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# TEMPORAL CHANGES IN LENGTH-WEIGHT RELATIONSHIPS OF SCIAENIDAE (PISCES: TELEOSTEI) SPECIES IN SOUTH BRAZIL

## Mudanças temporais na relação peso-comprimento de espécies de Sciaenidae (Pisces: Teleostei) no Sul do Brasil

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## ABSTRACT

This study reports the importance to evaluate the length-weight relationships (LWR) across the years. We evaluate the LWR for 8 Sciaenidae species of Paranaguá Estuarine Complex, South Brazil, sampled between 2016 and 2018 by bottom trawls similar to the used by artisanal fisheries in this region. There were differences between growth type among the years for 5 species, and all species showed differences in the slope of LWR in at least one year. These results show the importance of fauna and fisheries monitoring programs to better evaluate the population dynamics and fisheries stocks.

**Keywords:** estuarine fish, fisheries biology, marine fish, sciaenid, weight-length relationship.

## *RESUMO*

*Este estudo demonstra a importância de se avaliar as relações peso-comprimento ao longo dos anos. Avaliamos a relação peso-comprimento de 8 espécies de Sciaenidae no Complexo Estuarino de Paranaguá, Sul do Brasil, amostrados entre 2016 e 2018 por redes de arrasto similares às utilizadas*

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*pela pesca artesanal na região. Houve diferenças no tipo de crescimento entre os três anos analisados para 5 espécies, e todas as espécies mostraram diferenças no coeficiente angular (b) da relação peso-comprimento em ao menos um ano. Esses resultados demonstram a importância dos programas de monitoramento de fauna e de pesca, para melhor avaliar a dinâmica das populações e dos estoques pesqueiros.*

***Palavras-chave:*** *biologia pesqueira, peixes estuarinos, peixes marinhos, relações comprimento-peso, scianídeo.*

## INTRODUCTION

Length-weight relationship (LWR) is a species-specific biological index very useful in fisheries science and management. The length of fishes is usually measured without a purpose; however, for management uses it is very needed, as well as the body weight (Froese; Thorson & Reyes Jr., 2014). The biomass estimation is a management tool to regulate catches, and it can be estimated with the length information by the LWR (Froese, 2006). Moreover, LWR may inform the body and health condition, population growth, ontogenetic changes and is needed to reproductive studies (Le Cren, 1951; Petrakis & Stergiou, 1995; Torres *et al.,* 2017; Possamai *et al.,* 2019).

The Sciaenidae family is composed of several economically important species, supporting the majority of artisanal and industrial small-scale fisheries in South Brazil (Vasconcellos; Diegues & Kalikoski, 2011; Haimovici & Cardoso, 2017; Leis; Chuenpagdee & Medeiros, 2019). More than a half of the marine landings in Brazil are from small-scale fisheries (Vasconcellos; Diegues & Kalikoski, 2011), and as in the South region many of these fisheries resources are Sciaenidae, of which some stocks had been collapsed along the years (Haimovici *et al.,* 2006; Vasconcellos; Diegues & Kalikoski, 2011; Chao *et al.,* 2015). Therefore, monitoring the catches and evaluating the LWR along the time may inform the state of the populations of Sciaenidae species and helps management efforts. Although many studies have been shown the LWR for Sciaenidae species and it can be accessed in the FishBase platform (Froese & Pauly, 2020), this relationship is influenced by environmental conditions, interspecific relationships, sex and life stage (Froese, 2006; Nallathambi *et al.,* 2019; Possamai *et al.,* 2019; Possamai; Passos & Carvalho, 2020), and all these features may change across the space and time.

The changes across the years in LWR are not usually evaluated. This could be in reason to the difficulty to maintain monitoring programs (Lindenmayer *et al.,* 2012), or to the acceptance in using a global LWR. In this sense, we estimated the LWR parameters for eight Sciaenidae species in different years and compared them, aiming to evaluate the reliability in using the same coefficients of LWR at different time scales. The different results could highlight the importance of faunal monitoring to fisheries management.

## MATERIAL AND METHODS

Paranaguá Estuarine Complex (PEC) (25°15′ - 25°35′ S; 48°20′ - 48°45′ W) is located in Paraná state coast, Brazil, and is composed of six bays totaling 612 Km² of surface area. There are many islands in their interior, and mangroves, salt marshes, rocky shores, tidal

marshes, and sand beaches as well. This region is classified as a humid subtropical climate, with an average temperature of 18°C and the average annual rainfall is 2,500 mm (Lana *et al.,* 2001). The estuarine salinity ranges from 12 to 29 in winter and 20 to 34 in the summer (Lana *et al.,* 2001).

