Review of: "The Role of Metabolic Strategies in Determining Microbial Community Diversity along Temperature Gradients"

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This paper builds on previous theoretical models as well as empirical studies to explain microbial community diversity across a temperature gradient. Specifically, the authors focused on Carbon Use Efficiency (CUE) as a proxy for fitness along a temperature gradient. CUE variation with temperature is included in a relatively recent consumer-resource model allowing for resource secretion (including mass and energy flux conservation) as a temperature dependence of resource uptake rates. This temperature dependence is also included in each species' maintenance cost. The rationale for such dependencies is that both enzymatic uptake/transport rates as well as respiration rates present a unimodal (exponential increase up to a maximum followed by deactivation) temperature dependence that can be modeled with the Sharpe-Schoolfield equation.

While I find this to be a perfectly legitimate modification of the model, the question arises as to why other parameters of the model are kept independent of temperature. In particular, the model as given by Eqs. (1)-(2) in the manuscript differs from the original consumer-resource model in that species dynamics should include a 'yield' parameter (efficiency of energy to biomass conversion for each species) and the 'quality factor' of each metabolite (the energy provided by metabolite mass consumed). I don't know if these parameters are set to 1 in the model or somehow included in the uptake rates/resource preferences u_{i \alpha} (T). In particular, the 'yield' should be temperature dependent (may be through the Boltzmann factors of the anabolic rates). Furthermore, one could envision that the metabolic matrix/tensor l^i_{\alpha, \beta} (the partition of leaked energy into different resources) may also be affected by temperature.

A first result of model simulations is that, at all temperatures, species with higher uptake rates and lower maintenance costs, as well as lower resource requirements, survive in a setting of competition for resources. I guess, but it is not clear from the caption and the text, if simulations in Figure 2 are made by choosing l^i_{\alpha} = 0 (no secretion, only competition) where the competitive exclusion principle holds.

Another question that arises is that, in their simulations, consumer preferences are completely random for each species and sampled using Dirichlet distributions. It is not specified whether the concentration vectors for these distributions are chosen such that species randomly consume one or few resources (specialists) or have uniform consumption preferences (generalists). It would be interesting to know if modulating consumer preference (as well as maybe the connectance of the consumer preferences matrix) has an effect on survival along the temperature gradient.

Finally, model simulations qualitatively reproduce the peak in richness with temperature also observed in empirical microbial communities (Figure 4). Since CUE can be calculated with the model, the authors conclude that the variance in CUE drives the pattern of diversity observed along the temperature gradient. I wonder whether there are available empirical data on CUE temperature dependence (as the ones obtained by the authors in Smith et al. Eco. Lett. (2021)) that can help to support this claim. A final observation is that the empirical dataset used is a collection of data in very different and heterogeneous environments, while simulations are done assuming a constant supply of resources in a homogeneous environment. I would like to know whether the qualitative results obtained are relatively insensitive to the choice of environment, or if the comparison with experimental data holds due to the ‘averaging’ of the empirical communities across different environments for a given temperature.

In summary, I find this manuscript interesting and addressing a relevant question, providing a fresh approach to answer it using a combination of models and empirical observations. While the paper is well-motivated and written, I think it would benefit from a more in-depth discussion of some model assumptions and details.