# GROWTH RESPONSE OF CALCIFYING AND NON-CALCIFYING PHYTOPLANKTON TO CHANGES IN SEAWATER CARBONATE SPECIATION AND DIVALENT CATION CONCENTRATION

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## Phytoplankton, carbonate chemistry and Mg/Ca alterations over geological time

The seawater carbonate chemistry and the Mg/Ca ratio has changed considerably over the geological time scales(1) with highest Ca concentrations of approximately 30-40 mM during the Cretaceous (145 to 66Ma). High Ca concentrations can interfere with cellular physiology(2, 3) and phytoplankton must have developed strategies to cope with high external Ca concentrations as their intracellular Ca pool in the cytosol is kept at ~0.1µM. It is under scientific discussion whether phytoplankton functional groups have developed different strategies against Ca poisoning and if these processes are influenced by variations in seawater carbonate chemistry.

Calcifying species, such as coccolithophores, may have developed an efficient mechanism to alleviate cellular calcium poisoning by excreting Ca in form of calcite (coccoliths). This might have facilitated their success compared to non-calcifying species during the Cretaceous because high cytosol Ca concentrations may interfere with cellular Mg biochemistry resulting in reduced fitness(3,4).

In this study, we aim to investigate the growth rate of calcifying (*E. huxleyi* and *P. carterae*) and non-calcifying species (*I. galbana* and *D. salina*) under variations in seawater carbonate chemistry (pH, DIC, $pCO_2$), Ca and Mg concentrations relevant for the past 300 million years.

**MAIN QUESTIONS:**

**(1)** Is Ca-poisoning aggravated at low pH conditions in calcifying compared to non-calcifying phytoplankton?

**(2)** Is the intensity of Ca-poisoning influenced by seawater Mg concentrations?

## Methods

We used monocultures of *I. galbana*, *D. salina, E. huxleyi and P. carterae* under nutrient replete conditions. Cultures were maintained at 22° C, light intensity of 80-90 µmol quanta $m^{-2}$ $s^{-1}$ at 12:12 light:dark cycle. Cell numbers were measured with a Coulter Counter (Z2) to calculated the relative species specific growth rate. Carbonate chemistry was monitored based on dissolved inorganic carbon and total alkalinity analysis.

## Pilot results and observations

**Non-calcifying spp.**

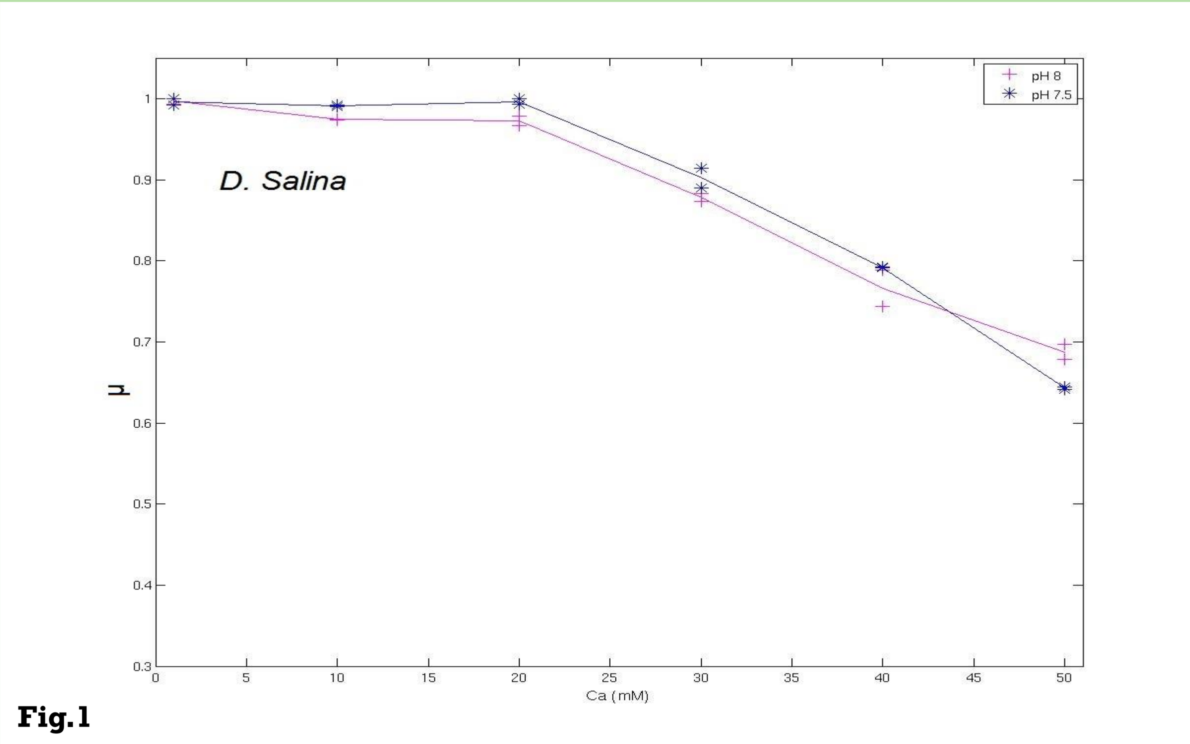
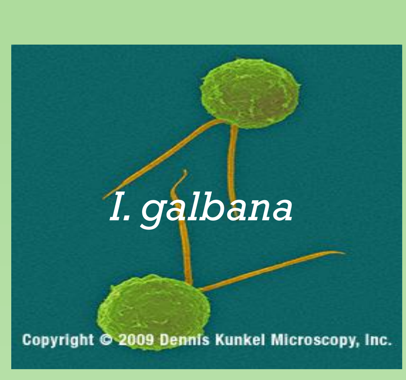



