Refuge use and mobility of blue crabs and toadfish while in mesocosms for a week in 2015 (Variation in Metabolic Processes project)

Website: https://www.bco-dmo.org/dataset/635833
Data Type: experimental
Version:
Version Date: 2016-01-22

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

Contributors	Affiliation	Role
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Dataset Description

Related Reference:

Belgrad, B. and B. Griffen. 2016. Predator-prey interactions mediated by prey personality and predator hunting mode. *Proc. Roy. Soc. B*: 283: 20160408. http://dx.doi.org/10.1098/rspb.2016.0408.

Related Datasets:

P. herbstii mortality data
P. herbstii personality data

Methods & Sampling

We collected 300 mature mud crabs that were not missing any limbs (mean ± SD carapace width = 24.1 ± 2.2 mm) by hand from intertidal oyster reefs within the North Inlet National Estuarine Research Reserve (33°20’N, 79°10’W, Georgetown, South Carolina). Crabs were collected in three cohorts of ten individuals during each of 10 blocked sampling periods (i.e., each blocked trial consisted of 30 crabs total). Individuals were randomly selected from 1 m^2 plots to ensure that natural cohorts of ten crabs were measured. Crab gender was identified by examination of the telson (167 males, 133 females). Crabs were starved for 24 h and the carapace of each was marked with a unique nail polish (Sonia Kashuk) design to identify individuals. Preliminary work determined that these markings did not alter crab behavior.

Cohorts were randomly assigned a predator cue treatment and placed into one of three separate flow-through mesocosms (circular with diameter 1 m; water height 15 cm). Each mesocosm contained ~2 cm sediment under a ~8 cm matrix of cleaned oyster shells covering the entire tank bottom. Thirty scorched mussels were distributed in three mesh containers within each mesocosm outside the reach of crabs to continuously stimulate foraging behavior [20]. Flow-through mesocosms were supplied with water from the estuary which was first pumped through a head tank. The head tank for each mesocosm contained either a mature toadfish (caudal length ± SD = 28.4 ± 2.8 cm), blue crab (carapace width ± SD = 14.8 ± 0.6 cm), or no predator depending on the predator odor cue treatment. Predators were caught from the estuary by dip net no more than one week prior to the experiment and fed mud crabs each day to ensure kairomones were produced. We conducted all experimental trials at night under red light following the observational procedures of Griffen et al. (2012) and Toscano et al. (2014) to ensure mud crabs were at their most active and were undisturbed by the observer.

Crabs were tested in trials consisting of one cohort per treatment (toadfish, blue crab, no predator) with six days separating the commencement of each trial. All trials began between the hours 2000-2100, and once cohorts were placed in the mesocosms, crabs were given 10 minutes to acclimate. After acclimating, we recorded whether crabs were actively exposed on the surface of the shell layer or were taking refuge underneath the shells at six minute intervals for the next three hours. The proportion of these 30 observations in which crabs hid in refuge and were not visible to the observer was used as our response variable to determine behavior.

Immediately after observing crab behavior, we used the same crab cohorts to assess whether crab predation risk was influenced by the proportion of time individual crabs spend in refuge within oyster shells and by predator species. We assigned crabs the same predator treatment they experienced previously to keep cohorts intact throughout the entire study. Crabs were fed a satiating amount of fish (*Fundulus heteroclitus*), marked with individually-numbered bee tags (queen marking kit: the Bee Works, Orillia, Ontario, Canada), and starved for 24 h. After the starvation period, the cohorts were placed into one of three large flow-through mesocosms (diameter 2m; water height 90 cm). Each mesocosm contained ~ 2 cm of sediment underneath four clusters of live oysters (length ~38 cm, width ~31 cm, height ~28 cm) which were standardized by weight (15.000 kg within <0.1 %). Oysters were collected from the estuary and cleaned of any inhabiting crabs. Scorched mussels naturally attached to these collected oysters were standardized by number of individuals (within 8.3 %) and served as the mud crabs' food source to mimic natural conditions.

During each blocked trial (n=10), a single toadfish, blue crab, or no predator (to serve as a control for cannibalism) was placed in each mesocosm depending on the experimental treatment. We used the same individual predators which provided odor cues in the previous behavior experiment as predators within the large mesocosms. Predators were starved 24 h to standardize hunger levels and placed in the mesocosms 10 minutes prior to the mud crabs to ensure kairomones were distributed throughout the tank (no crabs were lost to predation during introduction into the tanks). Mud crab survival was checked daily for seven consecutive days to determine which individuals were consumed. This was done by removing all the oyster clumps and thoroughly raking the sediment. Any missing crabs were presumed dead as there was no way for crabs to escape and remnants of missing animals were often found.

This dataset: We monitored predator behavior during five of the ten experimental trials described in the previous section to determine the hunting strategies of blue crabs and toadfish, and to assess whether hunting strategy could potentially explain the preferential consumption of bold or shy crabs. We examined two aspects of predator hunting behavior: predator location and movement within the mesocosms. These were each recorded every hour between 700 – 2200 h (20 observations) during the second and fifth day of the trial, then data from these two time periods were combined for analyses.

Data Processing Description

We analyzed proportion of time within vs. outside of oysters and proportion of time moving vs. stationary using two separate mixed-effects GLMs with a binomial distribution, using predator species as a fixed effect and trial block treated as a random effect.

Statistical software: R, version 3.0.3 (R Development Core Team, Auckland, New Zealand; R Package *lme4* v. 3.0.3)

BCO-DMO Processing:

- added conventional header with dataset name, PI name, version date, reference information
- renamed parameters to BCO-DMO standard
- changed month names to numbers

- added ISO_DateTime_UTC and yrday for plotting purposes
- changed time_utc from 2400 to 0000 and added 1 day

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Data Files

File
Pherb_pred_behavior.csv (Comma Separated Values (.csv), 34.10 KB) MD5:aa81d6cd48b9987c634194be17897331 Primary data file for dataset ID 635833

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Related Publications

Bates, D., Maechler, M., & Bolker, B. (2013). lme4: Linear mixed-effects models using S4 classes. R package version 0.999999-2.
Software

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Parameters

Parameter	Description	Units
trial	tiral number	unitless
lat	latitude; north is positive	decimal degrees
lon	lonitude; east is positive	decimal degrees
year	year	yyyy
timezone	hours different from UTC	hours
predator	predator name: toadfish or bluecrab	unitless
animal_id	predator (toadfish or bluecrab) identification	unitless
day	day on month	1-31
month	month of year	1-12
time_utc	UTC time	HHMM
yrday_utc	UTC day and decimal time; as 326.5 for the 326th day of the year or November 22 at 1200 hours (noon)	unitless
ISO_DateTime_UTC	Date/Time (UTC) ISO formatted based on ISO 8601:2004E standard	YYYY-MM-DDTHH:MM:SS
hiding	hiding code: 0 = exposed; 1 = hiding	unitless
mobility	mobility code: 0 = still; 1 = moving	unitless
observation	observation identification: either 1st or 2nd	unitless

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Deployments

Griffen_2015

Website	https://www.bco-dmo.org/deployment/635813
Platform	Univ_S_Carolina
Start Date	2015-05-01
End Date	2015-07-31
Description	Atlantic mud crab studies

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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

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Funding

Funding Source	Award
NSF Division of Ocean Sciences (NSF OCE)	OCE-1129166

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