Landscapes of facilitation: bio-physical self-organization of aquatic plants promotes diversity in streams

Loreta Cornacchia*†[1,2,3], Daphne Van Der Wal[1,4], Johan Van De Koppel[1,3], Geraldene Wharton[5], Sara Puijalon‡[2], and Tjeerd Bouma[1,3]

[1]Royal Netherlands Institute for Sea Research (NIOZ) – Netherlands
[2]UMR 5023 LEHNA, Université Lyon 1, CNRS, ENTPE, Villeurbanne Cedex – CNRS : UMR5023, Université Claude Bernard - Lyon I – France
[3]Groningen Institute for Evolutionary Life Sciences, University of Groningen – PO Box 11103, 9700 CC Groningen, Netherlands
[4]Faculty of Geo-Information Science and Earth Observation (ITC), University of Twente [Netherlands] – P.O. Box 217, 7500 AE, Enschede, Netherlands
[5]School of Geography, Queen Mary University of London, London – United Kingdom

Abstract

Spatial heterogeneity plays a crucial role in species coexistence. Despite the importance of self-organization in creating environmental heterogeneity in otherwise uniform landscapes, little is known about the effects of self-organized pattern formation on species coexistence and facilitation. We investigated the effects of large-scale pattern formation on species interactions using the aquatic macrophyte *Callitriche platycarpa* in streams as a model system. Specifically, we focused on the effects of *Callitriche* on other macrophyte species through flow velocity modification and turbulence generation. Our theoretical model predicted that feedback interactions between plant growth and water flow could promote species coexistence by creating spatial heterogeneities in hydrodynamic conditions. Field observations and transplantation experiments in naturally vegetated rivers supported this hypothesis: we found a significant spatial aggregation of two macrophyte species around *C. platycarpa* and a facilitative effect on their growth through hydrodynamic stress reduction. Next to flow velocity modification, we explored the effects of turbulence generation by macrophytes on species interactions. Flume experiments showed that the dense patches of *Callitriche* had a strong hydrodynamic effect, creating high-turbulence regions that facilitated nutrient uptake by a sparser species with weaker hydrodynamic effects. Our results emphasize the importance of self-organized patchiness in promoting landscape-scale species coexistence and influencing ecosystem functioning. Understanding the link between spatial pattern formation and facilitation is therefore essential for successful management of ecosystems.

*Speaker
†Corresponding author: loreta.cornacchia@univ-lyon1.fr
‡Corresponding author: sara.puijalon@univ-lyon1.fr