Competition between *Littoraria irrorata* and *Melampus bidentatus* in the high marsh zone

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Abstract

Strong pressures from abiotic conditions (e.g., temperature, salinity, inundation) and biotic interactions, such as competition, lead to unique distributions of the gastropods, *Melampus bidentatus* and *Littoraria irrorata*, in low-, mid- and high-marsh zones of southeastern salt marshes. Although *Littoraria* can displace *Melampus* from mid-marsh to high-marsh zones, *Littoraria* abundance and biomass is relatively high in the high marsh zone. Three *Littoraria* density manipulations were used in two habitats differing in dominant plant species *Juncus roemerianus* and *Salicornia virginica*, to test whether competition or abiotic conditions affected the distribution of *Melampus* in the high-marsh zone. Growth rates and survivorship were recorded to assess the competitive effects of *Littoraria* on *Melampus*. Soil constituents (e.g., sodium, pH), soil temperature, and soil salinity analyses within patches of *Juncus* and *Salicornia* were used to examine if abiotic conditions influenced differences in distribution of *Melampus* in the high marsh. *Melampus* growth was not significantly different among the three density treatments in either *J. roemerianus* or *S. virginica* habitats. *Melampus* survivorship was significantly different between habitats (higher in *Juncus* than in *Salicornia*) but not among varying density treatments. Soil content was significantly different between *Juncus* and *Salicornia* for pH, phosphorous, and sodium. Temperatures were, on average, higher in *Salicornia* than in *Juncus*. No evidence for competition was found in either *Juncus* or *Salicornia*. Therefore, habitat suitability, in particular abiotic conditions such as salinity and temperature, are most likely determining gastropod assemblages in the high marsh zone of Waites Island.

Introduction

- *Melampus bidentatus* is known to be limited to the high marsh of southeastern US salt marshes by competitive displacement from the mid-marsh by *Littoraria irrorata*. However, *Littoraria* may also be abundant in the high marsh zone.
- Patterns in *Melampus* distributions suggest either abiotic conditions or biotic interactions may be structuring gastropod assemblages in the high marsh.
- The overall goal was to examine the effects of *Littoraria irrorata* on the growth and survivorship of *Melampus bidentatus* in the high marsh and to understand the mechanisms structuring *Melampus* distributions.

Objectives

- Examine the distribution of *Littoraria irrorata* and *Melampus bidentatus* (Figure 1) in the high marsh.
- Examine effects of *Littoraria* on growth and survivorship of *Melampus* in habitats dominated by two plant species:
  - *Juncus roemerianus*
  - *Salicornia virginica*
- Examine abiotic conditions in *Juncus* and *Salicornia* that may affect distributions of *Melampus* and *Littoraria*.

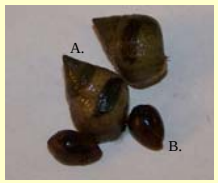


Figure 1. Marked individuals of *Littoraria irrorata* (A) and *Melampus bidentatus* (B).

Figure 2 . Enclosures used in Growth and Survivorship Experiment.

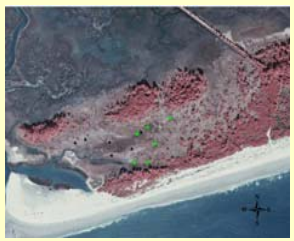


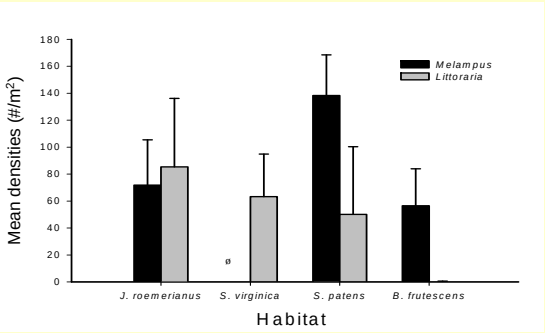
Figure 3. Ariel view of field site. Patches were south of causeway. Green boxes represent patches of *Juncus roemerianus* and black triangles represent patches of *Salicornia virginica.*

Methods

- Studies were conducted in the salt marsh behind Waites Island, SC (Figure 3).
- Distributions were estimated in 1 m X 1 m quadrats haphazardly placed in habitats differing in dominant plant species
- Differences among habitats were statistically assessed using MANOVA.
- Individuals for growth and survivorship were collected, marked and were placed in square enclosures (area = 1 m^2 height = 0.5 m) (Figure 2)
- Three treatments included *Melampus* at a constant density of 40 individuals. *Littoraria* densities consisted of three levels: zero, an ambient density of 40 individuals, and 80 individuals (2× ambient). A control enclosure of zero individuals was used to estimate cage effects on habitat.
- Treatments were repeated in *Juncus* (n = 6) and *Salicornia* (n = 6).
- Growth and survivorship were estimated at end of experiment (12 weeks) on recovered individuals. Survivorship was repeated during Fall months to assess survivorship during cooler temperatures (*Melampus* were found dead during first two weeks of summer survivorship experiment).
- Differences among treatments were assessed statistically using a one-way ANOVA for growth and survivorship.
- Soil samples from *Juncus* and *Salicornia* were tested for concentrations of Na, P, Mg, Mn, B, Zn, Copper, Calcium, Potassium and pH.
- Differences in concentrations of soil constituents between *Juncus* and *Salicornia* were assessed statistically using a one-way ANOVA.
- Temperatures(ºC) were measured during the 12-week experiment to assess differences in temperatures between habitats.
- Chlorophyll *a* and plant stem heights, density and percent coverage were also assessed.

