PERFORMANCE OF COMMERCIAL STARTER DIETS DURING FIRST-FEEDING OF LANDLOCKED FALL CHINOOK SALMON

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ABSTRACT

Changes in the availability of starter diets traditionally used during landlocked fall Chinook salmon *Oncorhynchus tshawytscha* rearing necessitated the testing of potential alternatives. Three diets, Silvercup® salmon starter, Silvercup 0.7 mm extruded micro-pellet, and BioVita® #0 starter, were compared during a 28-day trial. Weight gain was significantly greater in the tanks of salmon receiving Biovita compared to 0.7 mm Silvercup. Feed conversion ratio was also improved with the feeding of Biovita versus 0.7 mm Silvercup, with Silvercup starter producing results not significantly different from the other two diets. Mortality was 50% lower in Biovita and 37% lower in 0.7 mm Silvercup in comparison to Silvercup starter, although none of these three means were significantly different. Individual fish weights and lengths were significantly lower in the fish fed the 0.7 mm Silvercup in comparison to the other two diets. Based on these results, Biovita #0 is recommended for initial feeding of landlocked fall Chinook salmon fry.

Key Words

Chinook salmon, *Oncorhynchus tshawytscha*, starter diet, Silvercup, Biovita,

INTRODUCTION

Landlocked fall Chinook salmon *Oncorhynchus tshawytscha* in Lake Oahe are an important fisheries resource in South Dakota. This population is sustained entirely by artificial propagation, with no natural reproduction ever documented and extremely unlikely (Marrone and Stout 1997). During hatchery rearing, Lake Oahe Chinook salmon typically experience considerable mortality prior to hatch and present a number of rearing challenges (Barnes et al. 2000). Substantial mortality has also been observed during initial feeding, possibly due to dietary issues (Barnes et al. 2002).

There have been few evaluations of commercially-available Chinook salmon starter diets. Fletcher and Barnes (2008) compared the performance of BioVita

#0 starter and Silvercup soft-moist. They determined that either diet was acceptable for use, but recommended the use of Biovita to maximize survival. Twibell et al. (2009) used BioVita, Silvercup soft-moist, EWOS Micro, Rangen Starter, and Rangen soft-moist with Chinook salmon and observed the highest growth rates in fish fed Biovita #0 starter.

Two diets that were historically used during the initial feeding of Lake Oahe salmon are no longer available, with Silvercup soft-moist only recently removed from the market. With the loss of these traditional starter feeds and the availability of novel diets with new formulations, research evaluations are needed. Thus, the objective of this study was to compare the performance of three commercially available starter diets during the initial rearing of landlocked fall Chinook salmon.

METHODS

The trial was conducted at McNenny State Fish Hatchery, Spearfish, South Dakota. Well water at a constant temperature of 11°C (total hardness as $CaCO_3$, 360 mg/L; alkalinity as $CaCO_3$, 210 mg/L; pH, 7.6; total dissolved solids, 390 mg/L) was used throughout rearing. Eggs were obtained from spawning a feral stock of landlocked fall Chinook salmon from Lake Oahe, South Dakota, incubated in jars, and placed in 1.8-m diameter circular tanks after hatching.

After the observance of free-swimming salmon fry suspended in the water column on December 23, 2011, 20 fish were weighed to the nearest 0.01 g and total length measured to the nearest 0.1 mm. Based on mean (SE) weights of 0.26 (0.01) and lengths of 31.9 (0.22), approximately 500 Chinook salmon (130 g total weight) from the same 1.8-m circular tank were placed into each of nine 100-L cylindrical tanks (4,500 fish total). Flows in each tank were set at 21 L/min. Just before moving the fish from the 1.8-m diameter tank to the experimental tanks, we weighed 20 fish to the nearest mg and measured them to the nearest mm. Feeding commenced on December 27, 2011 and daily feed rations were dispensed hourly from 08:00 to 12:00, due to faulty programming, using automatic feeders (Sweeney Enterprises, Inc., Boerne, TX). The faulty programming was corrected on January 8, 2011 and daily feed rations were dispensed hourly from 08:00 to 16:00. Tanks were cleaned as needed to eliminate excess food and fish waste, and mortalities were removed and recorded daily.

