Site fidelity and circatidal activity of Atlantic fiddler crabs (*Uca pugnax*)

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Introduction

Figure 1. Male fiddler crab with yellow paint marking.

Uca pugnax, Atlantic fiddler crab (Fig. 1), have traditionally been found in low to mid-tidal regions in marshes along the Atlantic coast. The structure of salt marshes in the CT region has been changing due to erosion, and low marsh plants are beginning to encroach into the higher marsh (Luk & Zajac 2013). In recent years, researchers have also observed crabs higher in the marsh than previously reported (Klepner 2010).

Fiddler crabs eat detritus and usually burrow near saltmarsh cordgrass (*Spartina alterniflora)* and mussel (*Mytilus spp*.) colonies (Montague 1980; Bertness & Miller 1984). The burrows allow crabs to avoid heat and desiccation (Montague 1980), and serve to aerate the substrate and increase drainage (Bertness & Miller 1984). As low marsh plants move into the high marsh, the crabs may be expanding into this novel habitat. It is not clear if the crabs observed in the high marsh represent a distinct group that has been excluded from optimal low-marsh habitat by conspecifics , or if there is routine exchange between the two areas as crabs move and forage.

Tidal rhythms have been observed in marine, freshwater, and terrestrial organisms that follow 12.4 or 12.8 hour cycles related to the orbit of the moon (Bennett 1963). In their natural low-tidal habitat, fiddler crabs dig and feed during low tide and hide in burrows to avoid predation during high tide (Palmer 2000). In captivity, crabs have been shown to have peaks of activity three to five hours before low tide that persist in constant laboratory conditions for up to a week before starting to deteriorate (Bennett 1963; Bennett *et.al.* 1957; Barnwell 1966; Palmer 2000; Palmer 1974).

Tidal rhythms are entrained by the onset of inundation during the flood tide. If crabs are long term residents of the high marsh, it is expected that they would have altered activity cycles relative to crabs in the low marsh; however, if crabs routinely move between habitats, no difference in activity patterns would be expected.

Research Goals

- Determine the amount of exchange groups of crabs living in the upper and lower marsh.
- Examine periods of activity for fiddler crabs from both the upper and lower marsh in the lab and compare those to tidal rhythms for the area

Figure 2. L. Kircher, J. Norstog, and Dr. J. Kelly measuring crabs in the high marsh (Banca Marsh, Branford, CT, USA)

Methods

Field: Atlantic fiddler crabs were caught over a 20-min period in high and low marsh regions of Banca Marsh in Branford, CT, USA. Crabs were sexed, measured (carapace width), marked with nail polish (Figs. 1 & 2), and released on two days (June 17th and July 29th) (Fig. 4 A & B). The following day, as many crabs as possible were collected in the same areas over 20-min periods and the numbers of marked and unmarked crabs were recorded. Different colors of nail polish were used to mark the crabs and subdivide the study area into three high marsh and three low marsh zones. In the first trial, only the zone of recapture was recorded, whereas in the second trial, the locations of recapture crabs were marked by GPS, permitting calculations of the distance the crab moved. Total crab population estimates were calculated using the Lincoln-Peterson method.

Lab: Male fiddler crabs were collected from upper and lower Banca Marsh and transported to the University of New Haven. Each crab was set up in an individual habitat (33Lx20Wx12H cm) supplied with marsh mud and a pool of water. Habitats were observed for a week under 24-hr lighting, monitored by motion-activated cameras that recorded activity to laptop PC's (Fig. 3). The data were entered into ActogramJ (v0.8, Yoshii & Schmid 2013, URL: http://actogramj.neurofly.de) to examine activity patterns and plotted against tide tables for the nearest tide station (Branford River, NOAA station 8465233).

Figure 3. Laboratory fiddler crab activity-detection habitats.

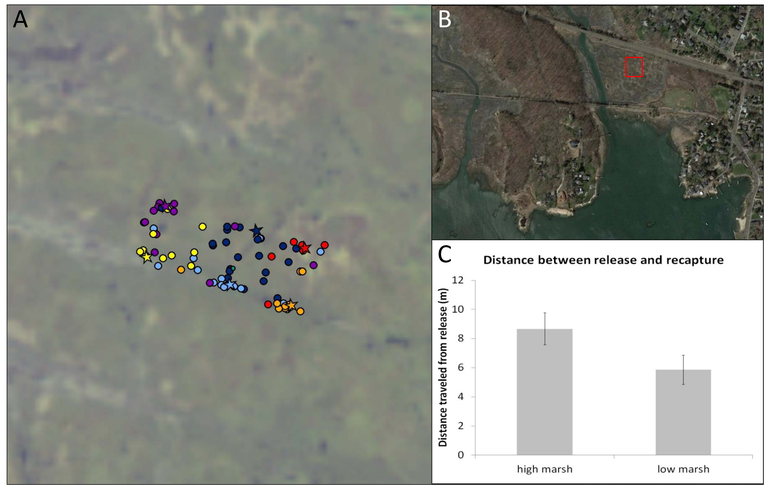

Figure 4. Mark/recapture experiment: A) 29-30 July, stars denote release points, circles denote recapture points of individual crabs; B) Banca salt marsh, CT, USA, red box indicates the study area; C) mean (±SEM) distance between release and recapture for high and low marsh crabs in the second recapture trial.

