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Short Communication

Length-weight relationship and diet of the catfish *Cambeva guareiensis* (Siluriformes; Trichomycteridae)

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Abstract: The length-weight relationship (LWR) and diet of a small trichomycterid catfish, *Cambeva guareiensis*, was studied based on 58 specimens captured in Corrente stream, Guareí River basin, São Paulo, Brazil. LWR analyses showed values of *a* ranged from 0.0097 to 0.0149 and *b* from 2.858 to 3.250. The analysis of the diet showed that high amounts of aquatic insects (93.75% of total items) were consumed by the species. In addition, we found no statistically significant differences when comparing the diet between the dry and rainy periods. Our study contributes to the knowledge on populational biology and feeding ecology of trichomycterid fishes in Brazilian streams.
Keywords: *Chironomidae; Functional trait; Populational biology; Stomach content; Stream fish; Upper Paraná basin.*

Relação peso-comprimento e dieta do bagre *Cambeva guareiensis* (Siluriformes; Trichomycteridae)

Resumo: A relação peso-comprimento (RPC) e dieta de um pequeno bagre trichomycterídeo, *Cambeva guareiensis*, foi estudada com base em 58 espécimes capturados no riacho Corrente, bacia do rio Guareí, São Paulo, Brasil. As análises de RPC mostraram valores de *a* variando entre 0,0097-0,0149 e de *b* entre 2,858-3,250. A análise da dieta mostrou que altas quantidades de insetos aquáticos (93,75% do total de itens) foram consumidas pela espécie. Além disso, não encontramos diferenças estatisticamente significativas quando comparamos a dieta entre os períodos seco e chuvoso. Nosso estudo contribui para o conhecimento da biologia populacional e ecologia alimentar de peixes trichomicterídeos em riachos brasileiros.
Palavras-chave: *Bacia do Alto Paraná; Biologia populacional; Conteúdo estomacal; Peixe de riacho; Traço funcional.*

Introduction

The Trichomycteridae family—comprising siluriforms of freshwater ecosystems—holds a wide geographic distribution in South America; occurring, for example, from Andean to Brazilian waterbodies (e.g., Fernández & Vari 2009; Reis et al. 2019; Katz & Costa 2020). Most species are known to occur in surface waters (epigean), but some are found in hypogean environments (Rizzato et al. 2011; Castellanos-Morales 2010). In Brazil's freshwaters, most species occur in first to third order streams (e.g., Azevedo-Santos et al. 2020a). In the southeast of the country, many species of *Cambeva* and *Trichomycterus* have been reported (e.g., Casatti 2002; Lima et al. 2008; Barbosa & Azevedo-Santos 2012; Katz et al. 2018; Cetra et al. 2020; Reis et al. 2020; Costa & Katz 2021).

The genus *Cambeva* was recently proposed by Katz et al. (2018) based on *Pygidium davisi* Haseman, 1911. According to a recent compilation (Fricke et al. 2021), *Cambeva* holds over thirty described species. In just the Paranapanema River system (Upper Paraná River, Brazil), for instance, there were reported *C. davisi* (Haseman, 1911), *C. diabola* (Bockmann, Casatti & de Pinna, 2004), *C. guareiensis* Katz & Costa, 2020, *C. pascuali (*Ochoa, Silva, Silva, Oliveira & Datovo, 2017), and *C. perkos* (Datovo, Carvalho, & Ferrer, 2012) (Katz & Costa 2020). *Cambeva guareiensis*, in particular, occurs exclusively in small tributaries of sub-basins of the Paranapanema River system (Katz & Costa 2020; Azevedo-Santos et al. 2020a; Lisboa et al. 2020).

Scientific data (e.g., biology) is scarce for most *Cambeva* species. For *C. guareiensis*, there are studies only recording its distribution in streams (e.g., Azevedo-Santos et al. 2020a) and describing a case of albinism (Azevedo-Santos et al. 2020b). Data on population biology and feeding ecology of the species need to be available in the scientific literature. This is justifiable especially by the eminent growth of functional studies that need basic information. For example, knowing the diet of species may be a useful trait for future investigations about anthropic impacts on fish assemblages.

