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Biogeography of shell morphology in over-exploited shellfish reveals adaptive trade-offs on human-inhabited islands and incipient selectively driven lineage bifurcation

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Abstract

Aim: Humans are unintentionally affecting the evolution of fishery species directly through exploitation and indirectly by altering climate. We aim to test for a relationship between biogeographic patterns in the shell phenotypes of an over-exploited shellfish and the presence of humans to identify human-mediated adaptive trade-offs. The implications of these trade-offs are discussed with respect to the sustainability of the fishery.

Taxon: The endemic Hawaiian intertidal limpet, ‘opihi makaiauli (Patellagastropoda, Nacellidae, Cellana exarata)

Methods: We surveyed phenotypic characters associated with temperature and predation avoidance across the entire species range and tested for differences in the relationship between these characters and latitude, on islands with and without humans.

Results: Among all limpets surveyed, there was a bimodal distribution in shell colour (light, dark) and a parapatric pattern of shell coloration across the archipelago with lighter shells being prevalent on the uninhabited islands and darker, more camouflaged shells being prevalent on the inhabited islands. On the cooler, uninhabited islands, all morphometric characters associated with thermal avoidance (surface area, height and doming) increased with decreasing latitude. On the hotter, inhabited islands, however, shells were flatter, less variable and less adapted for avoiding thermal stress than predation.

Main Conclusions: The biogeographic patterns in shell phenotype and previous genetic studies suggest that the population is beginning to bifurcate in response to disruptive and directional selection as well as geographic isolation between the islands with and without humans. Decreased phenotypic and genetic diversity on the inhabited islands despite much larger populations of ‘opihi suggests a prominent historical bottleneck. The prevalence of maladaptive dark, flat phenotypes for thermal avoidance on the inhabited islands suggests that predation is a stronger selective force, driving adaptive trade-offs in shape and colour. We propose that this is likely a case of fisheries-induced evolution and a millennium of harvesting is the most likely selective pressure driving the observed biogeographic patterns in shell morphology. The flatter, darker shells will

