SMALL FISH, BIG INDICATORS: STUDY ON GROWTH AND CONDITION FACTOR IN SPECIES FROM THE RIO VERMELHO, MT

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ABSTRACT: The length-weight relationship (LWR) provides biological information that allows estimating the weight of an individual based on its length or vice-versa, in addition to indicating its condition factor. This study aimed to estimate the length-weight relationship and condition factor of four small-sized fish species in a section of the Rio Vermelho, MT, Brazil. Sampling was conducted using a 5 mm mesh trawl net at four distinct sampling sites along the river from July 2010 to July 2011. The collected specimens were fixed in 10% formalin in the field and later preserved in 70% alcohol in the laboratory. For each specimen, the standard length (L) in cm and total weight (W) in g were measured to calculate the condition factor (*K*). To assess significant statistical differences in the condition factor among sampling sites for each species, Student's t-test was used. The type of growth was determined using the equation $W = aL^b$, size classes were defined using Sturges' algorithm, and theoretical L_{50} values were estimated directly from standard length values. A total of 2,059 specimens were collected, including 96 *Odontostilbe pequira*, 953 *Odontostilbe paraguayensis*, 856 *Aphyocharax dentatus*, and 154 *Engraulisoma taeniatum*. The *K values* were significantly different ($p < 0.05$) among most sampling sites for each species. The species *O. pequira*, *A. dentatus*, and *E. taeniatum* exhibited negative allometric growth ($b < 3$), while *O. paraguayensis* showed positive allometric growth ($b > 3$). Based on the results, it was concluded that differences in condition factors may be associated with the environmental characteristics of each sampling site and that the studied species did not exhibit a clear distribution pattern regarding size classes. Further studies on feeding, sex determination, and L_{50} are necessary for a better understanding of the biology of these species.

Keywords: *Odontostilbe pequira*, *Odontostilbe paraguayensis*, *Aphyocharax dentatus*, *Engraulisoma taeniatum*, condition factor, size classes, Pantanal.

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PEQUENOS PEIXES, GRANDES INDICADORES: ESTUDO SOBRE O CRESCIMENTO E FATOR DE CONDIÇÃO EM ESPÉCIES DO RIO VERMELHO, MT

RESUMO: A análise da relação peso-comprimento (RPC) fornece informações biológicas que possibilitam a estimativa do peso do indivíduo a partir do conhecimento do seu comprimento ou vice-versa, além de indicar seu fator de condição. Este trabalho teve por objetivo estimar a relação peso-comprimento e o fator de condição de quatro espécies de peixes de pequeno porte em um trecho do Rio Vermelho, MT. As coletas foram realizadas com o uso de uma rede de arrasto de malha 5 mm em quatro pontos de amostragens distintos do rio, no período de julho de 2010 a julho de 2011. Os espécimes coletados foram fixados em formalina a 10% no campo e posteriormente, em laboratório, conservados em álcool a 70%. Para cada exemplar foi aferido o comprimento padrão (C) em cm e o peso total (P) em g para cálculo do valor do fator de condição (*K*). A fim de se observar a existência de diferenças estatísticas significativas do fator de condição entre os pontos de coleta, para cada espécie, utilizou-se o teste t de *Student*. A determinação do tipo de crescimento foi realizada através da equação $P = aC^b$, as classes de tamanho foram determinadas pelo algoritmo de Sturges e os valores do L_{50} teórico foram estimados diretamente através dos valores referentes ao comprimento padrão. Foram coletados 2.059 exemplares no total, sendo 96 da espécie *Odontostilbe pequira*, 953 de *Odontostilbe paraguayensis*, 856 de *Aphyocharax dentatus* e 154 de *Engraulisoma taeniatum*. Os valores de *K* foram significativamente diferentes ($p < 0,05$) entre os vários pontos de coleta para cada espécie. As espécies *O. pequira*, *A. dentatus*, e *E. taeniatum* apresentaram crescimento alométrico negativo ($b < 3$) e a espécie *O. paraguayensis* crescimento alométrico positivo ($b > 3$). Diante dos resultados, concluiu-se que as diferenças nos fatores de condição possivelmente estejam associadas às características ambientais de cada ponto de coleta e que as espécies estudadas não apresentaram um padrão claro de distribuição em relação às classes de tamanho. Estudos futuros sobre alimentação, determinação sexual e do L_{50} são necessários para um melhor entendimento da biologia das espécies.

Palavras-chave: *Odontostilbe pequira*, *Odontostilbe paraguayensis*, *Aphyocharax dentatus*, *Engraulisoma taeniatum*, fator de condição, classes de tamanho, Pantanal.

INTRODUCTION

The Neotropical region stands out as the richest in the number of fish species, with estimates suggesting the existence of up to 9,000 species in freshwater alone (Reis et al., 2016). In the Paraná River Basin, which covers an area of approximately 2,600,000 km² (Langeani et al., 2007), about 341 fish species have been recorded (Dagosta et al., 2024).

Associated with large rivers, there is a high number of headwater streams, inhabited mainly by small fish species, typically less than 15 cm in standard length. These species have restricted geographic distributions, little or no commercial value, and strongly depend on riparian vegetation for feeding, shelter, and reproduction (Böhlke et al., 1978; Lowe-McConnell, 1987). These fish are essential components of freshwater ecosystems, playing a relevant ecological role, especially as they constitute numerically dominant populations in their assemblages (Matheus, 2006). Among them, species of the family Characidae stand out as the most common throughout the Neotropical region (Súarez et al., 2007).

Small fish species account for about 50% of the total freshwater fish species described in South America (Castro et al., 2003). However, until 2009, their biological characteristics were rarely studied or practically unknown (Benitez & Súarez, 2009). Esteves and Aranha (1999) highlighted that ecological studies on stream fish were scarce or, when available, fragmented. According to these authors, the possible explanation for the limited number of studies in this area is primarily related to the lack of knowledge about faunal composition and the absence of economic interest. In recent years, greater attention has been given to smaller water bodies, and the number of studies has grown significantly (Nascimento & Smith, 2016). However, many gaps in these aspects still persist and need to be addressed. This scarcity of information reinforces the importance of studies on the systematics, evolution, and general biology of these species.

The structural characteristics of individuals in a population can be described through the weight-length relationship (WLR) (Benedito-Cecílio & Agostinho, 1997), which establishes the weight corresponding to a given length, regardless of the fish's age (Gomiero & Braga, 2003; Froese, 2006; Gomiero et al., 2008; Gomiero et al., 2010). This relationship provides fundamental information for studying various biological characteristics of different species.

The weight-length relationship can exhibit different growth patterns: (1) isometric growth, when $b = 3$, indicating that weight increases proportionally to length; (2) negative allometric growth, when $b < 3$, characterized by a greater increase in length than in weight; and (3) positive allometric growth, when $b > 3$, where the increase is more pronounced in weight than in length.

These applications allow the indirect determination of weight from length, as well as the analysis of growth and fattening rates through the allometric coefficient, revealing potential changes in shape during ontogenetic development (Braga, 1993; Agostinho, 1997; Santos, 2002). The applications of the weight-length relationship range from estimating the weight of an individual based on its known length to assessing the degree of fattening, known as the condition factor. Additionally, this relationship is useful as an indicator of fat accumulation, gonad development (Le Cren, 1951), and the potential estimation of standing crop in bioecological studies (Lotrich, 1973). The weight-length relationship also serves to describe growth patterns at different stages of the life cycle of fish species, becoming a good indicator of feeding and reproductive activities (Weatherley, 1972). Furthermore, it can be used as a basis for comparing the degree of stress or different environmental conditions among fish with wide geographic distributions (Bolger & Connolly, 1989).

The relationship between weight and body length allows the calculation of the condition factor (K), an index that reflects the interactions between the fish and the biotic and abiotic factors of the environment (Le Cren, 1951; Gomiero & Braga, 2003; Tavares-Dias et al., 2008).

For this reason, the condition factor is widely used in fish biology studies, as it provides relevant information on the physiological state of individuals (Gomiero & Braga, 2003; Santos et al., 2006). Moreover, this index allows the assessment of the condition of fish in a given environment, enabling comparisons between populations subjected to different feeding regimes, climatic conditions, population densities, and stages of gonadal maturation, as well as periods of higher or lower feeding activity (Lizama & Ambrósio, 2002).

