TESTS OF HATCHERY FOODS FOR SALMON, 1952

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TESTS OF HATCHERY FOODS FOR SALMON, 1952

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The feeding trials conducted in 1952 at the Entiat Salmon-Cultural Laboratory were a continuation of feeding experiments conducted annually since 1944 (Burrows et al. 1951, Robinson et al. 1951a, Robinson et al. 1951b, and Burrows et al. 1952). Both blueback salmon (Oncorhynchus nerka) and chinook salmon (O. tshawytscha) were used as the test animals.

Two experiments were run simultaneously, each for a 12-week cold-water period followed by a 12-week warm-water period, with the exception that two of the diets in the first experiment were tested under the cold-water conditions only.

The first experiment, utilizing blueback salmon fingerlings, contained the following tests: (1) dry meal toxicity tests in which vitamin supplementation reduced the mortality, (2) meal evaluations wherein two meals were found to be comparable to the control, and (3) potential production diets composed of two different groups. Substitutions in the standard blueback diet to avoid the use of beef liver and hog spleen comprised one group; the other was a series utilizing a 50 percent salmon viscera base and various combinations of meat and fish products. A good production diet resulted from each group.

The second experiment, using chinook salmon fingerlings, embodied a retesting of combinations already found practicable as food for blueback salmon fingerlings. Four of the best meat-viscera mixtures of the 1951 trials with blueback salmon were compared with the standard chinook ration. These tests provided an additional comparison of the requirements of chinook and blueback salmon which were found to be similar in 1951.

CONDITIONS OF EXPERIMENT

In the first experiment 30 troughs were stocked with 500 grams each of fingerling blueback salmon at an average size of 1,236 fish per pound. Sample troughs were counted and found to average 1,361 fish each.

The fingerling chinook salmon used in the second experiment averaged 274 per pound. They were stocked into 6-foot circular tanks at 1,000 grams per tank. Counts made in the tanks showed an average of 603 fish per tank.

During the cold-water phase of the experiments the average water temperature was 44.9° F. Daily temperatures fluctuated greatly in the second 12-week phase with an average water temperature of 50.4° F.

The techniques, equipment, and methods used were the same as described by Burrows et al. (1951 and 1952).

RESULTS OF BLUEBACK FEEDING TRIALS

The first experiment was limited to trials in which blueback salmon were used as the test animals. Both cold-water and warm-water trials were conducted. In the cold-water tests no meals were included in the diets except in specific instances where it was desired to determine toxicity. All the diets that were carried through the additional 12-week warm-water period, with the exception of the beef-liver control, were supplemented with various dry meals. This supplementation was accomplished by a proportionate reduction of the other components of the diet.

A control diet of 100 percent beef liver (Diet 1) was included merely as a basis for comparison with the work of other investigators in which beef liver served as the control, and no reference has been made to this diet in the comparison of results.

The results of this experiment are summarized in table 1.

Meal toxicity Tests

This phase of the experiment was designed to determine whether a better fortification with vitamins would reduce the mortality experienced when fish meals were feed at cold-water temperatures. Burrows et al. (1952) reduced the mortality in meal-fed fish by supplementation with vitamins of the B-complex. While the reduction in mortality was significant, it was still not comparable to the mortality encountered in diets without meal.

In these tests the standard meat-viscera mixture (Diet 2) served as the control and this combination supplemented with 10 percent salmon meal (Diet 3) as the index of toxicity. The meat-viscera-meal combination was fortified with the vitamins of the B-complex plus A, C, D, E, K, inositol, and choline at levels determined by Phillips (1946) and McLaren et al. (1947) as adequate for trout. Table 2 shows the levels of fortification used in Diet 4. In addition the meat-viscera combination supplemented with 5 percent meal (Diet 5) was included to determine whether a lower meal level would still produce a toxic effect.

