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INSIGHTS ON THE INFLUENCE OF PHYLOGENETIC ON THE RELATIVE GROWTH USING *Atherinella brasiliensis* AS A TOOL*

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ABSTRACT

The length–weight relationship (LWR) is an important tool for ichthyology. It is very useful to demonstrate the environmental influence on growth. In this study we estimate the LWR of the *Atherinella brasiliensis* in the shallow areas of the São Francisco River estuary and compare the growth of this specie in different environments of the Brazilian coast. Specimens of Brazilian silverside (*A. brasiliensis*, n = 3483), between 2.1 and 13.6 cm in length, were caught in the shallow areas of the São Francisco River estuary between May 2017 and April 2018. The length-weight ratio of the species was represented by the equation $y = 0.0047x^{3.0913}$. Frequency distribution indicates that the species is present in the studied area in all its ontogenetic stages and apparently reproduces throughout the year with constant input of recruits into the population. Von Bertalanffy's growth model and longevity were adjusted to reach asymptotic length ($L\infty$) of 14.7 cm, growth coefficient (K) of 0.91 year^{-1} and longevity (A_{95}) of 3.25 years. The analysis of variance revealed differences for the maximum total length. However, the differences found between the present study and data available in the literature appear to be caused by environmental and methodological differences.

Keywords: age; beach seine; life history; fish growth; development.

INTROSPECÇÕES SOBRE A INFLUÊNCIA DA FILOGENÉTICA NO CRESCIMENTO RELATIVO USANDO *Atherinella brasiliensis* COMO FERRAMENTA

RESUMO

A relação peso-comprimento (LWR) é uma ferramenta importante para a ictiologia, muito utilizada para demonstrar a influência ambiental no crescimento. Neste estudo estimamos o LWR de *Atherinella brasiliensis* em áreas rasas do estuário do rio São Francisco e comparamos o crescimento desta espécie em diferentes ambientes do litoral brasileiro. Espécimes do peixe-rei (*A. brasiliensis*, n = 3483), entre 2,1 e 13,6 cm de comprimento, foram capturados nas áreas rasas do estuário do rio São Francisco entre maio de 2017 e abril de 2018. A relação peso-comprimento das espécies foi representada por a equação $y = 0{,}0047x^{3{,}0913}$. A distribuição de frequência indica que a espécie está presente na área estudada em todos os seus estágios ontogenéticos e aparentemente se reproduz ao longo do ano com entrada constante de recrutas na população. Os modelos de crescimento e longevidade de Von Bertalanffy foram ajustados para atingir comprimento assintótico ($L\infty$) de 14,7 cm, coeficiente de crescimento (K) de 0,91 ano^{-1} e longevidade (A_{95}) de 3,25 anos. A análise de variância revelou diferenças para o comprimento total máximo. No entanto, as diferenças encontradas entre o presente estudo e os dados disponíveis na literatura parecem ser causadas por diferenças ambientais e metodológicas.

Palavras-chave: idade; rede de arrasto de praia; história de vida; crescimento de peixes; desenvolvimento.

INTRODUCTION

The fish growth is a parameter described in many studies. Tools as the otoliths (Costa et al., 2013; Maciel et al., 2019; Soeth et al., 2019) and the length-weight relationships (LWR) are used mainly with marine and estuarine species as a means of estimating the relative growth (Bervian and Fontoura, 2007; Vaz-dos-Santos and Gris, 2016; Carvalho et al., 2017). The LWR are important tools for ichthyology (Froese, 2006), and its parameters are useful to estimate biomass (Le Cren, 1951), elaboration of stock and growth models (Haimovici and Velasco, 2000) and life stage (Possamai et al., 2020). However, relative growth is greatly influenced by the variation in temperature and salinity (Taylor, 1959; Fontoura and Agostinho, 1996; Boeuf and Payan, 2001).

The development and growth of Teleostei follow characteristics of the species themselves, however individuals are also influenced by environmental and ecological factors that control and influence their growth. Factors such as temperature and salinity act directly to increase or decrease species growth (Boeuf and Payan, 2001). The effects of temperature are evident in organisms (Boeuf and Le Bail, 1999) with wide geographic distribution that tend to show growth patterns related to the latitude of occurrence. At low latitudes organisms tend to have faster growth and smaller final lengths, while at high latitudes organisms tend to have slower growth and larger final lengths (Taylor, 1959; Pauly, 1980; Fontoura and Agostinho, 1996; Giacomini and Shuter, 2013; Peck et al., 2013). Species with wide latitudinal distribution are widely used to understand the influence of environmental parameters on growth (e.g. *Atherinella brasiliensis*) (Paiva-Filho and Giannini, 1990; Haimovici and Velasco, 2000; Pessanha and Araújo, 2001; Giarrizzo et al., 2006; Bervian and Fontoura, 2007; Macieira and Joyeux, 2009; Mazzei et al., 2011; Freire et al., 2012; Costa et al., 2013; Franco et al., 2013; Vaz-dos-Santos and Gris, 2016; Carvalho et al., 2017; Possamai et al., 2019).

The Brazilian silverside *A. brasiliensis* (Quoy and Gaimard 1824) shows high abundance in the Brazilian coast. This species is present in South America and distributed from Venezuela (10°N) to southern Brazil (32°S) (Brian and Dyer, 2006); is common in estuaries, but also occurs in coastal waters (Hostim-Silva et al., 1995; Pessanha and Araújo, 2001; Neves et al., 2006; Fávaro et al., 2007) and brackish water regions as in river mouths, being considered as a resident estuarine species (Andreata et al., 1990; Araújo et al., 1997).

Despite it is not efficiently caught by artisanal fishing, mainly due to the selectivity of the fishing gear used, *A. brasiliensis* is one of the most abundant species in both coastal and estuarine beach trawls in the south-southeast coast of Brazil (Vilar et al., 2011; Franco et al., 2013). This dominance occurs because the species spends most of its life cycle associated with shallow areas of estuaries, especially in locations with high environmental complexity such as marshes and mangroves (Fávaro et al., 2007; Carvalho and Spach, 2015; Golzio et al., 2017).

