Diet and feeding preferences of *Trichomycterus corduvensis* Weyenbergh, 1877 (Siluriformes, Trichomycteridae) in two rivers of the Quinto River basin (San Luis, Argentina)

Dieta e preferências alimentares de *Trichomycterus corduvensis* Weyenbergh, 1877 (Siluriformes, Trichomycteridae) em dois rios da bacia do Rio Quinto (San Luis, Argentina)

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Abstract: Aim: determine the diet, the environment food availability and food preferences of *Trichomycterus corduvensis*, and to compare the relative abundance of the items consumed in the hydrological periods of high and low waters and between rithronic and potamic zones; **Methods:** the diet, the environment food availability and food preferences of *Trichomycterus corduvensis* were studied in two stretches of the Cañada Honda and Quinto rivers belonging to the Quinto River (Popopis River) basin, in San Luis, both representing rithron and potamon zones, respectively. The relative abundance of the items consumed by *T. corduvensis* was compared between hydrological periods and limnological zones (rithron and potamon). Samplings were carried out in the hydrological periods of high and low waters, in four opportunities between May/05 and May/06. Fish were captured by electrofishing, and benthic macroinvertebrates were collected using Surber sampler to determine food availability. The gut contents of 58 samples were analyzed, and the I index (Oda and Parrish, 1981) and E index (Ivlev, 1961) were respectively used to determine the importance and selectivity of each food item; **Results:** the results show that the larvae of Chironomidae and Simuliidae and naiads of Ephemeroptera the most representative food items. The others most representative items consumed by the species included Trichoptera, Coleoptera and filamentous algae. No significant differences were found in the relative abundance of the items consumed by *T. corduvensis* neither between hydrological periods nor between the rithron and potamon zones. In relation to preferences, this species consumes the most abundant benthic macroinvertebrates found in both environments; **Conclusions:** this species may be considered a generalist benthic insectivore.

Keywords: diet, feeding preferences, *Trichomycterus corduvensis,* rithron, potamon.

Resumo: Objetivo: determinar a dieta, a disponibilidade ambiental de alimento e as preferências alimentares de *Trichomycterus corduvensis*, e comparar a abundância relativa dos itens consumidos nos períodos hidrológicos de águas altas e baixas e entre zonas rithronic e potamic; **Métodos:** a dieta, a disponibilidade de alimento e as preferências alimentares de *Trichomycterus corduvensis* foram estudadas em dois trechos, nos rios Cañada Honda e Quinto, situados na bacia do Rio Quinto (Popopis), em San Luis, que representam áreas ritron e potamon respectivamente. Comparou-se a abundância relativa dos itens consumidos por *T. corduvensis* entre os períodos hidrológicos e áreas limnológicas (ritron e potamon). As amostras foram realizadas em períodos hidrológicos de águas baixas e altas, por quatro vezes entre maio/05 e maio/06. Os peixes foram capturados com pesca elétrica. As coletas de macroinvertebrados bentônicos foram obtidos com rede Surber para determinar a oferta alimentar. Foram analisados os conteúdos estomacais de 58 exemplares, a importância de cada item alimentar foi determinada pelo índice I (Oda e Parrish, 1981) e da seletividade com o índice E (Ivlev, 1961); **Resultados:** os resultados apontam que os ítens alimentares de maior importancia foram: larvas Chironomidae, Simuliidae e náiades de Efemeroptera, secundariamente consumiram Trichoptera, Coleoptera e algas filamentosas. Não foram encontradas diferenças significativas na abundância relativa dos ítens consumidos por *T. corduvensis* entre períodos hidrológicos ou entre a zonas ritrônica e potâmica. Observou-se a preferência pelos macroinvertebrados bentônicos; **Conclusões:** esta espécie pode ser considerada um insetívoro bentónico generalista.

Palavras-chave: diet, preferências alimentares, *Trichomycterus corduvensis*, ritron, potamon.

1. Introduction

In the aquatic ecosystems, fish have a fundamental place in the trophic chains. As opposed to other vertebrates, they consume a great variety of food and exhibit different feeding habits. The survival, growth and reproduction of fish depend on the food energy and nutrients intake (Pianka, 1982; Wootton, 1990). Studies on the fish feeding regime and trophic relations have provided information about the energy flow, the ecology of a species and the interactions between the members of a community. Such information is necessary for a better interpretation of the community dynamics and for studies of biomanipulation, pisciculture and fishing, among others (Agostinho et al., 1997). Food preferences and feeding habits may vary even within the same species according to the habitat, food availability, seasonality, age or sex (Prejs, 1981).

