

Combination of macroalgae-conditioned water and periphytic diatom *Navicula ramosissima* as an inducer of larval metamorphosis in the sea urchins *Anthocidaris crassispina* and *Pseudocentrotus depressus*

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Abstract

The induction of larval metamorphosis in the sea urchins *Anthocidaris crassispina* and *Pseudocentrotus depressus* was investigated in the laboratory, using waters conditioned by 15 different macroalgae combined with the periphytic diatom *Navicula ramosissima*. Larvae of *P. depressus* did not metamorphose, but larvae of *A. crassispina* showed a high incidence of metamorphosis, especially in waters conditioned by coralline red algae or brown algae. High inductive activity for larval metamorphosis was detected in *Corallina pilulifera*-conditioned water during a 2.5-year investigation, but the activity was relatively low in February or March and in September, the off-growth seasons of the alga. By contrast, *Ulva pertusa*-conditioned water did not show metamorphosis-inducing activity except in spring or early summer. These results indicate that during their growth phase, red and brown algae release into their environment active substances that are involved in the larval metamorphosis of *A. crassispina*.

Key words: Macroalgae-conditioned water, *Navicula ramosissima*, metamorphosis, *Anthocidaris crassispina*, *Pseudocentrotus depressus*

Introduction

Macroalgae and microbial films are known to play important roles as inducers of metamorphosis in larvae of sea urchins (Pawlik, 1992; Wicczorek and Todd, 1998; Hadfield and Paul, 2001). Laboratory-reared larvae of the sea urchin *Strongylocentrotus droebachiensis* metamorphose upon contact with coralline red algae, brown algae, and green algae (Pearce and Scheibling, 1990, 1991). Field observations have shown that newly settled sea urchins (*S. purpuratus* and *S. franciscanus*) can form dense populations on rocky areas covered with crustose coralline red algae (Rowley, 1989). Metamorphosis of larvae of *S. purpuratus*, *S.*

franciscanus, *Loxechinus albus*, *Lytechinus pictus*, and *Arbacia punctulata* has been reported to be induced by microbial films (Cameron and Hinegardner, 1974; Cameron and Schroeter, 1980; Gonzalez *et al.*, 1987).

During mass production of the economically important sea urchin species *Pseudocentrotus depressus*, *Anthocidaris crassispina*, and *Hemicentrotus pulcherrimus*, diatom-based film grown on plastic plates, consisting of *Navicula*, *Achnanthes*, *Amphora*, and *Nitzschia* species, is used as an inducer of larval metamorphosis (Tani and Ito, 1979; Ito, 1984; Ito *et al.*, 1991). Mass-produced sea urchin larvae are also induced to metamorphose by the brown algae *Hizikia*