Among the studies already conducted on the weight-length relationship, the work of Lizama and Ambrosio (1999) stands out, which investigated this relationship in nine species of characids in the Upper Paraná River floodplain. Another relevant study was conducted by Villares-Junior et al. (2007), who analyzed the weight-length relationship and condition factor of *Salminus hilarii* (Osteichthyes, Characidae) in a specific stretch of the Sorocaba River Basin. The authors observed significant differences in weight-length relationships between males, females, and immature individuals, as well as seasonal variations in the condition factor. These variations were associated with the reproductive period of the species, providing valuable descriptive information on its biology and ecology.

Da Cunha et al. (2014) conducted studies on the weight-length relationship and relative condition factor of *Arapaima gigas* Schinz, 1822, a species popularly known as pirarucu. This species has significant economic importance, being commercialized both as an ornamental fish and as a protein source for food in various Amazonian communities (Cavero et al., 2003; Brandão et al., 2006). The results obtained by the authors provided insights for improving the management procedures of the pirarucu extraction chain. The condition factor (***K***) values indicated good management conditions, according to IBAMA criteria, with most captured fish within the commercial weight range and with high meat quality for commercial purposes.

Another relevant study was conducted by Araújo and Vicentini (2001), who analyzed the weight-length relationship of *Micropogonias furnieri* (Desmarest, 1823), known as corvina, a species that represents a significant portion of commercial catches in southeastern Brazil (Menezes & Figueiredo, 1980). Furthermore, research on the condition factor and weight-length relationship is fundamental for the conservation of endangered species. An example is the work of Gomiero and Braga (2006) with *Brycon opalinus*, a species classified as vulnerable by the IUCN (The World Conservation Union) and declared endangered.

Therefore, studies on weight-length relationships and condition factors provide essential information for understanding the functioning of aquatic ecosystems. These data are valuable tools for improving the management of natural and captive populations, both small and large, especially for species of economic relevance. Additionally, they serve as a basis for developing management and preservation plans for endangered species.

Considering the specific environmental characteristics and the linear distances between sampling sites, this study aimed to identify differences in intraspecific condition factor (***K***) values at different locations along the Rio Vermelho, MT. Given the scarcity of information in the literature on the weight-length relationship and condition factor of small fish species in the Rio Vermelho-MT Basin, the present study aimed to characterize four small species of the order Characiformes. The growth type and parameters indicating the best physiological conditions of these fish were analyzed through the study of the condition factor at different sampling sites along the river.

MATERIAL AND METHODS

Studied species: general characterization

The order Characiformes is the dominant group of freshwater fish in South America (Britski & Lopes, 1999). It is characterized by species with well-developed teeth, a lateral line, an adipose fin, and a short or moderately long anal fin. It comprises 24 families, approximately 520 genera, and about 2,300 species, distributed in freshwater environments in Africa, North America, and the Neotropical region (Nelson et al., 2016).

The subfamily Cheirodontinae (family Characidae) includes 17 genera and 55 species (Malabarba, 1998, 2003), such as *Odontostilbe pequira* and *Odontostilbe paraguayensis*. These species, which reach up to 10 cm in length, are commonly found in marginal vegetation of lotic and lentic environments in Brazil (Buckup & Malabarba, 1983). On the other hand, the subfamily Aphyocharacinae (Characidae) consists of small fish, reaching up to 8 cm in total length, with tricuspid and conical teeth arranged in a single series on the jaws (Garavello & Sampaio, 2010). Géry (1977) restricts this subfamily to the genus *Aphyocharax*, which includes the studied species, *Aphyocharax dentatus*.

Finally, *Engraulisoma taeniatum* (family Triportheidae) stands out for its small size, with specimens up to 4.2 cm in standard length. It has a prominent upper jaw, a long anal fin base, and a curved lateral line that ends at the caudal peduncle (Castro, 1981).

Climate and study area

The present study was conducted in a stretch of approximately 21 km of the Rio Vermelho, located in the southeastern region of the state of Mato Grosso, between the coordinates 16º25'S/16º30'S latitude and 54º40'20"W/54º34'50"W longitude, in the municipality of Rondonópolis, MT. The study area is part of the Rio Vermelho watershed, a tributary of the Rio São Lourenço, both of which are part of the Mato Grosso Pantanal system (Figure 1).

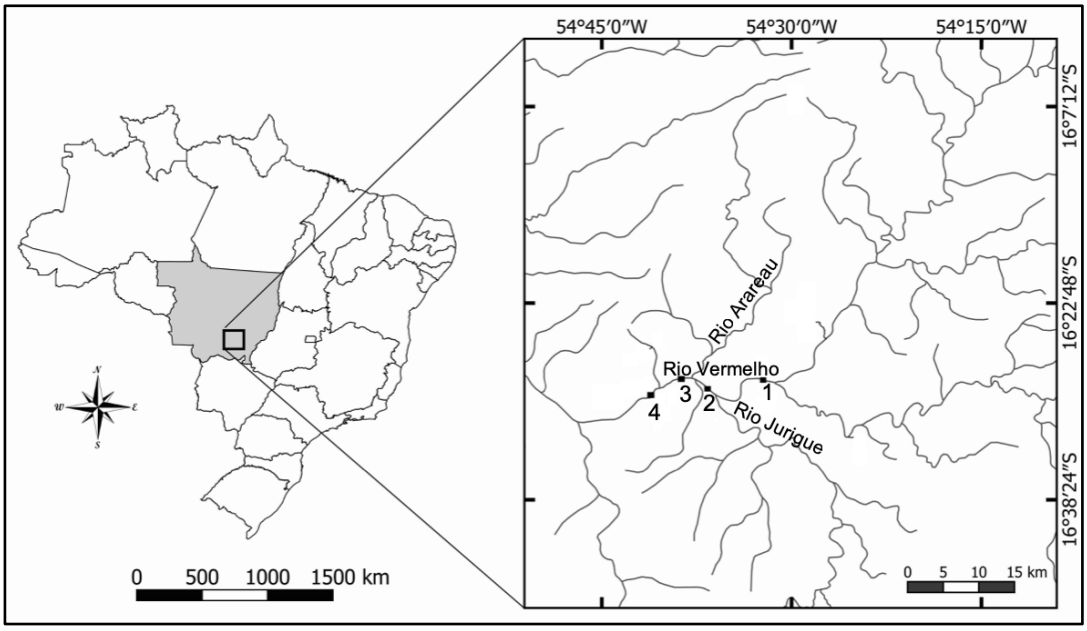

Figure 1. Rio Vermelho (Mato Grosso) and hydrographic basin with the sampling sites numbered from 1 to 4. Source: Image adapted from Vizzotto & Castro (2015) and provided by the authors.

The climate of the region is classified as tropical humid, with an average annual precipitation of 1,500 mm and an average annual temperature of 25°C, ranging between 18.6°C during the coldest periods and exceeding 26°C in the hottest months, September and October. During the coldest period, between June and July, the average temperature approaches 22°C (Sette, 2001).

The studied stretch exhibits lotic characteristics, with depth varying between the dry and rainy seasons. The sediment is predominantly muddy, sandy, or mixed, and the vegetation consists of rooted grasses, which may be fully or partially submerged depending on the time of year. Due to physiographic and hydrodynamic variations, the area was divided into four sampling sites:

Junção (Ponto 1) - Located on the left bank of the Rio Vermelho (coordinates: 16º29.277'S/54º31.320'W), Ponto 1 (Figure 1) features adjacent vegetation composed of grasses (pasture) and native riparian vegetation typical of the Cerrado biome, with tree-shrub species. During the dry season, sandbanks without marginal aquatic vegetation form. In the rainy season, the expansion of the flooded area promotes the growth of grasses with roots fixed along the banks. The average depth in the trawling area varies seasonally, reaching about 1.5 meters, with a sandy bottom. This site, located 11.4 km from Ponto 2, marks the confluence of the Tadarimana River with the Rio Vermelho.

Jurigue (Ponto 2) - Situated on the left bank of the Rio Vermelho, at coordinates 16º30.105'S/054º36.134'W, this site is located at the mouth of the Jurigue River into the Rio Vermelho (Figure 1). It has sandy-muddy sediment and banks covered mainly by grasses, completely devoid of other vegetation types. The bank has a low slope, with depth ranging between 0.5 and 1.5 meters. This site is located 4.3 km from Ponto 3.

Arareau (Ponto 3) - Located on the right bank of the Rio Vermelho (coordinates: 16º28.741'S/54º37.978'W), this point marks the mouth of the Arareau River. It is characterized by marginal vegetation composed mainly of grasses, with no tree-shrub species present. The area has a low slope, with depth ranging between 0.5 and 1.5 meters, forming a typical river mouth zone with a large amount of suspended material and a sandy bottom. Situated 5.2 km from Ponto 4, it suffers significant impacts due to its proximity to the municipality of Rondonópolis, receiving discharges of domestic and industrial pollutants.

