Flipping the 'genetic paradox of invasions'

September 14 2021

A close-up look at a green crab. A new study led by WHOI scientist Carolyn Tepolt is investigating the adaptive mechanisms of the green crab along the west coast of North America, where it has shown extensive dispersal in the last decade despite minimal genetic diversity. Credit: Ted Grosholz

The green crab, Carcinus maenas, is considered a globally distributed invasive species, an organism introduced by humans that eventually becomes overpopulated, with increased potential to negatively alter its new environment. Traditionally, it's been assumed that successful populations contain high genetic diversity, or a variety of characteristics

allowing them to adapt and thrive. On the contrary, the green crab—like many successful invasive populations—has low genetic diversity, while still spreading rapidly in a new part of the world.

A new study led by Carolyn Tepolt, an associate scientist of biology at Woods Hole Oceanographic Institution, is investigating the adaptive mechanisms of the green crab along the west coast of North America, where it has shown extensive dispersal in the last decade despite minimal genetic diversity. The study was published recently in *Molecular Ecology* and is a collaboration between WHOI, the University of California at Davis, Portland State University, and the Smithsonian Environmental Research Center.

"Invasive species like these are generally unwelcome. Green crabs can compete with native species, rip up eelgrass 'nurseries', and eat small shellfish before they have a chance to be harvested. Green crabs can be an ecological menace and an economic burden," Tepolt said. "In this study, we found that one of the world's most serious marine invasive species has evolved specific genetic variation that likely helps it adapt to new environments really quickly, even when it's lost a lot of genetic diversity overall."

Genetic diversity refers to small individual-to-individual differences in DNA, and often translates into a range of different inherited traits within a species. A population with high genetic diversity is more likely to include individuals with a wide range of different traits. In order for a population to adjust to changing environments, this variation can be crucial—or so scientists have often thought. Invasive species often challenge this assumption, successfully spreading in new regions despite low genetic diversity caused by descending from a small number of initial colonists.

This study focuses on a northwest Pacific population of green crab that

has spread within the last 35 years from a single source. High-profile marine invasive species, such as green crabs, often live across thousands of kilometers of ocean, spanning countless environmental differences, both small and large.

Using six U.S. west coast locations spanning over 900 miles from central California to British Columbia, Tepolt and her team examined the species' genetic structure at thousands of places across its genome. While this population has lost a large amount of overall genetic diversity relative to its European source, a piece of DNA associated with cold tolerance in a prior study appears to be under strong selection from north to south across its invasive West Coast range.

This may represent a type of genetic feature—a balanced polymorphism—that evolved to promote rapid adaptation in variable environments despite high gene flow, and which now contributes to successful invasion and spread in a novel environment. Researchers do occasionally find incredibly successful populations that have passed through severe bottlenecks, dramatically decreasing their genetic diversity relative to their source. This study is amplifying the need to consider that diversity at specific parts of the genome (rather than genome-wide diversity) may play a critical role in resilience in new or changing environments.

"This is exciting for two main reasons. First, the study tests a partial resolution to 'the genetic paradox of invasions', demonstrating that variation at key parts of the genome permits rapid adaptation even in a population with low overall genetic diversity. Second, it suggests that high gene flow in a widespread species' native range may generate evolutionary mechanisms, like this one, which provide that species with the substrate for rapid adaptive change as it spreads across new environments," Tepolt explained.

Identifying invasive species spread can also be a job for non-scientists. As the climate changes and as humans get better and better at moving stuff around the globe, there's more potential for species to come along for the ride and expand into new environments. Tepolt says it's important to keep an eye out for cues, changes in the environment and possible new species in places they haven't been before. She recommends seizing the opportunity to tell officials and researchers if there is something unusual at the coastline. There may be signs at beaches and boat ramps asking people to keep a lookout for particular species and giving contact information. If there are suddenly green crabs in an area for the first time, for example, on the West Coast in the Salish Sea and in Alaska, they likely should not be there and should be reported.

More information: Carolyn K. Tepolt et al, Balanced polymorphism fuels rapid selection in an invasive crab despite high gene flow and low genetic diversity, *Molecular Ecology* (2021). DOI: 10.1111/mec.16143

Carolyn K. Tepolt et al, Rapid Adaptation to Temperature via a Potential Genomic Island of Divergence in the Invasive Green Crab, Carcinus maenas, *Frontiers in Ecology and Evolution* (2020). DOI: 10.3389/fevo.2020.580701

Provided by Woods Hole Oceanographic Institution