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Individual-based models to study effects of resource competition and the anti-predator cooperation on motile phytoplankton aggregation

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SUMMARY

The phytoplankton spatial aggregation is a very important process that has large repercussions on the primary production and the marine life cycle. We believe that understanding this phenomena permits us to respond to many ecological and biological questions related to the passage from the unicellularity to the multicellularity for phytoplankton cells or other microorganisms having similar behavior. Our aim, in this work, is to understand the impact of some small scale interaction mechanisms observed at the level of phytoplankton cells such as the resource competition and the anti-predation cooperation between cells, on their spatial pattern. We developed two 3D spatially explicit individual-based models (IBMs) including two global mechanisms: (1) the cellular motion described by a stochastic differential equation in which the drift term takes into account the attraction mechanism between the cells due to their chemosensory ability and the dispersion term describes the spatial diffusion and (2) the branching process, that is the demographical process which is considered density-dependent to take into account effects of resource competition and anti-predator cooperation. The first IBM takes into account only the resource competition and ignores the cooperation process while the second IBM integrates both competition and cooperation mechanisms. Based on our simulation study, we found that competition and cooperation act on the aggregation process and the sizes of group but in the opposite way. Resource competition acts negatively while anti-predator cooperation favors groups formation. Also, this study explains rigorously how the cells can aggregate as a consequence of a trade-off between the benefits (reduction of predation risks) and costs (slowing down the division process) of being in aggregations.

Keywords: Stochastic individual-based model, Phytoplankton cellular aggregation, Aggregation size, Density-dependent demographical process.

AMS Classification: First code, second, third

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