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SEAWATER ADAPTABILITY OF TWO STRAINS OF ARCTIC CHAR (*Salvelinus alpinus*) REARED UNDER DIFFERENT LIGHT REGIMES.

by

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ABSTRACT

Groups of Arctic char (*Salvelinus alpinus*) were reared under three experimental light regimes. Two different strains of char were used, one non-migratory from south Norway, the other anadromous from northern Norway. All groups received a continous background illumination. One of the experimental light regimes consisted only of this background illumination. The remaining two treatments consisted of an additional simulated natural photoperiod, using either yellow light or daylight. Growth rate was monitored during the experiment. A Seawater Challenge Test (SWCT) was run for 24 hours to evaluate the ability of the two strains of char to tolerate and survive in seawater.

There were no significant differences in growth rate in either strain between the experimental light regimes. Condition factor increased during the experimental period for fish of both strains and all light regimes. Both strains tolerated the SWCT without mortalities. Size seems to be the most important factor for seawater adaptability of Arctic char. There were no signs of a smoltification process as seen in Atlantic salmon (*Salmo salar*)

INTRODUCTION

Arctic char (Salvelinus alpinus) is possibly one of the more ancestral species among the salmonids. In Europe it occurs further north than any other salmonid. This coldwater distribution has led to some interest in the species for aquaculture purposes, especially in northern regions where traditionally farmed species such as Atlantic salmon (Salmo salar) and rainbow trout (S. gairdneri) approaches their thermal limits for reasonably high growth rate and thus for economic production.

Anadromy in strains of Arctic char is largely restricted for northern regions, although some exceptions have been recorded during later years. There is however, no obvious reason for this north - south difference. Seagoing chars seem to avoid cold seawater by returning to freshwater during the winter, thereby spending only parts of the spring and summer in the sea. If forced to live in seawater during the winter, heavy mortalities may occur (Gjedrem, 1975; Wandsvik and Jobling, 1982).

The present experiment was set up to investigate possible influences of different photoperiods on the process of seawater adaption in Arctic char, using a dual photoperiod. Such photoperiods have proved to be effective in completing the smoltification process in Atlantic salmon.

To look for possible strain differences in ability to osmoregulate in seawater, both one northern anadromous strain and one landlocked strain from southern Norway, were included in the study.

MATERIALS AND METHODS

Fish stock

The fish used in this experiment were 1+ parr of Arctic char from two different strains, one anadromous from the lake Storvatnet in Hammerfest (Northern Norway), the other a landlocked strain from the coastal lake Skogseidvannet (Western Norway south of Bergen). The Hammerfest char was finclipped (adipose fin).

The fish were reared under continuous light from the time of first feeding until the start of the experiment. Prior to the experiment the fish were graded, and individuals which were large enough to tolerate seawater at the end of the experiment, were chosen.

Total numbers of char in each tank at the start of the experiment were 100; 50 from each strain.

Rearing conditions

The fish were reared in six 1xl m square fibreglass tanks with covers. Water depth was about 60 cm, giving a rearing volume of approximately 600 litres. pH-adjusted freshwater was supplied from an adjustable inlet creating a circular current in the tanks. Outlet was through a bottom sieve in the centre of each tank. The flow was approximately 15 l/min. Water temperature was kept at 11 +/- 1 C.

Commercial dry feed (Skretting Tess Elite 3.0) was dispensed from automatic feeders. Feeding intervals were adjusted so that a predetermined amount of feed was given during each 24 hour cycle. The amount of feed was calculated from temperature and fish size.

Experimental design

Three different kinds of illumination were used. Each photoperiod treatment consisted of two replicate tanks. Fish from both strains were distributed among the tanks (table 1).

Table 1: Letter codes and light intensities for combinations of light regimes and strains. C = Constant, A = Additional, Y = "Yellow light", D = "Daylight", F = freshwater strain.

