MARINE BIOLOGY

No head start

Non-genetic transgenerational acclimation cannot always be relied upon to provide populations with an effective, short-term response to climatic changes.

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In some species, parents are always right. In the past few years, we have learned that parents can predict the environment the offspring will experience and get them ready for it — a biological head start of sorts. As the climate changes rapidly, some ecologists have suggested that this acclimation may help species along. On the contrary, in this issue of *Nature Climate Change* Welch and colleagues[1] show that under high CO_2 conditions a tropical damselfish cannot help their offspring's predation-avoidance behaviour. For them, it will have to be adaptation or bust.

Transgenerational acclimation occurs when the environment of the parents helps shape how offspring look and behave. Importantly, these responses are not a result of genetic changes, so they can be rapid and effective. *Daphnia* parents in an environment full of predators can produce offspring that grow a better defensive helmet when compared with those from a more peaceful environment[2]. Desiccation resistance in dog ticks is tied to the maternal humidity environment, as mothers can provide the offspring with reliable information about the likely state of the environment they will encounter[3].

Many more examples like these exist. In fact, evidence is now rapidly accumulating on transgenerational acclimation in a wide range of traits, including metabolic (growth, aerobic scope), morphological (vertebral number, presence of wings), phenological (flowering time), and life history (age at maturation, fecundity, survival)[4]. And the environments in which offspring traits are found to be partially manipulated by the parents are quite varied as well: temperature, CO_2/acidification, drought, food availability, predation, and so on.

Given this growing body of evidence, some[4,5] have raised the possibility that transgenerational acclimation may provide an effective, response to climatic changes in the short term for some organisms. As Welch and colleagues[1] found, however, this may not always be the case.

Spiny damselfish, *Acanthochromis polyacanthus*, are able to smell chemical alarm cues (CAC) in the water when conspecifics are attacked, an adaptive behaviour particularly important in juveniles. Unfortunately for them, high levels of dissolved CO_2 (such as those predicted to occur in the near future) can interfere with this behaviour. So Welch *et al.*[1] tested whether parents could transgenerationally transfer resistance to the negative impact of CO_2 on CAC response. They also tested another behaviour related to cognitive function — lateralization (fish that favour one side of their bodies more tend to have higher cognitive abilities and avoid predators more effectively, evaluated in a maze by allowing fish to turn in one direction or the other).

The experimental set-up was straightforward: breeding pairs were maintained for an entire breeding season in waters reflecting either current, moderate, or high CO_2 concentrations (as projected for the end of this century). The offspring were then transferred to each of the same three treatments, grown for 40–45 days, and then tested for both CAC response and lateralization.

Juvenile spiny damselfish from control parents raised in control CO_2 waters (essentially, today's fish) strongly avoided CAC, while damselfish reared in mid and high CO_2 conditions lost this innate avoidance (and some were even attracted to them). Exposing parents to increased CO_2 did not lead to any tolerance in the offspring either. In fact, the opposite was true: exposing parents to CO_2 actually led to offspring spending more time near the alarm cue when grown in control waters. Lateralization did not fare much better. No parental exposure led to offspring behaving like control fish, although juveniles from parents kept under high CO_2 conditions were slightly less affected by increased CO_2 than ones from control parents. The authors speculate that altered ion gradients across gamma-aminobutyric acid (GABA) neurotransmitter receptors, due to acid–base regulation by this fish in a high CO_2 environment, may cause the behavioural and sensory problems.

Interestingly, other coral reef fishes, when exposed to increased CO_2, can produce offspring with metabolic rates similar to those of normal juveniles[6] (and this is not limited to tropical fishes;

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Spiny chromis (*Acanthochromis polyacanthus*) adult, swimming in the Lembeh Straits off Sulawesi, Indonesia.

temperate silversides can increase their offspring's survival if they are exposed to increased CO_2)[7]. So why would the underlying physiological mechanism of CAC avoidance be less flexible than metabolic traits, both within and across generations? That question remains unanswered, although it is worth noting that behaviours in other species do show transgenerational plasticity[8]. Regardless, these results indicate that behavioural responses like CAC avoidance in spiny damselfish will not be mitigated by transgenerational acclimation as the oceans continue to become more acidic. Other processes — such as adaptation, which involves genetic changes — will be necessary.

Just a few years ago, ecologists and evolutionary biologists were urged to start paying attention to transgenerational acclimation. It is a welcome sight that studies such as those of Welch *et al.*, demonstrating the lack of acclimation, are regarded as important — transgenerational plasticity has arrived! Where do we go from here? Of course, the directions will be as varied as those turns taken by the spiny damselfish. How important is the cue? Are the mechanism questions really critical? How do within- and across-generation plasticity interact? Are the long-term evolutionary questions really important? What are the ecological implications of transgenerational acclimation?

The work by Welch and colleagues[1] highlights the need for holistic approaches to predicting the effects of climate change on populations. We simply cannot rely on our preferred trait (growth, age at maturation, thorax length, foraging behaviour) or our preferred mechanism (phenotypic plasticity, transgenerational acclimation/plasticity, adaptation, migration) to tell us the whole story. ❐

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