Nucella canaliculata morphology and drill hole data from experiments conducted at Bodega Marine Laboratory from 2020 to 2021

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Project
» Coastal mosaics of local adaptation and the eco-evolutionary dynamics of a marine predator-prey interaction (Coastal Adaptation)

Contributors	Affiliation	Role
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Abstract
Most predator-prey interactions typically occur over large biogeographic areas with varying abiotic and biotic conditions. If these environmental or biotic gradients are consistent over time they can impose spatially varying selection pressures on the co-evolving predator or prey. Nucella canaliculata is a predatory dogwhelk that inhabits rocky shore ecosystems along the West Coast of North America and preys on multiple barnacle and mussel species by drilling a hole through the shell of their prey. Previous work has documented geographic variation in the ability of N. canaliculata to drill the foundation species, Mytilus californianus. However, the underlying mechanisms and scale of these phenotypic differences haven't been determined. We hatched and raised N. canaliculata from 6 populations, 3 in California and 3 in Oregon, for a year in the laboratory on a common diet of Mytilus trossulus. We then challenged these dogwhelks with a series of M. californianus mussels of increasing size and thickness to identify the largest and thickest mussel drilled for each dogwhelk. There were clear geographic differences in drilling capacity. Dogwhelks from California were able to drill mussels that were substantially larger and thicker than those from Oregon. We are exploring whether selection on drilling capacity is associated with a coastal mosaic of mussel shell thickness and if these differences can influence the dynamics of rocky intertidal ecosystems.

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Coverage

Spatial Extent: **N**:44.8378 **E**:-121.929 **S**:36.4472 **W**:-124.402
Temporal Extent: 2020-07-28 - 2021-02-05

Methods & Sampling

Sets of *Nucella canaliculata* egg capsules were collected from May to June of 2019 from the six study sites. Each set was assumed to contain dogwhelks that were full or half siblings, and considered a "family". Each set of egg capsules was placed in individual plastic tea-strainers with mesh sides and held in flowing seawater at Bodega Marine Laboratory. When dogwhelks hatched, 80 individuals from each family were transferred to a new tea strainer that was then placed in a 1-liter (L) container on a sea table with flowing seawater. Dogwhelks were fed ad libitum a diet of small blue mussel, *Mytilus trossulus*, that were regularly collected from Bob Creek, Oregon. When dogwhelks reached a size of 5 millimeters (mm) they were moved to a 1-L container to provide more room for growth.

Adult dogwhelks (10 dogwhelks x 8 families x 6 sites = 480 individuals) were scored on their ability to drill *M. californianus* by giving them mussels of progressively larger size during a 25-week experiment. Mussel size classes offered were: 20mm (+/-5mm), 40 (+/-5mm), 60 (+/-10mm), 90 (+/-10mm), 120 (+/-10mm), 150 (+/-10mm), 170 (+/-10mm). If a dogwhelk drilled a complete drill hole in a mussel of one size class, it then received mussels of the next size class. For mussels ranging from 20 to 120mm, each snail received two mussels, one slightly less and one slightly more than the mean for that size class. For the 150 and 170mm size classes, each dogwhelk only received one mussel. Mussels ranging from 20 to 150mm were collected from Bodega Marine Reserve. If a dogwhelk drilled a 150mm mussel from Bodega Marine Reserve, it then was given a 150mm mussel from Strawberry Hill, Oregon, and then a 170mm mussel from Strawberry Hill. Preliminary research had shown that mussels from Strawberry Hill were thicker than those from Bodega Marine Reserve. Containers were checked regularly to assess if dogwhelks had drilled: the first 2 checks were 2 weeks apart, the next 3 checks were 3 weeks apart, and the final 3 checks were 4 weeks apart. When a mussel was drilled or partially drilled, its length was measured. All drilled and partially drilled mussels were kept for further analyses. All dogwhelks were sexed and their lengths were measured prior to the start and at the end of the experiment to quantify growth.

The largest several mussels drilled or partially drilled for each dogwhelk were used to determine the maximum drill hole depth for each dogwhelk. Mussels were cut on a bandsaw through the drill holes or partial drill hole. Mussel cross sections were scanned (model: CanoScan LiDE 110) and photographs were used to determine the depth of each drill hole using imaging software (ImageJ; Java 1.80_172). Dogwhelks that did not drill any mussels during the course of the laboratory trial were assigned a maximum depth of 0mm.

BCO-DMO Curation Notes

- Imported original files "Nucella_canaliculata_morphology.xlsx" and "Nucella_canaliculata_Drill_Hole_Data.xlsx" into the BCO-DMO system.
- Flagged 'NA' as a missing data value (missing values are blank/empty in the final file).
- Joined the two data files into a single dataset using "Container" as the key.
- Created Latitude and Longitude columns and added the values for each site as provided in the metadata.
- Converted the latitude and longitude values to decimal degrees and rounded to 5 decimal places.
- Converted the Date column to YYYY-MM-DD format.
- Renamed columns/fields to comply with BCO-DMO naming conventions.
- Saved the final file as "908739_v1_drill_hole_and_morphology_data.csv".

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Data Files

File	
908739_v1_drill_hole_and_morphology_data.csv	(Comma Separated Values (.csv), 101.23 KB) MD5:56073181cca70ac9cb8fb72b6dfb15a2
Primary data file for dataset ID 908739, version 1.	

