E-ISSN: 2347-5129
P-ISSN: 2394-0506
(ICV-Poland) Impact Value: 5.62
(GIF) Impact Factor: 0.549
IJFAS 2020; 8(3): 355-360

www.fisheriesjournal.com
Received: 04-03-2020
Accepted: 06-04-2020

Regiane Mônica dos Reis
Programa de Pós-Graduação em Ciências Ambientais. Universidade Federal de Rondônia, Campus Rolim de Moura, Rolim de Moura, Rondônia, Brazil

Luzia da Silva Lourenço
Faculdade São Paulo, Rolim de Moura, Rondônia, Brazil

Hugmar Pais da Silva
Laboratório de Citogenética e Genética Animal, Instituto de Biociências, Universidade Federal de Mato Grosso, Mato Grosso, Campus Cuiabá, Cuiabá, Mato Grosso, Brazil

JhonyVendrusclo
Departamento de Engenharia Agrícola e Solos, Universidade Federal do Amazonas, Manaus, Amazonas, Brazil

Izaias Médice Fernandes
Laboratório de Biodiversidade e Conservação. Universidade Federal de Rondônia, Campus Rolim de Moura, Rolim de Moura, Rondônia, Brazil

Corresponding Author:
Regiane Mônica dos Reis
Programa de Pós-Graduação em Ciências Ambientais. Universidade Federal de Rondônia, Campus Rolim de Moura, Rolim de Moura, Rondônia, Brazil

Length-weight relationships and condition factor of the predatory fish, *Cichla pleiozona* and *Serrasalmus rhombeus*, from two tropical reservoirs, Amazon basin, Brazil

Regiane Mônica dos Reis, Luzia da Silva Lourenço, Hugmar Pais da Silva, JhonyVendrusclo, Izaias Médice Fernandes

Abstract
The aim of this study was to estimate the parameters of the weight-length relationship and the relative condition factor for *Cichla pleiozona* and *Serrasalmus rhombeus* in Branco River, Madeira river basin, Brazilian Amazon. For this, biometric data were collected between March 2018 and November 2019 in two reservoirs. While *C. pleiozona* showed isometric growth (b = 3), *S. rhombeus* showed positive allometric growth (b > 3). For *C. pleiozona*, the value for parameter b varied from 3.06 to 3.08 in Cachimbo Alto and Ângelo Cassol, respectively, while for *S. rhombeus* b value was 3.15 in Cachimbo Alto and 3.29 in Angelo Cassol. The relative condition factor was the same in both reservoir for *C. pleiozona* (1.006) and *S. rhombeus* (1.017), while wet season showed lower value then dry season for both species. The parameters of the weight-length relationship and the relative condition factor showed no spatial or temporal variation.

Keywords: Fish, Madeira River basin, allometric growth, carnivorous species

1. Introduction
Regions rich in freshwater resources, such as the Amazon basin, attract great interest from energy sector entrepreneurs [1, 2]. As a result, currently, of the five largest hydroelectric projects in Brazil, four are installed in the Amazon region. As they result in irreversible changes in the natural hydrological regime of rivers, the construction of large hydroelectric plants causes profound environmental changes, including modifying the habitat quality and the dynamics of the entire associated biota [3 - 5].
Accordingly, the conservation of Amazonian water resources faces many challenges, since it is under severe anthropic pressure [6], and also home to one of the most diverse ichthyofaunason the planet, with approximately 2,716 valid species [7]. Despite, or possibly because of, this extensive biodiversity, information on the biological and population aspects of most species of Amazonian fish is poorly-developed.
Among the diverse fish genera of the Amazon, two stand out: *Cichla* and *Serrasalmus*. Endemic to the Amazon basin, the species of the genus *Cichla* (peacock bass) represents one of the main groups of piscivores within the Cichlidae family in South America [8, 9]. The genus has 16 valid species [10 - 12], which, together, form an important natural resource for riverside communities, commercial and sport fishing in many regions of the Amazon basin [13]. Among the peacock bass species, *Cichla pleiozona* Kullander & Ferreira, 2006 is a species with distribution restricted to the Madeira River basin, and due to its recent description, there is no information on the biology of the species, except for data on its weight-length relationship [14].
The genus *Serrasalmus* contains 28 valid species [15]. Popularly known as horse piranhas or *pirambebas*, these are among the most abundant members of the Amazon fish fauna. Among them, *Serrasalmus rhombeus* Linnaeus, 1766 (red-eyed pirambeba) is present in all major drainage basins of the Amazon, is a piscivorous/carnivorous predator, and plays a key ecological role in maintaining the balance of aquatic populations [16 - 18].
Estimates of weight-length relationships for these two species will provide key biological knowledge, since measuring these parameters facilitates an understanding of the biological,

physiological, and ecological aspects of the organisms involved, thus providing information on the population dynamics of the species in a given environment [19 - 22]. In addition, calculating the condition factor (*K*) makes it possible to assess individual physiological condition [23, 24], and relate this to environmental conditions and behavioral aspects of species [25].