Here we provide the length-weight relationship of *C. guareiensis.* In addition, we described and compared the diet of the species in different periods (dry and rainy).

Material and Methods

1. *Study area*

The Corrente stream, where the collections were performed, is a tributary of the Guareí River, which, in turn, flows to the Paranapanema River (upper Paraná River system; Azevedo-Santos et al. 2020a). The source of the Corrente stream is located at approximately 700 meters above sea level in the region of "Mineiros" (~23°24'9.44"S, 48°23'42.21"W), in Angatuba municipality, São Paulo, Brazil. Fish were sampled above the waterfall of Corrente stream (~23°26'5.31"S, 48°23'18.78"W).

2. *Methods*

Sampling was done in September 2020 (dry season) and February 2021 (rainy season), and with the permission of the Brazilian Institute of Environment and Natural Resources (license number: SISBio 76135-1). Fish were caught with a hand net (1 mm mesh), in a stretch of ~ 200 meters of the Corrente stream. Sampling activity lasted ~ 50 minutes in both seasons. The collected specimens were euthanized with eugenol (exposed for more than 10 minutes - lethal dose) and fixed (with formalin 10%). Specimens were identified based on the original description provided by Katz & Costa (2020). Vouchers (10 specimens that were transferred to alcohol 70 %) were deposited at the UFRJ (Universidade Federal do Rio de Janeiro, Rio de Janeiro, Brazil).

2.1. Length-weight relationship

The specimens were removed from formaldehyde, washed in water and then weighed (0.1 g) and measured (standard length; 0.1 mm). Later they were transferred to alcohol (70%) for diet analysis.

For the calculation of the length-weight relationship (LWR, hereafter), we considered together specimens collected in dry and rainy seasons. For the analyses, we used a linear regression "$\log W = \log a + b \log L$" (Froese 2006; p. 243). Through a plot (i.e., log-log) the outliers for *Cambeva guareiensis* were excluded (*sensu* Froese 2006).

2.2. Diet

For stomach content analysis, we made an incision in all specimens from the anus to the isthmus to remove the stomachs. The stomach contents were placed in Petri dish and examined using a stereomicroscope (Stemi 305).

The animal content present in the stomach of the trichomycterids was identified only to the level of Order or Family based on Costa et al. (2006) and Mugnai et al. (2010) because they were often in an advanced state of digestion (preventing the determination at lower levels). Sometimes contents could only be identified as terrestrial insects. Pieces of plant leaves and roots were also found (vegetal fragments). We used the abundance of the food items found in the stomach of the trichomycterids as the variable to quantify the diet of the species.

With the data obtained, we built a matrix with the abundance of each item consumed by each specimen. Individuals without content, or with an advanced digestion process, were not included in the analyses. From the constructed matrix, we compared the food of the individuals in both sampling seasons (dry vs. rainy), in order to verify possible seasonal variations. With data converted to log (x+1), we used a permutational multivariate analysis of variance (PERMANOVA), with 9999 permutations, and Bray-Curtis distance. For analysis, we used the software PRIMER 6.1.13 PERMANOVA+ 1.0.3 (Clarke & Gorley 2006). Lastly, we also described the diet of the species using stomach contents during the studied period.

Results

1. *Length-weight relationship*

There were collected 58 individuals of *Cambeva guareiensis* (UFRJ 12717). The standard length of the specimens ranged from 24.0-62.5 millimeters and the weight from 0.18-3.70 grams. All sampled specimens were examined in the LWR (see Table 1).

2. *Diet*

Of the 58 specimens examined, 26 individuals sampled during dry season and 12 during rainy season had empty stomachs. The species ingested high amounts of aquatic insects (Figure 1), with predominance of Diptera of the families Chironomidae (56% of consumed items) and Simuliidae (14%). They also consumed aquatic insects of Trichoptera, comprising 12% of items, and vegetal fragments (5.8% of items). The PERMANOVA did not indicate a significant difference in species diet between dry and rainy seasons (Pseudo-F = 1.614, p = 0.159).

