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Quantifying zooplankton species: use of richness estimators

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ABSTRACT. Richness estimators (Jackknife 1, Bootstrap, Chao 1 and ACE) were used to relate zooplankton species richness with amount of water collected per sample and number of samples throughout the year for the limnetic region of Sapucai River compartment of Furnas reservoir, state of Minas Gerais, Brazil. Seven 100 L samples were collected in sequence using a motor pump, and seven 70 L samples were collected in sequence using a plankton net (68 µm mesh size) in vertical hauls, to totalize 450 L, in three stations of the reservoir. Twelve monthly samplings were carried out over a year. The assessment of richness was made by analyzing the asymptotic behavior of the estimator curves. The samplings reached the asymptote from 350 L of collection with trawls and 400 L using a suction motor pump and reached the plateau on the 8th collection, which included both dry and rainy seasons. Regardless of the type of sampling, the volume of 400 L and eight sessions throughout the year is enough to register 90% of the zooplankton richness in the environment.

KEYWORDS. Biodiversity, Cladocera, Rotifera, sampling effort, aquatic environments.

RESUMO. Quantificando espécies zooplanctônicas: uso de estimadores de riqueza. Buscando relacionar a riqueza de espécies zooplanctônicas com o volume de água coletado por amostra e com o número de amostragens ao longo do ano para a região limnética do compartimento do Rio Sapucaí no reservatório da UHE de Furnas, Estado de Minas Gerais, Brasil, foram utilizados estimadores de riqueza (Jackknife 1, Bootstrap, Chao 1 e ACE). Sete amostras de 100 litros foram coletadas com moto-bomba de sucção, e sete de 70 litros utilizando rede de plâncton de 68 µm e arrastos verticais em um ponto do reservatório. Foram realizadas doze coletas mensais ao longo de um ano, nas quais foram coletados 450 litros de água por amostra, em três pontos do reservatório de Furnas. A avaliação da riqueza foi feita analisando o comportamento assintótico das curvas dos estimadores. Estes atingem a assíntota a partir de 350 litros para a coleta feita mediante arrastos e com 400 litros com utilização de moto-bomba de sucção, alcançando o platô na 8ª coleta, tendo sido abrangidas as estações seca e chuvosa. Independente do tipo de amostragem, o volume de 400 litros e oito coletas ao longo do ano mostra-se suficientes para registrar 90% da riqueza zooplanctônica do ambiente.

PALAVRAS-CHAVE. Biodiversidade, Cladocera, Rotifera, esforço amostral, ambientes aquáticos.

Biological diversity can be understood at three levels: species, habitat and genetic diversity. Diversity indices use the density and richness of species and infer on the distribution equitability of species in the environment (Begon *et al.*, 2007; Melo, 2008).

Knowledge of aquatic diversity is fundamental to implement conservation programs and rational use of resources, to assess environmental impact for licensing of hydroelectric power plants and to regulate fish farm areas (King & Porter, 2005; Eskinazi-Sant'Anna *et al*., 2005; Santos, 2006; Pinto-Coelho, 2004; Rocha *et al*., 2010; Santos-Wisniewski *et al*., 2011; Brito *et al*., 2011). These inventories become important because the degradation of natural ecosystems and biodiversity loss have increased in recent years.

To identify and count every species of a study area is very complex. Ecological studies search to estimate the species richness of these environments by sub-samples and the use of statistical techniques (Muirhead *et al*., 2006; Melo, 2008). Hence, the standardization of procedures and sampling effort is indispensable to reduce uncertainties and to make possible the comparison of species richness between different study environments (Gotelli & Cowell, 2001). Among statistical techniques, non-parametric richness estimators, such as Chao, ACE and Jackknife estimators, have been used to improve sampling. These are based on the occurrence of rare species that appear in few samples or in low density (Magurran, 2011). Other estimators, such as Bootstrap, give the same value for every species collected, whether they are rare or common, to estimate the total richness (Santos, 2006).

The methodology and equipment used in samplings can interfere in species richness measurements, for example, the mesh size of the net used to collect aquatic organisms should consider organism size and escape capacity. In the same way, the collection procedure, such as the use of suction pumps or vertical hauls by net, integrating or not the water column, can interfere in results (Pinto-Coelho, 2004). Furthermore, the water volume for sampling should be enough to represent the environment diversity. For the aquatic environment, the standardization of sampling effort means that a minimal amount of collected water is established, per sample, for about 90% of the total environment richness to be registered (Heck *et al*., 1975).

Species accumulation curves are good tools for assessing the effectiveness of a sampling method, since they represent the cumulative number of species observed in an area (or volume) as a function of sampling effort (King & Porter, 2005; Muirhead *et al*., 2006). On the other hand, rarefaction curves are used for direct comparisons between populations, or samples, to obtain the number of species expected in a random sample (Magurran, 2011).

