

Effects of Prey Color and Background Color on Feeding by Atlantic Salmon Alevins¹

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Abstract.—The feeding preference of Atlantic salmon (*Salmo salar*) alevins was affected by combinations of background color and prey color. Carefully chosen color combinations can increase feeding efficiency and thereby growth rate and survival of cultured Atlantic salmon.

For teleost larvae, vision is the primary sensory modality employed in prey detection (Rosenthal 1969; Protasov 1970; Blaxter 1980). Accordingly, the characteristics of prey items (e.g., size, shape, color, motility patterns), when viewed against different environmental backgrounds, will affect feeding efficiency (Lythgoe 1979; O'Brien 1979; Blaxter 1980; Gibson 1980). Salmonid alevins are visual planktivores (Wankowski 1981; Williams 1981; Browman and Marcotte 1986, in press), and their feeding should be affected by changes in the color of their prey and the backgrounds against which they are presented (Ali 1961; Ginetz and Larkin 1973; Clarke and Sutterlin 1985).

High mortality among wild and hatchery-reared fish larvae of some species has been attributed to

inadequate or inefficient feeding responses at the onset of exogenous feeding (May 1974; Hunter 1980; Li and Mathias 1982). High mortality at this phase (under hatchery conditions) has been reported for Atlantic salmon (*Salmo salar*; Lemm and Hendrix 1981; Lemm 1983). It is possible that this mortality can be reduced by improving the efficiency of feeding by alevins through manipulations of prey color and background color. This communication reports the results of an experiment conducted to test the hypothesis that prey color and background color affect the feeding of Atlantic salmon alevins.

Methods

Unfed alevins of Atlantic salmon were obtained from the North American Salmon Research Center in St. Andrews, New Brunswick, and from the Florenceville Federal Fish Hatchery in Florenceville, New Brunswick, in May 1983. Fish of the same age (8 weeks posthatch) and size (25 ± 2 mm total length) were maintained under natural lighting conditions in identical 91-L holding tanks ($77 \times 32 \times 37$ cm) at the Huntsman Marine Laboratory, St. Andrews, New Brunswick. Aquaria were supplied with running fresh water from the hypolimnion of a nearby lake. The water supply was filtered through 64- μ m-mesh netting to prevent introduction of food and detritus and was maintained at approximately 12°C. Alevins were fed live zooplankton twice daily at a concentration of approximately 200 prey/L. Feeding of fish was discontinued 18 h prior to experimentation, when the fish were placed in a holding tank containing only filtered water.

To produce changes in background color, aquaria (identical to the holding tanks) were surrounded on all sides with red, blue, or aqua-green cloth. The cloth coverings also prevented external movement from alarming the fish. Air stones,

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placed in the center of each aquarium, created vortical water currents (which appeared laminar along the aquarium floor) upon which prey items were transported. The bubble curtain created by the airstone had no observable effect on alevin feeding behavior. Pale green graph paper with 1-cm squares was placed on the outside bottom of each aquarium so the horizontal distance traveled by particles in the current, and thus the current speed, could be estimated. Current speed in the areas where alevins fed was maintained at approximately 6–10 cm/s (Rimmer and Power 1978) by regulation of the air flow. Atlantic salmon alevins naturally orient their bodies into current (Kalleberg 1958; Wankowski and Thorpe 1979; Mighell 1981); our artificial situation at least partially simulated the normal one for feeding.

Zooplankton was obtained each morning at the outflow of a small, pristine glacial lake: Wheaton Lake, New Brunswick. A 125- μ m-mesh plankton net was placed in the outflow for 15 min. The contents were transferred into clean buckets, transported to the laboratory, and filtered through 1-mm mesh to remove large organisms and extraneous material. The filtrate was mixed thoroughly and equal volumes were poured into beakers according to the four-beaker subsampling method (VanGuelpen et al. 1982). By the same subsampling method, 100-mL aliquots were drawn from one of these beakers. A 5% solution of neutral red iodide stain was introduced into three of these and a 20% solution of the vital stain methylene blue into a second set of three. A third set was unstained. A period of 3 h was allowed for stain assimilation. Before introduction to the fish aquaria, the zooplankton were examined for vitality and consistency of stain intensity. If any visible difference in stain uptake was observed, the aliquot was discarded.

For each of the three background colors, one experiment was conducted. Ninety alevins, naive with respect to dyed prey, were removed from the holding tank and divided equally among the three experimental aquaria. After a minimum of 15 min acclimation (the fish settled down 10–15 min after transfer) one of each of the stained and unstained zooplankton aliquots was introduced into each of the three experimental aquaria. All experiments were conducted in natural light (tanks were in front of large windows) and all trials were run between 1100 and 1400 hours (Browman and Marcotte 1986).