GAC (Ponto 4) - Located 5 km downstream from the city of Rondonópolis-MT (coordinates: 16º29.509'S/54º40.312'W) on the right bank of the river, this site has a sandy bottom and banks without vegetation, with a low slope formed by sand deposits. The average depth is approximately 1.5 meters. Situated 21 km from Ponto 1, like Ponto 3, it experiences greater impact due to pollutant discharges compared to the other analyzed sites.

Sampling

Fish collections were conducted monthly between July 2010 and July 2011 along the riverbanks using a trawl net measuring 10 meters in length, 1 meter in height, and with a 5 mm mesh. After capture, the specimens were placed in plastic bags and fixed in 10% formaldehyde in the field. Each sample was labeled with information about the sampling site, date, and corresponding number.

In the laboratory, the biological material (juveniles and adults) was sorted visually or under a stereomicroscope and subsequently preserved in 70% alcohol in Petri dishes for taxonomic identification. Specimens of *Odontostilbe paraguayensis*, *Aphyocharax dentatus*, and *Engraulisoma taeniatum* were deposited in the fish collection of the Ichthyology Laboratory at the Federal University of Mato Grosso, Rondonópolis Campus, under the vouchers LZCUR 110, LZCUR 109, and LZCUR 114, respectively. Specimens of *Odontostilbe pequira* were incorporated into the Ichthyological Collection of Nupélia at the State University of Maringá (UEM), under the catalog number NUP 12225.

The collections were authorized by ICMBio (Chico Mendes Institute for Biodiversity Conservation), under license ICMBio-21546-1/2009.

To obtain the weight-length relationships (WLR) and size classes (SC), the standard length (SL) of each specimen was measured in centimeters using a manual caliper. The standard length was measured in a straight line, from the tip of the snout to the end of the caudal peduncle. The total weight (W), in grams, was measured using a digital scale (SCIENTECH, model SA 210), with a precision of four decimal places.

Data analysis

The weight-length relationship was established using the equation $\boldsymbol{W=aL^b}$, where ***W*** is the total weight in grams, ***L*** is the standard length in cm, ***a*** corresponds to the linear coefficient obtained, and ***b*** is the growth coefficient (angular coefficient), which determines the type of growth for each species, whether isometric or allometric (positive or negative). The number of size classes was defined using Sturges algorithm: $\boldsymbol{Ks = 1 + 3.33 \cdot log(n)}$ (Sturges, 1926), where ***Ks*** = number of classes and ***n*** = number of individuals sampled for each species. The determination of size classes was performed for each species captured at each of the four sampling sites separately.

The condition factor ($\boldsymbol{K = W/L^b}$) (Le Cren 1951, Weatherley 1972) was estimated for each species at each of the four sites, with the parameters ***W***, ***L*** and ***b*** as previously defined. Student's t-test was used to verify possible significant differences between the obtained values of ***K*** and ***b***, with test results considered significant whenever $p < 0.05$.

The theoretical L_{50}, corresponding to the length at which 50% of the population is capable of participating in the reproductive process, was estimated directly using the standard length values (cm) of each specimen for each species.

Since the objective was to characterize the species, the collected specimens were not separated by sex (male and female).

RESULTS

In this study, the total of 2,059 specimens were used, of which 953 were *O. paraguayensis* (46.2%), 856 were *A. dentatus* (41.6%), 154 were *E. taeniatum* (7.5%), and 96 were *O. pequira* (4.7%) (Figure 2).

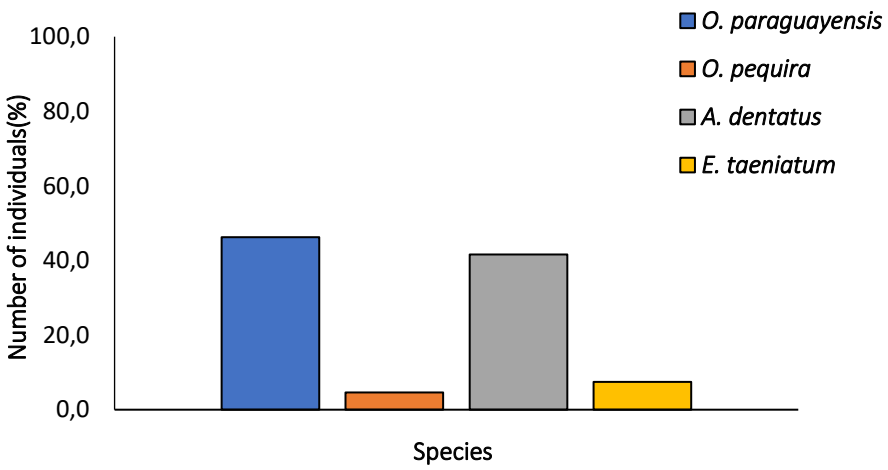

Figure 2. Number of individuals (%) of the species in relation to the total specimens collected in the Rio Vermelho/MT from July 2010 to July 2011.

Environmental variables

The precipitation (mm) and fluviometric level (m) data of the Rio Vermelho from July 2010 to July 2011 (Figure 3) showed that the rainfall had a well-defined wet season, from October 2010 to March 2011, with a peak observed in March 2011 (351.2 mm). The period of low rainfall (dry season) observed in the Rio Vermelho occurred from July to September 2010 and from May to July 2011. The fluviometric level of the Rio Vermelho ranged from 126.0 to 342.0 cm, with the lowest value recorded in September 2010 and the highest in March 2011, corresponding to a fluctuation of 2.16 m in the river level, a factor that hindered fish collection during this period. The fluviometric level values follow a direct trend with precipitation, a characteristic present in natural environments (rivers without dams). The temperature showed little variation between the studied months, with an average close to 27°C.

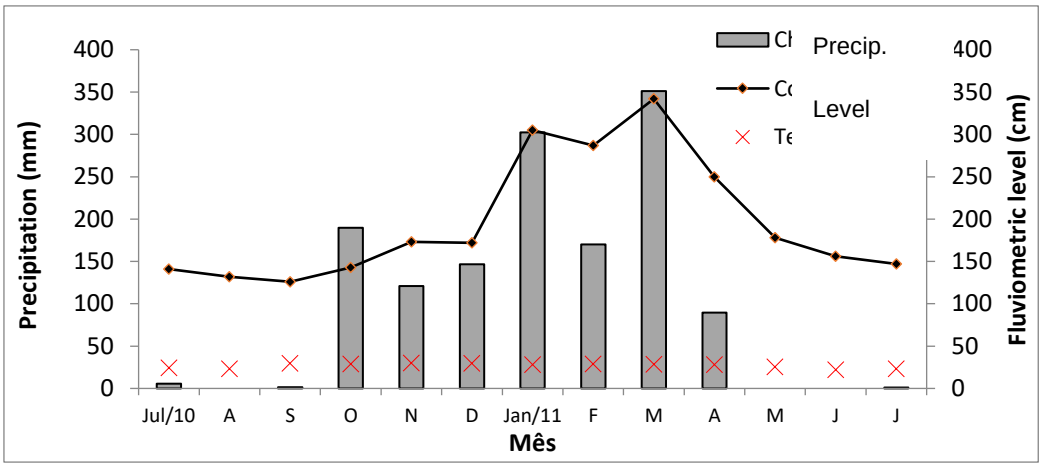

Figure 3. Monthly precipitation (mm), fluviometric level (cm) and temperature (ºC), data obtained from the meteorological station of the National Water Agency (ANA) in Rondonópolis, from July 2010 to July 2011.

Abundance and distribution

All species were collected at the four sampling sites, except for *E. taeniatum*, which was collected only at Ponto 1. The relative abundance of each species per sampling site is illustrated in Figure 4. *O. paraguayensis*, 65.5% occurred at Ponto 1, 11.8% at Ponto 2, 21.3% at Ponto 3, and 1.5% at Ponto 4. The species *O. pequira* showed a relative abundance of 11.5% (Ponto 1), 4.2% (Ponto 2), 51% (Ponto 3), and 33.3% (Ponto 4). *A. dentatus* had 23.1% (Ponto 1), 12.3% (Ponto 2), 33.3% (Ponto 3), and 31.3% (Ponto 4). Finally, the species *E. taeniatum* was collected only at Ponto 1, with a relative abundance of 100% (Figure 4).

