Interspecies competition based on the diel rhythms of P uptake in microalgae

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The diel rhythms in the phosphate (Pi) uptake rates for 3 species of green algae were examined in a P-limited cyclostat under a 12:12 h light/dark (L/D) cycle. For *Ankistrodesmus convolutus* and *Chlorella vulgaris,* the Pi uptake rates based on the cell number increased during the daytime and decreased at night. In contrast, *Chlamydomonas* sp. exhibited the opposite uptake pattern. The cell densities also oscillated under a L/D cycle, dividing at a species-specific timing rather than continually dividing. In general, the cell densities exhibited an inverse relationship with the Pi uptake rates. There were no allelopathic effects between species except for *Chlamydomonas* sp. on *A. convolutus*, reducing its growth about 30%. A competition experiment between *A. convolutus* and *C. vulgaris* in a P-limited cyclostat resulted in the dominance of *C. vulgaris*, regardless of the relative initial cell densities. *C. vulgaris* also dominated in a mixed culture with *Chlamydomonas* sp., irrespective of the initial seeding ratio and dilution rate. However, *Chlamydomonas* sp. and *A. convolutus* coexisted in the competition experiment with gradual decrease of *Chlamydomonas* sp., when equally inoculated. Mathematical expressions of the oscillations in the Pi uptake rate were used to develop a competition model. The new simulation model was based on Droop model with some modifications. This model reflected the effects of diel rhythms in Pi uptake and cell division gates. The simulation outcomes for algal growth and competition conformed reasonably well to the experimental data. The experimental competition processes were generally more delayed than the competition simulations. The developed model theoretically proved that species diversity could be enhanced by different oscillation patterns in resource uptake, even under conditions of limitation by the same resource.