Snails on acid: Effects of ocean acidification and fear on gastropod shell defenses

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Ocean acidification (OA), caused by CO_2 emissions, has negative consequences for many organisms, yet it is unclear how biotic interactions may be affected by OA. For example, calcified skeletons provide protection from shell-crushing predators, yet OA hampers calcification. Here we test the effects of both OA and predation cues on shell growth and strength in two common northeastern Pacific intertidal snails. *Tegula funebralis* (the black turban snail) and *Nucella ostrina* (the striped dogwhelk) live in the same habitat and are consumed by the same predators, including crabs, yet have different trophic roles, and distinct shell compositions. We grew 160 specimens of each gastropod species for 185 days under one of 4 water treatments: 1) ambient pH, no predator cue; 2) ambient pH, cue present; 3) low pH, no predator cue; 4) low pH, cue present. Shell growth and strength were measured as a proxy for vulnerability to crab predation. *T. funebralis* shell growth was greatly affected by both OA and predation, with controls growing 786% more than low pH and predator cue snails ($p < 0.0001$). Shell strength of low pH *T. funebralis* was also 50% less than controls ($p < 0.0001$). In contrast, shell growth of *N. ostrina* was only affected by cue, with non-cue treatments growing 150% more ($p < 0.0001$). However, shell strength of *N. ostrina* was 9% weaker under low pH conditions ($p = 0.0175$), indicating OA may compromise shells, even if growth appears unaffected. Our results suggest that OA will negatively affect predator-prey relationships by decreasing shell growth and/or strength. These results will be used to interpret how fossil ancestors of both gastropods have been affected by human-induced, and deep time OA events. Such multidisciplinary studies provide immediate value for conservation efforts, and promote the usefulness of the fossil record to conservationists.