How changes in vegetation patterns on the salt marshes caused by tidal inundation and climate change may be affecting reproduction of the salt marsh snail, *Melampus bidentatus*

Danielle Perry
Department of Biology and Environmental Science/ Marine Biology Major

Abstract

The reproductive patterns of the salt marsh snail, *Melampus bidentatus*, were examined at the Banca Marsh in Branford, Connecticut, during the summer of 2013. The focus of the study, was to determine if reproduction of *Melampus* has been influenced by climate change, tidal inundation, or possibly the decrease in *Spartina patens* vegetation patches. Statistical analysis shows that *Melampus* abundance among patch types is marginally significant, but the egg case abundance among patch types is not significant. The statistical analysis also shows that there is a significant difference in the number of eggs per egg case among patch types. More research on this topic is needed, but the findings of this project suggest that *Melampus* reproduction may be affected by changes occurring on salt marshes.

Introduction

Salt marshes and the various plant and animal species that reside in them have a significant role in the function of coastal ecosystems. These species may be impacted by climate change related alterations in salt marsh environments. Over the last decade, the changes caused by tidal inundation and erosion have become more apparent on Connecticut salt marshes. Tidal inundation and erosion have reduced the abundance of *Spartina patens*, the once dominant grass, which is causing the increases of short *Spartina alterniflora* patches on salt marshes. One of the major questions is how resident species are responding to the various changes within salt marshes. One of the species that may be affected by the environmental changes is the salt marsh snail, *Melampus bidentatus.*

Melampus bidentatus (Fig. 1) is a hermaphroditic, pulmonate snail species found in salt marshes along the east coast of North America (Hausman, 1932, 1948). The annual reproductive season lasts about six weeks between late May and early July. Each individual deposits about 40 gelatinous egg masses about 1-2mm in length (Fig. 2) and each mass contains an average of about 850 eggs (Apley 1970). The eggs develop into free-swimming veliger larvae which are transported to coastal waters by the receding spring tides that inundate the salt marsh. The larvae spend about 4-6 weeks as planktonic larvae before returning to the salt marshes during high tide where they metamorphose into juvenile snails (Apley 1970).

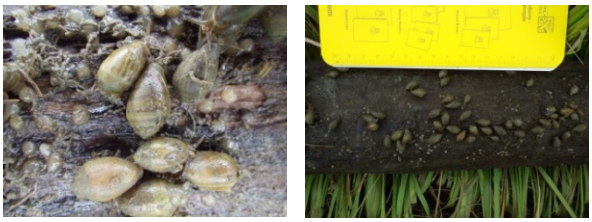

Figure 1. *Melampus bidentatus.* Yellow field book is 16 centimeters wide.

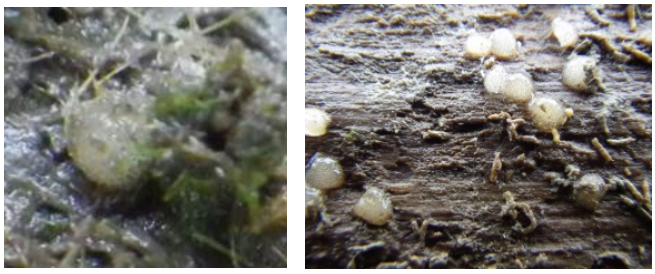

Figure 2. Cluster of *Melampus* egg cases on left. Close up view of egg case on right.

The main objective of this study was to examine the effects changes in salt marsh structure have on the reproduction of *Melampus*. Since the preferred habitat, *Spartina patens,* is declining and is being replaced by short *Spartina alterniflora*, the reproductive patterns of the snail may be impacted by such changes. Previous research conducted by Dr. Roman Zajac's lab on the Banca Marsh in Branford, Connecticut has shown that the vegetation that contains the highest abundances of *Melampus* is not consistent from year to year and changes between *Spartina patens* and short *Spartina alterniflora.* This study focuses primarily on how *Melampus*'

reproductive characteristics differ among various vegetation patches. Very few field studies have been conducted on *Melampus* reproduction, and as such this research is needed to make a complete conclusion.

Figure 3. Short *Spartina alterniflora* on left. *Spartina patens* patch, the native habit for *Melampus* on right.

Methods and Materials

The study was conducted at Banca Marsh in Branford, Connecticut. Five locations on the marsh were sampled (Fig. 4), representing different types of marsh habitats. Areas A, D and C are comprised of patches of *Spartina patens* bordered by either *S. patens* hummocks and/or short *Spartina alterniflora*. Area B is a small, remnant *S. patens* patch, and Area E has an extensive short *S. alterniflora* patch.

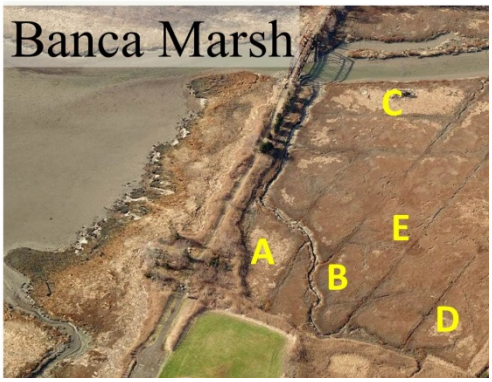

Figure 4. Aerial view of the study site indicating the five locations studied.