Due to seasonal variations in zooplankton composition and richness (Dumont & Segers, 1996), a preliminary sampling is recommended to determine which sampling effort is required to access the highest possible richness in tropical aquatic environments, especially in temporary ponds. In the tropics, the high predation rates by planktivorous fish, cyanobacterial blooms and high pollution due to anthropogenic activities, are factors that influence the loss of diversity and have significant effects in water bodies (Sarma *et al*., 2005).

This study aims to determine the minimum water volume needed per sample collected for the largest possible number of zooplankton species in the limnetic region of Sapucaí River compartment of Furnas reservoir, and the sufficient number of monthly samples over a year to reach maximum richness.

MATERIALS AND METHODS

The reservoir of the Hydroelectric Power Plant (HPP) of Furnas is located in the south of the state of Minas Gerais, Brazil. It has a flooded area of 1,450 km² and 250 km of length, in both of their two main sub-axes or compartments, the Sapucaí and Grande rivers, respectively (Corgosinho & Pinto-Coelho, 2006). The average depth is 13 m and the maximum reaches 90 m, near the dam.

Samplings were carried out in HPP Furnas reservoir at the junction of rivers Verde and Sapucai (VSJ) (21°27'03"S and 45°40'24"W) in December 2009, with a plankton net of 68 µm mesh size. First, seven samples of 100 L were collected sequentially integrating one-meter of water column, using a suction motor pump. After this, seven other samples of 70 L were collected with vertical hauls, using constant speed. Both methods were limited to one-meter depth from the water surface. The organisms were subjected to narcotization process with CO_2 saturation by the addition of carbonated water to avoid body contraction of the zooplankton individuals. The samples were maintained in polyethylene bottles and fixed with formalin 4% (v/v). Additional single samples of 400 L were collected monthly, in Barranco Alto region in this same reservoir, from March 2011 to February 2012. They were collected at stations BA1 (21°10'33"S; 46°00'51"W), BA2 (21°10'17"S; 46°00'38"W) and BA3 (21°10'04"S; 46°00'26"W). The suction motor pump was used to integrate the water column, from the station depth to the water surface, and the sample was prepared and maintained as above.

The quantitative analysis, restricted to cladocerans and rotifers, was carried out on a gridded acrylic slide, under a stereoscope microscope (50x magnification), in sub-samples or the whole sample, depending on the sample characteristics. An optical microscope (up to 2000x magnification) and specialized bibliography were used for species identification (Koste, 1978; Jersabek *et al*., 2003; De Melo & Hebert, 1994; Elmoor-Loureiro, 1997; Orlova-Bienkowskaja, 1998; Smirnov, 1998; Segers, 2007; Kotov, 2009; Sinev & Elmoor-Loureiro, 2010). The frequency of species was determined considering the number of samples in which they occurred in relation to the total number of samples. The species were classified as constant (present in more than 80% of samples), frequent (between 50 to 80%), common (from 20 to 50%) and rare (< 20%) (Dajoz, 1983).

From the sample analysis the non-parametric estimators (ACE, Chao1, Jackknife1 and Bootstrap) of species richness were calculated based on abundance using the EstimateS 8.2 software (Colwell, 2009). Generally, these estimators make comparisons between rare species (*uniques* or *singletons*), present in a unique sample, and species present in, at least, two samples (*doubletons* or *duplicates*). These estimates were chosen according to King & Porter (2005) and Sousa *et al*. (2014).

The richness evaluation was done by asymptotic behavior analysis of curves obtained from richness estimators.

RESULTS

Firstly, the analysis of samples from the VSJ station (unique sampling data) was carried out. The curves of ACE, Chao 1, Jackknife 1 and Bootstrap estimators, as well as the observed richness curve (Sobs), for the two types of samplings (vertical hauls with mesh and suction motor pump) both adjusted for increasing volume using the seven collected samples, in sequence, showed that 90% of the maximum richness was reached, on average, with up to 400 L of filtered water (see Figs 2, 3).

For the suction pump sampling, the asymptote was obtained by filtration of 600 L. Only the Jackknife 1 estimator curve showed the organism richness increasing up to 700 L of sample, given that the curve of *uniques* began to decrease again (Fig. 2). For vertical haul sampling, about 80% of the maximum richness was reached using up to 140 L and above 95% using up to 350 L, for every richness curve. The