Table 1. Length-weight relationship of *Cambeva guareiensis* based on 58 individuals captured in Corrente stream, São Paulo, Brazil. The *a* and *b* refer to equation used (see Material and Methods section) ranging 95% of confidence limits; and R^2 refers to the correlation coefficient

***a* (95% CI)**	***b* (95% CI)**	**R²**
0.0123 (0.0097-0.0149)	3.054 (2.858-3.250)	0.946

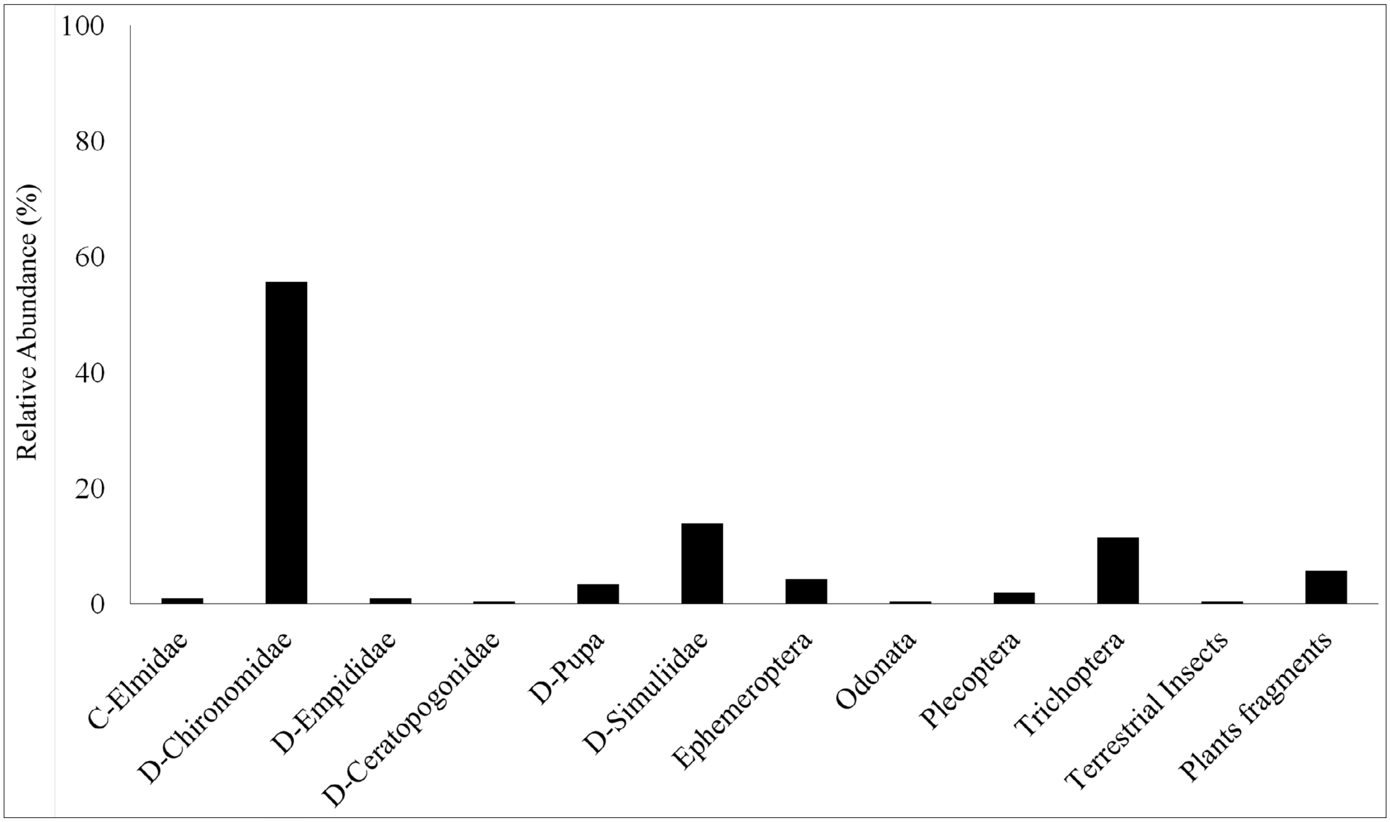

Figure 1. Relative abundance (%) of insects and vegetal fragments consumed by the analyzed fish in the dry and rainy seasons. C-Coleoptera and D-Diptera.

Discussion

1. *Length-weight relationship*

The value of *b* found for *Cambeva guareiensis* was 3.054 (2.858-3.250). Other species of the family Trichomycteridae, such as *Trichomycterus candidus* (Miranda Ribeiro, 1949), *T. pirabitira* Barbosa & Azevedo-Santos, 2012, and *T. piratymbara* Katz, Barbosa & Costa, 2013 (identification corrected herein to *T. sainthilairei* Katz & Costa, 2021, UFRJ 12719), had similar patterns (Azevedo-Santos et al. 2018). In fact, many stream fish species are expected to have *b* values in a similar range as that found for *C. guareiensis* and other trichomycterids (Froese 2006).

2. *Diet*

Insects were the main food item found in the stomach contents of the individual examined, especially aquatic insects. Other studies (e.g., Casatti 2002; Chará et al. 2006; Scott et al. 2007; Manoni et al. 2009; Rondineli et al. 2009) showed that other species of the same family or genus that *C. guareiensis* also feed on this group. The low prevalence of vegetal items, when compared with insects, and the morphology of the digestive system of *C. guareiensis*, suggests that leaves and roots were accidentally ingested during prey capture or that plants are not an important item in the diet of this species. However, only with the analysis of the diet—without observations in situ of the feeding behavior of the *C. guareiensis* (e.g., Casatti 2002)—, is impossible to confirm the first possibility suggested.

