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Effect of diet on rate of return of hatchery-reared Atlantic salmon *(Salmo salar)* smolts

by

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ABSTRACT

This paper presents a comparison of the performances of Atlantic salmon reared to smolt stage on two commercial diets, EWOS and Silver Cup. At the smolt stage the fish reared on the Silver Cup food were consistently larger than those fed the EWOS food. Rate of adult return from smolts reared on Silver Cup food was 41% higher than for fish fed the EWOS food ($P<0.001$). A part or all of this difference in return rate was independent of size difference between fish reared on the two diets ($P<0.001$). The results emphasize the importance of diet to Atlantic salmon culture and stock enhancement.

INTRODUCTION

The importance of diet to salmon culture has been stressed by several authors. Bergstrom (1973) working with Atlantic salmon demonstrated that fish flesh takes on the same fatty acid composition as the diet consumed. Furthermore, she suggested that parr-smolt transformation could be influenced by manipulating the fat or other ingredients in the diet. Peterson (1973) reported that the feeding of a special smolt food to salmon for a brief period before release resulted in an improved adult return rate. Burrows (1971) associated an increase in the return rate for Coho salmon (*Oncorhynchus kisutch)* with changes in hatchery diets.

This paper presents a comparison of the performances of Atlantic salmon reared to smolt stage on two commercial diets. The two diets, EWOS and Silver Cup, are the main commercial feeds available to Atlantic salmon culture operations in North America. The controversy as to which diet is producing the more viable salmon smolt relative to cost was the reason for the diet trials discussed herein. The assessment of the two diets encompasses both the performances of salmon while in the hatchery as well as after they leave the hatchery.

The commercial diets, EWOS and Silver Cup originated from manufacturers in Sweden and the United States. The EWOS food was produced at the Swedish plant near Stockholm while the Silver Cup food was purchased from Murray Elevators Ltd. in the State of Utah.

The trials were conducted at one Nova Scotia and two New Brunswick hatcheries from November 1973 to May 1975. They were carried out in production size facilities and were part of the regular fish production programs. The fish were monitored periodically through the trials at Antigonish Hatchery and at the smolt stage only at Mactaquac and Miramichi stations. Condition of fish on both diets were monitored through blood and fat analysis and determination of condition factor. Records of growth, survival, food conversion, and cost of food per kg of fish produced were maintained.

At the end of the two year rearing period representative and comparable groups of salmon reared on EWOS and Silver Cup feeds were marked with modified Carlin tags (Saunders 1968) at each of the three hatcheries and distributed shortly after into nearby rivers. This final assessment of the two diets was based on tags returned by commercial and sports fisheries and recovered at counting traps.

PERFORMANCE IN HATCHERY

Smolts produced on Silver Cup food were consistently heavier and longer at the three hatcheries than smolts reared on the EWOS food (Table 1). At Antigonish Hatchery this difference in growth was detected by the end of the first summer and was maintained until smolts were released (Table 2). Differences recorded for length and weight between hatcheries are attributed to differences in temperature regimes.

Food conversion and consequently food cost per kg of fish produced were consistantly lower for smolts produced on the Silver Cup food. The difference in cost per kg of fish produced reflects differences in food conversion as well as the cost per kg of feed for the two diets (Table 3).

Mortalities at two stations were lower for salmon fed EWOS food than for those fed Silver Cup food (Table 3).

Results of blood analysis and fat determination showed no consistent differences among the two groups at the three hatcheries (Table 1). At Antigonish hatchery differences in fat and blood analysis at the different stages were attributed to size differences and seasonal variation (Table 2).

PERFORMANCE AT SEA

Tag return rates for smolts produced on Silver Cup food were consistently greater at each hatchery than for smolts reared on EWOS food (Table 4). The average return rate for Silver Cup smolts was 41% greater than for the EWOS fish. Differences in return for smolts reared on the two diets were highly significant ($P<0.001$) when tested by chi-square.

This same trend was observed for small comparable groups of 1-year smolts produced at a hatchery in southern Nova Scotia (Ritter, unpublished). In this comparison, 1197 smolts reared on EWOS food produced 4 tag recaptures as compared to 8 returns recorded for 883 smolts reared on Silver Cup food. Adult return rates for EWOS and Silver Cup fed fish were 0.33% and 0.91%, respectively. Contrary to these results, Gray (1973) reported a return of 33 and 5 tags from comparable groups of 15,000 smolts produced on EWOS and Silver Cup feeds and distributed from Mactaquac Hatchery in 1970. In spite of the difference in return rates (0.22% vs 0.03%) for EWOS and Silver Cup fed fish the data is suggestive only ($P<0.05$) that smolts produced on EWOS food in the earlier diet trial survived better after leaving the hatchery.

It was hypothesized that the difference in sea survival of smolts reared on the two diets was attributed to a difference in smolt size as the Silver Cup smolts were on the average more than 1 cm longer at release. To test this hypothesis return rates for the Mactaquac hatchery smolts reared on EWOS and Silver Cup feeds were compared by fork length size class (Table 5). Specifically, return rates for similar size smolts reared on different diets were compared and found to be significantly different ($P<0.001$). This same trend was observed in data for comparable groups of smolts produced at the other two hatcheries, although their returns were too few to enable statistical comparison of return rates by fork length class. The results of these comparisons suggest that smolts produced on EWOS and Silver Cup feeds experience different sea survival rates independent of their differences in smolt size. A reason for this difference was not detected in the quantitative measurements made for blood and fat from the fish, although qualitative differences in fat and other ingredients present in the diets are suspected (Bergstrom, 1973).

