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Life history of a riverine, resident Atlantic salmon *Salmo salar* L.

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The Mellingselva river, a tributary of the River Namsen, in central Norway, supports a population of freshwater resident Atlantic salmon *(Salmo salar),* which resembles a parr and which completes its entire life cycle in the river. The maturing females of this population are particularly small-sized (13.6—22.8 cm, mean 17.6 cm). They mature at an early age (mean 3.9 years), and have a low fecundity (55—190 eggs, median 95 eggs) compared to that of other salmon populations, both nonanadromous and anadromous. The annual mean growth rate after age of two years is about 2.0 cm and the low annual survival rate reflects the poor living conditions in this river. In spite of its small size when adult, this salmon lays large eggs (5.0 mm). This may be a compensatory mechanism that promotes the survival of offspring in spite of the low fecundity and low survival rate of the adults. These life history traits resemble those recorded for both anadromous Atlantic salmon parr and of resident brown trout *(Salmo trutta)* that live in impoverished rivers.

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INTRODUCTION

The freshwater resident Atlantic salmon *Salmo salar* L. found in the Namsen river, central Norway (Berg 1953), probably became isolated about 9500 years ago from the population of anadromous salmon in the same river (Berg 1985). There are several populations of freshwater resident Atlantic salmon present in the different parts of the catchment area of the River Namsen. One of these resides in the River Mellingselva, a minor, rapidly flowing tributary in the upper reaches of the main river. The salmon population in the River Mellingselva is genetically distinct from the freshwater resident salmon population found in the main river, as differences in the allelic frequencies show (Vuorinen & Berg 1988).

The maturing females of the resident salmon in the River Mellingselva are particularly small sized in comparison to those of other populations of Atlantic salmon, both anadromous and nonanadromous. This publication describes the main life history parameters of this particular salmon.

MATERIAL AND METHODS

Altogether 344 fish were collected, between 1. July and 1. September each year, during the period 1978—1986. The fish were caught with small hooks baited with earthworms. Total length was measured to the nearest mm. Age was determined from scale-readings, which have proved to yield the same results as otolith-readings (Berg 1981). Age is expressed as the number of winter zones present in the scales. The age-specific lengths of the different age groups have been given as the actual lengths on capture, because all the material was collected during the same period of time each year. Individual fecundity was determined as the total number of ripe eggs in females of maturity stage IV or above (Dahl 1917). Egg diameter was investigated on one fish that matured in captivity.

RESULTS

The age composition diagram (Fig. 1) shows that fish 2 years-old and younger were scarce in the samples. This is due to gear selectivity.

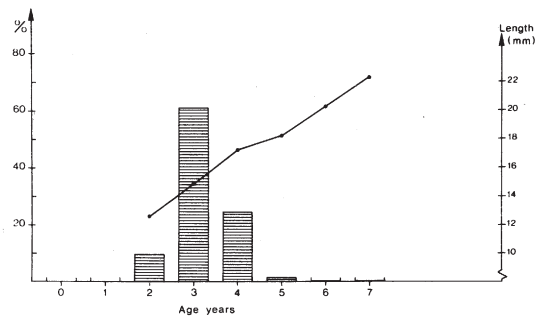

Fig. 1. Age distribution (percentage histograms) and growth curve for the nonanadromous Atlantic salmon in the River Mellingselva.

Fish that are 3 winters old constituted more than 60% of the catch. The survival rate from the third to the fourth year is about 50%. The survival rate from the fourth to the fifth year age is even lower, only about 14% of the 4 years old salmon surviving into their fifth year. Growth of the salmon after age 2 is approximately linear, with a mean annual growth rate of about 2.0 cm.

The length distribution of the females (Fig. 2) was not significantly different from that of males ($P<0.07$, Mann-Whitney U-test). No mature females had a body length less than 13.6 cm, while about 65% of the females above 16 cm in length were maturing. The length distribution of the maturing females