The Trichomycteridae Family is widely distributed in the continental waters of Costa Rica, Panamá and South America. The *Trichomycterus* genus has 88 species, most of which live in hilly rivers with rapid and cold currents (Ringuelet, 1975). *Trichomycterus corduvensis* has the widest distribution range (Ringuelet, 1975; Menni et al., 1984; Fernández, 1998; Menni, 2004). This species exhibits morphological features similar to fish adapted to the river bed. The information about biological and feeding aspects of *T. corduvensis* in Argentina is scarce and fragmented (Ringuelet, 1975; Menni et al., 1984; Ferriz, 1998; Fernández, 1998; Dillon and Haro, 2002). These previous studies on the species feeding habits have indicated that the diet is based on aquatic larvae and naiads of insects. These feeding items constitute the macrozoobenthos, which adjusts to a gradient of physical and chemical conditions along the river longitudinal profile by responding with modifications in the species abundance, richness and diversity (Hawkes, 1975; Vannote et al., 1980). The purpose of this work was to determine the diet, the environment food availability and food preferences of *T. corduvensis*, and to compare the relative abundance of the items consumed in the hydrological periods of high and low waters and between rithronic and potamic zones.

2. Material and Methods

2.1. Study area

The study was carried out in the Quinto River (Popopis River) basin, located in the north-central part of Sierras de San Luis, with a drainage area extending along 11,000 km^2 (Menni, 2004). Two sampling stretches were established: one in the Cañada Honda River (CH) (32° 56 S and 65° 59 W) and the other in the Quinto River (Q) (33° 36 S and 65° 34 W). Both sites represented two different limnological environments (rithron and potamon, respectively) due to their altitudinal and geomorphological characteristics (Illies and Botosaneanu, 1963) (Figure 1). Changes in the hydrological cycle determine a period of high waters (HW), which extends from October to March, and a subsequent period of low waters (LW), extending from April to September.

2.2. Sample collection and laboratory analysis

In each stretch the hydraulic parameters of the river bed were recorded: river width, surface current velocity and average depth. Water temperature and the substratum granulometry (using a grid of 1 m^2 with 16 intersections) were determined.

Benthos and fish samples were simultaneously collected in the hydrological periods of HW and LW in each sampling site from May/05 to May/06. In order to determine food availability, benthic macroinvertebrates samples were collected along 150 m using Surber sampler of 0.09 m^2 and 300 µm mesh. Five pseudoreplicates were randomly taken from each site in each hydrological period and kept in alcohol at 70%. Fish were captured upstream by giving them an electrical shock along a 150 m zigzag transect (Karr, 1981), and were then collected using trawl nets and hand nets, fixed in formalin 10% and preserved in alcohol 70%. The taxonomic determination of the organisms collected in the benthos and those found in the stomach contents was

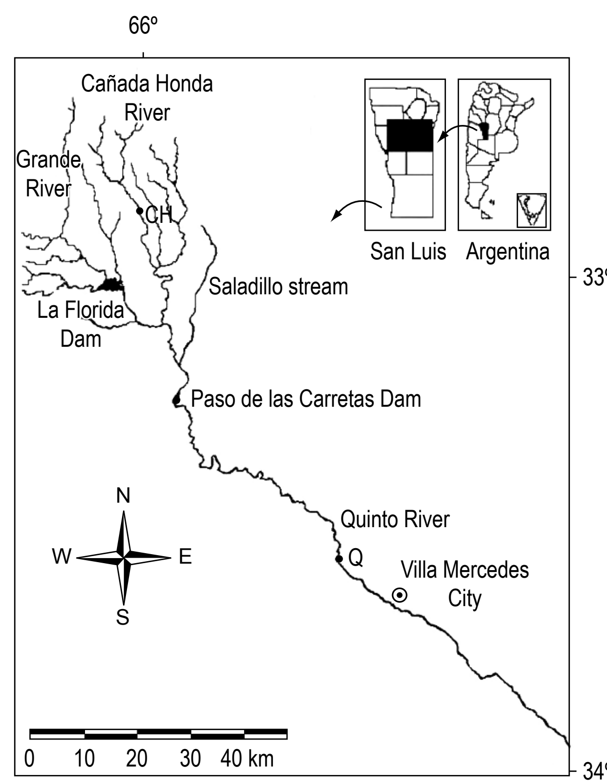

Figure 1. Quinto River basin, detail of the sampling sites on the Cañada Honda River CH (rithron) and the Quinto River Q (potamon).

carried out up to the family level, and the density of each taxa was afterwards estimated (ind.m^{-2}).