We found no statistically significative differences in the diet of *C. guareiensis* between different seasons (i.e., dry *vs.* rainy). Similar results were found by Manoel & Uieda (2019) for other species of the genus *Cambeva* in one impacted stream. A possible explanation is that Corrente stream has a similar characteristic such as those reported by these authors. Another explanation is that the availability of insects in the aquatic ecosystem may modulate the presence of this item in the diet of trichomycterids (*sensu* Scott et al. 2007). Therefore, the absence of seasonal changes in the diet of *C. guareiensis* may be related to low or no seasonal variation in the availability of aquatic insects in the stream, which was the predominant group among the food items. Both lines of investigation deserve attention in futures studies in Guareí River basin.

Here we contribute to the knowledge about the biology (LWR) and feeding ecology of *C. guareiensis*. These baseline data are extremely important, for example, for future studies on functional diversity. Trichomycteridae is a large and varied family of fishes (see de Pinna & Wosiacki 2003 with numerous species with little or no biological and ecological data. Therefore, studies in both fields should be encouraged for other species of the family.

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Author Contributions

Felipe H. N. P. Ribeiro: Collected the trichomycterids, led the writing, analyzed data, and collaborated with the writing.

Maria E. P. Bonan: Collected the trichomycterids, led the writing, analyzed data, and collaborated with the writing.

José Lucas Dias da Silva: Collected the trichomycterids and collaborated with the writing.

Valter M. Azevedo-Santos: Collected the trichomycterids, identified them, analyzed data, and collaborated with the writing.

Pedro S. Manoel: Analyzed the stomachs, analyzed data, and collaborated with the writing.

Eduardo M. Brambilla: Analyzed data and collaborated with the writing.

Carolina V. Silva: Idealized the work, collected the trichomycterids, analyzed the stomachs, analyzed data, and collaborated with the writing.

Conflicts of interest

The authors declare that they have no conflict of interest related to the publication of this manuscript.

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