IS SIZE A "MASTER TRAIT" PREDICTING PHYTOPLANKTON RESPONSES TO GROWTH AND LOSS FACTORS?

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Abstract

Trait based approaches are recently being developed to investigate if they can be used as a new tool to forecast the ecosystem response to the constantly changing by anthropogenic stressors environment and the biodiversity losses. In this content, we review literature data and present experimental findings on the influence of phytoplankton colony/cell size on phytoplankton growth, sensitivity to nutrient limitation, sinking losses and grazing sensitivity. From the reviewed literature and the experimental findings, it is clearly shown that cell size is extremely important for nutrient utilization, and at the same time it can be a driving factor for sinking losses and vulnerability to grazing.

Keywords: Phytoplankton, Mediterranean Sea, Growth, Nutrients

In the "Metabolic Theory of Ecology" (1) body size is considered to be a "Master Trait" (2) providing the basis for predicting the performance of species and large scale patterns in ecosystems. Spanning 4 to 5 orders of magnitude in linear dimensions of cell- or colony size, phytoplankton are an ideal model system to test to feasibility of size as a non-taxonomic predictor of the environmental abilities and requirements of organisms.

Maximal growth rates (μ_{max}) of phytoplankton were found in many studies to decline with cell volume (V), however the exponent b of the relationship $\mu max = aV^b$ has usually been found less negative than the universal -0.25 scaling coefficient thought to be a general rule for the relationship size – specific metabolic rates (1). Recently, even claims for a unimodal relationship with a peak of μmax at ca. 100 μm^3 have been made (3). Small cells are better at uptake of nutrients at low concentrations, but under pulses of elevated concentrations large phytoplankton can build up bigger storage pools for subsequent reproduction under reduced uptake (4). In Fig. 1 collected data from various sources in the literature show this relationship between maximal growth rates and cell sizes.

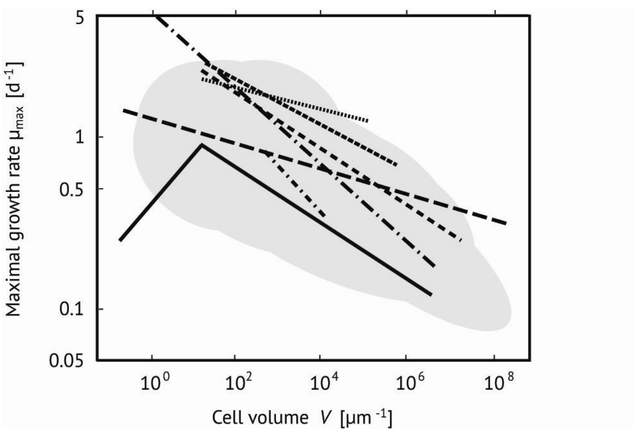

Fig. 1. Relationship between maximal growth rates and cell sizes of phytoplankton taken from various sources in the literature, measured at or recalculated for 20°C. Grey cloud: range of data assembled by Finkel et al. 2010, regression lines: square dots: Banse 1982, diatoms; dash-dot: Banse 1982, dinoflagellates; round dots: Sommer 1989; dash: Tang 1995; long dash: Finkel et al. 2010; long dash-dot: Edwards et al. 2012; black: Marañon et al. 2013

Larger phytoplankton have a bigger scope to exploit vertical nutrient and light gradients, be it by flagellar swimming (5) or by shifts between negative and positive buoyancy (6). When heavier than water, sinking velocity is proportional to the square of the diameter and the density difference between the water and the phytoplankton cell/colony. Under low turbulence, this becomes a selective disadvantage for immotile large algae, in particular for those large diatoms which cannot become lighter by ionic regulation.

Generally, larger herbivores prefer larger phytoplankton prey, however there are some exceptions, like heterotrophic protists feeding on phytoplankton of almost equal length or large pelagic tunicates filtering even the smallest picoplankton (7). Copepods feed on medium sized to moderately large phytoplankton (5 to 100 µm) conferring a selective advantage for smaller phytoplankton by simultaneously feeding on the protistan predators (8). In Fig. 2 the effect of grazing by the copepod *Acartia tonsa* on a phytoplankton community indicates the effect of extensive grazing on the size of the phytoplankton community, by suppressing an entire size class from the phytoplankton community.

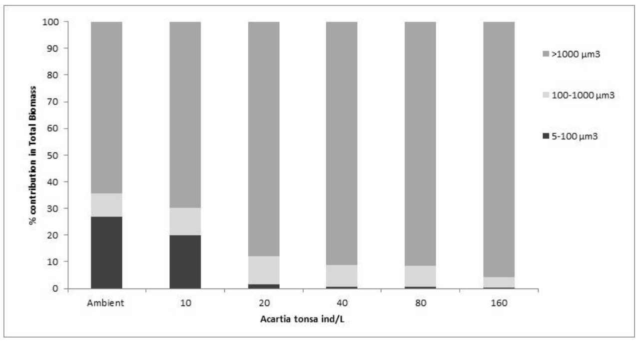

Fig. 2. *Acartia tonsa* (copepod) impact on phytoplankton size structure contribution to total biomass after 7 days of grazing. Plot of particle volume size classes: Black, 5-100µm3; Light grey, 100-1000 µm3, Dark grey, >1000 µm3

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