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Research Letters

Concordance among aquatic communities in a tropical irrigation system

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A B S T R A C T

Different biological communities may exhibit similar spatial and/or temporal distributional patterns, a property termed community concordance. This study was conducted in a tropical irrigation system (Araguaia River floodplain) and aimed to quantify concordance levels between three aquatic communities (zooplankton, benthic macroinvertebrates, and aquatic macrophytes), and between these communities and a set of environmental predictors. To accomplish these goals, we used ordination techniques and Procrustean analysis. There were no relationships between the communities, and only zooplankton community patterns were significantly correlated with environmental predictors. These results indicate that biological surrogacy can be a flawed approach at small spatial scales and highlight the importance of the zooplankton community as a reliable ecological indicator in this type of system.

Introduction

Ecological studies recurrently search for patterns in the spatiotemporal distribution of organisms and attempt to explain these patterns according to environmental gradients, biotic interactions, and dispersal processes (Bowman *et al.* 2008). However, a particular biological community can also be used to predict the distribution of the community of interest (i.e., the response “species x samples” data matrix). It may be asked, for instance, whether different groups of aquatic organisms generate patterns of classification or ordination of floodplain lakes in a similar way or, simply, whether they are

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concordant. If they are concordant, then we can try to identify the mechanism behind this pattern. Recent studies have suggested that biotic interactions (competition, predation, or facilitation) are the most likely mechanisms underlying concordance (see Johnson & Hering 2010). Moreover, concordant responses are also expected to arise from similar responses to environmental gradients (Bini *et al*. 2007; Rooney & Bayley 2012). As an important implication, strong levels of concordance may indicate that only one of the concordant groups could be used in biological monitoring programs (Sanchez-Fernandez *et al*. 2006), reducing costs and sampling processing time.

Aquatic macrophytes play an important role in the formation of environmental gradients. For instance, macrophytes are an important source of organic matter for benthic organisms and probably are the main substratum for periphyton in Neotropical lakes (Padial *et al*. 2012). Also, these plants can influence different communities by decreasing water velocity, increasing flood supply, and providing refuges (Declerck *et al*. 2007; Thomaz *et al*. 2008). Drastic changes in ecosystem properties (e.g., water transparency and nutrient concentrations) can be caused by changes in the composition of aquatic plants (Scheffer 2004). Thus, directly or indirectly, changes in the species composition of aquatic plants are likely related to changes in the structure of other aquatic communities.

Floodplain systems around the world have been intensively modified by different human activities, including agriculture-related impacts (e.g., water diversion and contamination; Lemly *et al*. 2000). However, agroecosystems (e.g., irrigated rice fields) can still contribute to regional biodiversity (Maltchik *et al*. 2011). Thus, the use of surrogate groups, after validation, may be a cost-effective strategy to monitor the status and attest the ecological importance of these systems. In the present study, we tested for patterns of community concordance between zooplankton, benthic macroinvertebrate, and aquatic macrophyte communities inhabiting a rice irrigation system in the Araguaia River floodplain of Brazil. We also tested the relationship between these communities and limnological predictors. We predict strong patterns of community concordance, considering the strong structuring role of aquatic macrophytes in shallow aquatic environments.

Material and methods

Study area

This study was conducted at the Sistema de Irrigação Luís Alves do Araguaia. This is a rice (*Oryza sativa* L.) irrigation system located in the Araguaia River floodplain (50°32' W and 13°12' S, São Miguel do Araguaia City), Goiás State, Brazil, with area of approximately 21,427,800 m². Data were gathered during March of 2005 at six sampling sites: (1) Lago de Luís Alves (LL), a lake that is used as water source for the whole system; (2) Rio Verde (RV), a river that receives the irrigation effluents; (3) adduction channel (AC); (4) drainage channel (DC); (5) secondary channel (SC); and (6) Lago do Brito (LB), a lake within the floodplain but outside the irrigation system (Fig. S1, supplementary material online).

Environmental variables

The following environmental variables were measured with a digital probe (WD-35642-60 model): pH, dissolved oxygen, and conductivity. Water samples were analyzed for biochemical oxygen demand (BOD), turbidity, iron, total Kjeldahl nitrogen, potassium, manganese, and sodium concentrations following the methods described by APHA (2005).

Biological data

Zooplankton samples were taken by pumping 1,000 L of water through a 68 μm plankton net. Samples were fixed immediately with 5% buffered formalin. With the use of a Sedgwick-Rafter chamber and an optic microscope, we counted five sub-samples (2 mL each) taken with a Stempel pipette from the concentrated samples (100 mL). Zooplankton density was then measured as individuals per m^3. Zoobenthic community was sampled by taking two sub-samples at each sample site with a Petersen grab (0.0252 m^2). Samples were kept in plastic bags with 4% formaldehyde. In the laboratory, the material was washed through a series of sieves with different mesh sizes (0.15 mm to 50 mm), and all individuals were counted and identified with the aid of a stereoscopic microscope. Macrophyte surveys were conducted in the sampling sites and in areas downstream and upstream of these sampling sites until the detection of all species. Emergent, floating, or leaf-floating macrophytes were collected manually, whereas submerged individuals were searched with a rake.

Data analysis

Detrended correspondence analysis (DCA; Hill & Gauch 1980) was used to ordinate sites according to each aquatic community (zooplankton, zoobenthos, and aquatic macrophytes). To test the effect of numerical resolution on patterns of community concordance, we used density and presence/absence datasets. A principal component analysis (PCA; Legendre & Legendre 1998) from a correlation matrix was performed to ordinate sites according to the abiotic variables. Except for pH and incidence data (in the case of aquatic macrophytes), all variables were log-transformed prior to analyses.

Procrustes analyses (Jackson 1995) were undertaken based on the scores of the first two DCA and PCA axes to quantify the levels of concordance between the communities and their relationships with the environmental variables. Procrustes analysis provides a measure of lack of fit or lack of concordance, which is the sum of the squared deviations between the corresponding ordinations (m^2). After, this measure can be converted to a correlation statistic r (the square-root of $1-m^2$), varying from 0 (no concordance) to 1 (total concordance). Its statistical significance (PROTEST) was assessed by 720 Monte Carlo randomizations (Jackson 1995). Significant r-values would then indicate that pairs of communities are concordant or that there are associations between community structure and environmental data.