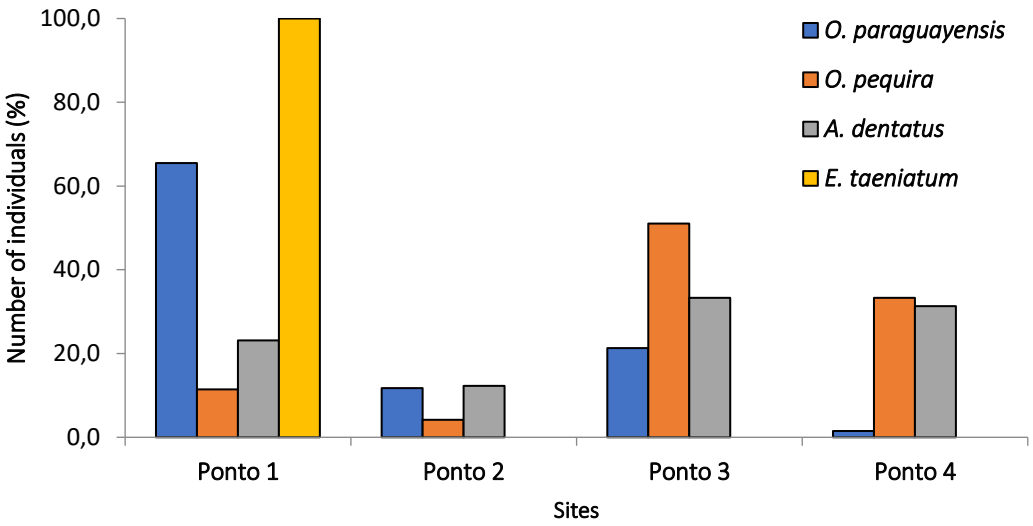

Figure 4. Number of individuals (%) of the species collected per sampling site in the Rio Vermelho-MT from July 2010 to July 2011.

Size classes

Eight size classes were determined for the species *O. pequira*, with a range of 1.81 to 3.01 cm in standard length. A total of 11 specimens were collected at Ponto 1 (Junção), with a standard-length range of 2.12 to 2.74 cm; 4 specimens at Ponto 2 (Jurigue), with lengths between 2.41 and 2.84 cm; 49 individuals at Ponto 3 (Arareau), with lengths ranging from 2.06 to 2.61 cm; and 32 specimens at Ponto 4 (GAC), with lengths ranging from 1.81 to 3.01 cm. The size class (SC) between 2.29 and 2.44 cm was the most representative at Ponto 1 (n = 5), Ponto 2 (n = 2), and Ponto 4 (n = 16). At Ponto 3, the most representative length class was 2.13 to 2.28 cm (n = 20) (Figure 5).

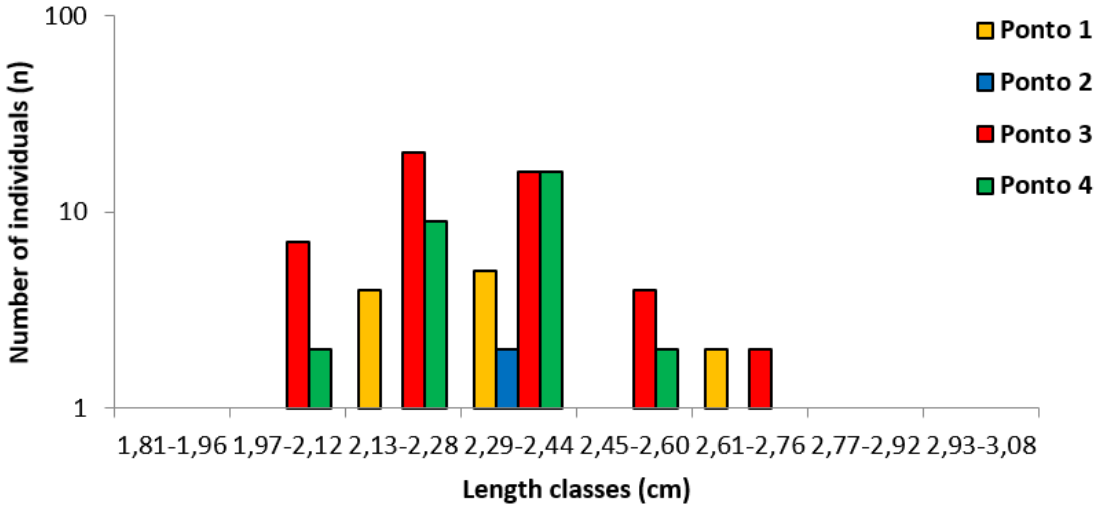

Figure 5. Abundance of *Odontostilbe pequira* **by size class on a logarithmic scale, determined for sites 1, 2, 3, and 4 during sampling conducted in the Rio Vermelho/MT from July 2010 to July 2011.**

The lengths of the species *O. paraguayensis* were distributed into eleven size classes, with a range of 2.11 to 3.35 cm in standard length.

A total of 624 individuals were collected at Ponto 1 (Junção), with a standard length range of 2.21 to 3.35 cm; 112 individuals at Ponto 2 (Jurigue), with standard lengths between 2.19 and 3.29 cm; 203 individuals at Ponto 3 (Arareau), with standard lengths between 2.11

and 3.18 cm; and 14 individuals at Ponto 4 (GAC), with standard lengths between 2.19 and 3.27 cm. The size class between 2.47 and 2.58 cm was the most representative at sites 1 (n = 166), 2 (n = 32), and 3 (n = 66). At Ponto 4, the most representative length class was between 3.07 and 3.18 cm (n = 4) (Figure 6).

Eleven size classes were also determined for the species *A. dentatus*, with a standard-length range of 2.04 to 6.22 cm. At Ponto 1 (Junção), 198 individuals were collected, with a standard-length range of 2.16 to 5.57 cm; 105 individuals at Ponto 2 (Jurigue), with lengths between 2.33 and 6.22 cm; 285 individuals at Ponto 3 (Arareau), with lengths between 2.15 and 5.99 cm; and 268 individuals at Ponto 4 (GAC), with lengths between 2.04 and 5.71 cm. The size class between 2.43 and 2.81 cm was the most representative at all study sites. The number of specimens in this size class was 71 (Ponto 1), 56 (Ponto 2), 178 (Ponto 3), and 154 (Ponto 4) (Figure 7).

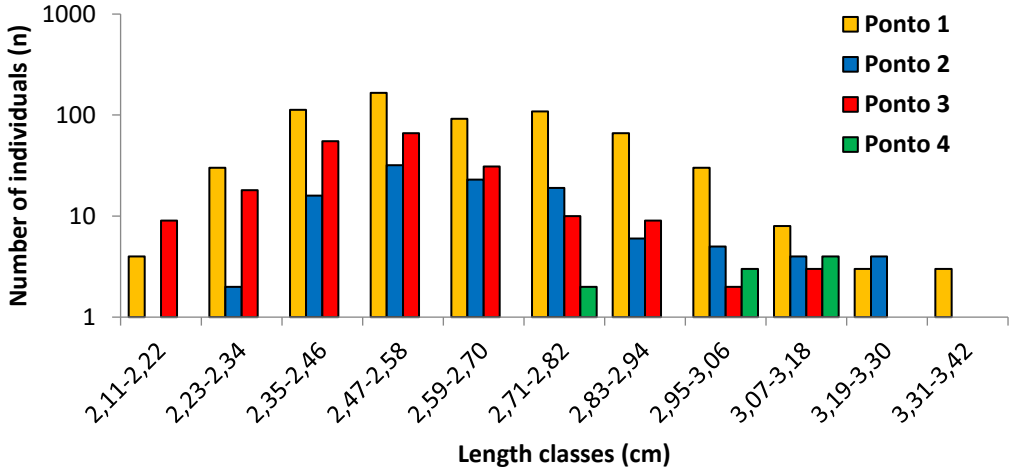

Figure 6. Abundance of *Odontostilbe paraguayensis* by length classes on logarithmic scale, determined sites during sampling conducted in the Rio Vermelho/MT from July 2010 to July 2011.