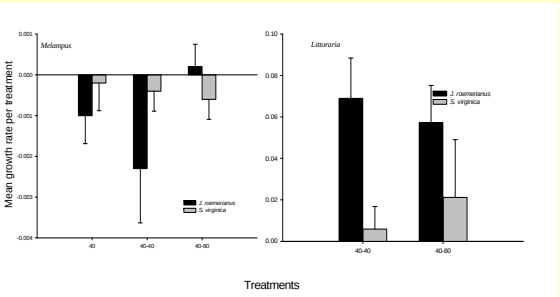
Results

Snail distributions per habitat



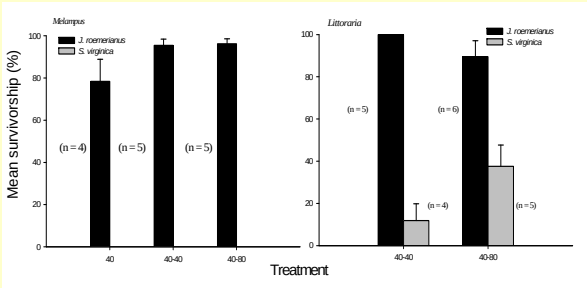
- A significant difference was found among habitats for *M. bidentatus* abundance (MANOVA, $F_{3,20} = 13.086$, $P < 0.001$). *Melampus* individuals were found in higher numbers in *J. roemerianus* and *S. patens*. No difference was detected among habitats for *L. irrorata* abundance (MANOVA, $F_{3,20} = 2.044$, $P = 0.140$).

Growth rates for *Melampus* and *Littoraria*



- Differences in growth rates for *M. bidentatus*, as well as, *L. irrorata* among treatments were not significant in *J. roemerianus* (ANOVA, *Melampus:* $F_{2,15} = 1.832$, $P = 0.194$; *Littoraria:* $F_{1,10} = 0.200$, $P = 0.664$) or in *S. virginica* (ANOVA, *Melampus:* $F_{2,15} = 0.070$, $P = 0.933$; *Littoraria:* $F_{1,10} = 0.260$, $P = 0.621$).

Littoraria and *Melampus* survivorship



- Percent Survivorship was not significantly different among treatments in *J. roemerianus* (ANOVA, $F_{2,11} = 3.00$, $P = 0.91$) or in *S. virginica* for *Melampus* individuals. *Littoraria irrorata* survivorship was not significantly different among treatments in *J. roemerianus* (ANOVA, $F_{1,9} = 1.553$, $P = 0.244$) or *S. virginica* (ANOVA, $F_{1,7} = 3.694$, $P = 0.096$)

Mean Percent Survivorship for *Melampus bidentatus*

Treatment	Summer	Fall
40	0.00	48.02
40/40	0.00	66.70
40/80	0.00	80.00

- *Melampus* survivorship increased from Summer to Fall in patches of *Salicornia.*
- Individuals were found burrowed within the first 2.5 cm beneath the soil during Fall survivorship.

Temperatures for *Juncus* and *Salicornia*

Patch	Max. Temperature	Min. Temperature	Mean Temperature	Degree Days
Juncus 2	45.5	11.3	24.7	2294
Juncus 3	48.7	12.6	26.7	2477
Salicornia 3	50.2	8.2	27.7	2577
Salicornia 5	50.2	8.8	26.8	2492
Salicornia 1	51.4	11.8	28.0	2600

- Mean temperatures (ºC) were consistently higher in *Salicornia* than in *Juncus.*
- Additional abiotic conditions were also significantly different between *Juncus* and *Salicornia.* Salinity, pH and P were significantly higher in *Salicornia;* interstitial Na concentrations were significantly higher in *Juncus.*

Conclusions

- Growth and survivorship of *Melampus* was not affected by presence or density manipulations of *Littoraria* in either habitat.
- Survivorship was significantly different between habitats, suggesting abiotic conditions (i.e., higher temperatures) are structuring *Melampus* distributions in the high marsh.
- *Melampus* populations may not be affected by competition because the high marsh may be more heterogeneous than expected allowing for less overlap of resources and more suitable habitats.

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