A. brasiliensis has a generalist and opportunistic feeding habit (Contente et al., 2010), estimated length at first maturity between 7.6 and 9.1 cm in total length (Fávaro et al., 2003; Bervian and Fontoura, 2007), spawns benthic sticky eggs with direct larval development (Del Río et al., 2005) and has positive allometric growth (Paiva-Filho and Giannini, 1990; Haimovici and Velasco, 2000; Giarrizzo et al., 2006; Bervian and Fontoura, 2007; Mazzei et al., 2011; Freire et al., 2012; Franco et al., 2013; Vaz-dos-Santos and Gris, 2016; Carvalho et al., 2017; Possamai et al., 2019). Regarding the parameters of Von Bertalanffy growth curve, the species has an estimated asymptotic length between 11.4 and 17.7 cm (Giarrizzo et al., 2006; Franco et al., 2013), with growth constant ranging between 0.825 and 0.93 year^{-1} (Pessanha and Araújo, 2001; Bervian and Fontoura, 2007) and longevity between 3.1 and 3.6 years old (Pessanha and Araújo, 2001; Bervian and Fontoura, 2007). Thus, the present study aimed to describe the relative growth pattern of *A. brasiliensis* in a Brazilian tropical estuary and verify the influence of phylogeny on the growth of this specie along the Brazilian coast. Since species with a wide distribution, like this, can show different growth patterns that are related to the latitude of occurrence.

MATERIAL AND METHODS

Between May 2017 and April 2018, 3483 specimens of *A. brasiliensis* were captured with a beach seine net (30 m long, 2.8 m high and 5 mm mesh size) at five sampling sites along the lower São Francisco River, between the village of Saramém and the municipality of Brejo Grande in the Estate of Sergipe (10°28'34,02"S - 36°24'27,02"W), at a maximum depth of 2 meters (Figure 1A). After collection, they were cooled, identified (Figueiredo and Menezes, 1978), measured for total length (TL; 0.01 cm), total weight (TW; 0.1g) and separated into 12 length classes with an interval of 0.9 cm according with Carvalho et al. (2017). Also, sex and the stage (juvenile and adults) were determined by macroscopic analysis according to Vazzoler (1996).

Subsequently, the length-weight ratio was adjusted using a power equation (Froese, 2006): $W = a.L^b$, where W is the weight (g), L is the total length (cm), a is the coefficient of proportionality and b is the allometric coefficient. The positive growth is considered when $b > 3$, isometric growt is $b = 3$ and negative growth is considered when $b < 3$. To avoid bias caused by logarithmic transformation (Smith, 1993), the function fit was performed with non-transformed data using the "Solver" tool of the Microsoft Excel 10.0 program (nonlinear GRG) (Carvalho et al., 2017).

To interpret the life cycle of the organisms, monthly graphs of frequency distribution in interval classes were generated. The frequency distribution by interval class of *A. brasiliensis* in the São Francisco River estuary were grouped bimonthly to increase consistency of the data.

The length by age of the individuals was described using the Von Bertalanffy (1938) growth curve: $L_t = L\infty[1-e^{-K.(T-T0)}]$, where: L is the total length (cm) at age t (years), L∞ is the asymptotic length, K is the instantaneous growth rate and T0 is the theoretical age at length zero. The parameters K and L∞ of the growth equation were obtained by FiSAT II software by the ELEFAN I routine (FAO, 2013), as well as the first age group. The other parameters were deduced from the equation. After the construction of Von Bertalanffy (1938) growth curve, the ages per length were calculated and thus the ages of the individuals captured were estimated based on their total length. Longevity, estimated as the time fish takes to reach 95% L∞, was calculated by: A95 = 2.96/K, where K is the Von Bertalanffy growth constant (Taylor, 1959).

The allometry of the undetermined individuals, male and female was tested for isometry ($b = 3$). For this, it was calculated individually using the logarithmic weight-length equation: log(W) = log(a) + b.log(L). After that, the allometric coefficient of each group was tested against an isometric group of equal size through a T test ($\alpha = 0.05$) performed in software R (R Core Team, 2019).

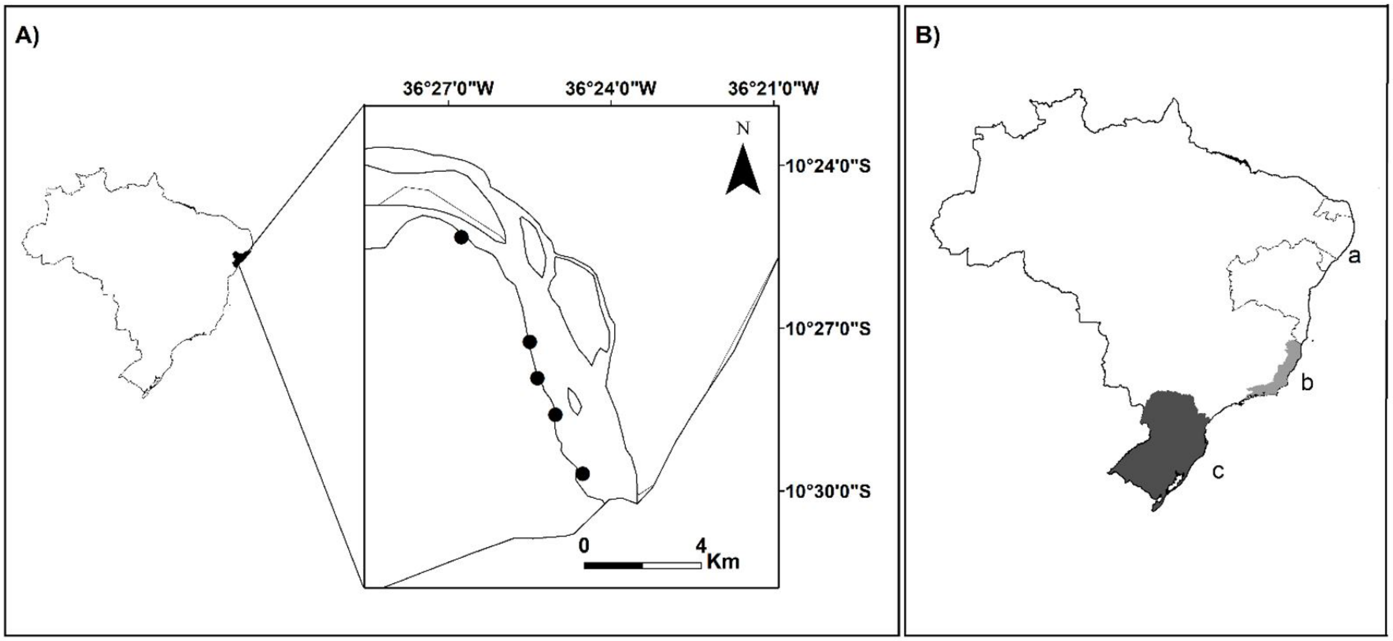

Figure 1. A) Sampling sites in the Lower São Francisco River, State of Sergipe, Brazil. B) phylogenetic populations defined based on the study by Baggio et al. (2017).