2.3. Data analysis

A variance analysis was carried out in order to prove if there were significant differences in the relative abundances of the food items consumed by *T. corduvensis* between the stomachs, the hydrological periods and the sampling stations. The relative abundances of the organisms consumed by *T. corduvensis* between HW and LW, and between sampling stations (CH and Q) were compared using *t*-test.

The relative importance of each food item was evaluated using the I index (Oda and Parrish, 1981), which relates the occurrence percentage (number of stomachs with item A/total number of full stomachs) with the volumetric percentage (volume of item A/volume of all the studied items) of each food item using the following formula: I = (Occurrence % x Volume %) /100. In order to estimate the volume of the diet components, test tubes of different capacities (0.8 and 1.5 mL) were used.

The benthic macroinvertebrates densities of the five pseudoreplicates obtained in each hydrological period were compared using ANOVA, and *t* test was used to compare the average densities between HW and LW and between the sampling stations (CH and Q). The Shannon-Wiener diversity index (H') and richness were compared between the studied sites.

Selectivity was determined through E index (Ivlev, 1961) which permits to show whether the preys are under- or over-represented in the diet in relation to their relative abundances in the environment. It is calculated by: $E = e_i - P_i / e_i + P_i$ where e_i is the prey relative abundance in the diet, and P_i is the prey relative abundance in the benthos of each stretch. This index varies between –1 and +1; the values close to zero (–0.05 to +0.05) indicate neutral selection. For the calculation, only preys with relative abundances higher than 1% in the diet and in the environment were included, considering that this value may be due to sampling errors or rarely appearing organisms (Habit et al., 2005).

3. Results

The environments characterization by the geographical, hydrological, physico-chemical and granulometric variables were in the Table 1.

The total number of captured specimens were 58, of which 26 belonged to the Cañada Honda River (HW: n = 6, $\bar{x}_{TL}$ = 8.3 cm; LW: n = 20, $\bar{x}_{TL}$ = 8.8 cm) and 32, to the Quinto River (HW: n = 29, $\bar{x}_{TL}$ = 6.3 cm; LW: n = 3, $\bar{x}_{TL}$ = 6 cm), and only 12% of the total number had their stomachs empty.

3.1. Trichomycterus corduvensis feeding

The variance analysis allowed to determine that the abundance of the feeding items consumed by *T. corduvensis* was similar between the stomachs in both hydrological periods (HW and LW) and sampling stations (CH and Q), respectively (p = 0.79, F = 0.34; p = 0.85, F = 0.61; p = 0.37, F = 1.12; p = 0.89, F = 0.62), so data were averaged. The HW and LW means were compared using *t* test, and no significant differences were observed (p = 0.41, t = –0.82; p = 0.65, t = –0.09); consequently, data were averaged for each sampling stretch. The comparison between the relative abundances of the items consumed by fish in CH and Q using *t* test revealed that there was no significant difference (p = 0.65, t = –0.44).

Trichomycterus corduvensis diet was constituted by 19 feeding items with the following distribution: 16 aquatic invertebrates, 1 terrestrial invertebrate (Thysanoptera), 1 filamentous alga (Cladophoraceae) and 1 belonging to

Table 1. Hydrological, geographic, and physical variables, and percentage of the granulometry of the sampling for each stretch (CH and Q).

Variables	Cañada Honda River		Quinto River	
Altitude (m a.s.l.)	1.273		530	
Distance to the river sources (km)	20		130	
River order	4º		7º	
Granulometry % (cm)				
< 1	26.80		72.36	
1-15	37.14		27.63	
15-60	29.62		0	
60-100	5.17		0	
> 100	1.25		0	
	HW (May/06)	LW (September/05)	HW (March/06)	LW (May/05)
River width (m)	9.23	7.52	9.40	6.50
Velocity ($m.s^{-1}$)	0.16	0.20	0.52	0.69
Depth (m)	0.12	0.12	0.19	0.19
Flow ($m^3.s^{-1}$)	0.17	0.15	0.72	0.82
Water temperature (°C)	10	20.10	14.50	11.30

undetermined remains. When the I index was applied to the total number of items found in the analysed stomachs in both sampling sites, the most representative groups were Baetidae, Chironomidae and Simuliidae, with higher values in the rithron than in the potamon. Pyralidae was also found in the rithron whereas Leptoceridae and Leptohyphidae were found in the potamon, the latter exhibiting a higher value. Hydroptilidae and Cladophoraceae were also found in both environments but in a lower proportion. The rest of the groups were represented with values lower than 0.5 (Tables 2 and 3).

