Meta-analysis suggests variable, but pCO$_2$-specific, effects of ocean acidification on crustacean biomaterials

Kyle Siegel[1], Muskan Kaur[1], A. Calvin Grigal[1], Rebecca Metzler[2], and Gary Dickinson[1]

[1]The College of New Jersey
[2]Colgate University

February 1, 2022

Abstract

Crustaceans comprise an ecologically and morphologically diverse taxonomic group. They are typically considered resilient to many environmental perturbations found in marine and coastal environments, due to effective physiological regulation of ions and hemolymph pH, and a robust exoskeleton. Ocean acidification can affect the ability of marine calcifying organisms to build and maintain mineralized tissue and poses a threat for all marine calcifying taxa. Currently, there is no consensus on how ocean acidification will alter the ecologically-relevant exoskeletal properties of crustaceans. Here, we present a systematic review and meta-analysis on the effects of ocean acidification on the crustacean exoskeleton, assessing both exoskeletal ion content (calcium and magnesium) and functional properties (biomechanical resistance and cuticle thickness). Our results suggest that the effect of ocean acidification on crustacean exoskeletal properties varies based upon seawater pCO$_2$ and species identity, with significant levels of heterogeneity for all analyses. Calcium and magnesium content were significantly lower in animals held at pCO$_2$ levels of 1500-1999 µatm as compared to those under ambient pCO$_2$. At lower pCO$_2$ levels, however, statistically significant relationships between changes in calcium and magnesium content within the same experiment were observed: a negative relationship between calcium and magnesium content at pCO$_2$ of 500-999 µatm and a positive relationship at 1000-1499 µatm. Exoskeleton biomechanics, such as resistance to deformation (microhardness) and shell strength, also significantly decreased under pCO$_2$ regimes of 500-999 µatm and 1500-1999 µatm, indicating functional exoskeletal change coincident with decreases in calcification. Overall, these results suggest that the crustacean exoskeleton can be susceptible to ocean acidification at the biomechanical level, potentially predicated on changes in ion content, when exposed to high influxes of CO$_2$. Future studies will need to accommodate the high variability of crustacean responses to ocean acidification, as well as ecologically-relevant ranges of pCO$_2$ conditions, when designing experiments with conservation-level endpoints.

Hosted file

`Siegel_et_al_draft_28Jan2022.docx` available at https://authorea.com/users/458315/articles/554893-meta-analysis-suggests-variable-but-pco2-specific-effects-of-ocean-acidification-on-crustacean-biomaterials