The mortality in the fish fed the 10 percent meal supplement (Diet 3), when compared with that in the meat-viscera combination (Diet 2), was significantly higher. The vitamin-fortified meal diet (Diet 4) did not differ significantly from the nonmeal diet. The meat-viscera combination supplemented with 5 percent meal (Diet 5) produced mortalities which, unlike those in the fish fed 10 percent meal, were no greater than in those fed the control diet. The least mortality occurred in the control (Diet 2), the next higher in the vitamin-fortified meal diet (Diet 4), and the third highest in the nonfortified 5 percent meal diet (Diet 5), and the highest in the nonfortified 10 percent meal diet (Diet 3) as shown in table 1. A significant difference in mortality was attained only between the meat-viscera control (Diet 2) and the 10 percent meal supplement.

TABLE 1.—Summary of 1952 feeding trials with blueback salmon

Initial number per trough: 1,361 fish
Initial weight per trough: 500 gr.

Initial average weight per fish: .37 gr.
Initial number per pound: 1,236 fish

Period: 4/8/52 to 9/23/52

Temperature: average for 1st 12 wks., 44.96°F.; average for 2nd 12 wks., 50.4°F.; average for 24 wks., 47.68°F.

Diet No.	Components	Percentage Composition	Mean weight in grams 12 weeks	Mean weight in grams 24 weeks	Percent mortality 12 wks	Percent mortality 24 wks	Conversions 12 wks	Conversions 24 wks	Hemoglobin g/100 ml. blood 12 wks	Hemoglobin g/100 ml. blood 24 wks	Deficiency Symptoms
1	Beef liver	100.0	1,831	6,530	6.02	7.24	3.6	4.4	11.9	12.8	None
2	Beef liver S1/ Hog liver Hog spleen Salmon viscera Salmon meal2/	22.2 22.2 22.2 33.4	3,077	16,954	5.40	6.02	2.5	2.3	12.2	12.7	None
3	Beef liver S Hog liver Hog spleen Salmon viscera Salmon meal	20.0 20.0 20.0 30.0 10.0	3,502		9.29		2.3		11.9		None
4	Beef liver S Hog liver Hog spleen Salmon viscera Salmon meal (vit. supp)	20.0 20.0 20.0 30.0 10.0	3,440		6.72		2.3		12.5		None
5	Beef liver S Hog liver Hog spleen Salmon viscera Salmon meal	21.1 21.1 21.1 31.7 5.0	3,218	16,568	7.42	8.16	2.4	2.4	12.4	13.0	None
6	Beef liver S Hog liver Hog spleen Salmon viscera Commercial whale meal2/	22.2 22.2 22.2 33.4	3,138	14,685	4.56	4.74	2.5	2.8	12.4	13.5	None
7	Beef liver S Hog liver Hog spleen Salmon viscera Wheat middlings2/	22.2 22.2 22.2 33.4	3,092	13,538	6.32	7.46	2.5	3.0	13.3	12.5	None
8	Beef liver S Hog liver Hog spleen Salmon viscera Seal meal2/	22.2 22.2 22.2 33.4	3,172	16,172	5.22	5.80	2.4	2.4	13.6	13.9	None
9	Beef liver S Hog liver Hog spleen Salmon viscera Distillers solubles2/	22.2 22.2 22.2 33.4	3,085	16,094	4.48	5.36	2.6	2.6	13.1	13.6	None
10	Beef liver S Hog liver Beef lung Salmon viscera Salmon meal2/	22.2 22.2 22.2 33.4	2,950	14,361	3.82	4.44	2.8	2.8	13.5	12.8	None
11	Herring S Hog liver Beef lung Salmon viscera Salmon meal2/	22.2 22.2 22.2 33.4	3,031		7.42 Diet discontinued 7/15/52		2.5		13.5		Dark in color; weak & listless; some exhibiting loss of equilibrium; some suffering violent nervous convulsions when startled; intestinal fat heavy.
12	Arrow-toothed halibut S Hog liver Beef lung Salmon viscera Salmon meal2/	22.2 22.2 22.2 33.4	3,026	14,889	5.11	5.99	2.6	2.7	12.8	12.7	None
13	Hog liver S Beef lung Salmon viscera Salmon meal2/	25.0 25.0 50.0	3,008	14,748	5.88	6.91	2.5	2.7	13.5	12.5	None
14	Herring S Beef lung Salmon viscera Salmon meal2/	25.0 25.0 50.0	3,036		7.94 Diet discontinued 7/1/52		2.5		13.3		Dark in color; weak & listless; some exhibiting loss of equilibrium; some suffering violent nervous convulsions when startled; intestinal fat heavy.
15	Arrow-toothed halibut S Beef lung Salmon viscera Salmon meal2/	25.0 25.0 50.0	3,084	15,210	8.89	10.32	2.5	2.5	13.3	12.8	None
	Least difference at the 5% confidence level:		217 grs. 12 weeks	922 grs. 24 weeks	3.1%	3.0%					