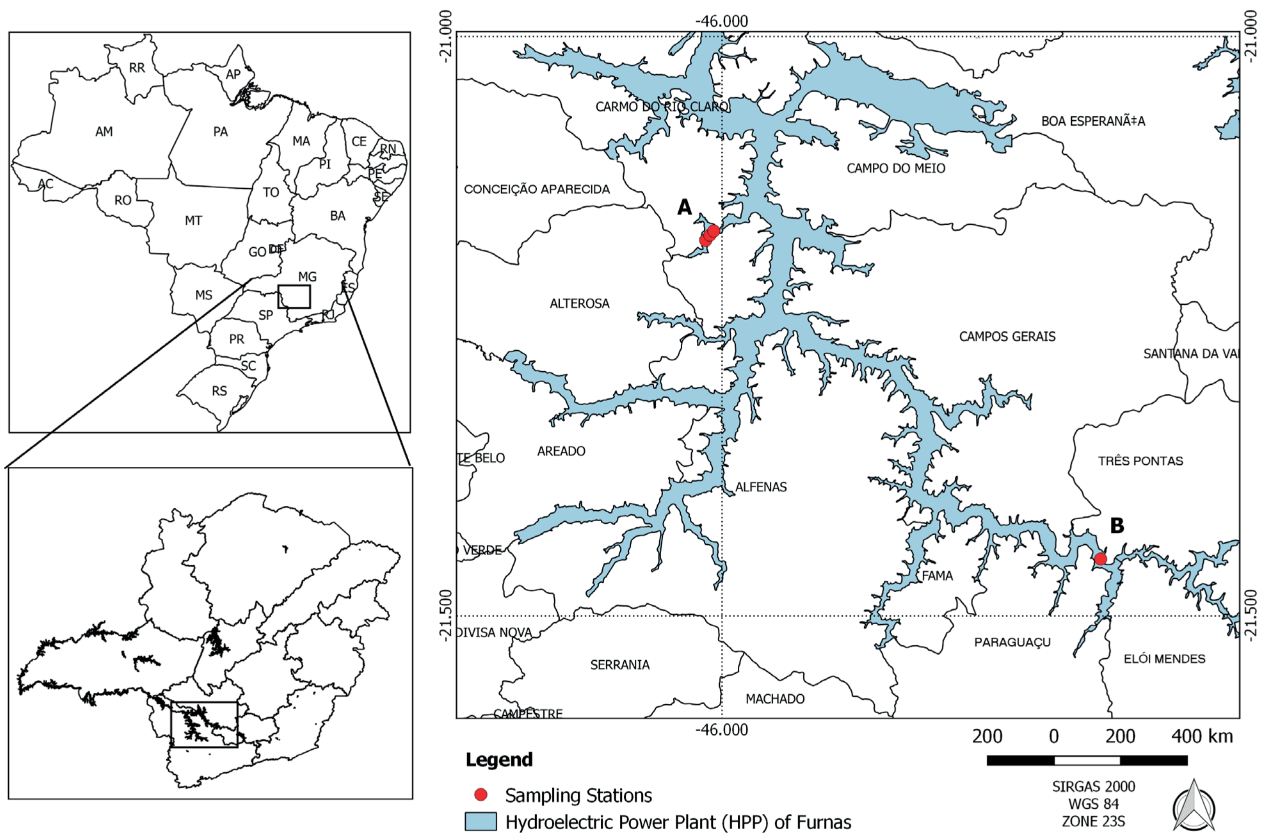

Fig 1. Sampling stations in the Hydroelectric Power Plant of Furnas reservoir, state of Minas Gerais, Brazil (A, Barranco Alto region; B, junction of rivers Verde and Sapucai - VSJ).

observation of estimator curves showed that the asymptote was reached using up to 420 L (Fig. 3).

Bosmina freyi, *Bosminopsis deitersi*, *Moina minuta*, *Asplanchna sieboldi*, *Filinia longiseta*, *Hexarthra intermedia*, *Kellicotia bostoniensis* and *Synchaeta* sp. were found for every one of seven samples which were collected with suction motor pump and vertical haul samplings. However, *Ceriodaphnia cornuta rigaudi*, *Brachionus falcatus*, *Collotheca* sp., *Conochilus* sp., *Keratella americana*, *Lecane curvicornis*, *Platyas quadricornis*, *Plationus patulus*, *Polyarthra* sp. and *Testudinella patina* were constant only in samplings using vertical hauls (Tabs I, II).

The rare species *Tricocherca bicristata*, *Beucampiella* sp., *Chydorus eurynotus* and *Ascomorpha* sp., as well as *Lecane cornuta*, *Ptygura libera*, *Brachionus calyciflorus*, *Iliocryptus spinifer* and *Alonella lineolata* were recorded in only one of the seven samples, being the earliest obtained from vertical hauls and the latest from suction pump sampling.

For analysis in time scale, twelve samples were collected every month for one year. Standard species accumulation curves were similar for the three sampling stations BA1, BA2 and BA3, showed by Figures 3, 5 and 6. Chao 1 and ACE estimator curves approximately overlapped with the Sobs curve, because there were no singletons or doubletons in the samples and species occurred in more than 10 ind.L^{-1}. Species with low frequency (*uniques* and *duplicates*) were recorded at high density, so Jackknife 1 and Bootstrap estimator curves showed species richness above those of the Sobs curve, in all samples. The minimal sampling effort was reached, for all curves, on the 8^{th} sampling (asymptote), for both dry and wet seasons samplings.