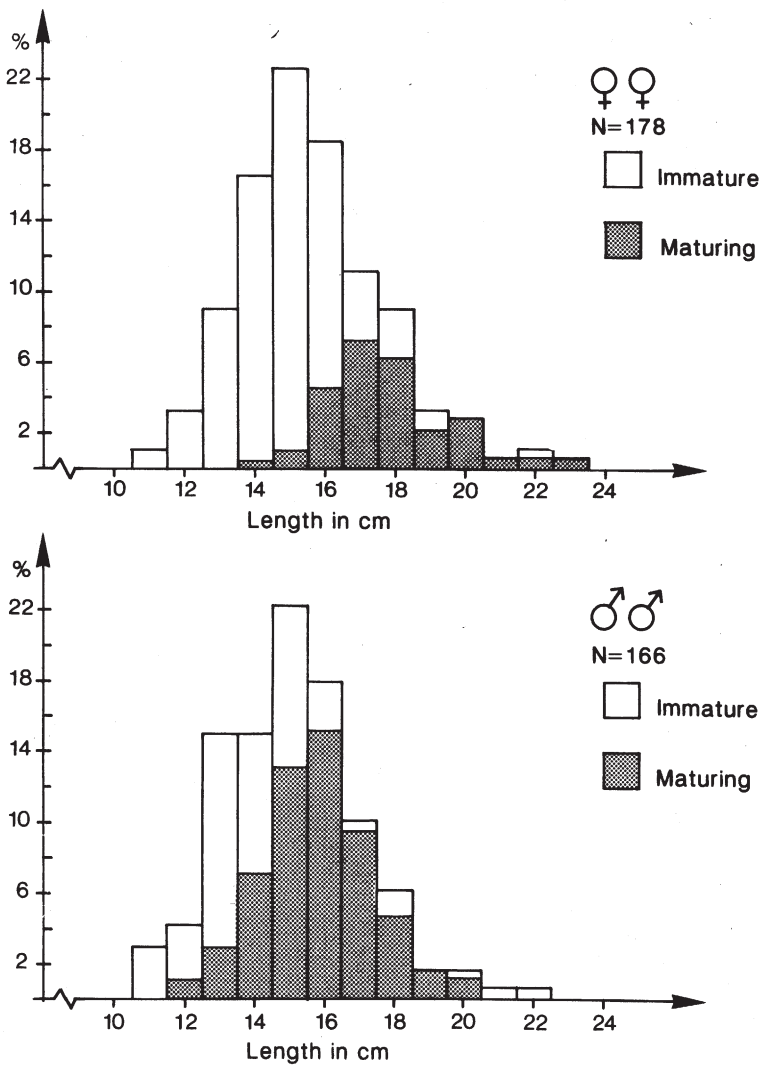

Fig. 2. Length distributions (% histograms) of immature and maturing females (above) and males (below).

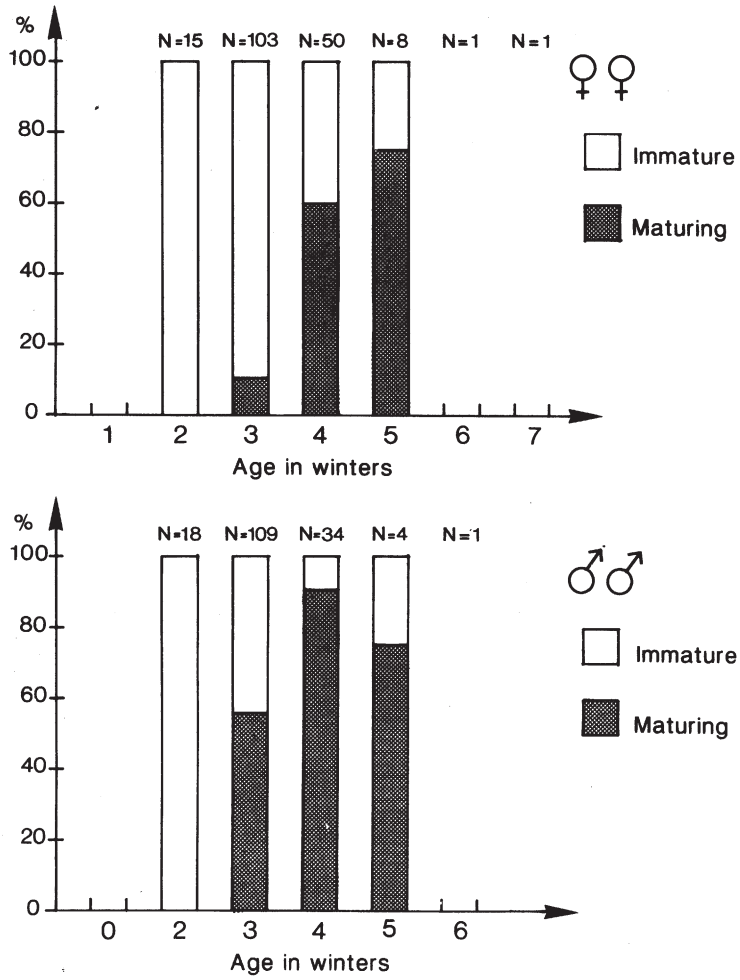

Fig. 3. Percentages of maturing females (above) and males (below) in each age group.

was significantly different from that of the males ($P<001$, Mann-Whitney U-test). The mean body lengths of the maturing females and males were 17.6 cm and 15.7 cm, respectively.

