Panopeus herbstii activity level and feeding with and without predator cues North Inlet Estuary, Georgetown, SC during 2012 (Variation in Metabolic Processes project)

Website: https://www.bco-dmo.org/dataset/638884
Data Type: experimental
Version: 2016-02-18

Project
» Linking Variation in Metabolic Processes as a Key to Prediction (Variation in Metabolic Processes)

Contributors	Affiliation	Role
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Table of Contents

Dataset Description

This data set comes from an experiment testing how crab behavior (activity level) affects consumption rate of mussels in the absence and presence of fish predation threat.

Related Reference:
Toscano BJ, Griffen BD (2014) Trait-mediated functional responses: predator behavioural type mediates prey consumption.*Journal of Animal Ecology* 83:1469-1477

Methods & Sampling

Experimental set-up
The experiment was run from May to August 2012 in a screenedin wet laboratory at the Baruch Marine Field Laboratory in Georgetown, South Carolina, USA. Organisms used in the experiment were collected from the adjacent Oyster Landing intertidal oyster reef in North Inlet estuary (33°200N, 79°100W).

To examine the effects of individual crab activity level on the functional response, we measured both the activity level and mussel consumption rate of individual crabs. Activity level was measured prior to consumption rate trials. We manipulated the presence of chemical cues from toadfish during measurements of both activity level and consumption rate to test how the presence of predation threat directly affects the functional response, and how threat could mediate the effects of activity level on the functional response. Specifically, both the activity level and consumption rate of individual crabs were measured under one of two predation threat treatments: toadfish chemical cue absent (n = 240 crabs) or toadfish chemical cue present (n = 207 crabs). Activity level measured under predation threat is a measure of boldness as defined in the animal personality literature (Carter et al. 2013). The consumption rate of individual crabs was measured at a single prey density rather than a range of prey densities to minimize the duration crabs were held in the laboratory, which could modify individual behaviour through conditioning (Butler et al. 2006). We ran the experiment in a complete block design and the following methods pertain to a single block of 4 day duration.

On the first day, 16 crabs (20-30 mm carapace width, CW) were collected from the high intertidal portion of the Oyster Landing reef. Mud crabs become important predators of adult bivalves in oyster reefs in North Inlet estuary when they reach c. 20 mm CW (Toscano & Griffen 2012), and attain a maximum size of 55 mm CW at this site (McDonald 1982). All crabs were fed with mussels ad libitum as soon as they were brought into the laboratory. Eight of these 16 crabs were then randomly assigned to the toadfish cue absent treatment while the other eight were assigned to the toadfish cue present treatment, and these treatments were maintained for both activity level and consumption rate trials (methods for activity level and consumption rate trials are detailed below). To create the toadfish cue present treatment, we pumped seawater through a holding chamber that contained a single adult toadfish (c. 30 cm total length) fed ad libitum with mud crabs in between experimental trials. This seawater was then divided equally among mesocosms containing crabs to keep the amount of chemical cue consistent within blocks. Crabs assigned the cue absent treatment received seawater that did not first pass by a toadfish, but was otherwise distributed using the same seawater system. Mesocosms receiving the toadfish cue absent and cue present treatments were always alternated spatially.

On the second day, four crabs receiving the toadfish cue absent treatment and four crabs receiving the cue present treatment (eight of the 16 crabs) were observed to measure their activity level, and on the third day, the other eight crabs were observed in the same manner. This second group of eight crabs was fed again on the second day to keep their starvation time before activity level measurement (24 h) consistent with the first group of eight crabs, and on the third day, all crabs were fed to maintain starvation consistency before consumption rate trials. On the fourth day, the consumption rate of all 16 crabs was measured in a 24-h feeding trial. All crabs were held in the laboratory for an additional 2 days after consumption rate trials to ensure that crabs were not approaching a molt cycle or female crabs were not becoming reproductive. This procedure for a single experimental block was repeated 33 times over the course of the summer (May through August). Any crabs molting, carrying eggs or dying during their time in the laboratory were removed from the final data set. Additionally, the toadfish chemical cue treatment failed during the measurement of crab consumption rate for five blocks and these crabs were therefore removed from the final data set. However, complete removal of these blocks (i.e. both cue absent and present treatments) from the final data set did not alter our results.

<u>Measurement of crab activity level</u>
The activity level of individual crabs was measured using a similar behavioural assay to that used in previous studies of mud crab BTs (Griffen, Toscano & Gatto 2012; Toscano, Gatto & Griffen 2014). Each crab was observed in a glass mesocosm (50 x 28 x 30 cm) containing a 3 cm layer of sand/mud substrate and 5 L of oyster shell that had been dried and cleaned to remove epifauna. This experimental crab density (one crab per 0.14 m2) is within the range of densities previously reported in North Inlet (McDonald 1982, B.J. Toscano unpublished data). Oyster shell was placed on top of the substrate to mimic natural reef habitat. This amount of shell ensured that crabs had ample space to hide completely. In each tank, eight large mussels (c. 25 mm shell length, SL) were suspended in a mesh bag near the surface of the water to release chemical cues and induce crab foraging behaviour while remaining out of reach of crabs.

