



# Predicting productivity in tropical reservoirs: The roles of phytoplankton taxonomic and functional diversity



Ana M.C. Santos<sup>a,b,c,\*</sup>, Fernanda M. Carneiro<sup>d,1</sup>, Marcus V. Cianciaruso<sup>c</sup>

<sup>a</sup> Centro de Biologia Ambiental and Ce3C – Centre for Ecology, Evolution and Environmental Changes, Faculdade de Ciências da Universidade de Lisboa, Edifício C2, Campo Grande, 1749-016 Lisboa, Portugal

<sup>b</sup> Department of Biogeography & Global Change, Museo Nacional de Ciencias Naturales (CSIC), C/José Gutiérrez Abascal 2, 28006 Madrid, Spain

<sup>c</sup> Departamento de Ecologia, Instituto de Ciências Biológicas, Universidade Federal de Goiás, 74001-970 Goiânia, GO, Brazil

<sup>d</sup> Núcleo de Educação Ambiental e Pesquisa em Biologia – NEAP-Bio Universidade Estadual de Goiás (UEG), Unidade Universitária de Iporá (UnU-Iporá), Bairro Jardim Novo Horizonte 2, CEP 76200-000, Iporá, GO, Brazil

## ARTICLE INFO

### Article history:

Received 22 May 2014

Received in revised form 20 August 2014

Accepted 25 August 2014

### Keywords:

Biodiversity  
Chlorophyll-*a*  
Ecosystem functioning  
Functional groups  
Linear mixed models  
Species richness

## ABSTRACT

Primary productivity is intimately linked with biodiversity and ecosystem functioning. Much of what is known today about such relationship has been based on the manipulation of species richness. Other facets of biodiversity, such as functional diversity, have been neglected within this framework, particularly in freshwater systems. We assess the adequacy of different diversity measures, from species richness and evenness, to functional groups richness and functional diversity indices, to predict primary productivity in 19 tropical reservoirs of central Brazil, built to generate hydroelectric energy. We applied linear mixed models (and model selection based on the Akaike's information criterion) to achieve our goal, using chlorophyll-*a* concentration as a surrogate for primary productivity. A total of 412 species were collected in this study. Overall we found a positive relation between productivity and diversity, with functional evenness representing the only exception. The most parsimonious models never included functional group classifications, with at least one continuous measure of functional diversity being present in many models. The best model included only species richness and explained 24.1% of variability in productivity. We therefore advise the use of species richness as an indicator of productivity in tropical freshwater environments. However, since the productivity–diversity relationship is known to be scale dependent, we recommend the use of continuous measures of functional diversity in future biodiversity and ecosystem functioning studies, in order to be certain that all functional differences between communities are being accounted for.

© 2014 Elsevier Ltd. All rights reserved.

## 1. Introduction

Unraveling the relationship between biodiversity and ecosystem functioning remains a primary focus of ecological research (Tilman et al., 1997, 2012; Mittelbach et al., 2001; Hooper et al., 2005). This topic has received much attention due to the widespread impacts of human activities on natural ecosystems

(e.g., Hooper and Vitousek, 1997; Isbell et al., 2013). One of the most recurrent topics in this research area is the study of primary productivity drivers, particularly biodiversity (e.g., Tilman et al., 1996; Corcoran et al., 2012; Isbell et al., 2013). Primary productivity, i.e., the intrinsic rate of increase in biomass in an ecosystem (Bellinger and Sigeo, 2010), is usually used as a common proxy for ecosystem functioning because it is directly related to

**Abbreviations:** BEF, biodiversity and ecosystem functioning; FD, functional diversity; S, species richness; Simp, Simpson index; FGRich\_R, number of functional groups defined based on Reynolds et al. (2002) classification; FGRich\_K, number of functional groups defined based on Kruk et al. (2010) classification; Simp\_R, evenness of the functional groups defined based on Reynolds et al. (2002) classification; Simp\_K, evenness of the functional groups defined based on Kruk et al. (2010) classification; FR, functional richness (convex hull volume, Villéger et al., 2008); MFD, unweighted mean functional distance; FEve, functional evenness (Villéger et al., 2008); MFDDens, mean functional distance weighted by species density; LMM, linear mixed models.