Considering that, due to the interactions between aquatic and terrestrial environments, hydrographic basins can be used as ecosystem design units [26], and knowing that anthropogenic disturbance can compromise basin functional dynamics, the current study aimed to estimate the parameters of the weight-length ratio and relative condition factor (*Kn*) for *Cichla pleiozona* and *Serrasalmus rhombeus* in two reservoirs, and answer the following questions: i) Do the parameters of the weight-length relationship and the relative condition factor (*Kn*) of the two species differ between reservoirs? ii) Does the condition factor of the two species vary over the annual hydrological cycle?

2. Materials and Methods

2.1 Study area

The Branco River is located in the southern part of the Brazilian Amazon (Figure 1). The region's climate is of the Monsoon (Am) type, with annual precipitation that varies from 1800 to 2300 mm, average annual temperature between 22 and 26° C [27], a dry period that lasts from May to October and rainy period from November to April [28]. The fish used in this study were captured in the reservoirs of the Ângelo Cassol and Cachimbo Alto Small Hydroelectric Power Plants (SHPs), two of the eight SHPs, currently in operation along of Branco River course (Figure 1).

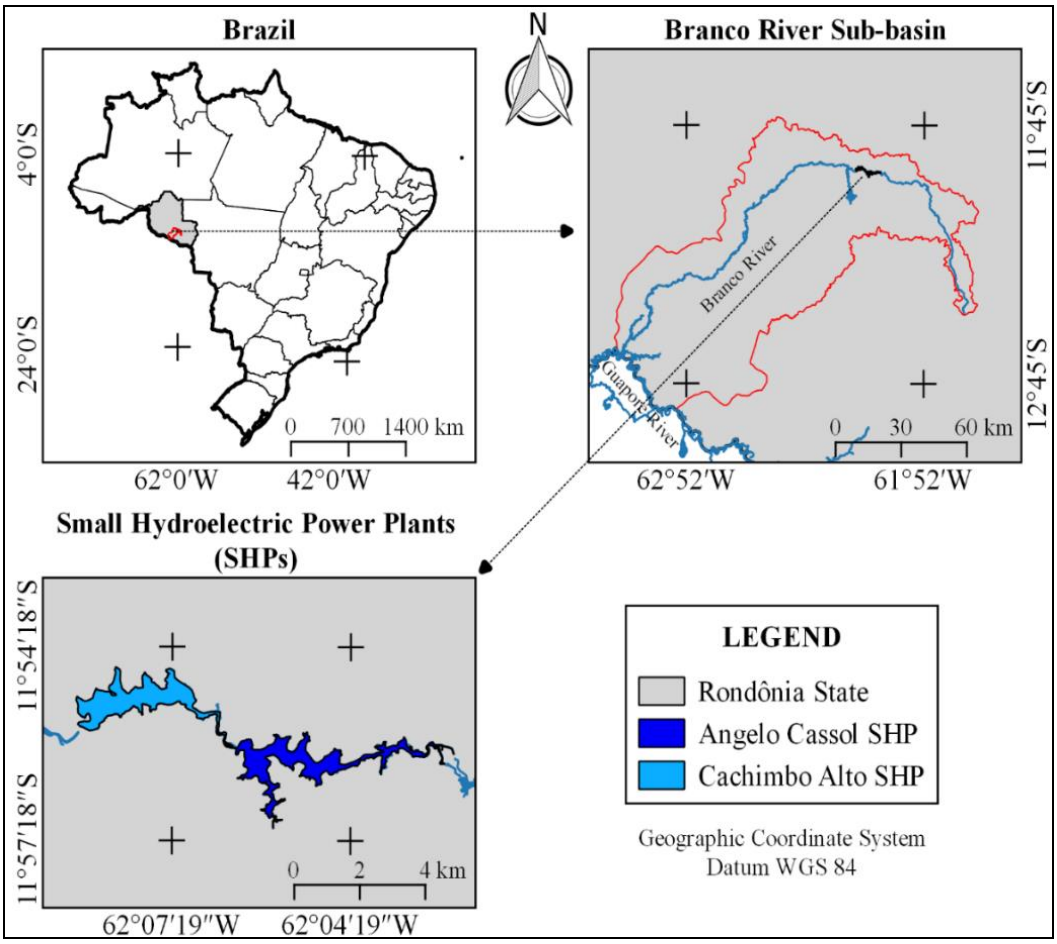

Fig 1: Study area and sampling sites

2.2 Biometric measurements

Individuals of *C. pleiozona* and *S. rhombeus* were captured via experimental fishing between March/2018 and November/2019. The captured individuals were preserved on ice, and transported to laboratory, where standard length (SL, in mm) and weight (W, in kg) were taken. This research was conducted under SISBIO Collection of Species Permit number 57920–2 issued by Brazilian Environmental Agency (ICMBio).

2.3 Statistical analyses

As males and females showed no difference in the parameters of the weight-length ratio (*a* and *b*), and the number of individuals captured with mature gonads was low, the combined weight-length ratio and the condition factor of each species were calculated separately for each reservoir, with sex not considered in the analyzes. The data from November to April were considered as the rainy season, and those from May to October as the dry season.

The length-weight ratio was calculated using the following equation: $W = a.L^b$, where *W* is weight, *L* is length, *a* is the intercept, the W value expected when L= 1, and *b* is the inclination function (allometry coefficient) [29]. To assess the influence of body morphology on weight-length parameters *a* and *b*, the equation was adjusted to a linear model, after log transformation ($Log\ W = log\ a + b\ Log\ SL$). Length (SL) and weight (W) data were plotted and extreme values removed before linear regression analysis. The determination coefficient (r^2) was used to calculate the degree of association between weight and length. For parameters *a* and *b*,

