From resources to population dynamics: a two-species competitive system driven by allelopathy

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Abstract

Recent works have shown the potential of allelopathy as a driver of biodiversity in two-species competitive phytoplankton systems. The interplay between allelopathy and resource competition generates contrasting outcomes: i) exclusion of the worst resource competitor and allelopathic species; ii) oscillatory coexistence and iii) exclusion of the best resource competitor and non-allelopathic species. The system undergoes a transition from states i) to iii) as the initial relative abundances of the species changes in favour to the allelopathic species. A mechanistic model of population dynamics accurately predicts the dynamics observed in the system both qualitatively and quantitatively. However, the allelopathy function in this model stablishes a negative exponential relationship between the abundance of the allelopathic species and the rate of allelochemical production. The biological mechanism behind this function is unknown, although it seems related with limiting resource (nitrate) dynamics.
The aim of this work was to study the causal relationship between the dynamics of the limiting resource (nitrate) in this system and the dynamics of allelochemical production.

We performed long-term interspecific competition experiments in continuous cultures using the allelopathic cyanobacteria *Phormidium* sp. and the chlorophyte *Ankistrodesmus falcatus*. We ran the cultures during 60 -90 days until the outcome of competition was observed. We manipulated the initial abundances (in the inoculum) of each species in order to be able to obtain the three outcomes described above (from i to iii). On a daily basis, we sampled species abundances, light absorption, nitrate concentration (the stablished limiting resource) and allelochemical production, which was estimated indirectly through a bioassay.
We found that allelochemical production is strongly positively related with nitrate availability for the cells, and this relationship is the basis that can explain all the dynamic properties of this system.

Keywords: Allelopathy, phytoplankton, competitive exclusion, coexistence, resource competition

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