Bosmina hagmanni, *Ceriodaphnia cornuta cornuta*, *C. cornuta rigaudi*, *C. silvestrii*, *Daphnia gessneri*, *Diaphanosoma birgei*, *D. spinulosum*, *Moina minuta*, *Conochilus unicornis* and *Keratella americana* were constant in all monthly samples (Tab. III).

DISCUSSION

The two tested sampling methods, suction pump and vertical hauls, showed similar results and included in the inventory most of the species already registered for this reservoir, thus the two sampling methods are comparable. At 400 L water volume about 90% of the environmental species had been accessed for samplings using suction pump and a similar percentage was recorded with 350 L for samplings with vertical hauls using plankton net. It is considered a satisfactory inventory of species when between 50 and 75% of the species which could potentially occur in the environment are registered and the more frequently found species (or common) should be included in this percentage (Heck *et al.*, 1975).

The greater species richness was recorded for samplings using vertical hauls with a plankton net. Rotifers

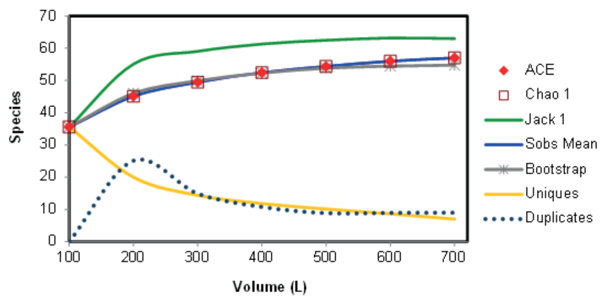

Fig. 2. Species accumulation curves, *uniques* and *duplicates* for the VSJ station in Furnas reservoir, state of Minas Gerais, Brazil, collected by suction pump.

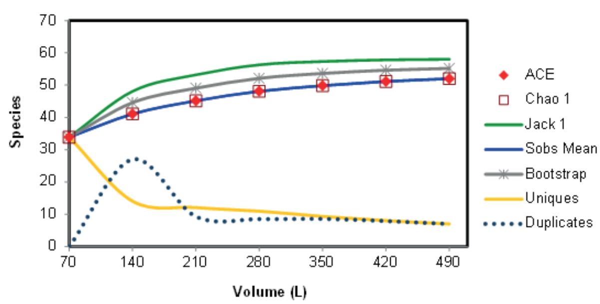

Fig. 3. Species accumulation curves, *uniques* and *duplicates* for the VSJ station in Furnas reservoir, state of Minas Gerais, Brazil, collected with vertical hauls.

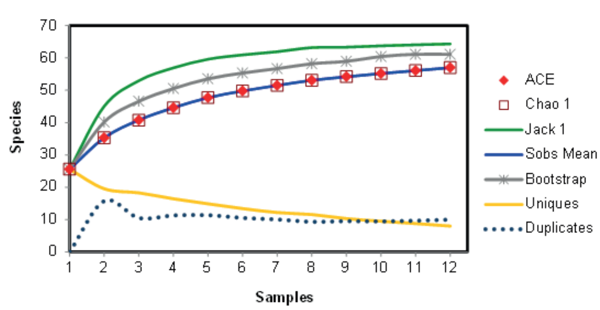

Fig. 4. Species accumulation curves, *uniques* and *duplicates* for the BA1 station of Furnas reservoir, state of Minas Gerais, Brazil, from March 2011 to February 2012.

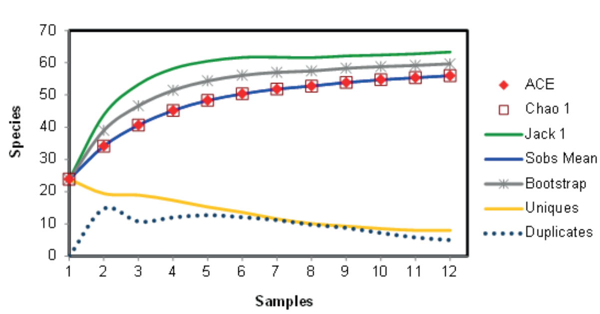

Fig. 5. Species accumulation curves, *uniques* and *duplicates* for the BA2 station of Furnas reservoir, state of Minas Gerais, Brazil from March 2011 to February 2012.

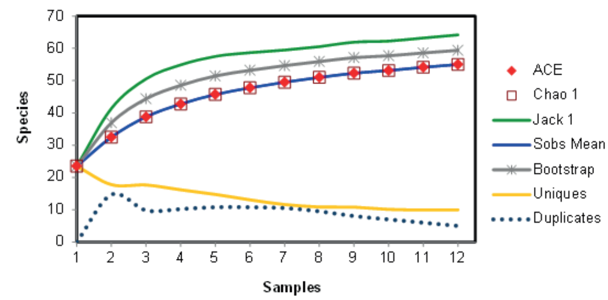

Fig. 6. Species accumulation curves, uniques and duplicates for the BA3 station of Furnas reservoir, state of Minas Gerais from March 2011 to February 2012.

were the most specious in this type of sampling while cladocerans were more representative with suction motor pump samplings. The most sensitive organisms, such as rotifers, may be damaged (including breakup and destruction of some individuals) during suction pump samplings, which makes their identification difficult (Kozlowsky-Suzuki & Bozelli, 1998; Pinto-Coelho, 2004). On the other hand, the suction motor pump samplings select organisms with reduced escape capability and low (and slow) swimming movements, such as Cladocera (Pinto-Coelho, 2004).

