ESTIMATION OF THE LENGTH AT FIRST MATURITY OF FISH SPECIES OF THE APODI/MOSSORÓ RIVER RESERVOIRS IN THE BRAZILIAN SEMIARID REGION

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Abstract. Knowledge of the length at first maturity (L_{50}) is an important tool for fish stock management and conservation. This study estimated the L_{50} values of 10 fish species in two reservoirs of the Apodi/Mossoró River in the tropical semiarid region of Brazil. The following species were studied: *Curimatella lepidura* (Eigenmann et Eigenmann, 1889); *Prochilodus brevis* Steindachner, 1875; *Leporinus piau* Fowler, 1941; *Leporinus taeniatus* Lütken 1875; *Triportheus signatus* (Garman, 1890); *Hoplias malabaricus* (Bloch, 1794); *Hypostomus pusarum* (Starks, 1913); *Loricariichthys derbyi* Fowler, 1915; *Trachelyopterus galeatus* (Linnaeus, 1766); *Crenicichla menezesi* Ploeg, 1991. The captured individuals were identified, separated by species, measured for total length (TL), and categorized as reproductive or immature after dissection. The L_{50} values for both sexes were estimated via a logistic regression for each species. Significant differences between values were tested for the species that occurred in both reservoirs (ANCOVA). The estimated L_{50} value varied between 7.37 cm (*C. lepidura*, female) and 19.40 cm (*H. malabaricus*, female). Only the L_{50} value of the males of the species *C. lepidura* and *P. brevis* differed between the two reservoirs. This study is the first report of the L_{50} for seven species and the first report for tropical semiarid river basins for two species. These results are important for fish resource management and species conservation.

Keywords: artisanal fisheries, reproductive strategy, freshwater fish, fisheries management

INTRODUCTION

The length at first maturity (L_{50}) is the value at which 50% of the individuals in a cohort have reproduced at least once (Barzotto and Mateus 2017), and it represents a critical life cycle transition since the resources and time that were previously solely allocated for growth and survival are now also used for reproduction (Wootton 1998). This very flexible reproductive characteristic exhibits high spatial variation resulting from different responses to local environmental conditions as well as variations in the growth rate, maximum body size, and biotic interactions (Sharpe and Hendry 2009, Lourenço et al. 2015).

The knowledge of the L_{50} of a fish species is an important tool in developing management, monitoring, and conservation programs for fish stocks as it prevents the catch of young individuals and the reduction of the reproductive stock of the species, allowing individuals to reproduce at least once (Fontoura et al. 2009); this is particularly important for stocks that are intensely fished and that have low recruitment rates (Agostinho et al.

2007). In Brazil, government agencies use L_{50} data to define the minimum length that a fish must reach before it can be caught, so it is essential to evaluate the spatial variation in this parameter before defining a single value for an entire river basin, as has historically been done in Brazil and other countries (Lourenço et al. 2015).

Thus, the objective of this study was to estimate and evaluate the L_{50} of 10 fish species from the reservoirs of the Apodi/Mossoró River in the tropical semiarid region of Brazil to assist in developing fishery management programs and ecosystem models for use in the conservation management and exploitation of these resources. In the course of this study the following species were studied: *Curimatella lepidura* (Eigenmann et Eigenmann, 1889); *Prochilodus brevis* Steindachner, 1875; *Leporinus piau* Fowler, 1941; *Leporinus taeniatus* Lütken 1875; *Triportheus signatus* (Garman, 1890); *Hoplias malabaricus* (Bloch, 1794); *Hypostomus pusarum* (Starks, 1913); *Loricariichthys derbyi* Fowler, 1915; *Trachelyopterus galeatus* (Linnaeus, 1766); *Crenicichla menezesi* Ploeg, 1991.

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MATERIAL AND METHODS

The fish collection was licensed by the Instituto Chico Mendes de Conservação da Biodiversidade (ICMbio, process number 27046). Sampling was performed quarterly from February to November in the Santa Cruz (05°45′47.3″S, 037°48′02.9″W, between 2010 and 2016) and Pau dos Ferros reservoirs (06°08′44.8″S, 038°11′28.2″W, between 2011 and 2012). Gill nets (with a mesh size of 12 to 70 mm between adjacent knots) were used for sampling between 17:00 h and 05:00 h. This period was selected because it includes both sunset and sunrise, periods during which fish experience greater displacement mainly for food activity (Barthem 1987). All collected fish were euthanized with a solution of 0.2 mL of clove oil dissolved in 500 mL of water, stored in labelled plastic bags, and transported to the laboratory where they were identified, and their total length (TL) and total weight (TW) were determined. The maturity stage of the fish was confirmed by macroscopic inspection of the gonads and classified according to Brown-Peterson et al. (2011) as immature, maturing, ripe, postspawning, and resting. Species identification was confirmed by taxonomists at the Universidade Federal da Paraíba (Federal University of Paraíba), and specimens were deposited in the fish collection of this institution.

All individuals with a gonadal stage other than immature were considered of reproductive age. The frequency of reproductive individuals was used as the response variable; TL was used (R Core Team. 2018) as the explanatory variable, and the L_{50} value was obtained via logistic regression

$$M = 1 \cdot (1 + \exp^{[r\,(L - Lm)]})^{-1}$$

where, M = frequency of reproductive individuals (number of adults per total number of individuals), L_m = length at first maturity, and L = TL, and r is the slope of the maturity curve (King 2007). For the species present in both reservoirs, ANCOVA was used to assess possible deviations from the logistic regression goodness of fit at a significance level of $P < 0.05$. The analyses were performed with R software (R Core Team 2018) using the FSA package (Ogle 2016).

