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VARIATION IN AGE AT SEXUAL MATURITY IN RAINBOW TROUT

By

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INTRODUCTION

For the last two decades farming of rainbow trout, Salmo gairdneri, has had growing interest in Norway. Most fish farmers produce fish of individual weights of more than 1.5 kg, often up to 3 or 4 kgs.

Sexual maturity at early age or at small size is a serious drawback for production of big rainbow trout, because maturation will retard the growth rate of the fish, and, as claimed by the fish farmers, cause increased mortality.

Several characteristics, including mean age of maturity of the rainbow trout have been altered by selection (Savost'yanova 1972). In the present report data on variation in age of maturity between sib groups, and tentative calculations of heritability are given. Also relation between growth and maturity is paid attention to.

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MATERIAL AND METHODS

Egg and milt material for the present experiments was obtained from a commercial Norwegian fish farm, Eros Laks, N-5627 BJORDAL, in winter 1972 and 1973. In 1973 milt from three males from another fish farm, Bolstad Fiskeanlegg, N-5972 HOLDHUS, was included.

Originally the rainbow trout at Eros Laks came from Denmark. Through two or three generations mass selection for high growth rate and high age at first maturation has been carried out by the owner of the fish farm, but due to lack of unselected material for control, the effect of the selection is unknown.

The present experiments were based on sib groups. The egg portion of each female was divided into two equal parts and fertilized with milt from different males. Each male was normally used for two females. For various reasons, this pattern of combinations was only partly followed in 1973.

The eggs were hatched at the hatchery of the research station Fisk og Forsøk, N-5198 MATREDAL. From start of feeding to an age of 16 months (1972 year-class) or 8 months (1973 year-class) the fishes were kept in 1.7 m^3 sylindrical plastic tanks. Thereafter they were kept in floating cages in brackish water until they were transferred to sea water; the 1972 year-class to a shore enclosure at Eros Laks, and the 1973 year-class to 50 m^3 floating cages kept at the commercial fish farm Risnefisk, N-5950 BREKKE.

In its first months of life each group was kept in a separate tank. From about six months of age they were marked with combinations of fin clipping (adipose fin or pelvic fins), and part of the material was also tagged with Floy Tag (FT4 Spaghetti tag, FT4 Lock on, FT6 Dart tag or FD67C, all from Floy Tag & MFG, Ina. 4616 Union Bay PL.N.E. Seattle, Wash. 98105).

Some of the sib groups died out during the egg or fry stages. The main reason for this was accidental causes (mostly technical problems with the water sypply), partly also outbreak of vibriosis.

Sexual maturity was recorded by inspection during fall and spring in the second year of the life of the fish. Length and weight of both mature and immature fish were recorded.

In October 1974, 20-30 of the biggest fishes in each group of the 1972 year-class were selected for the F_2 generation, while the rest was slaughtered. From slaughtered fish were recorded lengths, weights and stage of maturity. Maturity of the live fish was recorded by visual inspection during winter 1975.

RESULTS AND DISCUSSION

Relation between sexual maturity and growth

An account of mean lengths within groups of maturing, mature and immature fish is given in Table 1. In early November 1974 fishes of the 1973 year-class (mostly males) maturing in their second year of life, could be recognized. The material is scanty in most groups, but the mean lengths of maturing and immature fishes are very similar, indicating that at this time there is no relation between maturity and growth. Whether a fish will mature in its second year seems to be unrelated to the size of the fish, and up to 2-3 months before normal spawning time, maturity does not seem to affect growth.

In the spring nearly all groups of both year-classes show significantly lower mean lengths for the mature fishes than for the immature fishes, showing that maturation has caused retarded growth rate during the spawning season.

The proportions of matured fishes were found to be nearly the same in fall as in spring for the 1973 year-class, indicating that maturation has caused no significant increase in mortality. This is somewhat in contrast to the experience of fish farmers claiming that mature fish show increased mortality during early spring.

Maturation in the third year of life seems to be uncorrelated with individual length because mean lengths are similar for maturing and immature fishes also for the 1972 year-class in October 1974. The data in Table 1 also indicate that at this time of the year maturation has caused no significant decrease in growth rate.

Thus there seems to be no relation between growth and age at maturity within sib groups. To study the relation between age at

Table 1. Mean length (in cm) of maturing, mature and immature rainbow trout.
(Number in brackets)

1972 Year-class

Age in months		Sibgroup no. 1	5	6	7	8	9	12	13	14	15	16	17	18	19	20	21
Jun.1974 26 months	Mature	34.2 (17)	34.6 (20)	35.1 (43)	33.6 (26)	35.7 (14)	35.2 (9)	31.3 (7)	33.1 (5)	35.0 (1)	31.9 (13)	34.3 (6)	31.0 (6)	40.5 (1)	36.1 (8)	37.1 (4)	36.5 (12)
	Immature	37.2 (157)	37.8 (108)	37.6 (107)	35.9 (100)	36.8 (93)	36.4 (131)	34.7 (84)	36.1 (110)	36.1 (64)	38.3 (85)	37.4 (93)	37.4 (105)	38.9 (61)	40.1 (101)	38.6 (107)	38.1 (72)
Oct.1974 30 months	Maturing	52.9 (12)	49.0 (23)	51.6 (56)	47.9 (39)	47.0 (11)	47.3 (13)	49.5 (19)	48.5 (8)	50.1 (4)	46.9 (10)	48.8 (11)	48.9 (5)	58.0 (1)	51.4 (11)	52.1 (18)	45.5 (19)
	Immature	50.3 (98)	47.2 (25)	47.8 (64)	48.0 (42)	47.8 (38)	47.4 (86)	45.7 (101)	49.7 (46)	50.0 (21)	52.0 (42)	51.7 (35)	50.2 (55)	53.8 (29)	51.8 (44)	52.1 (48)	51.5 (29)