The species richness for the three stations was very similar regarding the sampling throughout the year. With increasing sampling effort, the rarest species were identified. However, when the sampling effort is excessive, errant species are recorded, contributing to an increase in the *uniques* curve and even in this case the estimators extrapolate the total richness of the environment (Magurran, 2011). Thus, it is believed that in 20 rare species sampled; only 8% are truly rare (King & Porter, 2005).

Many of the species identified in other studies in the Furnas reservoir were not recorded in this study, as they covered a larger area of this reservoir surrounding the limnetic and littoral regions and the two compartments (Rivers Grande and Sapucaí), resulting in greater richness. In the review by Santos-Wisniewski *et al.* (2011) for Cladocera fauna of Minas Gerais, 94 species were recorded for the state distributed in 88 water bodies. Of these, 62 species were identified in the Furnas reservoir. Among the species not recorded in this study in the limnetic region were *Bosmina longirostris*, *Bosmina tubicen*, *Daphnia ambigua*, *Simocephalus latirostris*, *Simocephalus serrulatus* and *Moina micrura*.

Generally, the records of *Bosmina longirostris* for Brazil are dubious, because according to De Melo & Hebert (1994), the species occurs in North America and *B. freyi* in South America. In the present study and in earlier studies in the Furnas reservoir, only *B. freyi* was recorded.

Although the study was carried out in the limnetic region, typical species of the littoral region were recorded, such as *Alona intermedia*, *Alona yara*, *Alona guttata*, *Camptocercus australis*, *Chydorus pubescens*, *Chydorus eurynotus*, *Ephemeroporus* sp., *Ilyocryptus spinifer* and

Tab. I. List of occurrence of zooplankton species and Dajoz Constancy Index (DCI) for the seven samples (S) collected by suction pump at the VSJ station in Furnas reservoir, state of Minas Gerais, Brazil (Ct, constants; F, frequent; C, common; R, rare).

Taxa	S1	S2	S3	S4	S5	S6	S7		
CLADOCERA								%	DCI
Alona sp.	X	X					X	43	C
Alonella lineolata Sars, 1901			X					14	R
Bosmina freyi De Melo & Hebert, 1994	X	X	X	X	X	X	X	100	Ct
Bosmina hagmanni Stingelin, 1904				X	X	X		43	C
Bosminopsis deitersi Richard, 1895	X	X	X	X	X	X	X	100	Ct
Ceriodaphnia cornuta Sars, 1886		X						14	R
Ceriodaphnia cornuta cornuta Sars, 1886			X		X	X	X	57	F
Ceriodaphnia cornuta intermedia Sars, 1886	X						X	29	C
Ceriodaphnia cornuta rigaudi Sars, 1886	X		X	X	X	X		71	F
Ceriodaphnia silvestrii Daday, 1902	X		X	X	X	X		71	F
Daphnia gessneri Herbest, 1967		X		X	X	X		57	F
Diaphanosoma birgei Korineck, 1981	X	X		X	X	X	X	86	Ct
Diaphanosoma spinulosum Korineck, 1981	X		X	X	X	X	X	86	Ct
Diaphanosoma sp.	X		X			X		43	C
Ilyocryptus spinifer Korineck, 1981						X		14	R
Leydigia striata Berabén, 1939			X	X				29	C
Macrothrix sp.	X	X	X	X		X	X	86	Ct
Moina minuta Hansen, 1899	X	X	X	X	X	X	X	100	Ct
ROTIFERA								0	
Asplanchna sieboldi (Leydig, 1854)	X	X	X	X	X	X	X	100	Ct
Beucampiella sp.	X		X	X	X	X	X	86	Ct
Brachionus calyciflorus Pallas, 1766				X				14	R
Brachionus dolabratus Harring, 1915				X		X	X	43	C
Brachionus falcatus Zacharias, 1898		X	X	X	X		X	71	F
Brachionus mirus (Daday, 1905)	X	X					X	43	C
Collotheca sp.		X		X	X	X	X	71	F
Conochilus sp.				X	X	X	X	57	F
Conochilus unicornis (Rousselet, 1892)		X				X		29	C
Euchlanis dilatata Ehrenber, 1832		X	X					29	C
Filinia longiseta (Ehrenberg, 1834)	X	X	X	X	X	X	X	100	Ct
Filinia opoliensis (Zacharias, 1898)				X		X		29	C
Hexartra intermedia (Weiszniewski, 1929)	X	X	X	X	X	X	X	100	Ct
Kellicotia bostoniensis (Rousselete, 1908)	X	X	X	X	X	X	X	100	Ct
Keratella americana (Carlin, 1943)		X	X	X	X	X	X	86	Ct
Keratella cochlearis (Gosse, 1851)	X	X		X	X		X	71	F
Keratella lenzi (Hauer, 1953)		X	X					29	C
Keratella tropica (Apstein 1907)		X	X		X		X	57	F
Lecane bulla (Gosse, 1886)				X		X		29	C
Lecane cornuta (Müller, 1786)		X						14	R
Lecane curvicornis (Murray, 1913)	X	X		X	X	X	X	86	Ct
Lecane proiecta Hauer, 1956	X	X	X	X		X		71	F
Lepadella sp.			X	X		X		43	C
Platyas quadricornis (Ehrenberg, 1832)	X	X	X		X	X	X	86	Ct
Plationus patulus (Müller, 1953)	X	X	X	X	X		X	86	Ct
Polyarthra sp.	X	X	X		X		X	71	F
Proales sp.	X	X	X	X	X	X		86	Ct
Ptygura libera Myers, 1934							X	14	R
Sinchaeta sp.	X	X	X	X	X	X	X	100	Ct
Testudinella patina (Hermann, 1783)	X	X	X		X		X	71	F
Trichocerca cylindrica (Sudzuki 1956)				X	X		X	43	C