1/ Salt added at the rate of 2 grams per 100 grams of ration.

2/ At the end of the first 12-week period 10% of meal was added to these diets with a corresponding proportional reduction in each of the original components

TABLE 2.— Vitamin Supplement, Diet 4, Blueback Salmon

VITAMIN	DAILY SUPPLEMENT MGS. PER KILO FISH WEIGHT
Thiamin hydrochloride	0.186
Riboflavin	0.680
Nicotinic acid	4.100
Pyridoxine hydrochloride	0.590
Calcium pantothenate	1.250
Biotin	0.077
Folic acid	0.295
Vitamin A. (beta carotene)	0.375
Vitamin C. (ascorbic acid)	30.000
Vitamin D_3 (7-dehydrocholesterol)	0.375
Vitamin E (alpha tocopherol)	6.000
Vitamin K (menadione)	0.600
Meso-Inositol	30.000
Choline	6.000
TOTAL:	80.528

In the 1951 trials, addition of the B-complex vitamins to the diet caused a significant reduction in the mortality although the losses were still significantly higher than those of the control diet. The addition of all of the major vitamins in the 1952 trials caused a significant reduction in the mortality, and the losses were comparable to those of the control. These results indicate that a relation exists between colder water temperatures and the utilization of, or demand for, vitamins in meal supplements.

The diets in which 10 percent meal was fed during the first 12 weeks (Diets 3 and 4) were discontinued at the close of the cold-water period. The 5 percent meal supplement was continued during the warm-water period.

A comparison was made between fish fed no meal at cold water and 10 percent meal in warm water (Diet 2) and fish fed 5 percent meal during the entire 24-week period (Diet 5). Mean weights at 12 weeks tended to be in favor of the 5 percent meal diet, though not significantly so. This trend was reversed during the warm-water period, but again a significant difference was not attained. The overall gain (451%) made during the second period by the Diet 2 fish was greater than the gain (415%) made by the Diet 5 fish. Diet 2 was more economical because during the period of greatest growth it received 10 percent meal (amounting to 536 grams) as against 5 percent meal (322 grams) in Diet 5 during the same period. The small amount of meal used at 5 percent (50 grams) during the cold-water period did not appreciably increase the total amount of meal used in Diet 5.

Meal Evaluations

Four commercial meals were tested in this series in comparison with vacuum-dried salmon viscera meal and in combination with the standard meat-viscera mixture. These meals were whale meal, wheat middlings, seal meal, and distillers solubles. The diets in the meal supplementation trials consisted of the meat-viscera combination for 12 weeks followed by supplementation with the respective meals at the 10-percent level during the last 12-week period. The fish fed wheat middlings (Diet 7) showed the least growth response; they were exceeded significantly by fish fed whale meal (Diet 6). Whale meal was inferior to both seal meal (Diet 8) and distillers solubles (Diet 9), both of which, on the basis of mean weights, were comparable to the salmon-viscera meal (Diet 2). Both seal meal and distillers solubles are recommended as dry-meal supplements for periods of warm-water feeding.

