Aquatic oligochaetes associated with bryophytes in an Atlantic Forest stream

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Abstract: There are few reports in the literature about the colonization of benthic macroinvertebrates on bryophytes. The aim of the present study was to analyzed the oligochaetes established on bryophytes adhered to stones in a first-order stream. The collections were carried out in an Atlantic Forest fragment area during the dry and rainy seasons. We identified 15 taxa from a total of 422 oligochaetes specimens, of which the most abundant were *Pristina* sp.1, Enchytraeidae and *Pristina jenkinae*. Unlike other habitats, where the abundance of macroinvertebrates tends to be greater in the dry season, we did not find any significant differences in the abundance, richness, composition and diversity between the two periods. The results of this study indicate that bryophytes are possible areas of refuge for oligochaetes in periods of faster water flow.
Keywords: *lotic environments, preserved areas, mosses, hepatics, Naididae.*

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Resumo: Existem poucos registros na literatura sobre a colonização de macroinvertebrados bentônicos em briófitas. O presente estudo teve como objetivo analisar a fauna de oligoquetas em briófitas aderidas a pedras em um córrego de primeira ordem. As coletas foram realizadas em um fragmento de Mata Atlântica durante os períodos seco e chuvoso. Foram identificados 15 taxa de um total de 422 espécimes de oligoquetas, sendo os mais abundantes *Pristina* sp.1, Enchytraeidae e *Pristina jenkinae*. Ao contrário de outros habitats, onde a abundância de macroinvertebrados tende a ser maior no período de estiagem, diferenças significativas na abundância, riqueza, composição e diversidade não foram observadas em relação aos dois períodos. Os resultados do presente estudo indicam que as briófitas são possíveis áreas de refúgio para os oligoquetas em período de maior corrente.
Palavras-chave: *ambientes lóticos, áreas preservadas, musgos, hepáticas, Naididae.*

Introduction

Bryophytes are plants frequently found in lotic ecosystems associated with rocky substrates (Heino & Korsu 2008). Their architecture allows them to retain different fractions of organic detritus (Habdija et al. 2004), providing favorable conditions for colonization by various groups of invertebrates, including the oligochaetes, especially the Enchytraeidae (Glime 2007) and Naididae (Gorni & Alves 2007). As a result, these invertebrates can reach densities on bryophytes up to two times greater than on other substrates, such as gravel streambeds (Suren 1992, Linhart et al. 2002). Baturina (2007, 2012) studying Oligochaeta on various substrates in streams and reservoirs found higher densities in stones covered by bryophytes in streams.

An extensive literature exists on the presence of oligochaetes in boglands, where the dominant vegetation is composed of *Sphagnum* L., being *Cognettia sphagnetorum* (Vejdovský, 1877) and other Enchytraeidae the most abundant and important invertebrates in these habitats (Standen & Latter 1977, Dózsa-Farkas 1990, Carrera et al. 2011). However, studies of oligochaetes living in bryophytes of running waters are relatively scarce in the literature.

The studies of Vlčková et al. (2002) and Habdija et al. (2004), for example, carried out in streams in temperate regions, although including oligochaetes in the fauna composition analyzed, only considered them at the class or family level. In Brazil, Gorni & Alves (2007) and Rosa et al. (2011, 2013) report, respectively, the presence of species of Naididae, benthic invertebrates and larvae of Chironomidae (Diptera) associated with bryophytes in lotic environments in the southeastern region of the country. The aim of the present study was to identify the aquatic oligochaetes associated with the bryophytes adhered to stones in a first-order stream in southeastern Brazil.

Material and Methods

The study was carried out in the Poço D'Anta Municipal Biological Reserve (21° 44' 23"-21° 45' 52" S and 43° 18' 29"-43° 19' 10" W), a fragment of the Atlantic Forest located in the municipality of Juiz de Fora, Minas Gerais state. The specific environment studied is a shallow first-order stream whose bed is composed mainly of sand containing a large quantity of leaf litter and stones of different sizes. It is located at an altitude of 850 m between the coordinates 21° 44' 36"-21° 44' 31" S and 43° 18' 51" - 43° 18' 53" W.

The samples were collected in the months of July, August and September 2007 (dry season) and January, February and March 2008 (rainy season). In a segment approximately 100 m long of the stream, each month we collected 400 mL of bryophytes (two pots of 200 mL) adhered to different stones (1-2 cm above the water surface) by scraping with a spatula. The bryophytes were composed of two families of mosses (Pilotrichaceae Kindb. and Hypnaceae Schimp.) and one family of hepatics (Geocalycaceae H.Klinggr.).