Tab. II. List of occurrence of zooplankton species and Dajoz Constancy Index (DCI) for the seven samples (S) collected with vertical hauls in VSJ station in Furnas reservoir, state of Minas Gerais, Brazil. (Ct, constants; F, frequent; C, common; R, rare).

Taxa	S1	S2	S3	S4	S5	S6	S7		
CLADOCERA								%	DCI
Alona sp.		X						14	R
Alonella dadayi Birgei, 1910		X	X					29	C
Bosmina freyi De Melo & Hebert, 1994	X	X	X	X	X	X	X	100	Ct
Bosmina hagmanni Stingelin, 1904	X	X		X		X	X	71	F
Bosminopsis deitersi Richard, 1895	X	X	X	X	X	X	X	100	Ct
Ceriodaphnia cornuta cornuta Sars, 1886	X	X	X	X	X		X	86	Ct
Ceriodaphnia cornuta rigaudi Sars, 1886	X	X	X	X	X	X	X	100	Ct
Ceriodaphnia silvestrii Daday, 1902	X	X				X	X	57	F

Tab. II. Cont.

Taxa	S1	S2	S3	S4	S5	S6	S7		
Chydorus eurynotus Sars, 1901			X					14	R
Daphnia gessneri Herbest, 1967				X		X	X	43	C
Diaphanosoma spinulosum Korineck, 1981	X	X	X	X	X	X		86	Ct
Diaphanosoma sp.	X	X	X	X	X	X	X	100	Ct
Macrothrix sp.	X			X	X	X		57	F
Moina minuta Hansen, 1899	X	X	X	X	X	X	X	100	Ct
ROTIFERA		X						14	R
Ascomorpha sp.									
Asplanchna sieboldi (Leydig, 1854)	X	X	X	X	X	X	X	100	Ct
Beucampiella sp.	X							14	R
Brachionus calyciflorus Pallas, 1766			X				X	29	C
Brachionus dolabratus Harring, 1915		X	X	X				43	C
Brachionus falcatus Zacharias, 1898	X	X	X	X	X	X	X	100	Ct
Brachionus mirus (Daday, 1905)					X	X	X	43	C
Cephalodella sp.				X	X			29	C
Collotheca sp.	X	X	X	X	X	X	X	100	Ct
Conochilus sp.	X	X	X	X	X	X	X	100	Ct
Conochilus coenobasis (Skorikov, 1914)		X						14	R
Conochilus unicornis (Rousselet, 1892)	X	X						29	C
Euchlanis dilatata Ehrenber, 1832		X			X		X	43	C
Filinia longiseta (Ehrenberg, 1834)	X	X	X	X	X	X	X	100	Ct
Filinia opoliensis (Zacharias, 1898)					X	X	X	43	C
Hexartra intermedia (Weiszniewski, 1929)	X	X	X	X	X	X	X	100	Ct
Kellicotia bostoniensis (Rousselete, 1908)	X	X	X	X	X	X	X	100	Ct
Keratella americana (Carlin, 1943)	X	X	X	X	X	X	X	100	Ct
Keratella cochlearis (Gosse, 1851)	X		X	X	X	X	X	86	Ct
Keratella lenzi (Hauer, 1953)	X	X	X		X	X	X	86	Ct
Keratella tropica (Apstein 1907)			X		X	X	X	57	F
Lecane bulla (Gosse, 1886)	X		X			X	X	57	F
Lecane curvicornis (Murray, 1913)	X	X	X	X	X	X	X	100	Ct
Lecane leontina (Turner, 1892)	X	X	X	X	X			71	F
Lecane papuana Murray 1913		X	X	X				43	C
Lecane proiecta Hauer, 1956			X			X		29	F
Lecane quadridentata (Ehrenberg, 1832)			X	X				29	F
Lecane sp.			X					14	R
Platyas quadricornis (Ehrenberg, 1832)	X	X	X	X	X	X	X	100	Ct
Plationus macracanthus (Daday, 1905)	X	X	X	X	X	X		86	Ct
Plationus patulus (Müller, 1953)	X	X	X	X	X	X	X	100	Ct
Polyarthra sp.	X	X	X	X	X	X	X	100	Ct
Proales sp.	X	X	X	X	X	X		86	Ct
Synchaeta sp.	X	X	X	X	X	X	X	100	Ct
Testudinella patina (Hermann, 1783)	X	X	X	X	X	X	X	100	Ct
Trichocerca bicristata (Gosse, 1887)				X				14	R
Trichocerca cylindrica (Suzuki 1956)					X		X	29	C
Trichotria tetractis (Ehrenberg, 1830)		X			X	X		43	F

