Seasonal fluctuations of the microcrustacean assemblages in the littoral zone of Lake Dom Helvécio (Parque Estadual do Rio Doce, MG)

Flutuação sazonal das assembléias de microcrustáceos na região litorânea do Lago Dom Helvécio (Parque Estadual do Rio Doce, MG)

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Abstract: This study aimed at evaluating the effects of seasonality on the structure of microcrustacean assemblages in the littoral zone of Lake Dom Helvécio, state of Minas Gerais, Brazil. Samples were collected in February and July 2006, corresponding to the rainy and dry seasons respectively. The microcrustaceans were sampled throughout the littoral zone, in locations without aquatic vegetation and in locations colonized by *Eleocharis interstincta*. The following variables were measured: pH, water temperature, conductivity, dissolved oxygen, total nitrogen and total phosphorus. Only the total phosphorus concentration did not show significant differences between the rainy and dry periods. The values of total density and microcrustacean richness were significantly higher only in the vegetated littoral zone and in the dry period, because of the larger quantity of detritus formed by the decomposition of vegetation with the decrease in water level. The high indexes of similarity between the composition of the microcrustacean species during the rainy and dry periods in both types of littoral environments (littoral zone with and without aquatic vegetation) suggest a low species turnover between these two seasons. However, the change in the most abundant species between these periods may reflect the seasonal effects at a population level. Thus, it is possible that *Ephemeroporus barroisi* and *Microcyclops anceps* are more adapted to the environmental conditions in the rainy period, whereas *Scapholeberis armata* is more adapted to the dry period, since these species were more abundant during these periods, independent of the littoral environment. *Diaphanosoma birgei* showed a higher contribution in the dry period only in the vegetated areas, which may be related to an increase in bacterioplankton and other food resources associated with organic detritus.

Keywords: microcrustaceans, limnological variables, seasonal fluctuation, Lake Dom Helvécio, aquatic vegetation.

Resumo: Este estudo teve como objetivos avaliar os efeitos da sazonalidade sobre a estrutura das assembléias de microcrustáceos na região litorânea do Lago Dom Helvécio (MG). Foram realizadas coletas nos meses de fevereiro e julho de 2006, correspondendo aos períodos de chuva e seca, respectivamente. As amostras de microcrustáceos foram coletadas ao longo da região litorânea em pontos sem vegetação aquática e em pontos colonizados por *Eleocharis interstincta*. Adicionalmente, foram medidas as seguintes variáveis limnológicas: pH, temperatura da água, condutividade, oxigênio dissolvido, nitrogênio total e fósforo total. Dentre as variáveis limnológicas, apenas a concentração de fósforo total não apresentou diferenças significativas entre os períodos de chuva e seca. A densidade total e a riqueza em microcrustáceos foram significativamente maiores no período de seca, apenas na região litorânea com vegetação aquática, o que pode estar associado à maior disponibilidade de alimento, devido à maior quantidade de detritos liberada pela decomposição da vegetação com a diminuição do nível da água. Os altos índices de similaridade da composição em espécies de microcrustáceos entre os períodos de chuva e seca nos dois tipos de ambientes litorâneos (região litorânea com e sem vegetação aquática) sugerem uma baixa renovação (turn-over) das espécies entre essas épocas contrastantes do ano. No entanto, a alternância das espécies mais abundantes entre os dois períodos pode estar refletindo os efeitos sazonais em um nível populacional. Assim, é provável que *Ephemeroporus barroisi* e *Microcyclops anceps* sejam mais adaptadas às condições ambientais do período chuvoso, enquanto *Scapholeberis armata* às do seco, pois independentemente do ambiente litorâneo estas espécies foram mais abundantes nestes períodos. Quanto a *Diaphanosoma birgei*, a sua maior contribuição no período de seca apenas nos ambientes com vegetação aquática pode estar relacionada ao aumento do bacterioplâncton e outros recursos alimentares associados aos detritos orgânicos.

Palavras-chaves: microcrustáceos, variáveis limnológicas, flutuação sazonal, lago Dom Helvécio, macrófitas aquáticas.

1. Introduction

The seasonal fluctuation of zooplankton is a common phenomenon in tropical and temperate aquatic environments, and it reflects the action of biotic and abiotic factors. In addition to these factors, such fluctuations are also a factor of the organisms' own physiology (Rocha, 1978). The wide fluctuations in zooplankton populations are due to their small body dimensions. According to Ricklefs (2001), small organisms tend to show more-intense population fluctuations compared to larger organisms, due to their short life cycle and limited ability to maintain homeostasis.