1973 Year-class

Age in months		Sibgroup no. 22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37
Nov.1974 20 months	Maturing	-	33.6 (6)	32.0 (1)	31.0 (2)	36.5 (1)	-	-	-	34.6 (36)	36.9 (4)	33.9 (8)	31.0 (1)	-	34.0 (1)	34.8 (14)	32.5 (2)
	Immature	36.5 (100)	33.2 (101)	34.0 (101)	33.9 (101)	34.0 (103)	35.5 (100)	30.0 (100)	33.9 (101)	36.4 (64)	36.0 (86)	34.6 (99)	34.9 (101)	34.9 (111)	35.8 (117)	34.6 (103)	33.1 (100)
Apr.1975 24 months	Mature	39.8 (4)	35.1 (7)	38.0 (1)	34.9 (8)	34.7 (3)	34.0 (1)	32.0 (1)	-	36.2 (54)	37.2 (11)	34.1 (22)	-	39.0 (1)	38.0 (1)	37.8 (16)	33.4 (5)
	Immature	43.2 (121)	38.3 (116)	41.2 (124)	40.5 (117)	40.0 (122)	41.9 (124)	35.2 (122)	40.3 (125)	43.4 (68)	43.4 (114)	42.1 (103)	41.9 (125)	41.3 (124)	43.3 (124)	42.3 (109)	39.7 (120)

maturation and mean growth rate of the groups, correlation factors between proportion of mature individuals ($\sin^{-1}\sqrt{\%\text{mature}}$) and mean length of groups in the fall prior to the spawning season were calculated. Conserning maturation in the second year of life, no such correlation was found. However, for the 1972 year-class a correlation factor of 0.52 ($0.2<P<0.5$) was found between mean length in the fall of the third year and proportion of matured individuals the following winter. This implies that part of the variation between groups (the present data indicate one fourth to one third) in maturity in their third year could be related to mean growth rate of the groups. Closer studies of variation in growth rate (length, weight and condition factor) will be reported later, and corresponding results of later year-classes will add further information as to confirm the present results.

Heredity and age at maturity

In the preceeding section were found no indications of relation of growth and age at maturity within sib groups, and only one indication of such relation between sib groups. As the environment was the same for all groups within the year-classes, it is reasonable to conclude that genetic factors must be responsible for the great observed variation in proportion of mature fish during their second and third year (see Table 1).

Donaldson (1959) altered the age of maturity of female rainbow trout by selective breeding. This implies that additive genetic factors control this trait. To estimate heritability factors a nested design of an analysis of variance was applied, utilizing correlation between halfsib groups (Becker 1967), with the corrections used for per cent data calculated from unequal sub-class numbers by Bogyo and Becker (1965). The per cent data were transformed to $\sin^{-1}\sqrt{x}$ before calculations.

Concerning maturation in their second year of life, calculated heritability factors (h) from paternal (S) and maternal (D) half-sib groups were rather low:

1972 year-class: $h_S \sim 0.09$, $h_D \sim 0.01$

1973 year-class: $h_S \sim 0.0$

In their third year of life, however, a heretability factor of 0.47 was calculated from paternal halfsibs, while based on maternal halfsibs a factor near zero was found. Calculated heritability factors from full sib groups within sets of half sibs, were in the order of 0.4 - 0.5.

Due to the rather low number of groups, the confidence intervals are rather wide for the calculated heritability factors, and thus the present results have to be confirmed by further studies. Additive genetic factors seem to be of little importance for maturity during the second year of life of rainbow throut judged from the low estimate of heritability from half sib groups. The rather high estimates of heritability factors calculated from full sib groups indicate that non-additive genetic factors could be of importance for age at maturity, as estimates based on full sib groups includes part of the dominant gene effect (Becker 1967). If this is confirmed by study of more extensive material, the best result of a genetic improvement program would be reached by hybridization of pure lines. However, genetic improvement may be obtained by selective breeding even if the heretability is low due to the high selection intensity which may be applied in fish species.

SUMMARY

1. Considerable differences between sib groups were found in proportion of fish maturing in their second and third year.

2. No relation between growth rate and age at maturity was found within groups.

3. A low, but significant positive correlation was found between mean growth rate of groups and proportion of fish maturing in their third year. No such correlation were found in the fish's second year.

4. With one exception, low heritability factors were calculated from half sib correlations, indicating that additive genetic factors play a minor role for age at maturation.

5. Considerably higher heritability factors were calculated from full sib correlations, indicating that non-additive genetic factors are of importance for age at maturity of the rainbow trout.

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