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WOLF LAKE FEEDING EXPERIMENT -- 1937

The third season of feeding experiments with trout at Wolf Lake extended over a period of twenty-three weeks from April 13, to September 20, 1937. Due to increase in price of fresh meats, the customary trout food in hatcheries, this series of experiments is being conducted in order to find a suitable substitute for the more expensive meat diets. This seems to be the most logical point of attack in the attempt to reduce the cost of feeding trout in Michigan's hatcheries and rearing stations.

The first season's work, 1935, was a qualitative study in which only brook trout were used. Different mixtures of dry meals and fresh meats were fed to the experimental lots of fish in order to develop some technique in preparing the food and feeding it to the fish. Mortality and growth records were kept and the relative merits of the diets used were based upon these data. During the 1935 season, from the first week in April until the last of August, no records of the amount of food used were kept, so that there were no means available for determining the food cost of rearing fish.

During the 1936 season, June 15 to September 15, a quantitative study was started with brook trout, but was discontinued at the end of two weeks

because of the heavy mortality caused by a disease condition (probably ulcer disease). The only trout available for continuation of the work were browns; and for ten weeks these trout were fed on known quantities of diets composed of fresh meats, dry meals, and canned fish. The results of this study are presented in Report No. 410 of the Institute for Fisheries Research.

Two diets from the 1936 experiment seemed worthy of further testing and so in April, 1937, feeding experiments were begun which included two diets used previously (diets 4 and 6; see Table 1), some others which were modifications of those used before, and some which were entirely new combinations.

During the 1937 season several experiments were conducted at Wolf Lake, the most important of which was that comparing the cost to rear, the food conversion factor, the mortality, and the growth resulting from the use of the various diets. This experiment is designated as Experiment A-37.

Experiment A-37. At the start this study included 96,000 brook trout fingerlings from Cape Cod eggs; 31,528 rainbow trout from Cape Cod eggs; and 50,490 brown trout from eggs taken at the State Hatchery, Paris, Michigan.

At intervals, it was necessary to remove some fish from the experimental lots to prevent crowding. Although the results are based on the number of fish in the various lots, these reductions were made on the basis of weight since counting fish when such large numbers are being used becomes an impossible task with the amount of help available. When these reductions in numbers were made all groups were reduced so that the same weight of fish remained in each trough, the number left being computed from the weight of a known number of fish.

It was intended at the start that these thinnings be made at regular intervals, but due to conditions beyond our control it was inconvenient to do so, the result being that the removals were made whenever possible.

The compositions of the diets as well as the cost per pound are shown in Table 1. The prices for the dry meals are taken as of April 1, the time at which they were purchased. Some fluctuations in price occurred during the term of the experiment, but these changes were ignored since under a production program an attempt would be made to purchase large quantities when the price was low. The price of the fresh meat is subject to change every two months at present and during this season pork melts increased from three and one-half cents per pound to five and one-half cents.

Fortunately this change occurred on June 1, a time at which it was desirable to know the cost to rear trout since some planting is usually done about this time. Consequently the cost is computed at the lower price up to this time and at the higher price during the balance of the time.

As it was purchased this year the price of the grasshopper meal was ten cents. However, local collection should reduce this cost considerably. Reference will be made to the cost to rear fish on the diet containing grasshopper meal later in this discussion.

As in previous years, these diets were thoroughly mixed and allowed to stand in a refrigerator from twelve to twenty-four hours before being fed to the fish. A record is kept of the daily amount of food placed in each trough. At the end of every two weeks period the sum of the weights of food placed in each trough is reduced, by means of a correction factor, to the weight of the food before any water was added, so that when the food conversion factors are computed they will refer only to the food as purchased.

The food conversion factor is the ratio of the amount of food fed to the increase in weight. In other words, it is the number of grams of food required to produce one gram gain in weight.

$$\text{F.C.F.} = \frac{\text{food fed per 1000 fish}}{\text{increment in weight per 1000 fish}}$$

$$= \frac{\text{total food fed (as purchased)}}{\text{average number of fish} \times .001}$$

$$= \frac{\text{increment in weight per 1000}}{\text{food fed}}$$

$$= \frac{\text{food fed}}{\text{average no. of fish} \times \text{increment in weight per 1000} \times .001}$$

Table 3 presents a recapitulation of the food conversion factors by periods with the average food conversion factor for each diet for the entire period. Table 4 contains the average food conversion factors for the first four periods for all three species, for the last two periods for the brooks and the last eight for the rainbows and browns.

The fish were weighed at intervals of two weeks to determine the increase in weight. The growth resulting from the diets used this year is shown in Figures 4, 5, 6, 7 and 8. The per cent increase in weight for the entire term of the experiment is shown in the summary, Table 5.

The mortality is recorded daily and the percentage of fish lost during the period is determined by dividing the loss by the number of fish at the start of the period. See Table 2 for a summary of the losses incurred during this experiment. The mortality record is quite important in a nutrition experiment, since in itself it is a pretty good index to the worth of the diet. Figures 1, 2 and 3 compare the losses occurring on each diet.

Disease caused a great part of the mortality which occurred throughout the experiment. The entire lot of brook trout on Experiment A was removed from the hatchery at the end of the sixth period because of an

epidemic of ulcer disease. Until the end of the sixth period there were four troughs of brooks, two of rainbows and two of browns on each diet. After the brooks had been removed, the experiment with rainbows and browns was expanded to include the space formerly occupied by the brooks, thus placing four troughs of rainbows and four of browns on each diet.

If the mortality became unusually large in all four troughs of fish receiving the same diet, the probability was that the fish were in a poor state of nutrition and consequently could not withstand the onslaught of the disease. The lots were placed at intervals of ten troughs throughout the hatchery so that no two troughs receiving the same diet were adjacent, until after the brooks were removed, at which time the two troughs of rainbows and two of browns on each diet were divided into four troughs, two of which received water from the two in the upper half of the series.

The most logical method for selecting the best diets is to begin by eliminating those which show the least promise of rearing fish at low cost. Considering for the time being that the brook trout were not under observation for a long enough period and that they were badly diseased, the eliminations can be made from the rainbows and browns and then if the results with the brooks agree with those of the other two species we can perhaps accept them as reliable also.

From Figure 11 it is easy to see that among the rainbows all diets but 18, 4, 6, and 17 should be eliminated when cost alone is considered. It must be remembered that for sixteen of the twenty-three weeks the price of pork melts is $0.055 per pound whereas all of the 1936 season and the first seven weeks of this the price was $0.035 per pound. However, a look at the food conversion factors, Figure 9, shows that unless the price of melts is relatively low it can not successfully compete with sheep liver as a portion of the diet.

Looking next at the mortality record, Figures 2 and 3, and at Table 5, it appears that only those diets containing liver can be retained. This then eliminates diet 6 from the four chosen on the basis of lowest cost, leaving 18, 4, and 17. If we now examine the growth record for these three we find that diets 17 and 4 rank second and third among all the rainbows as compared to fifth place for diet 18, or about twenty per cent better growth than diet 18. Here it becomes necessary to make a choice between cost and growth. If the chief aim is to grow larger fish,then diets 4 and 17 must win. Diet 17 has the best mortality record of all the rainbows, is second in growth, but fourth in cost to rear (not much more costly than diet 4). On diet 18, however, the fish are reared at a cost about fifteen per cent less than on diets 4 and 17. The mortality record (of diet 18) is good even though it ranks sixth; and the fish appeared in good condition.

Turning to the brown trout, immediately from the standpoint of cost, diets 2, 19, 20 and 23 can be eliminated, with 18, 6, and 22 giving the lowest cost to rear. The mortality record of diet 6, ranking ninth, is somewhat high and this diet should be eliminated on that basis. But diet No. 6 resulted in the best growth and was second lowest from the standpoint of cost. The high mortality occurred during periods 6, 7, and 8 and then receded. Diets 4 and 17 are not far behind diet 6 in cost and growth and both have excellent mortality records.

From the foregoing it appears that diets 4 and 17 have merit from the standpoint of mortality and growth and that diet 18 has merit from the standpoint of mortality and cost. Diet 6 has merit when the growth and cost of rearing brown trout are considered.

