

Phosphate-limiting conditions induce cell volume increase in natural coccolithophore populations

Miguel J. Frada

Hebrew University of Jerusalem, Department of Ecology, Evolution and Behavior, Alexander Silberman Institute of Life Sciences, Jerusalem, Israel; The Interuniversity Institute for Marine Sciences in Eilat, Eilat, Israel; miguel.frada@mail.huji.ac.il

Sabine Keuter

University of Hamburg, Department of Microbiology and Biotechnology, 22609 Hamburg, Germany; keuter@gmx.org

Gil Koplovitz

The Interuniversity Institute for Marine Sciences in Eilat, Eilat, Israel; gil.koplovitz@mail.huji.ac.il

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Coccolithophores are a key functional phytoplankton group that produce distinctive minute calcite plates (coccoliths) covering the cell surface. Calcification and subsequent export of coccoliths reduce alkalinity in the surface ocean and cause a net release of CO₂ into the atmosphere, counteracting the CO₂ drawdown by photosynthesis, thus constituting an important pathway of the global carbon cycle. Experiments in vitro indicate that the coccosphere size and coccolith length of *Gephyrocapsa huxleyi* increase when phosphate (P) is limited and decrease when nitrogen (N) is limited, relative to exponential cell growth in nutrient-replete conditions. However, variations occur between natural and experimental conditions. To test whether coccosphere size variations that occur in nature relate to nutrient availability, we examined coccolithophore communities in two oligotrophic ecosystems with marked seasonal variability: the Gulf of Aqaba (GoA) in the northern Red Sea and the Eastern Mediterranean (EM). In the GoA, we found that *G. huxleyi* cells are larger during the summer in the stratified layer, whereas winter cells are smaller in the mixed layer. Bioassays indicate that during the summer, cells are primarily P-limited, whereas nutrient limitation in the winter is absent or weak. Critically, no correlation between coccosphere size and coccolith length was detected. Similar size variations were detected for the similar species *Gephyrocapsa ericsonii*. The seasonal pattern in *G. huxleyi* size was the opposite in the EM. Coccospheres were larger in the mixed layer during winter and smaller during the stratified summer, which coincides with the prevalent pattern of limitation. The EM is permanently P-limited across all seasons, but during the summer, N limitation often predominates over P limitation. These results indicate that nutrient availability is a major regulator of coccolithophore size in marine ecosystems.