Fig.1

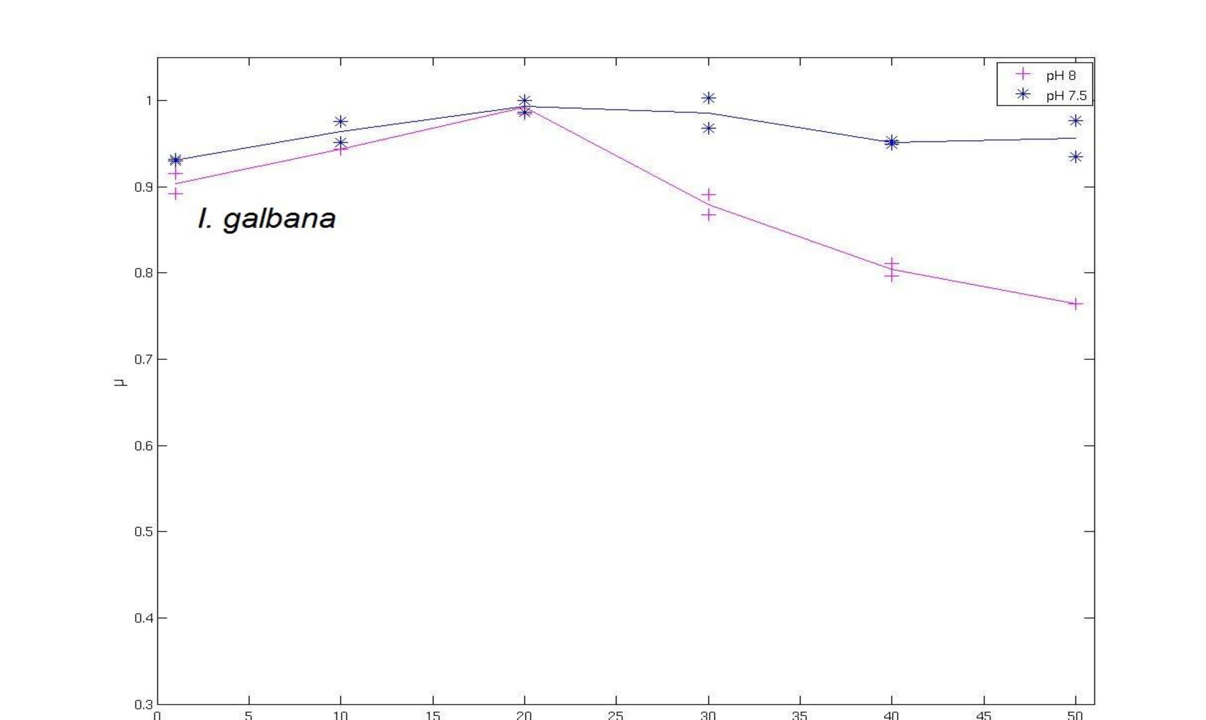
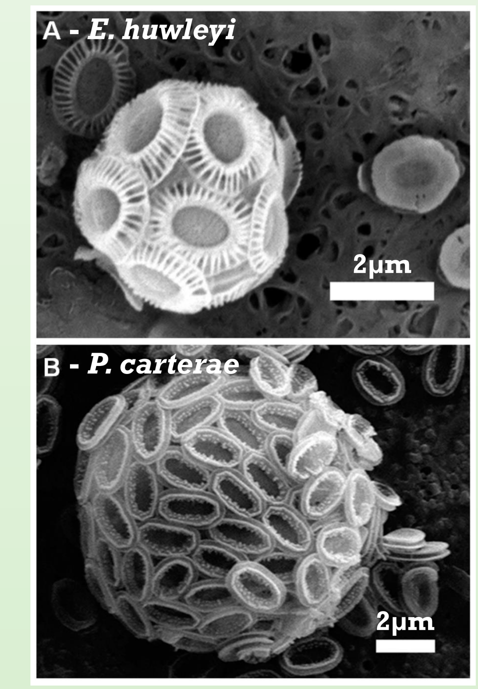




