Life-History traits of 
*Hollandichthys multifasciatus* 
(Eigenmann & Norris, 1900) 
(Characiformes: Characidae) in coastal 
Atlantic Forest blackwater streams from 
Southeastern Brazil

Vinicius de Carvalho Cardoso¹ & Katharina Eichbaum Esteves²

¹ Secretaria da Agricultura e Abastecimento do Estado de São Paulo, Agência Paulista de Tecnologia dos Agronegócios (APTA), Instituto de Pesca. São Paulo, SP, Brasil. ORCID: https://orcid.org/0000-0002-7604-6684. E-mail: viniciusc.cardoso@yahoo.com.br

² Secretaria da Agricultura e Abastecimento do Estado de São Paulo, Agência Paulista de Tecnologia dos Agronegócios (APTA), Instituto de Pesca, Centro de Pesquisa em Recursos Hídricos. São Paulo, SP, Brasil. ORCID: https://orcid.org/0000-0001-5123-9669. E-mail: kesteves.ke@gmail.com (corresponding author)

**Abstract.** Ecological and life history traits have been used to understand the basic ecology of fishes. This study aimed to examine the existence of plasticity in life history traits of populations of *Hollandichthys multifasciatus* in ten blackwater streams. This is an inseminating Characidae, endemic to the Atlantic coastal drainages of Brazil. Different aspects of the life-history of the species, such as mean length, sex ratio, absolute and relative fecundity, gonadosomatic index, condition factor, length-weight relationship and the growth parameter (b) of 185 specimens were studied during the period of low precipitation (June-September). Fish samples were obtained along a 100 m stretch of each stream, and some habitat variables recorded. ANOVA and Kruskal-Wallis tests indicated a similarity in most of the analyzed traits, with exception of the mean length of immatures, Gonadosomatic Index of mature males and condition factor of immatures and mature adults. Also, slope tests of the length-weight relationship were significantly different for immatures. The observed differences were attributed to heterogeneity in food availability and/or other site-specific factors, which may influence growth and/or breeding aspects among the studied localities. The approach used herein may improve understanding of trait plasticity under natural conditions, helping to understand fish-community responses to anthropogenic changes.

**Keywords.** Length-weight relationship; Condition factor; Humic waters; Baixada Santista.

**INTRODUCTION**

Variations in life-history traits between and within fish populations have been described for several native populations from tropical (Winemiller, 1989; Grether *et al.*, 2001; Gomes & Monteiro, 2007) and temperate habitats (Garcia & Braña, 1988; Lobón-Cerviá & Rincón, 1998; Craig *et al.*, 2017), with spatial and temporal patchiness of resources resulting in variation in reproductive traits. Resource availability is considered a major driver for selection of various life-history strategies in organisms and can affect population growth and productivity (Begon *et al.*, 2006). However, other factors, such as environmental stability (e.g., hydrology; Lytle & Poff, 2004), light radiance, temperature, and oxygen levels may be related to variations in growth and reproductive strategies (Jobling, 1994), and thus life-history traits of fish populations may vary among habitat types (Blanck & Lamouroux, 2007).

Several studies have shown that organisms in unproductive environments may grow more slowly and allocate their limited energy to growth for a longer time until they become large enough to produce sufficient offspring (Pianka, 1970). Organisms are likely to mature later than those in more productive environments where they can grow faster and get larger quicker (Stearns & Koella, 1986). In this respect, important drivers of freshwater productivity as Dissolved Organic Carbon (DOC) have been shown to affect life-history characteristics of *Lepomis macrochirus* Rafinesque, 1819 in North American lakes such

Pap. Avulsos Zool., 2022; v.62: e202262016
http://doi.org/10.11606/1807-0205.2022.62.016
http://www.revistas.usp.br/paz
http://www.scielo.br/paz
Edited by: Murilo Nogueira de Lima Pastana
Received: 11/08/2021
Accepted: 17/12/2021
Published: 10/03/2022

ISSN On-Line: 1807-0205
ISSN Printed: 0031-1049
ISNI: 0000-0004-0384-1825
that fish in high-DOC lakes reached smaller sizes, but had similar fecundity and egg size, at a given size (Craig et al., 2017).

Since streams exhibit variation in physiographic and physicochemical factors, which are often patchily distributed (Pringle et al., 1988), shifts in resource availability are important in predicting the adaptiveness of traits of species populations. Blackwater Atlantic Forest rivers and streams present some environmental heterogeneity, low pH (Camargo et al., 1997; Gonçalves & Braga, 2012) and varied levels of DOC concentrations (Felisberto, 2020), owing to high humic acid contents (Por, 1992). They are also part of Atlantic Forest coastal drainages, which correspond to a system of isolated streams that originate at different points in a region between marine and coastal environments, draining directly into the Atlantic Ocean. Freshwater fishes in these coastal basins have evolved in isolation with sporadic dispersal with inland basins of Brazil (Ribeiro, 2006). As small and/or non-migratory species with specific habitat requirements may be susceptible to variation in habitat across the landscape, limiting their dispersal between populations (Waters & Burridge, 2016), isolated streams may be good model ecosystems for understanding how intraspecific traits vary in response to different conditions.

Hollandichthys multifasciatus (Eigenmann & Norris, 1900) is an endemic characid to the Atlantic coastal drainages of Brazil, occurring from Rio de Janeiro to Rio Grande do Sul states, and in the upper Tietê river (Lima et al., 2007; Menezes et al., 2007). Despite being one of the most representative species in several coastal stream surveys (Ferreira & Petrere, 2009; Gonçalves & Braga, 2012; Lemos, 2019; Felisberto, 2020), biological aspects of H. multifasciatus are still poorly known. It is an inseminating species found in clear and blackwater streams (Sabino & Castro, 1990; Esteves & Lobón-Cerviá, 2001; Esteves et al., 2019) with little running water and a muddy bottom, associated with preserved Atlantic Forest riparian vegetation (Bertaco, 2003). Adults display solitary habits, while juveniles form shoals of three to six individuals (Bertaco & Malabarba, 2013). It is considered an omnivore which consumes few autochthonous items and great proportions of plants and terrestrial insects (Abilhoa et al., 2009; Gonçalves et al., 2018), displaying a surface picking behavior as described for several characin species (Sazima, 1986). Hollandichthys multifasciatus is classified as Data Deficient (DD) by the Brazilian federal list of endangered species (ICMBio/MMA, 2018) and as Least Concern (LC) in the regional list of São Paulo State (Oyakawa et al., 2009).

