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EDITED AND REVIEWED BY
Martin Siegert,
University of Exeter, United Kingdom

*CORRESPONDENCE
Felipe Polivanov Ottoni,
fpottoni@gmail.com

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Editorial: Freshwater biodiversity crisis: multidisciplinary approaches as tools for conservation Volume II

Felipe Polivanov Ottoni [1]*, Marcelo Ândrade [1], Elisabeth Henschel [2], Valter M. Azevedo-Santos [3,4], Carla Simone Pavanelli [5] and James S. Albert [6]

[1]Programa de Pós-Graduação em Ciências Ambientais, Federal University of Maranhão, Chapadinha, Maranhão, Brazil, [2]Department of Animal Biology, Federal University of Viçosa, Viçosa, Minas Gerais, Brazil, [3]Curso de Ciências Biológicas, Centro Universitário Eduvale de Avaré, Avaré, São Paulo, Brazil, [4]Programa de Pós-Graduação em Biodiversidade, Ecologia e Conservação, Federal University of Tocantins, Porto Nacional, Tocantins, Brazil, [5]Núcleo de Pesquisas em Limnologia, Ictiologia e Aquicultura and Programa de Pós-Graduação em Ecologia de Ambientes Aquáticos Continentais, State University of Maringá, Maringá, Paraná, Brazil, [6]Department of Biology, University of Louisiana at Lafayette, Lafayette, LA, United States

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Editorial on the Research Topic
Freshwater biodiversity crisis: multidisciplinary approaches as tools for conservation Volume II

This editorial extends comments by Ottoni et al. entitled "*Freshwater biodiversity crisis: Multidisciplinary approaches as tools for conservation*". As previously reported, the "*freshwater biodiversity crisis*" (e.g., Darwall et al., 2018; Harrison et al., 2018; Albert et al., 2020) is part of the emerging planetary emergency and sixth mass extinction event in Earth history arising from anthropogenic impacts (Ripple et al., 2020; Meier et al., 2025).

Although freshwater ecosystems cover a tiny fraction of Earth's surface, they comprise an astonishing diversity of species and ecological traits. According to Kopf et al. (2015), p. 799, rivers, lakes, streams and other freshwater habitats, collectively "*(. . .) make up less than 2% of the Earth's surface but are home to approximately 10% of all described species of fungi, plants, invertebrates, and vertebrates (...).*" In other words, the species richness presented consider only named species. Numerous species descriptions are still being published today. This suggests that it is likely that this freshwater species' richness will increase considerably in the next years, especially for groups such as invertebrates and fishes. Freshwater ecosystems also provide numerous services, especially in the group of provision (e.g., animal protein). However, they also provide other services, such as cultural (e.g., tourism), regulation (e.g., seed dispersal), support (nutrient cycling), and others (Albert et al., 2020; Pelicice et al., 2022).

It is important to emphasize that freshwater ecosystems and faunas face more risks than terrestrial and marine ones (Darwall et al., 2018; Harrison et al., 2018; Reid et al., 2019; Tickner et al., 2020; Ottoni et al.). Some examples of major threats are shown in Figure 1. Now, it is known that about one-quarter of all freshwater species are currently threatened with extinction, based on a study which investigated decapod crustaceans, fishes and odonates (Sayer et al.,

FIGURE 1
Examples of major threats to freshwater ecosystems: **(a)** Invasive species "Giant river prawn" introduced into the Lençóis Maranhenses National Park, northeastern Brazil (photo: Felipe Ottoni). **(b)** Polluted and channelized river heavily affected by urbanization, Rio de Janeiro municipality, southeastern Brazil (photo: Paulo Vilardo). **(c)** Polluted and channelized river receiving sewage effluents in the Codó municipality, northeastern Brazil (photo: Carlos Filgueira). **(d)** Polluted stream in the Adolpho Ducke Forest Reserve, Manaus municipality, northern Brazil (photo: Douglas Bastos). **(e)** Tributary of the Amazon River contaminated with plastic waste, Manaus municipality, northern Brazil (photo: Ricardo Oliveira). **(f)** River receiving pollution from industry, Sidoarjo Regency, East Java, Indonesia (photo: Prigi Arisandi). **(g)** Marimbondo hydroelectric power plant and reservoir, southeastern Brazil (photo: Valter Azevedo-Santos).

2025). The main threats are from water pollution (plastic, urban, industrial or agricultural pollution) (Figures 1b–f), dams (Figure 1g) that cause habitat degradation and loss as well as block migration routes of fish species, overharvesting, water diversion and extraction infrastructure, agribusiness induced land-use changes (i.e., deforestation and forest degradation), non-native invasive species (Figure 1a), and diseases, with 84% of the species affected by more than one threat (Sayer et al., 2025). These factors directly impact freshwater ecosystems, causing their degradation, modification and/or total destruction (Figures 1b–g) (Ottoni et al.; Sayer et al., 2025). Different taxa are impacted in distinct ways: odonates (dragonflies and damselflies) are mostly imperilled by habitat loss, while 60% of the studied decapod crustaceans (shrimps and crabs) are mostly affected by pollution, which is also a main threat for fishes, along with damming and the modification and degradation of aquatic ecosystems (Sayer et al., 2025).