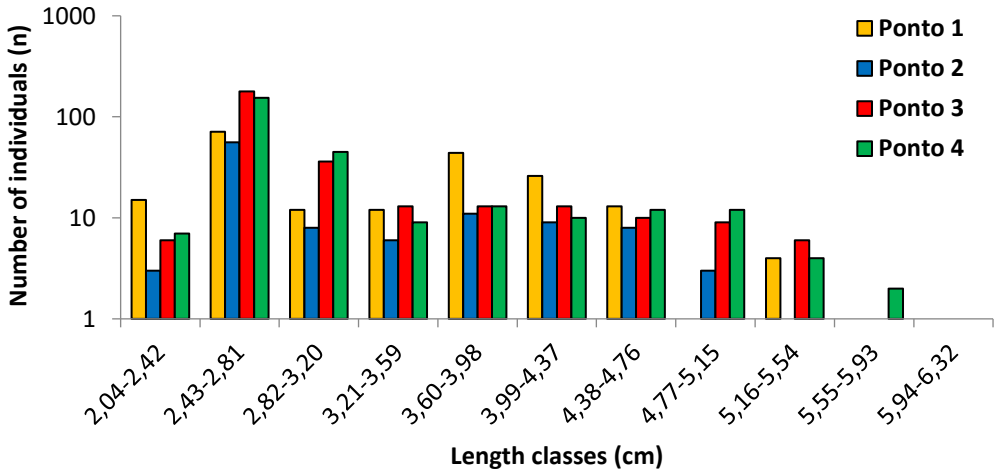

Figure 7. Number of individuals of *Aphyocharax dentatus* by length classes on a monolog scale, for sites during the study conducted in the Rio Vermelho-MT from July 2010 to July 2011.

The species *E. taeniatum*, with 154 specimens captured, only occurred at Ponto 1 (Junção), showing a standard-length range of 1.41 to 3.0 cm (Figure 8). Among the five size classes established for the species, the most representative SC was 2.46 to 2.66 cm (n = 64).

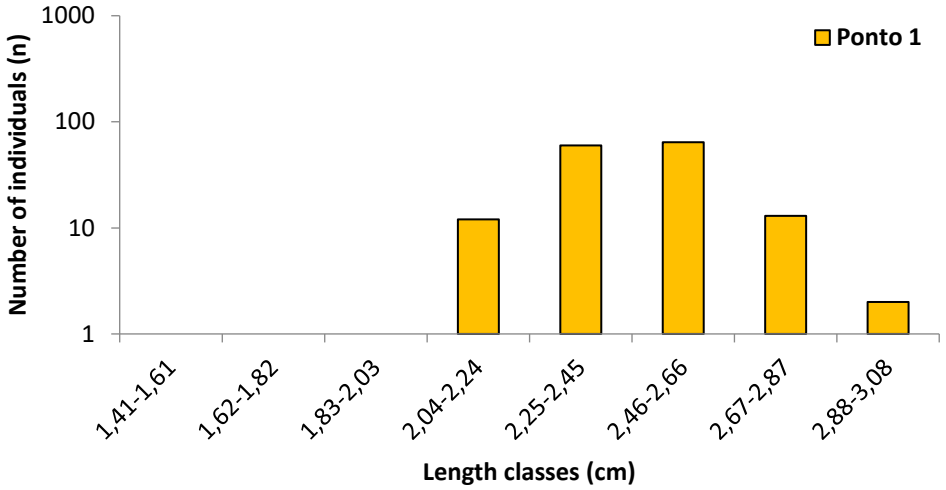

Figure 8. Number of individuals of *Engraulisoma taeniatum* **by size class on logarithmic scale, for Ponto 1, during the study conducted in the Rio Vermelho-MT from July 2010 to July 2011.**

Weight-length relationship

The weight-length relationship analysis was conducted for all species based on the standard lengths and total weights of all individuals of each species.

The values of **b** for each species were tested, showing significant differences in all cases, indicating allometric growth ($b \neq 3$).

Odontostilbe paraguayensis exhibited positive allometric growth ($b > 3$) with ***b* value** of 3.6114 (Figure 9). The other species showed negative allometric growth ($b < 3$): *O. pequira* with ***b value*** of 2.9529 (Figure 10), *A. dentatus* with ***b value*** of 2.7326 (Figure 11), and, *E. taeniatum*, with specimens collected only at Ponto 1, showed ***b value*** of 2.3405 (Figure 12).

