Larval settlement and juvenile growth of *Capitella* sp. I

Holly Parkis

hkparkis@mtholyoke.edu; Mount Holyoke College, 50 College St., South Hadley, MA 01075; Institute of Marine and Coastal Sciences, Rutgers University, New Brunswick, NJ 08901; http://marine.rutgers.edu/rios

***Capitella* sp. I larval settlement and growth were significantly higher in response to an increase in the organic matter present in the sediment. Different organic matter concentrations were established by mixing unbaked sediment with sediment baked at 325°C for 24 hours. Settlement was examined in a laboratory flume with a free stream velocity of approximately 5 cm s^{-1}. Short-term growth experiments were also performed. The results suggest that the opportunistic character of the species may be partially related to both larval selection and increased growth in sediments with a higher organic content.**

INTRODUCTION

This project examines *Capitella* sp. I larval settlement in response to variations of organic material in the sediment. *Capitella* sp. I (Fig. 1) is a small, opportunistic polychaete often abundant in organic-rich sediments (Butman et al. 1988, Snelgrove et al. 2001). It is found in nearly monospecific macrofaunal communities, and often undergoes a boom-bust life-cycle (Grassle and Grassle 1974, Tenore and Chesney 1985). *Capitella* sp. I populations are thought to highly dependent on the usable organic material in sediment (Linton 1999, Linton and Taghon 2000) depletion may cause the crashes (Snelgrove et al. 20 An increase inorganic matter has the opposite effect; *Capitella* sp. I has demonstrated earlier maturation and increased fertility in highly organic-rich sediments (Levin et al. 1996).

Figure 1. *Capitella* sp. I adult female.

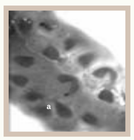

Figure 2. *Capitella* sp. I embryos in a brood tube. Note yolk (a).

As *Capitella* sp. I larvae (Fig. 2) are lecithotrophic and immediately competent upon release from the brood tube, larval selection is possible, and the possibility of increased fertility in richer sediment would be adaptive. *Capitella* sp. I larvae choose organic-rich sediment over organic-devoid sediment in still water (Butman et al. 1988), flume flow (Butman and Grassle 1992), and natural environments (Snelgrove et al. 1999). However, larval selectivity faced with different

While Linton (1999) concluded that the larvae settled on whatever sediment contained over a certain threshold of organic content -- although they did settle faster on sediment with high organic content -- it is possible that the apparent failure in discrimination was caused by the absence of flow. The hypotheses tested in my experiment were 1) that *Capitella* sp. I larvae would settle most preferentially on the most rich sediment available in the flume flow, with a decrease in settlement corresponding to the decrease in organic matter in the sediment, and 2) that *Capitella* sp. I juveniles would experience the most growth in the most rich sediment, with a decrease in growth corresponding to the decrease in organic matter in the sediment. The null hypotheses were that the organic matter in the sediment would not have an effect in either case.

MATERIALS & METHODS

I. Larvae: *Capitella* sp. I from J. Grassle's cultures were kept at 15ºC. Larval use procedures were according to Linton (1999). **II. Sediment:** Tape Mud Creek (TMC) sediment, collected near Tuckerton, NJ, was used. It was frozen and thawed, and bioavailable organic material was removed by baking for 24 hours at 375ºC (Linton 1999, Linton and Taghon 2000); the baked mud was ground and sieved at 150 µm. Mixtures of the baked and unbaked sediment were made at 25% unbaked and 75% unbaked levels, and samples of all four treatments were frozen for future CHN analysis. **III. Flume:** A small flume (see Figure 1), holding 120 l, was used in order to keep the quantity of water, sediment, and larvae low. It is constructed of Plexiglas and is 23.5 cm wide, with glass panes in the walls allowing for Laser Doppler Anemometry (LDA) flow characterization. A four-cell linear array was set perpendicular to the flow; each cell was a cylinder 3 cm in diameter and 1 cm deep. The flume was filled to a depth of 10 cm.

IV. Flume survival: 100 *Capitella* sp. I larvae were placed in the flume and allowed to circulate for two hours. They were then collected and their survival and recovery determined. **V. Flume experiment:** The four sediment mixtures (100% TMC mud, 75% TMC mud, 25% TMC mud, and 0% TMC mud) were randomly placed in the array and allowed to settle overnight in moving water. 200 larvae were dispersed upstream of the array and the water was allowed to circulate at 5 cm s^{-1} (Butman and Grassle 1992), measured by timing the rate of particle movement in the flow, for four hours. Five repetitions were performed. The percentage data were log-transformed and analyzed via ANOVA and the Least Significant Difference test.

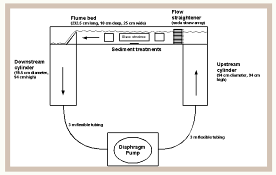

Figure 3. Small flume used in larval selection experiments.

VI. Short-term growth: Five larvae were placed in a Stender's dish containing one of the four sediment treatments at 15ºC, with 9 replicates of each treatment. At 5, 15, and 25 days 3 replicates of each treatment were removed and the worms counted and measured. We analyzed the length data using a Student *t*-test assuming unequal variance and grouping the 100% and the 75% TMC mud and the 25% and 0% TMC mud.

Table 1. Larval settlement. a = larvae ≤ 48 hours old, b = larvae ≤ 24 hours old, c = 150 larvae ≤ 24 hours old, 50 larvae ≤ 48 hours old. In each experiment 200 larvae were added.

