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Climate crisis and foraminifera: what does the future hold

The ongoing climate crisis is anticipated to cause various detrimental effects on the oceans including warming, acidification, and deoxygenation, leading to a triple-stress situation for marine life. Foraminifera are calcium carbonate-secreting marine microorganisms and are expected to be significantly affected by these stressors. This study aims to evaluate Foraminifera's response to these stressors by conducting a culturing experiment.

In natural environments, foraminifera are affected by many entangled stressors, making it challenging to attribute their impacts on survival and calcification. Culturing experiments allow a deconvolution of the combined parameters controlling foraminiferal response. We harvested *Ammonia confertitesta* (T6) specimens from the Gullmar fjord (Sweden) and cultured them under warmer temperatures, low pH, and low oxygen concentrations (see figure). Duplicate aquariums were used, ensuring separate tanks of the same species with similar water parameters. Laser Ablation-ICP-MS analyses were conducted on the foraminifera's newly formed chambers to evaluate trace elements (TE) incorporation for Mg, Mn, Ba, and Sr.

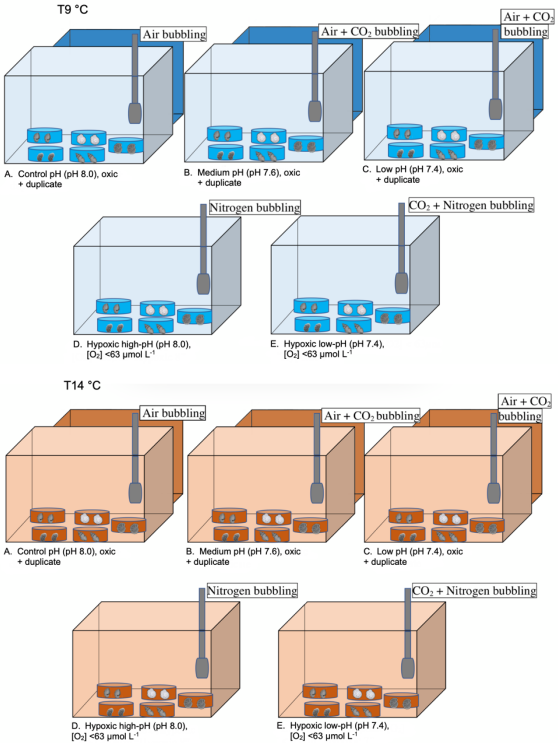

Figure 1: experimental set-up

This study proposes a viable experimental approach that yielded positive outcomes. Notably, *Ammonia confertitesta* (T6) demonstrated survival in nearly all tested conditions, except for the most extreme combination of stressors (warm temperatures, low pH, and low oxygen levels) suggesting that the species may have reached its tolerance threshold. However, there was a notable variation in foraminiferal response by a factor of two between conditions and their corresponding duplicates. This divergence implies the possibility of an internal foraminiferal response (physiological or metabolism) rather than being solely influenced by external environmental factors.

Low pH challenge?

Laser ablation analyses demonstrate consistency with previous studies, thus confirming the accuracy of the results. Each ratio serves as a well-established proxy for specific environmental factors such as water temperature (Mg/Ca), bottom-water oxygen concentration (Mn/Ca), nutrient availability (Ba/Ca), and ambient water chemistry (Sr/Ca). The results exhibited a variability in the ratios of foraminifera growing under low pH conditions and may suggest that foraminifera encounter challenges to calcify in equilibrium at low pH levels.

In a global context, this study demonstrates the vulnerability of a resilient species to the combination of stressors expected in future climate scenarios in terms of survival, calcification, and trace element incorporation. These findings further stress the need for effective environmental management strategies.

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