The fish were collected seasonally between 2016 and 2018 (4 sampling campaigns by year; 10 sites) in PEC and adjacent coast. Fishes were collected by bottom trawl with 40 and 26 mm stretched mesh openings in the body and codend, respectively, and spread by two flat, rectangular otter boards (0.47 *x* 0.90 m with 17 Kg each), similar to the nets used by artisanal fisheries in the region. In the field, the fish were stored in ice and brought to the laboratory, where they were measured in total length (cm) and total weight (0.01 g).

The length-weight relationship was assessed by the equation $Wt = aLt^b$, where Wt is total weight; Lt is total length; *a* is the intercept and; *b* is the slope (both coefficients determined using the least-squares method) (Le Cren, 1951). The LWR was determined for each year (2016, 2017, and 2018) separately and for all years grouped. The model fit verification was achieved by the determination coefficient ($R^2$), and the isometry of b was tested by a t-test ($\alpha = 0.05$), using as $H_0$: $b = 3$. The comparison of the b among years and between grouped b and years were performed comparing the slopes of each model by Covariance Analysis. The total length (TL) comparisons among the years were performed by Analysis of Variance (ANOVA) for normal-distributed data and by Kruskal-Wallis test for non-normal distributed ones. Normality was assessed by the Shapiro-Wilk test ($\alpha = 0.05$). Post-hocs used were Tukey for ANOVA and Dunn's test for Kruskal-Wallis. All statistical analysis was performed in the software R 3.5.3 (R Core Team, 2019) using the 'FSA package' and $\alpha = 0.05$.

## RESULTS

The LWR coefficients can be seen in Table I. All the species presented differences of isometry in at least one year (Table I). In general, for grouped LWR, 62.5% of the species presented isometric growth ($b = 3$, $p > 0.05$), while 32.5% showed allometric positive growth ($b > 3$, $p < 0.05$) (Table I). No allometric negative growth was recorded.

The comparison of slopes between groups ($b_g$) and separate by year ($b_y$) showed differences for all species, except *Menticirrhus americanus* and *Stellifer rastrifer*, in at least one year (Table I).

Table I – Length-Weight relationship parameters of the Sciaenidade species collected in Paranaguá Bay and adjacent coastal area, Paraná, Brazil. Samplings from 2016 through 2018. Total length (TL), total weight (TW), linear coefficient (a) and angular coefficient or slope (b). Deviation from isometric growth was tested by the t-test. Grouped b ($b_g$) and separated b by year ($b_y$) were tested by ANCOVA. Both tests considered $\alpha = 0.05$ and bold values denotes $p < 0.05$