Potential Production Diets

The goal of these feeding trials was to find combinations of relatively inexpensive fish and meats that would produce healthy, fast-growing fish. The blueback production diet (Diet 2) has proved a somewhat expensive diet because of the two components, beef liver and hog spleen. In Diet 10, hog spleen was replaced by beef lung to produce a diet with a similar bind. In previous tests (Burrows et al. 1952), this substitution gave equally as good growth as the standard diet; in the 1952 trials the substitution was a good diet but did not compare as favorably with the spleen diet as previously. The spleen used in 1952 was untrimmed, and its higher fat content may have made a greater contribution to the weight gains of the fish than was made by an identical diet in 1951 in which the fat content of the spleen was less.

Beef liver has been one of the more expensive meats in the past but its use has been found necessary in most diets to prevent anemia. In these trials certain combinations of meat and fish products were tested in an effort to eliminate beef liver from the diet. The beef liver, hog liver, beef lung, and viscera combination (Diet 10) was used as the control. Herring (Clupea pallasi) and arrow-toothed halibut (Atheresthes stomias) were substituted for beef liver in separate combinations (Diets 11 and 12). These two fish products were tested previously (Burrows et al. 1952) in exploratory trials in which these products were substituted for spleen in the standard meat-viscera mixture and were found to produce good growth. At the end of 13 weeks the herring diet (Diet 11) was discontinued because of heavy mortality caused by a thiamine deficiency. The fish fed arrow-toothed halibut (Diet 12) made gains comparable to those of fish fed a similar diet containing beef liver (Diet 10), but were inferior to fish fed the standard ration (Diet 2) in growth produced.

Both arrow-toothed halibut and herring were tested as replacements in another combination. Previous trials had indicated that a combination of hog liver 25 percent, beef lung 25 percent, and salmon viscera 50 percent (Diet 13) was comparable to the standard meat-viscera combination in growth potential and nutritional adequacy. In the present tests the hog liver was deleted and herring substituted in Diet 14 and arrow-toothed halibut substituted in a similar combination in Diet 15. In these trials the hog liver, beef lung, viscera combination, again, was not comparable, in weight gains of the fish, to standard meat-viscera mixture containing the hog spleen. The herring combination (Diet 14) was discontinued at the end of 12 weeks because of a high mortality attributed to a thiamine deficiency in the fish. Diet 15 containing arrow-toothed halibut produced gains comparable to those of hog liver combination (Diet 13) with no symptoms of a nutritional deficiency.

In the diets using herring and arrow-toothed halibut, it was not the intent to use these products to supply the antianemic qualities and vitamin content of the beef or hog liver deleted from these combinations, but rather to determine whether compatible combinations could be found in which other meat and viscera mixtures would supply the vitamin deficiencies which might occur because of the inclusion of the fish products. The occurrence of a thiamine deficiency in both the combinations in which herring was included indicated that hog liver and beef lung or beef lung alone in combination with salmon viscera supplied inadequate amounts of thiamine to overcome the thiaminase reaction of the herring. The presence of thiaminase was indicated by the fact that no thiamine deficiency occurred in comparable diets including arrow-toothed halibut.

The growth potential and compatability of arrow-toothed halibut is indicated as excellent from the results of these and previous trials with blueback salmon. This product is a scrap fish on the Pacific Coast and is reported to be available in quantity at a cost of less than 5 cents a pound. The use of arrow-toothed halibut in the combinations tested can be recommended on a production basis.

Herring, because of the presence of thiaminase, cannot be recommended as a diet component for blueback salmon.

RESULTS OF CHINOOK FEEDING TRIALS

The feeding trials with chinook salmon were limited to diets previously tested on blueback salmon. The diets selected were those which had produced good growth and no evidence of a nutritional deficiency when fed to this species. Essentially the same results were attained with chinook salmon as with bluebacks (table 3).