Possible differences in the growth of the species along the Brazilian coast were tested using growth compiled data from past studies, and as a grouping character, we used the three populations proposed by Baggio et al. (2017): "a" was used to code the north-northeast population (between 7 - 14°S latitudes), "b" for the central population (between 19 - 22°S latitudes), and "c" for the -southeast-south population (between 25 - 32°S latitudes) (Figure 1B). The variables tested for these groups were: proportionality coefficient (*a*), allometric coefficient (*b*) and maximum total length (TLmax). For this, in the R software (R Core Team, 2019), tests were applied for normality (Shapiro-Wilk), homoscedasticity (Levene's test) and analysis of variance (ANOVA; $\alpha = 0.05$). In case of significant result for analysis of variance, a post-hoc test (Tukey HSD test; $\alpha = 0.05$) was applied to compares all possible pairs of means to detect between which groups significant differences occurred. A graph was also generated with the maximum total lengths in relation to the sampling latitude using the data available in the literature. This graph is intended to show graphically possible trends in the latitudinal growth of the species.

RESULTS

Table 1 is an adapted version of the table proposed by Carvalho et al. (2017), where the growth data of the species *A. brasiliensis* available in the literature are displayed. The data obtained for the present study and the classification of populations according to Baggio et al. (2017) were added.

Specimens caught during the study period (n = 3483) ranged from 2.1 to 13.6 cm (mean TL = 7.6; SD ± 2.3 cm), and from 0.1 to 17.1 g (mean TW = 3.3, SD ± 2.8 g). The Figure 2 illustrates the length-weight ratios for all data ($y = 0{,}0047x^{3.0913}$) showing allometric positive growth for the total number of individuals grouped (Figure 2A; $b > 3$). The individuals of undetermined sex ($y = 0.007x^{2.84540}$) presented allometric negative growth (Figure 2B; $b < 3$). Males ($y = 0.0037x^{3.201}$) and females also ($y = 0.0033x^{3.2681}$) demonstrated allometric positive growth (Figure 2C, D; $b > 3$).

Through frequency distributions of undetermined, male, and female individuals by length class and bimester (Figure 3), it is possible to observe the constant input of individuals with undetermined sex into the population from the sampled areas, which was most intense between March and June. Between July and December, there was a dominance of adult specimens in the population observed.

From the adjustment of Von Bertalanffy's model, the asymptotic length was estimated in 14.7 cm. The growth coefficient was 0.91 $year^{-1}$ and the longevity for this population was estimated in 3.25 years (Figure 4).

Analysis of variance (ANOVA) evidenced no significant differences ($p > 0.05$) between the three populations tested (a, b and c) for either the proportionality coefficient (*a*) ($F = 1.372$; $p = 0.286$) or for the allometric coefficient (*b*) ($F = 1{,}223$; $p = 0.323$). However, ANOVA showed significant differences between populations in relation to the maximum total length (TLmax; $F = 0.98$; $p = 0.0169$) and Tukey HSD test indicated that this difference was caused by differences between populations b and c (Table 2).

In Figure 5 it is possible to notice an apparent tendency to increase the maximum total length in relation to the increase in latitude where the studies were conducted.

Table 1. Summary of published information on growth parameters and longevity of *Atherinella brasiliensis* along the Brazilian coast. TLmax is the maximum total length (cm); *a* and *b* are the proportionality and allometry coefficients of the length-weight ratio, respectively; notations I, M and F were used for indeterminate, male and female individuals, respectively; phylogenetic populations defined based on the study by Baggio et al. (2017). Adapted from Carvalho et al. (2017).

Author	Latitude	TLmax (cm)	L∞ (cm)	K ($year^{-1}$)	T0	Longevity (years)	*a*	*b*	Population
Giarrizzo et al. (2006)	0°10'S	11.4					0.0061	3.03	a
Freire et al. (2012)	05°46'S	14.9					0.004	3.23	a
Present study	10°S	13.6	14.7	0.91		3.25	0.0047	3.10	a
Freire et al. (2012)	14°48'S	13.4					0.005	3.11	b
Mazzei et al. (2011)	19°57'S	12.3					0.0061	3.01	b
Macieira and Joyeux (2009)	20°50'S	7.1					0.0072*	2.91	b
Franco et al. (2013)	22°49' - 22°57'S	17.7					0.005	3.01	c
Pessanha and Araújo (2001)	22°53' - 23°04'S	13.8	11.26	0.93		3.1			c
Vaz-dos-Santos and Gris (2016)	23°S	15.1					0.0045	3.13	c
Costa et al. (2013)	23°02'S	16.0					0.006	2.97	c
Paiva-Filho and Giannini (1990)	24°25'S	13.1					0.006*	3.03	c
Carvalho et al. (2017)	25°S	14.1	17.5	0.89	0.06	3.33	0.0053	3.10	c
Possamai et al. (2019)	25°S	16.0					0.0040 (M)	3.07	c
							0.0052 (F)	3.16	c
Haimovici and Velasco (2000)	28° - 34°S	15.5					0.0033	3.33	c
Bervian and Fontoura (2007)	29°58'S	17.0					0.0068 (I)	3.03	c
			16.0	0.884		3.4	0.0049 (M)	3.20	c
			17.0	0.825		3.6	0.0049 (F)	3.20	c

