The effects of herbivory by *Sesarma reticulatum* on salt marsh plants and food preference

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Abstract

The crab *Sesarma reticulatum* has been a focal point of recent studies of salt marsh vegetation die-off. Due to contributing factors including sea level rise, increased tidal inundation, and crab herbivory, salt marshes have been experiencing increased loss in area and denuding of vegetation. The purpose of this study was to determine the dynamics of *Sesarma reticulatum* herbivory in order to better understand its potential impacts on salt marshes. Laboratory studies and field manipulation experiments were used to determine food preference, calculate consumption rates of individual organism, and to observe feeding behaviors through night field observations. In the Lab experiments, eight organisms were collected and acclimated to laboratory conditions to determine individual food preference and consumption rates. Field experiments used vegetation transplants and exclusion cages. The results from laboratory studies and field experiments indicate that *Spartina alterniflora* is the preferred food over *Spartina patens.* Night observations indicate that crabs feed relatively slowly on individual plant stems, cutting these off and returning to their burrows where the consume the plant material.

Introduction

The purple marsh crab *Sesarma reticulatum* (Figure 1) is a nocturnal, herbivorous crab that inhabits salt marshes along the northeast US coast. Salt marshes serve as a vital component in life cycles of multiple species. This habitat is used as nursery ground for many juvenile fish, blue crabs, and bird species. *Sesarma* has been the focus of recent studies focusing on salt marsh die-off. In the absence of their primary predators, blue crabs and various fish species, it is hypothesized that *Sesarma* populations are increasing (Altieri et al., 2012). In a study by Holdredge et al. (2008), *Sesarma* were tethered in either vegetated or bare ground locations. The *Sesarma* in vegetated areas fell prey to predators, while those in bare locations survived. Reduction of predators is believed to be the result of increased fish angling and consumption of predator species by humans. *Sesarma* inhabit burrows in groups of two to three per burrow system throughout the middle to low levels of salt marshes (Coverdale et al., 2012). The burrows extend to the same depth as the roots system of salt marsh plants, allowing *Sesarma* to feed while escaping predation above ground (Bertness et al., 2009). Plant species like *Spartina alterniflora* have extensive root system comprised of rhizomes. These structures allow aclonal upshoots to be generated when above ground herbivory occurs. When the rhizome structures are consumed, the plant cannot recover as quickly. This study focused on the crabs' feeding behaviors and food preferences, as these are still unknown. Past studies have observed consumption of the salt marsh grasses *Spartina alterniflora* and *Spartina patens*, and most die back has been in *S. alterniflora* areas. However, specifics on the dynamics of their herbivory on marsh plants have not been studied. My research asked several questions: a) do the crabs prefer one grass type over another, b) what are their nocturnal activity patterns and feeding rates, and c) what is their distribution on high marsh habitats?

Figure 1 *Sesarma reticulatum* exiting burrow

Methods and Materials

Three different approaches were used to assess feeding dynamics: laboratory trials, exclusion cage field studies, and burrow density observations. The work was conducted between June and August 2014. Eight *S. reticulatum* were collected from the Banca Salt Marsh, in Branford, CT for laboratory trials. The organisms were individually placed in aquaria with two types of salt marsh plants, *Spartina alterniflora* and *Spartina patens*, in opposite corners (Figure 2). In the aquaria, the sediment surrounding the combs of plants was collected from areas in the marsh with similar plants species. The vegetation and sediment were sprayed with water collected from Banca Salt Marsh to simulate tidal inundation. Fresh water was placed in two dishes in each aquaria to prevent dehydration. This allowed similar conditions for the plants to grow as in the natural environment. The combs of grasses were counted before and after separate two and four week experiments, to calculate individual consumption rates and determine food preference.

Figure 2 Laboratory set-up: Upper right corner *Spartina alterniflora* and lower left corner *Spartina patens*

Field studies were conducted during the day and night. Night studies consisted of deploying an array of cameras overnight to record natural feeding behaviors (Figure 3). The array included GoPro cameras, flashlights with red bulbs, an infrared camcorder, and infrared lamps. Red light was used to illuminate the focus area of the GoPro cameras. Since *S. reticulatum* are nocturnal, white light is not desirable when attempting to observe natural feeding behaviors.