95%confidence intervals (CL) were calculated.
The relative condition factor (*Kn*) [30] was calculated using the equation *Kn = W/W',* where *W* is the observed weight and *W'* is the average weight predicted for the length, based on weight-length ratio parameters (W'= a L^b) [31]. To assess whether the *C. pleiozona* relative condition factor varied between the two reservoirs and between the two hydrological periods (dry and flooded) an Analysis of Variance (Two-Way ANOVA) was used [32]. As the *S. rhombeus* analysis of variance residuals did not show a normal distribution, a Two-Way Anova with permutation was applied. This analysis was performed using the "aovp" function of the lmPerm package [33]. All analyzes were processed in Program R Core Team [34].

3. Results

3.1 Length-weight relationship

A total of 77 specimens of *C. pleiozona* were captured, 23 in the Ângelo Cassol SHP and 54 in Cachimbo Alto SHP. A total of 214 *S. rhombeus* were captured: 111 at Ângelo Cassol SHP,103 at Cachimbo Alto SHP (Table 1).
Standard *C. pleiozona* length ranged from 20.5 to 38.5 cm, and weight from 0.150 to 1.370 kg in the Ângelo Cassol SHP. The weight-length ratio allometry coefficient was 3.08. Log weight on log length regression was significant ($p < 0.001$), and the determination coefficient (r^2) was 0.943 (Figure 2). In the Cachimbo Alto SHP, *C. pleiozona* individuals had a standard length of between 16.5 and 41.5 cm, while weight ranged from 0.080 to 1.735 kg. Weight-length ratio parameter *b* was 3.06, and regression between weight log and length log was significant ($r^2 = 0.968$ and $p < 0.001$). The allometry coefficient (*b* value) did not differ between the two SHPs (Ângelo Cassol CL 95% = 2.74 - 3.43; Cachimbo Alto CL 95% = 2.91 - 3.21) (Table 1).
Individuals of *S. rhombeus* showed lengths between 7.30 to 29.0 cm, while weights ranged from 0.009 to 0.740 kg in the Ângelo Cassol SHP. The weight-length ratio coefficient *b* was 3.15 and the regression between weight log and length log was significant ($r^2 = 0.933$, $p < 0.002$). In the Cachimbo Alto SHP, captured *S. rhombeus* specimens had a standard length ranging between 11.5 to 29.70 cm, and weight between 0.039 to 1.100 kg. The weight-length ratio coefficient *b* value was 3.29, and the linear regression model generated from the relationship between weight versus length was significant ($r^2 = 0.937$ and $p < 0.002$) (Figure 3). For *S. rhombeus*, the allometry coefficient (*b* value) did not differ between the two studied reservoirs (Table 1).