Here we examined the existence of plasticity in life history traits of populations of H. multifasciatus from ten preserved blackwater streams, assessing their mean length, absolute and relative fecundity, condition factor, length-weight relationship, type of growth (b), sex ratio and gonadal-somatic index among the streams.

**MATERIAL AND METHODS**

The present study was carried out in the coastal region of São Paulo State (southeast Brazil) in the municipalities of Bertioga and São Sebastião, comprising ten blackwater streams which belong to the Guaratuba, Itapanhau, Itaguare and Una sub-basins (Figs. 1, 2, Table 1). The first three sub-basins are located in the Baixada Santista Hydrographic Basin (Ribeiro, 2018), and the Una sub-basin in the Northern Coast, all of them included in the Ribeira do Iguape Ecoregion sensu Abell et al. (2008). Sampled streams are independent coastal slow-moving acidic environments with high humic acid content. They have their origins at low altitudes in the alluvial plains, also called Coastal Plain Forest, which represents one of the faces of the Atlantic Forest biome, commonly found in the region of the Serra do Mar hills (Marques et al., 2015). The area consists of Dense Ombrophilous Forest and Pioneer Formations, with emphasis on Restinga vegetation (coastal sand-dune habitats) (Instituto Ekos...
Table 1. Characteristics of the sampling sites in the municipalities of Bertioga and São Sebastião, SP. FaR — High dry Restinga Forest; FODT — Lowland Rainforest; FODM — Dense Sub-Montana rainforest (Adapted from Esteves et al., 2019).

| Sub-basin  | Catchment Area (ha) | Stream | Distance from the sea (km) | Acronym | Dominant vegetation | Coordinates |
|------------|---------------------|--------|---------------------------|---------|---------------------|-------------|
| Guaratuba   |                     | Peralta 1** | 1.75 | P1       | FaR, FODT | $23^\circ 44' 27.1"$ S $045^\circ 50' 28.5"$ |
|            |                     | Peralta 2** | 1.87 | P2       | FaR, FODT | $23^\circ 44' 23.7"$ S $045^\circ 50' 24.6"$ |
|            |                     | Peralta 3** | 2.97 | P3       | FaR, FODT | $23^\circ 43' 47.6"$ S $045^\circ 50' 07.9"$ |
|            | 11.30               | Peralta 4** | 2.35 | P4       | FaR, FODT | $23^\circ 44' 08.0"$ S $045^\circ 50' 18.3"$ |
|            |                     | Peralta 5** | 1.57 | P5       | FaR, FODT | $23^\circ 44' 31.0"$ S $045^\circ 50' 16.8"$ |
|            |                     | Peralta 6** | 1.56 | P6       | FaR, FODT | $23^\circ 44' 31.0"$ S $045^\circ 50' 11.8"$ |
| Itaguaré   | 9.04                | Maneco Pinto | 3.1 | MP      | FaR, Fdbb | $23^\circ 46' 08.2"$ W $46^\circ 00' 20.4"$ |
| Itapanhá   | 14.90               | João Pereira 1* | 3.17 | JP1     | FaR, Fdbb | $23^\circ 47' 06.6"$ S $046^\circ 03' 01.2"$ |
|            |                     | João Pereira 2* | 3.29 | JP2     | FaR      | $23^\circ 47' 03.0"$ S $046^\circ 03' 03.6"$ |
| Una        | 12.06               | Bora Bora 1* | 0.39 | BB1     | FODT, FDOM | $23^\circ 45' 21.8"$ S $045^\circ 48' 14.6"$ |

* sites located within the Parque Estadual Restingas de Bertioga (PERB). ** sites within private properties; † proximity of villages/roads.

Figure 2. View of one of the sampling sites (JP1, Itapanhá sub-basin), showing block nets at the 100 m sampled stretch.

Brasil, 2008), which range from grasslands and shrublands to forests, with a maximum canopy height of 20 m (Bonilha et al., 2012).

Samplings were performed during the low rainfall season (July-September/2016). The criteria used to select the sampling sites were accessibility, the adequacy for electrofishing, salinity ≤ 0.05 ppm and good conservation status of the streams, for instance, with preserved vegetation and with a minimum of anthropic influences.

Streams were characterized according to its dominant terrestrial vegetation, based on França & Rolim (2000), Instituto Ekos Brasil (2008), Guedes et al. (2006) and Pinto-Sobrinho et al. (2011). A physical assessment of some habitat variables was conducted along a 100 m stretch of each stream. The following descriptors were considered and scored according to Callisto et al. (2014): percentage of high canopy (Diameter at Breast Height > 0.3 m); leaf banks (%); overhanging vegetation (< 1 m from the surface) (%); sand (0.6-2 mm) (%); silt/clay (%). Some water variables as temperature, pH, dissolved oxygen and electrical conductivity were recorded at each stream with a HORIBA multiparameter probe, model U-5000G. Dissolved Organic Carbon (DOC) was analyzed according to APHA/AWWA/WEF (2012).

Each sample was sampled three times along a 100 m stretch isolated with block nets, where electrofishing was performed using a Honda EUi10 Generator (CA, 1000 W). Fish were separated into containers, anesthetized in eugenol solution, fixed in a 10% formalin solution, and transferred to 70% ethanol after 10 days. Specimens were deposited at the ichthiological collection of the Museu de Zoologia da Universidade Estadual de Campinas “Adão José Cardoso” (ZUEC 16629).

Specimens were measured (total length, mm) and weighed (W, g) in the laboratory. Sex was determined through macroscopic analysis of the gonads, which were removed, weighed, and fixed in 70% ethanol. The degree of maturation was determined according to Vazzoler (1996). Specimens were considered immature/juveniles if it was not possible to distinguish sex through gonads or secondary characteristics. The gonadosomatic index (GSI) was calculated for mature females and males according to Santos (1978), following the formula $GSI = 100 \frac{GW}{TW}$, where $GW$ is the gonad weight and $TW$ is the total weight. Fecundity was estimated by direct counts of fixed mature ovarian subsamples. Oocytes were sub-sampled three times with a Hensel-Stempel pipette, samples counted and measured in a Sedgewick Rafter chamber (Sá-Oliveira & Chelappa, 2002). A minimum of 50 oocytes were measured for each female according to Gomes et al. (2011). Absolute fecundity was calculated considering the total of vitellogenic oocytes (Vazzoler, 1981), herein considered those with a diameter ≥ 0.6 mm. To calculate the relative fecundity, the absolute fecundity of each female was divided by its weight (g) (Adebisi, 1987), and then the average relative fecundity per stream was calculated. The sex ratio was determined by the distribution of male and female frequencies in each stream.