Tab. III. List of occurrence of zooplankton species and Dajoz Constancy Index (DCI) in site BA1, BA2 and BA3 stations, from March 2011 to February 2012 (Ct, constants; F, frequent; C, common; R, rare;*, occurrence in 1 station; **, occurrence in 2 station; ***, occurrence in 3 stations).

Taxa	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	%	ICD
CLADOCERA														
Alona guttata Sars, 1862				*	*	***	*	*		*		*	25	c
Alona yara Sinev & Elmoor-Loureiro, 2010									**	*	**	*	17	R
Alona intermedia Sars, 1862			**										6	R
Bosmina freyi De Melo & Hebert, 1994	**		***	***	***	***	***	**	***	***	**	***	83	Ct
Bosmina hagmanni Stingelin, 1904	***	***	***	***	***	***	***	***	***	***	***	***	100	Ct
Camptochercus australis Sars, 1896											*		3	R
Ceriodaphnia cornuta cornuta Sars, 1886	***	***	***	***	***	***	***	***	***	***	**	***	97	Ct
Ceriodaphnia cornuta intermedia Sars, 1886		*	**	**	*	*			***	***	*	***	47	c
Ceriodaphnia cornuta rigaudi Sars, 1886	***	***	***	***	***	***	***	***	***	***	***	***	100	Ct
Ceriodaphnia silvestrii Daday, 1902	***	***	***	***	***	***	***	***	***	***	***	**	97	Ct
Daphnia gessneri Herbest, 1967	**	***	**	***	***	**	***	***	***	*	**	***	86	Ct
Daphnia laevis Birge, 1878		*					**	***					17	R
Diaphanosoma birgei Korineck, 1981	***	***	***	***	***	**	**	***	***	***	***	***	94	Ct
Diaphanosoma brevireme Sars, 1901	***	**	**			**	**	***	**	**	**	***	64	F

Tab. III. Cont.

