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Combined eco-morphological functional groups are reliable indicators of colonisation processes of benthic diatom assemblages in a lowland stream

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ABSTRACT

Classifying benthic diatom taxa based on ecological and morphological features became increasingly important in recent years due to the demand of understanding the dynamics and functioning of diatom assemblages. The great potential in using these functional classifications in diatom ecology involves further refinement of current classification. In our experimental study, colonisation processes of diatom assemblages were studied in a typical small lowland stream, using both diatom guilds and cell size categories. We also tested newly proposed combined eco-morphological functional groups (ecological guilds combined with cell size categories) in the study of the colonisation process in benthic diatom assemblages. We hypothesised that (i) there is a decrease in the proportion of low profile guild, while an increase in that of high profile and motile guilds in time with the decreasing rate of physical disturbance; (ii) the presence of small size categories will be pronounced at the beginning of the colonisation processes, while proportion of larger size categories will be higher in the latter phases of colonisation; and (iii) the relationship between taxa and environmental factors are better reflected by the use of combined eco-morphological functional groups than by the sole analyses of rough guilds or cell size categories. The first hypothesis was not confirmed, and our second hypothesis was only partially confirmed by the results. We found that the relationship between environmental factors and guilds, as well as cell size categories was not appropriate to reveal the relationship between abiotic factors and taxa composition. In contrast we found that compositional changes in colonisation were appropriately reflected by the newly defined combined eco-morphological functional groups. In the combined eco-morphological functional groups, such kind of taxonomical and ecological features can be prevailed which are hidden in guilds or cell size categories separately. Thus these combined eco-morphological functional groups could help to come one step closer to develop a widely used ecological classification in diatom researches.

1. Introduction

The ecological status assessment using species composition data have became increasingly debated by the authors of several comprehensive studies in aquatic biota (Reynolds et al., 2002; Padisák et al., 2009; Berthon et al., 2011). This is considered to be a rather static approach and especially problematic in assemblages with (i) high number of not-easy identifiable or taxonomically problematic taxa and in assemblages where (ii) highly stochastic processes frequently occur like in the phytoplankton or benthic diatom (Reynolds et al., 2002; Padisák et al., 2009; Berthon et al., 2011). While the functional classification of planktic algae and cyanobacteria has a rather long history (see Salmaso et al., 2014), classifying benthic diatoms (Chromista, Bacillariophyta – Guiry and Guiry, 2015) into functional groups began only very recently (CSR strategy types – Biggs et al., 1998; ecological guilds – Passy, 2007; Rimet and Bouchez, 2012a,b; biovolume – Berthon et al., 2011; Kókai et al., 2015). The link between the appearance, and abundance changes of diatom life forms (e.g. mobile, colonial, tube-forming, stalked, pioneer) and environmental factors are quite well

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studied (see for details for example Berthon et al., 2011). The composition and dynamics of benthic diatom assemblages are primarily linked to present environmental conditions and their changes (Ács et al., 2000; Porter et al., 2013). The establishment of a respective taxon in a benthic assemblage is primarily determined by its colonisation ability (Ács and Kiss, 1993a), while the success of the establishment is affected by some specific morphological characteristics like (i) the cell size and biovolume (Ács and Kiss, 1993a; Snoeijs et al., 2002; Kókai et al., 2015) or by ecological adaptation features like (ii) nutrient demand or (iii) tolerance against physical disturbances (Passy, 2007; Berthon et al., 2011; Rimet and Bouchez, 2012a,b; Stenger-Kovács et al., 2013; B-Béres et al., 2014).

Benthic diatom taxa can be classified into five classes based on the cell size (S1: 5–99 μm^3, S2: 100–299 μm^3, S3: 300–599 μm^3, S4: 600–1499 μm^3, S5: $\geq$1500 μm^3; Berthon et al., 2011). Distribution of the different sized diatom taxa in an assemblage and considerable changes in cell size structure of the assemblages can provide vital information about changes in abiotic and biotic factors (i.e. eutrophication; climate change; organic pollution; secondary salinisation; macroalgal host effect – Snoeijs et al., 2002; Berthon et al., 2011; Kókai et al., 2015). It has to be emphasised also that the changes of the cell size categories in time or in connection with the changing abiotic factors depend strongly not only on the size of a respective diatom taxa, but also on ecological characteristics. Some taxa with the same size could belong to different ecological guilds, life forms, or strategies (e.g. Plenkovic-Moraj et al., 2008; Kókai et al., 2015).

