Mussels Evolve Quickly To Defend Against Invasive Crabs

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August 10, 2006

DURHAM, N.H. -- Scientists at the University of New Hampshire (UNH) have found that invasive crab species may precipitate evolutionary change in blue mussels in as little as 15 years. The study, by UNH graduate student Aaren Freeman with associate professor of zoology James Byers and published in the Aug. 11 issue of the journal Science, indicates that such a response can evolve in an evolutionary nanosecond compared to the thousands of years previously assumed. The paper is called "Divergent induced responses to an invasive predator in marine mussel populations."

"It's the blending of ecological and evolutionary time," says Freeman, a Ph.D. candidate in the department of zoology. "It's an important development in the arms race between these crabs and these mollusks." Crabs prey on blue mussels by crushing their shells.

Freeman looked at the inducible defense – shell thickening – of blue mussels (Mytlius edulis) in the presence of two invasive crab species in New England, the Asian shore crab Hemigrapsus sanguineus and the green crab Carcinus maenas. While Carcinus was introduced to New England from Europe between 150 and 200 years ago, Hemigrapsus is a relative newcomer, arriving from Asia to New Jersey in 1988. While previous research had established that mussels recognize Carcinus, it had not be determined if they recognize Hemigrapsus. And, crucial to the design of Freeman's study, Hemigrapsus is not present north of mid-coast Maine.

"This set up a chance to look at populations that had been exposed to the predators for varying lengths of time," says Freeman. "We wanted to know, how is it that these mollusks can recognize a crab that is historically not present in North America?"

Freeman exposed mussels native to the northern – above mid-coast Maine – and southern New England to both Carcinus and the Hemigrapsus. Both populations thickened their shells when exposed to waterborne cues of Carcinus, but only the southern mussels – Freeman describes them as "more worldly" – expressed inducible shell thickening in the presence of Hemigrapsus.

"The mussel's inducible response to H. sanguineus reflects natural selection favoring the recognition of this novel predator through rapid evolution of cue specifity or thresholds," Freeman and Byers write.

Findings were consistent in two experiments over two years, one in a laboratory setting in Nahant, Mass., and one in the field at Woods Hole, Mass. "The consistency over two years and

two sites really suggests an underlying robust mechanism," says Byers, who is Freeman's dissertation advisor.

While this sort of rapid evolutionary response to predators has been exhibited in some other species, all have been vertebrates. The blue mussel, which Freeman describes as the lab rat of marine biologists, is an invertebrate "that people assume is not very bright," he says. Yet his findings indicate that within the brief span of 15 years, it has evolved an inducible response to a new predator.

How do mussels evolve so quickly? In southern New England, the scientists say, mussels are prey to many crabs as well as other marine species. "When Hemigrapsus came along the mussels' wheels were well-greased to respond," says Byers. "That's our best guess."

Byers helps put the impact of the research in context. Because extensive data does not exist on invasive ecology, "there's a tendency to extrapolate any data you get on an invasive species. But here we show that the response from the prey differs over just a couple hundred kilometers."

And while its "real world" impact is not immediately obvious, Byers suggests that perhaps northern Maine and Canadian shellfishers might consider "beefing up the worldliness of their naïve mussel populations before the Hemigrapsus arrives," he says, suggesting that this could be done by mixing some of the responsive southern mussels into the naïve northern stocks. "Although 15 years is fast to evolve better defenses to your predator, it can be painfully long if you're a shellfisherman," Byers adds.

This paper is one chapter of Freeman's doctoral dissertation, which also explores how mussels respond to sea stars and to multiple predators. He anticipates completing his doctoral work by October 2006, when he will begin a post-doctoral position with UNH research associate professor Fred Short.

Freeman notes that there's one predator mussels will not need to defend themselves against: him. "I used to like them, before I started working with them for my dissertation," he says. "Not anymore."

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Editors and reporters: A photograph is available to download here: http://www.unh.edu/news/img/colsa/Hemigrapsus_Carcinus.jpg.

Caption: Scientists Aaren Freeman and James Byers at the University of New Hampshire (UNH) have found that invasive crab species Hemigrapsus sanguineus (left) and Carcinus maenas (right) may precipitate evolutionary change in blue mussels in as little as 15 years. Credit: Aaren Freeman.