Mutual benefits of inducible defenses to crab predators in the blue mussel *Mytilus edulis* in a multi-predator environment

Sophie Walton '21

The blue mussel, *Mytilus edulis*, is a foundational species native to Maine's Rocky Intertidal ecosystem, meaning their presence or absence disproportionally impacts the ecosystem.[1] Blue mussels create substrate for other organisms to live on and provide an important source of food for many predators. Unfortunately, *M. edulis* populations have declined by sixty percent since the 1970s.[1] The green crab, *Carcinus maenas*, is an invasive crab species from the Atlantic coasts of Europe that now preys on blue mssels.[2] Thus, it is important to understand the ways in which an invasive species is impacting the critical and declining blue mussel population. In areas of high green crab abundance, blue mussels thicken their shells, a response known as an inducible defense.[3] Crabs must use greater crushing force or increased handling time to penetrate thicker shells, making these mussels less enticing prey.[4] But this defense comes at an energetic cost to the mussels, taking energy away from some form of growth or reproduction.[5] To understand these energy tradeoffs, I conducted a study on the shell thickness and adductor muscle size of blue mussels from sites with high or low green crab presence. Adductor muscles are used to hold the shells of bivalves like the blue mussel together; it is important for preventing predation from organisms like sea stars, that access mussel tissues by pulling the shells apart (while green crabs break open the shell, making the shell thickness more important in preventing crab predation).

To conduct this study, I collected mussels from 2 sites with a high crab population and 2 sites with a low crab population. At each site, I conducted field surveys to assess the ecological make up. At low tide, 1 meter above the water line, I laid down a tape measure to 100 meters. Then every 10 meters I used a quadrat—a 1 meter by 1 meter square—to measure the mussel, crab, sea star, and algae populations within the quadrat. I used these surveys to make sure the sites fit my requirements of high and low green crab predation in particular. I then collected ~25 mussels from each site. 10 mussels from each site were dissected to determine their shell thickness and the size of their adductor muscles. 10 muscles were used in sea star eating trials, where I measured the amount of time it took for *Asterias forbesi* sea stars to eat mussels from each site—this gave me information about the strength of adductor muscles in mussels from sites with differing crab populations. I found that mussels from sites with a high crab population had thicker shells, bigger adductor muscles, and sea stars took longer to eat mussels from high crab sites. This contradicts previous research that found adductor muscle size only changes in the presence of sea stars, and indicates that the prevalence of green crabs in intertidal habitats is causing blue mussels to put more energy into inducible defenses than ever before. On the other hand, the energy for these defenses still has to be coming from somewhere: reproduction now looks like a very likely candidate. In a struggling population, lessening energy allocation to reproduction is important to consider.

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