3.2. Selectivity of T. corduvensis

No significant differences were observed when analysing (ANOVA) the densities of the benthic macroinvertebrates of the 5 pseudoreplicates for each hydrological period (HW and LW) and for each site (CH and Q) respectively ($p = 0.59$, $F = 0.69$; $p = 0.94$, $F = 0.18$; $p = 0.36$, $F = 1.08$; $p = 0.35$, $F = 1.11$), so data for HW and LW were averaged for each sampling stretch. The comparison of the densities between both hydrological periods (*t* test) did not show any significant differences either for CH ($p = 0.97$, $t = 0.02$) or Q ($p = 0.07$, $t = 2.14$), so data were averaged for CH and Q, and were then analysed using the same test, revealing no significant differences ($p = 0.33$, $t = –0.96$).

The values of H' (CH = 0.776, Q = 0.718) and species richness (CH = 41, Q = 39) were quite similar in both sites.

The benthic macroinvertebrates taxa with the highest densities were Chironomidae, Oligochaetae and Baetidae in the rithron (Figure 2) and Simuliidae and Chironomidae in potamon (Figure 3). *Trichomycterus corduvensis* consumed

Table 2. Percentage of occurrence, volumetric percentage, relative abundance, I index, E index of items consumed by *T. corduvensis* in Cañada Honda River from rithron zone.

Taxa	O (%)	V (%)	Relative abundance	I index	E index
Nematoda	4.54	1.79	0.19	0.081	-
Baetidae	54.54	31.39	46.80	17.12	0.62
Aeshnidae	4.54	0.89	0.09	0.04	-
Hydroptilidae	36.36	2.69	0.89	0.97	−0.39
Phylopotamidae	4.54	0.89	0.09	0.04	-
Dytiscidae	13.63	2.24	0.59	0.30	-
Elmidae	4.54	0.89	0.09	0.04	-
Ceratopogonidae	4.54	0.89	0.09	0.04	-
Simuliidae	77.27	19.73	20.30	15.24	0.40
Chironomidae	90.90	24.21	29.50	22.01	−0.09
Pyralidae	22.72	4.48	0.49	1.01	-
Thysanoptera	4.54	0.89	-	0.04	-
Remains of Ephemeroptera	4.54	0.89	-	0.04	-
Undetermined remains	18.18	1.79	-	0.32	-
Filamentous green algae	18.18	6.27	-	1.14	-

Table 3. Percentage of occurrence, volumetric percentage, relative abundance, I index, E index of items consumed by *T. corduvensis* in the Quinto River from potamon zone.

Taxa	O (%)	V (%)	Relative abundance	I index	E index
Nematoda	20.69	0.56	1.88	0.11	-
Baetidae	89.65	12.32	27.49	11.04	0.56
Aeshnidae	3.45	0.11	0.09	0.003	-
Hydroptilidae	79.31	11.59	5.12	9.19	–0.07
Phylopotamidae	41.37	2.24	2.78	0.92	–0.34
Dytiscidae	34.48	5.60	1.43	1.93	–0.11
Elmidae	6.89	1.12	0.09	0.07	-
Ceratopogonidae	3.45	0.11	0.09	0.003	-
Simuliidae	3.45	0.05	0.09	0.001	-
Chironomidae	3.45	0.28	0.09	0.009	-
Pyralidae	51.72	16.97	22.64	8.77	–0.26
Thysanoptera	96.55	12.32	38.18	11.89	0.06
Remains of Ephemeroptera	10.34	0.28	-	0.02	-
Undetermined remains	13.79	5.60	-	0.77	-
Filamentous green algae	17.24	30.81	-	5.31	-

