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Relationships of Smolt Size and Age With Age at First Maturity in Atlantic Salmon

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SUMMARY

Relationships of smolt size and age with age at first maturity in Atlantic salmon, although previously reported on, are reviewed in this paper.

Tagging experiments with groups of hatchery-reared smolts in Canada and Sweden show a positive relationship between growth rate in freshwater and age at first maturity, with the faster-growing individuals reaching sexual maturity at an older age than slower-growing fish. These results suggest that size selection during the juvenile stage, as is presently practised in hatcheries through grading and culling small fish, can influence age composition of subsequent adult populations.

INTRODUCTION

Relationships between age at first maturity and smolt size (Ritter, 1972) and smolt age (Peterson, 1971 and 1973; Gray, 1973) of Atlantic salmon (*Salmo salar L.*) have previously

been reported on for hatchery-reared fish, but warrant further discussion concerning their importance. The purpose of this paper is to review and present additional evidence supporting the existence of these relationships, and to discuss their significance.

REVIEW

A relationship between size of hatchery-reared smolts and age at first maturity in Atlantic salmon was initially postulated by Allan (1967) and later confirmed by Ritter (1972). Ritter reported that, within groups of two-year hatchery-reared smolts, the larger smolts produced proportionately fewer grilse than did the smaller smolts. This positive relationship is the opposite to that reported by Wagner (1967) for hatchery-reared smolts of steelhead trout (*Salmo gairdneri*, Richardson) on the west coast of North America. Ritter also reported a lack of conclusive evidence of this relationship in wild Atlantic salmon smolts.

The presence of a relationship between age at first maturity and smolt size for hatchery-reared fish and yet absence of a similar relationship in wild fish suggests that age at first maturity in Atlantic salmon is related to the rate of growth in freshwater rather than the actual size of the smolts at migration from the river. The hatchery-reared smolts were all 2-year-olds at release whereas the wild smolts were a mixture of 2-, 3- and 4-year-olds at time of tagging and migration to sea. Among hatchery-reared smolts, smolt-size was indicative of growth rate, whereas among wild smolts, differences in size at migration did not reflect different rates of growth. The 2-year-old wild smolts may have been smaller at migration time than 3- and 4-year-old smolts, but yet the 2-year-old smolts would have experienced the highest growth rate of the three year-classes.

Because all fish within the groups of hatchery-reared smolts were reared together under the same conditions, growth differences within these groups cannot be attributed to different rearing environments. Instead, they are interpreted to be the result of genetic variation within the respective populations.

A relationship between smolt age and age at first maturity was first suggested by Peterson (1971) who reported that the groups of one-year smolts stocked from Swedish hatcheries produced few if any grilse in comparison to similar groups of two-year smolts. Gray (1973) has since reported that groups of one-year smolts released into a Canadian river (St. John River, New Brunswick) produced markedly fewer grilse than did a group of two-year smolts of the same stock origin. Results of the Canadian experiments have been updated and are presented below:

Hatchery, smolt age	Proportion grilse (%)
Yarmouth, 1 year	10
Mactaquac, 1 year	6
Mactaquac, 2 years	44

The different proportions of grilse produced by one- and two-year smolts are attributed to size selection practices employed during the tagging operation. The Canadian one-year smolts were the largest yearlings produced by the two hatcheries from which they originated. Approximately thirty-three percent and less than ten percent of the total yearling productions at Yarmouth and Mactaquac hatcheries, respectively, were one-year smolts. Similarly, the Swedish one-year smolts were the largest yearlings comprising only ten percent of the total yearlings produced. According to Peterson (1971) the remaining ninety percent of the yearlings had not attained smolt size at tagging.

Results from a second set of Swedish experiments with one- and two-year smolts reported by Peterson (1973) support the theory that removal of the slower-growing individuals from a group of juveniles results in a reduced production of grilse by the group. In these experiments, the one- and two-year smolts produced almost equal proportions of grilse. The one-year smolts, however, comprised ninety percent of the yearlings produced.

Size grading practices employed during tagging removed only a few fish compared to the two-thirds or more excluded during tagging of the groups of one-year smolts in the first experiments.

These results indicate that the juveniles in a particular group which are destined to mature as one-sea-winter salmon tend to be smaller and slower-growing than the others in the group which are destined to mature first as two- and three-sea-winter salmon. This same relationship can be detected in individual river escapements by comparing mean smolt ages of fish maturing first after one-, two-, and three-sea-winters, respectively. The following table presents relationships between mean smolt age and age at first maturity in Atlantic salmon escapements to five North American rivers. Numbers in parentheses are numbers of fish in each age group.

Location and year(s) of sampling	Mean smolt age for fish maturing first after:		
	1-sea-winter	2-sea-winters	3-sea-winters
Sand Hill R., Labrador, 1967-71[1]	4.07 (1783)	3.91 (185)	3.67 (3)
Miramichi R. estuary, New Brunswick, 1931[2]	2.94 (174)	2.92 (1177)	2.72 (29)
St. John R., Mactaquac, New Brunswick, 1969	3.04 (1873)	2.59 (1431)	2.60 (5)
North R., Cape Breton, Nova Scotia, 1970-72	3.40 (15)	3.28 (180)	3.00 (6)
Medway R., Nova Scotia, 1970-72	2.58 (184)	2.40 (55)	2.50 (2)

[1]Peet and Pratt, 1972
[2]Blair, 1935

The mean smolt ages of the one-sea-winter salmon are higher than those recorded for the two- and three-sea-winter salmon. This suggests that the smolts producing the maturing one-sea-winter salmon were older and therefore had experienced slower growth rates as juveniles in freshwater than had the smolts producing the sexually maturing two- and three-sea-winter salmon. Menzies (1926) did note a slight tendency of this phenomenon for salmon of the Moisie River, Quebec, but Calderwood (1927) did not make similar observations in salmon of the

Cascapedia River, Quebec. It should also be noted that this relationship persists even though there is significant variation in smolt age between river systems.

Selection practices in either hatchery or river environments which favour the survival of either slow- or fast-growing juveniles in a given age class influence the age compositions of adult populations of Atlantic salmon. In hatcheries, intensive grading practices normally remove the smaller, slower-growing fish from a group, thus favouring the production of smolts that are destined to mature first as two- and three-sea-winter salmon. Natural selection occurring in wild Atlantic salmon may also be favouring either the slower- or faster-growing juveniles and thus be contributing to yearly variation in age composition of individual adult populations.

The stocks from which these Canadian data were derived possess markedly different sex ratios within different age classes. The grilse are predominantly male while the maturing two- and three-sea-winter salmon are normally more than seventy percent female. Consequently, selection practices occurring in the hatchery or river, referred to in this paper, could also upset sex ratios of resultant adult populations.

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