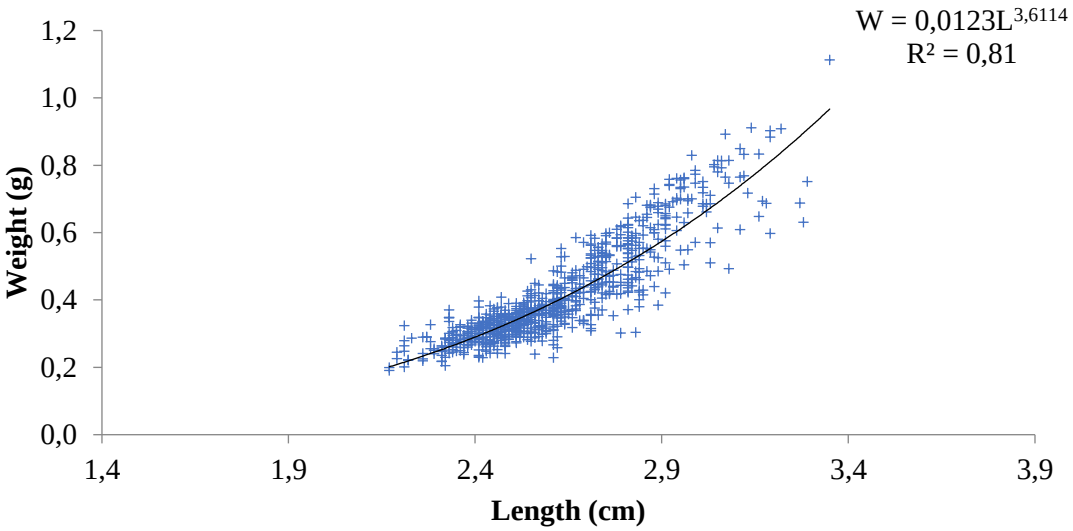

Figure 9. Weight-length relationship of *O. paraguayensis* **specimens.**

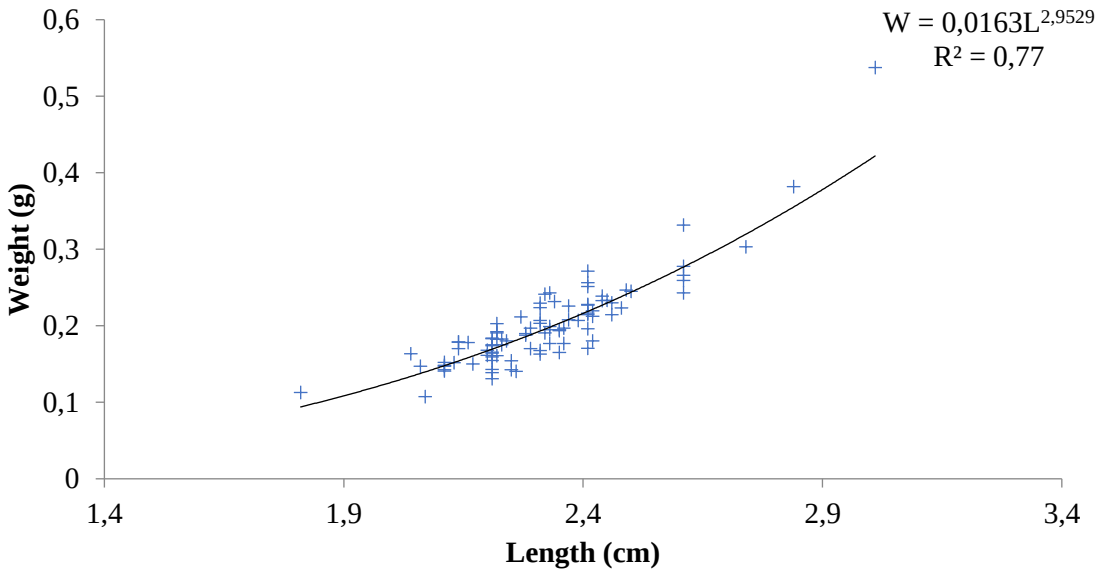

Figure 10. Weight-length relationship of *O. pequira* **specimens.**

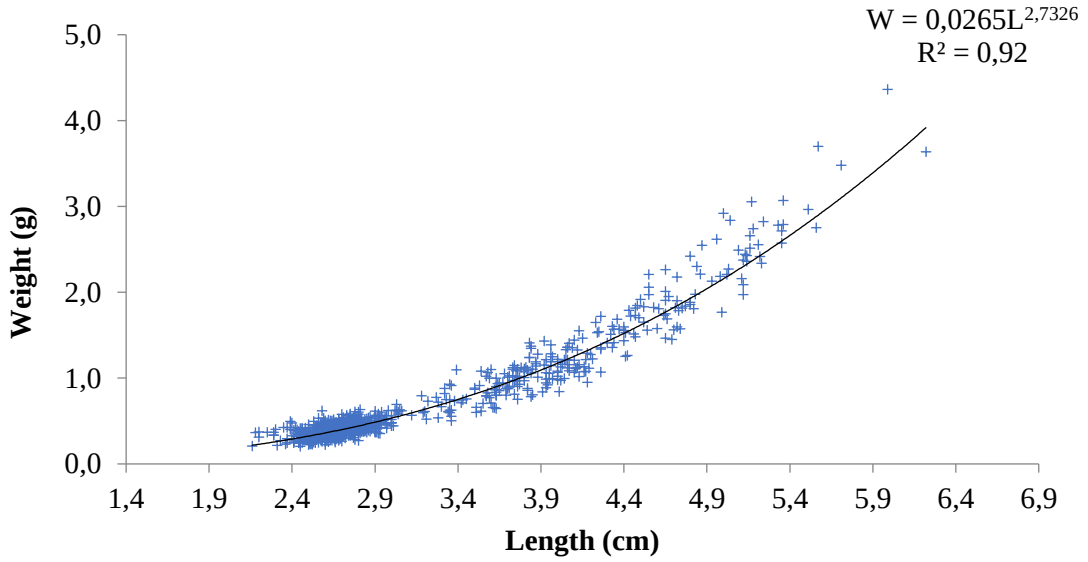

Figure 11. Weight-length relationship of *A. dentatus* **specimens.**

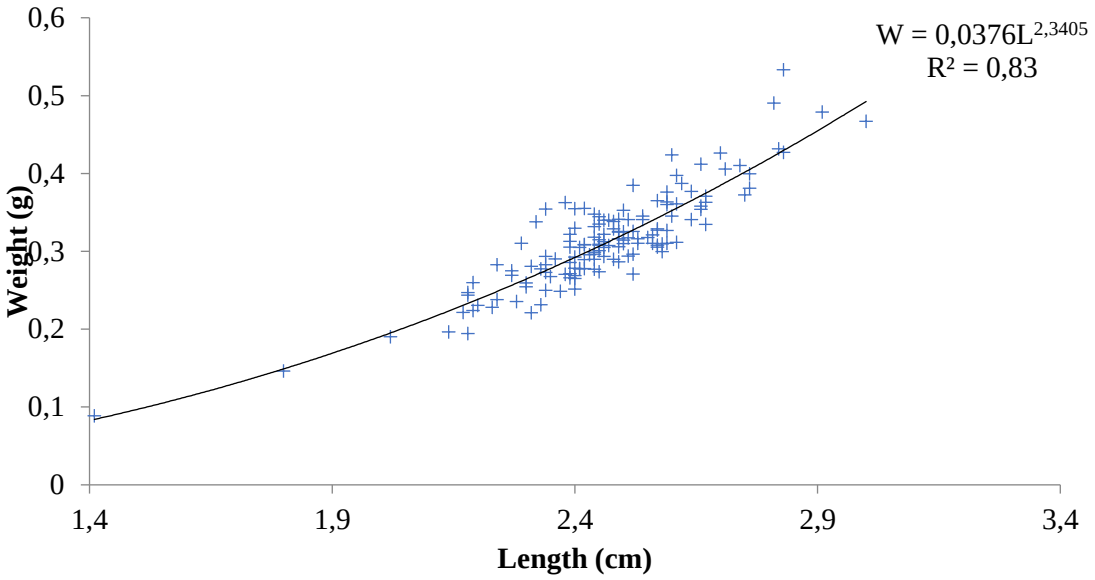

Figure 12. Weight-length relationship of *E. taeniatum* specimens.

Condition factor (*K*)

The condition factor (***K***) values were analyzed for each species, compared among the four different sampling sites, and tested using Student's t-test (Table 1). In the case of *Engraulisoma taeniatum*, since individuals were collected only at Ponto 1, such a comparison was not possible (Table 1) (Figure 13).

Based on the results of Student's t-test for the condition factor (***K***) values, significant differences ($p < 0.05$) were observed for *Aphyocharax dentatus* between most sampling sites, except between Ponto 1 and Ponto 3, where ($p > 0.05$) (Table 1) (Figure 14).

Table 1. Results of Student's t-test applied to the condition factor data of the studied species among the sampling sites in the Rio Vermelho-MT, from July 2010 to July 2011. Shaded cells indicate statistically significant differences ($p < 0.05$).

	Sites					
	1x2	1x3	1x4	2x3	2x4	3x4
A. dentatus	p < 0,05	p > 0,05	p < 0,05	p < 0,05	p < 0,05	p < 0,05
O. paraguayensis	p < 0,05	p < 0,05	p > 0,05	p < 0,05	p < 0,05	p < 0,05
O. pequira	p > 0,05	p > 0,05	p < 0,05	p < 0,05	p > 0,05	p < 0,05

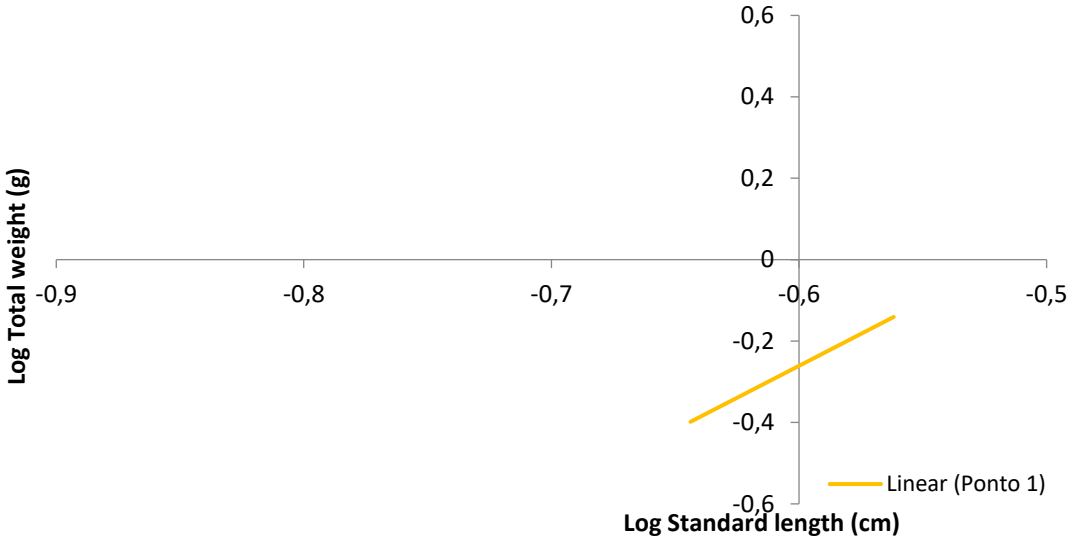

Figure 13. Condition factor value at sampling Ponto 1 for the species *Engraulisoma taeniatum* **during the study in the Rio Vermelho-MT from July 2010 to July 2011.**

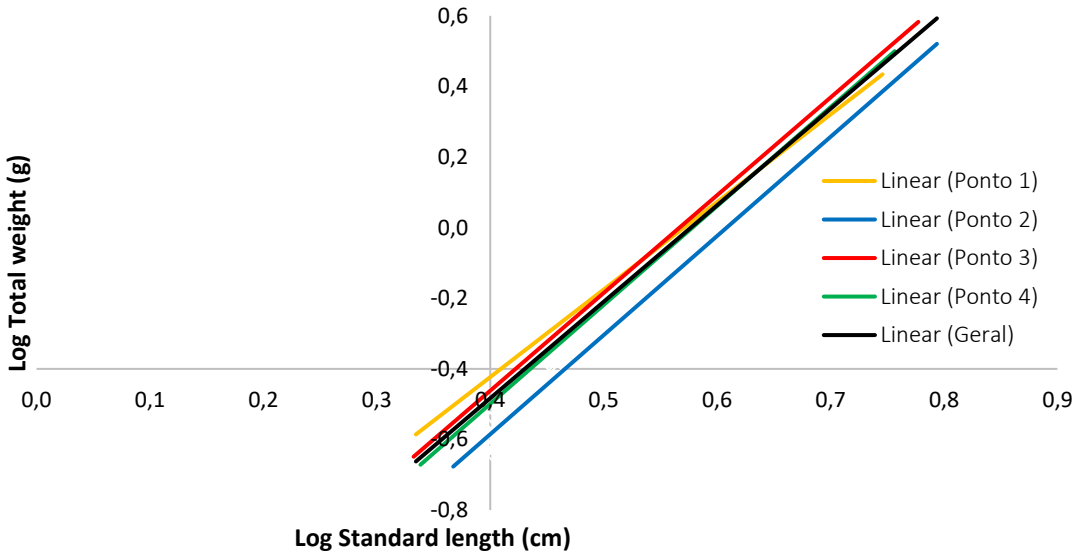

Figure 14. Condition factor values at the four sampling sites for the species *Aphyocharax dentatus* **during the study in the Rio Vermelho-MT from July 2010 to July 2011.**

The species *O. paraguayensis* also showed significant differences in ***K values*** at most points, except between Ponto 1 and Ponto 4 (Table 1) (Figure 15).

