Report 2.12
Inter- and intra-specific size diversity of phytoplankton and its impacts on ecosystem functions (INSIDE)

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There is broad consensus on the influence that variation in the composition and diversity of species has on ecosystems. Evidence is starting to accumulate on the relevance of within-species variability for shaping community structure and functioning (Des Roches *et al.* 2018; Raffard *et al.* 2019). Specifically, interspecific effects directly impact communities via shifts in species composition, while intraspecific effects indirectly influence communities via changes in the phenotypic and genotypic composition of populations. What remains still elusive and forms the motivation of this Dynatrait project is how inter- and intra-specific trait variability interact under changing environmental conditions and how these interactive effects impact phytoplankton communities. These microbial communities show a large diversity of traits; cell size, for example, shows a broad range of variability and impact various ecosystem functions of planetary relevance. However, the effects of these two components of trait variability have been often overlooked in phytoplankton communities. In this Dynatrait project we took a joint experimental and modelling approach to disentangle the intra- and inter-specific components of phytoplankton size variability, and particularly to better understand if one component can functionally substitute the other.

Below we highlight two of the main outcomes of our Dynatrait project and provide an overview on other deliverables that we are actively working on, and which will be completed after the funding period of Dynatriat phase II.

We carried out experiments on an assembled community of three diatom species, for which we manipulated diversity (inter-specific component via changes in species composition and intra-specific component via changes in strain composition), nutrient concentration (high and low nutrient concentration) and temperature (low, intermediate, and high). The results show that both inter- and intra-specific components have an effect on biomass. Specifically, under low nutrient conditions, the two components decrease or have no effect on biomass production, however, interaction effects between inter- and intra-specific components become evident when nutrients and temperature increase. The latter observation confirms for phytoplankton communities that functionally substitutability is a plausible process that allows communities to compensate for the loss of diversity in one of the components. In addition, we quantify that both components positively affect size diversity, however, this increase in size diversity is not associated with an increase in biomass.

Models of phytoplankton communities struggle to capture the trait and species variability observed in nature and rarely allow to disentangle the intra- and interspecific components of such trait variability. These models typically describe the community using functional groups, size classes, or aggregate community properties, thus missing resolution of the trait diversity of individual organisms and the associated ecological implications. As part of the project, we developed a trait-based modelling tool (called *insidephy*) that simulates a high number of individual phytoplankton cells to disentangle the effects of intra- and inter-specific trait variability on the assembly and functioning of phytoplankton communities. insidephy is open-source software written in Python, which contains routines to quantify phytoplankton community size composition based on size classes or individual cells. We used previously published allometric relationships to design the trade-off in our model and initially tested the modelling tool with laboratory observations of Marañón et al (2013). We observed that the model based on individuals better captures the cell size variability observed in phytoplankton populations when compared with the model based on size classes.

We summarized the results of the experiments briefly mentioned here and the modelling tool in two manuscripts lead, respectively, by Patrick Thomas (Thomas *et al.* 2022b) and Esteban Acevedo-Trejos (Acevedo-Trejos *et al.* 2021). As part of his PhD project, Patrick is also analyzing data on experiments manipulating natural communities, which were exposed to different nutrient, temperature, and grazing regimes (Thomas *et al.* 2022a). These experiments will also be analyzed to test if there is evidence of interactive effects between inter- and intra-specific components on biomass and size diversity. Patrick is also leading a meta-analysis on phytoplankton food quality (Thomas *et al.* 2022c) and contributed to our understanding on the controls of Silica stoichiometry on riverine systems (Carey *et al.* 2019). These valuable contributions by Patrick will form the basis of his PhD thesis, which is initially scheduled to be defended in early spring 2022. Also, we conducted a systematic review lead by Helmut Hillebrand, where we evaluated the role of cell size as a driver and sentinel of community performance (Hillebrand *et al.* 2021). Last, we are working on contrasting the model assumptions with the observation of the assembled and natural community experiments. We will test the underlying assumptions of the model, i.e. the empirically derived growth and nutrient-acquisition trade-off, and whether such a trade-off has an effect on the functional substitutability between inter- and intra-specific components of phytoplankton diversity. These last results will be summarized in a manuscript that will be submitted to a peer-review journal earlier in 2022 (Acevedo-Trejos *et al.* 2022).

References

(in **bold face** are highlighted our main contributions generated during the project)

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