\* Corresponding author. Present address: Department of Biogeography & Global Change, Museo Nacional de Ciencias Naturales (CSIC), C/José Gutiérrez Abascal 2, 28006 Madrid, Spain. Tel.: +34 914111328 (ext. 1212).

E-mail addresses: [ana.margarida.c.santos@gmail.com](mailto:ana.margarida.c.santos@gmail.com), [amcsantos@mnch.csic.es](mailto:amcsantos@mnch.csic.es) (A.M.C. Santos).

<sup>1</sup> These authors contributed equally to this work.

how resources are utilized in natural communities (Tilman, 1999). Indeed, many studies in the field of biodiversity and ecosystem functioning (BEF) are based on the assumption that diversity, particularly species richness, controls biomass production (e.g., Declerck et al., 2007; Cardinale et al., 2009; Korhonen et al., 2011). Many studies relating primary productivity and biodiversity indicate a positive relationship between these two variables, at least for plant groups (Tilman et al., 1996; Van Ruijven and Berendse, 2005; Ptacnik et al., 2008; Zimmerman and Cardinale, 2014). However, this relationship is not universal, and in some cases it can either be hump-shaped (e.g., Declerck et al., 2007; Mittelbach et al., 2001; but see Whittaker, 2010), negative or even non-significant (e.g., Waide et al., 1999; Schmidtko et al., 2010; Adler et al., 2011).

Most of our current knowledge on BEF has come from terrestrial ecosystems, particularly grasslands (Tilman et al., 1997; Loreau et al., 2002), raising the question of whether existing results can be extended to other ecosystems. Indeed, only a small number of studies have considered other organisms such as the phytoplankton (e.g., Ptacnik et al., 2008; Korhonen et al., 2011; Corcoran and Boeing, 2012) and few have taken into consideration further facets of phytoplankton diversity apart from species richness (e.g., Griffin et al., 2009). Focusing BEF research mainly in only one type of ecosystems is indeed very limited, especially considering that most primary production on earth occurs in aquatic environments (Falkowski et al., 1998), where a high diversity can be encountered (Hutchinson, 1961). Undeniably, the unique features of aquatic ecosystems may offer insights that help understand the role of biodiversity in different ecosystem processes (Giller et al., 2004; Hortal et al., 2014). Indeed, some of the currently known hump-shaped relationships between species diversity and productivity come from studies in lacustrine systems (e.g., Dodson et al., 2000).

Traditionally, many of the advances made in the BEF agenda have been based on the manipulation of species richness (e.g., Tilman, 1999; Mittelbach et al., 2001; Corcoran et al., 2012). However, many ecosystem level processes are affected by the functional attributes of the coexisting species and not by their identity (Hooper et al., 2005; Naeem and Wright, 2003). Therefore, one important limitation of this approach is that it wrongly assumes that all species contribute equally to biodiversity (Hooper et al., 2005; Magurran, 2004), ignoring the fact that species have different traits and ecological roles (Tilman et al., 1997; Díaz and Cabido, 2001; Petchev et al., 2004). Thus, the last two decades have seen a growing interest in understanding the relationship between species richness, functional diversity and the functioning and maintenance of community processes (e.g., Díaz and Cabido, 2001; Naeem and Wright, 2003; Cianciaruso, 2011).