If the grasshopper meal, which has been considered at its purchase price of ten cents per pound, could be secured for much less, this diet could be considered fair since the mortality record and the growth are fair.

In any case trout can be reared more cheaply and with a mortality record almost as good on diets 4, 17, 18 and 6 as on diet 2, pure sheep liver. In general fish reared on 100% sheep liver present excellent growth and mortality records, but at about twice the cost of the other satisfactory diets.

Returning to compare the results of the rainbows and browns with those of the brooks, it appears that diet 18 again comes into the low cost division, this time in third place; and it has the lowest mortality record though diet 20 is very close. Although diet 6 provides good growth and low cost, here again its mortality record is against it.

From this study diets containing pork melts seem undesirable because of the heavier mortality. And unless the cost of melts is relatively low, the cost to rear a pound of trout will hardly compare with the diets containing liver. Diet 18 seems outstanding when cost to rear is considered; diets 4 and 17 appear best when low mortality and good growth are desired; diet 6 produced good growth with brown trout at low cost but with rather high mortality.

The food conversion factors are perhaps the most important single items disclosed in this kind of study since with the price of feed known and the food conversion factor known for a given set of conditions one may easily calculate the cost to rear a pound of trout on any diet he may choose.

INSTITUTE FOR FISHERIES RESEARCH

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Table 1

Composition and Cost of Diets "As Purchased", 1937

Ingredients	Cost Per Pound	Composition of Diets in Parts Per Hundred									
		22	23	21	6	4	17	19	20	18	2
Fresh Sheep Liver	$0.0850	...	...	...	...	50.0	50.0	50.0	50.0	30.0	100.0
Fresh Pork Melts	.0350	60.0	75.0	75.0	75.0	...	...	...	...	...	...
Vacuum Fish Meal	.0300	10.0	...	5.0	8.3	16.7	13.3	...	...	20.0	...
Cottonseed Meal	.0240	10.0	...	5.0	8.3	16.7	13.3	...	13.3	20.0	...
Oatmeal	.0304	10.0	...	10.0	...	...	10.0	30.0	10.0	10.0	...
Skim Milk Powder. Roller Process	.0560	10.0	...	5.0	8.3	16.7	13.3	20.0	13.3	20.0	...
Rowena Dog Diets #20	.0515	...	25.0	...	...	...	...	...	...	...	...
Grasshopper Meal	.1000	...	...	...	...	...	...	...	13.3	...	...
Water (Shown as per cent by weight of rest of diet.)	...	25.0	11.1	...	...	33.3	33.3	33.3	33.3	50.0	...
Cost per Pound	Before May 31	$0.0350	.0391	.0348	.0354	.0608	.0602	.0628	.0695	.0505	.0850
Cost per Pound*	After June 1	.0470	.0541	.0498	.0504	...	...	...	...	...	...

* After June 1 the price of pork melts became $0.0550 per pound.

Table 2

Mortality -- In Per Cent Lost By Periods

Diet		Period 1	2	3	4	5	6	7	8	9	10	11	12	Average Four Periods	Average Twelve Periods *
BROOKS	22	6.68	4.06	5.37	4.17	7.65	3.29	...	...	...	...	...	...	5.07	5.20
	23	5.74	3.94	9.11	13.40	14.53	11.04	...	...	...	...	...	...	8.05	9.63
	21	6.14	4.47	6.95	5.49	34.36	25.00	...	...	...	...	...	...	5.76	13.73
	6	6.63	5.13	7.26	4.58	28.21	30.50	...	...	...	...	...	...	5.90	13.72
	4	7.99	5.73	7.53	4.79	3.30	6.31	...	...	...	...	...	...	6.51	5.94
	17	5.59	3.81	6.24	4.72	3.92	7.15	...	...	...	...	...	...	5.09	5.24
	19	7.32	5.33	9.11	8.91	20.93	.73	...	...	...	...	...	...	7.67	8.72
	20	5.27	3.47	4.32	3.99	1.84	2.43	...	...	...	...	...	...	4.26	3.55
	18	6.13	3.54	5.54	3.86	1.44	.63	...	...	...	...	...	...	4.77	3.52
	2	6.55	4.83	3.60	4.62	7.62	7.43	...	...	...	...	...	...	4.90	5.78
Average		6.40	4.43	6.50	5.85	12.38	9.45	...	...	...	...	...	...	5.80	7.50
RAINBOWS	22	2.55	.59	1.61	2.58	2.27	2.25	1.59	.89	.69	.35	.43	.31	870 1.83	1.34
	23	1.55	.57	4.69	14.67	12.57	2.91	4.50	5.06	2.74	2.45	1.09	.61	5[illegible]5.37	4.45
	21	2.21	.34	2.30	2.91	2.02	2.18	1.01	2.35	.86	.32	.18	.18	849 1.94	1.41
	6	1.44	.29	2.59	3.29	2.43	3.71	5.20	.42	.50	.37	.14	.09	846 1.90	1.71
	4	1.64	.28	.95	.92	.48	1.10	2.37	1.19	.47	.21	.05	.00	[illegible] .95	.81
	17	2.26	.87	.71	.47	.27	.58	1.42	.94	.11	.00	.00	.00	[illegible] 1.08	.64
	19	3.19	.74	1.55	.75	.61	.51	.28	.04	.20	.00	.05	.00	[illegible] 1.56	.66
	20	3.23	.62	1.35	1.50	.98	.86	.38	.19	.38	.05	.05	.00	916 1.68	.80
	18	4.52	1.54	1.84	.90	.60	.25	.52	.24	.24	.19	.19	.00	916 2.20	.92
	2	3.19	.89	1.02	.45	.84	.56	.31	.25	.06	.25	.19	.00	[illegible] 1.39	.67
Average		2.56	.67	1.87	2.84	2.16	1.42	1.79	1.11	.63	.42	.24	.12	1.99	1.32
BROWNS	22	1.63	.76	4.09	5.27	4.06	5.26	4.83	20.11	8.95	5.40	3.34	6.34	[illegible] 2.94	5.83
	23	1.27	.74	6.42	30.71	26.75	11.31	24.95	29.24	22.00	19.22	13.07	7.44	93 9.79	16.09
	21	1.20	.88	3.09	6.72	3.81	6.94	9.76	13.52	8.08	4.53	3.55	2.61	[illegible] 2.97	5.39
	6	1.41	.67	4.16	6.27	4.69	10.66	14.08	14.62	7.87	3.92	2.96	2.51	[illegible] 3.13	6.15
	4	1.29	.46	1.10	.77	.73	1.38	5.12	11.45	7.21	3.26	2.16	2.38	687 .91	3.11
	17	1.21	.27	.90	.87	.89	1.41	1.82	5.58	6.49	7.05	4.07	2.24	722 .81	2.73
	19	1.53	1.32	1.60	1.94	1.18	2.57	4.04	3.58	10.90	5.86	2.64	2.04	[illegible] 1.60	3.27
	20	1.23	.61	.97	.98	1.34	1.53	1.52	9.37	9.63	7.89	4.17	5.51	637 .95	3.73
	18	.86	.54	.98	1.19	1.06	1.33	.89	2.06	12.76	10.24	5.49	3.82	[illegible] .89	3.43
	2	1.00	.42	.80	1.17	1.03	1.24	.83	.52	.73	1.97	1.12	1.16	[illegible] .85	1.00
Average		1.26	.65	2.41	5.59	4.55	4.36	6.78	11.01	9.46	6.93	4.26	3.60	2.46	5.07

* Only six periods for brook trout.

