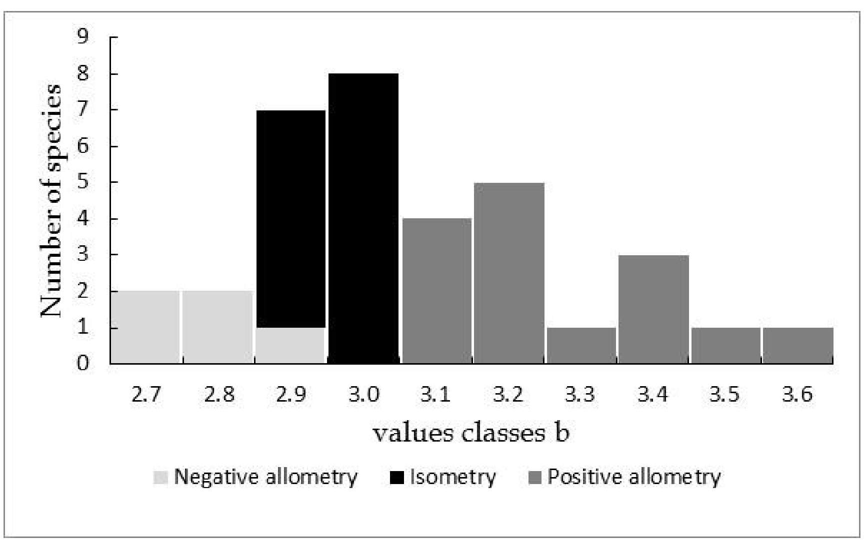

Figure 2. Frequency distribution of b values for 34 species caught in Três Irmãos reservoir, lower Tietê river basin, São Paulo, Brazil.

Table 2. Parameters of the relationship between standard length (cm) and total weight (g) for 34 species caught in Três Irmãos reservoir, during October/2015 and February/2018.

		Growth coefficient				L50% (SL - cm)				
Species	**N**	**a**	**b**	**r^2**	**Type of growth**	**Female**	**Male**	**Reference L50%**	**Imature (%)**	**Adult (%)**
Acestrorhynchus lacustris	71	0.0038	3.44	0.90	A+	13.0	10.7	Suzuki et al., 2004	0.0	100.0
Leporinus friderici	95	0.0099	3.28	0.96	A+	16.2	13.1	Suzuki et al., 2004	1.1	98.9
Schizodon borellii	32	0.0052	3.48	0.94	A+	17.8	14.6	Suzuki et al., 2004	0.0	100.0
Schizodon nasutus	46	0.0228	2.94	0.89	A-	14.8	13.0	Langeani and Rêgo, 2014 (Smi)	0.0	100.0
Astyanax lacustris	29	0.0164	3.23	0.96	A+	4.2	3.6	Suzuki et al., 2004	0.0	100.0
Cynopotamus kincaidi	57	0.0121	3.22	0.99	A+	?	?	?	?	?
Hyphessobrycon eques	39	0.0187	3.41	0.94	A+	1.8	1.6	Suzuki et al., 2004	7.7	92.3
Metynnis maculatus	974	0.0740	2.81	0.95	A-	11.0		Brazão et al., 2017	27,5	72,5
Piaractus mesopotamicus	11	0.0367	3.00	0.99	I	29.8		Langeani and Rêgo, 2014 (Smi)	54,5	45,5
Roeboides descalvadensis	145	0.0119	3.15	0.91	A+	4.3	3.9	Suzuki et al., 2004	4.1	95.9
Serrasalmus maculatus	1,049	0.0272	3.13	0.98	A+	10.8	9.8	Suzuki et al., 2004	16.3	83,7
Serrasalmus marginatus	125	0.0180	3.23	0.95	A+	12.2	11.5	Suzuki et al., 2004	16.8	83.2
Cyphocharax nagelii	18	0.0326	2.88	0.97	A-	8.9	7.0	Suzuki et al., 2004	5.6	94.4
Hoplias malabaricus	302	0.0198	2.98	0.99	I	16.4	15.2	Suzuki et al., 2004	13.2	86.8
Apareiodon affinis	155	0.0039	3.62	0.86	A+	7.9	7.3	Suzuki et al., 2004	0.0	100.0
Prochilodus lineatus	55	0.0221	3.08	0.98	I	24.0	21.3	Suzuki et al., 2004	10.9	89.1
Poecilia reticulata	20	0.0196	2.98	0.96	I	?	?	?	?	?
Astronotus crassipinnis	31	0.0360	3.14	0.99	A+	?	?	?	?	?
Cichla kelberi	251	0.0228	3.03	0.98	I	20.0	15.9	Suzuki et al., 2004	32.7	67.3
Cichla piquiti	100	0.0265	2.97	0.97	I	22.5		Luiz et al., 2011	13.0	87.0
Coptodon rendalli	30	0.0385	3.03	0.99	I	10.5		Barbieri et al., 2000	36.7	63.3
Crenicichla haroldoi	94	0.0259	2.91	0.99	I	?	?	?	?	?
Crenicichla jaguarensis	23	0.0100	3.35	0.98	A+	?	?	?	?	?
Geophagus sveni	1,160	0.0193	3.20	0.98	A+	?	?	Manuscript in preparation	?	?
Oreochromis niloticus	46	0.0415	3.03	0.99	I	7,6		Barbieri et al., 2000	50.0	50.0
Satanoperca pappaterra	256	0.0351	3.00	0.98	I	8.6	7.5	Suzuki et al., 2004	5.1	94.9
Plagioscion squamosissimus	1,513	0.0165	3.06	0.94	I	20.0	20.0	Braga, 1997	**58,7**	41,3
Hoplosternum littorale	49	0.0390	2.98	0.96	I	10.0	8.7	Suzuki et al., 2004	0.0	100.0
Ossancora eigenmanni	59	0.0090	3.54	0.91	A+	?	?	?	?	?
Rhamdia quelen	23	0.0169	2.98	0.93	I	14.0	13.4	Narahara et al., 1985	0.0	100.0
Hypostomus ancistroides	57	0.0589	2.72	0.90	A-	?	?	?	?	?
Loricariichthys platymetopon	193	0.0053	3.16	0.96	A+	15.7	14.5	Suzuki et al., 2004	1.0	99.0
Pterygoplichthys ambrosettii	196	0.0575	2.71	0.96	A-	24.3	24.1	Suzuki et al., 2004	26.0	74.0
Pimelodus maculatus	15	0.0208	3.01	0.91	I	15.8	14.7	Suzuki et al., 2004	6.7	93.3
Total	**7,319**									

