



Drivers of phytoplankton, bacterioplankton, and zooplankton carbon biomass in tropical hydroelectric reservoirs



Lúcia H.S. Silva^{a,*}, Vera L.M. Huszar^{a,1}, Marcelo M. Marinho^c, Luciana M. Rangel^{a,1}, Janderson Brasil^{a,1}, Carolina D. Domingues^{a,1}, Christina C. Branco^d, Fábio Roland^b

^a Universidade Federal do Rio de Janeiro, Museu Nacional, Laboratório de Ficologia, 20940-040 Rio de Janeiro, RJ, Brazil

^b Universidade Federal de Juiz de Fora, Juiz de Fora, MG, Brazil

^c Universidade do Estado do Rio de Janeiro, RJ, Brazil

^d Universidade Federal do Estado do Rio de Janeiro, RJ, Brazil

ARTICLE INFO

Article history:

Received 10 June 2013

Received in revised form 18 March 2014

Accepted 22 April 2014

Available online 20 May 2014

Keywords:

Plankton biomass

Carbon

Hydroelectric reservoirs

Driving forces

Tropical region

ABSTRACT

Studies of carbon sources in plankton communities are important because carbon content has become the main currency used in functional studies of aquatic ecosystems. We evaluated the contribution to the total organic carbon pool from different plankton communities (phytoplankton, bacterioplankton, and zooplankton – C-biota) and its drivers in eight tropical hydroelectric reservoirs with different trophic and hydrological status and different physical features. Our systems were separated into three groups based on trophic status and water residence time: (i) mesotrophic with low residence time (ML); (ii) mesotrophic with high residence time (MH); and (iii) eutrophic with low residence time (EL). Our hypothesis that reservoirs with low water residence times and low nutrient concentrations would show the lowest C-biota was supported. Phytoplankton carbon (C-phy) showed the highest concentrations in the EL, followed by MH and ML systems. The EL group also showed significantly higher zooplankton carbon (C-zoo). No significant difference was observed for bacteria carbon (C-bac) among the three system groups. In addition to trophic status and water residence time, regression analyses revealed that water temperature, light, pH, and dissolved organic carbon concentrations were the main drivers of plankton communities in these large tropical hydroelectric reservoirs.

© 2014 Elsevier GmbH. All rights reserved.

Introduction

Studies of carbon stocks in plankton communities are important because carbon content has become the main currency used in functional studies of aquatic ecosystems (Gosselain et al., 2000), allowing a better understanding of metabolic pathways (Kalff, 2002). The structure of plankton food webs strongly influences the fate of biogenic carbon in aquatic systems. A small part of the total organic carbon in freshwater is composed of particulate matter, and the dissolved organic carbon fraction is large and relatively constant (Wetzel, 1984). In temperate lakes, a number of studies have quantified how carbon biomass is partitioned among several compartments of plankton food webs (Auer et al., 2004; Gaedke and Kamjunke, 2006; Havens et al., 2007). Changes in carbon biomass partitioning are predictable across gradients of

nutrient enrichment, leading to a dominance of autotrophic over heterotrophic organisms (Callieri et al., 1999; Biddanda et al., 2001; Auer et al., 2004; Sarmiento, 2012). In contrast with the number of studies in temperate systems, little has been done to understand how plankton carbon biomass is partitioned and regulated in tropical and subtropical aquatic systems (Work et al., 2005; Pirlot et al., 2005; Havens et al., 2007), particularly in reservoirs.

Hydroelectric reservoirs cover an area of 3.4×10^5 km² globally and comprise about 20% of all reservoirs in the world (Barros et al., 2011). Besides power production, these systems are also used for multiple purposes, such as fishing, water supply, irrigation, flood control, and recreation (Kalff, 2002). They are complex systems with a predominant horizontal gradient (Jørgensen et al., 2013) and are subject to natural forces (regional climate and hydrological conditions) and anthropogenic influences (type of operation and construction, and watershed land uses). These factors affect their structure and function, as well as the spatial and temporal organization of their biological communities (Tundisi and Matsumura-Tundisi, 2008). Water-level fluctuations in reservoirs are generally human-controlled and strongly influence the abiotic

* Corresponding author. Tel.: +55 21 2567 2009; fax: +55 21 2567 2009.