RESULTS

For this study, a total of 9048 individuals (6007 from the Santa Cruz Reservoir and 3041 from the Pau dos Ferros Reservoir) belonging to 10 species and eight families were used to estimate L_{50}. The number of specimens analysed per species ranged from 106 for *Hoplias malabaricus* to 1754 for *Curimatella lepidura*, both of which were in the Pau dos Ferros reservoir. The sample size, minimum and maximum TL values, L_{50} value and ANCOVA results are shown in Table 1.

The L_{50} values estimated in this study ranged from 8.70 cm for *C. lepidura* in the Pau dos Ferros reservoir to 18.22 cm for *H. malabaricus* in the Santa Cruz reservoir. Among the species that occurred in both reservoirs, only *C. lepidura* exhibited a significant difference in L_{50} between reservoirs ($P < 0.001$).

DISCUSSION

This study represents the first report of the L_{50} for seven species, according to the information available in FishBase (Froese and Pauly 2019). For *H. malabaricus* and *Trachelyopterus galeatus*, species with wide distributions in Brazil, this study was the first to report the L_{50} values for the tropical semiarid region. In the case of *H. malabaricus*, several authors agree that it is a species complex (Mattox et al. 2014); therefore, the species in Brazilian semiarid river basins are likely different from those in other South American river basins.

Differences between L_{50} values were expected for the analysed species occurring in both reservoirs. First, the Apodi/Mossoró River was dammed in 1967 when the Pau dos Ferros reservoir was built. Blocking rivers with dams separates populations and interrupts gene flow, and the separated populations tend to show differences in their life cycle over time, including in L_{50} (Britto and Carvalho 2013). The L_{50} is also influenced by the abiotic characteristics of the environment (Orsi 2010), and the Santa Cruz and Pau dos Ferros reservoirs are very distinct limnologically, being classified as oligo-mesotrophic and eutrophic, respectively (Moura and Henry-Silva 2015).

However, only the males of *C. lepidura* and *Prochilodus brevis* showed a difference in the L_{50} values in this study, with a lower value observed in the Pau dos Ferros reservoir, indicating that these individuals presented a high reproductive effort in this reservoir. Several factors may influence the at-first-maturity characteristics, and determining the factors responsible based on the smallest value observed for A and B is difficult. Unfavourable environmental conditions may force individuals to have shorter lengths at first maturity to reduce the risk of dying before reproducing (Wootton 1998), and factors such as resource availability, fishing and biotic interactions (e.g., competition and predation) affect the onset of fish reproduction (Tomasini and Laugier 2005, Lappalainen et al. 2016) and may also explain the difference observed in the study for the males of *C. lepidura* and *P. brevis*.

CONCLUSION

The presently reported study provided information on the L_{50} for some species in two reservoirs of the Apodi/Mossoró River of the Neotropical semiarid region of Brazil. Data on length at first maturity are used by governmental agencies to define the minimum size that an individual must attain before it can be caught. This knowledge will assist in the management of fishery resources and the conservation of fish fauna in the region.

Table 1

Estimation of length at first maturity, L_{50} (95% CI), and ANCOVA results for the fish species of the Santa Cruz and Pau dos Ferros reservoirs in tropical, semiarid Brazil

| Species | Sex | Total length [cm] | | | | | | L_{50} | | | | P value (ANCOVA) |
| | | Santa Cruz | | | Pau dos Ferros | | | Santa Cruz | | Pau dos Ferros | | |
		n	Min	Max	n	Min	Max	L_{50}	95% CI	L_{50}	95% CI	
Curimatella lepidura[1]	F	618	9.20	17.50	753	7.70	22.50	8.64	3.81–10.12	7.37	6.24–8.36	0.112
	M	605	6.80	17.70	607	6.70	16.50	8.29	3.61–9.63	8.58	8.10–9.01	0.001[s]
Prochilodus brevis[2]	F	46	7.30	39.90	54	12.00	25.70	17.78	15.05–20.00	14.51	12.46–15.3	0.078
	M	67	7.30	33.50	59	7.50	29.20	17.41	15.98–18.78	12.52	10.29–15.83	0.009[s]
Leporinus piau[1]	F	108	12.90	31.90	97	12.00	25.80	15.07	12.21–16.30	13.44	9.40–14.45	0.115
	M	120	9.00	30.70	180	8.60	25.60	14.48	12.11–15.77	9.59	5.28–11.34	0.497
Leporinus taeniatus[1]	F				82	7.90	23.50			13.82	12.89–14.61	
	M				69	9.20	22.80			12.78	10.60–13.95	
Triportheus signatus[1]	F	531	8.10	23.80				11.07	5.24–12.67			
	M	594	10.90	23.50				9.68	3.71–11.98			
Hoplias malabaricus[2]	F	224	11.00	45.20	57	13.20	41.50	19.40	15.68–20.22	16.96	14.91–21.10	0.320
	M	225	9.50	45.10	41	13.40	40.50	18.87	17.28–19.69	16.95	14.87–20.04	0.246
Hypostomus pusarum[1]	F	491	8.20	34.80				14.78	15.43–16.07			
	M	279	8.50	33.20				16.99	15.93–17.82			
Loricariichthys derbyi[1]	F				164	12.40	19.70			13.49	10.61–16.75	
	M				94	9.00	28.20			13.81	12.14–15.47	
Trachelyopterus galeatus[2]	F	323	13.30	23.80				13.33	7.52–14.36			
	M	347	14.10	23.50				13.99	8.94–15.40			
Crenicichla menezesi[1]	F	53	9.70	22.50				10.46	5.06–11.38			
	M	83	9.00	23.00				10.93	10.44–13.82			

F = females, M = males, *n* = number of individuals, [1] First report of the L_{50}; [2] first report of the L_{50}, for the tropical semiarid region; [s] significant difference at $P < 0.05$.

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