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GROWTH RATE AND AGE AT SEXUAL MATURITY OF ATLANTIC SALMON SMOLTIFYING AT ONE AND TWO YEARS OF AGE

By

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ABSTRACT

Postsmolt growth rate and age at first maturation are compared for sibgroup or population groups of salmon originating from Norwegian rivers and fish farms. Generally high correlations were found between corresponding values (lengths at different ages and proportions of mature fish in the second and third sea year) for one and two year smolt. One year smolts were smaller at the smolt stage and grew slower the first sea year, but the two categories reached practically the same total length after two years in the sea. In most groups and in the total material one year smolt gave higher proportions of grilse. Proportions of mature fish during their third sea year were similar for one and two year smolt of the same groups. Pronounced variations between sibgroups and population groups were found both in growth rate and mean age at first maturation. This variation was much bigger than the variation between one and two year smolt of the same sib group.

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INTRODUCTION

In Norwegian rivers salmon normally smoltify 2-5 years old depending upon the environmental factors in the rivers and probably on genetic factors as well (Refstie, Steine and Gjedrem 1977). In commercial rearing of smolt for fish farming, one year smolt is commonly obtained by using heated water, offering good food supply and grading away the smallest individuals after one summer. In Norwegian fish farms about 2/3 of the smolt are now reared in one year and the rest in two years.

It has been widely discussed whether the fast presmolt growth rate and early smoltification have some influence on the subsequent growth rate and age at first sexual maturity of the fish. Ritter (1975) and Ritter and Newbould (1977) found significantly lower proportions of grilse in groups of one year smolt than in groups of two year or older smolt. Fish farmers have observed that two year smolt grow faster and are easier to handle than one year smolt the first weeks or months in the sea.

However, most observations suffer from the drawback that fish of different genotypes have been observed. The observations reported here were made on one and two year smolt of the same sibgroups ensuring that similar genotypes could be compared. The experiments are part of a genetic program for studying quantitative genetics of fish.

MATERIAL AND METHODS

The parent fish in the present investigations were collected from seven rivers and two fish farms in Norway in Autumn 1973. Normally two males and two females from each locality were used. The egg portion from each female was divided into two equal parts each of which was fertilized with sperm from one of the males, thus giving four groups of fullsibs from each locality (eight groups from one of the localities).

During fresh water stages the experiments were performed at the

research station Akvakulturstasjonen Matre. The eggs and the fish were kept in separate trays and parr tanks until they were about six months old (September 1974). Thereafter the groups were kept together two by two in the tank after removing the adipose fin of the fish in one of the groups. In May 1975 the one year smolt were marked with freeze branding (Refstie and Aulstad 1975) and transferred to sea water and later in the summer to the fish farm of Svanøy Stiftelse (Svanøy Foundation), Svanøybukt. The rest of the fish were transferred to brackish water (15-20 ppt) in net pens outside the research station in late summer. The next spring (May 1976) nearly all fish smoltified, and after freeze branding they were transferred to Svanøy Stiftelse. An outbreak of vibriosis reduced the number of one year smolt drastically, and many of the groups could not be used in further comparisons. During the sea water stage the fish were length measured after one year, one and a half year and at slaughtering about 24 months in the sea. Maturing fish were recorded during the second sea year, and whether the fish should mature during the third sea year was recorded at slaughtering.

The aim was to select parent fish for the second generation based on the results of the measurements in order to obtain genetic improvement for fish farming. However, this could not be done because IPN virus was detected in material belonging to the present experiments.

The two year old smolt of the yearclass hatched in 1973 were kept in similar net pens as the one year smolt at Svanøy Stiftelse, and data from the 1973 yearclass have therefore been used for comparison.

Standard statistical methods were used for calculations of correlation factors. Per cent values were transformed to $\sin^{-1}\sqrt{\text{proportion}}$ before calculations. Comparisons of corresponding values for one and two year smolt were based on the sibgroups, but where the numbers of one year smolt within groups were low, the sibgroups from the same locality were pooled.

RESULTS

GROWTH RATE

The main results concerning growth rate are shown in Fig.1. Marked differences in growth rate between groups were observed.

The mean lengths at the smolt stage were somewhat greater for the 2 year smolt than for the one year smolt, and after one year in the sea the mean lengths were considerably greater for the 2 year than for the one year smolt. For instance the total mean for the 2 year smolt was 42,5 cm while it was 35,5 cm for the one year smolt. However, during the second sea-year this difference nearly disappeared, and in many groups the one year smolt were greater than the 2 year smolt at the end of the second summer. The total mean then showed a difference of 1,7 cm in favour of the 2 year smolt. Half a year later the two categories were nearly of the same size.

The results were also compared to the mean of the 1973 year class which was composed of 2 year smolt and were reared in pens parallel to the one year smolt of the 1974 year class.

Fig.1 shows that the results of the 2 year smolt of the two year classes were very similar.