A+: positive allometry; A-: negative allometry; I: isometry
L50%: First sexual maturation
Smi: smallest mature individual identified
? No data

Table 3. Summary of the biological, ecological and behavioral characteristics of the species sampled for the reservoir of Três Irmãos, Tietê river, from October/2015 to February/2018.

Species	Origin	Porte	Food habit	Type of spawning	Migration	Parental care
Acestrorhynchus lacustris	Auth	M	Piscivorous	Partial	No	No
Leporinus friderici	Auth	M	Omnivorous	Total	Yes	No
Schizodon borellii	Auth	L	Herbivorous	?	No	No
Schizodon nasutus	Auth	L	Herbivorous	Partial	No	No
Astyanax lacustris	Auth	S	Omnivorous	Partial	No	No
Cynopotamus kincaidi	Alloc	M	?	?	?	?
Hyphessobrycon eques	Auth	S	Herbivorous	?	No	No
Metynnis maculatus	Alloc	S	Herbivorous	Partial	No	No
Piaractus mesopotamicus	Auth	L	Omnivorous	Total	Yes	No
Roeboides descalvadensis	Alloc	S	Insetivorous	Partial	No	No
Serrasalmus maculatus	Auth	M	Carnivore/Piscivorous	Partial	No	Yes
Serrasalmus marginatus	Auth	M	Piscivorous	Partial	No	Yes
Cyphocharax nagelii	Auth	S	Detritivorous/Iliophagous	Partial	No	No
Hoplias malabaricus	Auth	L	Insetivorous (Young)/ Piscivorous (Adult)	Partial	No	Yes
Apareiodon affinis	Auth	S	Detritivorous/Iliophagous	Partial	No	No
Prochilodus lineatus	Auth	L	Detritivorous/Iliophagous	Partial	Yes	No
Poecilia reticulata	Alloc	S	?	Partial	No	No
Astronotus crassipinnis	Alloc	M	Piscivorous/Insetivorous	Partial	No	Yes
Cichla kelberi	Alloc	L	Crustacea and Insect (Young)/ Shrimp (Adult)	Partial	No	Yes
Cichla piquiti	Alloc	L	Crustacea and Insect (Young)/ Piscivorous (Adult)	Partial	No	Yes
Coptodon rendalli	Exot	L	Omnivorous	Partial	No	Yes
Crenicichla haroldoi	Auth	S	Omnivorous/Invertivorous	?	No	Yes
Crenicichla jaguarensis	Auth	S	Insetivorous	?	?	Yes
Geophagus sveni	Alloc	M	Omnivorous/Invertivorous	Partial	No	Yes
Oreochromis niloticus	Exot	L	Omnivorous	Partial	No	Yes
Satanoperca pappaterra	Alloc	M	Omnivorous/Invertivorous/ Bentofagous	Partial	No	Yes
Plagioscion squamosissimus	Alloc	L	Piscivorous	Partial	**No**	No
Hoplosternum littorale	Auth	M	Invertivorous/Bentofagous	Partial	No	Yes
Ossancora eigenmanni	Alloc	S	?	?	No	No
Rhamdia quelen	Auth	L	Insectivorous (Young)/ Piscivorous (Adult)	Partial	No	No
Hypostomus ancistroides	Auth	M	Detritivorous	Total	No	Yes
Loricariichthys platymetopon	Alloc	M	Detritivorous	?	No	Yes
Pterygoplichthys ambrosettii	Auth	L	Detritivorous	Total	No	Yes
Pimelodus maculatus	Auth	L	Omnivorous	Partial	Yes	No