E-mail address: luciahssilva@gmail.com (L.H.S. Silva).

¹ Tel.: +55 21 2567 2009; fax: +55 21 2567 2009.

and biotic features (Wetzel, 1990). Water residence time is an important modifier of nutrient loading (Schindler, 2006), directly influencing the maintenance or non-maintenance of plankton communities in the water column (Callieri et al., 1999; Havens et al., 2007; MacDonagh et al., 2009; Wang et al., 2011).

Phytoplankton is mostly regulated by resources (light and nutrients) and grazing pressure (Reynolds, 2006; Elser et al., 2007; Havens et al., 2009; Kosten et al., 2009). It is widely accepted that nitrogen and phosphorus are the main limiting nutrients for phytoplankton growth. However, the relationships between phytoplankton biomass and nutrients seem to be more complex in tropical aquatic systems, where lower predictive power has been reported (Huszar et al., 2006). The influence of other factors such as light (Nürnberg, 1996), hydrology (Dillon and Rigler, 1974; Downing et al., 2001), and grazing pressure (Jeppesen et al., 2003) may also reduce phytoplankton production and biomass per unit of nutrients (Brett and Benjamin, 2008). Lower predation pressure on phytoplankton by zooplankton is expected in tropical and subtropical waters, because in warm lakes small-bodied zooplankters dominate (Lacerot, 2010; Havens and Beaver, 2011; Sarmiento, 2012). In addition, flushing is an important factor causing loss of the phytoplankton community. High flushing reduces algal biomass and negatively affects organisms with low growth rates, especially large colonies of cyanobacteria (Romo et al., 2013). In these intrinsically turbulent environments, large colonial diatoms (meroplankton) might be resuspended into the photic zone due to physical processes (Padisák et al., 2009; Beaver et al., 2013).

In addition to phytoplankton, bacteria are important components of the limnetic plankton food web in terms of both biomass and production (Sommaruga and Robarts, 1997; Comerma et al., 2003; Auer et al., 2004). The availability of organic carbon and other nutrients, particularly phosphorus, are important factors in controlling bacterioplankton (Stets and Cotner, 2008). The positive bacterioplankton–phytoplankton relationship potentially indicates bacterial dependence on phytoplankton carbon, but this relationship is weaker in the tropics than in temperate regions (Roland et al., 2010). Predation by protozoa and metazoan plankton is another factor controlling bacterioplankton (Jezbera et al., 2006). The dominance of small-bodied zooplankton and the higher abundance of rotifers, ciliates, and nanoflagellates in warm lakes may lead to a stronger grazing impact on bacterioplankton (Jeppesen et al., 2007; Sarmiento, 2012).

For zooplankton, the main drivers are the quantitative and qualitative availability of food (Ferrão-Filho et al., 2003; Hansson et al., 2007) and predation (Jeppesen et al., 2007; Attayde et al., 2010). Zooplankton biomass has been positively related to increased phyto- and bacterioplankton production resulting from eutrophication (Kalff, 2002; Bonecker et al., 2007; Rangel et al., 2012). Nevertheless, predation by zooplankton is also dependent on the size and shape, as well as the nutritional and toxicity characteristics of their prey (Gulatti and DeMott, 1997). Top-down control of zooplankton is exerted mainly by fish, in tropical and subtropical regions mainly by planktivorous and omnivorous fish (Jeppesen et al., 2007; Attayde et al., 2010). In reservoirs, advective losses caused by high flushing favor small-bodied zooplankton with short generation times, such as rotifers (Obertegger et al., 2007; Beaver et al., 2013).

The aims of this study were to evaluate the biomass contribution of different plankton communities (phytoplankton, bacterioplankton, and zooplankton) to the organic carbon pool and to identify its main drivers. We studied eight tropical hydroelectric reservoirs that differ in trophic status, hydrology, and physical features. We hypothesized that reservoirs with low water residence times and low nutrient concentrations would support low plankton biomass.