Mean lengths for one and two year smolt of the same groups were subjected to a correlation analysis. The following correlation coefficients were found:

smolt:	0,14
one year in the sea:	0,75
one and a half year in the sea:	0,71
two and a half year in the sea:	0,75

Except for the first one, these correlation coefficients are highly significant ($p < 0.01$), implying that each group has its

characteristic postsmolt growth potential regardless of whether they smoltify after one or two years.

AGE AT FIRST SEXUAL MATURATION

Per cent mature fish the second (grilse) and third year in the sea are shown in Fig.2. Great variation were observed between sibgroups and locality groups. Most groups showed higher proportions of grilse among the one year smolt than among two year smolt, and the total mean of the one year smolt amounted to 23% compared to 15% for the two year smolt. Concerning maturation during the third sea year, generally good correspondance between one and two year smolt of the same groups were found, although some groups diverged somewhat. It should be added that especially the values of the one year smolt are based on few individuals, and rather high sample variation may exist. Totally the two year smolt showed somewhat higher proportion of mature fish during the third sea year.

Corresponding values of one and two year smolt of the same groups were subjected to an analysis of correlation. The proportions were transformed to $\sin^{-1}\sqrt{\text{proportion}}$ before calculations. The following correlation factors were found:

Maturation	second	sea year:	0,81
"	third	" "	0,64

Both factors are highly significant ($p < 0.01$), and they show that on an overall basis there is very good correspondance between the results of the two categories. Age at maturation (after smolt stage) thus seems to be a characteristic trait of the groups, although there is a tendency towards higher proportion of grilse among one year smolt that among two year smolt of the same group. Compared to the two year smolt of the 1973 year class, both categories of the 1974 year class showed lower proportions of mature fish both in their second and third sea year. This, however, was expected because the 1973 year class contained several groups of a typical grilse population.

DISCUSSION

Differences in postsmolt growth rate between one and two year smolt the first sea year was expected because of the smaller initial size of the one year smolt. However, concerning growth rate, one and two year smolt are evidently of about the same value for fish farming, as they reach the same mean size at normal time for slaughtering.

The effect of parental age on age at first maturity in Atlantic salmon is observed by different authors (Piggins 1973, Ritter and Newbould 1977, Nævdal et. al. 1978). Genetic factors seem to be very important in determining the age at which the salmon is destined to mature. In the present study great variation between sibgroups and populations were found confirming the results of previous studies.

In most groups and in the total material higher proportions of grilse among one year than among two year smolt were found. This is somewhat in contrast to the findings of Ritter and Newbould (1977) who found proportionally fewer grilse among one year than among two year smolt. The reason for this discrepancy is unknown, but it seems reasonable that different populations may behave different also in this respect.

Hallingstad (1978) found higher proportion of early maturing rainbow trout among the faster growing than among the slower growing individuals. The fastest growing fish were mostly males and it is well known that most of the early maturing rainbow trout are males. A similar explanation could not be applied on the present results, because the distribution of sexes was nearly the same for the one and two year smolt.

One year smolt are those fishes showing the higher presmolt growth rate. If high presmolt growth rate causes or is connected with higher chance of early maturation, or if the fish destined

to mature early also show high presmolt growth rate, the differences between one and two year smolt may be explained. The present experiment can give no answer to this question, but for practical fish farming it would be important to know if high presmolt growth rate also will give high proportions of early maturing fishes. If this should be the case, the use of one year smolt in fish farming should be questioned.

However, the difference in maturation age between one and two year smolt was much smaller than the difference between populations. In some populations there was nearly no grilse regardless of age of smolt, and selection of such populations for farming could therefore probably solve the problem with grilse among the farmed salmon.