In each area, five replicate samples were obtained in a 10 cm by 10 cm quadrat (Fig. 5, Table 1). Vegetation within the quadrats was cut down to the base of the stems and checked for snails. Snails found on the surface and on stems were counted and recorded. Two different sampling methods were used during this study to determine which worked best for this type of field study. Initially, after the vegetation was cut, the eggs cases within the quadrat were counted. Egg cases were found on the marsh surface and on the base of the stems of vegetation. A sample of the peat was taken back to the lab in order to closely examine the egg cases (Method I). Subsequently, a method was developed to improve accuracy when counting egg cases. After the vegetation was removed, a blade was used to cut underneath the surface of the soil in order to remove it from the ground such that the area within the quadrat remained completely intact. This was placed in a plastic container, and returned to the lab where the samples could be more closely examined with the aid of a dissecting microscope to identify and count the egg cases (Method II). If egg cases were found, five egg cases from each sample were dissected under a microscope and the number of eggs within the egg cases was determined. Analysis of variance (ANOVA) was used to test differences in abundance and reproductive characteristics among vegetation patch types.

Figure 5. Sampling 10cm by 10cm quadrat

Date	Location	Method Used
June 17, 2013	D	Method I
June 18, 2013	D	Method I
June 25, 2013	E	Method II
July 2, 2013	A	Method II
July 8, 2013	A	Method II
July 11, 2013	C	Method II
July 16, 2013	E, B	Method II
July 24, 2013	D, C, A	Method II
July 30, 2013	B	Method II

Table 1. Dates when each area was sampled, and the sampling method that was used.

Results and Discussion

Over the past several decades, *Spartina patens* patches have been reduced on salt marshes and short *Spartina alterniflora* has become more abundant, likely due to some combination of reductions in sediment supply and climate related increases in tidal inundation. According to the literature, *Melampus* are mostly found in

Spartina patens vegetation (Hausman, 1932). However, research at the Banca Marsh has shown that for the last few years the highest abundances of *Melampus* have alternated between *Spartina patens* and short *Spartina alterniflora* patches (Zajac, unpublished data). In this study similar abundances of *Melampus* were found in *Spartina patens*, short *S. alterniflora* patches, and *S. patens* hummocks (Fig. 6). ANOVA results showed that abundances among patch types are marginally significant (p=0.073), which likely reflects the low abundance that was found in remnant *Spartina patens* patches.

Although similar *Melampus* abundance was seen in these patches, the number of egg cases found in *S. patens* hummocks was much lower than in short *Spartina alterniflora and S. patens (*Fig. 7). However, ANOVA testing showed that the egg case abundances were not significantly different among patches (p=0.314). The calculation of a variance to mean ratio to access dispersion indicates the egg cases occurred in clumps. The highly aggregated clumps of egg cases caused high variation in the mean number per patch. These results indicate that in the field snails lay their eggs while they are aggregated.

Many *S.patens* meadows on salt marshes are changing over to hummocked areas. Although snail abundances are similar to that found in other patches, low numbers of egg cases and numbers of eggs per egg case suggest that snails in these habits have a lower fecundity and thus may make smaller contributions to overall population maintenance in the salt marsh.

Although *Melampus bidentatus* is typically found in *Spartina patens*, my results indicate that while changes in salt marsh vegetation patterns and hydrologic characteristics may cause increasing areas of short *Spartina alterniflora* and hummocked *S. patens*, while areas of *Spartina patens* decrease, *Melampus* abundances do not appear to be affected. However, my study indicates that their reproductive characteristics may be changing in some patch types. ANOVA testing indicates that there is a significant difference in the number of eggs per egg case among the vegetation patches (p=0.013), with more eggs per egg case laid in the short *Spartina alterniflora* than the other vegetation patches (Fig.8).

Figure 9 shows the number of egg cases found in early summer (June 16-June 17, 2013) versus late summer (July 17-July 30, 2013). There is a great decrease in egg cases in late summer. According to the literature, reproduction takes place from late May to early July (Apley 1970). Therefore, this sudden drop in reproduction was expected when considering the typical reproductive period.

My observations indicate that in the field, *Melampus* lay their eggs on the marsh surface, on the base of plant stems, or on the underside of hard surfaces such as logs. This may allow the egg cases to withstand periods of desiccation, but make those on the mud surface vulnerable to predation.