Table 3

Food Conversion Factors by Periods

Diet	Period 1	2	3	4	5	6	7	8	9	10	11	12	Average
						Brooks							
22	2.639	2.797	3.271	3.996	4.415	4.428	...	...	...	...	...	...	3.591
23	3.103	4.291	3.864	5.400	5.536	4.751	...	...	...	...	...	...	4.491
21	2.641	2.745	3.449	3.870	4.951	4.166	...	...	...	...	...	...	3.637
6	2.130	2.942	2.923	3.930	5.050	3.196	...	...	...	...	...	...	3.362
4	2.067	2.491	2.465	2.669	3.315	3.260	...	...	...	...	...	...	2.711
17	2.093	2.772	2.531	3.208	3.512	3.310	...	...	...	...	...	...	2.887
19	4.025	4.141	3.572	3.661	3.975	4.169	...	...	...	...	...	...	3.924
20	2.289	3.226	2.764	2.780	3.750	3.551	...	...	...	...	...	...	3.060
18	2.346	2.513	2.663	2.901	3.693	3.288	...	...	...	...	...	...	2.900
2	1.821	1.615	3.115	3.739	5.547	3.388	...	...	...	...	...	...	3.204
Average	2.515	2.953	3.062	3.615	4.374	3.751	...	...	...	...	...	...	3.377
						Browns							
22	3.605	4.562	4.237	4.476	6.946	5.525	4.429	3.652	4.811	7.098	5.036	4.093	4.872
23	2.981	5.115	4.413	4.811	14.100	8.162	3.240	3.044	8.426	6.486	4.067	5.754	5.883
21	3.178	5.820	4.690	4.927	7.033	5.709	4.368	4.613	4.925	6.425	5.310	3.711	5.059
6	2.422	5.040	4.906	4.837	5.806	5.380	4.089	3.962	4.262	5.126	3.601	4.128	4.467
4	2.458	4.093	3.795	3.571	4.916	4.163	3.294	2.884	4.073	3.942	3.951	3.900	3.753
17	2.690	3.463	3.520	3.931	5.403	3.751	2.365	3.192	3.733	4.744	4.005	3.397	3.724
19	4.593	3.315	7.260	5.734	6.724	6.073	3.754	4.261	5.575	5.911	6.040	3.258	5.208
20	3.170	4.451	4.922	4.478	4.707	4.738	3.420	3.331	3.817	4.766	3.677	4.321	4.195
18	2.716	3.936	3.505	4.153	5.484	5.030	3.116	3.197	3.991	4.937	3.025	2.969	3.838
2	2.796	3.782	4.608	4.194	6.205	3.917	3.363	3.482	5.298	5.222	4.085	4.120	4.256
Average	3.031	4.358	4.586	4.516	6.732	5.250	3.594	3.562	4.891	5.466	4.230	4.151	4.526
						Rainbows							
22	2.632	4.310	4.218	4.202	6.394	7.971	5.073	4.775	6.166	6.821	5.870	6.830	5.442
23	3.756	4.480	5.924	5.175	6.906	7.041	4.663	5.010	6.082	6.597	7.419	7.806	5.905
21	3.662	5.179	5.044	4.807	7.220	6.447	4.772	4.772	5.382	6.983	7.271	6.678	5.684
6	2.675	2.664	5.163	3.924	6.413	6.556	4.023	4.690	4.646	5.268	5.099	5.150	4.689
4	2.191	3.319	3.320	3.251	3.804	4.653	3.448	3.445	3.391	3.988	3.790	3.968	3.547
17	2.758	3.813	3.244	2.945	3.946	4.435	3.528	3.579	3.756	3.893	4.451	3.907	3.638
19	5.021	4.284	5.151	4.759	5.786	5.238	4.502	4.546	4.905	5.578	5.964	6.026	5.146
20	3.228	4.331	4.430	3.483	4.318	4.439	3.142	3.336	3.532	4.019	4.288	4.231	3.939
18	2.933	4.002	3.539	2.780	4.514	4.464	3.193	3.381	3.853	4.291	3.172	3.962	3.673
2	3.025	2.411	3.987	2.911	3.901	3.632	3.674	3.305	3.794	4.067	4.631	4.396	3.652
Average	3.193	3.929	4.402	3.824	5.320	5.493	4.002	4.084	4.551	5.151	5.201	5.296	4.537

Table 4

Computation of Food Conversion Factors,
Cost of Diets and Food Cost Per Pound of Trout

Diet		Average F. C. F.			Food Cost Per Pound		Food Cost Per Pound of Trout		
		Periods 1 to 4	Periods 5 to 12	Periods 1 to 12	Periods 1 to 4	Periods 5 to 12	Periods 1 to 4	Periods 5 to 12	Periods 1 to 12
BROOKS*	22	3.176	4.422	3.591	.0350	.0470	.1112	.2078	.1434
	23	4.165	5.144	4.491	.0391	.0541	.1628	.2783	.2013
	21	3.176	4.558	3.637	.0348	.0498	.1105	.2270	.1493
	6	2.981	4.123	3.362	.0354	.0504	.1055	.2078	.1396
	4	2.423	3.238	2.711	.0608	.0608	.1473	.1999	.1648
	17	2.651	3.361	2.887	.0602	.0602	.1596	.2023	.1738
	19	3.848	4.072	3.924	.0628	.0628	.2417	.2557	.2464
	20	2.765	3.651	3.060	.0695	.0695	.1922	.2537	.2127
	18	2.606	3.491	2.900	.0505	.0505	.1316	.1763	.1465
	2	2.573	4.468	3.204	.0850	.0850	.2187	.3798	.2723
Average		3.036	4.058	3.377	...	...	.1581	.2389	.1350
RAINBOWS	22	3.353	6.238	5.442	.0350	.0470	.1349	.2932	.2404
	23	4.834	6.441	5.905	.0391	.0541	.1890	.3485	.2953
	21	4.673	6.191	5.684	.0348	.0498	.1626	.3083	.2597
	6	3.606	5.231	4.689	.0354	.0504	.1273	.2636	.2182
	4	3.020	3.311	3.547	.0608	.0608	.1836	.2317	.2157
	17	3.190	3.937	3.688	.0602	.0602	.1920	.2370	.2220
	19	4.304	5.318	5.146	.0628	.0628	.3017	.3340	.3232
	20	3.993	3.913	3.939	.0695	.0695	.2775	.2720	.2738
	18	3.314	3.954	3.673	.0505	.0505	.1674	.1946	.1855
	2	3.084	3.938	3.652	.0850	.0850	.2621	.3347	.3104
Average		3.837	4.887	4.537	...	...	.1998	.2818	.2574
BROWNS	22	4.220	5.199	4.872	.0350	.0470	.1477	.2444	.2122
	23	4.330	6.660	5.883	.0391	.0541	.1693	.3603	.2966
	21	4.654	5.262	5.059	.0348	.0498	.1620	.2620	.2237
	6	4.314	4.544	4.467	.0354	.0504	.1527	.2290	.2036
	4	3.479	3.390	3.753	.0608	.0608	.2115	.2365	.2282
	17	3.401	3.886	3.724	.0602	.0602	.2047	.2339	.2242
	19	5.226	5.200	5.208	.0628	.0628	.3282	.3266	.3271
	20	4.255	4.166	4.195	.0695	.0695	.2957	.2895	.2916
	18	3.578	3.969	3.338	.0505	.0505	.1807	.2004	.1938
	2	3.345	4.462	4.256	.0850	.0850	.3268	.3793	.3618
Average		4.130	4.724	4.526	...	...	.2179	.2762	.2568

* Note: Brook trout experiment was discontinued at end of period 6; "Periods" therefore 1 to 4, 5 to 6 and 1 to 6 for this species.

