Limnologica 70 (2018) 49–57

Contents lists available at ScienceDirect

Limnologica

journal homepage: www.elsevier.com/locate/limno

# Diatom diversity at multiple scales in urban reservoirs in Southern Brazil reveals the likely role of trophic state

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ARTICLE INFO

*Keywords:*
Beta diversity
Additive partitioning
Community variation
Nestedness
Turnover
Stochasticity

ABSTRACT

Diatoms grow under very specific physical and chemical conditions, and eutrophication may cause community variation. We aimed to describe spatial and temporal variation in diatom community diversity in two urban reservoirs of different throphic status at different spatial scales. We collected samples of epiphytic diatoms from aquatic macrophytes from six sites in each reservoir in the metropolitan region of Curitiba, Southern Brazil, in fall and in spring. We assessed the variation in cell density and taxa richness (considering the lower taxonomic level possible) between the reservoirs and periods using *t*-tests, and the differences in community composition using PERMANOVA. Principal coordinates analysis (PCoA) was used to observe the change in floras between reservoirs and periods. We also partitioned gamma diversity into alpha and beta diversities using Additive Partitioning. In this case, variation components at different spatial scales were generated for each period. Beta diversities at different scales were also divided into turnover and nestedness components. We identified 132 infrageneric taxa in each reservoir. Spatial and temporal variation in species diversity and composition occurred in both reservoirs at different scales. Even so variation between reservoirs is a component that cannot be expected by a null model, indicating a possible role of eutrophication in community variation. Community variation at different scales was higher in the more eutrophic reservoir, in line with the positive relationship between beta diversity and productivity. Turnover was always the main component of beta diversity considering all spatial and temporal community variation. Nestedness occurred particularly in community variation among time periods at a same location, in line with studies suggesting community stability in urban reservoirs. Taken together, our results highlight the key role of nutrient availability in determining species composition, community variation within reservoirs, and community variation over time.

## 1. Introduction

A major goal in community ecology is to explain biodiversity variation across space and time. Indeed, there is a great growth in the number of studies explaining variation patterns in the composition of communities (Melo et al., 2011). In aquatic ecosystems, factors such as productivity and environmental heterogeneity are often considered chiefly responsible for changes in biodiversity (Bini et al., 2014).

In modified systems, such as reservoirs, environmental changes related to trophic conditions affect communities (Yang et al., 2012; Wojciechowski et al., 2017a), and community variation is expected among reservoirs of different trophic levels (Silva et al., 2014). Indeed, changes in the structure of periphytic diatom communities are commonly related to eutrophication processes (Mattila and Räisänen, 1998; Taniwaki et al., 2013). A decrease in nutrients concentration and an increase in water transparency toward the dam is also a common pattern within a reservoir (Ribeiro Filho et al., 2011), although it depends on morphometric characteristics and retention time. Anyway, community variation is expected to occur within and between reservoirs (Kennedy and Walker, 1990; Straškraba et al., 1993; Taniwaki et al., 2013). Periphytic algae are model organisms because they respond quickly to environmental heterogeneity, which results in changes in the community structure (Stenger-Kovacs et al., 2007; Pellegrini and Ferragut, 2012; Liu et al., 2013).

Some observational studies have investigated the spatial and/or temporal patterns of periphytic algae in urban aquatic environments,

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https://doi.org/10.1016/j.limno.2018.04.001
Received 19 December 2016; Received in revised form 19 March 2018; Accepted 3 April 2018
Available online 12 April 2018
0075-9511/ 

