NATUREZA & CONSERVAÇÃO XXX (2016) XXX–XXX

ABECO
ASSOCIAÇÃO BRASILEIRA DE CIÊNCIA ECOLÓGICA E CONSERVAÇÃO

Natureza & Conservação
Brazilian Journal of Nature Conservation
Supported by Boticário Group Foundation for Nature Protection
http://www.naturezaeconservacao.com.br

Research Letters

Trends in studies of Brazilian stream fish assemblages

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ARTICLE INFO

Article history:
Received 19 November 2015
Accepted 12 June 2016
Available online xxx

Keywords:
Neotropical streams
Stream fishes
Spatial scale
Temporal scale
Meta-analysis

ABSTRACT

Studies about fish assemblages in Brazilian streams have grown in recent years, however, it remains unclear whether this increase is followed by increments in the diversity of addressed topics and theoretical frameworks adopted by researchers. We performed a systematic search for Brazilian studies on stream fish assemblages recording study region, publication year, objectives, and spatial and temporal scales adopted. The number of studies is unevenly distributed among regions. Most papers describe the general structure of local fish assemblages and their scientific objectives have not varied through time. Studies have been conducted mainly at small temporal and spatial scales, though the latter is increasing over time. We argue for the need of focusing on recently developed ecological theories and frameworks, and expanding the temporal and spatial scales of studies. These changes will improve regional and local conservation policies, and the visibility of aquatic Brazilian research in the global scientific community.

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http://dx.doi.org/10.1016/j.ncon.2016.06.003

Please cite this article in press as: Dias, M.S., et al., Trends in studies of Brazilian stream fish assemblages. Nat Conservacao. 2016. http://dx.doi.org/10.1016/j.ncon.2016.06.003

Introduction

Community ecology seeks to understand spatial and temporal patterns of species diversity and distribution. Throughout the last century, community ecology theory has fully changed from a stable and climax-based concept to a spatially dynamic core determined by local and regional processes (Ricklefs, 1987). Accordingly, the scale of studies on community ecology has considerably shifted, evolving from a small-scale reductionist perspective to a holistic macroscopic view of spatially oriented approaches (Holyoak et al., 2005; Hubbell, 2001). Being informed about the turnover of concepts, ideas, and scales of analyses through time is fundamental for developing new, cutting-edge, theory in community ecology and conservation policies.

Although most of recent ecological paradigm shifts did not come from riverine studies neither by freshwater ecologists, there have been many important developments in the aquatic ecology literature that sought to delve these new ideas within the aquatic realm (Benda et al., 2004; Fausch et al., 2002; Jackson et al., 2001; Grant et al., 2007; Wiens, 2002). Such efforts are important for understanding diversity patterns in fresh waters, particularly in habitats known to contain a large proportion of the biotic diversity and endemisms, such as small headwater streams.

Neotropical fresh waters hold more than 5700 known fish species. About 3200 are present in Brazil (JZ, *pers. obs.*) and a significant number arguably occur in streams (Castro, 1999). Neotropical streams have been attracting the attention of ichthyologists as a source of new species and sampling efforts in Brazilian streams have therefore increased over the last two decades. A recent meta-analysis identified possible research gaps in Brazilian riverine fish research (Azevedo et al., 2010), though general lines to new stream fish studies are clearly lacking. We develop upon their work and address the following complementary questions: what ecological concepts have been applied in studies of stream fish assemblages and how have they changed over time? How have spatial and temporal study scales changed through time? Answering these questions will guide freshwater ecologists in their future methodological and conceptual choices, providing bases to advance new research lines and also contribute with valuable information to the conservation of stream fishes in Brazil.

We analyzed published research on stream fish assemblages in Brazil to identify (i) the most studied regions, (ii) the main objectives, (iii) the spatial and temporal scales most often analyzed and (iv) their temporal trends over the last two decades. We finally discuss conceptual and methodological aspects that could improve future studies of stream fish assemblages and regional conservation policies. Our research is limited to Brazil and contains most of the information published on stream fish assemblages (except books and papers published in journals not available online), thus representing an up-to-date picture of the Brazilian research on stream fish assemblages.

Methods

We searched for papers published in scientific journals through the ISI Web of Knowledge and Scielo websites (last assess 02/2012) using the strings "fish*," "stream," and "Brazil" in the title, topic, and authors' addresses, respectively. As we were interested in assemblage-based studies, only papers assessing all species from a sampled location (i.e., fish assemblages) were included, whereas others involving only one or a group of species were not considered. Non-indexed Brazilian journals constitute an important source of stream fish studies, and were therefore included in our analysis when they corresponded to our research criteria (Appendix 1, Table S1).

For each paper, we recorded the year of publication, the Brazilian region where surveys were conducted, the geographic coordinates of sampling sites, the number of sampled streams and sections, and the number of times each site was re-sampled (Table S1). We considered the terms "streams" and "sections" as they were defined in each paper. Overall, streams were distinct, non-contiguous sampling points that were not included in the same channel and separated by confluences; sections corresponded to different sampling points inserted within the same stream.

We recorded the objectives and keywords used by authors in the abstract and introduction of each paper in a presence/absence matrix (Table S1). Studies not testing predictions or patterns from the ecological literature (i.e., studying local richness, diversity, and evenness levels) were considered descriptive and assigned as "Describe the structure of assemblages". In order to test the variation of objectives over the last two decades, we first applied a non-parametric Multivariate Analysis of Variance (npMANOVA, 999 permutations) using the objective matrix as the response variable and the year of publication as a continuous predictor variable. The Euclidean distance was adopted when computing the dissimilarity matrix. We further analyzed if the diversity of objectives increased through time by applying the Shannon index to the objective matrix and relating it to the publication year with Ordinary Least Square (OLS) models. Finally, we tested if the high frequency of occurrence of the two main objectives could prevent detecting an increase in diversity and variation in objectives through time (Appendix 1).

The temporal scale of each study was defined as the difference between the last and the first sampling year. We used the published geographic coordinates of sampling sites from each paper to estimate the maximum linear distance (i.e., Euclidean distance) between them, representing the spatial scale of each study. When site coordinates were not available (Table S1), we determined the spatial scale directly from published maps by measuring (in cm) the largest distance among the whole set of pair-wise distances between sampling sites and then converting it in kilometers using the scale bar from the published figure.

We analyzed the number of published papers by regions, spatial and temporal scale, and objective category by computing their frequencies of occurrence. We tested for changes in number of streams and spatial and temporal scales over time

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