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Editorial: Biodiversity in a changing world: How do species traits reflect anthropogenic changes in aquatic ecosystems?

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Editorial on the Research Topic
Biodiversity in a changing world: How do species traits reflect anthropogenic changes in aquatic ecosystems?

Introduction

Global environmental changes, especially those related to human actions, are affecting nature in unprecedented ways and their consequences for biodiversity are still far from being fully understood. This Research Topic is a contribution toward understanding anthropogenic effects on aquatic ecosystems and the organisms they support. The studies included in this Research Topic used functional diversity, a facet of biodiversity, to elucidate some of those effects by considering species traits (*i.e.*, any morphological, physiological, phenological or behavioral characteristics of organisms that influence their performance or fitness) and their relationships with environmental changes. We received contributions focused on several taxonomic groups, including phytoplankton, ciliates, testate amoeba, rotifers, microcrustaceans, fish and macrophytes, across natural (floodplains and rivers) and man-made ecosystems (reservoirs and wastewater treatment plants). Here, we briefly summarize the findings of contributions to this Research Topic from the perspective of three leading causes of environmental changes in aquatic ecosystems addressed by the studies, which are, loss of water quality, habitat fragmentation by dams, and climate change and deforestation.

Water quality

Clean water and sanitation are essential for human life and wellbeing. They are among the 17 Sustainable Development Goals, which were set up by the United Nations as an urgent agenda for a more sustainable world (United Nations, 2020). The loss of water quality is an important global environmental problem to be overcome. There have been efforts toward improving wastewater treatments and water reuse, which Moreira et al. addressed in this Research Topic. They investigated whether ciliate communities responded *via* their traits to a wastewater treatment plant (WWTP) operating with a combined UASB-activated sludge system. They found that wastewater removal parameters were correlated with changes in trait diversity of ciliate communities. They discuss the applicability and the limitations of the use of ciliate traits as a biological indicator to be included in wastewater treatment protocols.

The assessment of aquatic organisms and their distribution patterns across space and time as a potential indicator of environmental changes was also addressed by Lansac-Tôha et al. They evaluate the cross-taxon congruence of taxonomic and functional beta diversity of multiple taxa including phytoplankton, ciliates, testate amoebae, rotifers, microcrustaceans, fish and macrophytes, from the four largest floodplains in Brazil (Amazônia, Pantanal, Araguaia and Paraná). They found that the spatial scale, the type of data, and the degree of anthropogenic impact can affect cross-taxon congruence, causing high variation in species diversity and functional traits among these aquatic ecosystems. Therefore, the authors discourage the use of taxonomic groups from one floodplain as a surrogate indicator for another floodplain, even when well-known taxonomic groups are considered.

Habitat fragmentation

Although reservoirs are essential to provide enough water and energy to meet increasing human demand, damming rivers can drastically affect the aquatic biodiversity of rivers and surrounding natural environments. For example, tourist demand for winter activities coupled with reduction in the ice-cover period caused by climate changes in the Austrian Alps led to the construction of about 460 man-made mountain reservoirs to generate artificial ice. Sommer et al. sampled eleven mountain reservoirs to study whether the functional diversity of ciliate communities was similar to those of natural lakes. They found that planktonic ciliates dominated the mountain reservoirs and that traits typical of natural (alpine) lakes were rarely observed, suggesting that artificial environments may serve as a source of species with different environmental traits and preferences which have potential to affect the ciliate species composition in natural lakes within dispersal range. In this Research Topic, Santos et al. evaluated the responses of functional and taxonomic phytoplankton diversity to environmental gradients in subtropical and tropical reservoirs. They found that taxonomic and functional diversity depended on the environmental conditions, with higher values occurring in warmer, more transparent, and enriched ecosystems, under lower zooplankton grazing pressure. They also found that functional diversity based on identities was not predicted better from environmental conditions than taxonomic diversity, based on species identities. The same trend was observed by Resende et al. who also compared phytoplankton functional and taxonomic diversity in tropical cascading reservoirs of reduced size. The authors aimed to investigate whether spatial variation would be better explained than temporal variation along the cascade gradient. They found that the reservoirs differed significantly in nutrients and suspended solids, but that these variables alone did not explain the distribution patterns of phytoplankton species along the cascade, which were mainly explained by reservoir hydrodynamics.

Climate change and deforestation

Climate change is an important factor influencing species distributions in aquatic ecosystems in situations where many species have limited abilities to disperse in areas fragmented by environment changes (Woodward et al., 2010). Changes in hydrological cycles are expected to intensify with global warming in the coming years, likely increasing extreme events (Tabari, 2020). Within this perspective, Gonçalves-Silva et al. studied the drying dynamics of an intermittent river in Brazil, and its consequences for fish functional diversity composition (*i.e.*, taxonomic richness and functional structure). The authors found higher functional diversity of fish communities in the dry season compared to the wet season. In the dry season, fish communities were represented by species with more unique trait combinations and a higher degree of complementarity in resource use.

In another study within this Research Topic, Mateus et al. assessed changes in *Piaractus mesopotamicus* (Holmberg 1887) diet in the upper and the lower catchment of the Cuiabá River, Brazil, in the dry and wet seasons. The authors also evaluated the sensitivity of *P. mesopotamicus* populations to a simulated loss of food resources due to the potential deforestation of riparian vegetation. By contrasting fish stomach contents from the two sections of the Cuiabá River in both the dry and wet periods, the authors found that in the upper catchment of the river, the fish population fed mainly on allochthonous sources, while in the lower catchment of the river the allochthonous contribution to diets was lower. In addition, they found that the identity of consumed resources changed with the seasons. Based on the network analysis performed, the authors

discuss how the aquatic ecosystem of the Cuiabá River and diet composition of *P. mesopotamicus* are vulnerable to scenarios of riparian deforestation.

Conclusion

This Research Topic makes a valuable contribution to understanding patterns in functional traits of aquatic species and communities under contrasting scenarios of loss of water quality, river damming, climate change and deforestation in natural and man-made ecosystems. We hope the results of papers in this Research Topic support a broader discussion of functional diversity, a facet of biodiversity, as a pathway towards understanding the effects of environmental changes on aquatic ecosystem functioning in the challenging Anthropocene epoch.

Author contributions

All authors listed have made a substantial, direct, and intellectual contribution to the work and approved it for publication.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Publisher's note

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