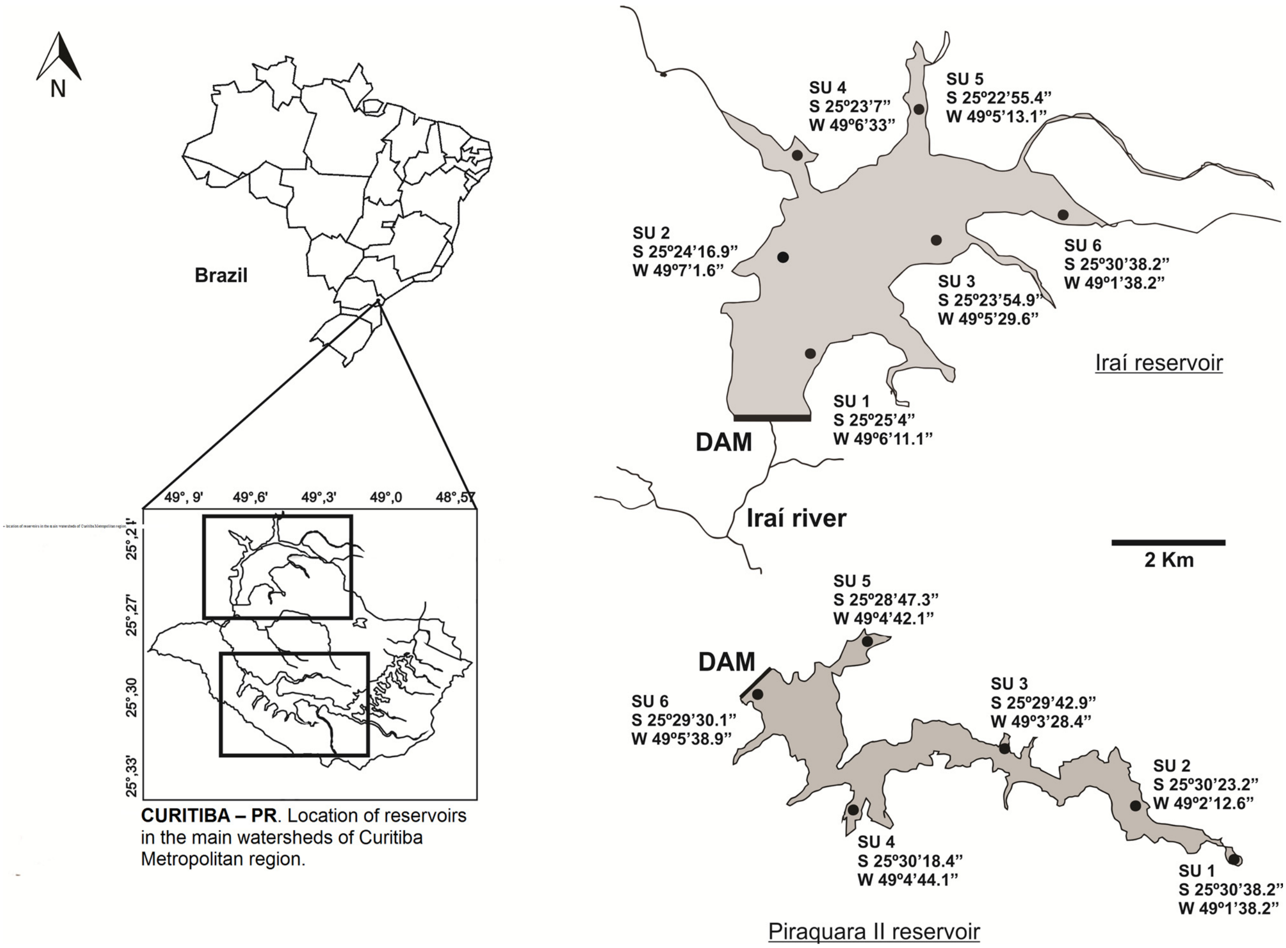


**Fig 1.** Location of the reservoirs and sample units (SU,●).

such as reservoirs (Vercellino and Bicudo, 2006; Silva et al., 2010; Pellegrini and Ferragut, 2012; Taniwaki et al., 2013). In such impacted ecosystems, the general expectation is that eutrophication should be the main driver of biological diversity (Taniwaki et al., 2013; Vilar et al., 2014). In this context, the composition and biodiversity should vary between reservoirs with different trophic state. On the other hand, reservoirs are human-made ecosystems that usually cause spatial homogenization in abiotic (other than trophic state) and biotic features (Papastergiadou et al., 2010, Daga et al., 2015). Thus, empirical evidence of how aquatic communities vary between and within relatively stable environments such as reservoirs is still needed, particularly when different trophic levels are observed, as in many urban reservoirs (Silva et al., 2014).

Biodiversity is a broad concept that encompasses many facets of biological variability, for instance, taxonomic, genetic and functional (Naeem et al., 2016). Also, any dimension of the biodiversity is scale dependent. The total diversity of a study area (gamma diversity) comprises the local diversity of one sample unit (alpha diversity), and the variation of diversity among sample units (beta diversity), according to Whittaker (1960, 1972). By splitting biodiversity into a local component and the variation among locals, one can investigate how biodiversity varies at different scales. Indeed, McArthur et al. (1966) and later Allan (1975) have proposed an additive partitioning method to describe gamma diversity as composed by components of variation at diferent scales. Given that variation among sampling sites can occur at more than one scale (e.g. among sampling sites within a region; or among regions), the overall diversity index (e.g. we used taxa richness considering the lower taxonomic level, hereafter species richness) of a region (i.e. gamma diversity) can be described as the mean species richness per sampling site (alpha diversity) and the variation among sampling sites considering several hierarchical scales (more than one beta diversity, see Crist et al., 2003). As a consequence, this method can be used as a strategy to identify the main source of variation in aquatic communities (e.g., within or between reservoirs as described above). Also, each component of gamma diversity can be compared to what could be expected in a partitioning according to a null model, indicating if the observed sources of variation in biological communities can be expected by chance (Flach et al., 2012).

In addition, the beta diversity at a given scale is the result of turnover – or real variation – and nestedness. Spatial turnover refers to the replacement of some species in a community by others, and nestedness occurs when less biodiverse communities are subsets of more biodiverse ones (Baselga, 2010). For example, higher habitat specificity and lower dispersion ability can favor turnover in communities (Barton et al., 2013). On the other hand, the increase in environmental impacts may be related to nestedness in communities, given that compositional variation among communities generated by species loss is a usual consequence of impacted areas (Karthick et al., 2011). Thus, investigating beta diversity helps to identify and understand patterns and processes which determine the diversity on local and regional scales (Soininen et al., 2007).

In this study, we investigated spatial and temporal variation of epiphytic diatom biodiversity in the water supply reservoirs of Iguaçu River sub-basin in the metropolitan region of Curitiba, Paraná. Firstly, we tested the hypothesis that there is a higher spatial and temporal variation in the composition of epiphytic diatoms between heterogeneous reservoirs than would be expected to exist by chance. If not rejected, we speculated that communities differ likely due to the clear