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Dendritic connectivity controls biodiversity patterns in experimental metacommunities

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Biological communities often occur in spatially structured habitats where connectivity directly affects dispersal and metacommunity processes. Many highly diverse landscapes exhibit hierarchical spatial structures that are shaped by geomorphological processes and riverine ecosystems, among the most diverse habitats on earth, represent an outstanding example of such mechanisms. Recent theoretical work suggests that dispersal constrained by the connectivity of specific habitat structures, such as dendrites like river networks, can explain observed features of biodiversity, but direct evidence is still lacking. Furthermore, in many environments intrinsic disturbance events contribute to spatio-temporal heterogeneity. Previous microbial experiments found that spatio-temporal heterogeneity among local communities induced by disturbance and dispersal events have a strong influence on species coexistence and biodiversity. These factors, directly affecting the history of community assembly, introduce variability in community composition in term of abundances and local species richness.

We investigate the effects of directional dispersal imposed by the habitat-network structure on the biodiversity of metacommunities by conducting a laboratory experiment using aquatic microcosms. Experiments were conducted in 36-well culture plates, thus imposing by construction a metacommunity structure: each well hosted a local community within the whole landscape and dispersal occurred by periodic transfer of culture medium among connected local communities, following two different geometries. Disturbance consisted of medium replacement and reflects the spatial environmental heterogeneity inherent to many natural systems. We compared spatially heterogeneous metacommunities following a river network geometry, with spatially homogeneous metacommunities, in which every local community has 2D lattice four nearest neighbors.

Local dispersal in isotropic lattice landscapes homogenizes local species richness and leads to pronounced spatial persistence. On the contrary, dispersal along dendritic landscapes leads to higher variability in local diversity and among-community composition. Although headwaters exhibit relatively lower species richness, they are crucial for the maintenance of regional biodiversity. Our results establish that spatially constrained dendritic connectivity is a key factor for community composition and population persistence.