| Species | Year | N | TL (cm) | | TW (g) | | Equation parameters | | | t-test (b = 3) | | F-test ($b_g = b_y$) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | min | max | min | max | a | b | $r^2$ | t | *p*-value | F | *p*-value |
| *Ctenosciaena gracilicirrhus* (Metzelaar, 1919) Barbel drum | 2016 | 25 | 7.3 | 13.5 | 3.19 | 39.95 | 0.0007 | 4.22 | 0.91 | 4.614 | **<0.001** | -20.562 | **<0.001** |
| | 2017 | 321 | 3.5 | 15.4 | 0.53 | 58.61 | 0.0128 | 3.02 | 0.98 | 0.890 | 0.373 | 1.169 | 0.244 |
| | 2018 | 16 | 4.3 | 7.3 | 0.77 | 5.44 | 0.0119 | 3.06 | 0.88 | 0.195 | 0.847 | -0.106 | 0.916 |
| | Grouped | 362 | 3.5 | 15.4 | 0.53 | 58.61 | 0.0126 | 3.02 | 0.97 | 1.180 | 0.238 | - | - |
| *Isopisthus parvipinnis* (Cuvier, 1830) Bigtooth corvina | 2016 | 53 | 5.5 | 18.0 | 1.53 | 62.71 | 0.0058 | 3.19 | 0.97 | 2.548 | **0.013** | -4.101 | **<0.001** |
| | 2017 | 48 | 2.3 | 17.7 | 0.14 | 63.67 | 0.0087 | 3.05 | 0.95 | 0.549 | 0.585 | -0.490 | 0.624 |
| | 2018 | 38 | 3.5 | 17.0 | 0.38 | 49.55 | 0.0087 | 3.06 | 0.97 | 0.763 | 0.450 | 0.185 | 0.854 |
| | Grouped | 139 | 2.3 | 18.0 | 0.14 | 63.67 | 0.0084 | 3.05 | 0.96 | 1.121 | 0.264 | - | - |
| *Macrodon atricauda* (Günther, 1880) Southern King Weakfish | 2016 | 15 | 6.8 | 24.0 | 1.57 | 151.95 | 0.0028 | 3.39 | 0.97 | 2.756 | **0.016** | -6.119 | **<0.001** |
| | 2017 | 47 | 3.5 | 17.4 | 0.41 | 53.30 | 0.0054 | 3.24 | 0.98 | 4.236 | **<0.001** | -4.492 | **<0.001** |
| | 2018 | 46 | 4.5 | 30.5 | 0.80 | 249.48 | 0.0095 | 2.97 | 0.97 | -0.402 | 0.689 | 2.494 | **0.013** |
| | Grouped | 108 | 3.5 | 30.5 | 0.41 | 249.48 | 0.0073 | 3.08 | 0.98 | 1.953 | 0.053 | - | - |
| *Menticirrhus americanus* (Linnaeu, 1758) Southern kingcroaker | 2016 | 499 | 3.7 | 30.5 | 0.39 | 352.39 | 0.0067 | 3.13 | 0.99 | 14.834 | **<0.001** | 1.621 | 0.107 |
| | 2017 | 308 | 3.5 | 27.8 | 0.64 | 232.32 | 0.0078 | 3.10 | 0.99 | 6.063 | **<0.001** | 1.532 | 0.127 |
| | 2018 | 181 | 9.1 | 29.6 | 6.80 | 307.25 | 0.0053 | 3.24 | 0.99 | 10.825 | **<0.001** | -0.922 | 0.357 |
| | Grouped | 988 | 3.5 | 30.5 | 0.39 | 352.39 | 0.0064 | 3.17 | 0.99 | 21.475 | **<0.001** | - | - |
| *Micropogonias furnieri* (Desmarest, 1823) Whitemouth croaker | 2016 | 194 | 3.1 | 41.0 | 0.30 | 751.14 | 0.0083 | 3.05 | 0.95 | 1.243 | 0.215 | 0.252 | 0.801 |
| | 2017 | 57 | 5.0 | 20.2 | 1.05 | 92.22 | 0.0071 | 3.14 | 0.98 | 2.935 | **0.004** | 2.092 | **0.037** |
| | 2018 | 150 | 2.2 | 18.7 | 0.09 | 74.97 | 0.0101 | 3.02 | 0.97 | 0.496 | 0.620 | -0.868 | 0.387 |
| | Grouped | 401 | 2.2 | 41.0 | 0.09 | 751.14 | 0.0090 | 3.04 | 0.96 | 1.356 | 0.175 | - | - |
| *Paralonchurus brasiliensis* (Steindachne, 1875) Banded croaker | 2016 | 68 | 4.7 | 21.0 | 0.71 | 97.47 | 0.0005 | 3.19 | 0.99 | 5.414 | **<0.001** | 0.288 | 0.774 |
| | 2017 | 59 | 4.2 | 23.3 | 0.57 | 132.30 | 0.0041 | 3.28 | 0.99 | 8.082 | **<0.001** | 2.826 | **0.005** |
| | 2018 | 68 | 2.6 | 22.6 | 0.26 | 130.72 | 0.0064 | 3.10 | 0.98 | 2.070 | **<0.001** | -0.952 | 0.342 |
| | Grouped | 195 | 2.6 | 23.3 | 0.26 | 132.30 | 0.0056 | 3.16 | 0.99 | 6.841 | **<0.001** | - | - |
| *Stellifer brasiliensis* (Schultz, 1945) Brazilian stardrum | 2016 | 19 | 4.8 | 16.6 | 1.12 | 74.21 | 0.0097 | 3.09 | 0.98 | 1.134 | 0.272 | -0.879 | 0.380 |
| | 2017 | 23 | 4.5 | 14.5 | 1.11 | 38.40 | 0.0077 | 3.16 | 0.98 | 2.137 | **0.044** | 2.905 | **0.004** |
| | 2018 | 33 | 4.5 | 16.2 | 1.23 | 58.31 | 0.0122 | 3.00 | 0.95 | 0.067 | 0.946 | -1.700 | 0.090 |
| | Grouped | 75 | 4.5 | 16.6 | 1.11 | 74.21 | 0.0102 | 3.06 | 0.97 | 1.050 | 0.296 | - | - |
| *Stellifer rastrifer* (Jordan, 1889) Rake stardrum | 2016 | 254 | 2.7 | 15.1 | 0.23 | 47.15 | 0.0064 | 3.28 | 0.98 | 12.216 | **<0.001** | 1.925 | 0.055 |
| | 2017 | 593 | 3.2 | 15.4 | 0.32 | 48.08 | 0.0081 | 3.17 | 0.98 | 12.162 | **<0.001** | -1.390 | 0.166 |
| | 2018 | 439 | 3.2 | 15.7 | 0.18 | 54.18 | 0.0076 | 3.21 | 0.98 | 9.895 | **<0.001** | -0.636 | 0.526 |
| | Grouped | 1286 | 2.7 | 15.7 | 0.18 | 54.18 | 0.0076 | 3.20 | 0.98 | 19.777 | **<0.001** | - | - |