The length-weight relationship (LWR) was calculated for mature and immature specimens separately. We calculated the regression for each stream according to the equation $W = a L^b$, where $W =$ weight, $L =$ Length, $a =$ intersection with y-axes and $b =$ slope (angular coefficient). After logarithmic transformation of the data we obtained the coefficient $A$ and $B$ by the least squares method for the equation $\log(W) = \log A + \log Bx$, where $a = e^A$ and $b = B$ (Santos, 1978; Braga, 1986). Prior to regression analysis, log$_{10}W$-log$_{10}L$ plots of $W$ and $L$ were used to detect and exclude outliers (Froese, 2006). Initially, to test for significant differences between males and females, we compared the slope ($B$) of the linearized re-
gressions for grouped streams using PAST 4.05 software. When slopes were statistically similar, males and females were grouped for each stream in the subsequent analysis. Linearized equations of the LWR were performed to compare the slopes (b) obtained for immatures and adults of the different streams, using the PAST 4.08 software (Hammer et al., 2001). The coefficient of determination R² was used as a measure of the strength of the straight-line relationship.

The allometric condition factor (K = W/Lᵇ) was assessed for comparisons among adults (females and males) and immatures (Le Cren, 1951; Weatherley, 1972) from the different streams, where b is the allometry coefficient related with the form of the individuals’ growth calculated from the length-weight relationship. A Student t-test (one-tailed; p < 0.025) was performed to test whether the estimated b values differed significantly from a value of 3. The species growth was considered isometric when the value of b = 3, and allometric when this value was lower or higher than 3 (Ricker & Carter, 1958).

Data analysis

We performed a Principal Component Analysis (PCA) from the linear correlation matrix of the environmental variables on the PC-ORD v.6.0 software (McCune & Mefford, 2011). Data in percentage were arcsin square-root transformed, and the axes retained for interpretation chosen through the Broken-stick criterion (McCune & Mefford, 2011).

The Shapiro-Wilk test of normality and Levene’s test of homoscedasticity were used to determine whether parametric ANOVA or the non-parametric Kruskal-Wallis test should be used to test for differences between mean oocyte diameter, gonadal-somatic index, condition factor and total length of females, males and immatures. When data fit assumptions of normality and/or homogeneity of variance, we employed a one-way ANOVA considering the streams as independent samples. A post hoc Tukey test was used to determine which streams showed significant differences (p < 0.05). For non-parametric data, the Kruskal-Wallis ANOVA and Dunn’s post-hoc test were employed. A chi-square test (α = 0.05) was applied to verify the existence of significant differences between the number of males and females, and a ‘two sample’ t-test to compare mean lengths between males and females (grouped streams), with significance at the 5% level. All analyses were performed with PAST 4.08 software (Hammer et al., 2001).

RESULTS

Environmental variables presented high variation among sites as shown by Table 2 and Fig. 3. The first PCA axis retained for interpretation (eigenvalue = 2.78) explained 27.9% of total variance, and the second axis (eigenvalue = 2.64) 26.4% (Fig. 3). Axis 1 reflected habitat characteristics related to substrate type, with sand (r = 0.950) and silt/clay (-0.834) showing the highest loadings, to which P5 was associated. Sites from the Itaguáre and Itapanhaú sub-basins (MP, JP1, JP2) were associated to high canopy and pH on the positive side of Axis 2, while most of the sites of the Guaratuba sub-basin were related to higher temperature (r = -0.863) and leaf banks (r = -0.698) on the negative side.

A total of 185 specimens were analyzed, comprising 82 adults (37 males and 45 females) and 103 immature individuals. Mean length of females and males was similar among streams (Table 3), while for immatures, the Kruskal-Wallis test indicated significant differences among sites. The highest values were observed in streams P2, P3 and MP (Table 4). The two sample t-test on mean length between males and females, showed no significant differences between them (t = 0.229; p = 0.81).

The sex ratio (male: female) varied among streams, however the values did not depart significantly from the expected 1:1 ratio in the different streams according to the χ² test (p ≥ 0.05). The mean Gonadosomatic Somatic Index (GSI) of the females was similar between stream samples, while significant differences were found between males according to the ANOVA (Table 3). The mean absolute fecundity for 25 females varied between 604 and 708 oocytes (SD = 98.7) and the relative fecundity between 132 and 192 oocytes (SD = 65.3). ANOVA did not show significant differences between these variables among streams (Table 3).

The condition factor of mature adults was significantly different among streams as indicated by the ANOVA, with exception of P4 and P6 from the Guaratuba sub-basin (Table 3). For immatures, the condition factor also differed significantly among streams, as shown by the Kruskal-Wallis test (Table 4), with highest value observed at MP (0.068) and the lowest value at JP2 (1.3 × 10⁻⁵). Dunn’s post hoc comparisons showed that P1 and P2 presented similar values.

Fecundity data was obtained from the analysis of 25 mature females which ranged from 58.0 to 99 mm TL. They were obtained at streams P2 (N = 4), P3 (N = 3), P4 (N = 10), P5 (N = 4), P6 (N = 4). Oocyte diameter varied from 0.35 mm to 0.90 mm, showing a more developed group ready to be released, with mode at 0.6 mm observed in all streams (Fig. 4).

### Table 2. Basic environmental characteristics of ten coastal blackwater streams sampled in the municipalities of Bertioga and São Sebastião, SP, in the low productivity season, indicating the range of values, mean and Standard Deviation (SD).

| Maximum | Minimum | Mean | SD |
|---------|---------|------|----|
| High Canopy (%) | 72.5 | 17.5 | 36.0 | 16.2 |
| Leaf Banks (%) | 95.0 | 20.0 | 63.5 | 23.9 |
| Overhanging vegetation (%) | 50.0 | 25.0 | 41.5 | 9.8 |
| Sand (%) | 73.0 | 12.0 | 41.0 | 18.9 |
| Silt/Clay (%) | 80.0 | 8.0 | 45.6 | 25.9 |
| Temperature (°C) | 20.5 | 17.0 | 19.2 | 1.2 |
| pH | 6.1 | 3.6 | 4.7 | 1.0 |
| Conductivity (µS.cm⁻¹) | 125.0 | 66.0 | 91.4 | 17.6 |
| Dissolved Oxygen (mg.L⁻¹) | 10.4 | 1.4 | 5.9 | 2.7 |
| Dissolved Organic Carbon (mg.L⁻¹) | 87.1 | 13.9 | 41.6 | 30.1 |
Figure 3. Principal Components Analysis (PCA) plot of environmental variables measured at 10 blackwater streams in the Baixada Santista and Northern Coast Basins, São Paulo state. Environmental variables are indicated by vectors. DOC = Dissolved Organic Carbon; Temp = Temperature; C = Conductivity; DO = Dissolved Oxygen; HC = High Canopy; S = Sand; SC = Silt/Clay; LB = Leaf Banks; OV = Overhanging vegetation. For stream acronyms see Table 1.