Fig. 2

**Fig. 1 & Fig. 2:** Relative growth rate response of *D. salina and I. galbana*, respectively, under two different pH conditions exposed to a Ca gradient from 1-50 mM.

**Calcifying spp.**



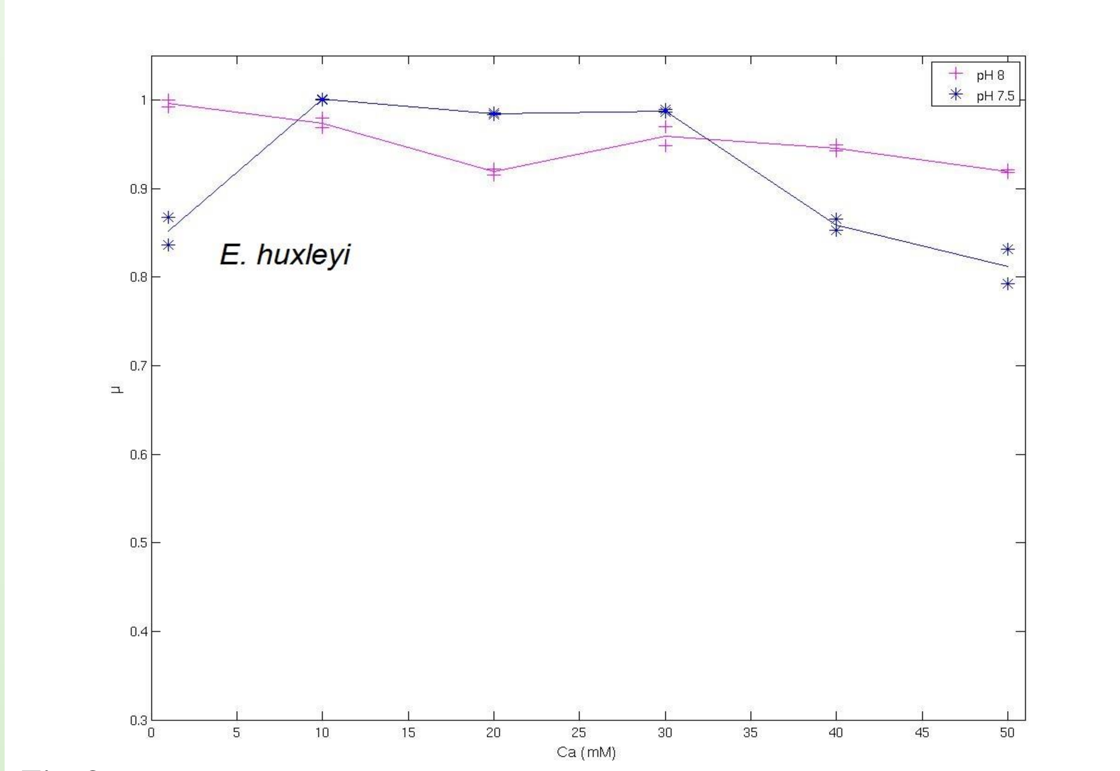




Fig. 3

**Fig. 3 & Fig. 4:** Relative growth rate response of *E. huxleyi* and *P. carterae*, respectively, under two different pH conditions exposed to a Ca gradient from 1-50 mM.