Comparing the slopes between the years, all species showed differences (Table II). There was no pattern of the years in altering the slope of the species. Moreover, the length ranges were similar in all species across the years, except for *Ctenosciaena gracilicirrhus*,

which presented higher lengths in 2016 when compared to 2017 and 2018, as well as did show an unusual b in 2016 (Table II). *Menticirrhus americanus* and *Stellifer rastrifer* presented differences in total lengths average across all years as well (Table II).

Table II – Comparison of *b* estimated and total length average (TL in cm) for the Sciaenidae species collected in Paranaguá Bay and adjacent coast, South Brazil among the years. The α = 0.05 and bold values denotes p < 0.05. Total length comparison tests: (AV) for ANOVA and (KW) for Kruskal-Wallis comparisons

| Species | Year | t | p | $R^2$ | TL Comparison | | |
|---|---|---|---|---|---|---|---|
| | | | | | p | *Post-hoc* | test |
| | 2016-2017 | -24.89 | **<0.001** | 0.99 | | **<0.001** | |
| *Ctenosciaena gracilicirrhus* | 2016-2018 | -20.68 | **<0.001** | 0.99 | **<0.001** | **<0.001** | KW |
| | 2017-2018 | 0.987 | 0.325 | 0.99 | | **<0.001** | |
| | 2016-2017 | -3.316 | **0.001** | 0.99 | | 0.074 | |
| *Isopisthus parvipinnis* | 2016-2018 | -2.826 | **0.005** | 0.98 | **0.007** | **0.007** | AV |
| | 2017-2018 | -0.879 | 0.380 | 0.99 | | 0.601 | |
| | 2016-2017 | -3.955 | **<0.001** | 0.99 | | **<0.001** | |
| *Macrodon atricauda* | 2016-2018 | -8.966 | **<0.001** | 0.98 | **<0.001** | 0.571 | KW |
| | 2017-2018 | -4.890 | **<0.001** | 0.98 | | **<0.001** | |
| | 2016-2017 | -0.500 | 0.618 | 0.99 | | **<0.001** | |
| *Menticirrhus americanus* | 2016-2018 | 0.703 | 0.483 | 0.98 | **<0.001** | **<0.001** | KW |
| | 2017-2018 | 2.546 | **0.011** | 0.98 | | **0.003** | |
| | 2016-2017 | 2.031 | **0.043** | 0.99 | | 0.077 | |
| *Micropogonias furnieri* | 2016-2018 | -0.745 | 0.457 | 0.98 | **0.006** | 0.104 | KW |
| | 2017-2018 | -2.399 | **0.017** | 0.99 | | **0.005** | |
| | 2016-2017 | 0.484 | 0.629 | 0.98 | | **0.006** | |
| *Paralonchurus brasiliensis* | 2016-2018 | -1.297 | 0.196 | 0.98 | **<0.001** | 0.065 | KW |
| | 2017-2018 | -3.557 | **<0.001** | 0.99 | | **<0.001** | |
| | 2016-2017 | 1.336 | **0.018** | 0.98 | | | |
| *Stellifer brasiliensis* | 2016-2018 | -0.870 | 0.385 | 0.99 | 0.108 | - | AV |
| | 2017-2018 | -3.08 | **0.002** | 0.98 | | | |
| | 2016-2017 | -2.381 | **0.018** | 0.99 | | **<0.001** | |
| *Stellifer rastrifer* | 2016-2018 | -1.550 | 0.123 | 0.99 | **<0.001** | **<0.001** | KW |
| | 2017-2018 | 0.897 | 0.371 | 0.98 | | **<0.001** | |

## DISCUSSION

The LWR is essential to a diversity of basic biology studies of fishes. Here, we present the LWR of 8 Sciaenidae species during three different years, showing the differences in the equation parameters among the years.

