Introduction

Body size is fundamental in studying the structure and function of all living organisms. Body size affects individuals, populations and even ecosystems. It impacts an individual's growth rate and rate of reproduction, a population's growth rate, and an ecosystem's flux. Body size impacts these traits because it influences an organism's metabolic rate and the rate of transformation of organic molecules to other products. Metabolic rate varies with surface area to volume ratio and hence is affected by size. This study focuses on how cell size affects growth rate of phytoplankton and compares the allometric relationship of prokaryotic phytoplankton(cyanobacteria) to that of eukaryotic phytoplankton

Methods

Cell volume for 216 species of Phytoplankton was collected from several sources and merged with the Global biotraits database. Cell volume was collected from a minimum of two sources for each specie and then averaged to get an approximate value for cell size. Phytoplankton were grouped on the basis of phylum and class and a plot between population growth rate and average cell volume for each phyla and class was created.The two parameters cell volume and population growth rate were then plotted on a logarithmic scale to fit a linear model and to estimate the slope. Eventually, a comparison based on the estimated parameters was made between cyanobacterial phytoplankton and non cyanobacterial phytoplankton.

Results

The plot between growth rate and cell volume suggests that growth rate scales linearly with cell volume for phytoplankton on a logarithmic scale. The slope suggests that growth rate is inversely proportional to cell volume. For the prokaryotic phytoplankton Cyanophyceae the slope is -0.043. Average slope for eukaryotic phytoplankton is -0.158. *Table 1* in supplementary material gives an estimate of the slopes of all the classes of phytoplankton. The results suggest that for Cyanophyceae the slope is less steep than the non cyanobacterial phytoplankton indicating that the growth rate of the cyanobacterial phytoplankton(prokaryotic) decreases with cell volume at a lower rate than that of the non cyanobacterial phytoplankton(eukaryotic). However, the results do not show if the growth rate is influenced by some other parameters such as temperature.

Discussion

Previous studies conducted on metabolic scaling with Body mass suggested that prokaryotes show higher metabolic scaling than eukaryotes and protists because of absence of non coding genes. Therefore with increase in mass, number of genes increase too which code for more proteins and enzymes and thereby complexing the biochemical network(Delong,2010. Our study focuses on comparing change of growth rate with cell volume between prokaryotic and eukaryotic phytoplankton.The graphs show that growth rate decreases with increasing cell volume. The possible correlation between growth rate and cell volume might be explained by the amount of DNA content in a cell and the length of S phase of cell cycle. Phytoplankton are asexual and during cell cycle there is an increase in the DNA content. This DNA content might set the volume of nucleus and hence the surface area of nuclear envelope is determined too. Quality of DNA determines the length of S phase, or the amount of time taken by DNA to double before cell division. Therefore, if there is a lot of DNA content, the length of S phase will increase, thereby reducing growth rate (Sharpe et.al. 2012)

Hence it can be concluded that growth rate for phytoplankton doesn't show a positive scaling with cell volume. The reason behind prokaryotic phytoplankton showing a lower decrease in cell volume might be because of quality of DNA and the length of S phase in prokaryotic phytoplankton may be shorter than eukaryotic phytoplankton.

Conclusion

The differences in growth rate between prokaryotic and eukaryotic phytoplankton could be due to other factors such as temperature, light, availability of resources and not just due to cell volume. Based on the raw data plots it could be hypothesised that prokaryotic phytoplankton (cyanobacteria) have a comparatively lower decrease in growth rate than eukaryotic phytoplankton (*merged class supplementary material*).The plots also show that a linear model is not the model of best fit for the data and a nonlinear model would fit the data better. Nonlinear model could also suggest if some other parameters such as temperature have an influence on growth rate. Fitting of a nonlinear model to the current data could therefore lead to further research into why prokaryotic phytoplankton show less decrease in growth rate with increasing cell volume than eukaryotic phytoplankton

Supplementary material


Table 1.xlsx

merged class.pdf

Bibliography-

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