* Length converted to centimeters

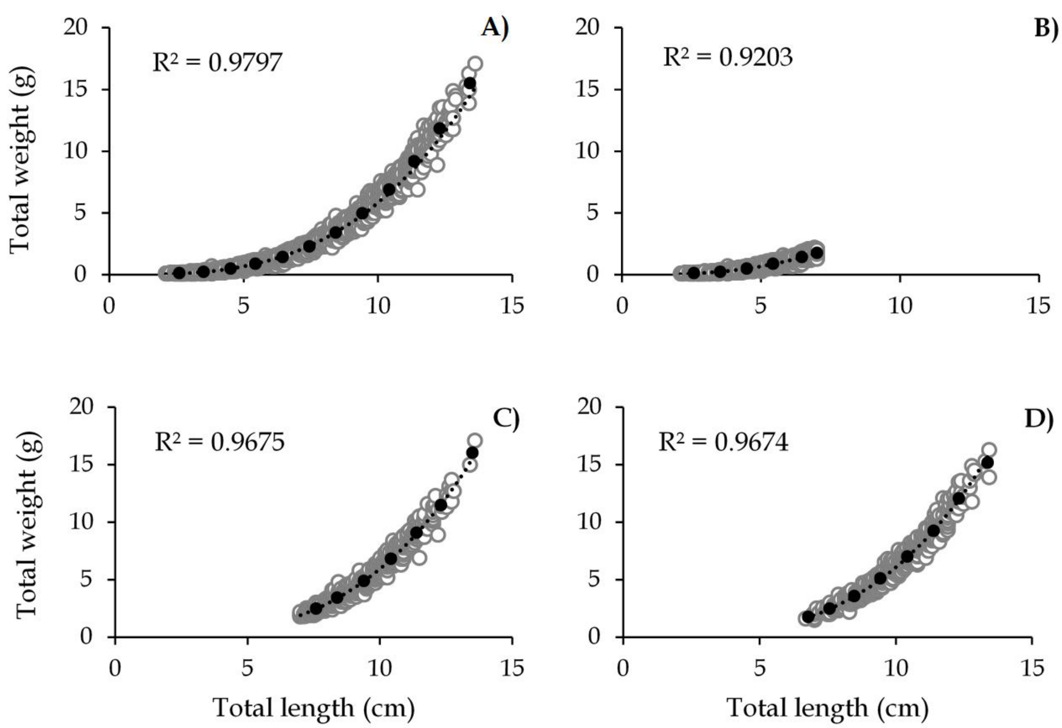

Figure 2. Length-weight ratios for *Atherinella brasiliensis* in the São Francisco River estuary. A) length-weight ratio for all individuals caught; B) length-weight ratio for individuals of undetermined sex; C) length-weight ratio for males; D) length-weight ratio for females. Black circles indicate the mean values and empty circles are the samples.

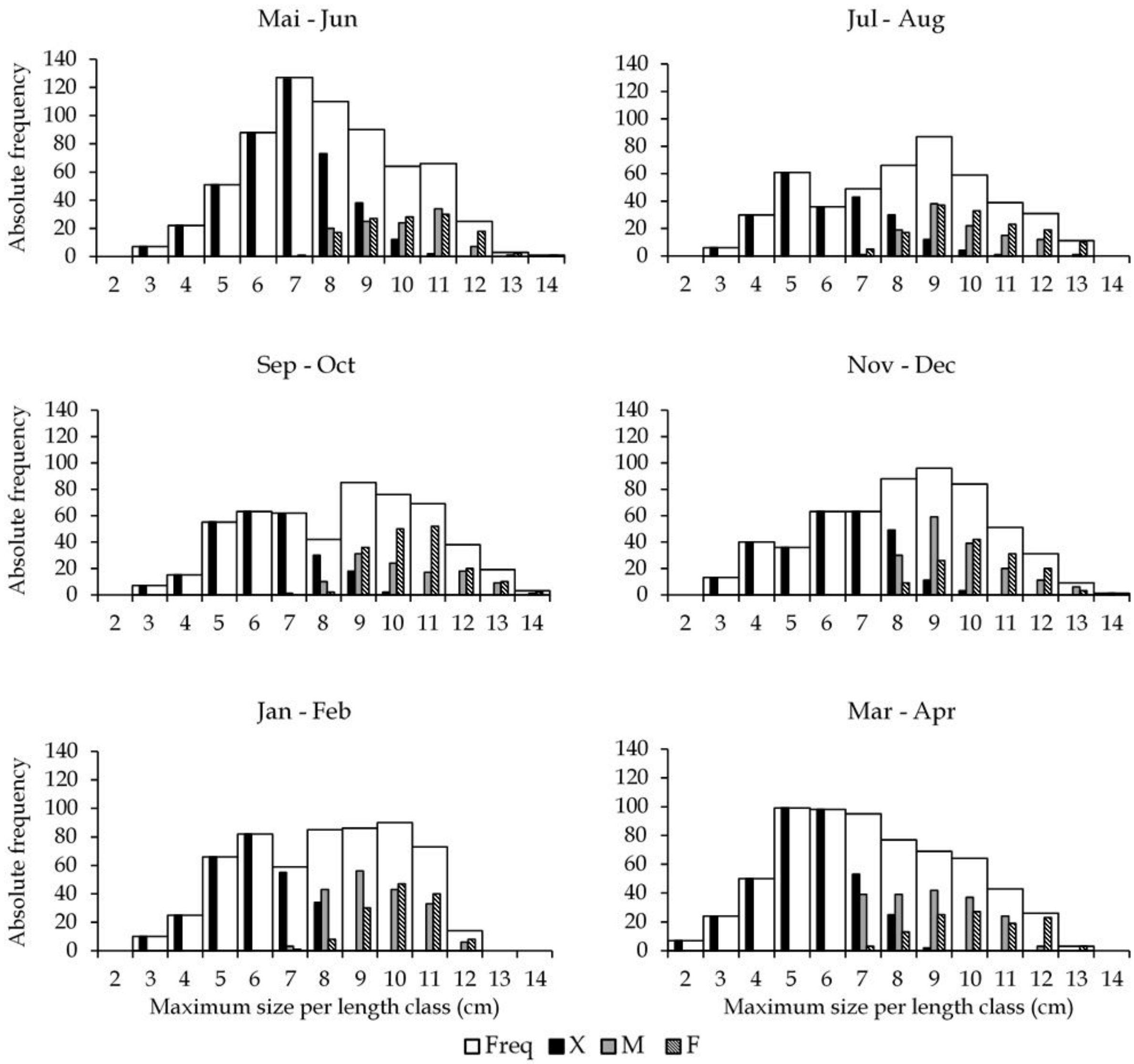

Figure 3. Bimonthly distribution of absolute size frequencies of *Atherinella brasiliensis* for all sampling stations in the São Francisco River estuary. The white columns represent the total number of individuals captured by length class (Freq); the columns representing the indeterminate individuals are indicated by the letter X; males by the letter M, and females by the letter F. On the x-axis, only the maximum sizes of each length class are indicated (in centimeters).