Crabs were observed at night (from c. 2000 to 2300 h) under dim red light and from behind a blind to minimize disturbance. Over a period of 3 h, we observed whether crabs were exposed and active (vs. hiding and remaining motionless) every 6 min (30 observations per crab in total). Activity level was measured as the proportion of 30 observations that crabs were visible to the observer and moving. In addition to activity level, we recorded the carapace width, major claw width and sex of each crab.

<u>Measurement of crab consumption rate</u>
Eight mussel (12-16 mm SL) prey densities (2, 4, 6, 8, 12, 16, 24 and 36 mussels per mesocosm) were randomly assigned to the eight crabs receiving the toadfish cue absent treatment as well as the eight crabs receiving the cue present treatment for each block. These mussel densities fall within the range of recorded mussel densities within a single large oyster cluster from the study site (Toscano & Griffen 2012). This created a total of 16 unique treatment combinations in each block. These trials were conducted in glass mesocosms of the same dimensions that we used to observe crab activity level. Mesocosms contained a 3 cm layer of sand/mud substrate and 10 large oyster shells, and were enclosed in black plastic to mimic the low-light conditions of North Inlet estuary during summer months (Dame et al. 1986; Toscano & Griffen 2013). Mussels were scattered evenly on oyster shells throughout each mesocosm and allowed to attach to oyster shells for 6 h prior to the start of trials. Crabs were allowed to forage for 24 h (starting and ending at c. 1500 h) and the number of mussels remaining as well as the water temperature was recorded at the end of trials.

Data Processing Description

BCO-DMO Processing:
- added conventional header with dataset name, PI name, version date, reference information
- renamed parameters to BCO-DMO standard
- reduced number of digits for temp from 8 to 1 after decimal and of activity_level from 9 to 2

[table of contents | back to top]

Data Files

File
Pherb_active_feeding.csv(Comma Separated Values (.csv), 12.85 KB) MD5:94eb71684196f662817a0b8068f75f26 Primary data file for dataset ID 638884

[table of contents | back to top]

Parameters

Parameter	Description	Units
prey_density	prey density	each
carap_width	carapace width	centimeters
expt_block	id number for the time block for experimental work	unitless
temp	temperature	degress Celsius
claw_width	claw width	centimeters
treatment	treatment (toadish cue present or absent)	unitless
activity_level	activity level: proportion of 30 observations that crabs were visible to the observer and moving	unitless
prey_eaten	number of prey eaten	each

[table of contents | back to top]

Instruments

Dataset-specific Instrument Name	
Generic Instrument Name	Water Temperature Sensor
Generic Instrument Description	General term for an instrument that measures the temperature of the water with which it is in contact (thermometer).

[table of contents | back to top]

Deployments

Griffen_lab

Website	https://www.bco-dmo.org/deployment/638572
Platform	Univ_S_Carolina
Start Date	2012-01-01
End Date	2016-12-31

[table of contents | back to top]

Project Information

Linking Variation in Metabolic Processes as a Key to Prediction (Variation in Metabolic Processes)

Description from NSF award abstract:
A major goal of biological and ecological sciences is to understand natural systems well enough to predict how species and populations will respond to a rapidly changing world (i.e., climate change, habitat loss, etc.). A population under any conditions will grow, shrink, or disappear altogether depending on how efficiently individuals consume resources (food), utilize that food metabolically, and eventually reproduce. However, making accurate predictions based on these metabolic processes is complicated by the realities that each species has different resource requirements and that no two individuals within a species are exactly alike. Rather, individuals vary and this variation, both within and across species, is central to many ecological and evolutionary processes. Developing the ability to predict responses of biological systems to a changing world therefore requires a mechanistic understanding of variation. The goal of this project is to improve this mechanistic understanding by examining variation within a metabolic context across a range of species that have a spectrum of commonly-seen resource requirements. Further, the work capitalizes on a unique biological characteristic of this group of species that allows control and manipulation of individual reproduction, facilitating experimental study of the mechanistic links between variation in individual consumption, metabolism, and reproduction. The foundation this research is a combination of field measurements and laboratory experiments using both well-established and newly-developed techniques to quantify these links. The result will be a quantitative framework to predict how individuals will respond reproductively to changes in resource use. Because of the close link between individual reproduction and population dynamics, this research will contribute substantially to predictions in population dynamics under realistic conditions where individuals use more than a single resource, and improve the prediction of responses to current and future ecological changes.