Table 3. Intraspecific variation of life-history traits in streams where mature adults of *Hollandichthys multifasciatus* were found, and results of the ANOVA and Chi-Squared test ($\chi^2$). F = Females; M = Males; GSI = Gonado-Somatic Index; RF = Relative Fecundity; AF = Absolute Fecundity. Means with different superscripts were significantly different ($p < 0.05$). For stream acronyms see Table 1.

| Site | P2 | P4 | P5 | P6 | P1* | BB1* |
|------|----|----|----|----|-----|------|
| Size range (mm) | 48-87 | 42-90 | 47-107 | 58-90 | 51-99 | 45-84 |
| Sex ratio (M:F) | 1:1.1 | 1:1.2 | 1:0.7 | | | |
| Mean GSI (F) | 5.2 | 6.1 | 7.4 | 7.5 | | |
| Mean GSI (M) | 1.96<sup>a</sup> | 0.77<sup>b</sup> | 1.35<sup>c</sup> | | 1.57<sup>d</sup> | 6.014 | 0.003 |
| Mean Condition Factor (K) | $3.22 \times 10^{-5}$<sup>a</sup> | $9.45 \times 10^{-6}$<sup>b</sup> | $4.08 \times 10^{-5}$<sup>c</sup> | $7.72 \times 10^{-4}$<sup>d</sup> | $1.23 \times 10^{-3}$<sup>e</sup> | 683.4 | 0.000 |
| Mean RF | 157.8 | 192.9 | 132.6 | 148.9 | 154.1 | 1.066 | 0.388 |
| Mean AF | 604.1 | 713.3 | 679.1 | 708.2 | 605.5 | 1.269 | 0.314 |
| Mean length (mm) (F) | 59.2 | 66.8 | 74.3 | 70.3 | 73.2 | 1.895 | 0.133 |
| Mean length (mm) (M) | 64.5 | 67.6 | 73.7 | | | | |
| N – Females | 9 | 18 | 6 | 6 | 4 | 2 |
| N – Males | 8 | 15 | 9 | 0 | 0 | 5 |

* site with low number of specimens not used to calculate all variables.

** values obtained at the different streams.
Table 4. Intraspacific variation of mean length and condition factor (K) in streams where immature specimens of *Hollandichthys multifasciatus* were obtained, and results of the Kruskal-Wallis (H) test. Means with different superscripts were significantly different (p < 0.05). For stream acronyms see Table 1.

| Site | JP1 | JP2 | P1 | P2 | P3* | MP | H   | p   |
|------|-----|-----|----|----|-----|----|-----|-----|
| Size range (mm) | 22-40 | 23-76 | 15-35 | 48-62 | 48-55 | 47-96 |
| Mean Condition Factor (K) | $3.55 \times 10^{−5}$ | $1.31 \times 10^{−5}$ | $9.38 \times 10^{−6}$ | $5.78 \times 10^{−6}$ | 0.068 | 90.62 | 0.000 |
| Mean length (mm) | 29.8$^a$ | 30.3$^b$ | 24.0$^c$ | 53.6$^b$ | 52.6$^b$ | 60.9$^b$ | 65.41 | 0.000 |

* site with low number of specimens not used to calculate all variables.

Figure 4. Frequency distribution of oocytes diameter (mm) of mature females of *Hollandichthys multifasciatus* sampled at the different coastal blackwater streams in the Baixada Santista and Northern Coast Basins, São Paulo state. P2 (N = 4); P3 (N = 3); P4 (N = 10); P5 (N = 4); P6 (N = 4).
Table 5. Coefficients of the length-weight regressions of mature adults (females + males) (A) and immatures (B), according to the equation: log (TW) = log (a) + b * log (TL), where "a" is the intercept (coefficient related to condition factor), "b" is the regression coefficient (indicative of growth type), and R² is the coefficient of determination, or proportion of variance explained by the model; t = t-test for the results of b values compared to the theoretical value (b = 3, p < 0.025). For stream acronyms see Table 1.

| Stream/Parameters | N  | a          | b        | R²       | t       |
|-------------------|----|------------|----------|----------|---------|
| P4                | 28 | 0.95 × 10⁻¹| 3.04     | 0.960    | 0.310   |
| BB1               | 7  | 1.23 × 10⁻¹| 2.99     | 0.996    | 0.104   |
| P2                | 15 | 3.22 × 10⁻¹| 2.79     | 0.973    | 1.512   |
| P6                | 6  | 7.72 × 10⁻¹| 3.09     | 0.991    | 0.950   |
| P5                | 13 | 4.08 × 10⁻¹| 2.70     | 0.980    | 2.149*  |
| Slope Test (F)    | 1.354 |          |          |          |         |
| p                 |     | 0.259     |          |          |         |

| Stream/Parameters | N  | a          | b        | R²       | t       |
|-------------------|----|------------|----------|----------|---------|
| JP1               | 25 | 3.53 × 10⁻¹| 2.70     | 0.948    | 2.092*  |
| JP2               | 24 | 1.29 × 10⁻¹| 3.01     | 0.959    | 0.048   |
| P1                | 27 | 9.21 × 10⁻¹| 2.42     | 0.882    | 2.720** |
| P2                | 11 | 0.02       | 2.63     | 0.924    | 1.396   |
| MP                | 10 | 0.07       | 1.04     | 0.961    | 26.625**|
| Slope Test (F)    | 5.47 |          |          |          |         |
| p                 |     | 0.001     |          |          |         |

* b is significantly different from 3 (P = 0.025).
** b is significantly different from 3 (P = 0.01).

The high coefficient of determination values obtained in the assessment of LWRs for adults and immatures at the different streams indicated a good quality of the prediction of the linear regression for (R² > 0.88) (Table 5). The slope test (b) between the LWR obtained for the different streams indicated no significant differences between adults (p = 0.259), but significant differences between immatures (p = 0.001). The b coefficient, which is indicative of the type of growth, varied from 2.7 to 3.09 for adults (males and females) and 1.04 to 3.01 for immatures. The growth was predominantly isometric in streams P4, BB1, P2 and P6, and allometric in P5, JP1, P1 and MP.