L- large porte; M- medium porte; S - short porte
Auth -Authochthonous; Alloc -Allochthonous; Exot -Exotic
? - no data

Sampling fauna is composed of native (n=20; 58.8%) and non-native species (allochthonous + exotic) (12; 41.2%), medium and large size (n=24; 70.6%), sedentary (n=28; 82.4%) and migratory species (n=4; 11.8%), partial spawning (n=23; 67.6%), with different eating habits: carnivorous/piscivorous (n=9; 26.5%), omnivorous (n=9; 26.5%), detritivorous/iliofagous (n = 6; 17.6%), herbivorous (n=4; 11.8%), insectivorous (n=3; 8.8%) and with no information in the literature (n=3; 8.8%) (Table 3).

DISCUSSION

Knowledge of existing fish species in a river basin is the minimum condition necessary for the implementation of any protecting measure both for water and fishery resources (Holzbach et al., 2005). The results presented in this study can contribute to the current knowledge of the parameters the Lengh-Weight Relationships (LWR) of fish species present in the Três Irmãos reservoir, located in the lower Tietê river basin. Such information can benefit fishery scientists in the fishery diagnoses and management. The LWR is an excellent monitoring tool in commercial fishing landings (King, 1995; Gubiani et al., 2009; Vaz-dos-Santos and Gris, 2016), and weight is a good estimator of fish welfare or condition in a given environment (Vazzoler, 1996).

The captured fish assembly consisted mainly of adult fish, since most species were already over the length of first sexual maturation (L50%) (Table 2), based on estimates of L50% obtained in other studies (Braga, 1997; Vazzoler et al., 1997; Barbieri et al., 2000; Suzuki, et al., 2004; Luiz et al., 2011), and by the smallest mature individual identified in the sample (Langeani and Rêgo, 2014).

The proportion of imature/mature was higher only for *Piaractus mesopotamicus* (54.5%/45.5%) and *Plagioscion squamosissimus* (58.7%/41.3%) (Table 2), indicating that pacu, a migratory and autochthonous species in this basin, has reproduced in a lentic/transition environment, despite its characteristics of lotic habits and of the piracema event (Table 3). The high proportion of immature specimens of *P. mesopotamicus* may be influenced by the systematic introduction of young fish in the reservoir by the hydroelectric concessionaires. However, the confirmation of this fact is necessary through studies of eggs and larvae in tributaries of the Três Irmãos reservoir; and genetic studies. Regarding the curvina/pescada-do-piauí, an allochthonous species from the Amazon basin, of lentic habits, the highest proportion of immature individuals shows that the specie is well adapted to this environment, finding favorable areas for reproduction and growth (Tables 2 and 3). These attributes has promoted the increase of commercial and recreational/sport fishing (Agostinho et al., 2007; Castro et al., 2018). However, despite the positive social/economic impacts on the fisher population, it is necessary to investigate the ecological impacts of this carnivorous/piscivorous species on native sedentary species in this environment, aiming at the best balance in the conservation and use of fishery resources, over the years.