The following publications and data resulted from this project:

Belgrad, B. and B. Griffen. 2016. Predator-prey interactions mediated by prey personality and predator identity.*Proc. Roy. Soc. B*: In Review. [2016-01-20]
P. herbstii mortality data: Mortality of crabs when exposed to either a single blue crab, toadfish, or no predator for a week
P. herbstii personality data: Refuge use of crabs when exposed to predator odor cues from either blue crabs, toadfish, or control of no cue
P. herbstii predator behavior data: Refuge use and mobility of blue crabs and toadfish while in mesocosms for a week - behavior measured during two days.

Belgrad, B. and B. Griffen. 2016. The influence of dietary shifts on fitness of the blue crab, *Callinectes sapidus*. *PloS One. DOI: 10.1371/journal.pone.0145481.*
Blue crab activity: Activity of crabs fed different diets over a summer
Blue crab egg size: Volume of eggs for crabs fed different diets
Blue crab hepatopancreas index (HSI): Weight of hepatopancreas for crabs fed different diets
Blue crab hepatopancreas lipid content: Hepatopancreas lipid content of crabs fed different diets
Blue crab reproductive tissue analysis (GSI): Gonadosomatic index of blue crabs on various diets
Blue crab survival: Blue crab survival data during the dietary study

Knotts ER, Griffen BD. 2016. Individual movement rates are sufficient to determine and maintain dynamic spatial positioning within *Uca pugilator* herds. *Behavioral Ecology and Sociobiology* 70:639-646
Uca pugilator: behavior change with carapace marking: Search space behavior due to carapace treatment

(control, nail polish, and food dye)
Uca pugilator: field spatial position: Assessment of individual's position within a herd at 3 min. intervals; for proportion of time found at edge of herd
Uca pugilator: herd position proportion: Individual's proportion of time spent in an edge/alone position among a herd
Uca pugilator: search space distribution: Search space that crabs traveled; to evaluate the sample's distribution of exploratory behavior

Belgrad, B. and B. Griffen. 2015. Rhizocephalan infection modifies host food consumption by reducing host activity levels. *Journal of Experimental Marine Biology and Ecology*. 466: 70-75.
E. depressus digestion time : Time taken for food to pass through gut of flat-backed mud crabs infected by a parasite
E. depressus metabolism: Respiration rate of infected/uninfected flat-backed mud crabs
E. depressus reaction time to prey: Time taken for infected/uninfected flat-backed mud crabs to react to the presence of prey

Blakeslee, A.M., C.L. Keogh, A.E. Fowler, B. Griffen. 2015. Assessing the effects of trematode infection on invasive green crabs in eastern North America. *PLOS One* 10(6): e0128674.(pdf)
Carcinus: hemocyte density: Counts of circulating hemocyte density in Carcinus maenas
Carcinus: parasites physiology behavior: Behavior and physiology of Carcinus maenas infected with trematode parasite

Griffen BD, Norelli AP (2015) Spatially variable habitat quality contributes to within-population variation in reproductive success. *Ecology and Evolution* 5:1474-1483.
P. herbstii diet: sampling site characteristics (Eco-Evo 2015)
P. herbstii diet: body measurements (Eco-Evo 2015)
P. herbstii diet & reproduction (Eco-Evo 2015)
P. herbstii: collection sites (Ecol-Evol 2015)

Griffen BD, Riley ME (2015) Potential impacts of invasive crabs on one life history strategy of native rock crabs in the Gulf of Maine. Biological Invasions 17:2533-2544.
Cancer consumption and reproduction (Bio.Inv. 2015): Lab experiment linking dietary consumption and reproduction

Griffen BD, Vogel M, Goulding L, Hartman R (2015) Energetic effects of diet choice by invasive Asian shore crabs: implications for persistence when prey are scarce. *Marine Ecology Progress Series* 522:181-192.
Hemigrapsus diet 1 (MEPS 2015)
Hemigrapsus diet 2 (MEPS 2015)

Hogan and Griffen (2014). The Dietary And Reproductive Consequences Of Fishery-Related Claw Removal For The Stone Crab *Menippe* Spp. Journal of Shellfish Research, Vol. 33, No. 3, 795–804.
Stone crab: 052012-DietChoiceExp1: Prey choice for 2-clawed and 1-clawed Stone Crabs (Menippe spp.)
Stone crab: 052012-LongTermConsumption: Long-term consuption for 2-clawed and 1-clawed Stone Crabs (Menippe spp.), summer of 2012
Stone crab: 062013-DietChoiceExp2: Prey choice for 2-clawed and 1-clawed Stone Crabs (Menippe spp.)
Stone crab: 062013-PreySizeSelection: Prey Size selection ranking for 2-clawed and 1-clawed Stone Crabs (Menippe spp.)

