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Editorial

Tropical and subtropical streams: A synthesis

A B S T R A C T

Tropical and sub-tropical streams harbor great biodiversity and are responsible for crucial ecosystem services. Intending to contribute to the understanding of how anthropogenic stressors and pressures alter functional or taxonomic diversity in biotic assemblages or processes in these systems, *Water Biology and Security* published eight papers. The research originated from Cameroon (Central Africa), southeastern Brazil, eastern Amazonia, and eastern China, representing eight river basins: Huai, Sui and Yishusi from east Asia; São Francisco, Doce, Jequitinhonha, and Amazon from South America; and Congo from Africa. The last two are the most biodiverse on the planet. The studied biomes included tropical rainforest and savanna, neotropical savanna and rainforest, neotropical savanna mountains, and subtropical monsoon forest. The response variables included fish assemblages (3 papers), entire macroinvertebrate assemblages or sub-groups (4 papers), and stream physical habitat structure (1 paper).

1. Results

We found five key results from the fish assemblage studies. (1) The land use/land cover (LULC) of river floodplain forests explained 30% of the variation in fish catch, with five species being positively, and two species being negatively, affected (Castello et al., 2022). (2) The niche breadth of fish diets was higher in the sites surrounded by forest than in those surrounded by agriculture. However, fish condition indicated by occurrence of diseases, deformities, eroded fins, lesions or tumors was not related to LULC (Castello et al., 2022). (3) River sites in the Huai River watershed had significantly higher fish phylogenetic alpha diversity and taxonomic and phylogenetic beta diversity than those in the Yishusi or Sui watersheds but significantly lower beta diversity (Liu et al., 2023). (4) Local, regional, climate, and spatial variables structured alpha and beta fish diversity, but local and spatial variables were more important than climate and regional variables (Liu et al., 2023). (5) Headwater fish assemblage composition was restructured by TSDs (mine tailings storage dams) located downstream, even though the upstream habitats were not altered and indicating the importance of connectivity in headwater streams (Salvador et al., 2023). These results indicate that local variables, spatial proximity, floodplain land use, and downstream dams can alter fish assemblage conditions.

The four macroinvertebrate papers demonstrated the importance of both local and landscape environmental drivers. Five gastropod taxa had different environmental preferences. *Littoridina* related negatively with stream slope, *Biomphalaria* related positively with total dissolved solids and the proportions of cobble, fine sediment and organic matter. *Gundlachia* correlated positively with elevation and the proportion of pools. *Physa* related negatively with total dissolved solids and positively with alkalinity. *Melanoides tuberculata* correlated positively with the proportion of coarse gravel (Linares et al., 2022). CPOM (coarse particulate organic matter) availability was an important explanatory variable for drifting gathering-collectors and scrapers; altitude was important for shredders and predators, and filtering-collectors were linked to water discharge (Callisto et al., 2023). Gerromorpha species composition was mainly affected by primary forest cover, habitat integrity, leaf substrate, and water temperature; species richness was mostly influenced by physical habitat heterogeneity and phosphorus concentrations (Cunha et al., 2022). These results indicate that different gastropod taxa, Gerromorpha indicators, and macroinvertebrate functional groups respond to different environmental drivers.

Several biological indicators can be useful for assessing anthropogenic impacts on macroinvertebrate assemblages. Biological Monitoring Working Party (BMWP, a family-based tolerance index), Average Score Per Taxon (ASPT, the BMWP divided by taxa richness), EPT (Ephemeroptera, Plecoptera, Trichoptera) taxa richness, abundance, and Shannon-Wiener diversity were assessed for evaluating the impacts of different land use intensities on Amazonian streams. Those land use intensities ranged from types and magnitudes of primary forest, logged forest, pasture, agriculture, and mining. All but EPT-ASPT were significantly responsive to that anthropogenic pressure gradient; however, EPT taxa richness was slightly more responsive (Santos et al., 2023). These results support the use of multiple biological indicators in assessing anthropogenic changes.

Finally, natural regional features (geology, climate) and geographic position, followed by average elevation and discharge, were most important for determining physical habitat characteristics (Caldeira et al., 2023). Their results corroborate those of Kaufmann et al. (2022a) for temperate North American streams and rivers, who also reported that physical habitat structure is a key determinant of fish and macroinvertebrate assemblage condition (Kaufmann et al., 2022b).