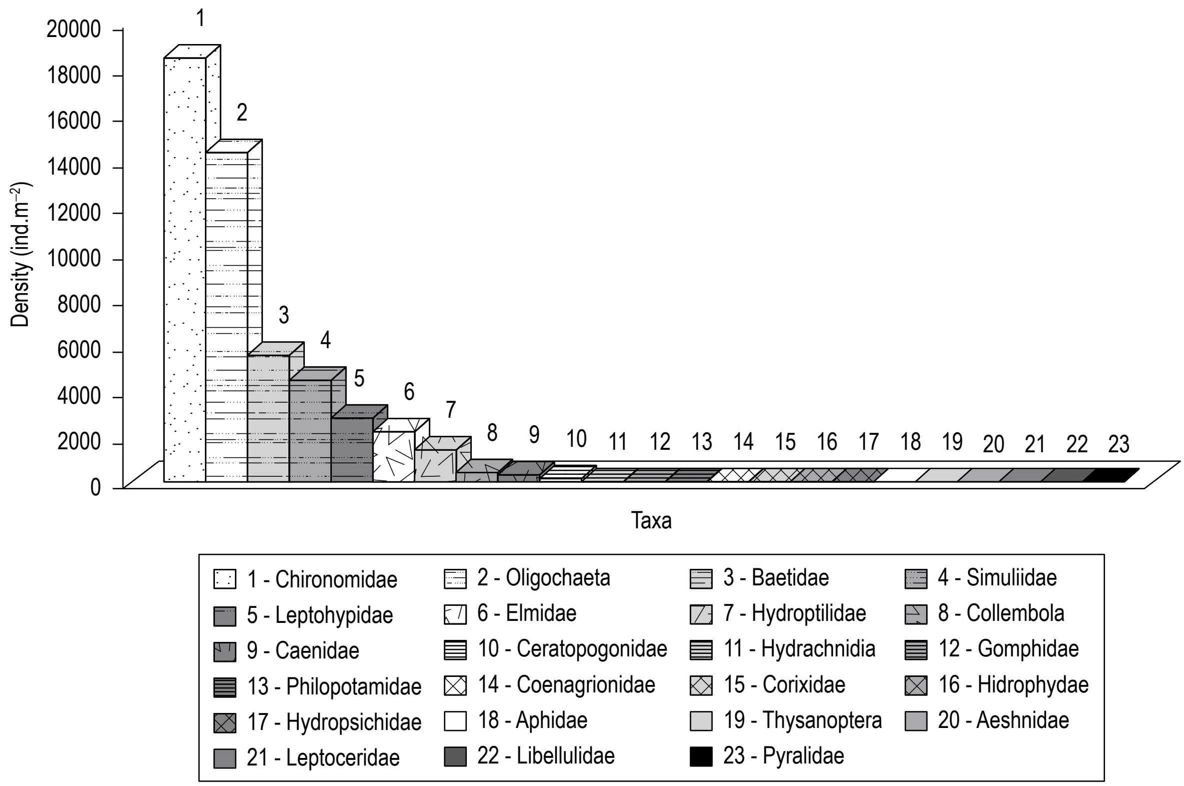

Figure 2. Densities (ind.m^{-2}) of taxa collected in the benthos samples in the Cañada Honda River sampling stretch (taxa with densities lower than 10 ind.m^{-2} are not included).

