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The Role of Adult Fiddler Crab Environmental Acoustic Cues and Chemical Cues in Stimulating Molting of Field-Caught Megalopae

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Abstract
In mid-Atlantic estuaries, three fiddler crab species, Uca pugilator, Uca pugnax and Uca minax co-occur, with their adults occupying different habitat types distinguished by salinity and sediment size. Some evidence exists that selective settlement is responsible for this separation but the mechanism is largely unknown. We tested the hypothesis that field-caught megalopae would accelerate metamorphosis in the presence of adult species-specific environmental acoustic cues and conspecific chemical cues. We placed megalopae in seawater with and without adult chemical cues, exposed them to one of three sound treatments for 8 days, and recorded the time each megalopa took to metamorphose. In the absence of adult chemical cues, very few megalopae molted regardless of sound treatment. Molting in the presence of habitat sound and chemical cues varied by species. Many U. pugilator molted in all sound and odor combinations, including no odor/sound. U. pugnax was stimulated to molt by chemical cues from either U. pugilator or U. pugnax, but molting was similar across sound treatments. Our results do not support the hypothesis that sound stimulates molting by fiddler crab megalopae, but support the role of chemical odors from adults as molting cues.

Keywords
fiddler crabs, megalopae molting, chemical cues, acoustic cues

Disciplines
Ecology and Evolutionary Biology | Environmental Studies | Marine Biology | Terrestrial and Aquatic Ecology

Comments
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The role of adult fiddler crab environmental acoustic cues and chemical cues in stimulating molting of field-caught megalopae

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Abstract

In mid-Atlantic estuaries, three fiddler crab species, Uca pugilator, Uca pugnax and Uca minax co-occur, with their adults occupying different habitat types distinguished by salinity and sediment size. Some evidence exists that selective settlement is responsible for this separation but the mechanism is largely unknown. We tested the hypothesis that field-caught megalopae would accelerate metamorphosis in the presence of adult species-specific environmental acoustic cues and conspecific chemical cues.

We placed megalopae in seawater with and without adult chemical cues, exposed them to one of three sound treatments for 8 days, and recorded the time each megalopae took to metamorphose. In the absence of adult chemical cues, very few megalopae molted regardless of sound treatment. Molting in the presence of habitat sound and chemical cues varied by species. Many U. pugilator molted in all sound and odor combinations, including no odor. U. pugnax was stimulated to molt by chemical cues from either U. pugilator or U. pugnax, but molting was similar across sound treatments. Our results do not support the hypothesis that the sound stimulation molt by fiddler crab megalopae, but support the role of chemical odors from adults as molting cues.

Background

• The sand fiddler crab, Uca pugilator, the mud fiddler crab, Uca pugnax and the red-legged fiddler crab, Uca minax commonly co-occur in mid-Atlantic estuaries (Crane 1975) but occupy different microhabitats (Teal 1958; Miller & Maurice 1973).

• U. pugilator occupies moderate to high salinity sandflats and sandy areas of salt marshes. U. pugnax occupies low salinity sandflats and sandy areas of salt marshes. U. minax occupies low salinity salt marshes.

• Fiddler crab zoae of all species develop offshore: megalopae reinvent estuaries using flood-tide transport ( DeVries et al. 1994).

• Some evidence exists for selective settlement (Broker et al. 2005, Welch et al. 2015), but the mechanism driving the process is unknown.

• Cues from favorable habitat may stimulate and/or accelerate molting by megalopae to the benthic first crab instar, whereas cues from unfavorable habitat may inhibit and/or delay metamorphosis.

• Odors of adult conspecifics and/or adult habitat have been shown to accelerate molting in lab-reared megalopae of all species (e.g. Christy 1989, O’Connor 1991, O’Connor & Jude 2004, O’Connor & Van 2006) and stimulate settlement in field-caught megalopae (Welch et al. 2016).

• Recent studies have determined that environmental acoustic cues trigger settlement behavior in some common coral species, sponges, and reef fish larvae (e.g. Vermeij et al. 2010, Lillis et al. 2014, Barth et al. 2015) and coastal crab megalopae (Stanley et al. 2011).

• It is important to study acoustic cues because: sound travels farther underwater and can be detected at greater distances than chemical cues; Uc spp. rely on sound for mating rituals; and the spatial and extent intensity of anthropogenic sound in the ocean is increasing.

Hypothesis

Field-caught megalopae will be stimulated to molt faster when exposed to the specific sound of their adult habitat and chemical cues from adult conspecifics.

Methods

• We deployed a Sound Trap in a sandflat and salt marsh to record the soundscape of adult settlement sites (Fig. 1) over a 282:229 2016

• Using Adobe Audition, we clipped a 60-minute sound segment during the peak of the flood tide from each recording and amplified the signals so megalopae in each experimental container in the were exposed to ~115dB re: 1µPa (~20dB louder than sounds in the control tanks: ~95dB re: 1µPa).

• To prepare chemical cue odor water, we collected adult U. pugilator from the Rachel Carson Estuarine Research Reserve on Carrot Island in Beaufort, North Carolina (USA) and adult U. pugnax from the Bell Creek Salt Marsh, approximately 10 km from the Duke University Marine Laboratory (Fig 1). We soaked 50 g of adult crabs in 1000 ml of filtered seawater for 1 hour (Fig. 2a).

• We collected megalopae with a plankton net near the Duke Marine Lab in Beaufort, North Carolina on nocturnal flood tides in July 2016 (Fig. 2b).

• We placed 26 megalopae in 400 ml of either filtered estuarine seawater or one of the 2 odors for 8 days at 25º C and a 14:10 light:dark cycle in one of the three sound treatments. We changed the water and fed the megalopae Artemia nauplii daily (Fig. 2c).

• Molting status was monitored 4 times daily (0600, 1200, 1800, 2400). We preserved any megalopae that molted in KL, ethanol for identification. After the 8 days, we preserved all remaining megalopae from either treatment, and Carrot Island sound treatment. Number above indicates each sample size.

• The proportion of each species of fiddler crab (genus Uca) megalopae that molted in each water treatment—control (no sound), Bell Creek sound treatment, and Carrot Island sound treatment. Number above indicates each sample size.

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