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M. J. DeBoer  
L. N. Allison  
E. F. Grassl  
C. T. Yoder  
J. A. Scully

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**THE RELATION OF A DRY PELLETED RATION TO NUTRITIONAL  
ANEMIA IN BROOK AND RAINBOW TROUT**

By

**Edward F. Grassl**

Department of Poultry Husbandry and Institute of Nutrition  
Michigan State University, East Lansing, Michigan

THE RELATION OF A DRY PELLETTED RATION TO NUTRITIONAL  
ANEMIA IN BROOK AND RAINBOW TROUT

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Michigan State University, East Lansing, Michigan

In the past, adequate trout nutrition required feeding raw fresh meat which contained a substance or a combination of substances essential for sustaining life and for growth. Lack of these substances resulted in anemia and death. McCay and Dilley (1927) found that diets containing a sufficient supply of vitamins A, C, D, E, and vitamin-B complex supported life and growth but that anemia developed.

Tunison et al. (1939) also produced anemia, similar to that described by McCay and Dilley, on a synthetic diet. They found that the fish died when the red cell count was less than 700,000 per cubic millimeter. After

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Formerly Nutrition Specialist, Michigan Department of Conservation, Lansing, Michigan; now associated with Commercial Solvents Corporation, New York, N. Y. Presented in partial fulfillment of requirements for the degree of Doctor of Philosophy at Michigan State University. Journal Article 1930, Michigan Agricultural Experiment Station.

feeding this diet for 4 weeks, various amounts of liver were added with the result that the anemic group of fish fed 100 percent liver sustained no further excessive mortality. Subsequent tests of various liver extracts, autolyzed beef liver, raw liver, and fly maggots showed that the last two could cure and prevent this anemia. In feeding tests conducted for one year, the liver extracts increased the red cell count. However, the same effect was not obtained in later experiments.

It was thought possible that fly maggots and insect larvae contain one of the pterins and that its presence prevents anemia in fish. (Tunison et al., 1941). Norris and Simmons (1941) found that injecting xanthopterin into anemic fingerling salmon resulted in an increase of erythrocytes up to an approximate maximum of 1,600,000 per cubic millimeter and that there was a positive correlation between the amount of xanthopterin given and the increase in the number of red blood cells. However, later experiments by Tunison et al. (1942) at the Cortland Hatchery did not substantiate this claim. McLaren, Herman, and Elvehjem (1947) reported on this problem and stated that when folic acid and biotin were added to an anemia-producing diet, no anemia developed.

In 1953, the Michigan Department of Conservation began to investigate the possibility of using dry animal and vegetable meals for trout diets. During this investigation, erythrocyte counts were made on brook and rainbow trout blood to determine whether the dry rations affected the level of red cells in the blood of the fish.

#### Procedure

Groups of rainbow trout and brook trout varying in number from 1,000 to 4,000 each were fed a control ration (100 percent raw beef liver) and a "dry" experimental ration. The fish in each group ranged from 3 to 5

inches in length and were 9 months old at the time the dry diet was introduced. Fish receiving the control ration were treated identically as those receiving the dry ration. Prior to feeding the dry pelleted diet, all fish had been fed raw meat diets of various mixtures. The dry diet was fed in amounts equal to 1.5 to 1.9 percent of body weight per day and the control was fed in amounts equal to twice the dry ration. The amount of food per day was altered to correspond with seasonal water temperature changes.

The erythrocyte or red corpuscle counts were made on blood taken from the severed caudal peduncle of trout. Duplicate blood specimens were taken from each of four fish from each group. The blood was diluted with Hayme's solution in a pipette by filling the capillary to the 0.5 mark with blood and to the 101 mark with the diluting fluid. The diluted blood was shaken in the pipette for two minutes. After shaking, a small drop of blood was placed on the counting chamber of an AO Bright-Line Haemocytometer and the number of red blood cells counted under the microscope.