LIGHT REGIME	GROUPS	BACKGROUND/ADDITIONAL LIGHT INTENSITY (lux)
CONTINUOUS BACKGROUND	CY, CYF	35/35
CONT. BACKGR. ADD. "DAYLIGHT"	AD, ADF	35/920
CONT. BACKGR. ADD. "YELLOW LIGHT"	AY, AYF	35/960

All groups were exposed to a common continuous background illumination, from a single 15W bulb. One of the light regimes consisted only of this background illumination. The light temperature and Ra values of the light sources are given in Table 2.

Table 2: Colour temperature and colour reproduction of the light sources.

LIGHT SOURCE	TEMPERATURE (Kelvin)	COLOUR REPRODUCTION (Ra)
15 W bulb	2,500	100
75 W bulb	2,500	100
20 W tube	6,500	92

For the remaining two groups, additional light was used to simulate a naturally increasing daylength for the months from April through May. This increasing daylength was created using light from two different light sources. One of the groups received yellow light from three 75W bulbs. For the remaining group two 20W fluorescent "daylight" tubes (Phillips TL 20W/55) were used, producing light over a wider specter than the light bulbs (Table 2).

Light intensities were measured using a Tektronix J6511 Digital photometer. The sensor was placed on the sieve pointing upwards through the water coloumn. Both additional light sources generated approximately the same light intensities (Table 1).

Growth rate was monitored during the experiment as increase in mean length of each experimental group. All fish from each tank were measured on the following dates: 07 April (start), 21 April, 21 May and 03 June (termination).

Fork lengths were measured to the nearest mm, and the fish were weighed to the nearest 0.1 g.

Fultons condition factor (K) was calculated using the formula: $K = 100 * W * L^{-3}$, were W (g) is the weight of each individual and L (mm) is the corresponding length.

Seawater Challenge Test

To evaluate seawater adaptability of both strains, a Seawater Challenge Test (SWCT) (Clarke and Blackburn, 1977) was performed for 24 hours at 09 - 10 June.

Five fish from each strain and tank were randomly sampled and transferred directly into running seawater of 28 ppt. salinity, Fish were not fed one day prior to the test. Freshwater control fish were sampled from remaining fish (CY/CYF) in the light regime tanks.

Temperature was kept the same as in the experimental tanks. All fish were blood sampled after 24 hours. Plasma was analysed for chloride using a Radiometer chloride titrator.

Data analysis

To test for normality, two different tests were used depending on sample size. A Wilk-Shapiro test was used for sample sizes less than 50, whereas the Kolmogorov-Smirnov test was used for larger samples.

Analysis of vasiance (one-way ANOVA) was applied to replicates from each treatment, and to compare length and condition factor distributions from each treatment at the end of the experiment. We consequently used a 0.05 level of significance. A two-way ANOVA (simultanously classification by two different factors) was used to analyse plasma chloride levels between strains and light regimes.

RESULTS

Growth

At the end of experiment, no significant differences in mean length were found in either strain between treatments (Figs 1 and 2). Mean lengths were significantly higher in the anadromous strain from the start of the experiment throughout the experimental period ($p<0.001$).

Condition Factor

All experimental groups showed a significant increase in condition factor (K) during the experiment ($p<0.001$, Figs 3 and 4). At the end of the experiment, significant differences in K were found between treatments for the freshwater strain ($p<0.01$). For the anadromous strain, no differences were found.

Sewater Challenge Test

There was no mortality during the 24 hours Seawater Challenge Test. Plasma chloride levels (Table 3) were not significantly different, neither between strains nor between photoperiod treatments. However, levels from control fish kept in freshwater were significantly lower than levels from fish challenged in seawater ($p<0.001$).

There was no correlation between fork length and level of plasma chloride (Fig 5).

Table 3: Plasma chloride values (mM) from SWCT.