Study sites

All the eight reservoirs included in the study are used for power generation. SER, which began operations in 1998, belongs to the Tocantins–Araguaia hydrographic basin (13°49' S; 48°18' W), and is the largest Brazilian reservoir in volume and the fifth-largest in area (Fig. 1). MAN is about half the area of SER, lies in the Paraná-Paraguay hydrographic basin (14°52' S; 55°46' W), and began operations in 2000. COR (17°59' S; 48°31' W) and ITU (18°24' S; 49°05' W) also belong to the Paraná-Paraguay hydrographic basin, and began operations in 1997 and 1980, respectively. FUR (20°39' S; 46°18' W), MSM (20°16' S; 47°03' W), and LBC (20°09' S; 47°16' W) are cascade reservoirs along the Grande River, also in the Paraná-Paraguay basin, and began operations in 1963, 1957, and 1969, respectively. FUN (22°35' S; 44°35' W) is located on a river that drains waste from densely populated and industrial areas in the Paraíba do Sul basin, and began operations in 1969 (Fig. 1). For all the reservoirs, the regional climate is humid tropical (Köppen Aw), with a warmer rainy season during summer (December through March) and a colder dry season during winter (June through August; Niemer, 1989). Historical data for annual mean air temperature range from 18 °C at FUN to 25 °C at MAN.

Two groups of reservoirs were identified according to the water residence times: 0.05–0.35 years (MSM, LBC, COR, ITU and FUN) and 1.11–4.14 years (MAN, SER and FUR) (Rangel et al., 2012). According to the vertical temperature profiles, all systems except for MAN were stratified during the winter dry season, when this reservoir was completely mixed. Most of the reservoirs tend to be mesotrophic, except FUN which is eutrophic, and potential P limitation to phytoplankton growth occurs in half of these systems (Rangel et al., 2012). In COR and FUN, a potential light limitation to phytoplankton growth was found (for more details see Rangel et al., 2012).

Methods

Sampling and data collection

Sampling was programmed to follow the climatological cycle, i.e., the rainy (November and March), and dry (July) seasons in 2003–2004 (MAN and SER), 2004–2005 (COR and ITU), 2005–2006 (FUR, MSM, and LBC), and 2006–2007 (FUN). A total of 144 samples were taken using a Van Dorn bottle at the subsurface (1.0 m) of the pelagic zone. In each period, samples for limnological variables were taken at a total of 48 sampling stations (3–11 sampling stations, according to the reservoir area). Bacteria (C-bac) and phytoplankton (C-phy) samples were fixed, respectively, with formalin (final concentration 1%) and Lugol's solution. Zooplankton (C-zoo) was sampled with a 1.5 m-long plankton net of 68 µm mesh, in the euphotic zone, and samples were fixed with formalin (final concentration 4%). Samples were filtered in a Whatman GF/C filter for analyses of nitrate (N-NO₃⁻), nitrite (N-NO₂⁻), ammonium (N-NH₄⁺), soluble reactive phosphorus (SRP), and dissolved organic carbon (DOC). Unfiltered samples were used to analyze total organic carbon (TOC), total phosphorus (TP), and total organic nitrogen (TON). Filtered and unfiltered samples for nutrients were kept frozen until analyzed. Samples for TOC and DOC were preserved by acidification (H₂PO₄). Water transparency was measured by the Secchi disk (SD) extinction depth; water temperature and pH by a multi-parameter probe (YSI – 6600); and turbidity by a La Motte-2020 turbidimeter. Total annual precipitation in each region, water residence time, inflow and outflow discharges, volume, area, and mean depth of the reservoirs, during the entire sampling year on a daily basis, were obtained from Furnas Centrais Elétricas S.A. These climatological and morphometric data are expressed as mean

Download English Version:

<https://daneshyari.com/en/article/4400372>

Download Persian Version:

<https://daneshyari.com/article/4400372>

[Daneshyari.com](https://daneshyari.com)