The growth parameter value of b=3.62 for *Apareiodon affinis* (n=155) was outside to limits of 2.5 to 3.5 (Bagenal and Tesch, 1978). According to Calender, apud Gubiani et al. (2009), values of b< 2.5 or b>3.5 are often a consequence of small sample size and size range. In this case, for this species, such justifications are not adequate since *A. affinis* was well represented in number and size range. Although *P. mesopotamicus* sampling was small (n = 11), it did not affect the growth parameter for this species (b = 3.0) possibly due to the wide range of sizes sampled (A) (18.0-60.0 cm SL), also it presented a good fit quality (r^2 = 0.99). The other species (Table 2) were within the limits recommended by Bagenal and Tesch (1978).

For the 34 species analyzed, nine reached maximum length above that referenced in FishBase (Froese and Pauly, 2017): *Cichla piquiti* (TL= 55.4 cm), *Crenicichla haroldoi* (SL= 21.5 cm), *C. jaguarensis* (SL= 23.5 cm), *Cyphocharax nagelii* (TL= 22.9 cm), *Hypostomus ancistroides* (TL= 28.5 cm), *Metynnis maculatus* (TL= 19.5 cm), *P. mesopotamicus* (SL= 60.0 cm), *Roeboides descalvadensis* (SL= 11.3 cm) and *Schizodon borellii* (TL= 40.0 cm).

The maximum lengths (SL) reached in this study were higher than those observed in the Porto Primavera reservoir by Marques et al. (2016) for *C. piquiti* (SL = 49.5 cm) and *C. nagelli* (SL = 19.5 cm). Samples of *P. mesopotamicus*, *C. haroldoi* and *H. ancistroides* captured in Três Irmãos reservoir presented higher maximum sizes than those obtained in Gubiani et al. (2009) for 30 neotropical reservoirs.

For the length-weight relationship (LWR), the value of the parameter b depends on the shape and fatness of the fish species. The parameter b may vary temporally and spatially (Bagenal and Tesch, 1978). Thus, the LWR in fish is affected by a number of factors, including gonad maturity, sex, diet, stomach fullness, health, and annual differences in environmental condition, as well as season and habitat (Le Cren, 1951; Pauly, 1984; Froese, 2006).

Values of b = 3 indicate that the fish grow isometrically, while values of b ≠ 3 indicate allometry in the growth of the species. When the value of b> 3 the type of growth of the species is allometric positive, that is, the increase in weight is greater proportionally than its growth in length. If b <3, the growth is negatively allometric, the species grows more in its length then in weight (Benedito-Cecílio et al., 1997). A total of 14 fish species exhibited isometric growth, 15 positive allometric growth, and 5 allometric negative. The parameter b varied between 2.71 and 3.62. According to Froese (2006), b <2.5 indicates that the growth in length of a species is proportionally greater than its growth in weight; on opposite way, b> 3.5, the growth in weight is proportionally greater than its length.

Considering the ecological and behavioral characteristics of all species captured (Table 3), it is noticed a composition mostly of native species, with medium and large size. The majority is sedentary, with partial spawning, and most without parental care, with carnivorous and omnivorous eating habits. However, although the lower number of non-native species (n=14; 41,2%), abundance and biomass, by species is higher than for all native species present in commercial and experimental (scientific) fishing (Castro et al., 2018). The migratory species showed low abundance and higher biomass, represented by four species: *Leporinus friderici* (piau-de-três-pintas), *Prochilodus lineatus* (curimbatá), *Pimelodus maculatus* (mandi-guaçu) and *P. mesopotamicus* (pacu-guaçu) (Table 1).

CONCLUSION

This study represents contribution for length-weight relationships in dammed environments in the Southeastern region of Brazil, which can be useful for comparisons with similar data from other Brazilian reservoirs. The LWR is an excellent monitoring tool in commercial fishing landings, as it can benefit fisheries scientists in the elaboration of diagnostics and fisheries management when information is only length and not weight.

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