EXPERIMENTAL GROUP	MEAN	SEM	SD
CYF	134.75	1.88	5.93
CY	134.59	2.83	9.39
ADF	135.45	1.79	5.94
AD	129.81	2.26	6.40
AYF	135.91	1.72	5.71
AY	131.85	1.54	4.88
FRESHWATER CONTROLS:			
Freshwater strain	124.10	5.27	11.78
Anadromous strain	127.50	1.85	4.14

DISCUSSION

Growth

Several reports concerning growth rate in salmonids conclude that extended daylengths increase growth rate and affect the seasonal changes in seawater adaptability (Hoar, 1976; Wedemeyer et al., 1980). Previous experiments in our laboratory have showed that parr of Atlantic salmon (Salmo salar) grow faster under continuous light than under a static 16L:8D or 8L:16D photoperiod (Stefansson et al., 1985). This is probably due to stimulation of an endogenous rhythm in growth capacity, as the growth enhancement seems to be restricted in time and/or to a certain part of the year (Eriksson and Lundqvist, 1982; Saunders et al., 1985; Stefansson, 1986).

Our results indicate no significant differences in growth rate, or saltwater tolerance between the three experimental light regimes. In a similar experiment with Atlantic salmon (Stefansson and Hansen, in press), we found significantly higher growth rate in groups with additional light. We related this growth enhancement to the stimulation of a seasonally changing growth capacity. A similar stimulation was not observed in the present experiment with Arctic char.

The endogenous rhythms of the Arctic char seem not to be similarly susceptible to photoperiod manipulation, compared to Atlantic salmon. In an experiment on Brook trout (Salvelinus fontinalis), McCormick and Naiman (1984) found no effect on growth of a three month delayed photoperiod, compared to a simulated natural control. Other environmental factors are evidently more important than light regimes and light intensity in controlling the growth rate of species of the Salvelinus group, e.g. temperature and food availability.

Change in condition factor during the experiment was similar for both strains under all light regimes. The significant increase during the experiment suggests favourable environmental conditions and food availability for growth. Again, this development is in contrast to Atlantic salmon, which shows a significant decrease in condition factor during smoltification. Some of the physiological and morphometric changes occuring in Atlantic salmon during smoltification are absent or less dramatic in Arctic char. Again, this reflects the physiological differences between the two species.

Seawater adaptability

The 24 hours SWCT revealed no differences, judged by survival and level of plasma chloride, between fish from different strains or photoperiods, in ability to tolerate seawater. The significantly higher levels in fish which had experienced seawater compared to the control fish indicate a slight increase in plasma osmolarity on transfer to seawater. This phenomenon is also seen in smolts of Atlantic salmon (Stefansson and Hansen, in press). A higher plasma osmolarity is natural for fish living in a saline environment.

These results further support our conclusions that Arctic char is less susceptible to photoperiod manipulation than Atlantic salmon. Atlantic salmon reared under dual photoperiod smoltified completely, whereas fish under a continuous background illumination did not, and performed poorly in a Seawater Challenge Test. None of these differences were found for Arctic char.

The similar performance of fish from the two strains during the 24 hours in seawater indicate an equal osmoregulatory ability in seawater, irrespective of genetic background. Both strains therefore seems to exhibit euryhaline osmoregulatory ability, and the process of anadromy seems to depend at least partly on

environmental factors. This is in accordance with Nordeng (1983) who states that the potential for anadromy exists in certain populations of char in the southern nonanadromous area in Norway.

The fish challenged with seawater were rather homogenous in size. We therefore assume that they were all above the critical size necessary to survive in seawater. Further, we found no correlation between body size and levels of plasmachloride. From this we conclude that at once the fish grow bigger than a certain minimum length, they are able to osmoregulate in seawater.

Conclusions

Growth rate and seawater adaptability in two strains of Arctic char were not influenced by a dual photoperiod compared to continuous light. These results show a different process of sewater adaptability compared to Atlantic salmon, more like sea trout and rainbow trout.

Above a certain minimum size, fish from both migratory and non-migratory strains seem to tolerate seawater, and may adapt to an anadromous strategy. The Arctic char seems to tolerate seawater without going through a smoltification process, and morphological and physiological changes are less distinct than in Atlantic salmon.