Most females matured at an age of 4 years or above (Fig. 3), while a high proportion of the males matured one year earlier. This difference in age of maturity is significant ($P<0.001$, Mann-Whitney U-test). The mean ages of maturing females and males were 3.9 years and 3.4 years, respectively.

The median fecundity was 95 eggs, with extremes of the range being 55 and 190 (Fig. 4). Egg number (F) increased significantly with body length (L) ($P<0.003$), the best linear equation being:

$F = 1.47*L—145.$

Several of the females caught in August 1986 were subsequently kept in a cage submerged in the river. Only one of them survived to maturity, at the end of October. The mean egg diameter for this female (length 18.5 cm) was 5.0 mm (Fig. 5).

DISCUSSION

In contrast to the salmon population found in the River Mellingselva, freshwater resident salmon usually migrate into lakes as smolts (e.g. Barbour & Garside 1983, Chernitskiy & Loenko 1983, Koch 1983, Birt & Green 1986). Such lake dwelling salmon usually both live longer and have a higher growth rate than the values recorded for the salmon in the River Mellingselva (e.g. Runnström

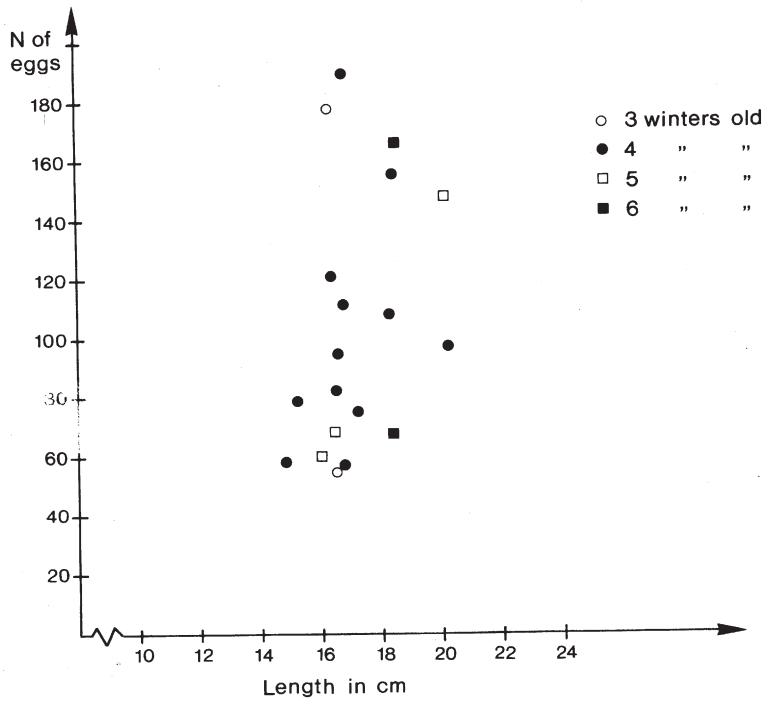

Fig. 4. Number of eggs of 3 to 6 years old females, in relation to body length.

1940, Warner 1962, Scott & Crossman 1964, Leggett & Power 1969, Wickström 1974, Leclerc & Power 1980, Dirin 1983, Riley & Power 1987). Lakes may provide better conditions for the survival and growth of Atlantic salmon compared to riverine conditions (Hutchings 1986). The island of Newfoundland possesses thousands of isolated populations of nonanadromous Atlantic salmon. The extreme dwarf form appears to be restricted to small ponds in barren areas at high elevations (Sutterlin & MacLean 1984).