Taxa	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	%	ICD
Diaphanosoma spinulosum Herbst, 1967	***	***	***	**	***	**	**	**	***	***	***	***	89	Ct
Diaphanosoma sp.		*	*	*	*	*	*		*	*		*	25	c
Diaphanosoma fluviatile Hansen, 1899	*	**			**	**	**		***	***	***	***	58	F
Ilyocryptus spinifer Herrick, 1882		*		*									6	R
Macrothrix sp.							**	*		**			14	R
Moina minuta Hansen, 1899	***	***	***	***	***	***	***	***	***	***	***	***	100	Ct
Simocephalus mixtus Orlova-Bienkowskaja, 2001			*	**		**	***	*	*				28	c
Chydorus pubescens Sars, 1901			*	*		***	*	**			*		25	c
Chydorus sp.									*				3	R
ROTIFERA														
Anuraeopsis sp.		*							*			*	8	R
Ascomorpha saltans Bartsch, 1870			*		**		*		**	*	*		22	c
Ascomorpha ovalis (Bergendal, 1892)			**	*	*	***	***	***	**	*	*	**	53	F
Asplanchna sieboldi (Leydig, 1854)	***	*		**	*	***	***	*	***	***		*	58	F
Brachionus calyciflorus Pallas, 1766										*			3	R
Brachionus dolabratus Harring, 1915	*	*								***	***	***	31	c
Brachionus falcatus Zacharias, 1898		***	*		**						***	**	31	c
Brachionus mirus (Daday, 1905)			*				*	*	**	**	***	**	33	c
Brachionus sp.				*									3	R
Collotheca sp.	*	***	**	*							***	*	31	c
Conochius natans (Seligo, 1990)	***	**		*			*						19	R
Conochilus sp.				*	*	***		*					17	R
Conochilus coenobasis (Skorikov, 1914)		*		*							**	**	17	R
Conochilus unicornis (Rousselet, 1892)	***	***	***	***	***	***	***	***	***	***	**	***	97	Ct
Euchlanis dilatata Ehrenber, 1832		*				***	***	**	***	***	*		44	c
*Filinia longiseta (*Ehrenberg, 1834)	**	**						*	*	*	***	**	33	c
Filinia opoliensis (Zacharias, 1898)	*	***	**	**			*	**	*	***	**	***	56	F
Filinia sp.				*									3	R
Gastropus sp.	*	***		*	**	*	**	*					31	c
*Hexartra intermedia (*Weiszniewski, 1929)	***	**	**	**					*	***	***	***	56	F
Kellicotia bostoniensis (Rousselete, 1908)			*	***	***		**	**		*	**	*	42	c
Keratella americana (Carlin, 1943)	*	***	***	***	***	***	***	***	***	***	***	***	94	Ct
Keratella cochlearis (Gosse, 1851)	*	**		*	**		**	**	**	***	***	***	58	F
Keratella lenzi (Hauer, 1953)	**	***	**	***	***	***	***	**	*	*			64	F
Keratella sp.							*		*				6	R
Keratella tecta Turner, 1986									**	***	**	**	25	c
Keratella quadrata Plate, 1886					*					*			6	R
*Keratella tropica (*Apstein 1907)									*	***	*	*	17	R
Lecane bulla (Gosse, 1886)												*	44	c
Lecane luna (Müller, 1776)		**											6	R
Lecane leontina (Turner, 1892)			*										3	R
Lecane lunaris (Ehrenberg 1832)					*	*						*	8	R
Lecane papuana Murray 1913						*		*					6	R
Lecane proiecta Hauer, 1956	***	***	***	***	**	*			*			*	47	c
Lepadella sp.					*	*	*						8	R
Plationus macracanthus (Daday, 1905)				*	*								6	R
Polyarthra vulgaris Carlin, 1943		*	**	***	**		**	**	**	*	**	**	53	F
Ptygura libera Myers, 1934		*										***	11	R
Synchaeta jollyii Shiel & Koste, 1993	***	**	***	**	***	***	**	**	***	**			69	F
Testudinella patina (Hermann, 1783)		*						*					6	R
Trichocerca cylindrica (Sudzuki, 1956)		***	*	*	***	**		*	***	***	***	**	61	F
Trichocerca chatonni (de Beauchamp, 1907)	*	**	**	**	*	**	**	*	***	**	***	*	61	F
Trichocerca similis grandis (Wierzejski, 1983)	*	**	*	***	*	***	***	***	**		***	*	64	F

Macrothrix cf. *elegans*. According to Fernando (2002), the distinction between limnetic and littoral zooplankton is often not observed in the tropics, which explains the occurrence of these phytophylous organisms in the samples.

In the review by Eskinazi-Sant'Anna *et al*. (2005), 300 species of Rotifera were recorded in Minas Gerais, which only six of these species are registered for the Furnas reservoir and recorded in this study, what indicates that an update for rotifers in Minas Gerais is necessary. Segers & Dumont (1995) identified 102 species of rotifers in 20 points distributed in the Broa reservoir, including sampling in the limnetic and littoral regions of the reservoir, while in this study 42 species were recorded, which only covered the limnetic region.

Jackknife 1 and Bootstrap estimators curves showed richness above that verified by the observed richness curve (Sobs) throughout the study. This result is common when non-parametric estimators are used to estimate the richness of zooplankton species (Dumont & Segers, 1996; Muirhead *et al*., 2006; Sousa, 2014). The estimator richness obtained by Jackknife 1 curve in BA1 station evidenced an asymptote, while for Bootstrap estimator curve, the asymptote was observed for BA1 and BA2 stations. The adjustments to other estimators curves showed a tendency to the formation of a asymptote, while for the *uniques* curves the asymptote was observed at all stations since 9th sampling.

The estimator curves showed that only between 3% and 16% of environmental potential richness was not recorded and the sampling may be considered satisfactory. The richness species determined by the *unique* curves showed the asymptote beginning at 9th successive monthly sampling. It indicates that the monthly sampling can be reduced to eight so that most of environment richness will be achieved in, in time scale. In the tropics, there is less variation in the seasonal succession of zooplankton species and species co-occur in both the summer and winter seasons (Dumont, 1994). Thus, a smaller amount of samples is necessary and the time and sampling costs could be reduced.

The results obtained with the volume collected showed that 400 L are sufficient to record 90% of the environment richness, regardless of the sampling type (vertical hauls with a plankton net or suction motor pump). Also, another recommendation is to decrease from twelve to eight the monthly collections throughout the year, to goal a zooplankton limnetic species inventory, as the maximum number of species of Cladocera and Rotifera will be obtained in the waters of the Furnas reservoir in eight months.

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