Constant water temperature allowed the use of the hatchery constant (HC) method to determine feeding levels for the tanks, with a planned feed conversion of 1.1 (Buterbaugh and Willoughby 1967). We held HC at 3.3 for the first five days of feeding to prevent the buildup of wasted feed in the tanks while the fish were learning to eat. HC was then increased to 5.28 for four days, 6.6 for five days and maintained at 7.92 for the remainder of the experiment. Feed amounts were weighed to the nearest g.

The nine tanks were assigned one of three diets: Silvercup salmon starter (Nelson and Sons, Inc., Murray, UT), Silvercup 0.7 mm extruded micro-pellets, and BioVita #0 starter (Bio-Oregon, Inc., Longview, WA). Three tanks received Silvercup starter, three tanks received Silvercup micro-pellet, while the other three

Table 1. Proximate composition and particle size from manufacturers specifications of BioVita #0 Starter, Silvercup 0.7mm Extruded Micro-pellet, and Silvercup Salmon Starter.

	BIOVITA	SILVERCUP MICRO-PELLET	SILVERCUP STARTER
Protein (%)	53	54	52
Fat (%)	17	18	16
Fiber (%)	1	3	1
Ash (%)	9	12	12
Particle size (mm)	0.44-0.59	0.7	0.6

Table 2. Manufacturer's ingredients list for various starter diets fed to fall Chinook salmon fry. Ingredients are listed in the order that they appear on the manufacturers feed tag.

BIOVITA	SILVERCUP MICRO-PELLET	SILVERCUP STARTER
Fish Meal	Fish Meal	Fish Meal
Fish Oil	Stabilized Fish Oil	Wheat Flour
Wheat Gluten	Wheat Flour	Feather Meal
Wheat Flour	Krill	Fish Oil
Krill Meal	Wheat Gluten	Poultry Meal
Whey Powder	Poultry By-Product Meal	Krill Meal
Lecithin	Hydrolized Feather Meal	Wheat Gluten
Gelatin	Corn Gluten Meal	Dried Whey
Vitamin/Mineral premix[1]	Yeast	Vitamin/Mineral premix[4]
Brewer's Yeast	Astaxanthin	Brewer's Yeast
Astaxanthin	Vitamins[2]	Astaxanthin
Ethoxyquin	Minerals[3]	Ethoxyquin
	Ethoxyquin	Choline Chloride

[1]Vitamin A Acetate, Vitamin D3, Ascorbyl Polyphosphate (C), Vitamin E, Inositol, Zinc Sulfate, Nicotinic Acid, Calcium Pantothenate, Manganese Sulfate, Riboflavin, Pyridoxine Hydrochloride (B6), Thiamine Mononitrate, Vitamin K, Copper Sulfate, Folic Acid, Calcium Iodate, D-Biotin, Sodium Selenite, and Vitamin B12.

[2]Vitamin A Acetate, D-Activated Animal Sterol (D3), Vitamin B12 Supplement, Riboflavin Supplement, Niacin, Folic Acid, Menadione Sodium Bisulphite Complex, Calcium Pantothenate, Pyridoxine Hydrochloride, Thiamine, Biotin, DL Alphatocopherol (E), Ascorbic Acid, Choline Chloride.

[3]Zinc Sulfate, Copper Sulphate, Ferrous Sulphate, Managenous Sulphate, Ethylenediamine Dihydroiodide.

[4]Vitamin A Acetate, Vitamin D3, Ascorbyl Polyphosphate (C), Vitamin E, Inositol, Zinc Sulfate, Nicotinic Acid, Calcium Pantothenate, Manganese Sulfate, Riboflavin, Pyridoxine Hydrochloride (B6), Thiamine Mononitrate, Vitamin K, Copper Sulfate, Folic Acid, Calcium Iodate, D-Biotin, Sodium Selenite, Vitamin B12.

tanks received BioVita starter. Proximate analysis of these diets provided by the manufacturer is listed in Table 1. At the end of four weeks, five fish per tank were weighed to the nearest 0.01 g and total length measured to the nearest 0.1 mm. Total tank weights were obtained by removing all of the fish from each tank and weighing them en masse to the nearest g.