Table 1: *C. pleiozona* and *S. rhombeus* descriptive statistics and estimated LWR parameters

Species	Reservoirs	N	Standard length (cm)		Weight (kg)		*a* (95% CL)	*b* (95% CL)	r^2
			Min.	Max.	Min.	Max.			
Cichla pleiozona	Ângelo Cassol	23	20.50	38.50	0.150	1.370	0.0154 (0.0049 – 0.0487)	3.08 (2.74 -3.43)	0.943
	Cachimbo Alto	54	16.50	41.50	0.080	1.735	0.0182 (0.0109 – 0.0304)	3.06 (2.91-3.21)	0.968
Serrasalmus rhombeus	Ângelo Cassol	111	7.30	29.00	0.009	0.740	0.0152 (0.0097 - 0.0239)	3.15 (3.01-3.34)	0.933
	Cachimbo Alto	103	11.50	29.70	0.039	1.100	0.0112 (0.0069 - 0.0182)	3.29 (3.12 -3.45)	0.937

Abbreviations: N, number of individuals; Max, maximum; Min, minimum; a, intercept; b, slope; CL, confidence limits; r^2, determination coefficient.

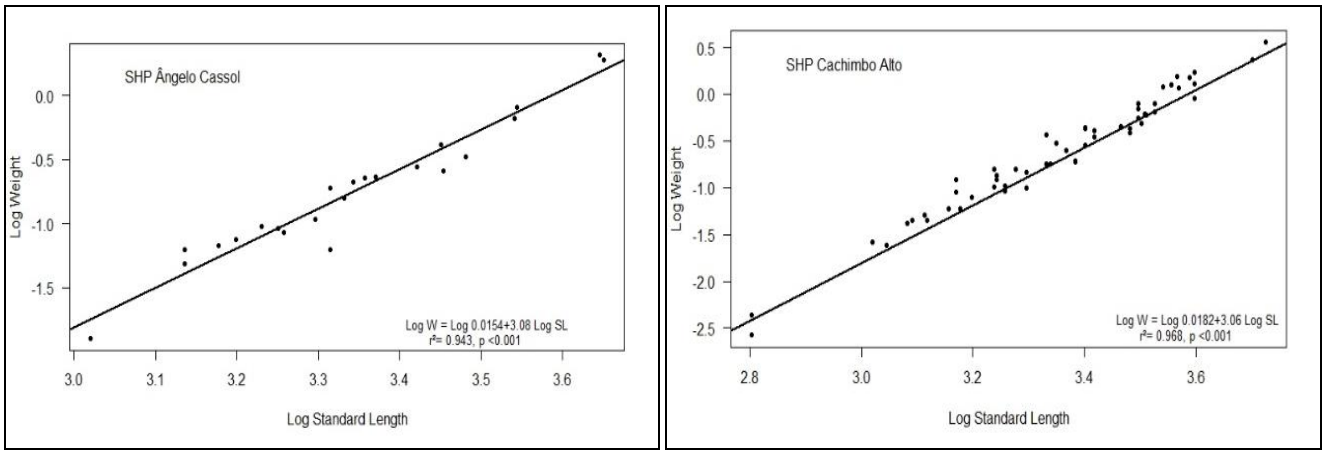

Fig 2: Relationship between weight and standard length for *Cichla pleiozona* at Ângelo Cassol and Cachimbo Alto SHPs