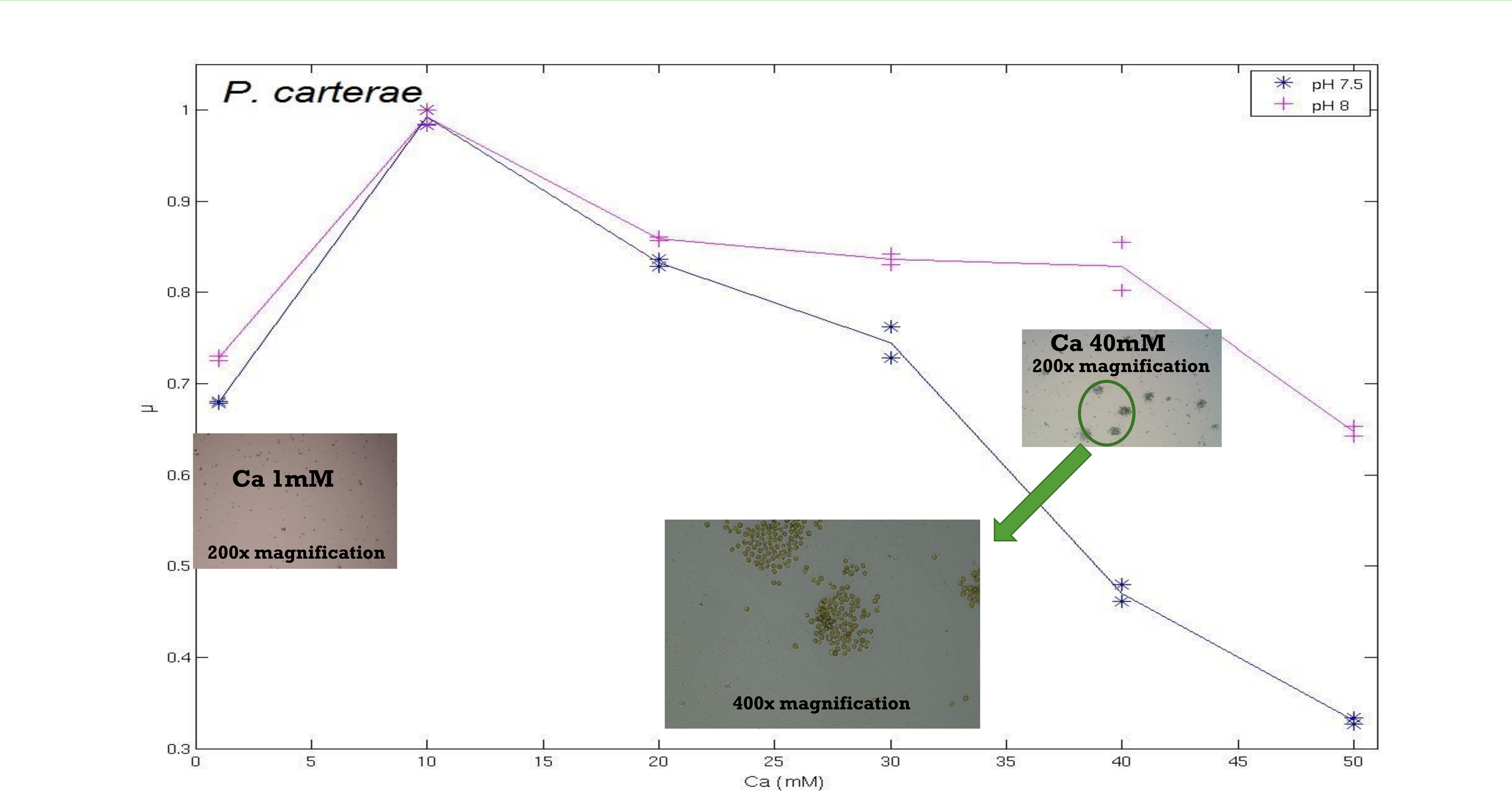



Fig. 4

- Effects of Ca poisoning was observed in all species;
- *D. salina* showed a similar response to Ca under low and high pH;
- The effect of Ca poisoning was mediated by low pH / high $CO_2$ in *I. galbana;*
- *E. huxleyi* indicated higher Ca poisoning effects under low pH;
- Growth response of *P. carterae* to Ca showed clear differences between low and high pH;
- *P. carterae* showed aggregation at elevated Ca concentrations;
- High seawater Ca concentrations (>30 mM) occasionally resulted in inorganic precipitations influencing SW carbonate speciation.

## Speculations, questions and future work

- *I. galbana* might be positively affected by low pH due to increased carbon availability – Implications for its response to anthropogenic OA?
- *D. salina* is very tolerant to high salinities, however it didn't seem to be tolerant to elevated Ca, why?
- Different response of *P. carterae* in comparison to *E. huxleyi* related to their different calcification strategies (external vs internal)?
- Aggregation of *P. carterae* might provide a microenvironment to control seawater chemistry at the cell surface (creating a low Ca environment through calcification);
- Aggregation of *P. carterae* presented a problem for counting cell numbers with a Coulter Counter;
- In the next experiments - Reduction of SW $SO_4^{2-}$ concentrations to avoid precipitation and using additional parameters for fitness assessment (e.g. Fv/Fm, chl-a).

### References

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Coccolithophore pictures were taken from Sun, S. et al.: Int. J. Mol. Sci., *15*, 23604-23615, 2014.

### Acknowledgements

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