Based on ecological characteristics Passy (2007) classified diatom taxa into three functional groups (low profile, high profile and motile guilds). Classification of taxa into these functional groups (in the forthcoming called 'guilds') was based on their resistance to nutrient enrichment and physical disturbances. Rimet and Bouchez (2012a) added to Passy's original classification a fourth planktic guild, because planktic diatom taxa are also able to settle into the biofilm. The intensive study of the relationship between the diatom guilds and environmental factors started only in the last few years (Passy, 2007; Berthon et al., 2011; Gottschalk and Kahlert, 2012; Rimet and Bouchez, 2012a,b; Stenger-Kovács et al., 2013; B-Béres et al., 2014). Based on these studies it can be stated that there is a great potential in the use of diatom guilds for environmental status assessment. However, it was also stressed, that further refinement of the robust guild classification is necessary (B-Béres et al., 2014). One possible solution for this refinement can be based on the combination of morphological (cell-size) and ecological features (guild affiliation), which jointly in an eco-morphological functional classification might provide enough high number of groups for a fine-scale assessment of a given status and also compositional and dynamical changes.

Directional changes characterised also by highly stochastic fluctuations in composition, like colonisation processes in diatom assemblages could be displayed as robustly by the use of functional groups as by the conventional taxonomical approach. Despite of this fact, there is rather limited information about the changes of ecological guilds during colonisation (Passy and Larson, 2011; Stenger-Kovács et al., 2013), and there are only indirect and sporadic data provided for changes of cell size categories during colonisation (but see Roberts et al., 2004; Sekar et al., 2004; Plenkovic-Moraj et al., 2008; Passy and Larson, 2011). However, the development of a biofilm (colonisation) provides a new perspective for evaluating the effect of environmental factors and their alterations on compositional changes of aquatic assemblages (Stenger-Kovács et al., 2013). The retained information can play a decisive role in ecological status assessment or in watercourse typification. In spite of these facts, according to our present knowledge there is no information about the use of combined ecological groups assessing the changes of diatom assemblages in changing environments, and/or during colonisation processes.

In this study we followed the colonisation processes in diatom assemblages using ecological guilds, cell size categories and newly created combined eco-morphological functional groups in a small lowland stream. We used the following study hypotheses directly linked to present literature:

(i) Guild-hypothesis – There is a decrease in the proportion of low profile guild, while an increase in that of high profile and motile guilds with increasing time and/or decreasing rate of physical disturbance (Stenger-Kovács et al., 2013)
(ii) Cell-size hypothesis – The proportion of small size categories will be high at the beginning of the colonisation process, while that of larger size categories will be higher in the latter phases of colonisation (Ács et al., 2000; Berthon et al., 2011).
(iii) Combined eco-morphological functional group hypothesis – Colonisation processes and the relationship between taxa and environmental factors are better reflected by the use of combined eco-morphological functional groups than by the sole analyses of guilds or cell size categories (B-Béres et al., 2014).

2. Materials and methods

2.1. Sampling setup and environmental parameters

Samples were collected at Debrecen-Józsa on the stream bed of Tócó (EOVX: 254755; EOVY: 839873, Fig. 1). Colonisation

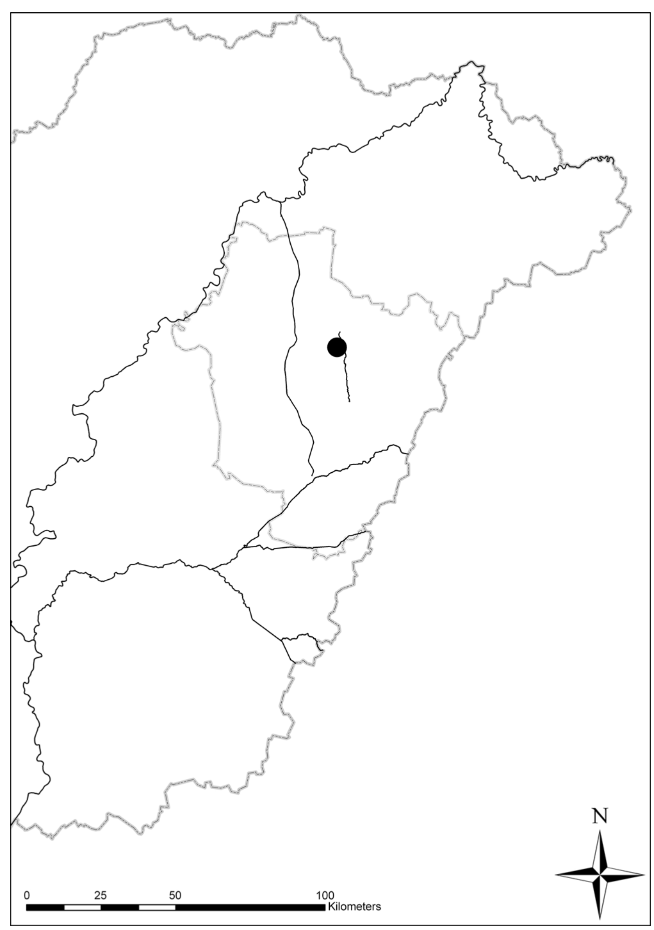

Fig. 1. The sampling site on the Tócó stream in Trans-Tisza region of Hungary. Black lines: the main rivers in the region and the Tócó stream. Black mark: The sampling site on Tócó stream.