According to Hutchinson (1967) most zooplankton species show maximum and minimum population abundances at different times of the year. However, his statement referred to organisms in the temperate zone, where seasonal differences in temperature and light are greater than in the tropics. Twombly (1983) working with zooplankton community of Lake Malawi reported that the population densities remained almost constant, due to the more homogenous environmental conditions throughout the year.

Microcrustaceans of the littoral zone exhibit a seasonal dynamic that can be quite different from that observed for the limnetic fauna (Nogueira et al., 2003). According to Balayla and Moss (2003), besides the physical and chemical conditions and the predation and competition relationships, littoral populations are also influenced by the dynamics of the aquatic macrophytes (growth, death and decomposition) during the year.

The seasonal fluctuations of the microcrustacean assemblages of the limnetic zone of Lake Dom Helvécio have been studied since 1970 (Santos, 1980; Matsumura-Tundisi and Okano, 1983). The initiation in 1999 of the PELD (Long-Term Ecological Research Program) monitoring program allowed for intensive long-term studies. However, there are still few studies of the temporal dynamics of the microcrustaceans in the littoral zone of this lake.

The present study had as its objectives: i) compare the richness and density of microcrustaceans between the rainy and dry periods in areas of the littoral zone with and without aquatic vegetation; and ii) evaluate the differences in the species composition and fluctuations of the main microcrustacean species between the rainy and dry periods.

2. Material and Methods

2.1. Study area

Lake Dom Helvécio (Figure 1) is located in the Parque Estadual do Rio Doce, Minas Gerais, Brazil (19° 45' and 19° 50' S and 42° 35' and 42° 40' W). It has an area of 6.87×10^6 m^2, maximum depth of 32.5 m, volume of 8.31×10^6 m^3 and perimeter of 45,000 m. Its dendritic shoreline is bordered almost entirely by riparian vegetation typical of the Atlantic Forest biome. The lake is olig-