The plant material collected was fixed in 4% formaldehyde, washed in running water using a 0.21 mm sieve and sorted under a stereoscopic microscope to separate the fauna. The organisms found were preserved in alcohol 70° GL and identified according to the taxonomic criteria adopted by Righi (1984), Brinkhurst & Marchese (1989) and Erséus et al. (2008). The average current speed was obtained using the float method (Martinelli & Krusche 2007). The rainfall and air temperature data were obtained from the Climatology and Environmental Analysis Laboratory of Juiz de Fora Federal University.

The faunal structure was analyzed by the abundance, richness and diversity (Shannon's index). The data were checked for homogeneity of the variances (Levene test) and normality (Shapiro-Wilk) and submitted to the T-test for significant differences between the dry and rainy seasons, using the Statistica 7 program (Statsoft 2004). To verify differences in the faunal composition between the two seasons, analysis of similarity (Anosim) was performed with the R program (R Development Core Team 2011). Simple linear regression was used to test the relation between the dependent variables (abundance and richness) and the explanatory variable (water speed), also using the Statistica7 program. For this analysis, the data were transformed into log (x + 1). It is accepted $p < 0.05$ for all statistical tests.

Results

The average monthly rainfall was greater in the rainy season (Figure 1), causing a significant increase (df= 5; Z= 2.930; p= 0.003) in the water speed. The air temperature, precipitation, water velocity and water depth values are reported in Table 1.

Oligochaetes (422 specimens) belonging to the Naididae and Enchytraeidae families and the superorder Megadrili were found associated with the bryophytes (Table 2). Among the species found, the most abundant were *Pristina* sp.1 (29.38%) and *Pristina jenkinae* (18.95%). The Enchytraeidae accounted for 30% of the fauna.

The abundance and richness observed did not differ between the two collection periods (df= 10; t= –0.250; p= 0.807 and df= 10; t= –0.691; p= 0.505, respectively) (Figure 2). There also was no difference in the composition (df= 10; Anosim R= –0.032; p= 0.605) and diversity (df= 10; t= 0.696; p= 0.501) of the oligochaetes fauna between the two seasons. The results of the regression analysis indicated that there was no cause and effect relationship between water velocity and abundance (R^2= 0.026; F= 0.108; p= 0.758) or between water velocity and taxa richness (R^2= 0.015; F= 0.064; p= 0.812) (Figure 3).

Discussion

Unlike other stream habitats, such as submersed leaf litter, where the abundance and richness of macroinvertebrates tend to be lower in the rainy season (Kikuchi & Uieda 2005, Silveira et al. 2006), the results of the present study appear to indicate that the bryophytes serve as areas of refuge when the current is strongest, an important condition for a group of organisms that does not have adaptations for fixation or anchorage. Besides refuge, the bryophytes normally retain periphyton and detritus that serve as food for invertebrates (Suren & Winterbourn 1992).

In a temperate region, Percival & Whitehead (1929) studied the fauna of macroinvertebrates in different types of substrates in streams and found that the mosses sheltered the greatest abundance of oligochaetes and that this abundance was greater in areas with slower current. On the other hand, Habdija et al. (2004) reported an increase in the density of macroinvertebrates associated with mosses with increasing water flow, besides significant differences in the composition and diversity of fauna. Baturina (2012) also found greater diversity of oligochaetes in mosses adhered to rocks in small streams with fast currents. Although the regression analysis did not

Table 1. Environmental characterization of the study area during the dry and the rainy season.

	Mean and standard deviation	
	Dry season	**Rainy season**
Air temperature (°C)	19.6 ± 1.2	21.93 ± 0.30
Precipitation (mm)	4.33 ± 3.07	316.00 ± 13.57
Water velocity (m/s)	0.07 ± 0.11	0.39 ± 0.40
Water depth (cm)	4.53 ± 0.97	6.73 ± 0.75