ACKNOWLEDGEMENT

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FIGURES

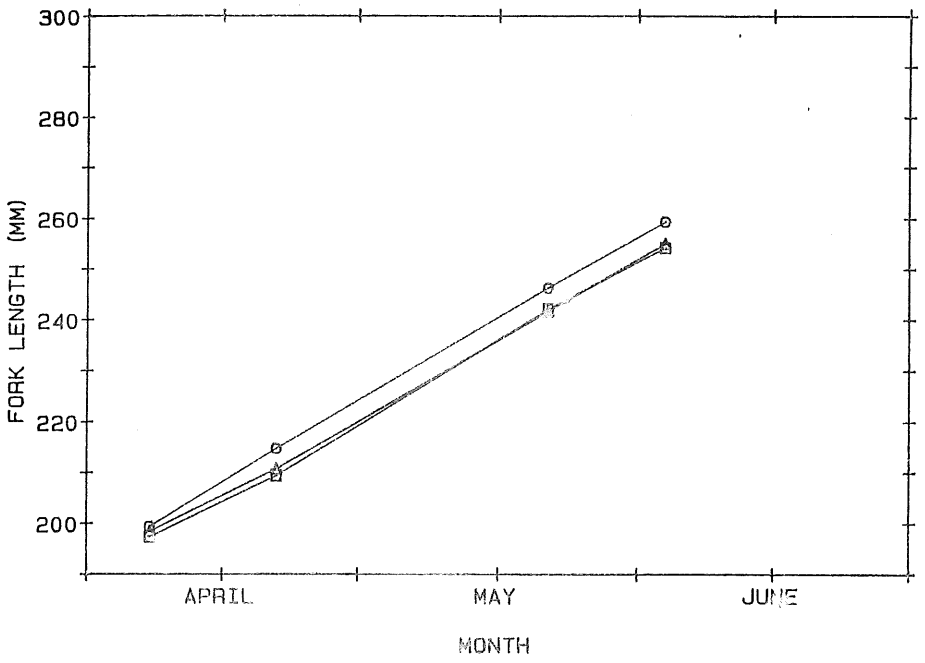

Fig. 1: Mean lengths of the non-migratory strain.
Circles = CYF, triangles = ADF, squares = AYF.

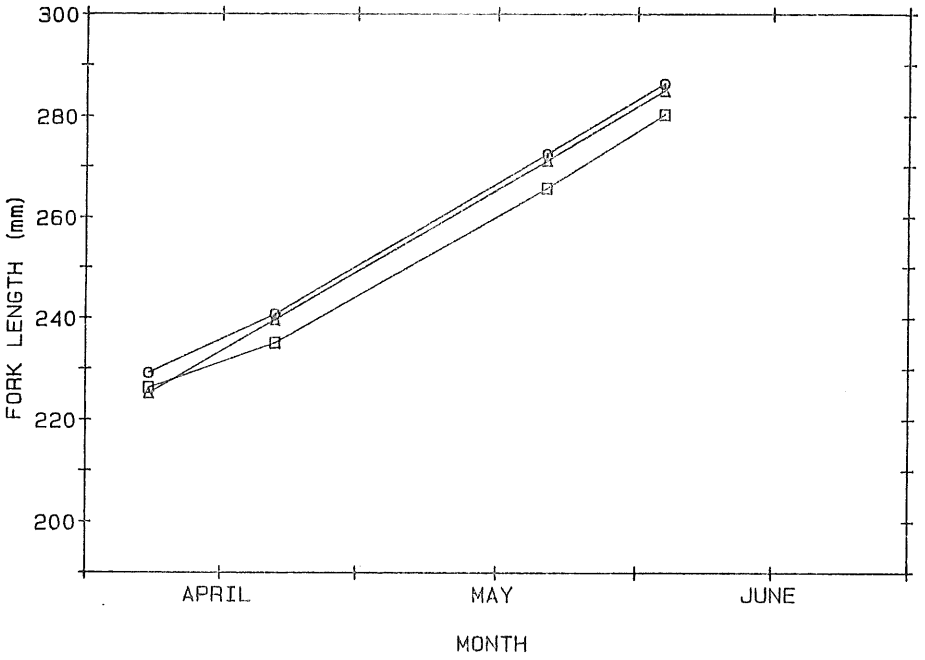

Fig. 2: Mean lengths of the anadromous strain.
Circles = CY, triangles = AD, squares = AY