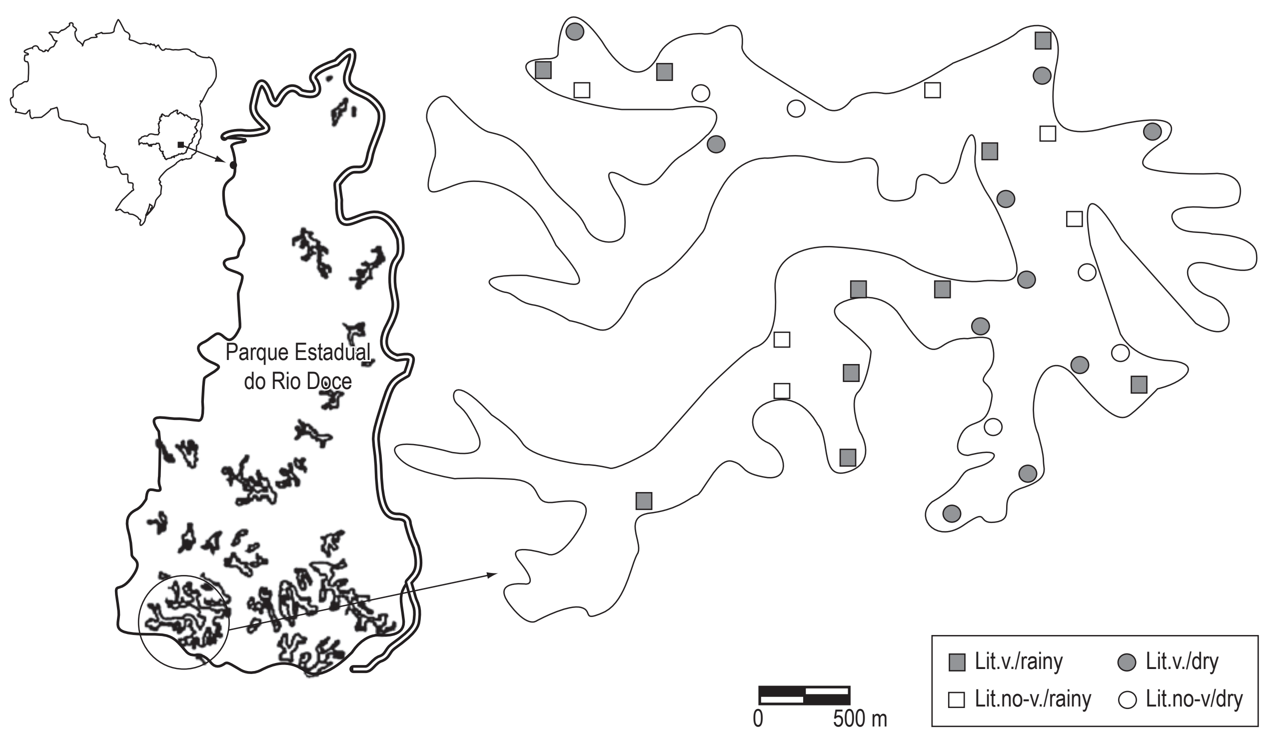

Figure 1. Lake Dom Helvécio: Geographic localization and sampling stations.

otrophic, and is thermally stratified during summer (warm monomictic), with circulation from May to September. Most of the littoral zone is covered by large banks of aquatic macrophytes, including more or less homogeneous areas of *Eleocharis interstincta*, *Typha domingensis*, *Eichhornia crassipes* and *Nymphaea* sp. (Ikusima and Gentil, 1997), as well as mixed banks.

2.2. Sample collection and laboratory analysis

The samples were collected in February (rainy) and July (dry) 2006, at 16 locations throughout the littoral zone in each period. Ten of these locations were colonized by the emergent *Eleocharis interstincta*, and 6 had no aquatic vegetation. The zooplankton samples were obtained at the subsurface, by filtering 200 liters of water in a plankton net of 68 μm mesh size. The samples were preserved in buffered 4% formaldehyde. The microcrustaceans (Copepoda and Cladocera) were counted in acrylic cuvettes under a stereoscopic microscope.

The water temperature, pH, conductivity, and dissolved oxygen concentration were measured with a Horiba U22 multi-analyzer. Water samples were also collected, to determine the total nitrogen and total phosphorus concentrations, according to the recommendations of Mackereth et al. (1978).

2.3. Data analysis

The differences between the limnological variables in the rainy and dry periods, and between the littoral zone with and without aquatic vegetation, were evaluated by variance analysis (one-way ANOVA). In order to evaluate the seasonal differences in the total density and richness of the microcrustacean species, the two-tailed *t*-test was used. These analyses were carried out using the program Statistica 6.0.

The similarity between the microcrustacean assemblages in the rainy and dry periods was calculated for the littoral zone, with and without aquatic vegetation. This index was obtained by the total species composition of all samples, for each type of environment, and was calculated according to Sørensen (1948).

The mean relative abundance of each taxon was calculated as a percentage of the total number of individuals for the rainy and dry periods, in the areas with and without aquatic vegetation. This was done in order to compare the composition and abundance of the species in these periods of the year.

3. Results

Water temperature and dissolved oxygen showed higher values during the rainy period, whereas pH, conductivity and total nitrogen and total phosphorus concentrations were higher during the dry period (Table 1). The differences were all statistically significant except for total phosphorus ($p > 0.05$; one-way ANOVA). Between the two types of littoral environments, none of the limnological variables showed statistically significant differences.

The total density and richness of microcrustacean species (Figure 2) were both significantly higher (*t*-test) during the dry period in the littoral zone with aquatic vegetation ($t = 3.31$; $p = 0.006$ total density of microcrustaceans, $t = 2.15$; $p = 0.048$ richness in species). Neither parameter showed differences in the littoral zone without vegetation ($t = 0.28$; $p = 0.78$ total density of microcrustaceans; $t = 1.81$; $p = 0.41$ species richness).

