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Sodium provides unique insights into transgenerational effects of ocean acidification on bivalve shell formation

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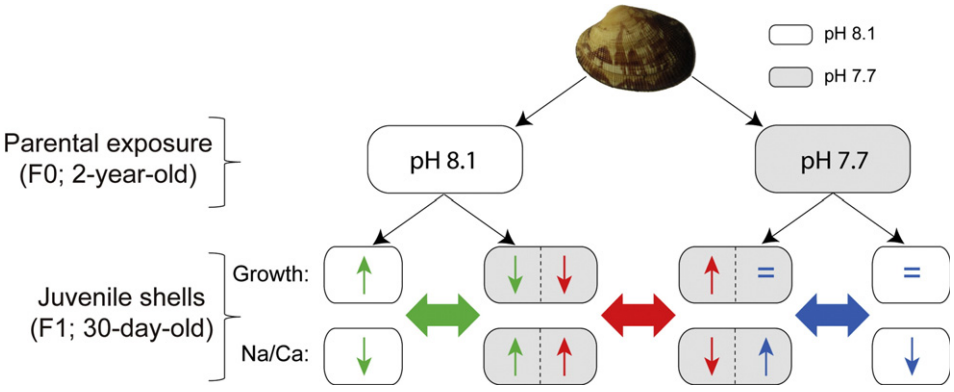
HIGHLIGHTS

- Transgenerational effects alleviate the impacts of high CO_2 on bivalve shell formation.
- At pH 7.7, Na/Ca_{shell} decreases significantly following transgenerational exposure.
- Na/Ca_{shell} sheds new light on the mechanisms for such acclimation.

GRAPHICAL ABSTRACT



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ABSTRACT

Ocean acidification is likely to have profound impacts on marine bivalves, especially on their early life stages. Therefore, it is imperative to know whether and to what extent bivalves will be able to acclimate or adapt to an acidifying ocean over multiple generations. Here, we show that reduced seawater pH projected for the end of this century (i.e., pH 7.7) led to a significant decrease of shell production of newly settled juvenile Manila clams, *Ruditapes philippinarum*. However, juveniles from parents exposed to low pH grew significantly faster than those from parents grown at ambient pH, exhibiting a rapid transgenerational acclimation to an acidic environment. The sodium composition of the shells may shed new light on the mechanisms responsible for beneficial transgenerational acclimation. Irrespective of parental exposure, the amount of Na incorporated into shells increased with decreasing pH, implying active removal of excessive protons through the Na^+/H^+ exchanger which is known to depend on the Na^+ gradient actively built up by the Na^+/K^+-ATPase as a driving force. However, the shells with a prior history of transgenerational exposure to low pH recorded significantly lower amounts of Na than those with no history of acidic exposure. It therefore seems very likely that the clams may implement less costly and more ATP-efficient ion regulatory mechanisms to maintain pH homeostasis in the calcifying fluid following transgenerational acclimation. Our results suggest that marine bivalves may have a greater capacity to acclimate or adapt to ocean acidification by the end of this century than currently understood.

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