The fisheries in PEC and adjacent coast are only small-scale, using mainly gillnets with different techniques (variation in the position of the net on the water column, encircling nets, etc.), depending on the target species (Leis; Chuenpagdee & Medeiros, 2019). The Sciaenidae family is always present is the landings, being the whitemouth croacker

*Micropogonias furnieri* one of the most catches, and the hakes *Cynoscion leiarchus*, *C. microlepidotus*, *C. acoupa*, and the southern king weakfish *Macrodon* sp. target species (Leis; Chuenpagdee & Medeiros, 2019). These facts highlight the importance of studies on the basic biology of this family.

The slopes of almost all species were into the range of 2.5 to 3.5 proposed by Froese (2006). However, for *C. gracilicirrhus* we found for 2016 a b very far from this range. This must be occurred because of the higher average in TL of the individuals collected in 2016 compared to 2017 and 2018. Therefore, in 2016 the LWR was estimated only for sub-adults (see Vaz-dos-Santos & Rossi-Wongtschowski, 2019 for some population patterns), while in the other years the majority of the individuals were juveniles. Other studies had been speculating that life cycle influences in the LWR (Petrakis & Stergiou, 1995; Gonçalves *et al.*, 1997; Possamai; Passos & Carvalho, 2020), once the energy investment changes depending on the more important process for each phase (growth in juveniles *vs.* reproduction in adults). Moreover, the grouped slopes found for almost all species were very similar to the ones estimated by FishBase (Froese & Pauly, 2020) using several works from different parts of the world (Table III). Exceptions were *P. brasiliensis* and *S. brasiliensis*, which have the b with a difference > 0.10 compared to the FishBase estimates.

Table III – Comparison between the b estimates of this work and of the FishBase (Froese & Pauly, 2020). CV is the coefficient of variation of the different estimates

| Species | This work | | | | | FishBase | |
|---|---|---|---|---|---|---|---|
| | b 2016 | b 2017 | b 2018 | b group | CV | b | CV |
| *Ctenosciaena gracilicirrhus* | 4.22 | 3.02 | 3.06 | 3.02 | 15.44% | 3.06 | 6.64% |
| *Isopisthus parvipinnis* | 3.19 | 3.05 | 3.06 | 3.05 | 1.92% | 3.08 | 3.66% |
| *Macrodon atricauda* | 3.39 | 3.24 | 2.97 | 3.08 | 5.02% | 3.18 | 7.22% |
| *Menticirrhus americanus* | 3.13 | 3.10 | 3.24 | 3.17 | 1.66% | 3.11 | 6.97% |
| *Micropogonias furnieri* | 3.05 | 3.14 | 3.02 | 3.04 | 1.50% | 3.02 | 6.19% |
| *Paralonchurus brasiliensis* | 3.19 | 3.28 | 3.10 | 3.02 | 3.13% | 3.33 | 3.76% |
| *Stellifer brasiliensis* | 3.09 | 3.16 | 3.00 | 3.06 | 1.87% | 3.28 | 3.92% |
| *Stellifer rastrifer* | 3.28 | 3.17 | 3.21 | 3.20 | 1.25% | 3.12 | 6.82% |

Concerning the LWR over the years, we observed that the equation parameters change in time, which could be considered in biomass estimations. It may be more alarming when the growth type change, once this shows where the individuals are spending more energy and the health of them. Here, we could note that all species demonstrated changing from allometric positive to isometric growth, and it must be considered in inferences of stocks, reproduction, growth, and others (Petrakis & Stergious, 1995; Froese, 2006). However, our estimates considered a wide range of lengths for all species, and these lengths varied among the years for some species. In this sense, a caution in the interpretation of some results must be taken, mainly for the species which varied the TL average. We highlight the importance of fauna and fisheries monitoring programs to better evaluate the stocks condition.

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