DISCUSSION

Atherinella brasiliensis was abundant throughout the study period, a pattern also observed in other studies (Giannini and Paiva-Filho, 1995; Andreata et al., 1997; Pessanha and Araújo, 2001). This species is expected to be abundant in shallow transitional environments, as it is considered an estuarine resident species (Andreata et al., 1990; Araújo et al., 1997). Individuals of all lengths can be caught in these regions throughout the year, as reported by Carvalho and Spach (2015), because this species completes its ontogenetic development in shallow areas.

The value for the maximum total length observed in the present study is close and in agreement with the values presented by other studies carried out on the Brazilian coast, where *A. brasiliensis* was present (Paiva-Filho and Giannini, 1990; Pessanha and Araújo, 2001; Freire et al., 2012; Carvalho et al., 2017; Table 1). However, there are studies that present maximum total length values that are divergent from both the present study and the ones previously mentioned (Macieira and Joyeux, 2009; Franco et al., 2013). The range of results presented in literature for maximum total length does not seem to be the result of latitudinal trends, because according to Baggio et al. (2017), the species is divided into three genetically distinct populations along the Brazilian coast. The samplings at different latitudes also cannot be compared directly, even if graphically there is a suggestion that the maximum size increases with increasing latitude (Figure 5).

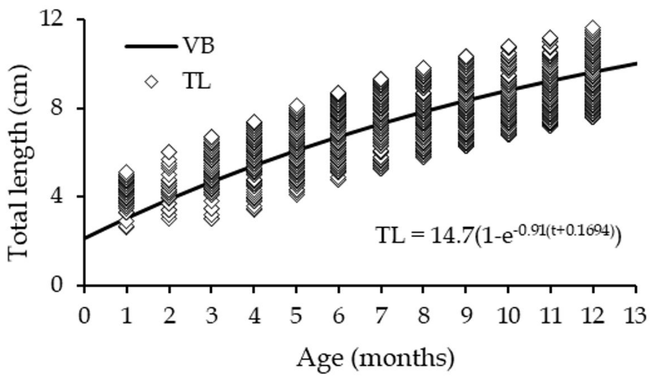

Figure 4. Growth curve according to Von Bertalanffy growth model for *Atherinella brasiliensis* in the São Francisco River estuary (n = 3483). The white diamonds indicate the total size of the individuals and the black line the calculated Von Bertalanffy growth model.

Table 2. Results of Tukey HSD test probabilities for maximum total length (TLmax) in relation to the three populations proposed by Baggio et al. (2017) for *Atherinella brasiliensis* on the Brazilian coast.

	Difference between means	95% Confidence interval		*p*-value
		Upper	Lower	
b-a	-2.347	-6.670	1.977	0.349
c-a	2.067	-1.463	5.597	0.299
c-b	4.413	0.883	7.943	0.015*

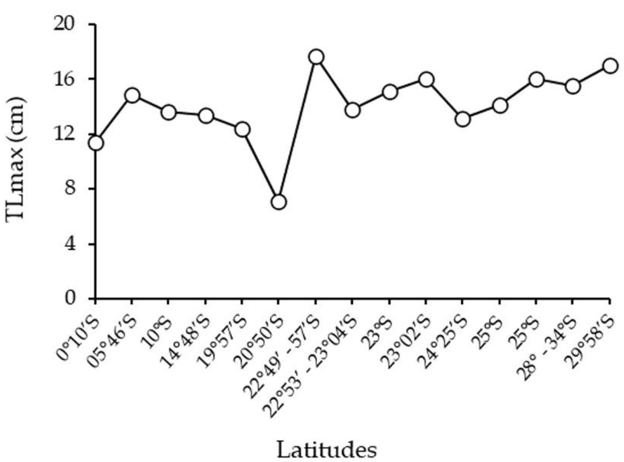

Figure 5. Distribution of data on maximum total length (TLmax) available in the literature regarding latitudes where studies were conducted.

The allometric coefficient (*b*) of the length-weight ratios indicated negative allometry only for all undetermined individuals, indicating that juvenile individuals increase more in length than in weight during this phase. Nevertheless, the result obtained is similar to that found in Macieira and Joyeux (2009) in the State of Espírito Santo, and in the study by Costa et al. (2013) conducted in State of Rio de Janeiro. In the study by Macieira and Joyeux (2009), the occurrence of negative allometry in the length-weight ratio was probably due to the absolute presence of individuals below the first maturity length, between 7.6 and 9.1 cm (Bervian and Fontoura, 1997; Fávaro et al., 2003). In Bervian and Fontoura (2007), the individuals with undetermined sex presented positive allometry, which disagrees with the present study; however, the methodology of macroscopic analysis of the gonads (Vazzoler 1996) used in that study may cause a mixture between small adults and juvenile individuals and this may be the reason of the positive allometry reported by the authors. The allometric coefficients of the length weight ratios for the grouped, male and female data indicate positive allometry, a result that confirms other studies on the growth of *A. brasiliensis* on the Brazilian coast (Table 1).

Frequency distribution by length class showed little change in number of adult individuals throughout the year and a peak input of young-adults between May and June (Figure 3). This is a disagreement with other studies conducted with the species. The studies performed on the Brazilian south-southeast coast indicate a reproductive peak near November, and a different distribution of frequencies (Bemvenuti, 1987; Paiva-Filho and Giannini, 1990; Hostim-Silva et al., 1995; Araújo et al., 1997; Pessanha and Araújo, 2001; Bervian and Fontoura, 2007; Carvalho et al., 2017). The presence of a reproductive peak in the warmer months of the year may be associated not only with the increase in temperature, but also with the increase of rainfall in the regions where the previously mentioned studies were carried out; the increase in rainfall leads to an increased continental input and consequently increased local productivity that favors the availability of food for juveniles, mainly in shallow areas (Bot Neto et al., 2018). The shift of peak reproduction and recruitment to late fall and early winter (May/June) detected in our study may have been caused once again by local differences between the present study and past studies on *A. brasiliensis*, since the present study was performed in a region where the temperature variation is small (mean temperature of the region 27 ± 5°C) and the period of maximum rainfall is in the winter (Knoppers et al., 2006). In addition, there is the input of juvenile individuals into the population throughout the all study period (Figure 3) indicating the possibility of this species reproducing throughout all the year in the study area.