Table 5

SUMMARY

	Diet	Rank	% Increase In Weight	Rank	Average % Mortality	Rank	F. C. F.	Rank	Cost to Rear Per Pound
BROOKS	22	7	645	3	5.20	7	3.591	2	$0.1434
	23	10	521	8	9.63	10	4.491	7	.2013
	21	5	763	10	13.73	8	3.637	4	.1493
	6	3	844	9	13.72	6	3.362	1	.1396
	4	2	870	6	5.94	1	2.711	5	.1648
	17	4	775	4	5.24	2	2.887	6	.1738
	19	9	534	7	8.72	9	3.924	9	.2464
	20	6	734	2	3.55	4	3.060	8	.2127
	18	8	606	1	3.52	3	2.900	3	.1465
	2	1	952	5	5.78	5	3.204	10	.2723
	Mean (11 weeks)				7.50		3.377		.1850
RAINBOWS	22	10	1877	7	1.34	8	5.442	5	.2404
	23	8	1965	10	4.45	10	5.905	8	.2953
	21	7	2032	8	1.41	9	5.684	6	.2897
	6	6	2433	9	1.71	6	4.689	3	.2182
	4	3	3139	5	0.81	1	3.547	2	.2157
	17	2	3255	1	0.64	4	3.688	4	.2220
	19	9	1941	2	0.66	7	5.146	10	.3232
	20	4	2809	4	0.80	5	3.939	7	.2738
	18	5	2596	6	0.92	3	3.673	1	.1855
	2	1	4088	3	0.67	2	3.652	9	.3104
	Mean (23 weeks)				1.32		4.537		.2574
BROWNS	22	6	2208	8	5.83	7	4.872	3	.2122
	23	4	2284	10	16.09	10	5.883	8	.2966
	21	8	2040	7	5.39	8	5.059	6	.2287
	6	1	2452	9	6.15	6	4.467	2	.2036
	4	2	2405	3	3.11	2	3.753	5	.2282
	17	5	2237	2	2.73	1	3.724	4	.2242
	19	10	1625	4	3.27	9	5.208	9	.3271
	20	7	2158	6	3.73	4	4.195	7	.2916
	18	9	1943	5	3.43	3	3.838	1	.1938
	2	3	2348	1	1.00	5	4.256	10	.3618
	Mean (23 weeks)				5.07		4.526		.2568

Figure 1

MORTALITY -- BROOK TROUT

Bars represent the summation of the per cent mortality for each period.

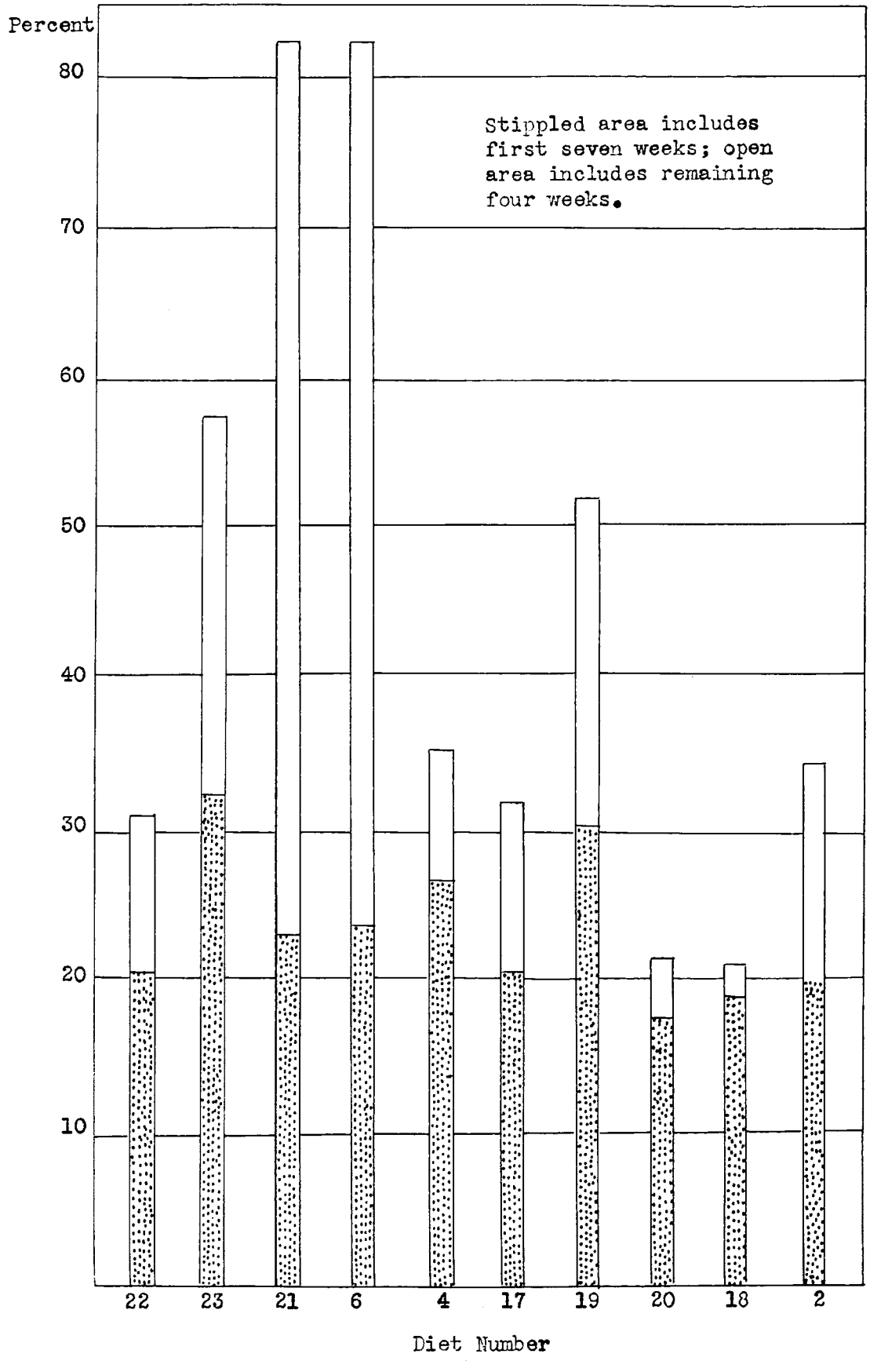
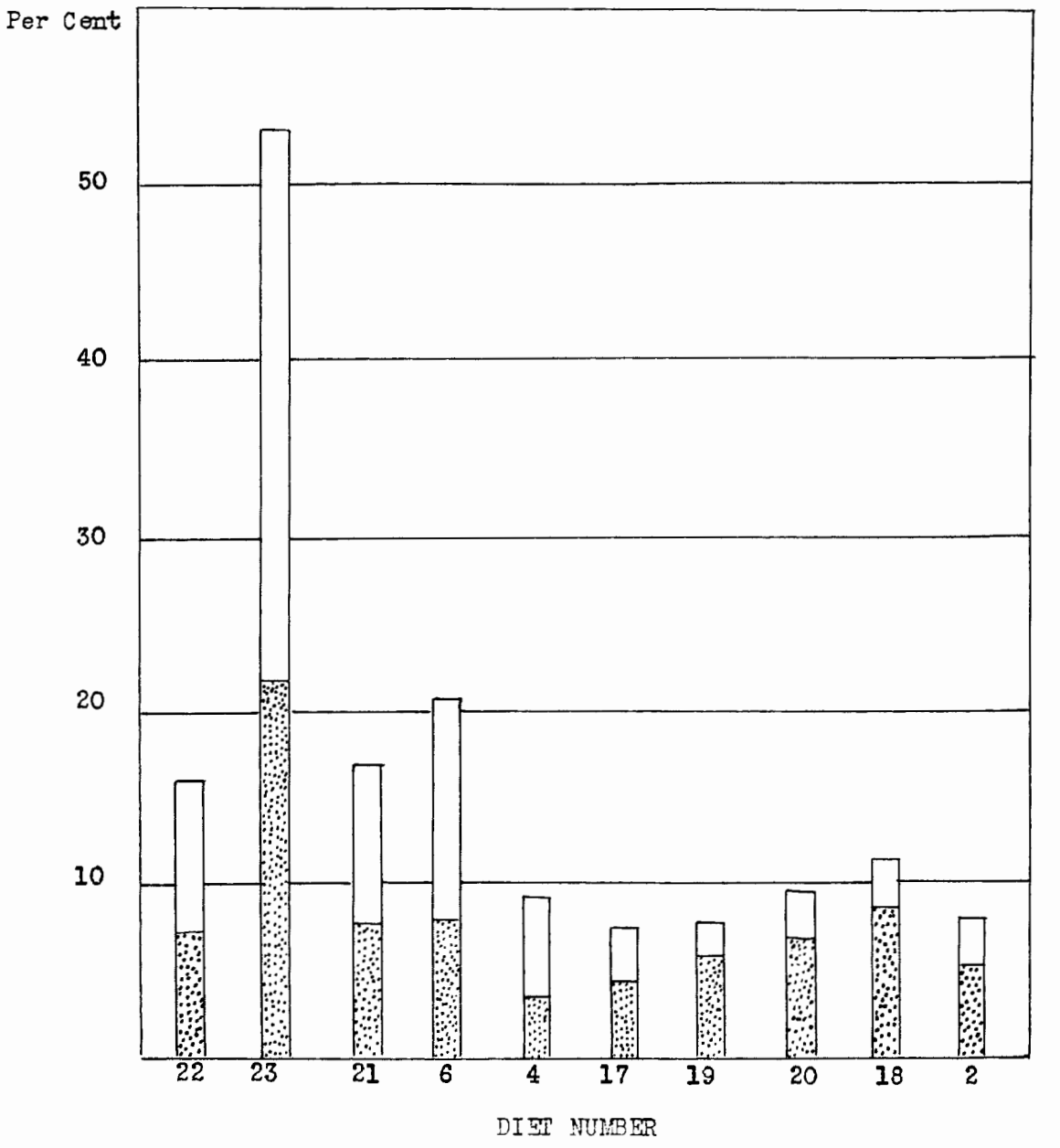


Figure 2

MORTALITY -- RAINBOW TROUT

Bars represent the summation of the Per Cent mortality for each period.