Despite the diversity of objectives and studied river basins, most papers addressed issues related to the determination of aquatic assemblage structure. Such an approach is globally relevant, considering that freshwater ecosystems and their associated biota represent some of the most threatened systems and imperiled organisms on Earth (Gangloff et al., 2016).

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2. Conclusions

The preceding results have multiple implications for managing fish assemblages in tropical and subtropical streams and rivers. Prevailing changes in floodplain LULC threaten the ecosystem security services provided by inland fisheries, highlighting the importance of policies that maintain native vegetation along riverbanks and in floodplain areas (Castello et al., 2022). River rehabilitation and management strategies for fish should consider local water pollution and habitat degradation as well as hydrological connectivity (Liu et al., 2023). Dams located downstream fragment streams and change headwater fish assemblages upstream, an impact often neglected in biomonitoring and bioassessment studies (Salvador et al., 2023). Reference sites for tropical streams should be set in the same regional landscape and with similar average elevation and discharge (Caldeira et al., 2023). Others have reached similar conclusions for temperate European and North American streams and rivers (Schinegger et al., 2016; Herlihy et al., 2020; Kaufmann et al., 2022a, 2022b).

As expected, assemblages as diverse as macroinvertebrates are driven by a diverse set of environmental drivers that suggest the need for multiple management strategies. Environmental preferences vary widely amongst gastropod taxa, and most are vulnerable to common anthropogenic disturbances (Linares et al., 2022). Invertebrate drift is linked negatively with organic matter transport, which is the opposite of what has been usually reported in the literature and may be driven by the sites' occurrence in OCBIL (old, climatically buffered, infertile landscapes) ecosystems. Such ecosystems differ markedly from young, often disturbed, fertile landscapes, and likely have important implications for OCBIL landscape management (Callisto et al., 2023). Forested aquatic systems had higher biological indicator scores because they provide greater riparian vegetation cover, channel canopy cover, bed stability, environmental heterogeneity, dissolved oxygen levels, and allochthonous energy inputs, which are favorable for maintaining stream EPT assemblages and functional diversity (Santos et al., 2023). Riparian forests – even in urban and industrialized areas – can help maintain the diversity of semiaquatic insect species and promote aquatic biodiversity in Amazonia (Cunha et al., 2022). Thus, nutrient-poor systems should not be expected to behave in the same manner as nutrient-rich systems, whether in tropical or temperate biomes (Davies and Jackson, 2006). Also, catchment and riparian forest cover (where it is expected to occur naturally) should be protected if we wish to protect the aquatic biodiversity of both tropical (Dala-Corte et al., 2020; Martins et al., 2021) and temperate (Herlihy et al., 2020; Kaufmann et al., 2022b) aquatic ecosystems—including those in cities (Stanfield, 2012; Maas-Hebner, 2014; Golgher et al., 2023).

3. Future perspectives

The articles published on this topic illustrate a wide variety of critical, current, and urgent approaches to the study of water resources and their biodiversity. On a planet undergoing global changes, non-perennial streams and rivers are predicted to dominate because of human actions (Datry et al., 2014). Therefore, identifying study priorities with indicator assemblages can help ensure the sustainability of water uses, conserve biodiversity, and protect ecosystem goods and services for riverside human populations. This is especially the case for threatened tropical and sub-tropical headwater streams, which are shifting from permanent to non-permanent flow, desperately need more studies to explain ecological processes, and are under-protected (Feio et al., 2022). Ideally, studies in tropical and subtropical aquatic ecosystems should include broad methodological approaches, with applied techniques, considering the accumulated basic knowledge about the structure and functioning of ecosystems and the necessity of understanding patterns at broad spatial extents. It also is essential to implement statutory bioassessment programs in the tropics and neotropics, similar to those now existing in Oceania, Europe, North America and South Africa, but including macroinvertebrates, fish, and macrophytes, at least. In addition, we should increase the number and extent of protected tropical and neo-tropical river catchments, protect and rehabilitate forested areas in riparian zones and catchments, reduce river fragmentation, and treat wastewater discharges (Feio et al., 2022). Lastly, water resource management measures must be based on available scientific knowledge to help enable and train new generations of scientists and decision-makers, in the search for a planet where humans feel part of, and care deeply about, aquatic ecosystems (Winemiller et al., 2016).

Declaration of competing interest

RMH is the Editor-in-Chief for Water Biology and Security and was not involved in the editorial review or the decision to publish this article. The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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