The fit of the Von Bertalanffy growth model was different from the estimates made by previous studies such as Carvalho et al. (2017), Bervian and Fontoura (2007) and that of the FishBase life history tool (L∞ = 17.0; K = 0.83). However, the values of our model approximated the results presented by Pessanha and Araújo (2001), which also estimated a higher growth constant and a lower asymptotic growth compared to other studies, resulting in a rapid growth pattern, but with a reduced final length. As already pointed out by Carvalho et al. (2017), the difference reported by Pessanha and Araújo (2001) may have been mainly caused by the mesh size of the net used to sample the organisms, since larger individuals have already been reported for the same region (Costa et al., 2013). However, variations in physical-chemical and geomorphological parameters influenced by local climate and habitat differences may also have been the cause of these differences in the growth pattern of the species.

The estimated lifespan of 3.25 years, although shorter, is similar to that proposed by Carvalho et al. (2017), Bervian and Fontoura (2007) and that of the FishBase Life History Tool (3.4 years). Nevertheless, as in Carvalho et al. (2017), no individuals were caught with lengths compatible with the estimated length for life span. The largest individuals captured in the present study had a total length of 13.6 cm and individuals with a total length greater than 13.0 cm had low capture frequencies. It is possible that individuals belonging to larger length classes occur in the area but are occupying deeper water environments (Carvalho et al., 2017). This can be a way to avoid intraspecific competition, however it is important to emphasize that the life span and the total length for this age are estimates that may not occur in the environment.

Considering the number and range of distribution of growth studies including *A. brasiliensis*, it was initially considered to test the influence of latitudinal variation (Taylor, 1959) on its growth. However, Baggio et al. (2017) show, through genetic analysis, that because it is an estuarine species, *A. brasiliensis* suffers isolation and has three populations along the Brazilian coast. These are in the north-northeast region, in the central region and in the south-southeast region of the coast. Thus, in the present study, the growth parameters available in the literature (Table 1) were tested using as factor the populations proposed in Baggio et al. (2017). Of the parameters (maximum total length, probability coefficient and allometric coefficient) tested by analysis of variance, only the maximum total length had significant differences between the three populations, and the post hoc test indicated that the detected difference is between population located in the south-southeast region (c) and the population located in the central region (*b*) (Table 2). This result diverges from that reported by Carvalho et al. (2017), who detected no differences when testing latitudinal trends in species growth along the coast applying linear regressions. The difference found for the maximum total length may have been caused by the presence of the value belonging to the study of Macieira and Joyeux (2009), which has a maximum total length (7.1 cm) smaller than the first maturity length already mentioned in the literature (between 7.6 and 9.1cm; Bervian and Fontoura, 1997; Fávaro et al., 2003), and this result is in disagreement with the studies carried out in the same region and other studies carried out along the Brazilian coast (Table 1). Thus, the presence of this value reduced the mean and increased the variance of group b (central region population) possibly causing the observed difference.

CONCLUSION

The original objective of the present work was to define the growth parameters of the species and to identify latitudinal trends in its growth. However, the occurrence of different populations along the Brazilian coast makes this type of comparison difficult. Nonetheless, the growth parameters presented here are not less important, since they are unprecedented for the region and can serve as a framework for other local and comparative studies. Although it is not possible to make comparisons for the entire coast of brazil, it is important to highlight the similarities in the growth of the species along the coast. Finally, the need for further studies focusing on the growth of fish species is evident, as for many species (mainly non-commercial fish) there is not much information available yet. And even for relatively well-known species, there is still a lack of standardized, more widely distributed studies to define which factors are directly affecting the growth of these species.

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REFERENCES

Andreata, J.V.; Barbieri, L.R.R.; Sebíua, A.S.C.; Silva, M.H.C.; Santos, M.A.; Santos, R.P. 1990. Relação dos peixes da Laguna de Marapendi, Rio de Janeiro, Brasil. Atlântica, 12(I): 5-17.

Andreata, J.V.; Marca, A.G.; Soares, C.L.; Santos, R.S. 1997. Distribuição mensal dos peixes mais representativos da Lagoa Rodrigo de Freitas, Rio de Janeiro, Brasil. Revista Brasileira de Zoologia, 14(1): 121-134. https://doi.org/**10.1590/S0101-81751997000100013**.

Araújo, F.G.; Cruz-Filho, A.G.; Azevedo, M.C.C.; Santos, A.C.A.; Fernandes, L.A.M. 1997. Estrutura da comunidade de peixes jovens da margem continental da Baía de Sepetiba, RJ. Acta Biologica Leopoldensia, 19(I): 61-83.

Baggio, R.A.; Stoiev, S.B.; Spach, H.L.; Boeger, W.A. 2017. Opportunity and taxon pulse: the central influence of coastal geomorphology on genetic diversification and endemism of strict estuarine species. Journal of Biogeography, 44(7): 1626-1639. https://doi.org/**10.1111/jbi.12934**.

Bemvenuti, M.A. 1987. Abundância, distribuição e reprodução de peixe-rei (Atherinidae) na região estuarina da Lagoa dos Patos, RS, Brasil. Atlântica, 9(1): 5-32.

Bervian, G.; Fontoura, N.F. 1997. Reprodução de *Atherinella brasiliensis* no estuário do rio Tramandaí, Imbé, Rio Grande do Sul, Brasil (Teleostei, Atherinopsidae). Biociencias, 5: 19-32.

Bervian, G.; Fontoura, N.F. 2007. Growth of the Silverside *Atherinella brasili*ensis in Tramandaí Estuary, Southern Brazil (Actinopterygii: Atherinopsidae). Neotropical Ichthyology, 5(4): 485-490. https://doi.org/**10.1590/S1679-62252007000400008**.

Boeuf, G.; Le Bail, P.Y. 1999. Does light have an influence on fish growth? Aquaculture (Amsterdam, Netherlands), 177(1-4): 129-152. https://doi.org/**10.1016/S0044-8486(99)00074-5**.

Boeuf, G.; Payan, P. 2001. How should salinity influence fish growth? Comparative Biochemistry and Physiology. Toxicology & Pharmacology : CBP, 130(4): 411-423. https://doi.org/**10.1016/S1532-0456(01)00268-X**.