CONCLUSIONS

The presence of a significant difference in the performance of salmon smolts reared on two commercial diets is the most striking aspect of this paper. This difference emphasizes the importance of diet to Atlantic salmon culture operations and stock enhancement. Of concern is the suggestion that the manufacturer of the diet that produced the poorer performing smolts in the most recent diet trials may have produced a diet that out-performed that of its competitor five years prior, as is suggested by data from the earlier diet trial referred to in this paper. This suggests that either one or both manufacturers have changed the formulae of their diets. Changes in formulation might not always be to improve the diet but instead may relate to price and supply of raw materials or some other factor. The authors would like to suggest the use of open formulae diets to alleviate inconsistency of performance suspected from closed formulae diets for Atlantic salmon. Research for developing open formulae diets is already in progress in both Canada and the United States.

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TABLE 1. Comparison of mean lengths, weights, condition factors, hemoglobin levels and fat content for Atlantic salmon smolts produced on EWOS and Silver Cup diets. Mean values for hemoglobin and fat content are based on samples of 25 fish.

Hatchery	Diet	Population	Number Sampled	Fork length(cm)	Weight(g)	Condition Factor	Hemo globin(g%)	Fat[1](g%)
Antigonish	EWOS	3,450	75	16.0	41.4	0.96	8.0±0.9	4.7±1.0
	Silver Cup	3,760	75	18.3	65.1	1.00	8.3±1.1	4.3±0.8
Mactaquac	EWOS	7,221	100	22.0	117.1	1.06	7.9±1.8	6.8±1.1
	Silver Cup	76,357	650	23.4	144.5	1.09	10.0±2.3	6.5±1.0
	EWOS	29,814	249	22.2	120.8	1.07	8.5±1.4	-
	Silver Cup	12,831	150	23.6	152.9	1.10	-	-
	EWOS	21,118	200	21.3	107.9	1.09	10.2±4.4	5.3±0.9
	Silver Cup	7,365	50	21.9	126.8	1.15	9.9±4.7	5.8±1.0
	EWOS	7,868	100	20.6	100.8	1.13	9.1±1.3	5.6±0.8
	Silver Cup	6,993	50	23.0	139.4	1.12	7.4±2.4	5.4±1.1
Miramichi	EWOS	5,376	75	14.5	33.2	1.07	9.1±3.2	3.7±0.7
	Silver Cup	5,760	75	15.6	41.8	1.05	9.2±1.7	3.8±0.9

[1] Fat content for whole fish (wet basis).

TABLE 2. Fork length (FL), weight(wt), condition factor (CF), hemoglobin (Hb), total plasma protein (TPP), albuim (Alb), and fat content (mean values ± SD) recorded during Atlantic salmon diet trial at Antigonish Hatchery, 1973-75.

	Diet	FL(cm)	wt(g)	CF	Hb(g%)	TPP(g%)	Alb(g%)	Fat(g%)*
End of 1st summer	EWOS	8.4±1.4	7.9±3.5	1.3±0.1	9.6±1.0	4.7±0.3	1.2±0.2	7.2±1.0
	Silver Cup	9.9±1.4	12.9±5.7	1.2±0.1	9.9±1.1	4.7±0.4	1.2±0.2	7.6±0.9
Middle of 2nd summer (yearlings)	EWOS	9.8±1.2	12.2±4.4	1.2±0.1	8.7±0.9	3.4±0.2	1.0±0.2	6.7±0.8
	Silver Cup	11.1±2.0	17.9±9.8	1.2±0.1	8.8±1.0	3.4±0.3	1.0±0.2	6.4±1.0
End of 2nd summer	EWOS	14.0±2.2	32.2±7.2	1.1±0.1	9.3±1.0	3.7±0.4	1.1±0.3	7.5±1.0
	Silver Cup	15.9±2.8	45.8±11.3	1.1±0.1	9.2±1.1	3.9±0.4	1.0±0.3	7.2±0.9

* Fat content for whole fish (wet basis)

TABLE 3. Mortality, food conversion and food cost per kg of fish produced and recorded during Atlantic salmon trials at three hatcheries from 1973 to 1975.

	Antigonish		Mactaquac		Miramichi	
	EWOS	Silver Cup	EWOS	Silver Cup	EWOS	Silver Cup
Mortality (%)	36.1	35.4	33.3	45.8	36.3	38.7
Food conversion	2.18	1.66	2.21	2.13	2.87	2.56
Food cost/kg of fish produced ($)[1]	1.58	0.84	1.60	1.08	2.08	1.29

[1] Price of EWOS $0.72/kg
Price of Silver Cup $0.51/kg

TABLE 4. Comparison of tag return information for groups of Atlantic salmon smolts produced on EWOS and Silver Cup feeds.

Hatchery	EWOS			SILVER CUP		
	No. Released	Recaptures No.	%	No. Released	Recaptures No.	%
Antigonish	3,362	23	0.68	3,596	30	0.83
Mactaquac	11,989	275	2.29	11,969	398	3.33
Miramichi	3,998	25	0.63	3,996	33	0.83

TABLE 5. Comparison of tag return rates by smolt fork length class for groups of smolts produced on EWOS and Silver Cup feed. Data are for the Mactaquac Hatchery releases. Comparison is confined to length classes for which the number released in each group was 200 fish or more.

Fork length class	EWOS			SILVER CUP		
	No. Released	Recaptures No.	%	No. Released	Recaptures No.	%
19	843	18	2.14	362	18	4.97
20	1,902	54	2.84	716	24	3.35
21	2,927	62	2.12	1,221	45	3.69
22	2,766	62	2.24	2,261	85	3.76
23	1,718	45	2.62	2,861	98	3.43
24	716	14	1.96	2,243	56	2.50