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No evidence for environmental and spatial processes in structuring phytoplankton communities

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ABSTRACT

The relative importance of local and regional processes in shaping natural communities within a metacommunity context has been a focus of intense debate in recent years. Floodplain lakes provide a good system for testing this theoretical approach, as they undergo seasonal variations in physical, chemical and biological factors, as well as in their degree of connectivity. Here, we investigated how local phytoplankton communities in lakes of a tropical river-floodplain system (Araguaia River floodplain – Central Brazil) were affected by environmental and spatial (dispersal) predictors in two rainy and two dry seasons (two consecutive years). Partial redundancy analysis indicated that during the periods analyzed the effects of neither predictor were significant. Although we cannot exclude the possibility that these tropical phytoplankton communities could be regulated by stochastic events, we suggested that further studies will have greater explanatory power if they include other variables related to biotic interactions (e.g., abundance of grazers) and fine-scale environmental variation.

1. Introduction

Unraveling the processes that determine the structure of natural communities is a prime goal in ecology (Gonzalez et al., 1998; Chase and Leibold, 2002; Cottenie et al., 2003; Cottenie, 2005). For decades, patterns in community structure were assumed to be controlled mainly by environmental factors and niche differences among species (see Tokeshi, 1999). The neutral theory of biodiversity (Hubbell, 2001) challenged this view by assuming that interacting species are equivalent and that population dynamics are driven by random variation in births, deaths, and stochastic, but spatially restricted, dispersal.

A metacommunity is a set of local communities within a landscape that are linked by dispersal of multiple potentially interacting species (Holt, 1991; Wilson, 1992; Cottenie and De Meester, 2004 and references therein). Currently, there are four proposed metacommunity models (species-sorting, mass-effects, patch-dynamics and neutral; see Leibold et al., 2004; Holyoak et al., 2005; Thompson and Townsend, 2006). Recent attempts to distinguish between these models have been based on the quantification of the relative roles of local and regional factors (e.g., Tuomisto et al., 2003; Cottenie, 2005; Beisner et al., 2006; Langenheder and Ragnarsson, 2007; Vanschoenwinkel et al., 2007; Van der Gucht et al., 2007).

Tropical floodplain lakes provide a good system to test this theoretical approach, as they undergo seasonal variations in physical, chemical and biological factors, as well as in their degree of connectivity (Thomaz et al., 2007). According to the flood-pulse concept (Junk et al., 1989), flooding is the main driving force that controls local environmental conditions and interactions within the biota of lakes. Floodplain lakes are only periodically inundated; therefore access by organisms depends on the level of connectivity among lakes and on their life-history strategies, such as the ability to produce stages which are capable of dispersing via watercourses or overland (Bilton et al., 2001).

We used data from a set of lakes in a river-floodplain system in Brazil during two rainy and two dry seasons (two consecutive years) to quantify the relative importance of regional (dispersal predictors) and local (pH, conductivity, water transparency, etc.) factors in explaining variation in community structure of a phytoplankton metacommunity. Our objective here was to disentangle which processes are more important in structuring phytoplankton communities and to compare the observed patterns with those predicted by the general models of metacommunity theory. We hypothesized that spatial processes, as predicted by the neutral model with dispersal limitation, would play a major role during the dry season, when some lakes are

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isolated (Thomaz et al., 2007 and references therein). As dispersal limitation underlies the spatial component, spatial predictors of community structure were calculated considering different scenarios of dispersal (via watercourse, overland, and via a connectivity structure based on hydrological connections). We also hypothesized that local environmental factors would be more important in structuring phytoplankton communities during the rainy season, when most lakes are connected to the river. We expected that during this season, there would be no dispersal limitation and therefore, variation in phytoplankton community structure would be more closely associated with physical and chemical properties of the lakes.

2. Material and methods

2.1. Study area

The Araguaia River system (Amazon River Basin) rises in the highlands of Central Brazil, discharges into the Tocantins River, and has numerous floodplain lakes along its course. Twenty-one of these lakes were investigated in this study (Fig. 1).

Most of the study area is covered by savanna (Oliveira and Marquis, 2002). The regional climate is humid tropical, with wet summers and dry winters. Annual rainfall varies from 1700 to 2000 mm. The watershed covers 377,000 km^2 and the mean annual river discharge is 6100 m^3/s. The river has well-defined hydrologic periods, with high water levels usually occurring from November to April (Latrubesse and Stevaux, 2002). The region of this study is a low-sinuosity anabranch river with a tendency for braiding, which transports an abundant sandy load (Latrubesse, 2008).

