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The effects of daily ration on growth and smoltification in 0+ and 1+ Atlantic salmon (*Salmo salar*) parr

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Abstract

The effects of long-term variations in feed ration were studied during two experiments on Atlantic salmon parr. In the first experiment, three duplicate groups of approximately 500 salmon parr were fed at rates of 100%, 66% or 33% of the manufacturer's recommendation from shortly after first feeding. Each group was exposed to a photoperiod regime which was expected to result in smoltification 9 months after first feeding. In the second experiment, three duplicate groups of 550 fish were fed 100%, 66% or 33% of the manufacturer's recommendation from first feeding and exposed to a simulated natural photoperiod, which was expected to result in smoltification 13 months after first feeding.

In both experiments fish size increased with ration, with recruitment to the upper modal group (UMG) of the population also related to ration (85–96%, 64–88% and 28–42% UMG fish for the full, two-thirds and one-third ration groups respectively, recorded at the conclusion of each experiment). Throughout each experiment the full and two-thirds ration fish maintained similar whole body lipid concentrations, although lipid concentrations in the one-third ration fish were generally lower. At the conclusion of experiment 1, gill Na^+, K^+-ATPase activity in UMG fish fed full rations reached 9.5 μmol ADP hydrolysed mg^{-1} $protein^{-1}$ h^{-1}, whereas ATPase activities were lower in the other ration groups. In experiment 2, all groups had similar gill Na^+, K^+-ATPase activities at the conclusion of the experiment (6.4–9.3 μmol ADP hydrolysed mg^{-1} $protein^{-1}$ h^{-1}). Following 24 h seawater challenges, conducted during the parr–smolt transformation, UMG fish from the full and two-thirds groups of experiment 1 displayed high survival rates (100%) and low serum osmolalities (335 mOsm kg^{-1}), with lower survival rates (75%) and higher serum osmolalities (370 mOsm kg^{-1}) recorded in the one-third ration fish. In experiment 2 similar survival rates (100%) and serum osmolalities (350 mOsm kg^{-1}) were found in all ration groups.

It is concluded that under accelerated production regimes, feed restriction may result in underyearling Atlantic salmon smolts developing a poor hypo-osmoregulatory ability. Variations in ration significantly influence growth, although it is believed that growth is dependant on the maintenance of a specific lipid level in the body.

Keywords: Atlantic salmon; Parr; Growth; Smoltification; Nutrition; Photoperiod

1. Introduction

Photoperiod and feed manipulation are used in the salmon farming industry to influence growth (Storebakken and Austreng, 1987a; Handeland and Stefansson,

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2001), maturation (Bromage et al., 1984; Rowe et al., 1991) and smoltification (Skilbrei, 1991; Duston and Saunders, 1992). During freshwater production of Atlantic salmon, high growth rates allow individuals to achieve the size threshold for smoltification within short periods of time (Elson, 1957; Kristinsson et al., 1985; Skilbrei, 1988) and these growth rates can be achieved by manipulating both dietary and photoperiod regimes (Solbakken et al., 1994; Thrush et al., 1994; Helland and Grisdale-Helland, 1998; Handeland and Stefansson, 2001). Under a naturally changing photoperiod, the decision to smolt is made during the decreasing photoperiod and the parr–smolt transformation is then completed on the increasing phase (Duston and Saunders, 1992). Consequently, in commercial production, photoperiod regimes can be manipulated so that fish smolt out-of-season and at ages of 1 year or less (Thrush et al., 1994; Duncan et al., 1998).

Increases in feed ration enhance growth (Reinitz, 1983; Storebakken and Austreng, 1987a; Silverstein et al., 1998) as well as increasing lipid deposition (Reinitz, 1983; Johansson et al., 1995; Hillestad et al., 1998). Smoltification results in a reduction in body lipid (Saunders and Henderson, 1978; Woo et al., 1978; Rowe et al., 1991), and a nutritional threshold may influence which individuals can successfully undergo the parr–smolt transformation (Thorpe, 1986; Shearer, 1994). However, although the effects of growth on

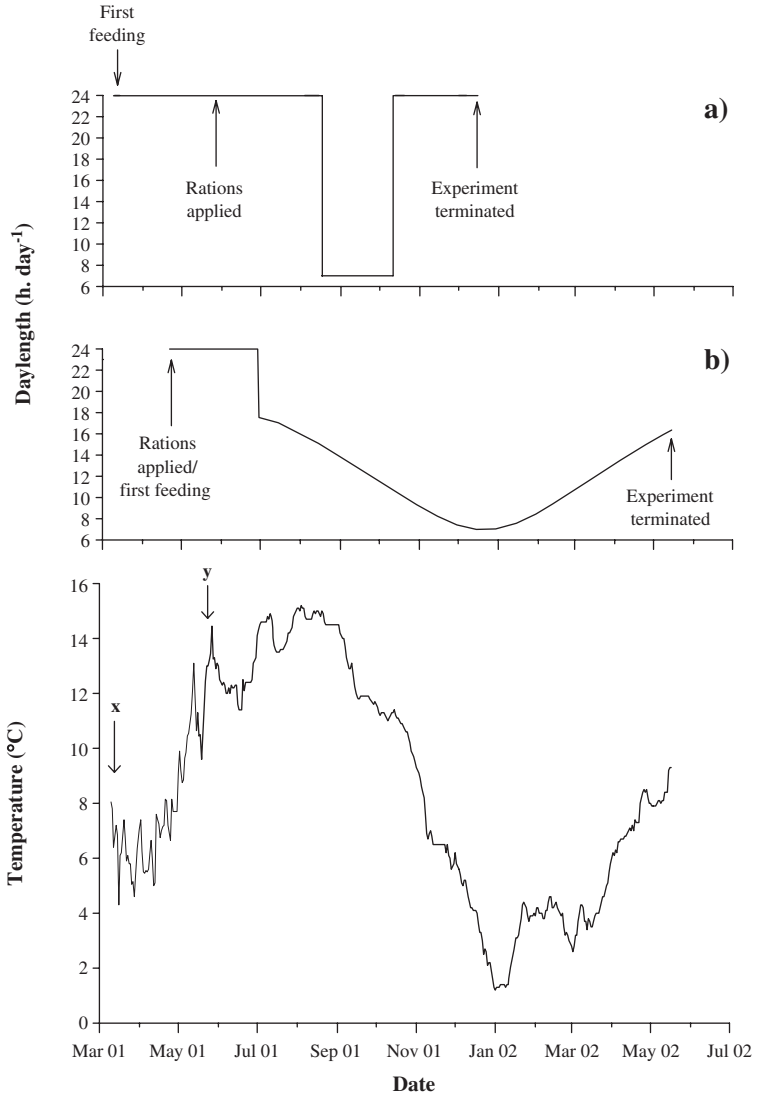

Fig. 1. Water temperatures and photoperiod regimes experienced by Atlantic salmon parr reared using either a 0+ (a) or 1+ (b) photoperiod regime. Between 'x' and 'y' water temperatures were elevated above ambient.