The similarity index between the rainy and dry periods was high, both in the littoral zone with aquatic vegetation (83%) and in the zone without aquatic vegetation (78%). In the littoral zone with aquatic vegetation, *Ephemeroporus barroisi* and *Microcyclops anceps* were the most abundant species in the rainy period, with a mean relative abundance of 50% and 20%, respectively (Table 2). During the dry period, these species were replaced by *Scapholeberis armata* and *Diaphanosoma birgei* with, respectively, 32 and 21% of the mean relative abundance. In the littoral zone without aquatic vegetation, *E. barroisi* and *M. anceps* were also more abundant during the rainy period (mean of 25 and 36%, respectively). During the dry period, *S. armata* was strongly

Table 1. Mean values and one-way ANOVA results for Temperature = Temp. (°C); pH; Conductivity = Cond. (μS/ cm); Dissolved oxygen = D.O (mg.L^{-1}); Total Nitrogen = N.tot. (μg.L^{-1}), Total Phosphorus = P.tot. (μg.L^{-1}) in the littoral zone: with aquatic vegetation (Lit./v) and without aquatic vegetation (Lit.no/v) in Lake Dom Helvécio (Parque Estadual do Rio Doce, MG), in the rainy (February) and dry (July) periods of 2006.

Variables	Rainy		Dry		One-way ANOVA	
	Lit./v	Lit.no/v	Lit./v	Lit.no/v	Season	Environmental
Temp.	32.3	32.4	24.5	24.4	F = 1,248; p = 5.3 x 10^{-23}	F = 7 x 10^{-4}; p = 0.98
pH	6.39	6.29	7.6	7.82	F = 38.47; p = 7.9 x 10^{-7}	F = 0.6; p = 0.41
Cond.	45.6	47.2	53	53.6	F = 53.4; p = 3.9 x 10^{-8}	F = 0.08; p = 0.78
D.O.	10.2	10.38	7.36	7.61	F = 331.83; p = 10^{-12}	F = 0.16; p = 0.7
N. tot.	626.78	678.54	1,360.88	1226.38	F = 241.33; p = 9,5 x 10^{-18}	F = 0.06; p = 0.82
P. tot.	20.05	20.80	22.53	21.86	F = 0.26; p = 0,61	F = 10^{-4}; p = 0.99