Riley M, Johnston CA, Feller IC, and Griffen B. 2014. Range expansion of *Aratus pisonii* (mangrove tree crab) into novel vegetative habitats. *Southeastern Naturalist* 13(4): 43-38
A. pisonii: range expansion: Aratus pisonii survey in native mangrove and novel salt marsh habitats

Riley M, Vogel M, Griffen B. 2014. Fitness-associated consequences of an omnivorous diet for the mangrove tree crab *Aratus pisonii*. *Aquatic Biology* 20:35-43, DOI: 10.3354/ab00543
A. pisonii: fitness and diet: Impact of diet variation on physiological and reproductive condition of A. pisonii

Toscano BJ, Newsome B, Griffen BD (2014) Parasite modification of predator functional response. Oecologia 175:345-352b
E. depressus - parasite and feeding (Oecologia, 2014): Feeding with and without parasitic barnacle infection
E. depressus - parasite and prey handling (Oecologia, 2014): Food handling with and without parasitic barnacle infection
E. depressus - parasite study - field survey (Oecologia, 2014): Parasitised field survey

Toscano BJ, Griffen BD (2014) Trait-mediated functional responses: predator behavioural type mediates prey

consumption.*Journal of Animal Ecology* 83:1469-1477
P. herbstii - activity and feeding (JAE, 2014): Activity level and feeding with and without predator cue

Toscano BJ, Gatto J, Griffen BD (2014) Effects of predation threat on repeatability of individual crab behavior revealed by mark recapture. *Behavioral Ecology and Sociobiology* 68:519-527
P. herbstii - recapture behavior (BESB, 2014): Mud crabs refuge use and activity level - initial measurements
P. herbstii - refuge use (BESB, 2014): Effect of predation threat on repeatability of individual crab behavior revealed by mark-recapture

Griffen BD, Altman I, Bess BM, Hurley J, Penfield A (2012) The role of foraging in the success of invasive species. Biological Invasions. 14:2545-2558
Hemigrapsus seasonal diet (Bio.Inv. 2012): Percent herbivory and gut fullness for Hemigrapsus sanguineus at different times of year

Griffen BD, Toscano B, Gatto J (2012) The role of intraspecific trait variation in mediating indirect interactions. Ecology 93:1935-1943
P. herbstii refuge use (Ecology, 2012): Proportion of time that Panopeus herbstii spent using refuge habitats in a lab experiment
P. herbstii: Field personality distribution (Ecology, 2012): Field distribution of personality types in the mud crab Panopeus herbstii relative to tidal height
P. herbstii: Trait mediated indirect effect (Ecology, 2012): Influence of refuge use by the mud crab Panopeus herbstii on consumption of bivalves

Riley ME, Griffen BD (2017) Habitat-specific differences alter traditional biogeographic patterns of life history in a climate-change induced range expansion. PLOS One 12(5):e0176263
A. pisonii: egg size: Comparing egg size in Aratus pisonii populations from mangrove and salt marsh habitats
A. pisonii: fecundity: Determining fecundity of Aratus pisonii populations in mangrove and salt marsh habitats
A. pisonii: larval starvation resistance: Comparing larval quality in Aratus pisonii populations from mangrove and salt marsh habitats
A. pisonii: latitudinal body size: Survey examining latitudinal body size patterns in Aratus pisonii
A. pisonii: predation: Comparing predation pressure on Aratus pisonii in mangrove and salt marsh habitats
A. pisonii: reproductive effort: Survey comparing Aratus pisonii reproductive effort in native and novel habitats
A. pisonii: herbivory: Relationship between leaf herbivory, tree characteristics, and refuge availability
A. pisonii: mangrove tree survey: Mangrove tree distribution and characteristics in a dwarf mangrove system

Cannizzo ZJ, Dixon SR & Griffen BD (2018). An anthropogenic habitat within a suboptimal colonized ecosystem provides improved conditions for a range-shifting species. Ecology and Evolution, 8(3):1524-1533.
A. pisonii: behavior: Proportion of time the mangrove tree crab Aratus pisonii spent in different behaviors related to diet and energy storage
A. pisonii: dock-marsh thermal: Thermal readings from under a dock and in a nearby salt marsh
A. pisonii: sun-shade: Proportion of time that mangrove tree crab Aratus pisonii spent in sun and shade in three habitats, 2015-2016.
A. pisonii: thermal picture: Thermal condition of A. pisonii in three habitats: under dock, mangroves, saltmarsh

[table of contents | back to top]

Funding

Funding Source	Award
NSF Division of Ocean Sciences (NSF OCE)	OCE-1129166
Slocum-Lunz Foundation	Lerner Grey Memorial Fund of the American Museum of Natural History

[table of contents | back to top]