Bot Neto, R.L.; Passos, A.C.; Schwarz Junior, R.; Spach, H.L. 2018. Use of shallow areas by ichthyofauna (Teleostei) on the north-south axis of the Paranaguá Estuarine Complex, State of Paraná, Brazil. Pan-American Journal of Aquatic Sciences, 13(1): 64-78.

Brian, S.; Dyer, H. 2006. Systematic revision of the South American silversides (Teleostei, Atheriniformes). Biocell, 30(suppl. S): 69-88.

Carvalho, B.M.; Barradas, J.R.S.; Fontoura, N.F.; Spach, H.L. 2017. Growth of the silverside *Atherinella brasiliensis* in a subtropical estuary with some insights concerning the weight-length relationship. Anais da Academia Brasileira de Ciências, 89(3, suppl.): 2261-2272. http://dx.doi.org/**10.1590/0001-3765201720160784**.

Carvalho, B.M.; Spach, H.L. 2015. Habitat use by *Atherinella brasiliensis* (Quoy and Gaimard, 1825) in intertidal zones of a subtropical estuary, Brazil. Acta Scientiarum. Biological Sciences, 37(2): 177-184. https://doi.org/**10.4025/actascibiolsci.v37i2.25205**.

Contente, R.F.; Stefanoni, M.F.; Spach, H.L. 2010. Feeding ecology of the Brazilian silverside *Atherinella brasiliensis* (Atherinopsidae) in a sub-tropical estuarine ecosystem. Journal of the Marine Biological Association of the United Kingdom, 91: 1197-1205. https://doi.org/**10.1017/S0025315410001116**.

Costa, M.R.; Pereira, H.H.; Neves, L.M.; Araújo, F.G. 2013. Length–weight relationships of 23 fish species from Southeastern Brazil. Journal of Applied Ichthyology, 30(1): 230-232. https://doi.org/**10.1111/jai.12275**.

Del Río, V.; Rosas, J.; Velásquez, A.; Cabrera, T. 2005. Desarrollo embrionário larval y tiempo de metamorfoses del pez tropical *Xenomelaniris brasiliensis* (Pisces: Atherinidae). Revista de Biología Tropical, 53: 1-10.

FAO – Food and Agriculture Organization of the United Nations. 2013. FISAT II - FAO-ICLARM Stock Assessment Tool [online]. Rome: FAO. URL: <http://www.fao.org/fishery/topic/16072/en>

Fávaro, L.F.; Lopes, S.C.G.; Spach, H.L. 2003. Reprodução do peixe-rei, *Atherinella brasiliensis* (Quoy and Gaimard) (Atheriniformes, Atherinidae), em uma planície de maré adjacente à gamboa do Baguaçu, Baía de Paranaguá, Paraná, Brasil. Revista Brasileira de Zoologia, 20(3): 501-506. https://doi.org/**10.1590/S0101-81752003000300022**.

Fávaro, L.F.; Oliveira, E.C.; Verani, N.F. 2007. Estrutura da população e aspectos reprodutivos do peixe-rei *Atherinella brasiliensis* (Quoy and Gaimard) (Atheriniformes, Atherinopsidae) em áreas rasas do Complexo Estuarino de Paranaguá, Paraná, Brasil. Revista Brasileira de Zoologia, 24(4): 1150-1156. https://doi.org/**10.1590/S0101-81752007000400036**.

Figueiredo, J.L.; Menezes, N.A. 1978. Manual de peixes marinhos do sudeste do Brasil- Teleostei I. São Paulo: Museu de Zoologia, Universidade de São Paulo. 110p.

Fontoura, N.F.; Agostinho, A.A. 1996. Growth with seasonally varying temperatures: an expansion of the Von Bertalanffy growth model. Journal of Fish Biology, 48(4): 569-584. https://doi.org/**10.1111/j.1095-8649.1996.tb01453.x**.

Franco, T.P.; Araújo, C.E.O.; Araújo, F.G. 2013. Length–weight relationships for 25 fish species from three coastal lagoons in Southeastern Brazil. Journal of Applied Ichthyology, 30(1): 1-3. https://doi.org/**10.1111/jai.12271**.

Freire, K.M.F.; Nascimento, F.P.; Rosário, L.M.O.; Rocha, G.R.A.; Alves, G.A.; Lins-Oliveira, J.E. 2012. Characterization of some biological aspects of *Atherinella brasiliensis* caught during sport fishing tournaments: a case study from Northeastern Brazil. Boletim do Instituto de Pesca, 38(2): 171-180.

Froese, R. 2006. Cube law, condition factor and weight–length relationships: history, meta-analysis and recommendations. Journal of Applied Ichthyology, 22(4): 241-253. https://doi.org/**10.1111/j.1439-0426.2006.00805.x**.

Giacomini, H.C.; Shuter, B.J. 2013. Adaptive responses of energy storage and fish life histories to climatic gradients. Journal of Theoretical Biology, 339: 100-111. **https://doi.org/10.1016/j.jtbi.2013.08.020**.

Giannini, R.; Paiva-Filho, A.M. 1995. Análise comparativa da ictiofauna da zona de arrebentação de praias arenosas do estado de São Paulo, Brasil. Boletim do Instituto Oceanográfico, 43(2): 141-152. https://doi.org/**10.1590/S0373-55241995000200006**.

Giarrizzo, T.; Silva De Jesus, A.J.; Lameira, E.C.; Araújo De Almeida, J.B.; Isaac, V.; Saint-Paul, U. 2006. Weight-length relationships for intertidal fish fauna in a mangrove estuary in Northern Brazil. Journal of Applied Ichthyology, 22(4): 325-327. https://doi.org/**10.1111/j.1439-0426.2006.00671.x**.

Golzio, J.E.S.A.; Falkenberg, J.M.; Praxedes, R.C.G.; Coutinho, A.S.; Laurindo, M.K.; Pessanha, A.; Madi, R.R.; Patricio, J.; Vendel, A.L.; Souza, G.T.R.; Melo, C.M.; Lacerda, A.C.F. 2017. Gill parasites of fish from two estuaries in northeastern Brazil: new hosts and geographical records. Anais da Academia Brasileira de Ciências, 89(3, suppl.): 2281-2291. https://doi.org/**10.1590/0001-3765201720160883**.