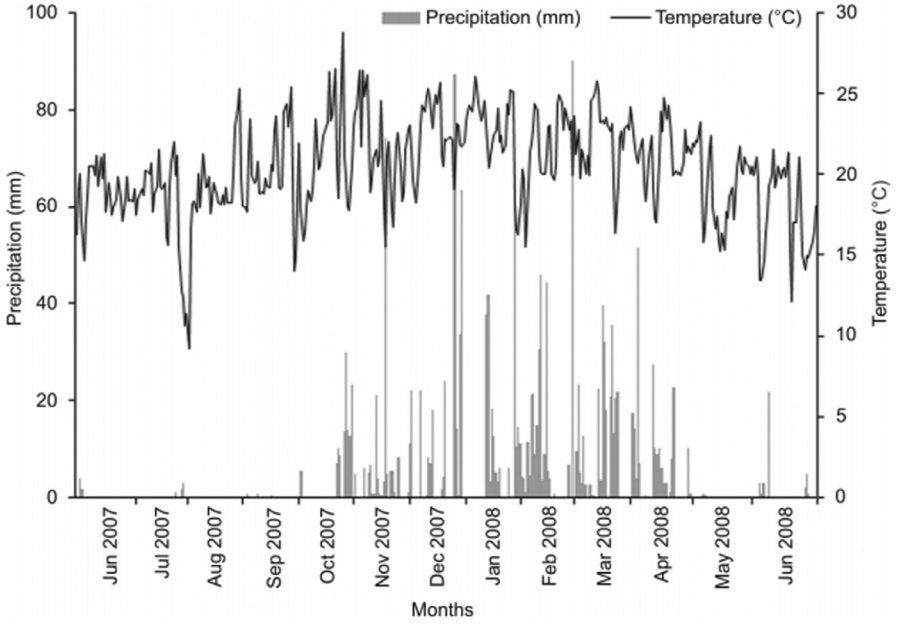

Figure 1. Monthly rainfall and average air temperature from June 2007 to June 2008 in Juiz de Fora, Brazil. The bars indicate rainfall and the lines temperature. Source: Laboratory for Climatology and Environmental Analysis, Juiz de Fora Federal University, Brazil.

Table 2. Abundance, richness and diversity of oligochaetes associated with bryophytes during the dry and the rainy season in a first-order stream in the Poço D'Anta Municipal Biological Reserve, southeastern Brazil. *The abundance values refer to the sum of the two samples collected each month.

Season	Dry			Rainy		
	July*	August*	September*	January*	February*	March*
NAIDIDAE						
Naidinae						
Nais communis Piguet, 1906	0	0	0	0	2	1
Pristininae						
Pristina aequiseta Bourne, 1891	0	0	0	0	2	1
Pristina leidyi Smith, 1896	0	0	0	0	1	0
Pristina proboscidea Beddard, 1896	0	0	0	0	1	0
Pristina sima (Marcus, 1944)	12	0	0	1	0	0
Pristina osborni (Walton, 1906)	5	0	0	0	18	2
Pristina minuta (Stephenson, 1914)	8	0	1	0	8	1
Pristina jenkinae (Stephenson, 1931)	2	0	0	2	76	0
Pristina sp.1	88	0	3	0	26	7
Pristina sp.2	4	0	0	0	1	0
Pristina sp.3	0	0	0	0	2	0
Tubificinae						
Immature tubificines	9	0	4	0	4	2
ENCHYTRAEIDAE						
Achaeta sp.	5	0	3	0	1	2
Other enchytraeids	35	3	7	1	59	11
MEGADRILI	1	0	0	0	0	0
Abundance		190			232	
Richness		10			14	
Shannon-Wiener diversity		0.963			1.087	

show any effect of water velocity on the abundance and richness of oligochaetes, Habdija et al. (2004) showed that in bryophytes the abundance increased with faster water flow, indicating that this substrate provides refuge for fauna. An increase in abundance and richness in the rainy season has also been reported for other groups of macroinvertebrates in bryophyte habitats (Rosa et al. 2011, 2013).

Enchytraeidae represented 30% of the fauna collected. Percival & Whitehead (1929) found that Enchytraeidae were frequent inhabitants of mosses in shallow areas of temperate streams. According to Johnson & Ladle (1989), probably the majority of records of Enchytraeidae in low-order streams are the result of accidental derivation from adjacent terrestrial populations, since these streams are very narrow and shallow, intensifying the interaction between the components of the water and land.

The Naididae family was the best represented, with 12 taxa. Most species of the subfamilies Naidinae and Pristininae are free swimmers (Verdonschot et al. 1982), allowing these invertebrates to colonize a variety of substrates in streams, including bryophytes.