DISCUSSION

Streams were located in preserved areas with some heterogeneity of environmental conditions, which distinguished streams from the Guaratuba sub-basin from the other sub-basins due to higher values of temperature and leaf banks. Compared to other Atlantic Forest coastal plain rivers (Ferreira et al., 2014), lower values of pH and higher conductivity were observed in our study. For DOC values, no information was found for Atlantic Forest backwater streams, but when they are compared to those observed in blackwaters of the Rio Negro, the major tributary to the Amazon, we obtained higher values than Duarte et al. (2016), who recorded concentrations between 8-12 mg C L⁻¹, but up to 35 mg C L⁻¹.

Most of the analyzed life-history traits of *H. multifasciatus* were similar among streams, suggesting that site-specific factors did not influence size of adults, maturation, sex ratio or fecundity. Resource availability seems to play an important role in life-history aspects of different species, being considered theoretically a potent agent of selection on life history traits (Grether et al., 2001). High levels of dissolved organic carbon (DOC) reduce ecosystem productivity and resource availability (Craig et al., 2015), and such relations were observed by Craig et al. (2017) for populations of bluegill (*Lepomis macrochirus*). They found a strong negative relationship between maximum size and DOC concentration and lower fecundity in a set of lakes with DOC concentrations ranging from 3 to 24 mg. L⁻¹. Guppies (*Poecilia reticulata* Peters, 1859) from Trinidad streams living in resource-rich streams were able to grow faster, reach larger sizes, and allocate more resources to reproduction (Grether et al., 2001), and in this case, stream differences in canopy cover could translate into stream differences in resource availability. Although these aspects must be further investigated in blackwater streams, the similarity in the several life-history traits of *H. multifasciatus*, suggests that the preserved riparian conditions of the different streams may be more important than the high DOC levels in determining resource availability for this species. This may be explained by the food habits of *H. multifasciatus*, which is considered an omnivorous species that consumes great proportions of plants and terrestrial insects, due to its surface picking behavior (Abilhoa et al., 2009).

We observed that mature females with vitellogenic oocytes displayed a similar spawning pattern among sites during the sampling period, suggesting that mature oocytes are spawned at once within this reproductive event. This agrees with Lemos (2019) who found that *H. multifasciatus* had high frequencies of mature females in the rainy and dry seasons in coastal streams of Bertioga (SP). Frequency distribution of oocyte diameter indicated total spawning, and size was higher than that observed by Oliveira (2019) for this species (0.15-0.7 mm). Nevertheless, fecundity was lower than the mean values recorded by this author in clear and blackwater Atlantic Forest streams (860.2), which may be attributed to a higher size attained by the species in their study, since larger fish have large gonads and consequently can produce more oocytes and more offspring (Wootton, 1992). Observed fecundity values can be considered low when compared to non-inseminating characids, as found by Mazzoni et al. (2005) for *Astyanax janeiroensis* Eigenmann, 1908 (3.169-18.714 oocytes) in coastal streams of Rio de Janeiro State. This may be explained by the fact that among small sized species, lower relative fecundity values may be associated with the presence and efficiency of insemination (Azevedo, 2010).

Environmental factors may also regulate variations in either egg size or number between and within populations of freshwater fish, as reported by Lobón-Cerviá et al. (1997), who found that trout at sites which were fully covered by canopy spawned fewer, but larger, eggs.
than fast-growers in unshaded sites. In coastal streams, rainfall regime may be considered an important factor as pointed out by Menezes & Caramaschi (1994). Braga et al. (2008) for example, reported that inseminations of the Glandulocaudinae Mimagoniates microlepis (Steindachner, 1877) seem to occur in the dry season, when the habitat is reduced and encounters between males and females are most probable. As H. multifasciatus and M. microlepis are both inseminating and related species (Thomaz et al., 2010), it is possible that the low water level during the period of our study may also influence the reproductive behavior of H. multifasciatus.

The condition factor of adults, immatures and the mean length of immatures were the only parameters that showed intraspecific variations, which can be related to differences in such factors as temperature and food supply, as condition factor is an index that indicates the “well-being” of the fish (Froese, 2006). The higher condition factor observed for immatures suggests that they are in a rapid growth phase, directing the feeding resources to their growth. This has been observed for other Neotropical species, as several characids in the Upper Paraná River floodplain (Lizama & Ambrósio, 2002) and Micropogonias furnieri (Desmarest, 1823), with higher condition independent of the time and distribution area (Costa & Araújo, 2003).

Spatial differences in the condition factor among adults were observed even at nearby streams like P2 and P4, which showed similar environmental conditions, suggesting that site-specific factors other than food availability may have influenced these values. In fact, differences in the condition factor have been interpreted as a measure of several biological events, such as fat reserves, adaptation to the environment and gonadal development (Le Cren, 1951). It is known that fish usually decrease their feeding activity and use their lipid reserves during spawning which results in a decrease in condition (Lizama & Ambrósio, 2002). Thus, it is possible that the observed dissimilarities in condition were related to differences in growth and/or breeding of fish between localities, as confirmed by the difference in slopes of the LWR for immatures. Similar observations were found for trout, by Lobón-Cerviá & Rincón (1998) who observed differences in growth between localities 1-2 km apart.

It can be concluded that H. multifasciatus showed few intraspecific variations of the analyzed life-history traits under natural conditions during the low precipitation period, despite variations in some environmental conditions among sub-basins. Although other aspects of the biology of H. multifasciatus should be further investigated, the obtained results may help to document natural variations of traits of an endemic fish species, providing foundation for future efforts to examine the biotic and abiotic factors associated with the life histories of imperiled fishes.

AUTHORS’ CONTRIBUTIONS: VCC: Investigation, Writing – original draft; KEE: Resources, Conceptualization, Supervision; VCC, KEE: Writing – review & editing. All authors actively participated in the discussion of the results, they reviewed and approved the final version of the paper.

CONFLICTS OF INTEREST: Authors declare there are no conflicts of interest.

FUNDING INFORMATION: Funding for this work was provided by FAPESP (grant #2015/26728-6). VCC was funded by CNPq (PIBIC #03/2018).

