German Centre for Integrative Biodiversity Research (iDiv) Halle-Jena-Leipzig
Deutscher Platz 5e, 04103 Leipzig, Germany

sDiv working group meeting summary

”sYNGEO – The geography of synchrony in dendritic networks: understanding the causes, dynamics, and consequences across multiple scales”

First meeting in Leipzig 14 to 18 January 2019

The first meeting of sYNGEO successfully brought together a great team of scientists from a diversity of backgrounds and expertise, including established and emerging leaders in the fields of traits-based ecology and metacommunity ecology, advanced time-series modelling, network theory, and global change ecology. In addition to their complementary expertise in these topic areas, the participants also came from a variety of countries: Canada, Germany, France, Hungary, Italy, Portugal, Switzerland and United States.

Understanding biotic synchrony – the extent to which biotic responses covary positively across space and time – is critically important for species persistence and thus considered paramount for biodiversity conservation and ecosystem management. During this first meeting, we established our working agenda to tackle the challenge of revealing the causes, dynamics, and consequences of synchrony in population fluctuations and aggregate community properties in riverine ecosystems. Overall, our time was divided as follows: 10% presentations, 60% brainstorming in small groups, and 30% large group exchange and task assignment.

The first morning was devoted to short presentations by the PIs summarizing the objectives of the working group (Julian Olden), key concepts and datasets available (Lise Comte), and state-of-the-art methods to the study of synchrony (Xingli Giam). These were followed by discussions among the entire group during which we identified two main research questions: (1) how traits-based approaches can provide new insights into the mechanisms and implications of synchrony?, and (2) how species dispersal and environmental heterogeneity interplay to drive synchrony patterns across dendritic networks? Over the subsequent days at sDiv, the meetings were organized around two small working sub-groups focusing on the main themes of the project, together with a third group processing the datasets that were compiled before the meeting. Larger sessions comprising the whole group to foster exchange of expertise and stimulate additional innovation were organized at the end of each day. The

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last afternoon was focused on additional side projects proposed by individual group members.

Functional perspective on biotic synchrony. Despite its ubiquity and ecological importance, many aspects of biotic synchrony are still poorly understood. Theoretical studies indicate that spatial synchrony can arise from three mechanisms, alone or in combination: (1) dispersal among connected populations, (2) community processes such as predator-prey or parasite-host interactions and (3) spatial correlation in the environmental drivers of population dynamics, also known as the Moran effect. The influence of these intrinsic and extrinsic factors may differ considerably among species, causing large interspecific and meta-community differences in the strength and scale of synchrony, and ultimately influencing species persistence and ecosystem stability. Here, the idea is to highlight how traits-based theory and approaches can support novel advances in the investigation of biotic synchrony, and use the global database of riverine fish time series as an exemplar. We identified five emerging research opportunities: (1) traits provide a common currency to compare patterns and mechanisms underlying synchrony, thus bridging diverse phylogenies across broad biogeographic regions; (2) traits inform the temporal and spatial scales at which synchrony should be studied; (3) traits reveal new insight into key mechanisms underlying synchrony; (4) traits allow for enhanced assessment of temporal stability in ecosystem functioning; and (5) traits deliver fresh perspectives into the ecological implications of synchrony. While taxonomic approaches to synchrony remain squarely in the majority, we argue that a new traits-based perspective will provide exciting opportunities to reveal the mechanisms behind observed patterns in biotic synchrony and better elucidate their consequences for ecological processes and ecosystem functioning. We have outlined our future working plans and scientific output, including the submission of a proposal for the Opinion section of *Trends in Ecology and Evolution*. We expect the manuscript to be ready for submission by the next meeting, at the end of July 2019.

Synchrony patterns across dendritic networks. The dendritic geometry of riverine systems distinguishes these ecological networks from other spatially structured habitats. For strictly aquatic organisms, dispersal is constrained by network structure, and consequently, population and meta-community dynamics are expected to be highly sensitive to connectivity, topology and directionality among occupied branches. In addition, evolutionary adaptations to natural flow regimes through the synchronization of life-history events with long-term flow patterns are common among running water species such as fishes. The goal of this project is thus to understand how species dispersal interplay with the environment to drive synchrony patterns across dendritic networks. Using empirical and stimulated data, we want to test the existence of a

relationship between the strength and range of synchrony and (1) species dispersal ability, (2) network complexity, and (3) environmental heterogeneity. The discussions of this sub-group focused (among other) on the theoretical expectations regarding the distance-decay patterns in river networks according to the structure of the habitat (i.e. homogeneous, gradient, patchy), for flow-connected versus flow-unconnected reaches, and how local density-dependent mechanisms can influence the interaction between environmental correlation (Moran) and dispersal. One manuscript was sketched around the questions described above and is expected to be in advanced stage before the next meeting.

Datasets & analyses. Prior to the first meeting, we collected 2,977 time series of fish abundances scattered across 237 hydrographic basins around the world (Australia, France, Hungary, Spain, Sweden, United Kingdom, United Stated). During the first meeting, the satellite group in charge of the data identified, processed and organized the time series relevant to each specific working group objectives. This included optimizing the time window covered by the time series within basins and datasets, as well as homogenizing the taxonomy across datasets. This allowed the first analyses of fish biotic synchrony (performed in R) to be realized before the end of the meeting!

Side projects. Additional discussions around side projects included (1) understanding the drivers of time varying synchrony, and (2) testing the effects of non-natives on the variability and synchrony of stream fishes. For the latter, we outlined a plan to build a global trait database for riverine fishes based on the individual efforts of the group members, that will include trophic and life-history characteristics. We expect these two manuscripts to be in advanced stages before the next meeting.

In summary. This was a very productive and fun meeting thanks to the friendly attitude and creativity of all the group members, together with the great facilities and support provided by sDiv. We believe that our working group is well positioned to tackle the proposed work, and that sYNGEO will be an incubator for new ideas to advance the field of biotic synchrony.