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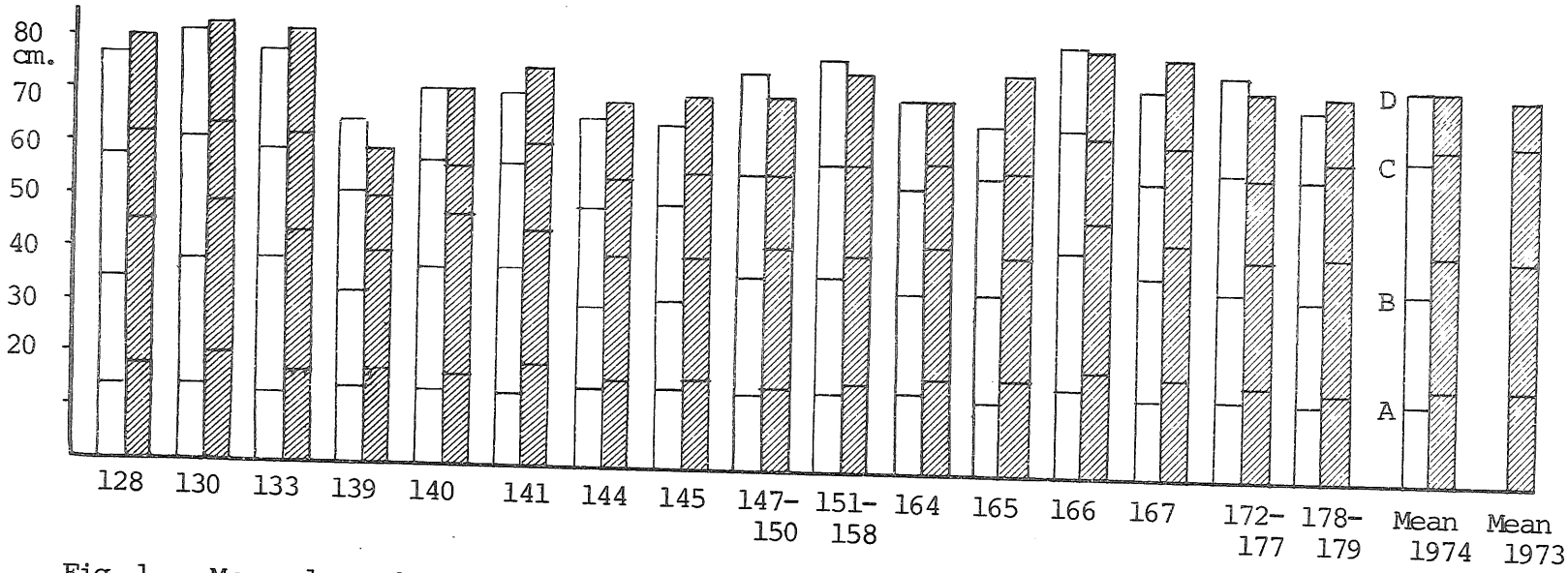

Fig. 1. Mean length of salmon sib groups as smolt (A), after one year (B), after one and a half year (C) and after two years in the sea (D).
Open histograms: one year smolt, hatched histograms: two year smolt.

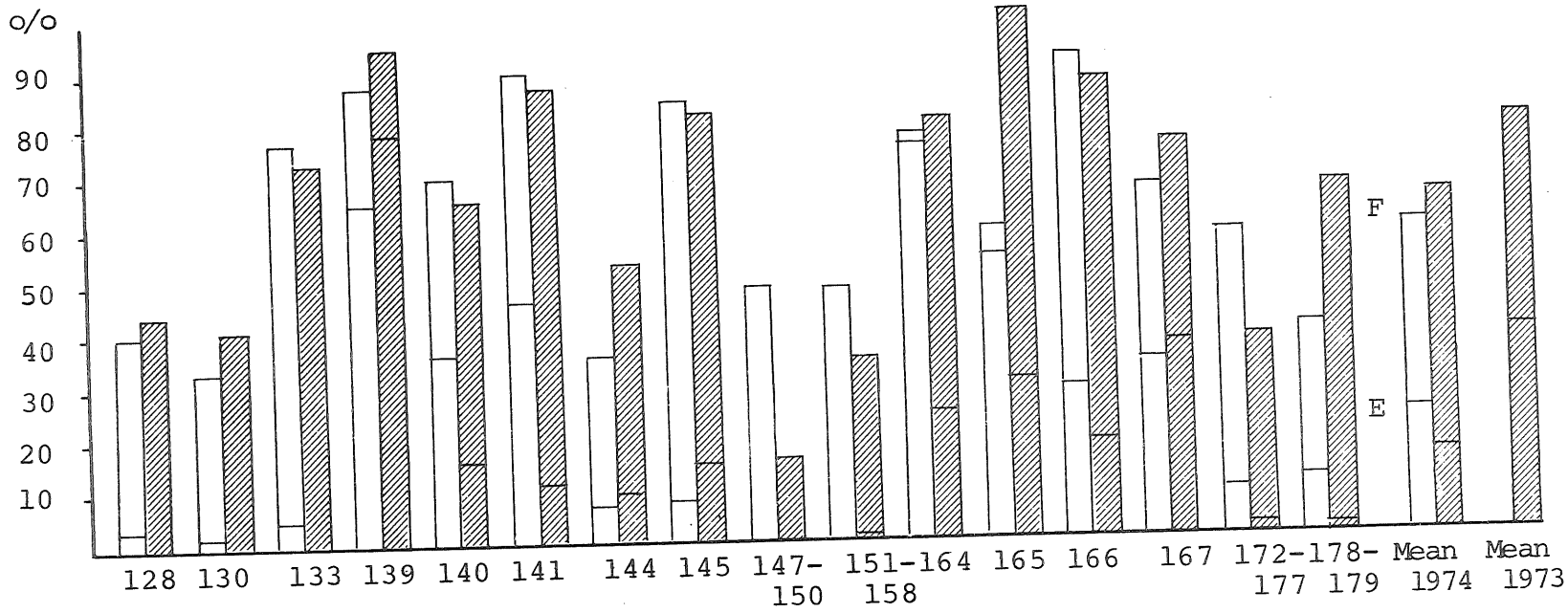

Fig. 2. Proportions of salmon sib groups maturing during their second (E) and third year in the sea (F). Open histograms: one year smolt, hatched histograms: two years smolt.