ACKNOWLEDGMENTS: We thank Maria Letizia Petessee for comments on the manuscript. We also thank Maressa Helena Nanini Costa, Marcelo Horikoshi Candido da Silva, Sergio Luiz da Silva, Ronaldo de Flores Bernardino, Luiz Evangelista and Renato Horikoshi Candido da Silva for help in the fieldwork. João Batista Pinheiro da Silva, Marizete Ramos dos Santos and Bolivar Barbanti assisted us during the collections. The Peralta group allowed us to perform part of the study on their property. We thank the Forestry Institute of São Paulo State (SMA Process: 30 260108-003286/2016). Permissions for collecting specimens and experimentation were granted by ICMBio/SISBIO (№ 54432-1) and the Animal Experimentation Ethics Committee from the Fisheries Institute (№ 05/2016), respectively.

REFERENCES

Abell, R.; Thieme, M.L.; Revenga, C.; Fryer, M.; Kottelat, M.; Bogutskaya, N.; Coad, B.; Mandrak, N.; Balderas, S.C.; Bussing, W.; Stassev, M.L.J.; Skelton, P.; Allen, G.R.; Unmack, P.; Naseka, A.; Ng, R.; Sindorf, N.; Robertson, J.; Armijo, E.; Higgin, J.V.; Hebel, T.J.; Wikramanayake, E.; Olson, D.; López, H.L.; Reis, R.E.; Lundberg, J.G.; Pérez, M.H.S. & Paula Petry. 2008. Freshwater ecoregions of the world: A new map of biogeographic units for freshwater biodiversity conservation. Bioscience, 58(5): 403-414. https://doi.org/10.1641/B580507.

Adeebi, V.; Bornatowski, H. & Otto, G. 2009. Temporal and ontogenetic variations in feeding habits of Hollandichthys multifasciatus (Teleostei: Characidae) in coastal Atlantic rainforest streams, southern Brazil. Neotropical Ichthyology, 7(3): 415-420. https://doi.org/10.1590/S1679-62522009000500001.

Adebisi, A.A. 1987. The relationships between fecundities, gonadosomatic indices and egg sizes of some fishes of the Ogun River, Nigeria. Archiv für Hydrobiologie, 111(1): 151-156.

American Public Health Association (APHA); American Water Works Association (AWWA) & Water Environment Federation (WEF). 2012. Standard methods for the examination of water and freshwater. Washington DC, APHA/AWWA/WEF.

Azevedo, M.A. 2010. Reproductive characteristics of characid fish species (Teleostei, Characiformes) and their relationship with body size and phylogeny. Iheringia, Série Zoologia, 100(4): 469-482. https://doi.org/10.1590/S0085-51732010000400001.

Begon, M.; Townsend, C.R. & Harper, J.L. 2006. Ecology: From individuals to ecosystems. Oxford, Blackwell Publishing.

Bertaco, V.A. 2003. Taxonomía e filogenia do gênero Hollandichthys Eigenmann, 1909 (Teleostei: Characidae) do sul e sudeste do Brasil (Master’s Dissertation). Pontifícia Universidade Católica do Rio Grande do Sul, Porto Alegre (RS).

Bertaco, V.A. & Malabarba, L.R. 2013. A new species of the characid genus Hollandichthys Eigenmann from coastal rivers of southern Brazil.
Cardoso, V.C. & Esteves, K.E.: Life-History traits of *Hollandichthys*

Blanc, A. & Lamouroux, N. 2007. Large-scale intraspecific variation in life-history traits of European freshwater fish. *Journal of Biogeography*, 34(5): 862-875. https://doi.org/10.1111/j.1365-2699.2006.01654.x.

Bonilha, R.M.; Casagrande, J.C. & Soares, M.R. 2012. Characterization of the soil fertility and root system of restinga forests. *Revista Brasileira de Ciências do Solo*, 36(1): 1804-1813. https://doi.org/10.1590/S0100-06832012000600141.

Braga, F.M.S. 1986. Estudo entre fator de condição e relação peso-comprimento para alguns peixes marinhas. *Brazilian Journal of Biology*, 46(2): 339-346.

Braga, M.R.; Aranha, J.M.R. & Vitule, J.R.S. 2008. Reproduction period of *Mimagoniates microlepis*, from an Atlantic Forest stream in southern Brazil. *Brazilian Archives of Biology and Technology*, 51(2): 345-351. https://doi.org/10.1590/S1516-89132008000200014.

Callisto, M.; Pompeu, O.S.; Alves, C.B.M.; Santos, G.B. 2014. Perspectivas na abordagem de índices de Integridade Biótica com peixes e bentos em bacias hidrográficas no cerrado. In: Callisto, M.; Alves, C.B.M.; Lopes, J.M. & Castro, M.A. (Eds.). Condições ecológicas em bacias hidrográficas de empreendimentos hidrelétricos. Belo Horizonte, Companhia Energética de Minas Gerais. p. 235-240.

Camargo, A.F.M.;ucci, P.R.; Binj, L.M. & Silva, I.L. 1997. The influence of the geology on the limnological characteristics of some lotic ecosystems of the Itanhaém River Basin, SP, Brazil. *SIL Proceedings*, 26(2): 860-864. https://doi.org/10.1080/03680770.1995.11900840.

Costa, M.R. da & Araújo, F.G. 2003-Length-weight relationship and condition factor of *Micropogonias furnierii* (Desmarest) (Perichromis, Sciaenidae) in the Sepetiba Bay, Rio de Janeiro State, Brazil. *Revista Brasileira de Zoologia*, 20(4): 685-690. https://doi.org/10.1590/S0101-81752003000400022.

Craig, N.; Jones, S.E.; Weidel, B.C. & Solomon, C.T. 2015. Habitat, not resource availability, limits consumer production in lake ecosystems. *Limnology and Oceanography*, 60(6): 2079-2089. https://doi.org/10.1002/loio.10153.

Craig, N.; Jones, S.E.; Weidel, B.C. & Solomon, C.T. 2017. Life history constraints explain negative relationship between fish productivity and dissolved organic carbon in lakes. *Ecology and Evolution*, 7(16): 6201-6209. https://doi.org/10.1002/ece3.3108.

Duarte, R.M.; Smith, D.; Val, A.L. & Wood, C.M. 2016. Dissolved organic carbon from the upper Rio Negro protects zebrasfish (*Danio rerio*) against ion regulatory disturbances caused by low pH exposure. *Scientific Reports*, 6: 20(377): 1-10. https://doi.org/10.1038/srep20377.

Esteves, K.E. & Lobón-Cerviá, J. 2001. Composition and trophic structure of a fish community of a clear water Atlantic rainforest stream in southeastern Brazil. *Environmental Biology of Fishes*, 62(4): 429-440. https://doi.org/10.1007/s01015-001-0158-x.