Two groups of blood count data are reported. One is from rainbow and brook trout fed the dry ration 4 days per week, raw beef liver one day per week, (no food was given two days per week); the other is from rainbow and brook trout fed the dry ration for a 12-month period without raw meat supplementation. Table 1 shows the composition of the dry diet; Table 2 reports the proximate analysis on a moist and on a dry basis.

### Results

Rainbow and brook trout with red blood counts below 900,000 per cubic millimeter are approaching an anemic condition. As shown in Table 3, the blood of both species of trout fed the dry pelleted diet with meat supplementation for nearly two years contained numbers of erythrocytes approximately equal to numbers in the blood of liver-fed fish.

Table 1.--Percentage composition of a dry  
pelleted diet fed to rainbow and brook trout

Ingredients	Percentage
Red fish meal	38
Cotton seed meal	23
Wheat flour middlings	25
Torula yeast	5
Condensed fish solubles	3
Skim milk	5
Iodized salt	2

Table 2.--Proximate analysis of rations fed to rainbow and brook trout

Item	Constituents (percentage)							
	Moisture	Crude protein	Crude fat	Crude fiber	NFE	Ca	P	Ash
Dry ration								
Moist basis <sup>1</sup> ✓	8	39.6	5.0	4.7	25.2	3.2	2.1	13.3
Dry basis	0	42.8	5.5	5.1	27.2	3.5	2.3	14.3
Control <sup>2</sup> ✓								
Moist basis <sup>1</sup> ✓	70	20.2	3.1	0.0	6.0	0.007	0.358	1.3
Dry basis	0	66.0	9.9	0.0	19.9	0.023	1.3	4.3

<sup>1</sup>✓ Ration in its natural state, before drying.

<sup>2</sup>✓ Raw beef liver.

Table 3.--Number of red blood cells per cubic millimeter in blood of rainbow and brook trout fed different diets

Species, and date	Weekly diet ↓	
	Dry diet, 4 days; raw beef liver, 1 day	Raw beef liver, 5 days
<u>Rainbow trout</u>		
May 20, 1953	1,123,000	1,120,000
July 24, 1953	1,130,000	1,200,000
November 6, 1953	1,020,000	1,260,000
April 30, 1954	1,370,000	1,170,000
February 4, 1955	1,298,000	1,153,000
Average	1,188,000	1,181,000
<u>Brook trout</u>		
May 18, 1953	1,269,000	...
July 12, 1953	1,130,000	...
October 14, 1953	1,111,000	...
February 4, 1955	1,386,000	...
February 15, 1955	1,074,000	1,201,000
April 26, 1955	1,170,000	1,116,000
Average	1,190,000	1,158,000

✓ Fish were not fed on two days of each week.

In order to determine the extent to which the raw meat supplement affected the erythrocyte count of fish blood, groups of rainbow and brook trout which had been fed as previously described were placed on the dry pellet diet given in Table 1, without raw meat, in March 1954. One year later, erythrocyte counts from these fish were compared with counts from fish fed a raw-beef-liver diet (Table 4). Erythrocyte counts were closely comparable among fish of both groups at the beginning and the end of the 12-month period. Brook and rainbow trout fed on a dry diet had a slightly higher red-cell count after 12 months than did the liver-fed fish; the count for both species on the dry diet increased slightly during the experimental period, whereas the count among liver-fed fish decreased slightly.

The small differences noted in erythrocyte counts are not held to be important. However, it is clear that under the conditions of these experiments neither brook nor rainbow trout developed nutritional anemia when fed the pelleted dry diet, with or without a raw meat supplement.



Table 4.--Number of red blood cells per cubic millimeter in blood of rainbow and brook trout fed dry or liver diets

Date	Rainbow trout		Brook trout	
	Dry diet	Liver diet	Dry diet	Liver diet
March, 1954	1,140,000	1,344,000	1,269,000	1,215,000
March, 1955	1,298,000	1,153,000	1,386,000	1,158,000

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INSTITUTE FOR FISHERIES RESEARCH

Edward F. Grassl

Approved by: P. H. Eschmeyer

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