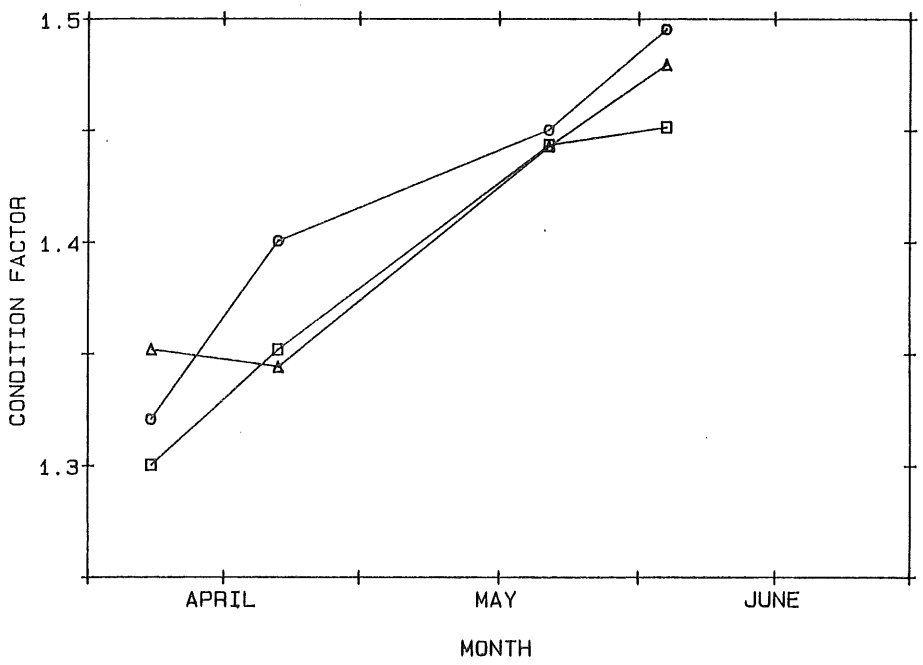

Fig. 3: Mean condition factors of the non-migratory strain. Circles = CYF, triangles = ADF, squares = AYF.