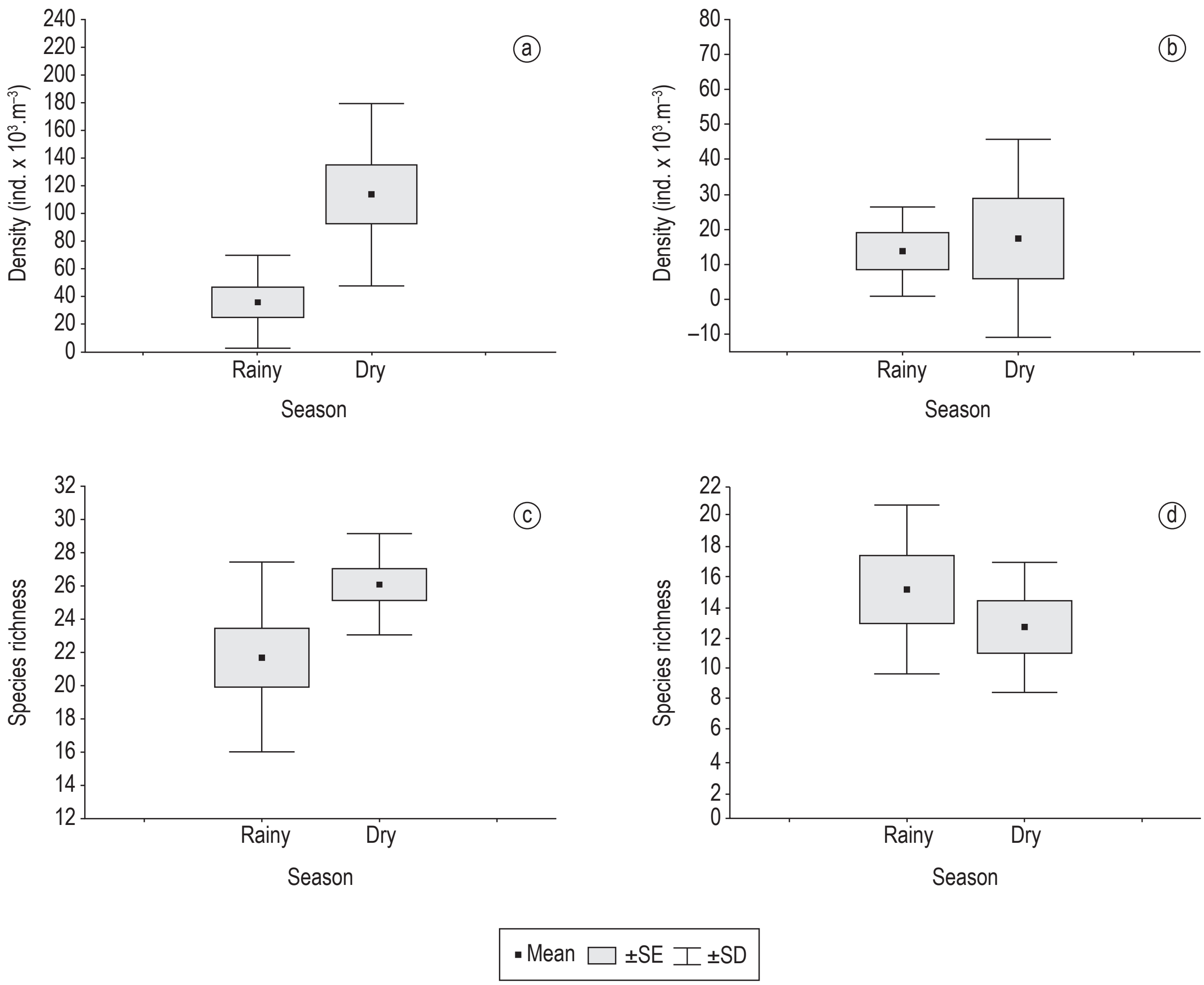

Figure 2. Mean density of microcrustaceans in the littoral zone: a) with aquatic vegetation, b) without aquatic vegetation; Mean richness of microcrustaceans in the littoral zone: c) with aquatic vegetation, d) without aquatic vegetation. SE = Standard Error, SD = Standard Deviation.

dominant in this type of environment, with a mean of 87% of the total number of individuals.

4. Discussion

Seasonal differences in the physical and chemical variables of the water were observed. Of the analyzed variables, only the total phosphorus concentration was not statistically different between the rainy and dry periods. The lack of significant differences for the limnological variables between the two types of littoral environments (with and without aquatic vegetation) within the same period, probably resulted from daily horizontal water mixing caused by wind action.

The higher microcrustacean density and richness during the dry period in the littoral zone without aquatic vegetation were probably related to the higher food availability (larger quantities of organic detritus, which is nutritionally enriched by bacteria, fungus and protozoa), as *Eleocharis interstincta* decayed more rapidly with the decrease in water level. Santos and Esteves (2004) studied the influence of variations in water level on this species in Lagoa dos Cabiúnas in northeastern Rio de Janeiro, and observed increased detrital biomass with a lower water level. In the present study the higher decomposition rate of *E. interstincta* during the dry period was also evidenced, by the higher quantity of detritus found with the microcrustacean samples.

The lack of significant changes in microcrustacean alterations for density and species richness in the littoral zone without aquatic vegetation may be related to the relatively stable environmental conditions during the year. Although almost all the limnological variables did show statistically significant differences between the rainy and dry periods, only the total nitrogen concentration showed a wider variation.

The high similarity indexes in the microcrustacean composition between the rainy and dry periods in both types of littoral environments suggest a low turnover of the

Table 2. Mean relative abundance (%) of Copepoda and Cladocera in the littoral zone: with aquatic vegetation (Lit./v) and without aquatic vegetation (Lit.no/v) of Lake Dom Helvécio (Parque Estadual do Rio Doce, MG), in the rainy (February) and dry (July) periods of 2006. Nauplii and copepodites are excluded.