Stippled area includes first seven weeks; open area includes remaining sixteen weeks.

Figure 3. Mortality -- Brown Trout

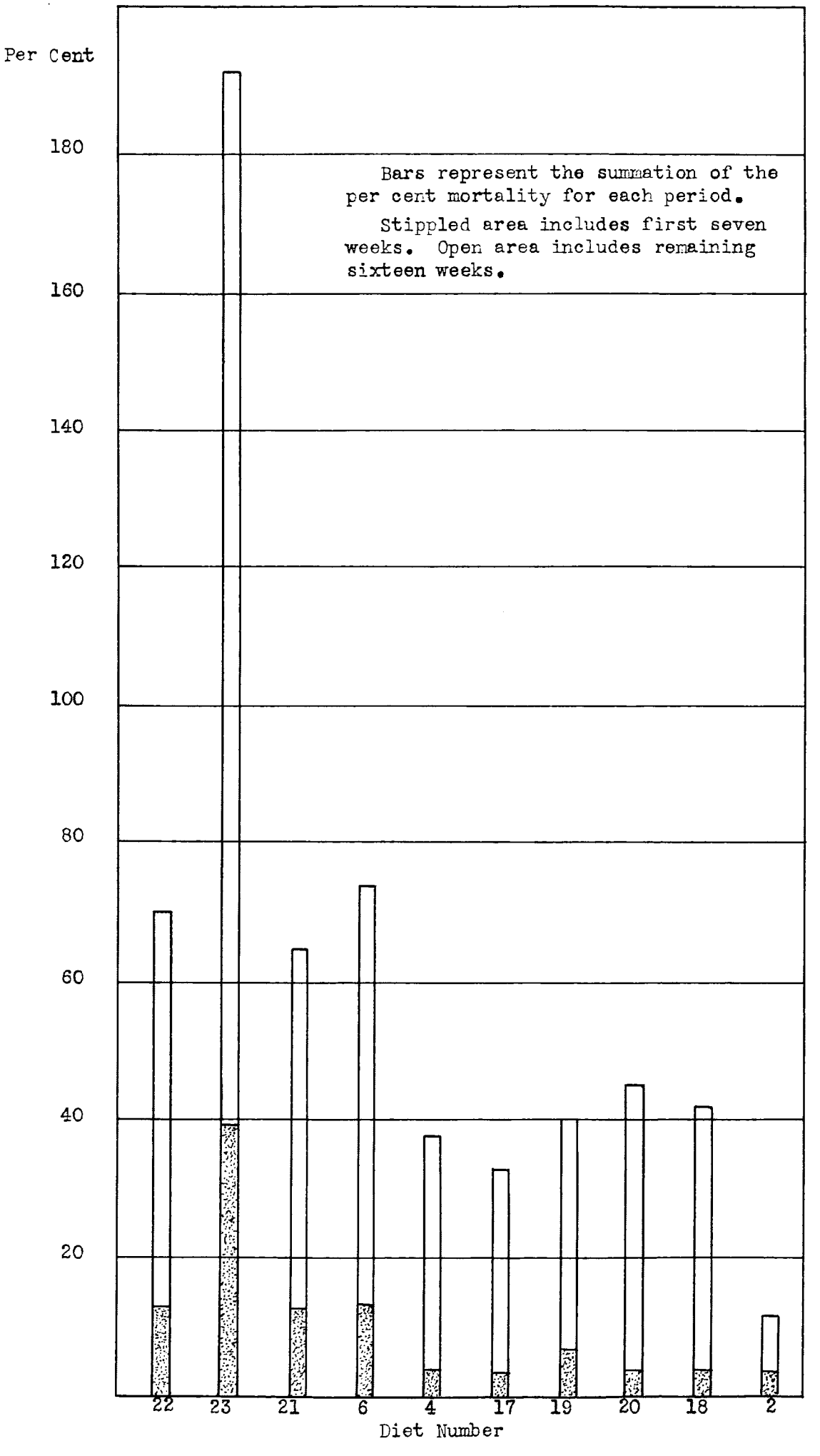


Figure 4. Average Growth for All Diets