After 30 min of feeding, the alevins were removed from the experimental tanks and pre-

served in concentrated formalin (preliminary trials revealed no regurgitation). Before the stains dissipated from the prey, the fish gut was removed under a dissecting microscope. From the foregut, counts were made of gross taxonomic groups (cladocerans, copepods, water mites, miscellaneous) and their color. Incomplete prey were counted only if their anterior sections were present.

Six 2×3 contingency tables were constructed (prey type present or absent in fish stomachs; three background colors), one for each of the six experimental prey types (red, blue, and clear copepods; red, blue, and clear cladocerans). Entries were recorded as zero or greater than zero occurrence of each prey type in each of 20 alevin stomachs per aquarium. The chi-square statistic (Zar 1984) was calculated for each contingency table to test the null hypothesis that the number of alevins which had consumed a given prey type was the same against each background color.

Results

The number of alevin guts containing red copepods was higher in aquaria with blue or red backgrounds than in the aquarium with a green background (Table 1). More alevins consumed red cladocerans against a blue background than against either red or green backgrounds. Blue copepods were found in more alevins feeding against green and blue backgrounds than against red backgrounds. The numbers of alevins which consumed blue or clear cladocerans against different background colors were not statistically different. The incidence of clear copepods in alevin guts was higher in the red aquarium than in either the blue or the green aquarium.

Discussion

In most hatcheries, fish are incubated and reared in colored tanks. Our results indicate that manipulation of the color of rearing tanks and of the food presented can affect the prey choice of Atlantic salmon alevins.

Hinshaw (1985) reported a 30% increase in survival of larval yellow perch (*Perca flavescens*) larvae when fed *Artemia* spp. against a black background and concluded that this was the result of enhanced prey contrast with the environment. Dendrinis et al. (1984) reported improved feeding efficiency by larval sole (*Solea solea*) when they fed on brightly stained artemia. Clarke and Sutterlin (1985) reported that first-feeding Atlantic salmon alevins possess innate color preferences

TABLE 1.—Contingency-table evaluations of the effect of background color on the selection of colored copepods and cladocerans by Atlantic salmon alevins.

Measure	Data	Background color			Total	χ^2	P
		Red	Blue	Green			
Prey = red copepods							
Number of guts with 0 prey	Observed	5	5	12	22		
	Expected	7.3	7.3	7.3			
Number of guts with >0 prey	Observed	15	15	8	38		
	Expected	12.7	12.7	12.7			
Total, statistic		20	20	20	60	7.05	<0.05
Prey = blue copepods							
Number of guts with 0 prey	Observed	17	11	10	38		
	Expected	12.7	12.7	12.7			
Number of guts with >0 prey	Observed	3	9	10	22		
	Expected	7.3	7.3	7.3			
Total, statistic		20	20	20	60	6.19	<0.05
Prey = clear copepods							
Number of guts with 0 prey	Observed	0	14	8	22		
	Expected	7.3	7.3	7.3			
Number of guts with >0 prey	Observed	20	6	12	38		
	Expected	12.7	12.7	12.7			
Total, statistic		20	20	20	60	21.3	<0.001
Prey = red cladocerans							
Number of guts with 0 prey	Observed	19	12	15	46		
	Expected	15.3	15.3	15.3			
Number of guts with >0 prey	Observed	1	8	5	14		
	Expected	4.7	4.7	4.7			
Total, statistic		20	20	20	60	6.86	<0.05
Prey = blue cladocerans							
Number of guts with 0 prey	Observed	19	19	16	54		
	Expected	18	18	18			
Number of guts with >0 prey	Observed	1	1	4	6		
	Expected	2	2	2			
Total, statistic		20	20	20	60	3.33	>0.05
Prey = clear cladocerans							
Number of guts with 0 prey	Observed	16	16	12	44		
	Expected	14.7	14.7	14.7			
Number of guts with >0 prey	Observed	4	4	8	16		
	Expected	5.3	5.3	5.3			
Total, statistic		20	20	20	60	2.74	>0.05

and that this preference is flexible; it can be altered by a single associative learning event. These and our results suggest that prey and background color influence the ability of young fish to perceive food items. Easily perceived food items should result in higher feeding efficiency, consumption, growth rate (Jakobsen et al. 1987), and survival—all primary goals of hatchery managers.

The implications of these findings for hatchery production schemes warrant further examination. This could be accomplished through a series of controlled experiments comparing alevin feeding rates and efficiency, and growth rates and survival,

under various conditions of prey contrast. The resulting information might then be used to enhance hatchery rearing programs.

Acknowledgments

We thank Brian Glebe, North American Salmon Research Center, and Redge Hitcock, Florenceville Federal Fish Hatchery, for supplying alevins. Fred Purton and John Foster provided invaluable logistic aid and many useful suggestions. Our manuscript benefitted from the constructive criticisms of Richard O. Anderson and several anonymous reviewers.