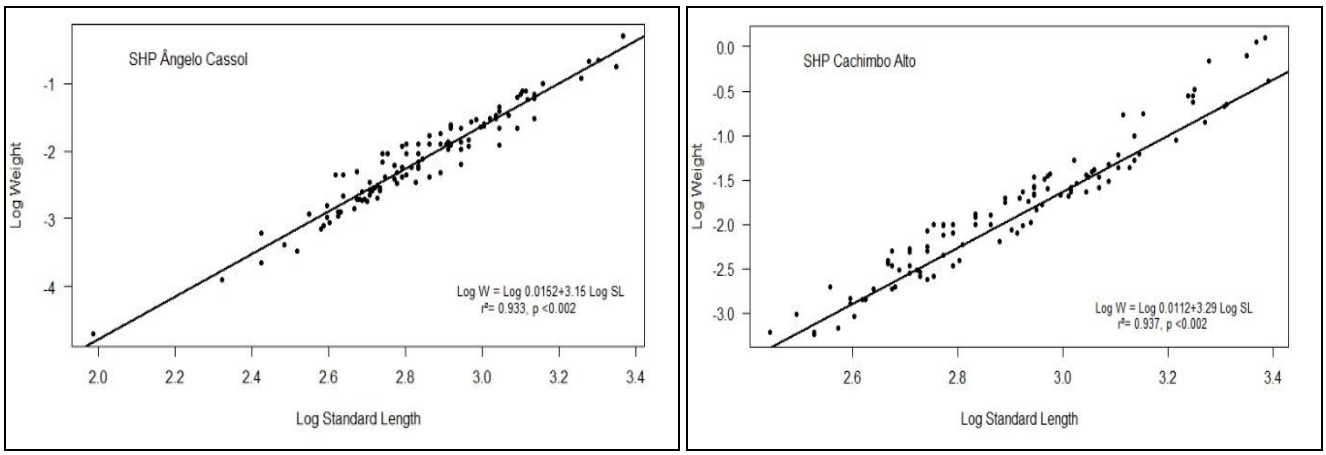

Fig 3: Relationship between weight and standard length for S*errasalmus rhombeus* at Ângelo Cassol and Cachimbo Alto SHPs

Relative Condition Factor (*Kn*)

For both *C. pleiozona* and *S. rhombeus* the relative condition factor (*Kn*) did not vary either between the two reservoirs, or between the flood and low water periods (Table 2), demonstrating that water quality standards do not differ between the two environments and nor seasonally. Both *C. pleiozona* and *S. rhombeus* have a mean relative condition value greater than 1 (*Kn* > 1), except for *C. pleiozona* during the wet season, where values were less than 1 (Table 2).

Table 2: Mean±standard deviation of the relative condition factor (*Kn*)

Cichla pleiozona				
		Two-WayAnova		
Variables	Mean ± standard deviation	F	df	*p*
SHP Ângelo Cassol	1.006 ± 0.115	0.00	1.76	0.985
SHP Cachimbo Alto	1.006 ± 0.114			
Wet season	0.991 ± 0.118	1.71	1.76	0.194
Dry season	1.017 ± 0.111			
Serrasalmus rhombeus				
		Two-Way Anova- permutation		
Variables	Mean ± standard deviation	Interaction	df	*p*
SHP Ângelo Cassol	1.017 ± 0.191	75	1.214	0.573
SHP Cachimbo Alto	1.017 ± 0.195			
Wet season	1.009 ± 0.177	905	1.214	0.100
Dry season	1.060 ± 0.264			

4. Discussion

Cichla pleiozona growth was isometric (*b* = 3), while that of *S. rhombeus* was positive allometric (*b* > 3), in the two reservoirs examined in this study. Although the two species showed relative condition factor (*Kn*) values close to the reference value (*Kn* = 1), no spatial or temporal variation was found. The *b* values found in this study are in agreement with that proposed by Froese [29], who stated that *b* values can vary from 2.5 to 3.5. Values of *b* < 3 indicate that the fish increases more in length than in weight, a value of *b* = 3, characterizes isometric growth, with fish showing symmetrical grow relations between weight and length, while for values of *b* > 3 individuals have a greater increase in weight and width than in length [29, 30].

Although *C. pleiozona* in the current study showed isometric growth, when the confidence interval is considered, the *b* value is similar to that found for this species in natural environments on the Madeira River [14]. Studies carried out with other species in the genus, in reservoirs in southeastern Brazil, reported positive allometric growth for *Cichla* cf. *ocellaris* (*b* = 3.28), *Cichla monoculus* (*b* = 3.18) [35], *Cichla kelberi* (*b* = 3.06), and isometric growth for *Cichla piquiti* (*b* = 2.99) [36].

The positive allometric growth (*b* > 3) shown by *S. rhombeus* in the current study is in line with that found for the same species in the Tucuruí reservoir, Tocantins river, in the state of Pará, Brazil [37]. Although, these individuals inhabit artificial environments, coming from hydroelectric dams, they corroborate the coefficient *b* values found for populations in natural environments [14, 20, 38].

The similarity between weight-length relationship parameters from two reservoirs, for both *C. pleiozona* and *S. rhombeus*, may be linked to the biology of the two species. *Cichla pleiozona* is a sedentary fish, and lacks reproductive and piscivorous migrations (I. M. Fernandes, unpublished data). Like other species of the genus, it shows extended spawning, low fertility rates, large eggs and parental care [39]. The species *S. rhombeus* feeds at several trophic levels, has an omnivorous diet in the reservoirs used for the current study (I. M. Fernandes, unpublished data). The reproductive cycle involves several spawning events during the annual hydrological cycle, nest construction, large and adhesives eggs and parental care [40].

