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Ingestion of bacteria in a eutrophic subtropical reservoir pond with food web mainly controlled by zooplankton grazing

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ABSTRACT

This study evaluated the zooplanktonic bacterivory at a eutrophic subtropical reservoir pond by the quantification of the bacterial grazing and clearance rates of the protozooplanktonic (ciliates and nanoplankton) and metazooplanktonic (rotifers, cladocerans and copepods) populations during one year period. For this purpose, *in situ* experiments with fluorescently labeled bacteria (FLB) were carried out every two months on the sub-surface of the reservoir pond. Considering the individual grazing and clearance rates, the metazooplanktonic organisms showed the highest consumption of bacteria. However, in terms of population and considering all the zooplanktonic community, the heterotrophic nanoplanktonic organisms (HNP) accounted for 73% of the total bacteria ingested, being the most important bacterial consumers in the reservoir, due to their high population densities. Among them, the HNP smaller than 5 μm showed the highest population grazing rates, also due to their high abundance. These organisms were the main responsible for bacteria regulation by grazing in the reservoir. Among the metazooplanktonic organisms, the highest ingestion of bacteria occurred by the copepods (10%) during the wet season, and by the rotifers (22%) during the dry season. Thus, the metazooplanktonic population grazing rates were significantly different over the year, between the cold/dry and hot/rainy season. These seasonal differences were not observed in the density and biomass of picoplankton nor in the population grazing rates of ciliates and HNP. Nevertheless, the protozoa (ciliates and HNP) were directly responsible for most of the predation on bacteria, while the metazooplanktonic populations were indirectly responsible for it by the consumption of protozoa in a cascading effect.

Introduction

Bacteria are considered key components of aquatic food webs due to the extraordinary diversity of their metabolic pathways and their ability to process organic and inorganic substrates with high efficiency and versatility (Pomeroy et al. 2007). In aquatic systems, bacterial densities are controlled by several factors, such as nutrients, mainly available organic matter (e.g. Pinhassi et al. 2006), viral lysis (e.g. Motegi et al. 2009), temperature (e.g. Pomeroy and Wiebe 2001) and predation (e.g. Šimek et al. 2007). Among these, predation is known as the top-down control, which is considered one of the regulatory and modifying factors of bacterial populations and communities (Wright 1988), able to cause direct impacts on bacterial production (turn over) and biomass. It can also be responsible for several structural, morphological, physiological and taxonomic changes on bacterioplankton (Pernthaler 2005; Corno et al. 2008) and can influence even its diversity. The bacterial top-down control is commonly attributed to protozoan and metazooplanktonic organisms, such as rotifers, cladocerans and copepods (e.g. Saccà et al. 2009; Zöllner et al. 2009), which, together with bacteria, form part of a complex and dynamic food web that channels the energy flow in aquatic ecosystems.

This study aimed to evaluate the annual and seasonal importance of the protozooplanktonic (ciliates and heterotrophic nanoplankton) and metazooplanktonic (rotifers, cladocerans and copepods) populations in regulating bacterial communities in the Monjolinho reservoir pond, a representative shallow eutrophic subtropical environment.

Methods

Study site and sampling

The Monjolinho reservoir is a eutrophic environment similar to a pond located at an altitude of 816 m in an urbanized area of São Carlos city, São Paulo, Brazil (Fig. 1), with an area of 47,150 m^2,