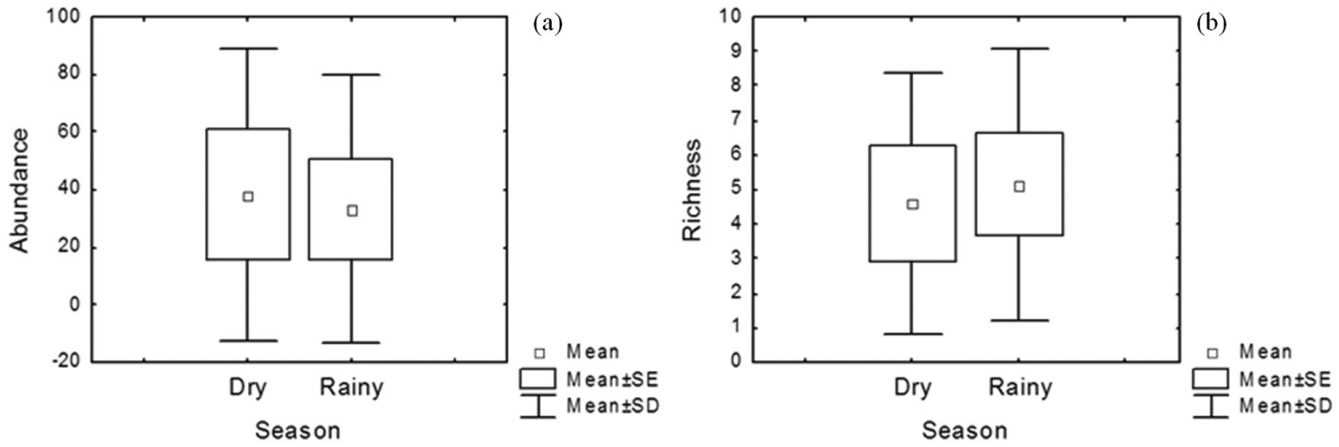

Figure 2. Abundance (a) and richness (b) of oligochaetes in the two collection periods.

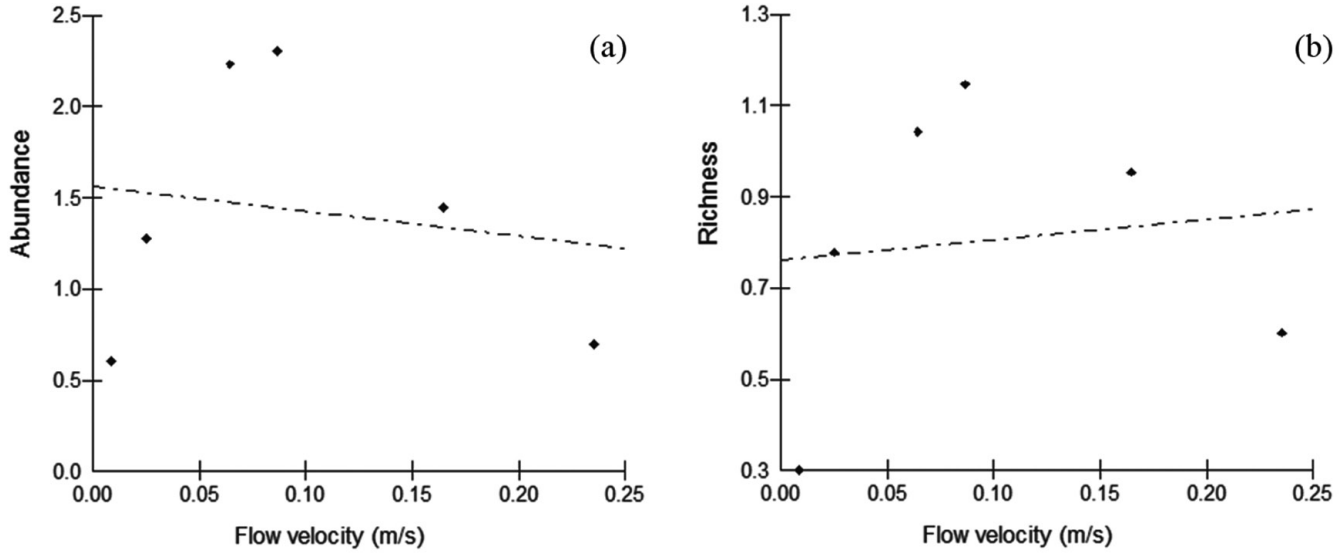

Figure 3. Effect of flow velocity on abundance (a) and richness (b) of oligochaetes associated with bryophytes in a first-order stream in the Poço D'Anta Municipal Biological Reserve, southeastern Brazil.

Baturina (2007) reported dominance of Naidinae and Pristininae (up to 70% of the oligochaetes) in bryophytes adhered to rocks in Russian streams. Naidinae and Pristininae also were the only subfamilies found by Gorni & Alves (2007) in bryophytes collected on rocky substrates of riffles. *P. jenkinae* was the most abundant species in bryophytes collected by Gorni & Alves (2007), who observed greatest abundance in the rainy season (spring). Parish (1981) observed that species such as *N. communis* and *C. diastrophus* presented peak abundance in the spring, while *P. aequiseta*, *P. leidyi* and *P. osborni* presented peaks in the autumn. However, according to Smith (1986), there is no consensus on a single and constant time period or season when Naididae are most abundant. An explanation is that besides air temperature, which increases the metabolism and stimulates asexual reproduction, promoting peaks of abundance, the availability of food and other physical and chemical parameters, such as electrical conductivity, act together for population regulation of the Naididae, resulting in a wide range of conditions favorable to peaks of abundance. The relatively short observation period (six months) in the present study, although allowing the collection of information on the numerical abundance of the species found in the two collection periods, did not allow us to detect temporal variation patterns.

The results of this study indicate that the bryophytes are important substrates for oligochaetes, offering protection against natural hydrological disturbances. The results also indicate the importance of preserved streams for maintenance of the diversity and preservation of these invertebrates.

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