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Effect of diatom diets on growth and survival of the abalone *Haliotis discus hannai* postlarvae

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Abstract

Growth and survival of postlarval abalone *Haliotis discus hannai* Ino fed different diatom diets were examined for one month from settlement. Two diatoms, *Amphora luciae* Cholnoky and *Navicula* cf. *lenzii* Hustedt, supported high postlarval growth and survival, especially when supplied in combination. A third species, *Nitzschia laevis* Hustedt, did not support survival for more than two weeks as a unialgal diet and had limited value in mixed diets.

Diatom mixtures were superior to single-species diets as of the first week after settlement. The mixture of *N.* cf. *lenzii* and *A. lucia* supported the highest survival, up to 50%, and growth rate up to 36μm of shell length per day, reaching a size of 1.4mm 30 days after settlement. The three diatom species contained high levels of total lipids (6.4%–14.5% of dry weight) and fatty acids (16%–22% of lipids); from 39% to 48% of fatty acids were polyunsaturated (PUFA). The three diatoms were richer in n-3 PUFA than in n-6 PUFA. The content of the essential fatty acid 20:5n-3 (EPA) was highest among the PUFAs and higher, though not significantly, in the two diatom species *A. luciae* and *N.* cf. *lenzii* that produced the better results. Among the free amino acids, arginine was dominant in *N. laevis*, proline in *N.* cf. *lenzii*, and both free amino acids plus glutamic acid were equally dominant in *A. luciae*. The suitability of *A. luciae* and *N.* cf. *lenzii* for enhancing growth and survival of postlarvae was attributed to their complementary balanced nutritional properties.

Keywords: Abalone; Postlarvae; Biochemical composition; Growth; Survival; Diets; Diatoms; Fatty acids; Amino acids

1. Introduction

Benthic diatoms are the principal food source for postlarval abalone in hatcheries (Kawamura, 1996, Kawamura et al., 1998a). In spite of the increasing number of studies on the nutrition of newly settled abalone larvae (Kawamura and Takami, 1995; Kawa-

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mura, 1996; Kawamura et al., 1998a,b; Daume et al., 1999, 2000; Roberts et al., 1999; Searcy-Bernal et al., 2001), growth and survival rates during the early postlarval stages as reported in the literature are variable and generally low (Searcy-Bernal et al., 1992). Poor and unpredictable performance is related to variability in food (different diatoms and their composition), as well as to abalone species and the growing conditions in hatcheries (Kawamura et al., 1998a). To improve growth and survival of abalone postlarval stages in a specific growing system using specific diatom species, a better understanding of their basic diet requirements is necessary. Cell density, digestion efficiency, ingestibility, extra-cellular products, and associated bacteria are known to affect food value of diatoms in early postlarval stages (Kawamura and Takami, 1995; Kawamura et al., 1995, 1998a,b; Roberts et al., 1999; Searcy-Bernal et al., 2001). The biochemical composition of algal cells is another important factor (Dunstan et al., 1994), but its effect has been examined mostly in juvenile abalone (Mercer et al., 1993; Mai et al., 1994, 1995a,b, 1996) rather than in newly settled postlarvae.

The biochemical composition of the diet is most important once the postlarvae acquire the capability to digest and benefit from diatom cell content (Kawamura et al., 1998a). According to them, the diatom diet has little impact on growth rates during the first two weeks after settlement. Diet-dependent postlarval growth rates diverge at 800 μm SL, when the postlarvae begin digesting and utilizing the cell content. According to Daume et al. (1999), differences in growth rates by postlarvae fed different diatoms can already be observed earlier, a week following settlement.

The nutritional value of microalgae as a feed is influenced to a great extent by the fatty acid composition of their lipids (Brown et al., 1997; Renaud et al., 1999) and to a lesser extent by sugar composition (Chu et al., 1982). The protein amino acid composition of microalgae is generally conserved (Brown et al., 1996) and is unlikely to account for major differences in the nutritional value of a particular species (Brown, 1991; Brown and Jeffrey, 1995; Brown et al., 1997). Free amino acids (FAA) may constitute a significant proportion of the total amino acids in the algal cell (Dortch et al., 1984; Brown, 1991) and their composition does vary among algal species (Derrien et al., 1998). FAA are easily absorbed by postlarvae (Manahan and Jaeckle, 1992), a fact that is especially important in very early life stages, before the complete development of the gut enzymes involved in protein digestion (Takami et al., 1998). For this reason the diatom composition phase of the present study has focused on FAA and fatty acids.

Diatoms, as a class, offer high levels of lipids and PUFAs, especially the essential PUFA 20:5(n-3) (Dunstan et al., 1994; Brown et al., 1997), and therefore may fulfill the nutritional requirements of abalone postlarvae better than other algae. Polyunsaturated fatty acids (PUFA) of both n-3 and n-6 families are essential for growth of juvenile *Haliotis discus hannai* (Mai et al., 1996). Their primary function is considered to be structural (Mai et al., 1995a; Floreto et al., 1996). Among PUFAs, 20:5(n-3) seems to contribute the most to faster growth of juvenile *H. discus hannai* (Mai et al., 1996).

The aim of this research was to investigate growth and survival of *H. discus hannai* postlarvae fed different diets of diatoms (including local species), which had previously been shown to induce larval settlement (Gordon et al., 2004), and verify whether these could be correlated to the diatoms' nutritional quality.

2. Materials and methods

2.1. Preparation of abalone postlarvae

Larvae of *H. discus hannai* were obtained from an indoor abalone hatchery in Eilat (Red Sea, Israel). Adults were induced to spawn using ultraviolet light (Kikuchi and Uki, 1974). Fertilized eggs were collected and transferred into 20-L aquaria at a concentration of 12 eggs/ml. To control bacterial growth, an antibiotic (Rafamycin) was added at a concentration of 1.5 mg/L. Larvae were kept at 22 °C with a 12 L:12 D photo cycle (60–70 μmol photons m^{-2} s^{-1}), for 4–5 days, until reaching competence. Larval competency on day 5 was assessed by observing the swimming behavior, as described by Seki and Taniguchi (1996). Competent larvae were used for the growth experiments.

2.2. Diatom cultures

Benthic diatoms were isolated from the Red Sea (Eilat, Israel) and from the Atlantic Ocean (Massachu-