Functional diversity (FD) can be defined as “the value and its range, for the species present in an ecosystem, of those traits that influence one or more aspects of the functioning of an ecosystem” (Tilman, 2001). In practical terms, FD is a representation of how species are distributed in an n-dimensional space defined by functional traits (Petchev and Gaston, 2006). Because FD links species and individuals with functions they perform on the ecosystems, it constitutes a better candidate measure than species richness to explain community and ecosystem processes (Díaz and Cabido, 2001; Hooper et al., 2005). Classically, functional diversity has been measured as the number of functional groups present in an assemblage, i.e., functional group richness (FGR; e.g., Tilman et al., 1997; Díaz and Cabido, 2001; Tilman, 2001; Naeem and Wright, 2003). Functional groups are usually defined as sets of species that show similar responses to the environment or have similar effects on ecosystem processes (Tilman, 2001), therefore being a simplified alternative to the taxonomic approach (Padisák et al., 2009). Such groups can be

defined by experts using a priori knowledge on the species' biological traits related to their ecological role (e.g., Reynolds et al., 2002), or by using multivariate analyses, like hierarchical classification (Legendre and Legendre, 1998), to identify clusters of species with similar traits (e.g., Weithoff, 2003; Kruk et al., 2010). However, as pointed out by Petchev and Gaston (2006), such approximation has several drawbacks. First, it is based on arbitrary decisions regarding which differences among organisms are functionally significant (Petchev and Gaston, 2006). Second, the number of functional groups can be greatly influenced by species richness (Petchev and Gaston, 2002). Finally, by using functional groups, one has to follow two assumptions that are rarely true: (i) all species within a particular group are functionally similar (i.e., are completely redundant); and (ii) species from different groups are equally different (i.e., are complementary).

Several alternative continuous measures have been proposed for measuring FD. These have the advantage of not having so many limitations and do not require making as many assumptions and decisions as with the FGR approach (Petchev and Gaston, 2006; but see Villéger et al., 2008; Pavoine and Bonsal, 2011). Nowadays there is an increasing range of continuous trait-based diversity indices (see review in Petchev and Gaston, 2006; Pavoine and Bonsal, 2011) that focus on three components of FD: (i) functional richness – “the amount of space filled by species in the community”; (ii) functional evenness – the equitability of abundance distribution in filled niche space; and (iii) functional divergence – “the degree to which abundance distribution in niche space maximizes divergence in functional characters within the community” (Mason et al., 2005).

In this work, we evaluated the relationship between productivity and different diversity measures in freshwater reservoirs of central Brazil, particularly focusing on phytoplankton species. Phytoplankton communities are known to be responsible for a large amount of the global primary production, largely participating in the carbon cycle (Falkowski et al., 1998). Also, they can be related not only with productivity but also with other environmental variables like available nutrients, water characteristics and the surrounding landscape (e.g., Carpenter, 2005; Nabout et al., 2006). They are indeed the ideal candidates for such type of studies as they have well defined traits that determine their ecological niche (Litchman and Klausmeier, 2008). Typically, patterns of diversity in freshwater systems and their relationship with productivity and the environment have been addressed through species diversity (e.g., Dodson et al., 2000; Ptacnik et al., 2008; Korhonen et al., 2011) and functional groups (e.g., Kruk et al., 2002; Hoyer et al., 2009). Despite the potential advantages of using continuous measures of FD, and the fact that species richness and FGR are often an inadequate surrogate for productivity, these have rarely been used on studies related to phytoplankton (Hortal et al., 2014; but see Griffin et al., 2009; Longhi and Beisner, 2010; Vogt et al., 2010). Also, few attempts have been made to understand the interplay of distinct measures of biodiversity and functional aspects of biodiversity (Petchev and Gaston, 2002). Here we aim to reverse this trend by evaluating which measure(s) of phytoplankton taxonomic and functional diversity, either based or not on density data (measured using functional groups or continuous indices), are the most appropriate for predicting productivity in tropical reservoirs of central Brazil. Although some previous studies have focused on the identification of surrogates for predicting phytoplankton's richness, community composition and response to environmental variability (e.g., Carneiro et al., 2010, 2013; Gallego et al., 2012; Hu et al., 2013), as far as we know, this paper represents one of the first attempts for testing the performance of different diversity measures as predictors of productivity (see Vogt et al., 2010).

Download English Version:

<https://daneshyari.com/en/article/6295057>

Download Persian Version:

<https://daneshyari.com/article/6295057>

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