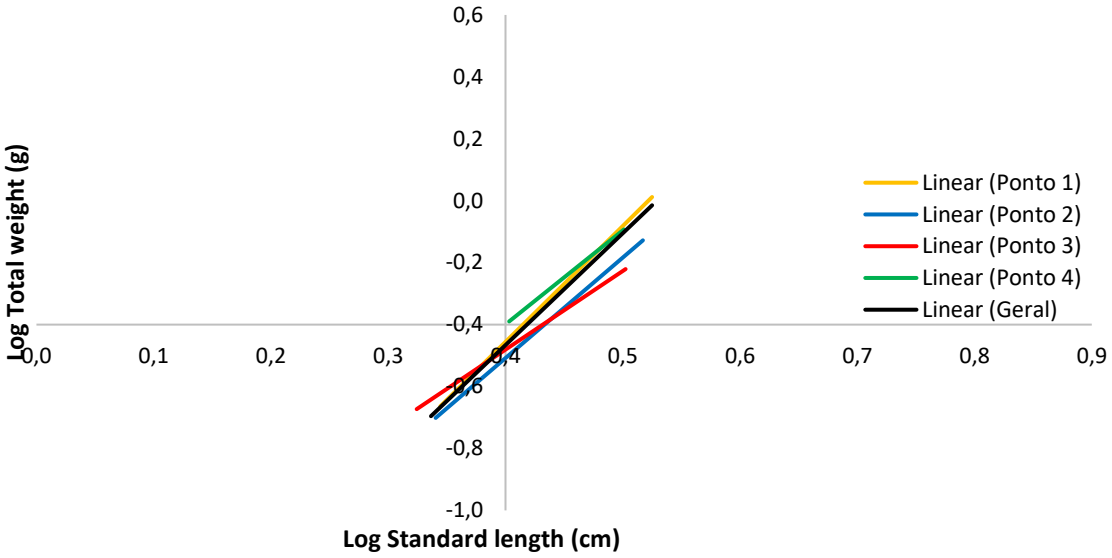

Figure 15. Condition factor values at the four sampling sites for the species *Odontostilbe paraguayensis* **during the study in the Rio Vermelho-MT from July 2010 to July 2011.**

Finally, the species *O. pequira* showed significant differences in the condition factor between sites 1 and 4, 2 and 3, and 3 and 4 (Table 1) (Figure 16).

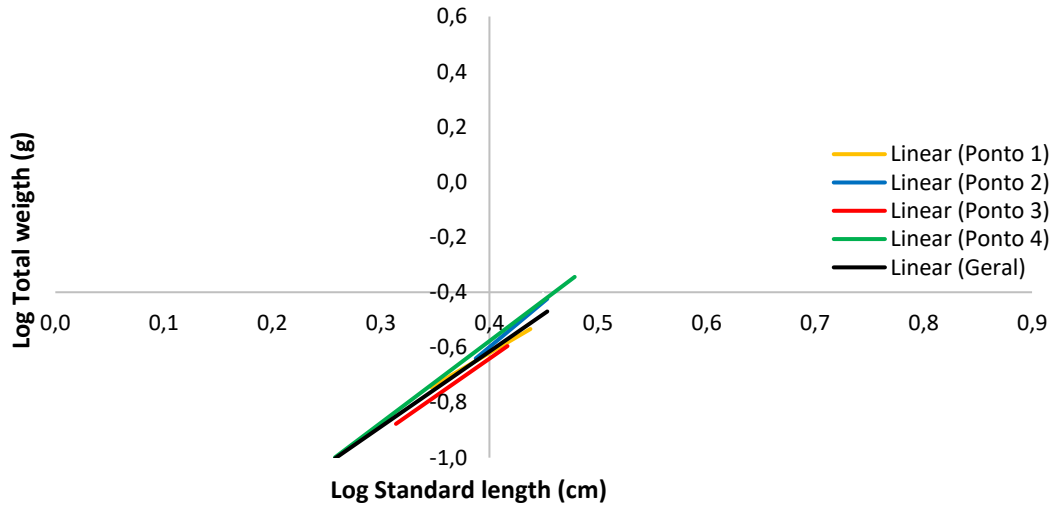

Figure 16. Comparison of condition factor values at the four sampling sites for the species *Odontostilbe pequira* **during the study in the Rio Vermelho-MT from July 2010 to July 2011.**

DISCUSSION

The distribution of length classes of the species *A. dentatus* across the sampling sites demonstrated a clear predominance of the size class ranging from 2.43 cm to 2.81 cm. This result is very close to that obtained by Lizama & Ambrosio (1999) for the congeneric species *Aphyocharax nasutus*, which showed the highest abundance of specimens in the 3.2 cm class. The maximum length recorded for *A. nasutus*in the Upper Paraná River Basin was 4.6 cm (Vazzoler, 1996), while in this study, the maximum standard length of *A. dentatus* reached 6.22 cm. The theoretical L_{50} (mean size at first gonadal maturation) for *A. dentatus* was estimated at 2.76 cm, indicating that at all sampling sites, there was a predominance of adult individuals.

The results obtained for the species *O. pequira* did not reveal a clear distribution pattern across the sampled sites. The L_{50} value for the genus *Odontostilbe* was estimated at 1.6 cm by Sanchez-Botero and Araújo-Lima (2001), based on studies conducted in three floodplain lakes in Central Amazonia (apud Ferreira et al., 1998). In the present study, the theoretical L_{50} for the species was 2.31 cm, a value close to the 2.22 cm (males) and 2.42 cm (females) recorded by Tondato et al. (2013) in the Pantanal of Porto Murtinho, in the southernmost part of the Pantanal. The analyses indicated a predominance of adult individuals at most sampling sites, suggesting a population without a defined spatial distribution.

According to Lourenço et al. (2012), biotic and abiotic factors can distinctly influence the distribution and abundance of juveniles and adults in different habitats. Juvenile individuals, which make up the smaller length classes, tend to be more sensitive to environmental variations, exhibiting higher mortality rates compared to adults. This greater vulnerability of juveniles may partly explain the absence of a clear distribution pattern for *O. pequira* in the studied locations.

O. paraguayensis did not exhibit a defined pattern in the distribution of size classes among the sampled sites. However, Ponto 4 stood out for the dominance of the length class between 3.07 cm and 3.18 cm, indicating the presence of larger individuals compared to the other locations. The theoretical L_{50} value for the species was estimated between 2.56 cm and 2.57 cm, confirming the predominance of adult individuals at all sites. A possible explanation for the difference in fish length among the sites may be related to the disproportion in the number of males and females captured, although this hypothesis requires confirmation through future studies. The presence of larger individuals at Ponto 4 may be associated with a higher number of females captured, as in many fish species, females tend to be larger than males (Clutton-Brock et al., 1985; Parker, 1992; Biazza & Pilastro, 1997). Additionally, the proximity of Ponto 4 to the urban area of Rondonópolis may influence the characteristics of the local population. The greater discharge of pollutants in this region may be related to the increase in the length of individuals, as the higher load of nutrients and organic matter in water bodies can elevate the availability of food resources. Oliveira and Bennemann (2005) emphasized that changes in aquatic systems, especially those caused by anthropogenic actions, alter the structure and dynamics of fish assemblages, directly affecting the availability of autochthonous and allochthonous food resources.

Therefore, the observed differences in the length of *O. paraguayensis* individuals can be attributed to both biological factors, such as the proportion of males and females, and environmental factors, such as the influence of pollution and the greater availability of food at Ponto 4.