Esteves, K.E.; Silva, M.H.C.; Nanini-Costa, M.H. & Petesce, M.L. 2019. Organization of fish assemblages in blackwater Atlantic Forest streams. *Neotropical Ichthyology*, 17(1): e180120. https://doi.org/10.1590/1982-0224-20180120.

Felisberto, M.L.G. 2020. Eutrofia da comunidade de peixes em rios costeiros de águas pretas da Mata Atlântica no Sudeste do Brasil. *SIL Proceedings*, 27(6): 1-16. https://doi.org/10.1590/S1679-62252012000300022.

Gonçalves, C.S.S.; Braga, F.M.S. 2012. Changes in ichthyofauna composition along a gradient from clearwaters to blackwaters in coastal streams of Atlantic forest (southeastern Brazil) in relation to environmental variables. *Neotropical Ichthyology*, 10(3): 675-684. https://doi.org/10.1590/S1679-62251003000200002.

Gonçalves, C.S.; de Souza Braga, F.M. & Casatti, L. 2018. Trophic structure of coastal freshwater stream fishes from an Atlantic rainforest: evidence of the importance of protected and forest-covered areas to fish diet. *Environmental Biology of Fishes*, 101(6): 1-16. https://doi.org/10.1007/s10692-018-0749-8.

Grether, G.F.; Millie, D.F.; Bryant, M.J.; Reznick, D.N. & Mayea, W. 2001. Rain Forest Canopy Cover, Resource Availability, and Life History Evolution in Guppies. *Ecology*, 82(6): 1546. https://doi.org/10.1890/0012-9658(2001)082[1546:RFCAV]2.0.CO;2.

Guedes, D.; Barbosa, L.M. & Martins, S.E. 2006. Composição florística e estrutura fitossociológica de dois fragmentos de Floresta de restinga no município de Bertioga, SP, Brasil. *Acta Botanica Brasilica*, 20: 299-311. https://doi.org/10.1590/S0102-33062006000200006.

Hammer, O.; Harper, D.A.T. & Ryan, P.D. 2001. PAST: Paeontological Statistics software package for education and data analysis. *Palaeontologia Electronica*, 4(1): 9p. https://doi.org/10.1590/1982-0224-20180120.

Instituto Chico Mendes de Conservação da Biodiversidade (ICMBio)/Ministério do Meio Ambiente (MMA). 2018. *Livro Vermelho da Fauna Brasileira Ameaçada de Extinção*. Brasilia, ICMBio/MMMA.

Instituto Ekos Brasil. 2008. *Diagnóstico socioambiental para criação de unidades de conservação polígono Bertioga: relatório final*. Available: http://assets.wwfbr.panda.org/downloads/diagnostico_socioambiental_para_criacao_de_unidades_de_conservacao.pdf. Access: 20/12/2020.

Jollib, M. 1994. *Fish Bioenergetics*. London, Chapman & Hall.

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

Lemos, C.A. 2019. *Biologia de populações de peixes do Riacho da Vila de Itatinga, Bertioga, São Paulo (Doctoral Thesis)*. Universidade Federal de São Carlos, São Carlos (SP).

Lima, F.C.T.; Buckup, P.A.; Menezes, N.A.; Lucena, C.A.S.; Lucena, Z.M.S.; Toledo-Piza M. & Zanata, A. 2007. Família Characidae: gêneros incertae sedis. In: Buckup PA, Menezes NA, Ghazzi MS (Eds.). *Catálogo das espécies de peixes de água doce do Brasil*. Rio de Janeiro, Museu Nacional. p. 44-62.

Lizama, M.L. & Ambrósio, A.M. 2002. *Família Characidae: gêneros incertae sedis*. In: *Diagnóstico socioambiental para criação de unidades de conservação polígono Bertioga: relatório final*. Available: http://assets.wwfbr.panda.org/downloads/diagnostico_socioambiental_para_criacao_de_unidades_de_conservacao.pdf. Access: 20/12/2020.

França, F.S. & Rolim S.G. 2000. Estrutura de um trecho de floresta de restinga no município de Bertioga (SP). In: Watanabe S. (Ed.). *Simpósio de Ecossistemas Brasileiros: Conservação, 5os. Anais*. São Paulo, ACIESP. p. 84-91.

Froese, R. 2006. Cube law, condition factor and weight-length relationships: History, meta-analysis and recommendations. *Journal of Applied Ichthyology*, 22(4): 241-53. https://doi.org/10.1111/j.1439-0426.2006.00805.x.

Garcia, E. & Braña F. 1988. Reproductive biology of brown trout (*Salmo trutta*) in the Aller river (Asturias, Northern Spain). *Polish Archivum Hydrobiologii*, 3(3-4): 361-374.
Brazilian Journal of Biology, 62(1): 113-124. https://doi.org/10.1590/0100-929X.20110003.

Lobón-Cerviá, J. & Rincón, P.A. 1998. Field Assessment of the Influence of Temperature on Growth Rate in a Brown Trout Population. Transactions of the American Fisheries Society, 127(5): 718-728. https://doi.org/10.1577/1548-8659(1998)127<0718:FAOTOT>2.0.CO;2.

Lobón-Cerviá, J.; Utrilla, C.G.; Rincón, P.A. & Amezua, F. 1997. Environmentally induced spatio-temporal variations in the fecundity of brown trout Salmo trutta: Trade-offs between egg size and number. Freshwater Biology, 38(2): 277-288. https://doi.org/10.1046/j.1365-2427.1997.00217.x

Lytle, D.A. & Poff, N.L. 2004. Adaptation to natural flow regimes. Trends in Ecology & Evolution, 19(2): 94-100. https://doi.org/10.1016/j.tree.2003.10.002.

Marques, M.C.M.; Silva, S.M. & Liebsch, D. 2015. Coastal plain forests in southern and southeastern Brazil: ecological drivers, floristic patterns and conservation status. Brazilian Journal of Botany, 38(1): 1-18. https://doi.org/10.1590/0100-929X.20110003.

Mazzoni, R.; Mendonça, R.S. & Caramaschi, E.P. 2005. Reproductive biology of Astyanax janeirensis (Osteichthyes, Characidae) from the Ubatita River, Maricá, RJ, Brazil. Brazilian Journal of Biology, 65(4): 643-649. https://doi.org/10.1590/S1519-69842005000400012.

McCune, B. & Mefford, M.J. 2011. PC-ORD. Multivariate Analysis of Ecological Data. Version 6.0 MJM Software, Gleneden Beach, Oregon, U.S.A.

