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Editorial: Biodiversity conservation and ecological function restoration in freshwater ecosystems

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Editorial on the Research Topic
Biodiversity conservation and ecological function restoration in freshwater ecosystems

The significance and problems of freshwater ecosystems

As an essential resource for human life, freshwater has no substitutes. Freshwater ecosystems are among the most diverse and dynamic ecosystems on the planet, covering <1% of the planet's surface, yet supporting ∼9.5% of animal species and ∼ one third of vertebrate species (Dudgeon et al., 2006; Balian et al., 2008; Wu et al., 2023). They also provide a wide range of ecosystem services to humans, such as flood regulation, food supply and cultural significance. These ecosystem services are intrinsically linked to the functional diversity of existing organisms and can therefore connect human societies to their habitat. Freshwater ecosystems are among the most degraded ecosystems on earth due to land use intensification, point and non-point source pollution, river modifications and overexploitation (Vörösmarty et al., 2010; Couto and Olden, 2018; Reid et al., 2019). Multiple stressors such as those described above will continue to have a profound impact on biodiversity and ecological system functions of freshwater ecosystems (Hering et al., 2015; Guo et al., 2020; Juvigny-Khenafou et al., 2020, 2021; Zhou et al., 2020), and the changes related with climate and global change are meaning additional threats for the freshwater communities (e.g., Martínez-Capel et al., 2017; Muñoz-Mas et al., 2018). In order to maintain biodiversity and key ecosystem processes, the conservation and restoration of freshwater ecosystems must be a top priority; thus global coordinated efforts are fundamental to advance in freshwater biodiversity science and conservation (Darwall et al., 2018).

Our goal is to address recent advances in the biodiversity-ecological functioning relationship, to illuminate the biodiversity maintaining mechanisms, and to proclaim the main environmental factors (flow discharge, river connectivity, etc.) that influence the biodiversity and ecosystem functions of freshwater ecosystems at different spatial scales. Through these scientific advances, we aim to improve our understanding of theories related to ecosystem function and provide support for biodiversity conservation and ecosystem restoration in freshwater ecosystems globally. This collection of 15 papers is our modest contribution to achieving this goal.

Impacts and solutions

In this research theme we have collected many latest pieces of research on freshwater ecosystems functions and freshwater biodiversity (including fish, micro-eukaryotic, phytoplankton, benthic algae, wetland plant and macroinvertebrates).

Uncovering the underlying drivers of biodiversity patterns has been a major Research Topic in ecology and biogeography for a long time (Myers et al., 2000; Chase, 2003; Leibold et al., 2004). Here we present three studies on the community assembly processes and their drivers. Ren at al. used 18S rRNA gene sequencing to assess the biogeography of micro-eukaryotic communities (MECs) and their driving factors in sediments of thermokarst lakes across the Qinghai-Tibet Plateau and concluded MECs in this region were jointly controlled by spatial and climatic factors as well as sediment properties. Wang, Li et al. showed through a temporal food web study of urban and woodland rivers that land use and seasonal changes in environmental conditions influence biological communities and their trophic interactions in riverine ecosystems. Xiang, Wang et al. studied the spatio-temporal dynamics of fish assemblages in the karst tributaries of the upper Yangtze River and showed that fish assemblages differed significantly between river reaches, whereas did not vary in a significant manner during 4 months. Fish communities in that region should therefore be protected by conserving intermediate habitats, particularly the many pools and riffles. The development of effective monitoring and management strategies to halt biodiversity decline has become an important topic in freshwater research (Myers et al., 2000; Stendera et al., 2012; Hermoso et al., 2016), and several of the above studies provide support for a comprehensive understanding of the processes that shape freshwater communities.

Recently, community ecologists have realized the need to start with information not only at the taxonomic level, but also from a functional perspective to understand the environmental interactions and the mechanisms shaping the community assembly in animals and plant communities (McGill et al., 2006; Tabacchi et al., 2019; Liu et al., 2021). Ao et al. harmonized and searched representative databases of macroinvertebrate traits from several continents and implemented this method in the Three Parallel Rivers Region, China, filling a research gap in those regions, including China, where macroinvertebrate trait studies were lagging. This approach has greatly contributed to the uniformity of global trait studies and to the accuracy and comparability of trait studies in different regions (Vieira et al., 2006; Sarremejane et al., 2020).

