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Editorial: Freshwater biodiversity crisis: Multidisciplinary approaches as tools for conservation

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Editorial on the Research Topic
Freshwater biodiversity crisis: Multidisciplinary approaches as tools for conservation

Freshwater ecosystems represent less than 0.5% of Earth's surface, and less than 0.01% of Earth's water volume (Miller, 2021; Val et al., 2022). Despite comprising just a small percentage of space compared to terrestial and marine environments, freshwater ecosystems support astonishing levels of biodiversity (Albert et al., 2020; Miller, 2021; Val et al., 2022). For instance, freshwater fishes alone correspond to more than 20% of all vertebrate species (Miller, 2021; Val et al., 2022). Freshwater ecosystems encompass extremely diverse habitats, such as streams, medium to large sized rivers (e.g., Amazon, Nile and Mekong), small ponds, lakes or even very large lakes (e.g., African Great Lakes), waterfalls, rapids, marshes, flooded areas, swamps, puddles, pools (temporary or permanent), underground waters, and rivers or lakes inside caves. The conditions and characteristics of these environments can vary greatly, including the type of the substrate (rocky, sandy or muddy), water flow (lotic or lentic), water pH (ranging from acidic to alkaline), amount of water dissolved oxygen, sunlight exposure, water temperature, vegetation cover, type of bank (rocky, sandy or with plants), depth, turbidity, and many other variables. Environmental filtering drives the composition of species assemblages and the diversification of freshwater species, often resulting in niche specialists with specific habitat adaptations (Dudgeon et al., 2006).

Human activities pose serious threats to the persistance of freshwater biodiversity due to damage and modification of ecosystems that specialist species rely on, and even complete habitat destruction (Figure 1) (Dudgeon et al., 2006; Reid et al., 2019; Albert

FIGURE 1
Some of the main threats to freshwater ecosystems: **(A)** a large hydroelectric dam; **(B)** mining raft on river; **(C)** *Cichla piquiti* Kullander and Ferreira, 2006 (Peacock bass), a widespread species usually introduced in Neotropical reservoirs, especially for sport fishing; **(D)** plastic pollution; **(E)** small river dammed aiming to create a reservoir for water supply; and **(F)** stream close to urban area with riparian vegetation completely removed, and in silting process.

et al., 2020; Castro and Polaz, 2020; Rocha et al., 2023; Vieira et al., 2023). These losses have been exacerbated due to freshwaters lacking protection and their respective biodiversity being neglected from most global policies. The Ramsar Convention on wetlands attempts to designate areas of biological importance to encourage conservation action, however, there are no direct protections incorporated, rather countries must agree to oversee a broad management framework. Protected area delimitation has typically occured with limited consideration of the biodiversity and connectivity patterns present in freshwater ecosystems. For example, in megadiverse countries such as Brazil, protected areas fail to preserve the freshwater biodiversity of large lakes and rivers (Azevedo-Santos et al., 2019).

Ecosystem services derived from freshwaters are crucial for human wellbeing, paradoxically, we are now living through *"The freshwater biodiversity crisis"* (Harrison et al., 2018; Albert et al., 2020). This global phenomenon is characterized by an accelerated extinction of freshwater species or populations at alarming rates—about twice of that observed in other realms (Dudgeon et al., 2006; Darwall et al., 2018; Harrison et al., 2018; Reid et al., 2019; Albert et al., 2020). This scenario stresses that urgent conservation interventions are critical to bend the curve of freshwater biodiversity loss (Darwall et al., 2018; Reid et al., 2019; Albert et al., 2020; Tickner et al., 2020). Therefore, this Research Topic aims to discuss and reflect on multidisciplinary approaches and tools that can be used, preferably within an integrative approach, to assess and resolve aspects of the freshwater biodiversity crisis. This Research Topic and its editors welcomed articles dealing directly or indirectly with the theme *"The freshwater biodiversity crisis"*, discussing research methods, threats and possible solutions related to this Research Topic. We consider this Research Topic, and contributions within, a much needed step towards the necessary immediate and coordinated actions against biodiversity loss. Below, we briefly describe the contributions from this Research Topic.

Walsh et al. used a basin level functional trait assessment to determine whether major lotic theories such as the river wave continuum and environmental filtering act on Afrotropical systems. They identified a high species and trait diversity in both the upper and lower basins of the Kouilou River (Congo), suggesting

that conservation actions in the Afrotropics should be guided by environmental filtering studies, supporting different strategies for the conservation of species diversity in both the lower and upper portions of a system.

Almada Cajado et al. aimed to determine whether the climatic anomaly, El Niño Southern Oscillation, affected larval fish assemblages in the eastern Amazon River. Both La Niña and El Niño caused different environmental conditions which drove phenological changes in fish recruitment patterns. Their results indicate that increased climatic anomalies, or further climate forcing, will disrupt fisheries and ecological balance through altering recruitment processes in the Amazon.

Oliveira et al. demonstrate the occurrence of plastic debris drifting with larvae in the Tapajós River, a main tributary of the Amazon River, with larvae in the Tapajós River, a main tributary of the Amazon River, one of the most important river basins on the planet. This study shows the occurrence of high amounts of plastic waste in the Tapajós River. More importantly, it suggest that this drifting plastic may favor negative interactions (e.g., ingestion) between fish and synthetic polymers, as well as reducing the function of fish nursery areas.

Pérez et al. used molecular techniques to assess the impacts of a dam construction in the Magdalena-Cauca River basin in Colombia on the characiform *Brycon henni* Eigenmann, 1913. There are signals of a homogenization process in dam-regulated areas, reinforcing the need for monitoring programs targeting the loss of genetic diversity and the development of targetted conservation actions. Potential interventions may include removal of small sized barriers to enhance population connectivity and improve natural environmental flows.

In summary, these contributions focus on threats to freshwater biodiversity and aquatic ecosystems, changes caused by a prominent climatic anomaly, and the role of population genetics in conservation, emphasizing threats and changes or proposing possible solutions to these threats. All inferences rely on a strong biodiversity and taxonomic input. An accurate taxonomic understanding underlies solid works on ecology, policies and measures for conservation and assessment of impacts. The myriad threats which occur simultaneously in freshwaters must be urgently addressed. Point sources of pollution—both solid and liquid, can be improved through better waste water design and remediation technologies. Strategic assessment and removal of redundant barriers and impediments to natural flow and connectivity should occur at a global level. Indeed, in Europe and North America barrier removal programs have been recently implemented with much success. Removal of barriers has the second benefits of restoring habitats to a more heterogenous state and increasing resources. Freshwater ecosystem services are threatened by climatic anomalies which drive diferences in fisheries recruitment and persistence. Community integrated fisheries management is needed to create a less exploitative industry with higher resilience. Unfortunately, the climate crisis underpins all major global change. This cannot be tackled without cohesive and meaningful cultural changes in uses of fossil fuel energy at a global level.

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.

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