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Mathematical comparison and empirical review of the Monod and Droop forms for resource-based population dynamics

Almost all biological models use either the Droop or Monod form to describe the resource-based growth of a living organism. Empirical evidence overwhelmingly suggests the Droop form describes data more accurately than the Monod form, however, the Monod form is more popular due to its simplicity. Focusing on phytoplankton, we illustrate the underlying logics behind these two forms via conceptual comparison, experimental data validation, transient, and asymptotic dynamics. The conceptual illustration provides the primary difference in their mechanisms via a paradox. Data validation is tested via field and laboratory experiments. The Droop and Monod forms have consistent asymptotic dynamics in the closed nutrient case, whereas the transient dynamics are significantly different when the nutrient uptake rate is small.