Results

Field: In both trials, the proportion of crabs moving or remaining in high vs. low marsh habitats was the same (Fig. 5). Most crabs move laterally within habitats rather than between them. The mean distance traveled by high marsh crabs was 8.7 m compared to 5.9 m in low marsh crabs (Fig. 4C); however, this trend was not significant (t-test, p= 0.062).

A total of 842 and 1236 crabs were marked on 18 June and 30 July, respectively. Population calculations using the Lincoln-Peterson method estimated a density of 13.9 crabs/m² in June and 20.1 crabs/m² in July.

Lab: Three lab trials were performed with twelve crabs per trial. There were two mortalities in the first trial and was a technical malfunction in trial three in which two cameras were lost. There is an apparent relationship between activity pattern and tidal rhythms in most of the trials with a mean tidal shift of 62.3 minutes. Low and high marsh crabs do not show a noticeable difference of activity patterns (Fig. 6). Percent activity each day decreased during the trial, and the rhythmicity of the activity patterns decayed and disassociated from the natural tidal cycles over time.

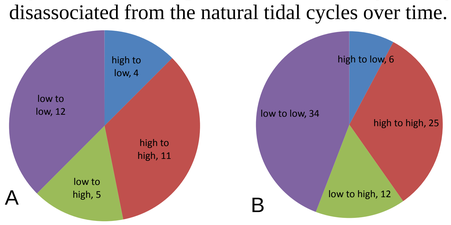

Figure 5. Interhabitat movement patterns of *Uca pugnax* on Banca Salt Marsh
A. Trial 1: 18 June , 2013
B. Trial 2: 30 July , 2013

Discussion

There was some exchange of crabs between the high and low zones, but the majority stayed near to where they were released (Fig.4A), and more crabs moved within the same tidal zone than between (Fig.5). These findings suggest that the crabs in the high and low marsh are not distinct sub-groups and that movement throughout the marsh is commonplace.

Crabs in the high marsh traveled almost 2-m farther than crabs in the low marsh, though this was not quite significant. The low marsh is regularly inundated by tides that bring new food resources, whereas the high marsh is sporadically flooded, and for shorter intervals. It is possible that crabs in the high marsh are more nomadic, traveling farther in search of resources. It is possible that this trend may be come more clear with repeated field trials, a larger sample size, and more detailed categorization of habitat quality.

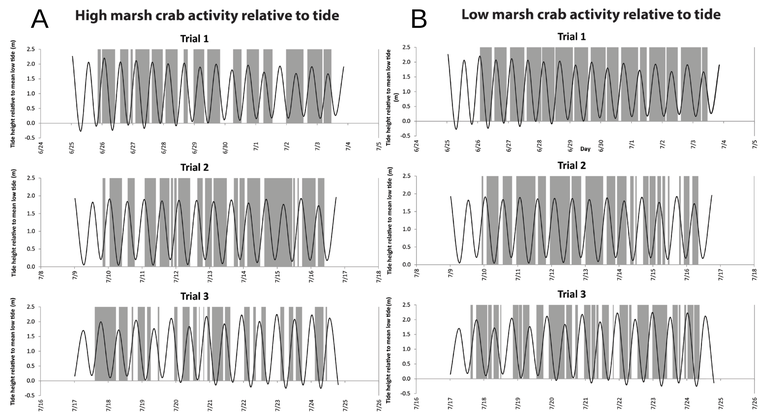

Figure 6. Activity of A) high and B) low marsh crabs relative to natural tidal cycle at the Branford River mouth. Gray areas indicate active periods, black line indicates tide height.

Discussion (cont.)

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Crabs in the high marsh traveled farther than crabs in the low marsh, though this was not quite significant. The low marsh is regularly inundated, bringing new food resources, whereas the high marsh is sporadically flooded, and for shorter intervals. Since food and water resources available, low marsh crabs do not need to expend energy for extra movement and may be less likely to move long distance, whereas crabs in the high marsh are more nomadic, traveling in search of resources. This trend may become more clear with repeated field trials, a larger sample size, and more detailed categorization of habitat quality.

In a previous study, crabs showed distinct tidal activity rhythms that shifted 50.1 minutes/day (Brown & Schriner 1957). In this study, the tidal shifts were longer, averaging 62.3 minutes/day. Some of this shift is related to the tidal cycle, which shifts by 25 minutes/day. Additionally, biological rhythms, when removed from the cues that entrain them (e.g. inundation), typically advance ~15 minutes per day. Our results, though slightly longer than expected, support the argument that activity in fiddler crabs is related to circatidal rhythms. As noted previously, crab activity in the 1st and 2nd trial peaked after high tide and several hours before low tide, and persisted through the low tide (Brown & Schriner 1957, Bennett 1963). This was expected because crabs typically maintain their burrows, forage, or mate during low tide while during high tide they hide from predators in their burrows (Palmer 2000). As noted by other researchers, *Uca pugnax* started to lose the association with tidal rhythms when held under constant conditions (Barnwell, 1966). Similar results were noted in this study, with the peaks of activity becoming more sporadic and less orderly over time, and the amount of activity decreasing.

Based on the field and lab trials in this study, high and low marsh crabs cannot be considered distinct groups. There is exchange and movement between the groups, though low marsh crabs appear less likely to range widely than their high marsh relatives.

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