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Effect of mussel density and size on the morphology of blue mussels (*Mytilus edulis*) grown in suspended culture in Prince Edward Island, Canada

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Abstract

Mussels usually exhibit morphological variations in response to their environment. We conducted two field experiments in which we assessed the effect of mussel density and size on the morphology of blue mussels (*Mytilus edulis*) grown in suspended culture using longlines. Morphological measurements were taken over two and a half years on mussels reared at different initial densities (ranging from 100 to 800 mussels per 30 cm of sock) at two sites in Prince Edward Island, Canada. Generally, growing density of mussels did not have an effect on shell width, shell height or tissue-to-shell ratio. However, in some instances, mussels became narrower (reduced shell width-to-length ratio) and had a lower tissue-to-shell ratio at high density. The effect of mussel size (measured as shell length) was more consistent, whereby the shell width-to-length ratio increased and the shell height-to-length ratio decreased as mussels grew. The lack of density-dependent morphological plasticity and variation in tissue-to-shell ratio may be attributed to density-dependent mortality and fall-off observed in mussels reared on longlines.

Keywords: Allometry; Blue mussels; Density; Morphology; *Mytilus edulis*; Suspended aquaculture

1. Introduction

Marine invertebrates can exhibit a wide range of morphological variations in their natural environment. In mussels (*Mytilus* spp.), such variations can result from an ontogenetic process (Dickie et al., 1984; Stirling and Okumus, 1994; Karayucel and Karayucel, 2000) or a plastic response to environmental conditions such as wave exposure and tidal height (Seed, 1973; Raubenheimer and Cook, 1990; Akester and Martel, 2000; Beadman et al., 2003), exposure to predators (Reimer et al., 1995; Leonard et al., 1999; Reimer and Harms-Ringdahl, 2001) and density of conspecifics (Coe, 1946; Seed,

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1968; Brown et al., 1976; Richardson and Seed, 1990). Conspecific density has also been observed to influence shell morphology and tissue mass of *Mytilus edulis* (Linnaeus, 1758) reared in growth chambers (Alunno-Bruscia et al., 2001). Although density was observed to affect the growth of cultured mussels in terms of tissue mass (Mallet and Carver, 1991) and total mussel mass (Fréchette et al., 1996), no study to our knowledge has yet looked at its effect on shell morphology of mussels in an aquaculture situation.

Mussel aquaculture can be done in various ways, including suspended culture (using rafts or longlines), bottom culture (by seeding intertidal beds) and on "bouchots" (mussels attached to a vertical wooden stakes planted in the intertidal area) (Hickman, 1992). Advantages of suspended culture over bottom culture are faster growth rates of mussels and a higher tissue-to-shell ratio. In Atlantic Canada, most production is done on longlines, with mussel seed packed in plastic mesh sleeves (called socks) attached to the floating longline (Mallet and Myrand, 1995). These mesh sleeves can be elastic, which enables mussel farmers to optimize growth by controlling the density of mussels in each sleeve. Since mussels in suspended culture are subject to different growing conditions than wild, bottom-cultivated or laboratory-grown mussels (due to differences in wave and air exposure, temperature, food supply, current, ice cover, etc.), the effect of crowding on their morphological variation may not be predictable from other studies. In order for aquaculturists to use this information, it is necessary to test whether suspended mussels will react to growing densities in a similar manner as bottom-cultivated or laboratory-grown mussels.

Because socking density is one variable that can be manipulated by mussel growers, to maintain a high quality product, it is important for the mussel aquaculture industry to understand how mussel density affects both morphology and tissue-to-shell ratio in growing blue mussels. In this study, we examined the effect of growing density and mussel size on the morphology and tissue-to-shell ratio of *M. edulis* grown in suspended culture. This work is part of a larger study on the dynamics of cultivated mussel populations (Lauzon-Guay et al., 2005).

2. Materials and methods

2.1. Study sites

Experimental sites were set up in Fall 2001 (Experiment I) and 2002 (Experiment II) in St. Peter's Bay (46°25′16″ N; 62°37′19″ W) and New London Bay (46°29′34″ N; 63°27′05″ W) on the north shore of Prince Edward Island, Canada. Both bays are used intensively for blue mussel (*M. edulis*) aquaculture, with landings over 1000 and 1500 tons in 2002 for St. Peter's Bay and New London Bay, respectively (Department of Fisheries and Oceans Canada, personal communication). Water temperature ranged from −1 to 24 °C throughout the study and ice covered both bays from December to late March each year. Three parallel longlines, 10 m apart and measuring 100 m in length, were floated at each experimental site.

2.2. Experimental design

A randomized block design was used, with each block containing one replicate of six seeding treatments (Table 1, see also Lauzon-Guay et al., 2005, for details). Three sizes of mussels were collected, "declumped", graded and packed in socks by a local mussel farmer following commercial practices. As well, each of the three seed sizes was socked at a low and a high initial density (ranging from 100 to 800 mussels per 30 cm of sock). The densities used in our study go beyond the average range used by aquaculturists in order to maximize the chance of detecting a treatment effect if one existed. In Experiment I, a total of 144 socks arranged in 24 blocks were hung, at 30 cm intervals, on 17 November 2001 at each site. The same design was used in Experiment II, with a total of 108 socks arranged in 18 blocks hung on 23 October 2002 in St. Peter's Bay and on 25 October 2002 in New London Bay.

2.3. Sampling protocol

Socks deployed in Experiment I were sampled on 17–21 November and 19–22 December 2001, and on 1–3 June, 1–3 August and 26–29 September 2002 at both sites. A final sample was collected at the New London Bay site on 1–2 December 2002,