Effects of Ocean Acidification on Locomotion and Foraging in Molluscs

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Leung J, Russell B, Connell S, Ng J, Lo M. 2015. Acid dulls the senses: impaired locomotion and foraging performance in a marine mollusk. Animal Behaviour 106: 223-229.

Understanding how organisms respond to changing pH levels in the ocean is important for determining the role that pH plays in an organism's ability to survive. Specifically in coastal regions, estuarine organisms must be capable of adapting to rapid reductions in pH over short periods of time. These fluctuations result from a combination of environmental, and human factors (such as acidic soil runoff from industrial factories into coastal regions). These rapid fluctuations in pH levels can cause disruptions, especially in many estuarine invertebrates' behavior and ability to find food via chemoreception. Previous studies have found that many estuarine organisms use chemoreception for a wide variety of purposes that are fundamental to their survival, such as locating distant food sources, feeding, and escaping from predators (Croll, 1983). Thus if chemoreception is disturbed by sudden drops in pH, many estuarine invertebrates' fitness to survive is compromised.

Leung et al. (2015) investigated the effects of rapid acidification on the locomotion and foraging success in a savaging marine mollusk, *Nassarius festivus*, which relies on chemoreception to locate food. Typically these molluscs burrow in the sand until they receive chemical cues that indicate the presence of carrion, its food source; once detecting these cues, it quickly emerges and navigates towards the carrion using chemoreception. Because *N. festivus* is dominant in sandy shore habitats and is consistently exposed to rapid pH fluctuations, the researchers wanted to examine whether or not *N. festivus* was adapted to tolerate pH fluctuations as well as its ability to recover from acidification effects. Specifically, they investigated whether a decrease in pH would decrease locomotion activity as well as travel speed and foraging success (i.e. locating the food source).

Adult *N. festivus* were collected from sandy shores, specifically from an area in Lok Wo Sha that had been impacted by runoff from a nearby construction site. After allowing the gastropods to acclimate to their tanks for 2 weeks under conditions most similar to their natural environment (pH: 8.03 ± 0.03), the molluscs were then starved for 1 week before the trail to standardize hunger levels. Two pH levels were used that fell within the normal levels for *N. festivus* (pH 8.0 and 7.5) and one pH that was much lower than normal levels (pH 7.0). To examine locomotary activity, five individuals were randomly selected for each pH condition and exposed to that condition for 1 hour. Locomotory activity for each individual was then classified as moving, resting, burrowing, or retracted (meaning that all body parts were pulled into the shell). To examine how travel speed and foraging success (and thus chemosensory function) were affected by acidification, three types of tanks were used for each pH that had food located

2.5 cm (control distance), 10 cm and 15 cm away from the center. The number of individuals engaged in feeding (and thus had foraging success) as well as the time it took each individual to reach its prospective food source was recorded. The researchers also investigated recovery ability by allowing the individuals to rest in normal water conditions for 48 hours before retested in the same conditions.

Based on their results, Leung et al. concluded that lower pH levels significantly change the behavioral patterns in *N. festivus* as compared to normal pH levels. While in pH levels of 8.0 and 7.5 more than 60% of individuals were either moving or resting, in the low pH environment (pH 7.0), about 70% of individuals were retracted into their shells, a sign of inactivity and avoidance behavior seen in molluscs. Travel speed and foraging success was significantly reduced in pH 7.0 as compared to normal pH levels when the food source was 10-15 cm away, but not when 2.5 cm away (Fig. 1). However, after the allotted recovery period, travel speed and foraging success increased significantly so that it was similar to pH 8.0 ad 7.5 (Fig. 1).

These results suggest that when exposed to low pH levels, *N. festivus* utilize avoidance behavior in response by retracting into their shells to avoid damage. Additionally, these results suggest that ability to find food is also compromised; thus, Leung et al. were able to demonstrate that chemoreception in these molluscs was inhibited as made evident in a lack of ability to locate food in low pH conditions. Further implications of these results suggest that *N. festivus* would be more likely to starve in acidified conditions if its food source was located further away, as indicated by a significantly lower foraging success in molluscs whose food source was 10 cm or more away. However, *N. festivus* exhibited an ability to recover from exposure to acidic conditions, which suggests that pH can act as a selection pressure in organisms living in estuarine environments. Those organisms that are able to recover from brief but rapid acidification are more likely to find food, survive, and reproduce.

This study manifests that if ocean acidification continues, these rapid decreases in pH might become increasingly longer, which in turn will increase the risk of starvation in organisms that rely on chemoreception to locate food. This could easily lead a large amount of die off in species due to inability to locate and reach food sources. Yet, the recovery ability in *N. festivus* is a positive sign, so further research might involve looking at whether this recovery ability can remain intact with longer exposure to low pH levels. Recovery at longer exposure could indicate the ability of these organisms to adapt to the increasing acidification of oceans. Determining how much prolonged acidification these types of organisms can tolerate would therefore be an important new direction to pursue.

Other Literature Cited

Croll, P. 1983. Gastropod Chemoreception. *Biological Reviews* 58: 293-319.

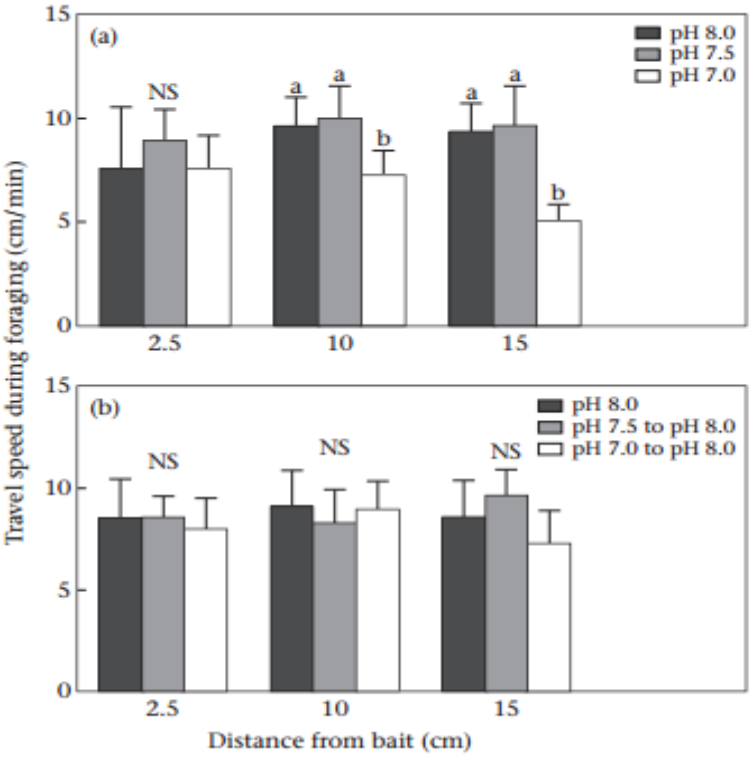

Figure 1. Percent of foraging success (mean + SD) in *N. festivus* after 1 hour exposure (a) and after a 48 hour recovery period (b). These results suggest that foraging success from farther distances is significantly lower in lower pH levels. However, if given time to recover, there is no significant difference (NS= not significant data).