Figure 3 Camera array, right: GoPro with red flash lights, left: infrared camcorder with infrared lamps

Feeding preference was accessed using a field manipulation experiment. Three experimental treatments were deployed: full cages, cage controls, and non-caged vegetation controls (Figure 4). The cages completely enclosed clumps of plants to prevent any predation (predator exclusion). The cages extended into the ground to prevent underground herbivory. The cage control had holes cut out large enough for *Sesarma* to enter and tested any cage effects (shading, moisture retention, etc.). The third treatment had no cage to mimic the natural environment. Lastly, burrows were counted in different regions of the marsh to calculate burrow density and herbivory pressures. The main focal point for this part of the study was near the main inflow creek on the back portion of Banca Marsh. There was a quick transition from low marsh along the creek banks to high marsh around the central rock structure (Figure 5). This location provided ideal conditions because of the proximity of the two marsh plants to each other. *S. reticulatum* burrows were found in both the high and low regions of the marsh around the central rock.

Figure 4 Field exclusion cages: left to right: full cage, cage control, and non-caged vegetation control

Figure 5 Main focal area of Banca marsh. High marsh is light green in color, while low marsh is darker

Results

Two time periods were observed for the laboratory trials: two-weeks (Figure 6) and four-weeks (Figure 7). An equal variance t-test was performed showing a marginally significant difference in food preference for both the two week ($p=0.077$) and four week ($p=0.083$) time periods, with greater consumption on *S. alterniflora.* Using the difference between the number of combs before the laboratory trials and after the trials, the percent consumed can be used to estimate individual consumption rates (Table 1).

An ANOVA was performed for the caging experiment (Figure 8). There were significant differences among cage treatments ($p = 0.00671$) with greater herbivory on uncaged plants and plant type consumption ($p = 0.000899$). As in the lab trials, the field studies show a preference of *S alterniflora* over *S patens*.

Table 1 Percent consumed 2-week laboratory trial

Crab	Spartina alterniflora	Spartina patens
Francis Crick	0.00	6.25
James Watson	40.00	20.00
Barbara Walters	0.00	0.00
Jacques Cousteau	25.00	2.38
Steve Irwin	40.00	2.78
Betty White	25.00	4.76
Barbara McClintock	0.00	0.00
Average	18.57	5.17