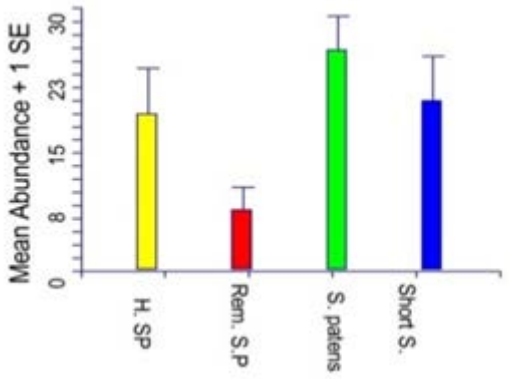

Figure 6. Mean number of snails found in each particular habitat. H.SSP - hummock *Spartina patens*, Rem. S.P. - remnant *Spartina patens*, S. patens- *Spartina patens*, and Short *S.*- short *Spartina alterniflora*.

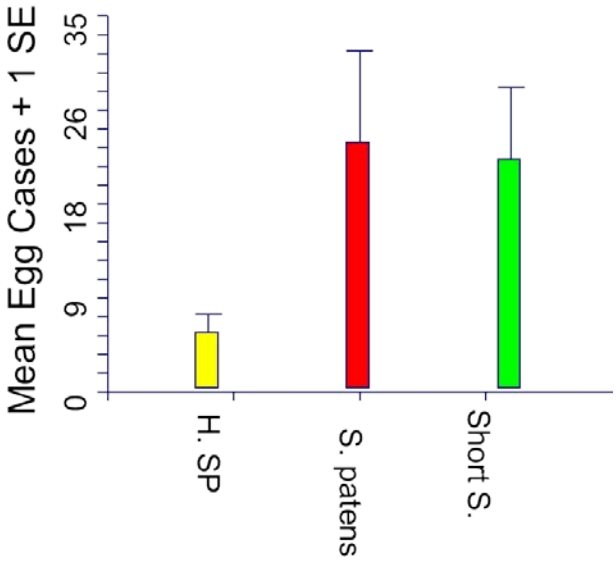

Figure 7. Mean number of egg cases in different salt marsh habitats. Habitat designations as in Fig. 6.

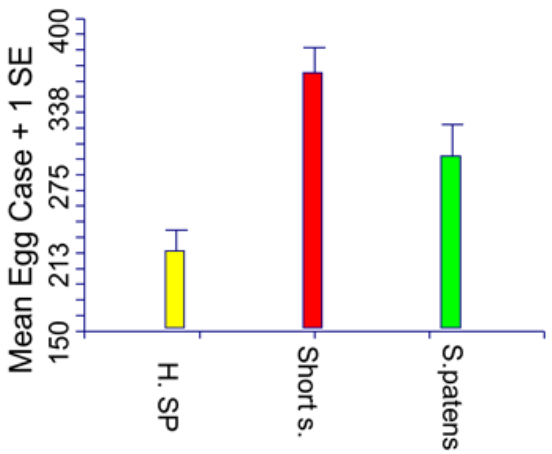

Figure 8. Mean number of eggs per egg case in different salt marsh habitats. Habitat designations as in Fig. 6.

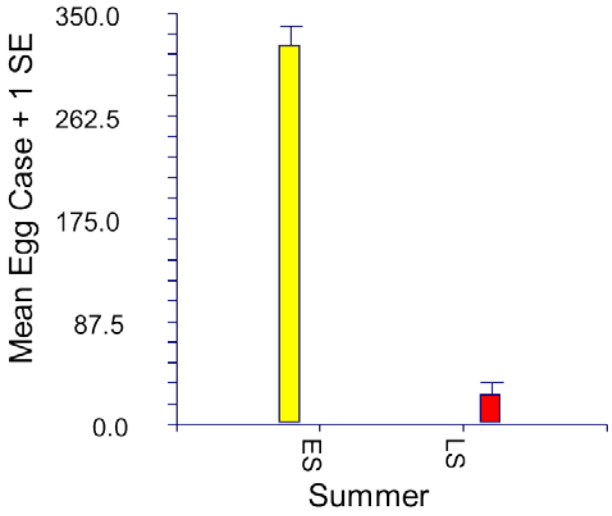

Figure 9. Mean number of egg cases found in early summer, ES, (June 16-June 17 2013) versus late summer, LS (July 17 –July 30 2013).

Conclusions

Since this was the first study of *Melampus* reproduction on changing salt marshes, it is difficult to come to a complete understanding of how habitat changes are affecting *Melampus* reproduction. The distribution of egg cases indicates that eggs are being laid in clumps, which supports the idea that the snails lay their eggs while they are aggregated. Although more eggs are being laid in short *Spartina alterniflora*, the ANOVA testing indicates this is not statistically significant due to the high variability caused by clumped aggregations of egg cases across the vegetation patches. However, the average number of eggs per egg case, approximately 400 eggs, is lower than previously reported in literature, 850 eggs per egg case (Apley 1970). This suggests a possible decline in the overall fecundity due to environmental conditions. More research is needed in order to determine trends and draw more robust conclusions about how salt marsh changes may be impacting resident marsh species.

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Biography

Danielle Perry is currently a junior and expects to graduate in 2015 with a Bachelor's Degree in Marine Biology and Environmental Science. She plans on pursuing graduate education.