Menezes, M.S. de & Caramaschi, E.P. 1994. Características reprodutivas de Hypostomus grupo H. punctatus no rio Ubatita, Maricá, RJ (Osteichthyes, Siluriformes). Revista Brasileira de Biologia, 54(3): 503-513.

Menezes, N.A.; Weitzman, J.; Oyakawa, O.T.; Lima, F.C.T.; Castro, R.M.C. & Weitzman, M.J. 2007. Peixes de água doce da Mata Atlântica: lista preliminar das espécies e comentários sobre conservação de peixes de água doce neotropicaís. MZUSP, São Paulo.

Oliveira, J.C. 2007. Aspectos reprodutivos do lamarí-listrado Hollandichthys multifasciatus (Characiformes: Characidae) de rios costeiros da Mata Atlântica, São Paulo, Brasil. (Undergraduate Monography), Universidade Estadual Paulista, Rio Claro.

Oyakawa, O.T.; Menezes, N.A.; Shibatta, O.A.; Lima, F.C.T.; Langeani, F.; Pavanelli, C.S.; Nielsen, D.T.B. & Hilsdorf, A.W.S. 2009. Peixes. In: Bressan P.M.; Kierulf, M.C.M.; Sugieda A.M. (Eds.). Fauna ameaçada de extinção no Estado de São Paulo: vertebrados; Fundação Parque Zoológico de São Paulo, Secretaria do Meio Ambiente.

Pianka, E.R. 1970. On r- and K- selection. American Naturalist, 104: 592-597. https://doi.org/10.1086/282697.

Pinto-Sobrinho, F.A.; Souza, C.R.D.G. & Mogollón, J.E.J.B. 2011. Análise Estructural de Florestas de Restinga associadas a Depósitos Marinhos Pleistocénicos e Holocênicos na Bacia do Rio Itaguaré, Bertioga (SP). Revista do Instituto Geológico, 32: 27-40. https://doi.org/10.5935/0100-929X.20110003.

Por, F.D. 1992. Sooretama, the Atlantic rainforest of Brazil. The Hague, SPB Academic Publishing.

Pringle, C.M.; Naiman, R.J.; Gretschko, G.; Kerr J.R.; Oswood, M.W.; Webster, J.R.; Welcomme, R.L. & Winterbourn, M.L. 1988. Patch dynamics in lotic systems; the stream as a mosaic. Journal of the North American Benthological Society, 7(4): 503-524. https://doi.org/10.2307/1467303.

Ribeiro, A.C. 2006. Tectonic history and the biogeography of the freshwater fishes from the coastal drainages of eastern Brazil: an example of faunal evolution associated with a divergent continental margin. Neotropical Ichthyology, 4(2): 225-46. https://doi.org/10.1590/S1679-62252006000200009.

Ribeiro, R.B. 2018. Relatório de situação dos recursos hídricos da Baixada Santista 2018. Available: https://sigrh.sp.gov.br/public/uploads/documents/CBH-BS/13787/nt-2018-bs.pdf. Access: 22/11/2021.

Ricker, W.E. & Carter, N.M. 1958. Handbook of computations for biological statistics of fish populations, Bulletin. Fishery Research Board of Canada, 119.

Sabino, J. & Corrêa and Castro, R. 1990. Alimentação, período de atividade e distribuição espacial dos peixes de um rios da Floresta Atlântica (Sudeste do Brasil). Revista Brasileira de Biologia, 50(1): 23-36.

Santos, E.P. 1978. Dinâmica de populações aplicada à pesca e piscicultura. São Paulo, Huajecom.

Sá-Oliveira, J.C. & Chellappa, S. 2002. Fecundidade e tipo de desova do Hoplosternum littorale Hancock (Osteichthyes, Siluriformes) no Rio Curiaia, Macapá, Amapá. Revista Brasileira de Zoologia, 19(4): 1053-1056. https://doi.org/10.1590/S0100-9011-2002000400009.

Sazima, I. 1986. Similarities in feeding behaviour between some marine and freshwater fishes in two tropical communities. Journal of Fish Biology, 29(1): 53-65. https://doi.org/10.1111/j.1095-8649.1986.tb04926.x

Stearns, S.C. & Koella, J.C. 1986. The evolution of phenotypic plasticity in life-history traits: predictions of reaction norms for age and size at maturity. Evolution, 40(5): 893-913. https://doi.org/10.2307/2408752.

Thomaz, A.T.; Malabarba, L.R. & Bonatto, S.L. 2010. The phylogenetic placement of Hollandichthys Eigenmann, 1909 (Teleostei: Characidae) and related genera. Molecular Phylogenetics and Evolution, 57(3): 1347-1352. https://doi.org/10.1016/j.ympev.2010.10.006.

Vazzoler, A.E.A.M. 1981. Manual de Métodos para estudos biológicos de populações de peixes. Reprodução e crescimento. Brasília, CNPq, Programa Nacional de Zoologia.

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

Waters, J.M. & Burridge, C.P. 2016. Fine-scale habitat preferences influence within-river population connectivity; a case-study using two sympatric New Zealand Galaxias fish species. Freshwater Biology, 61: 51-56. https://doi.org/10.1111/fwb.12675.

Weatherley, A.H. 1972. Growth and ecology of fish populations. London, Academic Press.

Winemiller, K.O. 1989. Patterns of Variation in Life History among South American Fishes in Seasonal Environments. International Association for Ecology, 81(2): 225-241. https://doi.org/10.1007/BF00379810.

Wootton, R.J. 1992. Life-Histories and Population Dynamics. In: Fish Ecology. Dordrecht, Springer. p. 132-160. https://doi.org/10.1007/978-94-011-3832-1_6.
Erratum

In the article “Life-History traits of Hollandichthys multifascitus (Eigenmann & Norris, 1900) (Characiformes: Characidae) in coastal Atlantic Forest blackwater streams from Southeastern Brazil”, http://doi.org/10.11606/1807-0205/2022.62.016, published in the Journal Papéis Avulsos de Zoologia, Volume 62: e202262016,

In the title:

Where you read:
Life-History traits of Hollandichthys multifascitus (Eigenmann & Norris, 1900) (Characiformes: Characidae) in coastal Atlantic Forest blackwater streams from Southeastern Brazil

Read it:
Life-History traits of Hollandichthys multifasciatus (Eigenmann & Norris, 1900) (Characiformes: Characidae) in coastal Atlantic Forest blackwater streams from Southeastern Brazil

Published with the financial support of the “Programa de Apoio às Publicações Científicas Periódicas da USP”