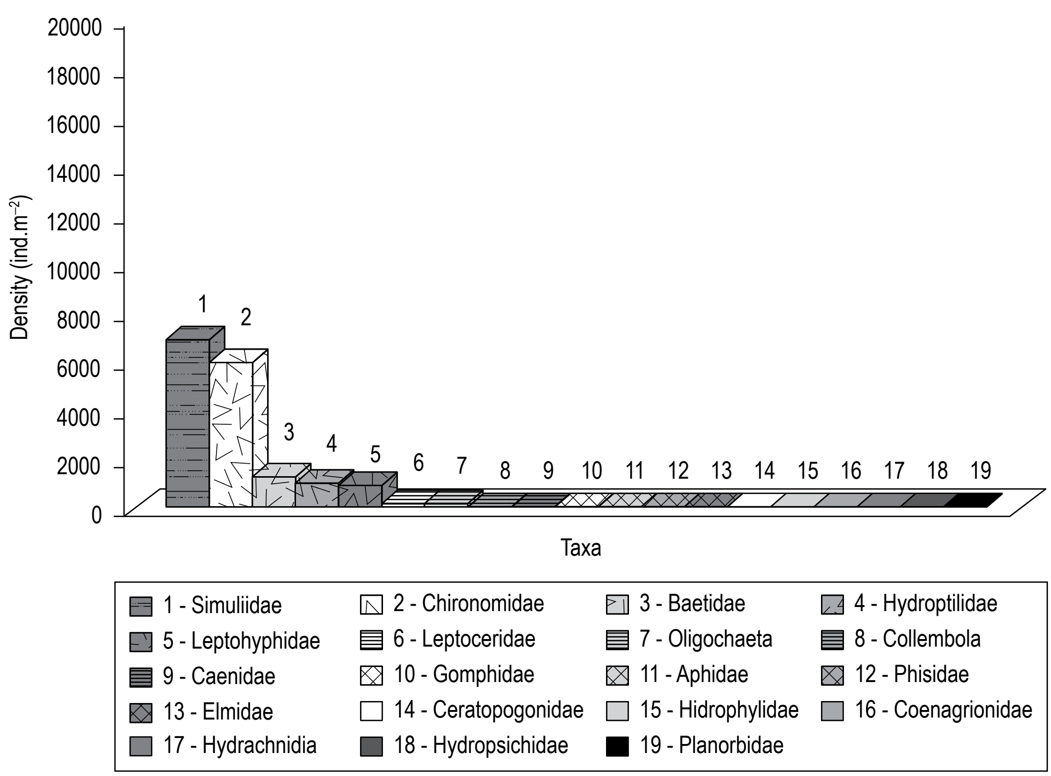

Figure 3. Densities (ind.m^{-2}) of taxa collected in the benthos samples in the Quinto River sampling stretch (taxa with densities lower than 10 ind.m^{-2} are not included).

the items with higher representation in the rithron and potamon. The E index showed an almost neutral selection for Leptohyphidae in the Quinto River and for Chironomidae in both environments. Baetidae was positively selected in CH and Q whereas Simuliidae was positively selected only in CH. There was a negative selection for Simuliidae and Leptoceridae in Q and for Hydroptilidae in both limnological regions (Tables 2 and 3).

4. Discussion and Conclusions

The results obtained in this work indicate that *T. corduvensis* is a species with zoophagous feeding habits, with an occasional appearance of vegetal elements in its diet. This trichomycterid can be considered a generalist insectivore, which feeds almost exclusively with the autochthonous fauna. This is in agreement with the results found by Ferriz (1998) for this species in other rivers in San Luis and for *T. areolatus* in Chile and for *Hatcheria macrei* in Mendoza, Argentina. According to Duarte et al. (1971), *T. areolatus* preferably consumes any kind of prey living in contact with the river bottom, coinciding with *T. corduvensis*, which captures benthic preys which are either fixed to stones, mobile or associated to vegetation. In relation to filamentous algae, in this study they were scarcely found in the gut contents, in agreement with the results reported by Ferriz (1998) and in opposition to Dillon and Haro (2002) who did not observe any filamentous algae in the diet of this species in the province of Cordoba. No significant differences were found in the algae percentage (Cladophoraceae) in the studied environments, which might be due to the predominance in both sites of riparian vegetation constituted by grasslands which do not produce shadow and contribute with scarce aloctonous organic matter, although in the potamic zone there is greater diversity of aquatic vegetation. Even though algae are the most important primary production source in both environments, we consider that this item intake might be related to the consumption of the organisms associated to it.

In relation to macroinvertebrates, no differences in the density, diversity and richness were found between the rithronic and potamic zones, as opposed to Hawkes (1975) and Vanotte et al. (1980) reports.

The trophic spectrum of *T. corduvensis* is mainly represented by aquatic larvae and naiads of insects. According to this, the species might be considered as a mesopredator of small preys (Welcomme, 1992), an invertivore (Oberdoff and Porcher, 1992) and an insectivore (Karr et al., 1986). The mainly-consumed items in rithron and in potamon were Chironomidae, Baetidae and Simuliidae. Hydroptilidae, Coleoptera and filamentous algae were also consumed but in a lower proportion whereas Pyralidae was only observed in CH and Leptohyphidae and Leptoceridae in Q.

Although the hydrological, geographical and physical characteristics are usually very different in both sites, no significant differences were found in the relative abundance of the organisms consumed by *T. corduvensis* between the hydrological periods (HW and LW) nor between the limnological zones. This might be due to the fact that the sampling period during high waters coincided with an atypical rainfall period since precipitations were scarce, and there were not significant increases in the river flows, which might have altered the abundance and composition of the benthic macroinvertebrates community.

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