Haimovici, M.; Velasco, G. 2000. Length-weight relationship of marine fishes from Southern Brazil. Naga, 23(1): 19-23. Available at: <http://repositorio.furg.br/handle/1/2458> Accessed: July 1, 2019.

Hostim-Silva, M.; Clezar, L.; Ribeiro, G.C.; Machado, C. 1995. Estrutura populacional de *Xenomelaniris brasiliensis* (Quoy and Gaimard, 1824) na Lagoa da Conceição, SC. Brazilian Archives of Biology and Technology, 38: 949-960.

Knoppers, B.; Medeiros, P.R.P.; Souza, W.F.L.; Jennerjahn, T. 2006. The São Francisco Estuary, Brazil. In: Wangersky, P. (ed.). The handbook of environmental chemistry. Berlin: Springer Verlag. v. 5 - Water Pollution: estuaries, pp. 51-70. https://doi.org/**10.1007/698_5_026**.

Le Cren, E.D. 1951. The length-weight relationship and seasonal cycle in gonad weight and condition in the perch (*Perca fluviatilis*). Journal of Animal Ecology, 20(2): 201-219. https://doi.org/**10.2307/1540**.

Macieira, R.M.; Joyeux, J.C. 2009. Length–weight relationships for rockpool fishes in Brazil. Journal of Applied Ichthyology, 25(3): 358-359. https://doi.org/**10.1111/j.1439-0426.2008.01118.x**.

Maciel, T.R.; Vaz-Dos-Santos, A.M.; Barradas, J.R.S.; Vianna, M. 2019. Sexual dimorphism in the catfish *Genidens genidens* (Siluriformes: Ariidae) based on otolith morphometry and relative growth. Neotropical Ichthyology, 17(1): e180101. https://doi.org/**10.1590/1982-0224-20180101**.

Mazzei, E.; Joyeux, J.C.; Simon, T. 2011. Length-weight relationships for juvenile and small-sized adult fishes of the surf zone. Journal of Applied Ichthyology, 27(4): 1137-1138. https://doi.org/**10.1111/j.1439-0426.2011.01772.x**.

Neves, M.L.; Pereira, H.H.; Costa, R.M.; Araújo, G.F. 2006. Uso do manguezal de Guaratuba, Baia de Sepetiba, Rio de Janeiro, pelo peixe-rei *Atherinella brasiliensis* (Quoy and Gaimard) (Atheriniformes, Atherinopsidae). Revista Brasileira de Zoologia, 23(2): 421-428. https://doi.org/10.1590/**S0101-81752006000200017**.

Paiva-Filho, A.M.; Giannini, R. 1990. Contribuição ao conhecimento da biologia do peixe-rei, *Xenomelaniris brasiliensis* (Quoy and Gaimard, 1824) (Atherinidae), no complexo baía-estuário de Santos e São Vicente, Brasil. Boletim do Instituto Oceanográfico, 38(1): 1-9. https://doi.org/**10.1590/S0373-55241990000100002**.

Pauly, D. 1980. On the interrelationships between natural mortality, growth parameters, and mean environmental temperatures in 175 fish stocks. ICES Journal of Marine Science, 39(2): 175-192. https://doi.org/**10.1093/icesjms/39.2.175**.

Peck, M.A.; Reglero, P.; Takahask, M.; Catalán, I.A. 2013. Life cycle ecophysiology of small pelagic fish and climate-driven changes in populations. Progress in Oceanography, 116: 220-245. https://doi.org/**10.1016/j.pocean.2013.05.012**.

Pessanha, A.L.M.; Araújo, F.G. 2001. Recrutamento do peixe-rei, *Atherinella brasiliensis* (Quoy and Gaimard) (Atheriniformes, Atherinopsidae), na margem continental da Baía de Sepetiba, Rio de Janeiro, Brasil. Revista Brasileira de Zoologia, 18: 1265-1274. https://doi.org/**10.1590/S0101-81752001000400021**.

Possamai, B.; Hoeinghaus, D.J.; Odebrecht, C.; Abreu, P.C.; Moraes, L.E.; Santos, A.C.; Garcia, A.M. 2020. Freshwater inflow variability affects the relative importance of allochthonous sources for estuarine fishes. Estuaries and Coasts, 43(4): 880-893. https://doi.org/**10.1007/s12237-019-00693-0**.

Possamai, B.; Zanlorenzi, D.; Machado, R.C.; Fávaro, L.F. 2019. Length–weight relationships for estuarine fishes in South Brazil. Journal of Applied Ichthyology, 35(2): 608-613. https://doi.org/**10.1111/jai.13846**.

R Core Team. 2019. R: A language and environment for statistical computing [online]. Vienna, Austria: R Foundation for Statistical Computing. URL: <https://www.R-project.org/>

Smith, R.J. 1993. Logarithmic transformation bias in allometry. American Journal of Physical Anthropology, 90: 215-228. https://doi.org/**10.1002/ajpa.1330900208**.

Soeth, M.; Spach, H.L.; Daros, F.A.; Adelir-Alves, J.; Almeida, A.C.O.; Correia, A.T. 2019. Stock structure of Atlantic spadefish *Chaetodipterus faber* from Southwest Atlantic Ocean inferred from otolith elemental and shape signatures. Fisheries Research, 211: 81-90. https://doi.org/**10.1016/j.fishres.2018.11.003**.

Taylor, C.C. 1959. Temperature and growth - the Pacific razor clam. ICES Journal of Marine Science, 25(1): 93-101. https://doi.org/**10.1093/icesjms/25.1.93**.

Vaz-Dos-Santos, A.M.; Gris, B. 2016. Length-weight relationships of the ichthyofauna from a coastal subtropical system: a tool for biomass estimates and ecosystem modelling. Biota Neotropica, 16(3): e20160192. https://doi.org/**10.1590/1676-0611-BN-2016-0192**.

Vazzoler, A.E.A.M. 1996. Biologia da reprodução de peixes teleósteos: teoria e prática. Maringá: Eduem. 169p.

Vilar, C.C.; Spach, H.L.; Joyeux, J.C. 2011. Spatial and temporal changes in the fish assemblage of a subtropical estuary in Brazil: environmental effects. Journal of the Marine Biological Association of the United Kingdom, 91(3): 635-648. https://doi.org/**10.1017/S0025315410001943.**

Von Bertalanffy, L. 1938. A quantitative theory of organic growth (inquiries on growth laws. II). Human Biology, 10(2): 181-213.