Lack of information on the abundances and distributions of freshwater species is an impediment to scientific conservation and sustainable management (Edgar, 2025). While the International Union for Conservation of Nature (IUCN) Red List of Threatened Species provides a rigorous methodology for assessing conservation status, the enterprise is hampered by the sheer scale of the task and limited information on the ecology and biogeography of most species (Edgar, 2025). As a result, the IUCN Red List is strongly biased towards species with large body sizes or commercial importance (Edgar, 2025), obscuring the actual magnitude of the global biodiversity crisis. The Red List under-reports the conservation status of species with small body sizes (e.g., invertebrates and small-sized fish) and inconspicuous habits (e.g., nocturnal, underwater or underground). Consequently, these species often exhibit undetected population declines but are categorized as Data Deficient rather than receiving a higher threat category (Edgar, 2025). Population trends, one of the main evaluation criteria for the IUCN Red List, are easier to assess in large terrestrial vertebrates, but difficult to evaluate in inconspicuous species.

Although inconspicuous and cryptic species may benefit from measures that target charismatic taxa, many lesser-known species require specific conservation measures. Many species are still unknown to science and face accelerated extinction rates, creating an eternal information gap on species that will disappear before being described or known. Modern approaches such as environmental DNA (eDNA), integrative taxonomy, revisions at small geographic scales, and "dark taxonomy" protocols (Meier et al., 2025) can help us accurately recognize species. This recognition is crucial for adopting efficient conservation policies and for providing stakeholders with accurate information. This is urgent, given the risk of losing species before we even know them.

In this research topic, 10 papers explore various aspects related to freshwater biodiversity conservation. We provide a brief overview of these publications. Recently, eDNA metabarcoding has become a powerful method for estimating species richness in local communities by employing high-throughput sequencing to detect species from environmental materials. Wu et al. developed a new portable eDNA collector that performs similarly to other commercial kits. Yet, to improve eDNA extraction, Zhao et al. experimentally evaluated the impacts of biotic and abiotic factors on eDNA degradation and found that bacterial abundance and pH are the main causes behind this decay. Kanjuh et al. utilized microsatellite loci to assesss the structure of 15 brown trout populations and non-native genetic material introgression into native populations. Substantial genetic similarities among populations were found, owing to stocks from fish farms that included non-native phylogenetic lineages.

This editorial also approached the effects of damming on biotic and abiotic factors. Novitskyi et al. examined the fishing losses in an exploded reservoir in the Ukraine, which caused long-term socioeconomic impacts and means a challenge for water supply and fishery in a post-war recovery. Pompeu et al. focused on the consequences of damming for irrigation on freshwater communities of mountain streams, concluding that dams strongly affect the riverine flow regime and diatom communities. López-Casas et al. modeled spawning areas for potamodromous freshwater fish in the Magdalena basin in Colombia and found that these areas strongly overlap with hydropower projects, emphasizing the importance of water management measures and promoting habitat connectivity.

Although the impacts of environmental change on the spread of diseases are often overlooked, Costa et al. analyzed the connection between pollutants and host-parasite interactions, highlighting how freshwater pollution significantly increases the transmission risk of schistosomiasis. Qu and Zhou explored the relationship between freshwater lake water quality and the phytoplankton community, stressing the need for monitoring to ensure the reduction of eutrophication. Ye et al. studied the relationship between water quality and watershed land cover at the Three Gorges Reservoir (TGR), advising long-term management to improve water quality. Lastly, Ma et al. discovered a direct link between the reduction of freshwater biodiversity and threats to ecosystem functioning, finding that in urbanized areas strongly affected by water pollution, phytoplankton community evenness contributes more to ecosystem functionality than environmental factors.

We conclude with a gentle reminder of the need to conserve aquatic ecosystems on different fronts, including new taxonomic studies, programs to prevent negative impacts on areas relevant to threatened freshwater biodiversity, the implementation of adequate protected areas, and engagement of scientists in policy formulation to protect freshwater biodiversity (Azevedo-Santos et al., 2021; Azevedo-Santos and Ottoni, 2025). For example, enhancing investments in new studies on taxonomic diversity (especially using integrative approaches), ecology, and regional species estimates (e.g., inventories and DNA-barcoding) are urgent, aiming to understand ecological aspects of species, estimate our freshwater biodiversity, as well as reveal and describe undescribed species. This is justified by the fact that undescribed species (i.e., not named) are frequently left out of legal protections, biodiversity assessments, and conservation planning. This invisibility means they may be lost to extinction before they are even discovered, particularly in fragile freshwater habitats threatened by deforestation, climate change, and other human activities. On the other hand, for example, the ecological roles of inconspicuous and cryptic freshwater species, which maintain water quality and support aquatic food webs, remain poorly known—limiting our understanding of aquatic ecosystem processes, and undermining efforts to conserve the rich biodiversity and ecosystem services of these vital habitats.

Author contributions

FO: Conceptualization, Data curation, Formal Analysis, Funding acquisition, Investigation, Methodology, Project administration, Resources, Software, Supervision, Validation, Visualization, Writing – original draft, Writing – review and editing. MÂ: Conceptualization, Data curation, Formal Analysis, Funding acquisition, Investigation, Methodology, Project administration, Resources, Software, Supervision, Validation, Visualization, Writing – original draft, Writing – review and editing. EH: Conceptualization, Data curation, Formal Analysis, Funding acquisition, Investigation, Methodology, Project administration, Resources, Software, Supervision, Validation, Visualization, Writing – original draft, Writing – review and editing. VA-S: Conceptualization, Data curation, Formal Analysis, Funding acquisition, Investigation, Methodology, Project administration, Resources, Software, Supervision, Validation, Visualization, Writing – original draft, Writing – review and editing. CP: Conceptualization, Data curation, Formal Analysis, Funding acquisition, Investigation, Methodology, Project administration, Resources, Software, Supervision, Validation, Visualization, Writing – original draft, Writing – review and editing. JA: Conceptualization, Data curation, Formal Analysis, Funding acquisition, Investigation, Methodology, Project administration, Resources, Software, Supervision, Validation, Visualization, Writing – original draft, Writing – review and editing.

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