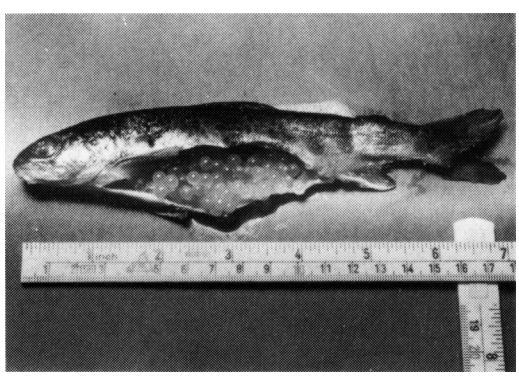

Fig. 5. A nonanadromous salmon from the River Mellingselva matured in captivity (total length 18.5 cm, number of eggs 167, mean egg diameter 5.0 mm).

The growth rate of the resident salmon in the River Mellingselva is similar to that reported for anadromous Atlantic salmon parr in this part of Norway (Heggberget 1974, Johnsen 1976). It also retains its parr-marks throughout its entire life. However, the age distribution of anadromous salmon parr is quite different, because of the short time they spend in the river before seaward migration. Both the survival rate and the growth rate are similar to those recorded for the resident brown trout, *Salmo trutta,* in the River Mellingselva and in the neighbouring reaches of the main Namsen river (Berg 1981).

The maturing females found in the River Mellingselva (body length 13.6 to 22.8 cm) are among the smallest Atlantic salmon known. Sutterlin & MacLean (1984) have reported maturing resident females with a length of 12 cm and above from Five Mile Pond East, Newfoundland. Leggett & Power (1969) reported a body length of 16.0—20.7 cm for the smaller maturing females in the resident population of Flatwater Pond, Newfoundland, an oligotrophic lake with a poor invertebrate population and no forage fish. Both the growth rate and survival rate of that

salmon population, however, were somewhat higher than those recorded for the stock in the River Mellingselva. Couturier et al. (1986) recorded a minimum size of 18.8 cm for maturing nonanadromous females in Newfoundland. Low frequencies of miniature females have been recorded among anadromous Atlantic salmon on both the northern (length 27.5—30.5 cm when 6—8 years-old; Power 1969) and southern fringes of its distributional range (Maisse & Bagliniere 1983).

The mean age at maturity of the females in the River Mellingselva was 3.9 years. This value is similar to that (3.8 years), reported by Couturier et al. (1986) although low in comparison with those of freshwater resident populations that migrate into lakes (e.g. Warner 1962, Scott & Crossman 1964, Wickström 1974, Dirin 1983) and with the values for anadromous populations in the same part of Norway (Johnsen 1976). Earlier maturation of the males, as found in the River Mellingselva, appears to be a general trait among salmonids (Gross 1985).

The average fecundity of the fish in Flatwater Pond was 153 eggs per female for the smaller-sized ripe fish (Leggett & Power 1969), a somewhat higher value than for the River Mellingselva (median 95). A mean value of 130 eggs per female was recorded for the dwarfed freshwater resident salmon population of Five Mile Pond, in Newfoundland (Sutterlin & MacLean 1984).

Egg diameter for the resident salmon stock in Five Mile Pond ranged from 4.4 to 4.8 mm (Sutterlin & MacLean 1984), compared with 5.0 mm recorded for the only fully ripe female from the River Mellingselva. Thorpe et al. (1984) reported egg diameter values varying from 4.5 to 6.5 mm (mean 5.7 mm) for anadromous salmon.

Sexual maturation of anadromous salmon at the parr stage occurs as a part of a mixed life history strategy. In the River Mellingselva this is a pure strategy, since these salmon complete their entire life-cycle in the river, resembling a parr in both outward appearance and in growth.

According to Jonsson et al. (1984) maturation occurs at an age that promotes maximum reproductive success during the lifetime. In the present case, selection for a low age at maturity probably occurs, because the low survival rate and growth rate results in a minimal increase in fecundity with increasing age.

Similar life history traits have been recorded for other stocks of nonanadromous salmon living under poor nutritional conditions, as also for resident brown trout living in fast flowing, impoverished streams, such as those found in the River Mellingselva and the upper reaches of the River Namsen.

The life history of the nonanadromous salmon in the River Mellingselva represents an extreme case among the wide range of life histories reported for Atlantic salmon stocks. This is almost certainly a consequence of the poor habitat conditions in this river. Among the most notable features, the large size of the eggs in relation to the female body size should be stressed. This may represent a compensatory mechanism to promote survival of the offspring in spite of the low fecundity and low survival rate of the adult fish.

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