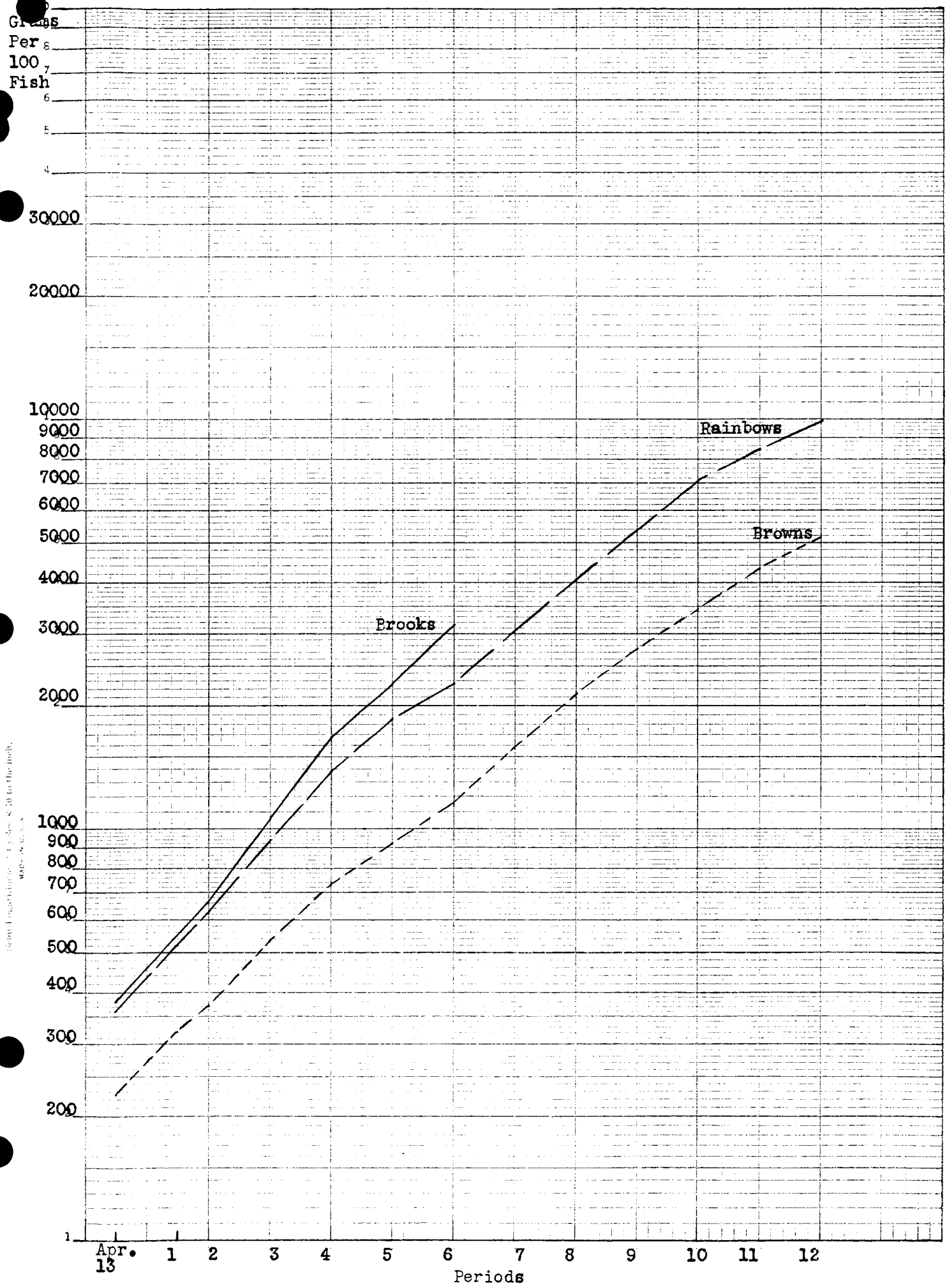


Figure 5. Growth Curves

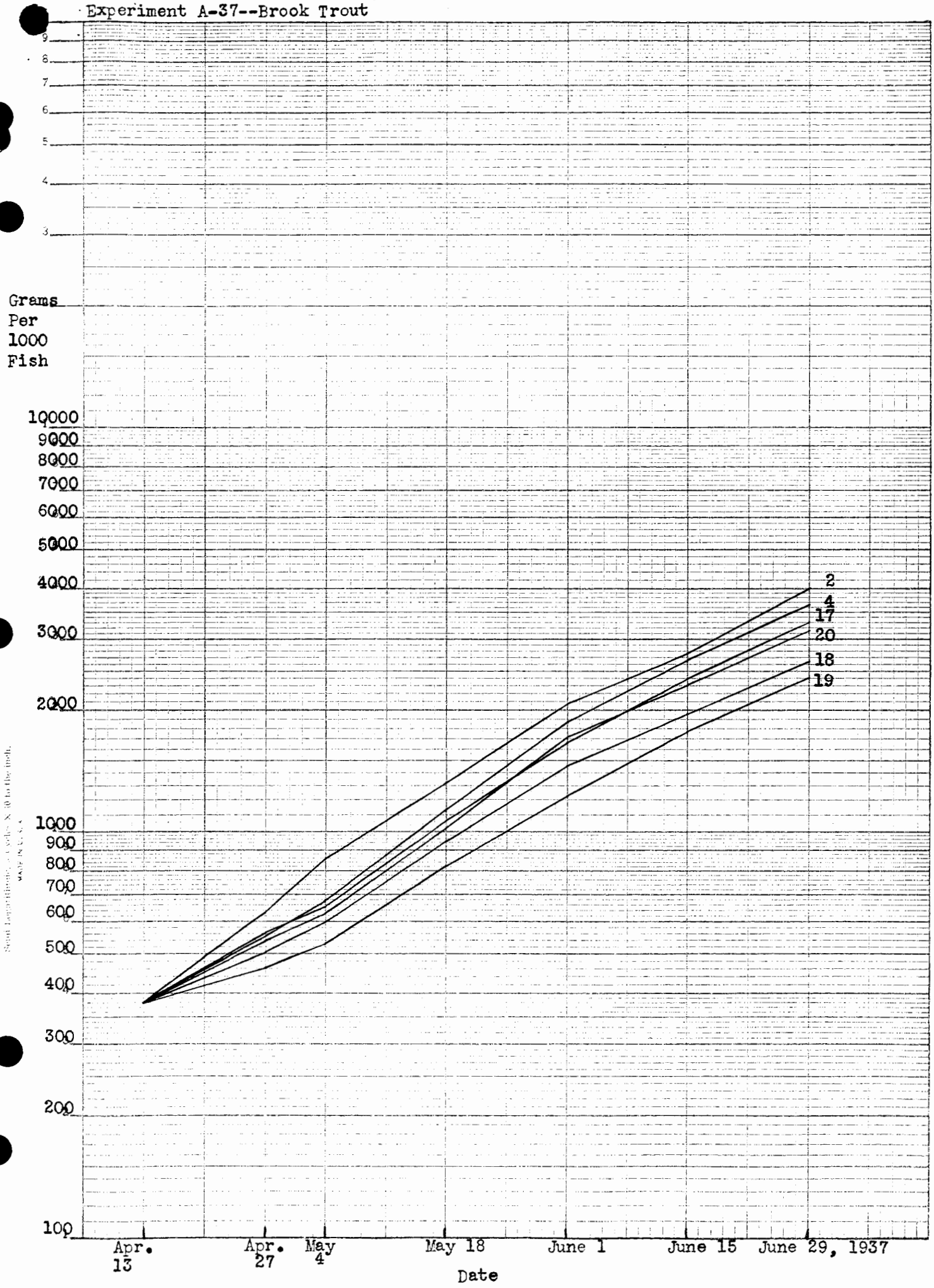


Figure 6. Growth Curves

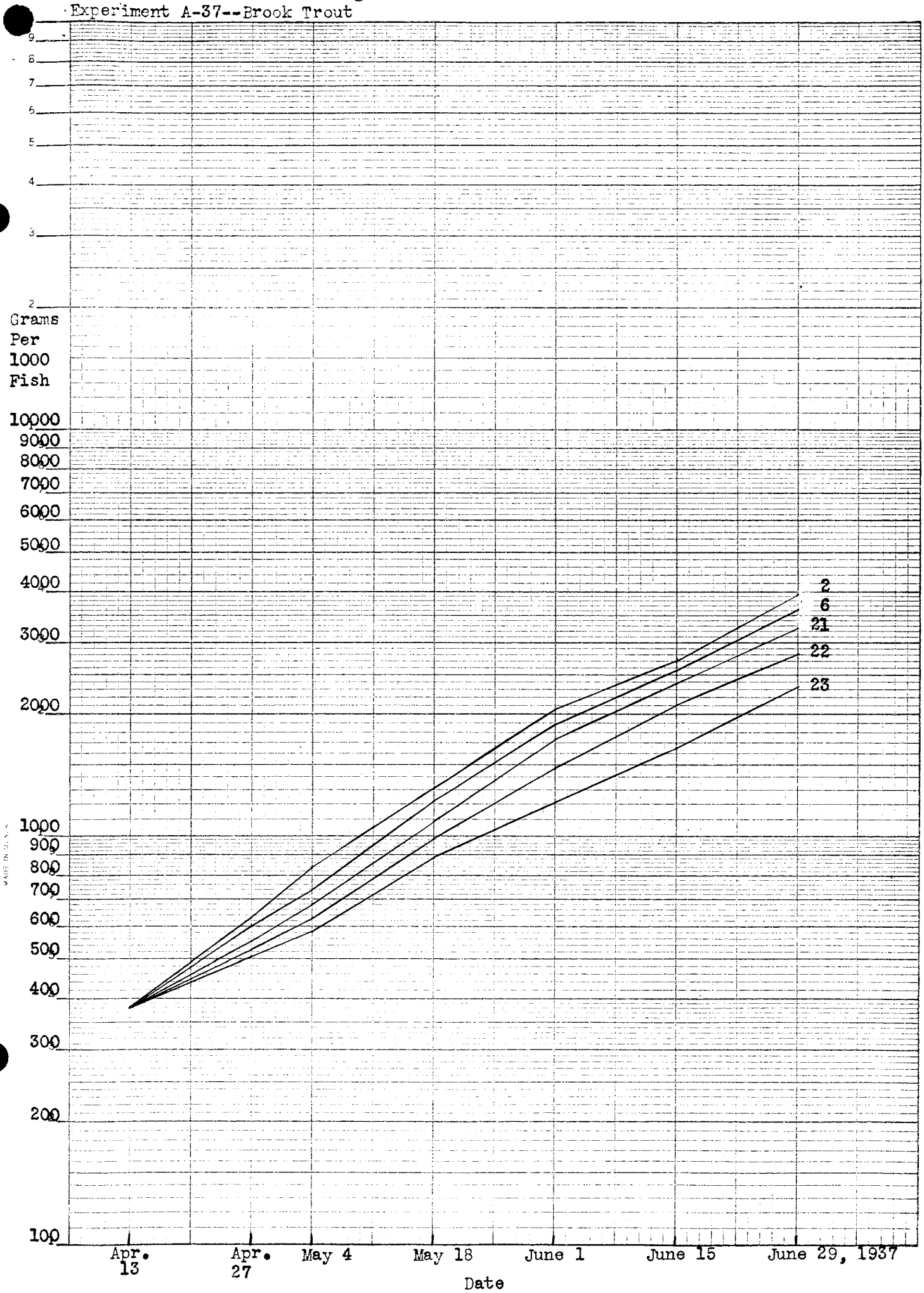


Figure 7. Growth Curves