The data were collected during the rainy (February) and dry (August) seasons of 2000, and during the rainy (March) and dry (September) seasons of 2001. During the rainy seasons (high-water periods), all of the 21 lakes studied were connected to the river. Most of the lakes were classified as oxbow lakes.

2.2. Phytoplankton data

Phytoplankton samples of 100 ml were placed in dark bottles, fixed with a modified Lugol–acetic acid solution (Vollenweider, 1974), and stored in the dark. Phytoplankton biovolume was approximated according to Hillebrand et al. (1999) and expressed in mm^3/l. The classification system of Van Den Hoeck et al. (1993) was adopted for the taxonomic classes. Further details on phytoplankton sampling can be found elsewhere (Nabout et al., 2006, 2007).

2.3. Environmental variables

Limnological data were gathered concomitantly with phytoplankton data. Water temperature, pH, and electrical conductivity were measured with portable equipment (HORIBA model U-21®). Water transparency was estimated with a Secchi disk, and water depth was measured with a marked stick. Water samples were also collected for total phosphorus and total nitrogen analyses, following standard procedures (Golterman et al., 1978; Mackereth et al., 1978, respectively).

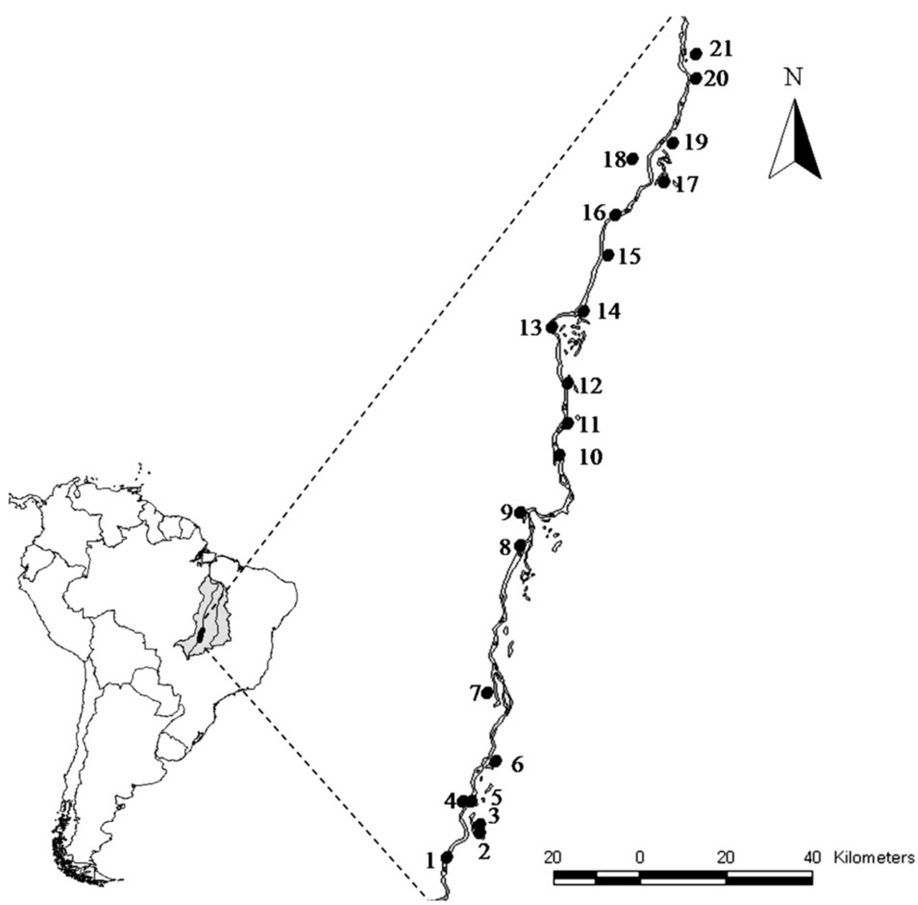

Fig. 1. Location of Tocantins-Araguaia basin in South America and the sampling sites in the Araguaia River floodplain. Code numbers follow those of Nabout et al. (2006).