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Parameters

Parameter	Description	Units
Container	Container number. Each container held 1 dogwhelk so this identified the population and family that the dogwhelk was from.	unitless
Site	Code of the field site that the dogwhelk was from. Egg capsules were collected from 3 sites in California and 3 in Oregon.	unitless
Latitude	Latitude of field site	decimal degrees
Longitude	Longitude of field site; negative values = West	decimal degrees
Family	Identifies the family. Families (dogwhelks from the same egg capsule cluster were considered to be full or half siblings and classified as a family) from each site were numbered.	unitless
Dogwhelk	Individual dogwhelk ID.	unitless
Sex	Sex of dogwhelk - male or female.	unitless
Length_Initial	Initial length of dogwhelk.	millimeters (mm)
Length_Final	Final length of dogwhelk.	millimeters (mm)
Length_change	Change in length of dogwhelk.	millimeters (mm)
Check	Check number. The experiment lasted 25 weeks for a total of 10 checks.	unitless
Date	Date of experimental check.	unitless
Drill_Hole_Type	Describe the type of drill hole - either "Drilled" or "Partial" depending on if a dogwhelk successfully drilled or only partially drilled a mussel.	unitless
Mussel_Length	Length of mussel along anterior-posterior axis.	millimeters (mm)
Mussel_Population	Population that the mussel was from - either Bodega Marine Reserve, California (BMR) or Strawberry Hill, Oregon (SH).	unitless
Drill_Hole_Depth	Depth of drill hole measured using image analysis of scan of cross section.	millimeters (mm)

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Instruments

Dataset-specific Instrument Name	CanoScan LiDE 110
Generic Instrument Name	Image scanner
Generic Instrument Description	An electronic device that generates a digital representation of an image for data input to a computer. OR a receiver designed to search for a signal within a specified frequency range. [Definition Source: NCI]

Dataset-specific Instrument Name	drill
Generic Instrument Name	Manual Biota Sampler
Generic Instrument Description	"Manual Biota Sampler" indicates that a sample was collected in situ by a person, possibly using a hand-held collection device such as a jar, a net, or their hands. This term could also refer to a simple tool like a hammer, saw, or other hand-held tool.

Dataset-specific Instrument Name	bandsaw
Generic Instrument Name	Manual Biota Sampler
Generic Instrument Description	"Manual Biota Sampler" indicates that a sample was collected in situ by a person, possibly using a hand-held collection device such as a jar, a net, or their hands. This term could also refer to a simple tool like a hammer, saw, or other hand-held tool.

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Project Information

Coastal mosaics of local adaptation and the eco-evolutionary dynamics of a marine predator-prey interaction (Coastal Adaptation)

Coverage: Northeast Pacific coast; California and Oregon, USA

NSF Award Abstract:
Historically, ecologists regarded evolution as a process that typically acts slowly over very long time scales. However, recent studies suggest that evolution might also shape the way species interact over much shorter timespans, ranging from weeks to years. Are these sorts of rapid feedbacks between evolution and ecology important in marine ecosystems? This project will address this question along the Pacific coast of the United States by studying predatory snails (Channeled Dogwhelks) that feed on California Mussels, an important habitat-forming species on rocky intertidal shores. Prior research shows that some dogwhelk populations are composed of an assortment of individuals that differ genetically in how effectively they can drill through mussel shells. This project will test whether short-term changes in the environment can impose rapid natural selection that favors some of these drilling variants over others, altering the effects that a dogwhelk population has on the surrounding mussel bed. At the same time, this project will examine whether regional differences in mussel

shell thickness have influenced the evolution of drilling ability among dogwhelk populations distributed along >900 kilometers of the California and Oregon coasts. Overall, this study seeks to understand the dynamic feedbacks between evolution and ecology that might influence marine communities in the face of changing ocean conditions. This project will train diverse undergraduate and graduate students and will provide the foundation for a significant public outreach component, including the production of accessible video documentaries.

This project seeks to advance our understanding of eco-evolutionary dynamics in the sea by investigating links among oceanographic variation, natural selection, species interactions, and community succession. This project will use the interaction between the Channeled Dogwhelk (*Nucella canaliculata*) and the California Mussel (*Mytilus californianus*) as a model system to address two central objectives. (1) The research team will explore how spatial mosaics of selection drive adaptive differentiation among populations of consumers. Newly collected and archived mussels will be analyzed to characterize variation in shell thickness along the coasts of California and Oregon, and to evaluate whether this spatial mosaic has been consistent or variable over the past two decades. Laboratory experiments will test whether dogwhelk populations distributed across this mosaic have diverged in the thickness of shell that they can drill successfully. (2) The research team will examine whether temporal variation in selection on consumer phenotypes shapes predator-prey interactions, with cascading effects on ecological dynamics. In particular, the project will test whether short-term variation in prey recruitment and shell thickness can impose rapid selection on the frequency of drilling phenotypes within a dogwhelk population. A field experiment will also test whether selection on these predator phenotypes in turn alters the trajectory of mussel bed succession.

This award reflects NSF's statutory mission and has been deemed worthy of support through evaluation using the Foundation's intellectual merit and broader impacts review criteria.

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Funding

Funding Source	Award
NSF Division of Ocean Sciences (NSF OCE)	OCE-1851462

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