E. taeniatum showed individuals mainly concentrated in the size class between 2.46 cm and 2.66 cm, with specimens collected exclusively at Ponto 1. The theoretical L_{50} value for the species was 2.46 cm, indicating a predominance of individuals transitioning from the juvenile to the adult phase. These results may be associated with the physical and chemical conditions of the water during the sampling period, in which the maximum recorded temperature remained below 25°C.

According to Hayes et al. (1996), variables such as transparency, temperature, depth, dissolved oxygen, conductivity, and pH are determining factors for the distribution and abundance of fish populations, varying between locations and periods. For *E. taeniatum*, the specific environmental conditions at Ponto 1 may have favored the occurrence of the species at this location.

Despite being known to the scientific community for over three decades, the species *E. taeniatum* is rarely recorded in Brazilian collections, and information on its ecology and biology remains limited (Ohara, 2012). The scarcity of data highlights the importance of additional studies to expand knowledge about the species, particularly regarding the factors influencing its distribution, abundance, and population dynamics.

The scarcity of juvenile individuals at almost all sampling sites for the analyzed species may be directly related to the rainfall patterns (mm) in the region of Rondonópolis, MT. In the Pantanal, there is what is known as the flood cycle and the dry cycle, which are associated with the height reached by annual floods. The flood level is a strategic factor for the dynamics of the Pantanal (Resende et al., 1996). Thus, the collections were predominantly carried out during the period of lower rainfall (dry season). The reproduction of many species is generally regulated by the rainy season and the rise in water levels during floods, which provides an expansion of habitat for fish and, consequently, greater availability of resources (Goulding et al., 1988; Santos & Ferreira, 1999; Mazzoni & Iglesias-Rios, 2002; Andrade & Braga, 2005; Lourenço et al., 2008). This condition may explain the absence of juveniles in the collections carried out. Additionally, the result may have been influenced by the selectivity of the capture method used (trawl net with a 5 mm mesh), as juvenile individuals may have passed freely through the net.

Odontostilbe pequira exhibited negative allometric growth (b=2.95*b*=2.95) in this study, indicating a greater investment in length than in weight. This pattern is consistent with that observed by Lopes et al. (2017), who reported a value of *b*=2.83 for the same species, reinforcing the expected trend for species with an elongated and laterally compressed body. On the other hand, *O. paraguayensis* displayed positive allometric growth, with a *b* value of 3.6114, suggesting a proportionally greater increase in weight than in length. According to Le Cren (1951), the values of the parameter *b* generally range between 2.5 and 4.0 for most fish species, and the value found for *O. paraguayensis* falls within this range, indicating positive allometry.

The difference in the type of growth observed between the two congeneric species may be related to differences in the maximum length reached by each. The maximum total length (*L*max) recorded for *O. paraguayensis* was 4.21 cm, while for *O. pequira* it was 3.67 cm. This variation in body size may directly influence the slope coefficient (*b*), as larger species tend to exhibit a greater investment in weight relative to length, which may explain the positive allometry in *O. paraguayensis* and the negative allometry in *O. pequira*.

Aphyocharax dentatus exhibited negative allometric growth, with a *b* value of 2.7326. This result differs from that observed by Lizama & Ambrosio (1999), who described the growth of the congeneric species *Aphyocharax nasutus* as isometric, with a *b* value of 3. According to Gonzalez et al. (1988), the value of *b* can vary among different populations, between sexes within the same population, and across months of the year, potentially being allometric or isometric depending on favorable or unfavorable environmental conditions. Thus, it is possible to suggest that resource availability, genetic variability, and other environmental factors related to the habitat may have influenced the growth of *A. dentatus* in this study.

Finally, *E. taeniatum*, like the species *O. pequira* and *A. dentatus*, also exhibited negative allometric growth, with a *b* value of 2.3405. Growth performance, i.e., the increase in weight and/or length, can be similar among different species, as, upon birth, individuals primarily invest in body growth. However, upon reaching gonadal maturity, the acquired energy is redirected toward reproductive events (Costa & Araújo, 2003). Due to the small size of these

three species, they become easy prey for larger fish. This phenomenon may accelerate growth in length, as the faster they reach the theoretical maximum length, the greater their chances of survival, since smaller individuals are more vulnerable to predation (Reznick et al., 1996). Thus, the observed negative allometry may reflect an adaptive strategy to maximize growth in length and reduce vulnerability during the early life stages.

The results of the condition factors for the studied species suggest a significant relationship with size classes and the environmental variations characteristic of each sampling site. The statistically significant differences observed in the condition factor for *A. dentatus* and *O. pequira* indicate that this parameter is not solely related to the length of the individuals but also to the environment in which they were collected. This is because the most representative size class was the same at all sampling sites for *A. dentatus*, and very similar size classes were observed for *O. pequira*.

Le Cren (1951) highlights that variations in the condition factor in different environments for the same species may be associated with the specific characteristics of each location. Santos et al. (2006) suggest that the condition factor can vary depending on aspects such as the availability and utilization of food throughout the year. Studies conducted by Silva (2016) support this idea, reporting significant differences in the condition factor values for the species *Astyanax fasciatus* (Cuvier, 1819) and *Astyanax bimaculatus* (Linnaeus, 1758) in different sections of the Paraíba River, PB. The author relates these variations to the environmental characteristics of each section, such as depth, temperature, water transparency, dissolved oxygen, river width, among other factors that directly influence the values of the condition factor.

Thus, the differences observed in this study may reflect the influence of specific environmental conditions at each collection site on the overall condition of the individuals. These findings reinforce the importance of considering both biological and environmental characteristics in the assessment of the condition factor, highlighting the complexity of ecological interactions that affect the health and well-being of aquatic species.

The analysis of the results for *O. paraguayensis* suggests that the environmental characteristics of each sampling site may influence the significant differences in the condition factor values, as the predominant size class was the same across the analyzed sites. However, the significant differences observed between Ponto 2 and Ponto 4 and Ponto 3 and Ponto 4 may be related to variations in the size classes of the sampled individuals. At Ponto 4, larger individuals predominated compared to Ponto 2 and Ponto 3. This pattern may be associated with the fact that the condition factor is influenced by the stage of gonadal maturation and the degree of stomach fullness over time.

According to Barbieri et al. (1982), individuals in better condition are expected to exhibit higher growth rates, greater reproductive potential, and higher survival capacity compared to those in less favorable conditions, in similar environments (Pope & Kruse, 2001). These findings reinforce the importance of considering both biological and environmental factors in interpreting variations in the condition factor in fish populations.

CONCLUSIONS

The study revealed significant variations in the condition factor and growth patterns among the analyzed species (*O. paraguayensis*, *O. pequira*, *A. dentatus*, and *E. taeniatum*), highlighting the influence of environmental and biological factors on their development. The differences in growth types (positive or negative allometry) and condition factors were associated with variations in body size, reproductive strategies, and habitat conditions, such as resource availability and pollution levels.

The predominance of adult individuals in most sampling sites suggests that the reproductive cycles of these species may be synchronized with seasonal environmental changes, particularly rainfall and flood cycles. The scarcity of juveniles in the collections may be attributed to the sampling period (dry season) and the selectivity of the capture method, which may have underestimated the presence of smaller individuals.

The results emphasize the importance of considering both biological and environmental factors in ecological studies of fish populations. The condition factor proved to be a valuable tool for assessing the health and well-being of species, reflecting the influence of habitat quality and resource availability on their physiological state. The condition factor was directly associated with the different environmental conditions at each sampling site, reflecting variations in the physical and biological characteristics of the studied habitats.

In summary, the analysis of the weight-length relationships and the condition factor of the four small-sized species from the families Characidae and Triportheidae allowed for the identification of the distinct environmental conditions present at the four sampling sites. Additionally, it was possible to determine the distribution of size classes, the theoretical L_{50} values, the condition factor values indicating the best physiological conditions of the fish, and the characteristic growth type of each species.

It is concluded that this study is of great relevance for future research aimed at addressing identified gaps, such as confirming the theoretical L_{50} values obtained for each species, investigating feeding habits, body size, and sex determination.

Future studies should focus on expanding the sampling period to include the rainy season, as well as using complementary capture methods to better represent the population structure, particularly juveniles. Additionally, further research is needed to better understand the reproductive biology and ecological dynamics of *E. taeniatum*, a species with limited available data.

Furthermore, the work provides valuable biological information for the development of management and conservation plans for the studied species, contributing to the preservation of biodiversity and the sustainability of aquatic ecosystems.

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