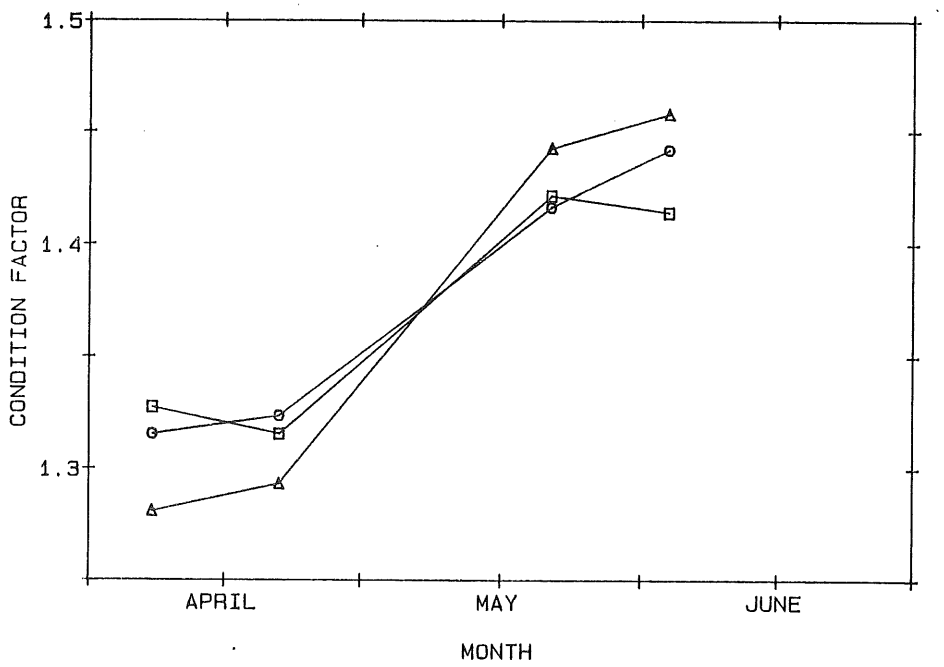

Fig. 4: Mean condition factors of the anadromous strain. Circles = CY, triangles = AD, squares = AY.

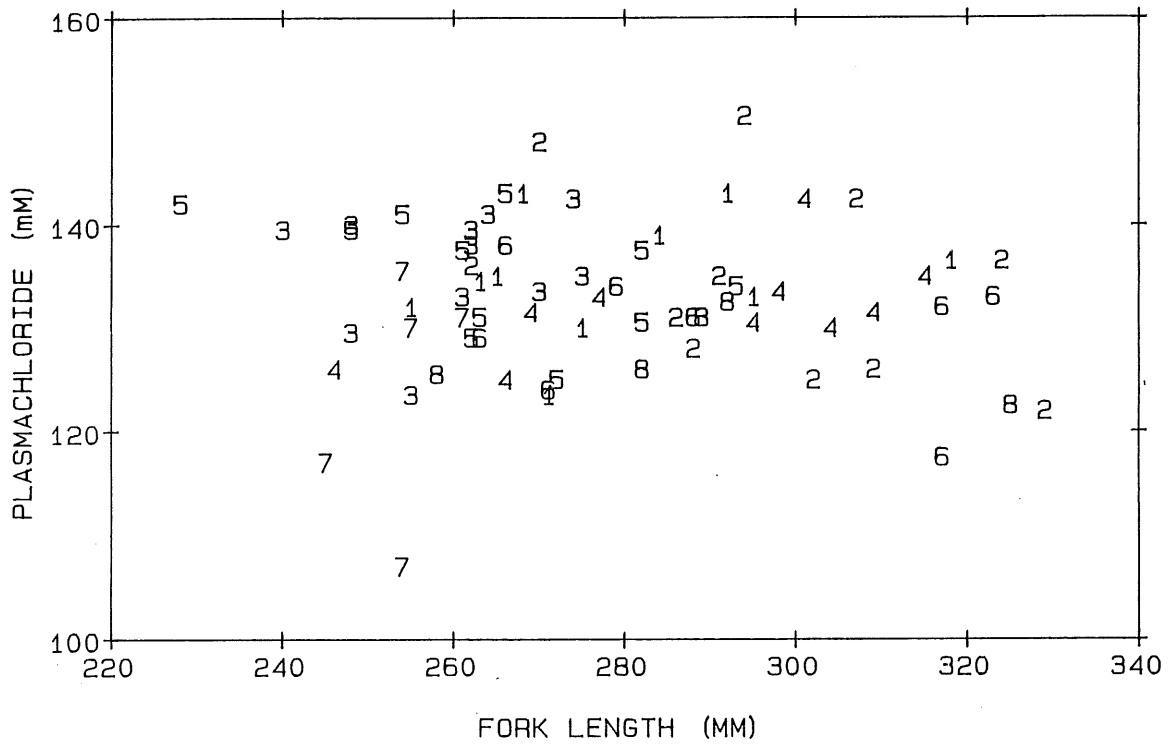

Fig. 5: Individual plasma chloride values from the salt water challenge test distributed on fish size. 1 = CYF, 2 = CY, 3 = AYF, 4 = AY, 5 = ADF, 6 = AD, 7 = non-migratory strain fresh water control, 8 = migratory strain fresh water control.