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4 Unimodal size scaling of phytoplankton growth and the size dependence of nutrient uptake and use.

Marañón E, Cermeño P, López-Sandoval DC, Rodríguez-Ramos T, Sobrino C, Huete-Ortega M, Blanco JM, Rodríguez J:

Ecol Lett. 2013 Mar; 16(3):371-9

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New Finding, Refutation

DOI: 10.3410/f.717968461.793468145

This remarkably thorough study compares the growth kinetics of 22 marine phytoplankton species, showing that maximum growth is a unimodal function of cell size, and that larger species may actually be better nutrient competitors, contrary to simple geometric expectations. A number of macro-ecological correlations between growth, size, nutrient use and acquisition have been made based on compilations of literature data. These meta-analyses have estimated allometric scaling of various populations and physiological rates, and contrasted different environments and phylogenetic groups. While meta-analyses reveal a number of patterns indicating functional trade-offs or associations among taxa, the differences in experimental protocol among studies always raise the question of how many unseen sources of variation influence the results. Marañon alleviate this concern by collecting a meta-analysis worth of their own data on growth, size, and nutrient uptake in 22 marine phytoplankton species spanning the full range of cell sizes.

The comparison leads to two remarkable conclusions. The first is that, rather than showing a constant allometric scaling relationship, maximum population growth peaks around cell volumes of 10^2 µm^3 and declines sharply as cells become either larger or smaller. The two sides of this relationship imply different constrains on resources acquisition, assimilation and growth. For instance, small cells are more nitrogen rich (lower C:N); thus, while they have a greater relative cell membrane area for surface proteins to acquire nutrients, their demands for nutrients are also greater. The largest cells also have higher ratios of respiration to photosynthesis, which may explain the decline in growth at the upper end of the volume spectrum. This paper is an excellent argument for the need for large comparative studies using consistent methodologies.

Disclosures
None declared

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27 Sep 2013 **Recommended**

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Good for Teaching, Interesting Hypothesis, New Finding

DOI: 10.3410/f.717968461.793484261

A common theme running through phytoplankton ecology (and ecology in general) is the differences in physiology conferred by the size of the individuals. The metabolic theory of ecology is one avenue toward explaining how size affects physiology and growth. It derives from empirical observation, and its parameters, such as the '3/4-power rule', purport to explain, in a very general way, how size regulates metabolism. As the authors of this article point out, phytoplankton, or unicellular organisms in general, may not accord with metabolic theory. Plus, within unicellular organisms, the size range we have to consider is analogous to the size difference from a salmon to a largish island, that is, much broader than multicellular life. The authors report extensive and comprehensive laboratory results that show that, instead of an increase with size, the maximum growth rate increases to a maximum, and then declines; this is what Marañón et al. call unimodal.

The explanation seems to be that very small cells don't have the storage capacity to match their ability to take up nutrients. Very large cells, on the other hand, are limited by their ability for intracellular transfers from converting nutrients to biomass. Cells in the middle of the size range have the capacity to take up nutrients, and also convert them to biomass more efficiently. And this may be why, the authors state, that it is in this size range that we find the phytoplankton that create blooms, the 'bloom-formers'.

This contribution puts the study of phytoplankton community structure on a new trajectory, and takes us beyond the venerable 'Margalef mandala' {1}.

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Margalef R. Oceanolog Acta 1978; 1(4):493-509 PDF

Disclosures
None declared

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Abstract:

Phytoplankton size structure is key for the ecology and biogeochemistry of pelagic ecosystems, but the relationship between cell size and maximum growth rate (μ(max)) is not yet well understood. We used cultures of 22 species of marine phytoplankton from five phyla, ranging from 0.1 to 10(6) μm(3) in cell volume (V(cell)), to determine experimentally the size dependence of growth, metabolic rate, elemental stoichiometry and nutrient uptake. We show that both μ(max) and carbon-specific photosynthesis peak at intermediate cell sizes. Maximum nitrogen uptake rate (V(maxN)) scales isometrically with V(cell) , whereas nitrogen minimum quota scales as V(cell) (0.84) . Large cells thus possess high ability to take up nitrogen, relative to their requirements, and large storage capacity, but their growth is limited by the conversion of nutrients into biomass. Small species show similar volume-specific V(maxN) compared to their larger counterparts, but have higher nitrogen requirements. We suggest that the unimodal size scaling of phytoplankton growth arises from taxon-independent, size-related constraints in nutrient uptake, requirement and assimilation.

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DOI: 10.1111/ele.12052

PMID: 23279624

Abstract courtesy of PubMed: A service of the National Library of Medicine and the National Institutes of Health.

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