Experiment A-37--Rainbow Trout

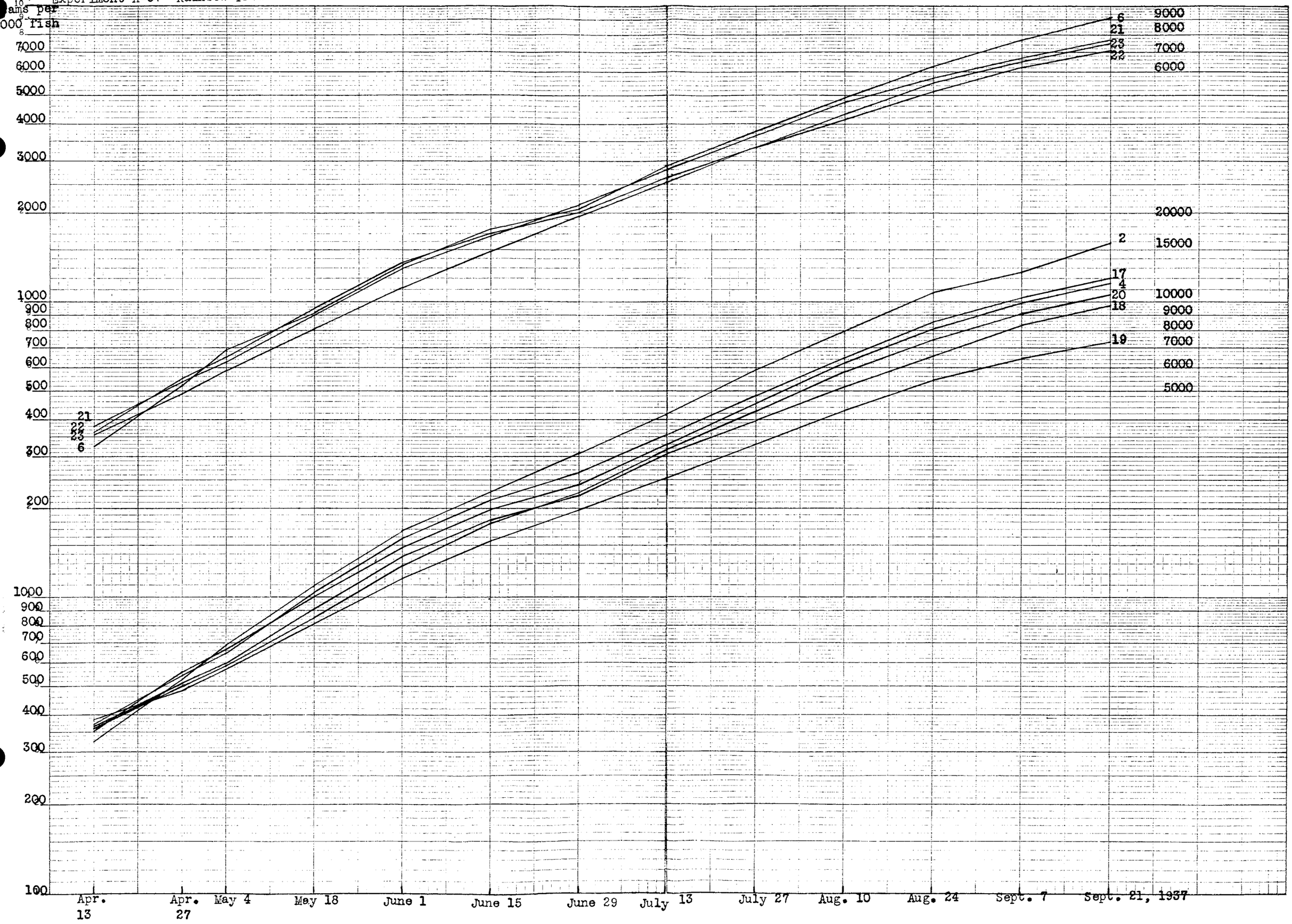


Figure 8. Growth Curves

Experiment A-37--Brown Trout

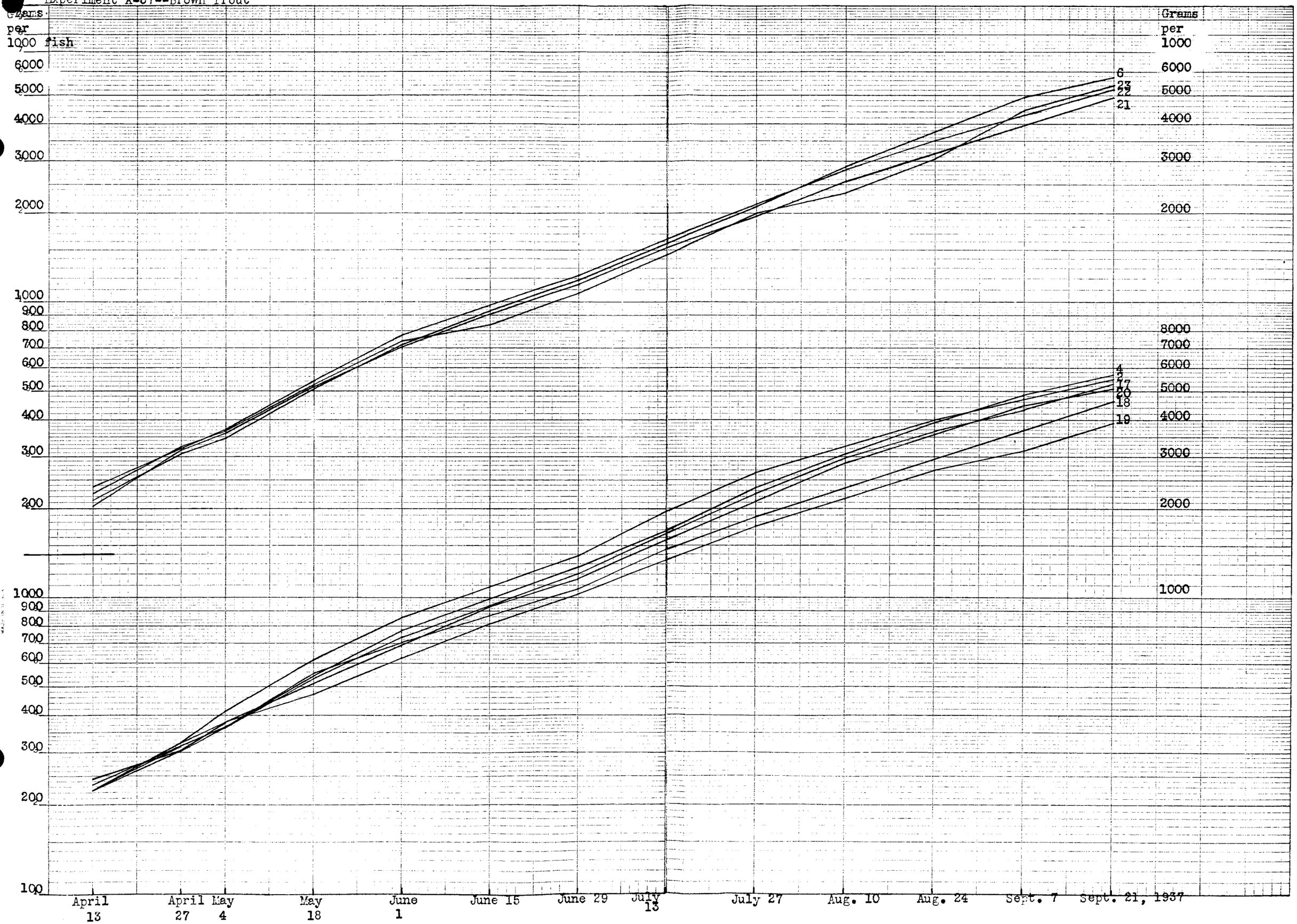


Figure 9. Food Conversion Factors

