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Influence of taxonomic and numerical resolution on the analysis of temporal changes in phytoplankton communities

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ABSTRACT

From December 2003 to November 2005, we analyzed the phytoplankton community of four streams located in Central Brazil (Goiás State) to evaluate if the temporal changes in phytoplankton community structure were dependent on the taxonomic/numerical resolution used to represent the data. Classification based on functional criteria was also contrasted with taxonomic classification to assess whether these classification schemes produce different ordination patterns. Procrustean analyses indicated that ordination patterns generated with data based on the presence or absence of genera correlated significantly with the patterns generated by species density. Temporal trajectories of scores derived from functional groups significantly matched those derived from analyses based on quantitative data (density or biovolume) for genus or family. In general, the results indicated that some simplifications are justifiable, mainly when one takes into account the need for uninterrupted biomonitoring programs over large spatial scales in a continent-sized country with increasing environmental problems and with a relative paucity of scientists.

1. Introduction

Freshwater monitoring programs are frequently based on the species-level identification of different taxonomic groups. However, identification at the species level is complex and laborious (Guzmán-Alvis and Carrasco, 2005) and may require at least double the time needed for genus-level identification (Balmford et al., 2000). The use of higher-taxon levels is one alternative to reduce the costs of monitoring programs, incurring less dependence on taxonomists and more rapid identification (Maurer, 2000; Dauvin et al., 2003; Sánchez-Moyano et al., 2006). The higher-taxa approach is justifiable when the identification of taxonomic levels higher than species does not result in considerable loss of information (Khan, 2006). In other words, when a given pattern (or, for instance, the detection of an impact) obtained with species data is reproduced by data for higher-taxon levels (Forrest and Creese, 2006).

These simplifications in sample processing and other schemes of classification may be particularly important in tropical and subtropical environments that have high species richness and require substantial financial resources and time to catalogue all the species present in samples (Villaseñor et al., 2005).

Despite the taxonomic difficulties of species-level identifications, phytoplankton communities are frequently monitored to detect environmental impacts (Cottingham and Carpenter, 1998). Therefore, it is important to evaluate whether results (e.g., an ordination plot) based on species-level identification differ from those based on identifications above the species level and on functional groups (Reynolds, 1997, 2006; Reynolds et al., 2002). In cases of concordance between different taxonomic resolutions or classification schemes, simplification of sample processing might be suggested.

In the original study of Reynolds (1980), 14 functional groups were identified. Since then more than twice as many groups have been identified, with most species included on the basis of expert judgment and experience (Reynolds et al., 2002). Currently, the list includes 31 groups, with the respective habitat, tolerances, sensitivities and typical species defined for each group (Reynolds et al., 2002; Reynolds, 2006). In essence, those species that are frequently found co-occurring and that show increases or reductions in number simultaneously are defined as a functional unit (Reynolds et al., 2002). These groups have similar morphological characteristics that are reflected in similar distributions along environmental gradients (Reynolds, 1997). The use of the

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algal functional groups proposed by Reynolds (1980, 1997, 2006) and Reynolds et al. (2002) has been recommended in ecological studies with different objectives as this approach had enhanced descriptions of phytoplankton dynamics (Reynolds, 2006; Carneiro et al., 2008). However, it is necessary to determine whether results produced by functional groups differ from those obtained by traditional taxonomic classification.

This study was carried out through analysis of data obtained for phytoplankton communities sampled in the João Leite stream, located in Central Brazil. Our study asks the following questions: (i) are the temporal ordination patterns of the phytoplankton community independent of the taxonomic and numerical resolutions used (presence/absence, density and biovolume data), so that simplification of sample processing (aggregation to higher taxonomic levels and/or the use of presence/absence data) can be recommended; and (ii) do the ordination patterns obtained with functional groups (Reynolds, 1997, 2006; Reynolds et al., 2002) differ from those obtained with the use of a taxonomic classification?

2. Materials and methods

2.1. Study area

The João Leite stream is one of many tributaries of the Meia Ponte River. About half of the population of the Goiás State lives in its watershed, which is subject to intense human impact as more than 60% of the land is used for cattle ranching. Native vegetation covers *ca.* 30% of the area. The João Leite stream drains north–south, with a maximum flow in the rainy season of 11.2 $m^3\ s^{-1}$ and a minimum of 4.0 $m^3\ s^{-1}$ in the dry season.