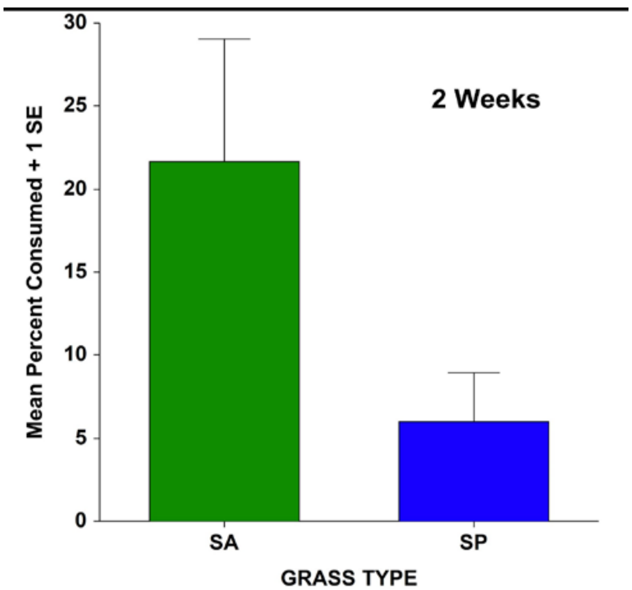

Figure 6 Two-week laboratory feeding preference

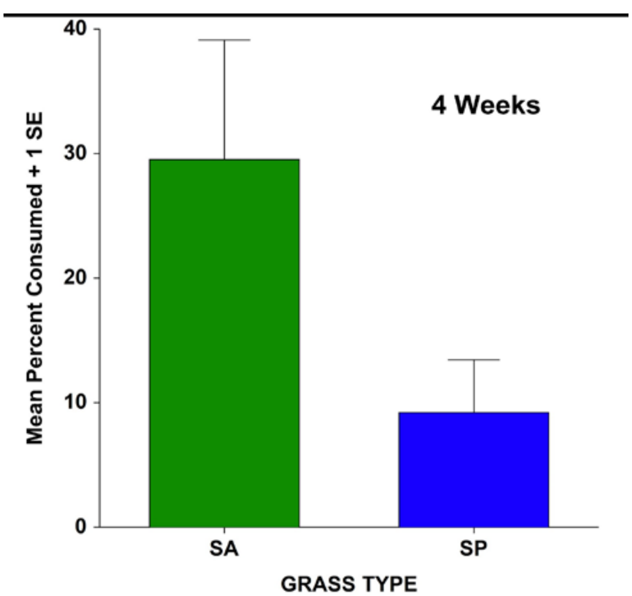

Figure 7 Four-week laboratory food preference

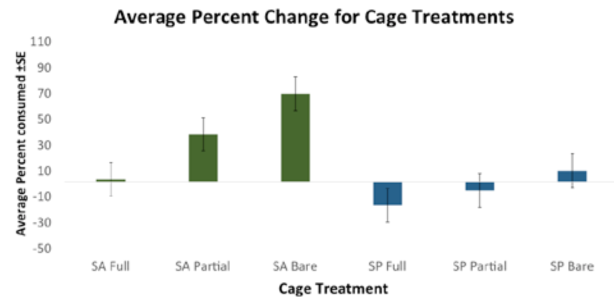

Figure 8 Field exclusion cages and food preference

To determine if there were differences in crab burrow density among different dieback regions, 5 regions were surveyed which were divided into three separate areas and sampled with five replicate quadrats. A nested ANOVA was performed to test for significance among the regions as well as for spatial variation within each region. There was a statistically significant difference in burrow density among regions, $p=0.00365$, but burrow density did not vary within regions, $p=0.538$.

The 30 hours of night video collected indicated that *Sesarma* make slow, deliberate movements, cut vegetation and pull the clippings into the burrow. The rate at which they did this was surprisingly slow, suggested that herbivory rates are slow overall. Crabs were observed clipping pieces of *Spartina alterniflora* off the combs and pulling the piece back into the burrow. The majority of the clippings came from the tips of the blades. The crab reached the tip by either pulling the blade down or climbing the comb to bend the blade down the ground.

Discussion/ Conclusion

The lab trials and field experiments suggest that *Sesarma* has a preference for *Spartina alterniflora* over *S. patens*. This agrees well with previous studies that indicate dieback to occur in primarily low marsh habitats dominated by *S. alterniflora*. However, there are increasing areas of *S. patens* that are also being denuded and this may represent a shift due to changing marsh conditions such as increased tidal level and sea levels. From field observation, *S. reticulatum* is believed to not inhabit burrows that are fully inundated with water. As the sea levels increase, low marsh habitats are inundated for longer periods of time. These extended periods of inundation, may force *S. reticulatum* to inhabit higher marsh habitats with more *Spartina patens.* The burrow densities varied by location on the marsh, usually highest near creeks, suggesting differences in herbivory pressure., Fewer *Sesarma* burrows were found further onto the higher marsh. The difference in burrow density further supports the food preference of *Sesarma*. The burrows are most dense in the lower marsh by the tidal inflow creeks where *Spartina alterniflora* grows, while *Spartina patens* grows further in the high marsh. Some future studies based on these results would be to recreate the lab trails with larger sample sizes and testing the food preference of other salt marsh flora. Since *Sesarma* are invading upper levels of the marsh, there may be a preference for other flora.

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Biography

Timothy Stankye is a current senior at the University of New Haven, expecting to graduate in May 2015 with a double major in Marine Biology and General Biology. Tim plans on pursuing higher education to a doctorate degree leading to a career in aquaculture research.