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Effect of increased water recirculation rate on algal supply and post-larval performance of scallop (*Pecten maximus*) reared in a partial open and continuous feeding system

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Abstract

In a commercial scallop hatchery spat production depends on a culture system which ensures high survival and good growth. Reuse of water with algae may increase the food exploitation and hence reduce the costs. Post-larvae of great scallop (*Pecten maximus*) were studied in a commercial hatchery using a partial open and continuous feeding tank system. Three different water recirculation rates (67, 83 and 92%) were tried out in two experiments with post-larvae originating from three spawning groups of ages between 43 and 57 days post-spawn, 316–886 μm shell-height and 1.1–9.6 μg ash-free dry weight. The post-larvae were held in sieves in tanks of 2500 l where a downwelling flow was maintained by airlifts. New water with a mix of monocultured algae was continuously added to the tanks at algal concentrations of 10 and 15 cells μl^{-1} in experiment 1 (groups 1 and 2) and 2 (group 3), respectively. The algal supply to each sieve was reduced along with increased recirculation rate, but was kept between 6 and 13 cells μl^{-1}. Generally no significant differences in survival, growth or chemical content were found between the three recirculation rates, while few differences were found between and within groups. Large variation in survival was found between and within groups (1–81%). Highest survival was found in experiment 1, and where post-larvae from two settlements were used, the first settlement survived better than the second. The daily growth ranged from 15 to 62 μm shell-height and from 0.3 to 2.6 μg ash-free dry weight. The scallop post-larvae could well be reared at all three recirculation rates studied as an increase from 67 to 92% did not seem to affect the post-larval performance seriously. The algal supply, however, had to be compensated by an increasing number of cells (>10 cells μl^{-1}) when increasing the recirculation rate.

Keywords: Algal supply; Chemical content; Growth; *Pecten maximus*; Post-larvae; Scallop; Survival; Water recirculation

1. Introduction

The choice of cultivation technology and methods are fundamental to a viable production of bivalve spat. A culture system ensuring high survival and good growth at a minimum cost is essential. The use of recirculation systems to intensify aquaculture production is developing. Purification treatment and careful control of the water quality are necessary in water recirculation systems used for fish cultivation (van Rijn, 1996; Summerfelt et al., 2004). The use of closed recirculation systems is not common in bivalve rearing, but have been tried on an experimental basis with nursery sized scallops, *Argopecten irradians irradians* (Widman, 1998), and clams, *Mercenaria mercenaria*

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(Pfeiffer and Rusch, 2000). More commonly used in intensive culture of bivalve larvae and post-larvae are batch (static) or flow-through (open) systems where a regular replacement of water avoids the build-up of organic matter and oxygen deficiency.

Seawater heating, pumping, and culture of micro-algae for feed are major costs in bivalve production, and the mass production of live algal cells is both a quantitative and a qualitative constraint (de Pauw, 1981; Smith and Wikfors, 1998; Robert and Gérard, 1999; Wikfors and Ohno, 2001; Heasman et al., 2002). The post-larvae are fed cultured algae in the water during intensive production, while filtered seawater may be adequate in semi-intensive systems during the natural production season. Partial recirculation of the water in post-larval rearing tanks reduces the volume of new water with algae that has to be added per unit time, thereby increasing the utilisation of algae and lowering the total production costs. The algae may get an extended residence time in the tank, which may influence the nutritional quality in a way that affects the growth progress of post-larvae. Changes in biochemical composition of algae are related to the algal growth phase (Whyte, 1987; Pernet et al., 2003), and have been shown to affect growth of juvenile bivalves (Flaak and Epifanio, 1978; Ryan et al., 1998).

The feeding regime may affect scallop growth and metabolism. Continuously feeding is experienced to give better growth and food assimilation in *Argopecten purpuratus* larvae and early juveniles compared with feeding once or twice a day (Martínez et al., 1995). Juvenile bay scallops (*Argopecten irradians*) fed four times per day have superior growth rates to both less (one and two times) and more (eight times) frequently fed scallops (Smith and Wikfors, 1998). In the hatchery, the scallops are usually fed a mixture of cultured algae rather than a single species diet to meet the required nutritional quality for good growth (Laing and Psimopoulous, 1998). Algal concentration, ration, water flow, and velocity are other factors affecting the growth of scallop post-larvae and juveniles (Wildish and Saulnier, 1992; Lu and Blake, 1996; Laing, 2000; Robert and Nicolas, 2000; Nicolas and Robert, 2001; Rupp et al., 2004). As there is a rapid increase in biomass during early life stages, the demand for algae and water increases correspondingly (Le Borgne, 1981; Bourne et al., 1989; Millican, 1997). By using a recirculation downwelling growth system in scallop post-larval production, a continuous algal supply and cost-effective reuse of water and algae may be provided.

Hatchery production of the great scallop (*Pecten maximus*) spat in Europe involves induced spawning and intensive larval and post-larval rearing to a size of approximately 2 mm shell-height (Millican, 1997; Robert and Gérard, 1999; Bergh and Strand, 2001). Batch culture and flow-through water systems have been the usual methods in the larval and post-larval rearing respectively, but recently flow-through systems have been tried out also during the larval phase (Robert and Gérard, 1999; Andersen et al., 2000; Torkildsen and Magnesen, 2004). After the planktonic larval phase, ''ready-to-settle'' larvae are transferred to a settlement system for further growth.

Using a water recirculation rate of 67% in post-larval rearing tanks has been a common practice at the Norwegian scallop hatchery Scalpro AS. Pilot studies of algal performance in tanks of different recirculation rates showed that up to 92% recirculation of added water per minute maintained acceptable algal concentrations (van der Meeren et al., 1997). In the present study, the effects of three different recirculation rates (67, 83 and 92%) on great scallop (*P. maximus*) post-larvae were investigated in the commercial production system at Scalpro AS. The aim was to assess if the selected recirculation rates would affect the feeding conditions (algal supply), survival, growth, and chemical content of post-larvae.

2. Materials and methods

2.1. Scallop post-larvae

The *P. maximus* post-larvae used in the experiment originated from induced spawnings in November 1996 and January 1997 at the hatchery Scalpro AS in Øygarden, western Norway. Each larval group was the product of cross-fertilisation between eggs and sperm of different parental origin. The scallop larvae were transferred to the settlement tank system between days 22 and 27 post-spawning when they reached the ''ready to settle'' stage and retained on 150 μm mesh. The eyed pediveliger larvae were ready to settle at different age, depending on fast or slow larval growth, resulting in different settlement groups from each spawning. Two experiments were carried out, using post-larvae from two (groups 1 and 2) and one (group 3) spawning groups, respectively. From groups 2 and 3 post-larvae from two larval settlement groups (2a and 2b, 3a and 3b) were included (Table 1). Experimental start was 15 January (experiment 1) and 19 February (experiment 2), and day 0 in the studies were days 57, 50, and 43 post-spawn for the larval groups 1, 2, and 3, respectively. The larvae were allowed to stay in the settlement system 3–5 weeks before experimental start (Table 1). Initial mean