The standard meat-viscera mixture supplemented with salmon-viscera meal during the second 12 weeks of feeding (Diet 1-C) and two variations of this combination were tested. In the first variation, hog spleen was replaced by beef lung (Diet 2-C). The results of this alteration were similar to those attained in the blueback tests in that the growth rate was reduced by the substitution of beef lung. The cause of this growth differential may be attributed to the higher fat content of the hog spleen in these tests. The second variation in which herring was substituted for spleen (Diet 3-C) substantiated the conclusions drawn from the blueback trials with herring. The herring diet tested on chinook was a duplicate of the 1951 test on blueback. The chinook showed no evidence of a thiamine deficiency, indicating that sufficient thiamine was supplied by the beef liver, hog liver, and viscera in this combination to meet requirements, despite the thiaminase present in the herring. The weight gain on this diet was comparable to the control (Diet 1-C) but did not exceed it as was the case in the 1951 trials on blueback. Two factors, the poor feeding consistency of this diet for chinook salmon and the higher fat content of the spleen in the 1952 trials, may account for the difference in growth response between the two species.

A combination of one third each of beef liver, hog liver, and salmon viscera supplemented with 10 percent meal during the second 12 weeks (Diet 4-C) was included in these trials for comparison in the event that a nutritional deficiency developed in the standard control (Diet 1-C). No such deficiency was indicated, confirming the conclusions of Burrows et al. (1952) that the differences in nutritional requirements between chinook and blueback salmon were not as great as anticipated. The growth of fish on this diet was not significantly different from that of fish fed the standard control.

TABLE 3.—Summary of 1952 feeding trials with chinook salmon

Initial number per trough: 603 fish
Initial weight per trough: 1,000 gr.

Initial average weight per fish: 1.66 gr.
Initial number per pound: 274 fish

Period: 4/8/52 to 9/23/52

Temperature: average for 1st. 12 wks., 44.96°F.; average for 2nd. 12 wks., 50.4°F,; average for 24 wks., 47.68°F.

Diet No.	Components	Percentage Composition	Mean weight in grams 12 weeks	Mean weight in grams 24 weeks	Percent mortality 12 wks	Percent mortality 24 wks	Conversions 12 wks	Conversions 24 wks	Hemoglobin g/100 ml. blood 12 wks	Hemoglobin g/100 ml. blood 24 wks	Deficiency Symptoms
1-C	Beef liver S[1] Hog liver Hog spleen Salmon viscera Salmon meal[2]	22.2 22.2 22.2 33.4	3,737	9,215	1.58	1.99	2.7	3.3	13.1	13.8	None
2-C	Beef liver S Hog liver Beef lung Salmon viscera Salmon meal[2]	22.2 22.2 22.2 33.4	3,376	7,315	2.74	3.73	3.0	3.9	13.3	13.3	None
3-C	Beef liver S Hog liver Herring Salmon viscera Salmon meal[2]	22.2 22.2 22.2 33.4	3,616	8,472	3.40	4.14	2.9	3.4	13.6	13.4	None
4-C	Beef liver S Hog liver Salmon viscera Salmon meal[2]	33.3 33.3 33.4	3,438	8,196	1.74	1.99	2.9	3.4	13.9	13.0	None
5-C	Hog liver S Salmon viscera Salmon meal[2]	50.0 50.0	3,584	7,586	2.90	4.06	2.8	3.7	13.0	12.2	None
6-C	Hog liver S Beef lung Salmon viscera Salmon meal[2]	25.0 25.0 50.0	3,554	7,839	4.31	4.98	2.9	3.6	13.5	11.6	None

Least difference at the 5% confidence level: 289 grs. 12 weeks 1,234 grs. 24 weeks 1.5% 1.2%

1/ Salt added at the rate of 2 grams per 100 grams of ration.

2/ At the end of the first 12-week period 10% of vacuum-dried salmon viscera meal was added to these diets with a corresponding proportional reduction in each of the original components.

Two diets using 50 percent salmon viscera supplemented with either 50 percent hog liver (Diet 5-C) or 25 percent each of hog liver and beef lung (Diet 6-C) were also tested. Both diets were supplemented with salmon-viscera meal during the second 12 weeks of feeding. Although these diets had a feeding consistency comparable to that of the blueback diets fed the previous year, the activity of the chinook during feeding caused a much greater loss of food particles in the water. As a result the gain in weight of chinook fed these diets was significantly less than those fed the standard meat-viscera-meal mixture (Diet 1-C).