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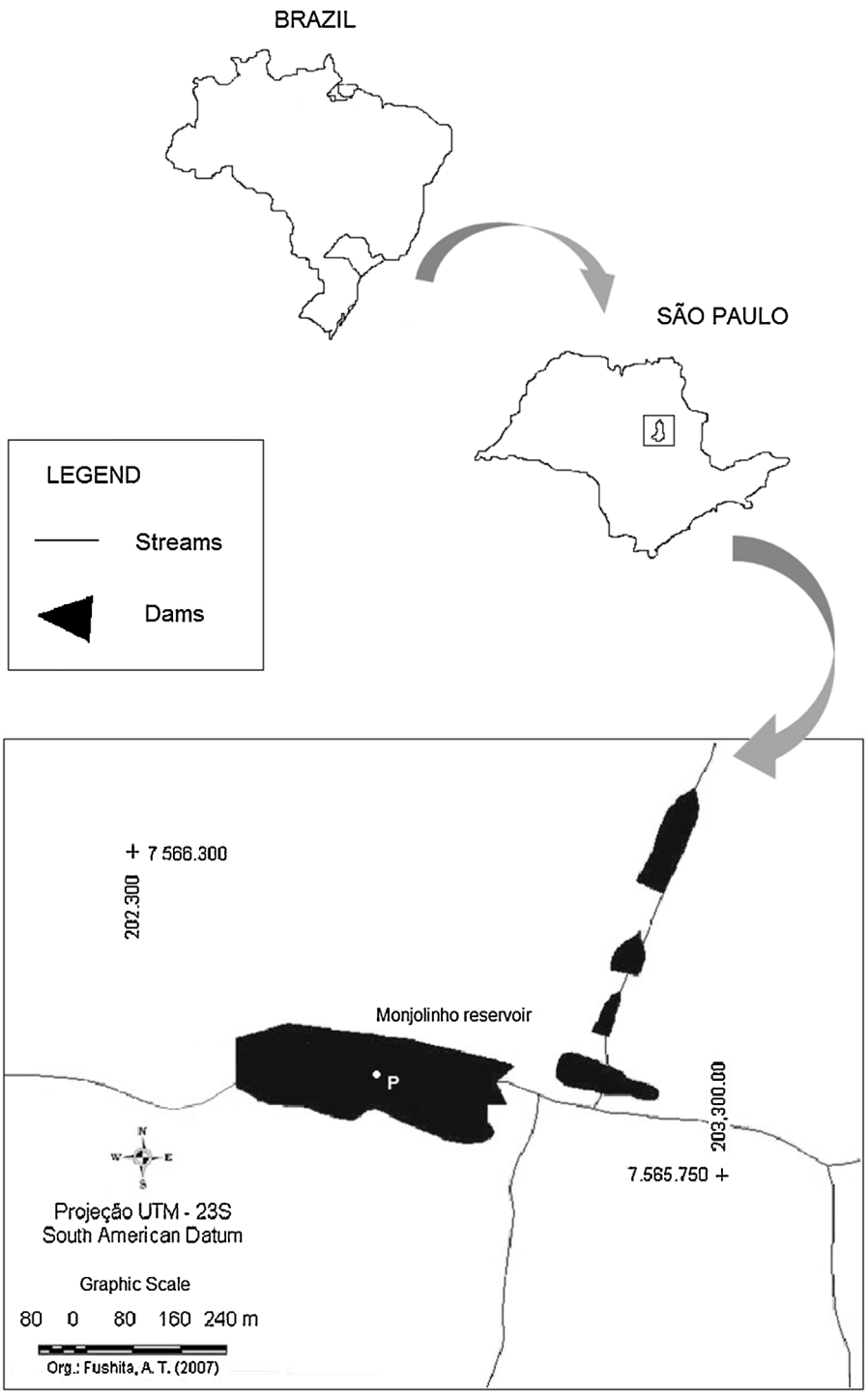

Fig. 1. Monjolinho reservoir pond indicating the sampling station (P).
Modified from Santos (2009).

a volume of 73,250 m^3 and maximum depth of 3 m. The climate is subtropical – Cfb, according to Köppen (1931), with a cold dry (April–September) and a hot rainy season (October–March). The reservoir is highly unstable and turbulent because of its small dimensions, shallow depth and short retention time of 22.9 days during the dry period and 2.1 days during the wet period (Nogueira and Matsumura-Tundisi 1994, 1996). According to Regali-Seleghim and Godinho (2004) the high instability of the reservoir promotes frequent resuspension of the sediment, which increases the nutrients in the water column and favors the occurrence of phytoplanktonic blooms at the end of the dry season.

Water samples were collected and *in situ* grazing experiments were carried out every two months throughout one year period, which included three surveys in the dry season and three in the rainy season, at the sub-surface (about 50 cm below the surface) of a central station of the reservoir (47°52′ W; 21°59′ S) (Fig. 1). In the field, water transparency was measured as Secchi depth (m), and the pH, dissolved oxygen ($mgO_2\ L^{-1}$), temperature (°C) and electrical conductivity ($\mu S\ cm^{-1}$) in the sub-surface of the water were measured with a multiparameter probe (Horiba U-10). With the water samples, suspended material ($mg\ L^{-1}$) analysis were performed according to Teixeira et al. (1965) and chlorophyll *a* ($\mu g\ L^{-1}$)