EFFECT OF EARLY LONG- AND SHORT-DAY EXPOSURE ON GROWTH AND DEVELOPMENT OF ATLANTIC SALMON

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Abstract Growth of underyearling Atlantic salmon was not suppressed by long-day treatment for three months from the time of first feeding. Fry were exposed to short- (LD 10:14) and long-day (LD 14:10) photoperiod from late February through May at temperatures of 12°C or 14°C. From early June, all groups were exposed to simulated natural photoperiod and ambient water temperature which increased to 17°C by the third week of July until early September. Growth was greater in the 14°C groups during the first three months but on ambient temperature and photoperiod, growth was most rapid in the treatment initially on SD 12°C. In November, none of the groups had the ability to regulate plasma sodium concentrations after a 24h seawater challenge test.

Introduction The annual photoperiod cycle is a very important synchronizing factor controlling growth and acquisition of seawater adaptability in all salmon species which have a characteristic smolting stage (Clarke, 1989, 1992). A period of short daylength followed by long daylength is stimulates the development of smolt characteristics. In nature, this stimulus is provided by the seasonal cycle of daylength. However, in commercial salmon farms, it is desirable to accelerate development to the smolt stage in order to remove the seasonal restriction on availability of smolts and thereby improve the efficiency of production. Underyearling coho and stream-type chinook salmon smolts can be produced by exposing fry to two months of short-day photoperiod followed by long-day photoperiod (Clarke et al., 1989; Clarke, 1992). Because Atlantic salmon are considerably larger as smolts and have a slower growth rate in fresh water than do Pacific salmon, production of underyearling smolts is more demanding in this species (Clarke, 1991). Still, at least a portion of underyearling Atlantic salmon can be induced to become smolts by the use of heated water in combination with alternating short- and long-day photoperiod (Saunders et al., 1990; Myrseth, 1991; Stefansson et al., 1992). However, the physiological limits for timing and duration of the short- and long-day treatment have not been determined precisely for Atlantic salmon. The present study was conducted to determine whether growth and development of Atlantic salmon fry is influenced by photoperiod at the time of first feeding.

Methods Two replicate groups of 150 fry were placed in 197 ℓ tanks at the time of first feeding (February 28) for each of three treatment combinations: short-day (LD 10:14) at 12°C, short-day at 14°C, and long-day (LD 16:8) at 14°C. After three months, all groups were subsequently held on a simulated natural photoperiod and ambient water temperature which

increased from 14°C at the beginning of June to 17°C by the third week of July. Water temperature remained at 17°C until early September and then declined to 9°C by late November. At monthly intervals, all fish were weighed individually. At the beginning of November, a sample of 12 fish were taken from each tank for a 24h seawater challenge test (Blackburn and Clarke, 1987) to determine seawater adaptability.

Results Growth in weight is shown in figure 1 on a log scale, so that the slopes of the lines represent growth rate during each sampling interval. Fry grew from 0.13 g in early March, slowly at first, then more rapidly during summer so that the mean weight exceeded 19g in all groups by mid September. At the end of the experiment on November 25, the mean weight for the two short-day groups were 30.7 and 30.4 grams, respectively, while that for the long-day group was 38.7 grams. The larger final weight in the long-day group resulted entirely from more rapid growth during the first three months of the experiment. Growth rates under ambient photoperiod from the beginning of June until the end of November were 1.96 %bw · d^{-1} for the short-day 12 °C treatment, 1.67%bw · d^{-1} for the short-day 14°C treatment and 1.62% bw · d^{-1} for the long-day 14 °C treatment.

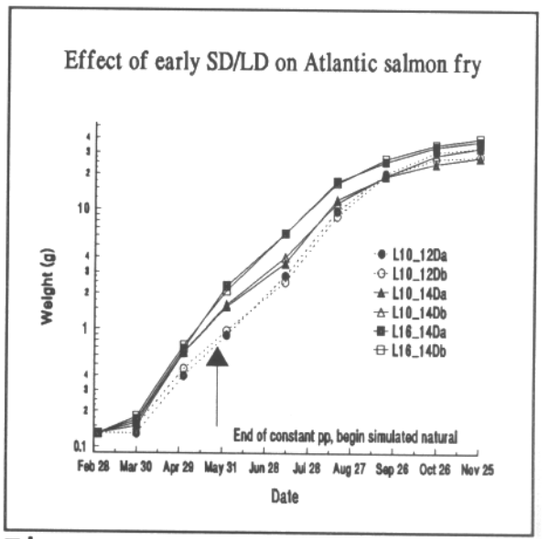

Figure 1 Effect of photoperiod and temperature on growth of Atlantic salmon fry.

Mortality was heaviest during the first month of rearing and subsided once the fry were feeding well. Cumulative mortality was 25% in the short-day, 12°C treatment, 40% in the short-day 14°C treatment and 23.5% in the long-day, 14°C treatment.

Following a 24h seawater challenge test, plasma sodium concentrations were 184.3 meq · ℓ^{-1} for the short-day 12°C treatment, 187 meq · ℓ^{-1} for the short-day 14°C, and 187.3 meq · ℓ^{-1} for the long-day 14°C treatment (Figure 2).

Inspection of the fish at the end of the experiment by laparotomy revealed that many of the males were becoming sexually mature. For those that had developing gonads, the mean gonosomatic index was 7.6% Within treatments, 47% of the males were maturing in the short-day 12°C treatment, 61.5% in the short-day 14°C treatment and 59% in the long-day 14°C treatment.

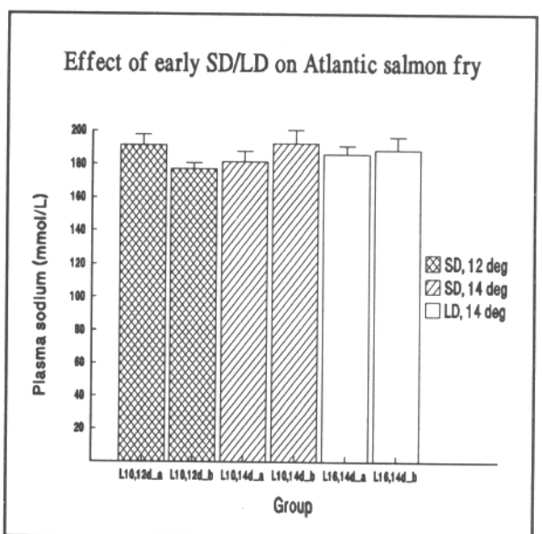

Figure 2 Effect of photoperiod and temperature on ability of Atlantic salmon to regulate plasma sodium concentrations in a 24h seawater challenge test.

Discussion Following the three-month photoperiod treatment, all groups grew well until the end of the study. This is in contrast to experiments with coho and stream-type chinook salmon fry in which exposure to long-day photoperiod for 2 months from the time of first feeding resulted in a subsequent reduction of growth and suppression of seawater adaptability in comparison with fry exposed to short-day

photoperiod for 2 months (Clarke, 1992). Thus, Atlantic salmon must be larger before they are responsive to short-day photoperiod. These results are consistent with the conclusion by (Skilbrei 1991) that Atlantic salmon must reach a minimum of 75 mm total length at the time of the short-day light stimulus in order to become smolts.

Plasma sodium concentrations following a 24h seawater challenge test were very high in all treatments, indicating that none had completed smolt development.

It is concluded that the short-day photoperiod required to stimulate juvenile Atlantic salmon to become smolts as underyearlings should be applied after they have grown to a threshold size under long-day photoperiod. Thus, the most efficient photoperiod manipulation would be a sequence of long-, short- followed by long-day. Work is under way at present to refine this technique.

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