2.2. Data collection

Phytoplankton samples were taken monthly between December, 2003 and November, 2005 at eight monitoring sites (five in the João Leite stream and three in tributaries, Fig. 1; see Supplementary data for a detailed description of the studied sites). Subsurface samples were stored in 100-mL dark bottles and fixed with Lugol-acetic solution (Vollenweider, 1974).

Phytoplankton density was estimated according to the method of Utermöhl (1958), with a ZEISS inverted microscope at a magnification of 400×. Sedimentation time of the samples was 3 h for each centimeter of height of the chamber, according to the criterion proposed by Lund et al. (1958). The sedimentation sample volume varied from 2 to 10 mL, depending on solids concentrations. Counting was carried out by means of horizontal and vertical transects and the minimum number of counted fields per sedimentation chamber followed the stabilization curve of the number of species, which was obtained based on new species added to each counted field. The biovolume was approximated

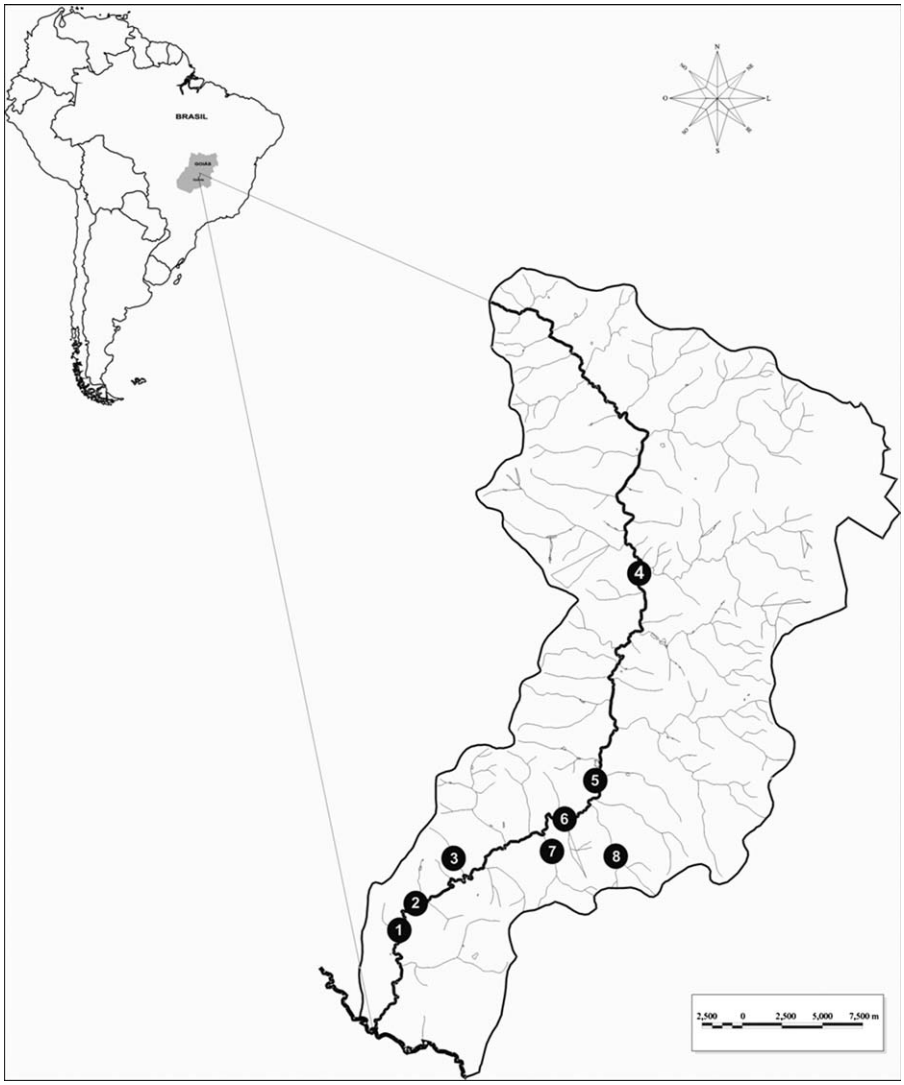

Fig. 1. Map of South America showing the State of Goiás (in gray) and the João Leite stream with monitoring sites.