Another factor that needs to be considered is the age of these reservoirs, since Ângelo Cassol SHP started operating nine years ago, while Cachimbo Alto SHP has been active for only three years, so they are young reservoirs. In dam-related reservoirs, species diversity can be affected by several factors, including the area flooded, the severity of environmental impact of the reservoir, original species diversity and reservoir age [3].

When a reservoir forms, there is a surge in organic material availability, resulting in a large and rapid rise in primary productivity in the newly-created habitat. This is often swiftly followed by increases in the size of populations of omnivorous, herbivorous and insectivorous species, all of which serve to feed piscivorous species [41]. Such a situation can benefit sedentary opportunistic feeding species adapted to lentic environments [3, 4, 42], such as *C. pleiozona* and *S. rhombeus*. However, with time, the reduction of primary production means that the size of the fish populations tends to diminish [41, 43]. This decline leads to a gradual substitution of fluvial species by those adapted to lentic conditions resulting, eventually, in lower heterogeneity [44].

Species similar to *C. pleiozona* and *S. rhombeus* are adapted to lakes and other permanently-flooded areas that show little variation along the annual hydrological cycle [41, 45], which could well explain the robust nutritional status of the species under reservoir conditions [31]. In contrast to our results, studies with *Cichla* sp., *Cichla* cf. *ocellaris*, *Cichla monoculus* [35], *Cichla kelberi* [24]. found seasonal variationin the condition factor for these species. However, our results with *S. rhombeus*, are similar to those reported for the species in tributaries of the Araguaia River [46], and for *Serrasalmus spilopleura* and *Serrasalmus elongatus* in marginal lakes along the Solimões River [47].

5. Conclusion

Both peacock cichlids and pirambebas are opportunistic feeders with reproductive strategies that allow them to overwhelm other species, including in artificial habits like reservoirs. The data described here, contributes to the biological knowledge of these species and to the future management planning for the use of this resource and the conservation of the local ichthyofauna, which may also allow analyses of the possible impacts of new proposed

hydroelectric developments in the Branco River.

6. Acknowledgements
We thank the Fundação Rondônia de Amparo ao Desenvolvimento das Ações Científicas e Tecnológicas e de Pesquisa do Estado de Rondônia - Fapero (Processo:01.1331.00031-00.049/2017) for financial support. Adrian A Barnett helped witht he English.