Data were analyzed using one-way Analysis of Variance (ANOVA) and Tukey's mean comparison procedure with the SPSS (9.0) statistical analysis program (SPSS 1999). Significance was predetermined at $P < 0.05$. All percentage data were arcsine transformed to stabilize the variances (Kuehl 2000). Individual fish data were analyzed as per sacrificial pseudoreplication (Hurlbert 1984).

RESULTS AND DISCUSSION

Weight gain was significantly less and feed conversion ratio significantly greater in the tanks receiving 0.7 mm Silvercup micro-pellet compared to Biovita starter (Table 3). Results from the Silvercup starter diet were intermediate and not significantly different than either of the other two diets. Individual fish weights and lengths were also significantly lower in the fish fed the 0.7 mm Silvercup in comparison to the other two diets (Table 4). Mortality was not significantly different among the three diets, even though it was 50% lower in Biovita and 37% lower in 0.7 mm Silvercup compared to Silvercup starter.

Similar to this study, Fletcher and Barnes (2008) found that fish fed BioVita experienced 28% less mortality than those fed Silvercup soft-moist. In contrast, Twibell et al. (2009) found that fish fed BioVita experienced the lowest survival (96.5%) of the five diets used in their research while Silvercup soft-moist had 97.9% survival. The results of Fletcher and Barnes (2008) indicated that fish fed Silvercup soft-moist were significantly greater in length and weight than fish fed Biovita, but this may be explained by the differences in mortality observed between the diet coupled with feeding rates that were not changed based on mortality. However, Twibell et al. (2009) found that fish fed Biovita had significantly greater weight gain than fish fed Silvercup soft-moist.

Table 3. Mean (± SE) rearing data, including Feed Conversion Ratio (FCR) from tanks of Chinook salmon fry fed one of three starter diets for 28 days. Means with different letters in a row are significantly different (P < 0.05; N = 3).

	BIOVITA	SILVERCUP MICRO-PELLET	SILVERCUP STARTER
Start Weight (g)	130	130	130
End Weight (g)	422 ± 15a	369 ± 10b	394 ± 7ab
Gain (g)	292 ± 15a	239 ± 10b	264 ± 7ab
Food Fed (g)	279	279	279
FCR	0.96 ± 0.05a	1.17 ± 0.05b	1.06 ± 0.03ab
Mortality (%)	1.5 ± 0.1	1.9 ± 0.4	3.0 ±0.8

Table 4. Mean (± SE) ending lengths (mm) and weights (g) from individual Chinook salmon fry fed one of three starter diets for 28 days. Means with different letters in a row are significantly different (P < 0.05; N = 15).

	BIOVITA	SILVERCUP MICRO-PELLET	SILVERCUP STARTER
Length (mm)	47.9 ± 0.5 b	45.4 ± 0.7 a	47.6 ± 0.7 b
Weight (g)	0.84 ± 0.03 ab	0.74 ± 0.03 a	0.87 ± 0.04 b

Because these diets are all closed formulas, it is difficult to determine the reason for the differences observed in landlocked fall Chinook salmon rearing performance. Protein and lipid levels are very similar, but at 3.0 %, the 0.7 mm Silvercup micro-pellets diet had three times the fiber present in the other two diets. This diet also had the largest particle size, although it was only 0.1 mm greater that either Biovita or Silvercup starter. Biovita differed from the other two diets by not having any poultry or feather meal, and was unique by incorporating lecithin. In an eight week study of the effects of four dietary lipids used in Pacific salmon diets, Feng and Qin (2006) found that fish fed a diet containing lecithin showed significantly higher specific growth rates than fish fed the other three dietary lipids (Feng and Qin 2006). The use of lecithin in salmonid diets was also found to increase food consumption in rainbow trout, *Oncorhynchus mykiss* (Iwashita et al. 2008). It is possible that the presence of lecithin in Biovita was a factor in this diet producing the lowest mortality rates and best growth in this study.

The use of any of these diets would likely be acceptable if fry are abundant and rapid growth is not a major concern. However, during times of low egg availability when maximum survival is vital, the use of either Biovita starter or Silvercup 0.7 mm extruded micro-pellet would be advisable. If growth is the most important factor, then either Biovita or Silvercup starter would be the best options. For the best all-around rearing performance, low feed conversion ratios, and low mortality, Biovita #0 starter is recommended for the first 28 days of landlocked fall Chinook salmon feeding.

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