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Transgenerational acclimation to seawater acidification in the Manila clam *Ruditapes philippinarum*: Preferential uptake of metabolic carbon

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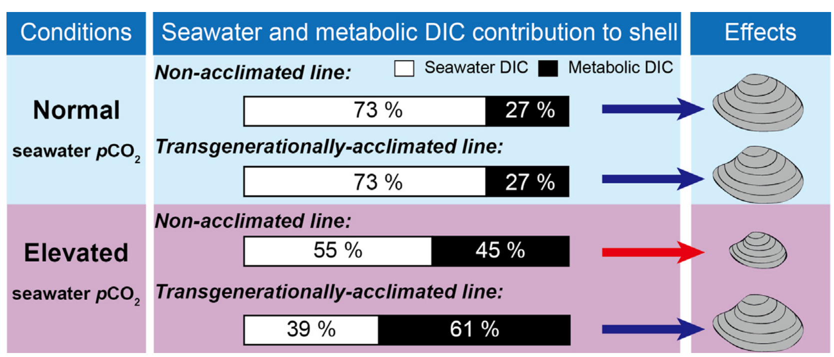
HIGHLIGHTS

- Rapid transgenerational acclimation can persist into adulthood.
- Stable carbon isotope analysis deciphers carbon sources of the shell.
- Transgenerational exposure elicits a large metabolic carbon contribution to shell carbonate.

GRAPHICAL ABSTRACT



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ABSTRACT

Ocean acidification may interfere with the calcifying physiology of marine bivalves. Therefore, understanding their capacity for acclimation and adaption to low pH over multiple generations is crucial to make predictions about the fate of this economically and ecologically important fauna in an acidifying ocean. Transgenerational exposure to an acidification scenario projected by the end of the century (i.e., pH 7.7) has been shown to confer resilience to juvenile offspring of the Manila clam, *Ruditapes philippinarum*. However, whether, and to what extent, this resilience can persist into adulthood are unknown and the mechanisms driving transgenerational acclimation remain poorly understood. The present study takes observations of Manila clam juveniles further into the adult stage and observes similar transgenerational responses. Under acidified conditions, clams originating from parents reproductively exposed to the same level of low pH show a significantly faster shell growth rate, a higher condition index and a lower standard metabolic rate than those without prior history of transgenerational acclimation. Further analyses of stable carbon isotopic signatures in dissolved inorganic carbon of seawater, individual soft tissues and shells reveal that up to 61% of shell carbonate comes from metabolic carbon, suggesting that transgenerationally acclimated clams may preferentially extract internal metabolic carbon rather than transport external seawater inorganic carbon to build shells, the latter known to be energetically expensive. While a large metabolic carbon contribution (45%) is seen in non-acclimated clams, a significant reduction in the rate of shell growth indicates it might occur at the expense of other calcification-relevant processes. It therefore seems plausible that, following transgenerational acclimation, *R. philippinarum* can implement a less costly and more

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efficient energy-utilizing strategy to mitigate the impact of seawater acidification. Collectively, our findings indicate that marine bivalves are more resilient to ocean acidification projected for the end of the century than previously thought.

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