The voracious feeding activity of the chinook and their inability to utilize, or their disinterest in, the smaller food particles resulting from this activity, is believed to be the cause for the difference in growth rates attained between the two species of fish. Another possibility is that an actual difference in amino-acid requirements exists between the two species. The obvious food wastage, rather than differences in the protein requirements of the species, appears to be responsible for the differences in diet utilization.

Certain of the diets produced mortalities higher than that of the standard control. While the differences in mortality were statistically significant, the greatest loss of fish did not exceed 5 percent for the 24-week period. Since no deficiency symptoms were apparent and the mortalities were comparatively low, it is not believed that these differences were great enough to preclude the use of any of these diets for production use on the basis of mortality alone.

The results of these feeding trials indicate that chinook salmon can be maintained for a 24-week period without beef liver in the diet. Hog liver or hog liver and beef lung in combination with salmon viscera appear to meet the vitamin requirements of chinook salmon. The growth potential of all the diets tested may be considered good. On the basis of cost per pound of fish produced, the diets containing 50 percent salmon viscera and either hog liver or hog liver and beef lung in combination are superior to any of the others. The inclusion of herring in chinook production diets is not recommended on the basis of the results of the blueback trials. The probable presence of thiaminase in herring makes its use dangerous in production operations.

SUMMARY OF RESULTS--BLUEBACK SALMON

The results of the 1952 trials utilizing fingerling blueback salmon as the test animal are summarized as follows:

1. During a 12-week period in cold water the addition of 10 percent salmon meal to a meat-viscera mixture significantly increased mortality

over a similar diet without the meal. The addition of vitamins to the meal supplement reduced the mortality to the equivalent of the nonmeal diet.

2. Continuation of a 5 percent meal diet for 24 weeks produced growth equal to the control diet fed for 12 weeks with no meal followed by 12 weeks of 10 percent meal. The mortality in each case was similar. The control diet, however, proved the most economical.

3. Four commercial meals were compared with vacuum-dried salmon-viscera meal as supplements during the warm-water period. Whale meal and wheat middlings were inferior to salmon-viscera meal. Seal meal and distillers solubles were comparable to salmon-viscera meal.

4. Beef lung substituted for hog spleen in the standard control diet produced less growth, although previously the growth had been equal. The higher fat content of the spleen used in this trial was assumed to account for the difference.

5. Herring, fed in combination with hog liver, beef lung, and salmon viscera, and with beef lung and salmon viscera, produced heavy mortalities caused by an inadequate thiamin content in the diet, insufficient to combat the thiaminase present in the herring.

6. Arrow-toothed halibut, when substituted for beef liver in the beef-lung variation of the control diet and hog liver in the hog liver beef lung salmon viscera combination produced comparable growth rates and no deficiency symptoms. Both combinations utilizing halibut are highly recommended for production feeding.

SUMMARY OF RESULTS--CHINOOK SALMON

The results of the 1952 feeding trials utilizing fingerling chinook salmon as the test animals are summarized as follows:

1. The standard control ration consisting of beef liver, hog liver, hog spleen, and salmon viscera when fed to chinook did not differ from the beef liver, hog liver, and salmon viscera diet.

2. Substitution of beef lung for hog spleen in the standard control diet reduced the growth rate of chinook salmon as it did that of blueback salmon. The higher fat content of the spleen used in these trials was assumed to account for the difference.

3. Herring substituted for spleen in the standard control diet showed no evidence of a thiamine deficiency and produced growth rates equal to spleen.

4. Hog liver salmon viscera and hog liver beef lung salmon viscera diets produced slightly less growth than the standard control diet but as low-cost diets are highly recommended.

5. Feeding consistency may be of more importance in food utilization by chinook salmon than by blueback salmon.

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