	100% TMC mud	75% TMC mud	25% TMC mud	0% TMC mud	Total sediment recovery	Flume water
Run One[b]	11	9	2	0	22	50
Run Two[a]	14	6	0	0	20	27
Run Two[a]	5	2	1	0	8	47
Run Three[b]	31	31	6	3	71	53
Run Four[c]	22	9	4	0	35	63

RESULTS

Recovery rate in the flume survival experiment was 88%, with the survival rate at 80%, but in the flume settlement experiments was much lower, with a total mean recovery rate of 39.6% and an average of 16% recovered from the sediment. Recovery was higher with younger larvae (Table 1) – when the larvae were ≤ 24 h old, the recovery was 49% on average, but when the larvae were ≤ 48 h old, the recovery was 23.5%. LDA analysis was unsuccessful, though the laser functioned on a larger flume. When analyzed with ANOVA, the sediment treatments were shown to have a highly significant effect on the percent settlement (P = 0.0001) (Fig. 4). The least significant difference test showed the 0% TMC mud, the 25% TMC mud and the 75% TMC mud to be significantly different from each other; however, there was no significant difference between the 75% TMC mud and 100% TMC mud, which had the highest settlement.

The *Capitella* sp. I grew significantly faster in the 100% and 75% TMC mud group than in the 25% and 0% TMC mud group, at P = 0.0001 (Fig. 5). However, growth in the 100% and the 75% TMC mud was not significantly different at the $P < 0.05$ level (P = 0.52), and neither was growth in the 25% and the 0% TMC mud (P = 0.3). Growth overall was very low, especially after the 5 day mark. Survival at 25 days was 87% in the 0% TMC mud, 80% in the 75% TMC mud, 73% in the 25% TMC mud, and 53% in the 0% TMC mud.

DISCUSSION

The *Capitella* sp. I larvae settled preferentially into sediment with higher organic content; the effect of organic content on settlement was highly significant. However, the 100% TMC mud and the 75% TMC mud had similar settlement; this may support the hypothesis that the *Capitella* sp. I larvae are unable to discriminate among sediment organic contents above a certain threshold (Linton 1999).

Overall recovery rate was relatively poor compared to the preliminary recovery experiment (23.5 to 62.0% overall, as compared to 88% in the preliminary experiment). It is worth noting that that the runs which used larvae ≤ 24 h old had much higher recovery (49%, on average) than those which used larvae ≤ 48 h old (24%), probably due to spontaneous settlement of older larvae on the plexiglas of the flume. The larval cultures are highly inbred as well, and inbred larvae are suspected of settling spontaneously more frequently than their outcrossed counterparts (J. Grassle, pers. com.). It is possible that the "threshold" above which discrimination putatively does not occur is merely a reflection of the masking of the selection effects by variation in larval quality. Also, the flume was operating at its maximum free stream velocity of 5 cm s^{-1}, and frequently produced air bubbles in the pump tubes at that speed. More comprehensive analysis of the flow is not available, as the LDA analysis was unsuccessful, for reasons as yet to be determined; the laser functioned perfectly on a larger flume. The flow, however, was visibly pulsed, despite the flow straighteners and regulators. These issues may also have impacted larval settlement.

The growth experiments indicate that *Capitella* sp. I is responsive to the organic content in the sediment. However, the poor growth rate, 1.4 mm at 15 d in 100% TMC mud, as compared to the 2.25 mm length reached after 16 d in Linton's experiments (1999), may point to a problem with the sediment's organic content. Samples saved for measuring CHN have not been tested as of yet.

While the larvae appear to have displayed selectivity, and may have done so even more vigorously with other sediment, more study is clearly needed in order to determine whether that is the case. The flume will be redesigned with an Archimedes screw pump, which may be gentler, and further experiments will be performed. It may also be a good idea to use outcrossed *Capitella* sp. I cultures.

Capitella sp. I's population dynamics are still not completely understood. However, we have shown that the larvae settle selectively on rich sediment in moving water, and the juveniles grow faster in that sediment. With this knowledge, the population dynamics begin to make more sense. Further study, using younger and more vigorous larvae and with the CHN content of the sediment known, may shed more light on the subject.

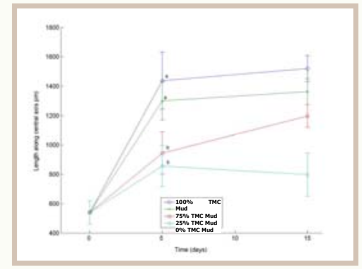

Figure 4. Growth of *Capitella* sp. I larvae in sediment with varying organic content. Data points are averages of 3 replicates, each with 5 larvae. Points grouped by letter were not significantly different from each other.

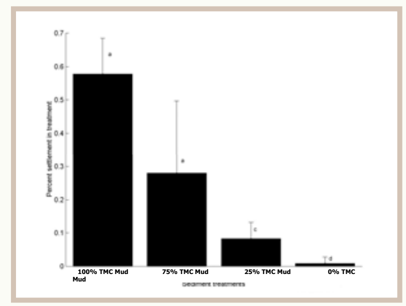

Figure 3. Mean percent settlement (± SD) of *Capitella* sp. I in sediment with varying amounts of organic matter. Treatments grouped by letter were not significantly different from each other. (n = 5)

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