7. References

1. Lees AC, Peres CA, Fearnside PM, Schneider M, Zuanon JA. Hydropower and the future of Amazonian biodiversity. Biodiversity and conservation. 2016; 25(3):451-466.
2. Winemiller KO, McIntyre PB, Castello L, Fluet-Chouinard E, Giarrizzo T, Nam S *et al*. Balancing hydropower and biodiversity in the Amazon, Congo, and Mekong. Science. 2016; 351(6269):128-129.
3. Agostinho AA, Gomes LC, Pelicice FM. Ecologia e manejo de recursos pesqueiros em reservatórios do Brasil. Eduem. Maringá. 2007.
4. Agostinho AA, Pelicice FM, Gomes LC. Dams and the fish fauna of the Neotropical region: impacts and management related to diversity and fisheries. Brazilian journal of biology. 2008; 68(4):1119-1132.
5. da Silva Bittencourt SC, Silva AL, Zacardi DM, Monteiro T, Nakayama L. Distribuição espacial de larvas de peixes em um reservatório tropical na bacia Araguaia-Tocantins. Biota Amazônia. 2018; 8(1):14-18.
6. Reis RE, Albert JS, Di Dario F, Mincarone MM, Petry P, Rocha LA. Fish biodiversity and conservation in South America. Journal of fish biology. 2016; 89(1):12-47.
7. Dagosta FC, De Pinna M. The fishes of the Amazon: Distribution and biogeographical patterns, with a comprehensive list of species. Bulletin of the American Museum of Natural History. 2019; (431):1-163.
8. Goldstein R. Cichlids of the world. TFH Publ. Inc. New Jersey. 1973.
9. Lowe-McConnell RH. Fish Communities in Tropical Freshwaters Longman. London 1975, 337.
10. Kullander SO, Ferreira EJ. A review of the South American cichlid genus *Cichla*, with descriptions of nine new species (Teleostei: Cichlidae). Ichthyological Exploration of Freshwaters. 2006; 17(4):289-398.
11. Fricke R, Eschmeyer WN, Vander Laan R. Eschmeyer's catalogof fishes: genera, species, references.http://researcharchive.calacademy.org/research/ichthyology/catalog/fishcatmain.asp.23 Abril, 2020.
12. Sabaj MH, López-Fernández H, Willis SC, Hemraj DD, Taphorn, DC, Winemiller KO. *Cichla cataractae* (Cichliformes: Cichlidae), new species of peacock bass from the Essequibo Basin, Guyana and Venezuela. Proceedings of the Academy of Natural Sciences of Philadelphia. 2020; 167(1):69-86.
13. Jepsen DB, Winemiller KO, Taphorn DC, Olarte DR. Age structure and growth of peacock cichlids from rivers and reservoirs of Venezuela. Journal of Fish Biology. 1999; 55(2):433-450.
14. Cella-Ribeiro A, Hauser M, Nogueira LD, Doria CRC, Torrente-Vilara G. Length–weight relationships of fish from Madeira River, Brazilian Amazon, before the construction of hydropower plants. Journal of applied ichthyology. 2015; 31(5):939-945.
15. Reis RE, Kullander SO, Ferraris CJ. Check list of the freshwater fishes of South and Central America. Edipucrs, 2003.
16. Goulding M. The fishes and the forest: explorations in Amazonian natural history. Univof California Press. 1980.
17. Araujo-Lima C, Goulding M. So fruitful a fish: Ecology, conservation, and aquaculture of the Amazon's tambaqui. Columbia University Press, 1997.
18. Santos G, Ferreira E, Zuanon J. Peixes comerciais de Manaus. Pro-Varzea, Ibama, Manaus, 2006.
19. Pazianoto LH, Souza ML, Veronezzi AL, Benedito E. Influência do ambiente no conteúdo calórico e na condição fisiológica de duas espécies migradoras de peixes neotropicais. Iheringia. Série Zoologia. 2013; 103(3):206-213.
20. Giarrizzo T, de Sena Oliveira RR, Costa Andrade M, Pedrosa Gonçalves A, Barbosa TA, Martins AR *et al*. Length–weight and length–length relationships for 135 fish species from the Xingu River (Amazon Basin, Brazil). Journal of Applied Ichthyology. 2015; 1(2):415-424.
21. Salvador GN, Frederico RG, PessaliTC, Vieira F, Freitas TM. Length-weight relationship of 21 fish species from Rio Doce River basin, Minas Gerais, Brazil. Journal of Applied Ichthyology. 2018; 34(5):1198-1201.
22. Santos GSD, Aguiar-Santos J, Castro ACLD, Piorski NM. Length-weight relationships of seven fish species from Amazonian Equatorial coast, Brazil. Journal of Applied Ichthyology. 2019; 35(5):1169-1171.
23. Dos Santos SL, Viana LF, Lima-Junior SE. Fator de condição e aspectos reprodutivos de fêmeas de *Pimelodella* cf. *gracilis* (Osteichthyes, Siluriformes, Pimelodidae) no rio Amambai, de Mato Grosso do Sul. Acta Scientiarum Biological Sciences. 2006; 8(2):129-134.
24. Gomiero LM, Junior GAV, Naous F. Relação peso-comprimento e fator de condição de *Cichla kelberi* (Perciformes, Cichlidae) introduzidos em um lago artificial no Sudeste brasileiro. Acta Scientiarum. Biological Sciences. 2008; 30(2):173-178.
25. Vazzoler AE. Biologia da reprodução de peixes teleósteos: teoria e prática, 1996.
26. Nogueira C, Buckup PA, Menezes NA, Oyakawa OT, Kasecker TP, Neto MBR *et al*. Restricted-range fishes and the conservation of Brazilian freshwaters. PlosOne. 2010; 5(6).
27. Alvares CA, Stape JL, Sentelhas PC, de Moraes G, Leonardo J, Sparovek G. Köppen's climate classification map for Brazil. Meteorologishe Zeitschrift. 2014; 2(6):711-728.
28. Butt N, De Oliveira PA, Costa MH. Evidence that deforestation affects the onset of the rainy season in Rondônia, Brazil. Journal of Geophysical Research: Atmospheres. 2011; 116(D11).
29. Froese R. Cube law, condition factor and weight–length relationships: history, meta-analysis and recommendations. Journal of applied ichthyology. 2006; 22(4):241-253.
30. Le Cren ED. The length-weight relationship and seasonal cycle in gonad weight and condition in the perch (*Perca fluviatilis)*. The Journal of Animal Ecology. 1951, 201-219.
31. Camara EM, Caramaschi EP, Petry AC. Fator de condição: bases conceituais, aplicações e perspectivas de

