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STREAM ECOLOGY

Preface: Stream ecology and environmental gradients

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Natural landscapes have been constantly fragmented in different parts of the world due to human activities that directly and indirectly alter the natural environment gradients (Foley et al., 2005; Chin et al., 2014). The intensity of human activities generates new environmental gradients at different scales that cause a decline in biodiversity and changes in the structure and functioning of ecosystems (Pretty et al., 2010). Considering the watershed and its drainage area, it is possible to observe environmental gradients caused by changes in habitat diversity, nutrient concentrations, organic matter, dissolved oxygen, pH, among other limnological variables (Barrios & Teixeira de Mello, 2022; Lucas et al., 2022; Wanderi et al., 2022). Still, on large scales, environmental gradients can be generated by changes in land use and land cover of the watershed, such as the reduction of riparian vegetation and the increase in the input of sediments to streams and rivers (Tóth et al., 2019; Monteles et al., 2021). More recently, studies have demonstrated the existence of contamination gradients by pollutants such as heavy metals (Loureiro et al., 2021), microplastics (Ríos et al., 2022), and pharmaceutical products (Ghazal, 2023).

Streams are dynamic environments with great variability that generate spatial and temporal gradients in abiotic and biotic characteristics (Allan & Castillo, 2007). These gradients can occur naturally or from modifications caused by human activities (Tylianakis & Morris, 2017; Torremorell et al., 2021). Natural examples of gradients in streams and rivers include those caused by changes in altitude, latitude or longitudinal (upstream–downstream) gradients that correlate with vegetation, temperature and other physical and chemical variables, generating gradients that can easily model the structuring of aquatic communities (Naiman et al., 2005; Riesch et al., 2018). On the other hand, pervasive human activities in natural environments have caused intense changes in the quality of water bodies, thus generating considerable environmental gradients (Kupiec et al., 2021).

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Environmental gradients influence the heterogeneity of streams and rivers and are intrinsically linked to the structure of ecological networks at the most different scales (Tylianakis & Morris, 2017). In turn, the heterogeneity of the environment is one of the main factors that influence the structure and dynamics of populations and communities (Yang et al., 2015; Barrios & Teixeira de Mello, 2022). However, environmental gradients generated by human interventions can cause the homogenization of ecosystems (Agra et al., 2021). Thus, knowledge about the effects of environmental gradients on the structure of communities and their relationships with ecosystem services enables us to understand these systems better and improve ecosystem integrity management strategies (Moi & Teixeira de Mello, 2022).

In this sense, the aim of this Special Issue in *Hydrobiologia* on "Stream Ecology and Environmental Gradients" is to expand the basic and applied knowledge on this topic. In this Special Issue, we gathered 10 papers addressing the subject of Stream Ecology and Environmental Gradients. These papers were developed by authors from different nationalities (i.e., Argentina, Brazil, Ecuador, Spain, Japan, Uruguay, and USA). In these papers, the authors approach the subject based on studies evaluating community patterns of diatoms, macroinvertebrates, and fishes. The gradients used as predictors of patterns of the structure and composition of aquatic communities focused on variations in land use and land cover, native vegetation cover, planting of exotic species (i.e., *Eucalyptus*), and water pollution, among other disturbances caused by anthropogenic actions. In general, readers of this Special Issue will realize that macroinvertebrates and fish are still the main models for studies and the knowledge generated about the effects of environmental gradients on aquatic communities has focused on land use gradients (Table 1—Supplementary Material).

In one of the studies, the findings show that *Eucalyptus* afforestation alters the water quality of streams and changes available habitats for organisms (1).[1] In addition, the density of sensitive taxa (especially Ephemeroptera, Plecoptera, and Trichoptera orders, EPT) decreases with the increase in the proportion of the basin with Eucalyptus afforestation. Following the same line, one of the papers (2), demonstrated that the contribution of periphyton as a food resource for invertebrates was lower in patches with closed canopy than in open canopy patches. Thus, it became evident that removing riparian vegetation could alter the availability of basal food resources for dominant consumers in a community, even on a small scale.

Studies on the effect of gradients on land use and occupation are important to understanding the effects of environmental changes on aquatic communities at different spatial and temporal scales (Ferreira et al., 2017; Milesi et al., 2023). In this Special Issue, several studies demonstrated that different types of land use and occupation alter the environmental heterogeneity and, in turn, modify the alpha and beta diversity patterns of EPT assemblages in streams (3), especially agriculture, on the structure of metacommunities of aquatic macroinvertebrates in streams (4, 5). These results demonstrated that bioindicator metrics were more efficient for environmental variation associated with agriculture than taxonomic abundance and functional attributes (4). In addition, when the source of pollution is specific, such as urbanization, the richness, dispersion, and uniformity decrease significantly (5). These effects on metacommunities can be observed in small assemblages, which present morphologically similar organisms, but which respond physiologically when subjected to a disturbance. For example, Odonata demonstrated great potential as a bioindicator of water quality when the identification is made up to the taxonomic level of the genus (6).

Functionally, fish communities are susceptible to changes in the quality of stream drainage areas (e.g., vegetation removal). These changes can affect the functional characteristics of species in a specific way (i.e., locomotion and feeding habits), depending on the environmental change or level of disturbance (7). In addition, the environmental degradation gradient influences fish biomass in subtropical streams in a seasonal scale (8). Fish biomass can decrease in both high- and low-quality degradation sites. In this way, functional characteristics can represent a biological response to environmental changes (8).

Finally, another way of evaluating the effects of environmental gradients is the analysis of multiple aquatic communities and the use of biological indices. In a study using diatoms and macroinvertebrates

[1] Numbers in brackets within the text refer to serial number of papers in Table 1 – Supplementary Material.

to evaluate the effect of pollution gradients, the authors concluded that diatoms were more sensitive to water pollution by nutrients. In contrast, macroinvertebrates were more sensitive to changes in habitat and land use (9). Regarding the use of multimetric tools in biomonitoring, a study carried out in Argentina (10) demonstrated that fish are sensitive organisms for the assessment of environmental integrity and that approaches using multimetric indices can be useful in managing and conservating fragile environments such as aquatic ecosystems.

We hope to demonstrate the different possible approaches for studies on the relationships between environmental gradients and aquatic communities in streams and rivers. In general, ecological patterns and processes across the most different environmental gradients in streams involve complex aspects that transcend a single area of knowledge. Thus, this set of studies will make it possible to understand the different aspects of biological diversification in aquatic systems at the most varied environmental scales. Finally, we would like to thank the numerous reviewers who collaborated with us in the process of reading and evaluating the manuscripts. Special thanks go to the authors who contributed successfully so that we could offer the readers of *Hydrobiologia*, a Special Issue with great potential for scientific contribution to the consolidation of knowledge of Stream Ecology.

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