Taxon	Lit./v		Lit.no/v	
	Rainy	Dry	Rainy	Dry
COPEPODA				
Attheyella fuhrmanni (Thiébaud, 1912)	1	1	<1	<1
Ectocyclops herbsti Dussart, 1984	<1	1	1	-
Ectocyclops rubescens Brady, 1904	1	<1	<1	-
Elaphoidella sp.	-	<1	-	-
Homocyclops ater (Herrick, 1882)	<1	<1	-	-
Macrocyclops albidus (Jurine, 1820)	1	<1	-	<1
Mesocyclops longisetus (Thiébaud, 1912)	-	2	-	-
Mesocyclops meridianus (Kiefer, 1926)	1	<1	1	<1
Mesocyclops ogunnus Onabamiro, 1957	-	<1	-	<1
Microcyclops alius (Kiefer, 1935)	2	<1	1	<1
Microcyclops anceps (Richard, 1897)	20	9	36	1
Neutrocyclops brevifurca (Lowndes, 1934)	-	<1	-	-
Notodiaptomus isabelae (Wright, 1936)	<1	<1	-	<1
Paracyclops chiltoni (Thomson, 1883)	<1	<1	1	<1
Thermocyclops minutus (Lowndes, 1934)	1	<1	2	1
Tropocyclops prasinus (Fischer, 1860)	1	<1	<1	<1
CLADOCERA				
Alona glabra Sars, 1901	<1	-	-	-
Alona guttata Sars, 1862	<1	1	<1	-
Alona poppei Richard, 1897	-	<1	-	-
Alona verrucosa (Sars, 1901)	1	<1	<1	<1
Alonella clathratula Sars, 1896	-	<1	-	-
Alonella dadayi Birge, 1910	<1	<1	<1	<1
Alonella cf. *lineollata* Sars, 1901	-	<1	-	-
Bosmina hagmanni Stingelin, 1903	1	1	3	<1
Bosmina tubicen Brehm, 1956	2	<1	7	<1
Bosminopsis deitersi Richard, 1895	<1	1	<1	5
Ceriodaphnia cornuta Sars, 1886	<1	<1	<1	<1
Ceriodaphnia silvestrii Daday 1902	<1	<1	1	-
Chydorus eurynotus Sars, 1901	1	<1	3	<1
Chydorus sphaericus (O.F. Müller, 1785)	<1	<1	<1	-
Dadaya macrops (Daday, 1898)	<1	-	<1	-
Daphnia laevis Birge, 1879	-	<1	-	-
Diaphanosoma birgei Korinek, 1981	2	21	2	1
Dunhevedia odontoplax Sars, 1901	1	<1	3	<1
Ephemeroporus barroisi (Richard, 1894)	50	1	25	<1
Ephemeroporus tridentatus (Bergamin, 1939)	3	3	4	<1
Ilyocryptus spinifer Herrick, 1882	1	<1	1	<1
Leydigiopsis curvirostris (Sars, 1901)	-	<1	-	<1
Leydigiopsis ornata (Daday, 1905)	<1	<1		
Macrothrix cf. *flabelligera* (Smirnov, 1992)		<1	1	<1
Macrothrix paulensis (Sars,1900)	4	9	5	<1
Macrothrix spinosa King, 1853	-	<1	-	-

Table 2. Continued...

Taxon	Lit./v		Lit.no/v	
	Rainy	Dry	Rainy	Dry
Notoalona sculpta (Sars, 1901)	-	<1	-	-
Oxyurella ciliata (Bergamin, 1939)	<1	<1	<1	
Pseudosida bidentada Herrick, 1884	<1	6	<1	<1
Scapholeberis armata (Herrick, 1882)	4	32	1	87
Simocephalus serrulatus (Koch, 1841)	1	8	<1	4
Simocephalus vetulus (O.F. Müller, 1776)	<1	-	-	-

species composition between the two seasons. However, the change in terms of more abundant species between the two periods may have reflected the seasonal effects at a population level. When the variation in a population's density is compared, the seasonal fluctuation patterns of the individual zooplankton species can be very different from that observed for the total zooplankton, since the species have their own reproductive cycles. This has been observed in the littoral zone of waterbodies both in the temperate zone (Williams, 1982; Hann and Zrum, 1997) and in the tropics (Zoppi de Roa, 1994; Lima et al., 2003).

It is possible that *E. barroisi* and *M. anceps* are more adapted to environmental conditions during the rainy period, whereas *S. armata* is more adapted to the dry period, since, whatever the environment (littoral zone with or without aquatic vegetation), these species were more abundant during these periods. Furthermore, the change in the most abundant species during the year may be a harmonic mechanism of co-existence which, by means of temporal segregation, decreases interspecies competition. The higher contribution of *Diaphanosoma birgei* during the dry period in the environments with aquatic vegetation may be related to the increase in bacterioplankton and other food items, such as protozoa and fungus, due to the larger quantity of organic detritus. According to Hessen (1990), bacteriophagy is an important component in the diet of several species of this genus.

The present study demonstrated that the microcrustacean assemblage structure was influenced by the dynamics of *E. interstincta* (growth, death and decomposition) in the rainy and dry periods. The effect of season on species composition was relatively weak, but was important at the population level.

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