uso em pesquisas ecológicas com peixes. Oecologia Australis. 2011; 15(2):249-274.
32. Sokal RR, Rohlf FJ. Biometry WH Freeman and Co. New York, 1995, 880.
33. Wheeler B, Torchiano M, Torchiano MM. Package 'lmPerm'. *R package version*, 2016, 1-1.
34. Core Team R. R: A language and environment for statistical computing. Vienna, Austria: R Foundation for Statistical Computing. Retrieved from https://www.R-project.org/, 2019.
35. Gomiero LM, Braga FMS. Relação peso-comprimento e fator de condição para *Cichla* cf. *ocellaris* e *Cichla monoculus* (Perciformes, Cichlidae) no reservatório de Volta Grande, rio Grande-MG/SP. Acta Scientiarum. Biological Sciences. 2003; 25(1):79-86.
36. Marques H, Nobile AB, Dias JHP, Ramos IP. Length–weight and length–length relationships for 23 fish species of Porto Primavera reservoir, Upper Paraná River, Brazil. Journal of Applied Ichthyology. 2016; 32(6):1342-1346.
37. Garcia-Ayala JR, Brambilla EM, Travassos FA, Carvalho ED, David GS. Length-weight relationships of 29 fish species from the Tucuruí Reservoir (Tocantins/Araguaia Basin, Brazil). Journal of Applied Ichthyology. 2014; 30(5):1092-1095.
38. Schmid K, Andrade MC, Jesus AJS, Araujo JS, Santos PRB, Giarrizzo T. Length-weight relationships for fish fauna from water bodies in the upper Tapajós river basin of Palito Mountain ridge, Brazilian Amazon region. Biota Amazônica. 2015; 5:112-114.
39. Batista VDS, Isaac VJ, Fabré NN, Gonzalez JCA, Almeida OT, Rivero S *et al*. Peixes e pesca no Solimões-Amazonas: uma avaliação integrada. Brasília: Ibama/ProVárzea, 2012.
40. Agostinho AA, Gomes LC, Suzuki HI, Julio Jr HF. Migratory fishes of the Upper Paraná River basin, Brazil. In: Migratory Fishes of South America: Biology, Fisheries and Conservation Status, 2003.
41. Agostinho AA, Gomes LC, Santos NC, Ortega JC, Pelicice FM. Fish assemblages in Neotropical reservoirs: Colonization patterns, impacts and management. Fisherie Research. 2016; 173:26-36.
42. Muniz CM, dos Santos NC, Baumgartner MT, Agostinho AA, Gomes LC. Chronological age and reservoir characteristics as predictors of trait composition in Neotropical reservoir fish assemblages. Ecology of Freshwater Fish. 2019; 29(2):241-251.
43. Mol JH, Mérona BD, Ouboter PE, Sahdew S. The fish fauna of Brokopondo Reservoir, Suriname, during 40 years of impoundment. Neotropical Ichthyology. 2007; 5(3):351-368.
44. dos Santos NCL, de Santana HS, Ortega JCG, Dias RM, Stegmann LF, da Silva Araújo IM *et al*. Environmental filters predict the trait composition of fish communities in reservoir cascades. Hydrobiologia. 2017; 802(1):245-253.
45. Andrade PM, Braga FMDS. Reproductive seasonality of fishes from a lotic stretch of the Grande River, high Paraná river basin, Brazil. Brazilian Journal of Biology. 2005; 65(3):387-394.
46. Gonçalves BB, Tejerina-Garro FL, de Melo C, Neto S. Comparison of the condition factor of five fish species of the Araguaia River basin, central Brazil. Fronteiras: Journal of Social, Technological and Environmental Science. 2016; 5(1):226-234
47. Tribuzy-Neto IA, Conceição KG, Siqueira-Souza FK, Hurd LE, Freitas CEC. Condition factor variations over time and trophic position among four species of Characidae from Amazonian floodplain lakes: effects of an anomalous drought. Brazilian Journal of Biology. 2018; 78(2):337-344.