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Dear Editor,

We would like to submit our manuscript entitled *"Strong self-regulation and widespread facilitative interactions between genera of phytoplankton"* for consideration as an article for the Proceedings of the National Academy of Sciences.

Understanding how very many species can coexist in spite of competition has presented, and still presents, a great challenge to ecology. Phytoplanktonic communities are a quintessential example of this coexistence problem: they exhibit high diversity in spite of a seemingly homogeneous environment and similar resources, which usually favors competitive exclusion. Theoreticians have then proposed various models to solve the "plankton paradox", but these are seldom compared to species-rich experimental data, and even less to observational datasets.
In this manuscript, we seek precisely to tackle the phytoplankton paradox using field-based data. We uncover and analyse the interactions governing the dynamics of 10 coastal phytoplanktonic communities, using long-term time series (>20 years, sampled every two weeks) of the abundance of up to 14 phytoplanktonic genera. We estimate interaction networks using a dynamic multivariate autoregressive model, a technique thoroughly tested on both real and simulated data (Ives 2003, Hampton et al. 2013, Barraquand et al. 2018). Community matrices then enable us to unveil the structure of interactions and coexistence conditions.

We confirm the crucial importance of niche differentiation to coexistence ("stabilizing niche differences", *sensu* Chesson 2000), exceeding previous estimates of the strength of intraspecific interactions relative to interspecific interactions (Adler et al. 2018 suggested 4 or 5), and definitely rejecting neutral explanations of coexistence. The ratio of intra- to inter-specific interaction strength is indeed at least 10, and possibly more. The plausibility of this result, based on our 10-sites dataset, has then been confirmed by a re-analysis of published interaction matrices, estimated with the same statistical technique in 12 articles. We conclude that there is widespread niche differentiation in phytoplanktonic communities and our discussion explores what those niches may be, with a notable focus on natural enemies.
More surprisingly, we show additionally that facilitative interactions and even mutualism are to be expected for phytoplanktonic communities (between 40 to 70% of positive interactions), which are often perceived a contrario as purely competitive. Finally, we also contribute to the stability-complexity debate: while links between network stability and connectivity are absent, indicators of species vulnerability and impact on heterospecifics covary with self-regulation and rarity at the species level, showing how rarer species can in fact persist.

Our manuscript therefore provides empirical, field-based answers to the plankton paradox (as opposed to the overwhelmingly experimental empirical evidence so far) and offer new suggestions to structure interaction matrices in theoretical matrix models, by including strong niches and many facilitative interactions. We therefore believe that our manuscript will be able to appeal to both empirical- and theory-driven sides of ecology, and that our focus on how species coexist can reach PNAS broad readership beyond ecology (e.g., applied mathematicians, biologists more generally). We hope that our manuscript provides a suitable match for PNAS, and we look forward to hearing from you,

Sincerely yours,

Frédéric Barraquand & Coralie Picoche

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