Furthermore, the relationship between biodiversity and ecosystem functioning is a central topic in ecological research. However, most relevant research publications mainly focus on grassland and forest ecosystems (Ptacnik et al., 2008; Filstrup et al., 2014). Zhang et al. highlighted the importance of functional diversity in maintaining the relationship between biodiversity and stability of phytoplankton community in the Xiangxi Bay of the Three Gorges Reservoir; this work contributes to the mechanistic understanding of the biodiversity-stability relationships in aquatic ecosystems.

In addition, several studies have shown that human infrastructure construction is a major driver of the losses in biodiversity and ecological function. For example, the construction of dams, reservoirs and hydropower stations threatens biodiversity, the ecosystem processes and services supported by rivers (Anderson et al., 2015; Grill et al., 2019); furthermore, the effects of flow regulation by dams can be intensified in an additive or synergistic way with climate and global change (Martínez-Capel et al., 2017; e.g., Bruno et al., 2019). Here we present a few articles on the impact of human engineering on organisms. Li Y. et al. elucidated the ecological response of planktonic eukaryotes by identifying their diversity and ecological distribution in trans-basin diversion channels. Liu et al. quantified the genetic diversity and population structure patterns of *Saurogobio dabryi* after habitat fragmentation caused by dams, which provided a reference for resource protection and management of this species in the upper Yangtze River. By studying the response of phytoplankton functional diversity to physicochemical conditions in subtropical cascade reservoirs, Shen et al. found inconsistent patterns concerning the cascading reservoir continuum concept (CRCC) and contributed to the further development of the theory of the CRCC. Wang, Wu et al., in the Xiangxi River, described how small run-of-river dams affect different facets of β-diversity and community assembly process of benthic diatoms, and suggested that such kind of studies could be extended to other aquatic organisms (such as macroinvertebrates, phytoplankton, fish).

Li D. et al. revealed the complex quantitative relationships of planktonic food chains in wild aquatic ecosystems from the perspective of species interactions. Ecological threshold detection of cladocera-cyanobacterial abundances provides a quantitative basis for early warning and a key to the mechanisms of cyanobacterial blooms, contributing to more effective control and prevention methods. Zhou et al. and Wagutu et al. elucidated the relationship between crayfish and hydrilla and their environment from a genetic ecology perspective, providing valuable information for management strategies of such species. The former study will contribute to control strategies for invasive species, thereby reducing the damage to ecosystem function caused by invasive species (Simberloff et al., 2013).

Finally, we also collected three novel and valuable papers. Higher water temperatures could accelerate the decomposition of leaf-litter. Xiang, Li et al. pointed out that this may lead to the depletion of food for detritivores during future summers. Golpour et al. showed the Shannon diversity index of water eDNA targeting fish (wf-eDNA) method was significantly higher than traditional sampling methods. Thus wf-eDNA seems to be a reliable and complementary approach for biomonitoring and ecosystem management of freshwater ichthyofauna. Finally, the study by Feng et al. provided guidance on the deployment of artificial spawning grounds at both temporal and spatial scales, and also supported the enhancement of lake fish breeding and fisheries in Chinese lakes.

Implications and conclusions

In summary, freshwater ecosystems provide us with numerous ecosystem services and are the ecosystems on which human beings depend for their survival. In the 21st century, human activities and climate change will continue to have a profound impact on freshwater ecology. We have collected numerous recent research advances on the conservation of biodiversity and restoration of ecological functions in freshwater ecosystems in this Research Topic. We believe this collection can provide additional useful information for the realization of the topic. From a broader perspective, we have a responsibility and an obligation to work together to protect freshwater ecosystems.

Author contributions

NW wrote the first draft. All authors contributed to the article and approved the submitted version.

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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.

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