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Effect of increasing salinity on physiological response in juvenile scallops *Argopecten purpuratus* at two rearing temperatures

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Abstract

Argopecten purpuratus can be cultivated using Recirculating Aquaculture Systems (RAS) as a method to increase production. In order to determine physiological response of *A. purpuratus* under different salinities and temperature conditions, two groups of juvenile scallops (small: $h=6.5$ mm and large: $h=25.5$ mm) were acclimated and close-cultured at salinities of 34, 38, and 42 g/l, at 16 and 22 °C and fed on *Isochrysis galbana* and *Chaetoceros calcitrans*. Survival, shell growth and scope for growth were determined at the end of the trials. Survival showed an inverse relationship with temperature and ammonia levels. In small scallops an increase in salinity at 16 °C increased survival. However, this relationship was not evident at 22 °C. On the other hand, salinity did not affect survival of large juveniles. Small juveniles had a lower survival (approximately 40%) than larger scallops (up to 85%) throughout the trials. Oxygen consumption was not affected by salinity. Small scallops showed similar oxygen consumption at 16 and 22 °C but in large juveniles higher values were registered at 22 °C. In large juveniles routine consumption at 16 °C was higher (up to 35%) than standard consumption. This pattern was not evident at 22 °C, suggesting that oxygen demand is higher regardless of feeding condition. NH_4^+–N excretion rate is inversely related to salinity. Only small juveniles showed a higher NH_4^+–N excretion rate at 22 °C. Scope for growth was positive in all treatments, although the upper limit of salinity should not be based only in this index. Higher scope for growth values at 38 and 42 g/l was related with a reduction in ammonia excretion and high absorption efficiency. In addition, an increase in salinity produced a reduction in NH_3–N proportion and under hypersaline conditions scallops tended to decrease excretion as a way of osmoconformation. This explains our findings of higher survival rates at higher salinities. Even though the scope for growth is positive at 42 g/l, the osmotic stress reduces the survival chances. The data obtained can be considered useful information for *A. purpuratus* culture under controlled conditions.

Keywords: *Argopecten purpuratus*; Salinity; Temperature; Oxygen consumption; Ammonia excretion; Scope for growth

1. Introduction

The northern scallop *Argopecten purpuratus* has a high commercial value and its aquaculture in Chile has increased significantly during the last decades (von Brand et al., 2006). The success reached in its reproductive conditioning and spat production in hatchery has supported that activity (von Brand et al., 2006). Scallop could be reared using Recirculating Aquaculture Systems

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(RAS) as an alternative method of production, making a significant reduction in water requirements through water treatment and reuse. Design of effective RAS requires knowledge of physiological aspects of target species in order to address the range of physiochemical water parameters.

In RAS processes there is loss of water by evaporation which affects water salinity. Variations in salinity and temperature may change water quality parameters such as dissolved oxygen (DO) and CO_2 levels, NH_3 to NH_4^+ ratio, and pH (Lawson, 1995). Salinity and temperature can also affect survival, growth, and scope for growth, a physiological process related to the energy acquisition (ingestion and absorption) and utilization (respiration and excretion) (Bricelj and Shumway, 1991). Although many authors have documented the effect of decreasing salinity under different temperature regimens (Mercaldo and Rhodes, 1982; Strand et al., 1993; Navarro and González, 1998; Laing, 2002; Christophersen and Strand, 2003; Rupp and Parson, 2004), available information regarding hypersaline tolerance of scallops at different temperature is scarce.

Pectinids are osmoconformists (Shumway, 1977; Singnoret-Brailowski et al., 1996) in which hemolymph is close to the osmotic pressure and ionic composition of seawater and ammonia excretion increases with decreasing salinity (Bricelj and Shumway, 1991; Navarro and González, 1998). Nonetheless, scallop species have limits where growth and survival are maximized. In addition, the physiological effect of salinity can modify or be modified by temperature (Kinne, 1964; Paul, 1980).

Knowledge of the physiological response of scallops under different salinity and temperature conditions is an important factor in the cultivation of this species. The main goal of this study was to determine the effect of increasing salinity on survival, shell growth and scope for growth in *A. purpuratus* juveniles under two temperature regimens reared in closed systems. Since, our objective was focused on salinity and temperature we chose the closed system because it allows us to isolate the effect of the other parameters (like nitrate, nitrite, alkalinity, etc.) which also occur in RAS and, their physiological effect on *A. purpuratus* is not known. Because of the commercial importance of this species, the information reported in this paper will be useful for managing these parameters under controlled conditions.

2. Materials and methods

2.1. Experimental set up

We obtained juvenile scallops from an experimental hatchery at Universidad Catolica del Norte, Coquimbo, Chile (30° LS), where the research was conducted. We divided scallops in two groups according to shell height (h): small juveniles (mean h=6.5 mm; SD=0.78) and large juveniles (mean h=26.5 mm; SD=1.9) and exposed both groups to three salinity regimes (34, 38, and 42 g/l), at 16 and 22 °C, in accordance with the values observed in our RAS with three replicates per salinity treatment. We cultivated scallops in 1 μm-filtered seawater (passed through UV lamps) on plastic trays (25×30×24) in 18, 15 l beakers which in turn were placed in two water bath containers (250 l, 160×64×26 cm), one for each temperature. Thus, this factor was pseudoreplicated. We placed 100 small scallops or 20 large scallops on each tray and water was renewed every 24 h, transferring the trays directly into a clean beaker containing new seawater at the appropriate salinity and temperature. We obtained hypersaline water by evaporating seawater. We used air-stones to provide aeration in order to maintain a DO level above 80% saturation. We fed the scallops on *Isochrysis galbana* and *Chaetoceros calcitrans* (ratio 1:1) in a quantity equivalent to 10% of the scallop's dry weight per day. We divided the daily food allotment into thirds, provided morning, noon, and evening. We acclimated scallops to different experimental conditions by increasing salinity and temperature by 1 g/l and 1 °C, respectively, per day. Experiments lasted for 2 months, or ended when we registered significant difference in survival between treatments.

We measured salinity, temperature, and DO daily using a hand-sensor (Yellow Spring Incorporated, YSI 85). We calibrated the oxygen-meter at room atmosphere. We used Solórzano's (1969) phenol-hypochlorite method to take a weekly measurement of total ammonia or ammonia (TA) (sum of NH_3 and NH_4^+). We collected water samples in acid-washed glassware and measured TA immediately after collection. At the time of water collection we used a pH meter (calibrated with buffer solutions of pH=7 and pH=10 before use) (Hanna Instruments, HI 9023C) to measure water pH. We calculated un-ionized ammonia (NH_3) from appropriate temperature, pH, and salinity according to Fivelstad (1988). We estimated ionized ammonia (NH_4^+) as a difference between AT and NH_3. We expressed values on a nitrogen basis and wrote them as TA–N, NH_3–N, and NH_4^+–N (Colt and Armstrong, 1981).

2.2. Survival and growth

We measured initial and final shell height from digital images. We transferred trays with scallops to a plastic plate containing seawater at appropriate salinity and temperature. We used a digital camera (Sony DSC P8;