Bars represent unit weights of food required to rear one unit weight of trout

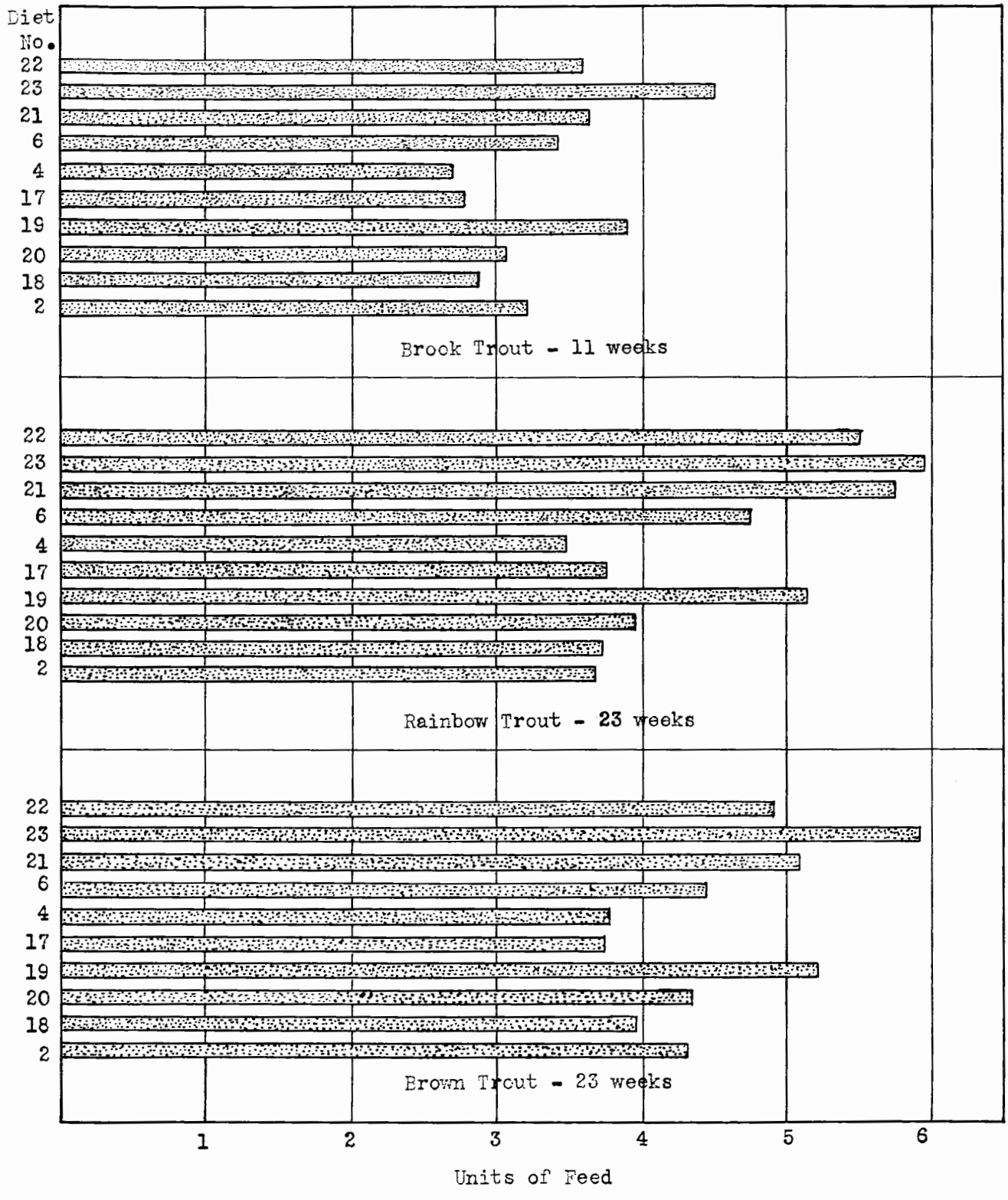


Figure 10. Fluctuations in Food Conversion Factors

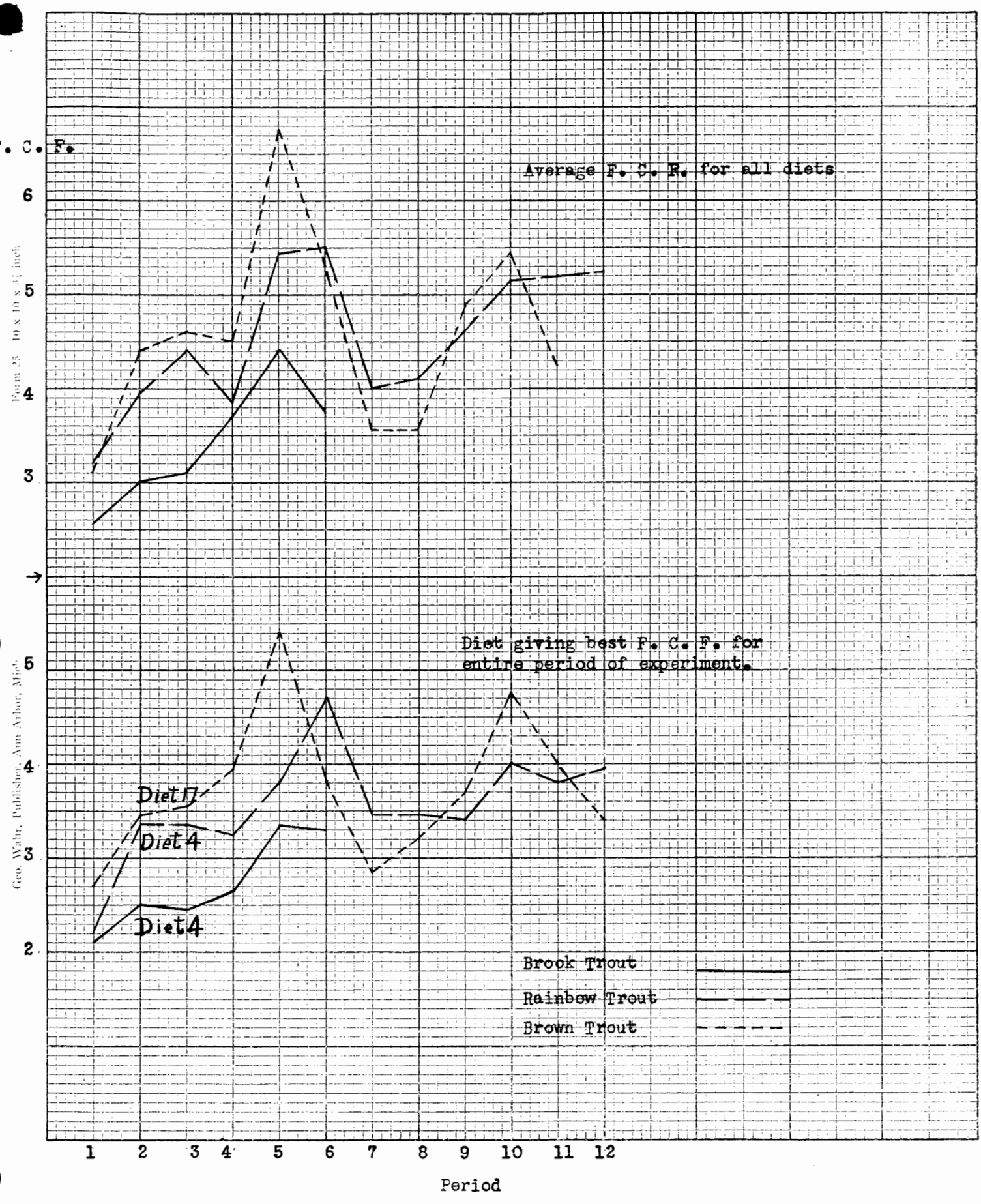
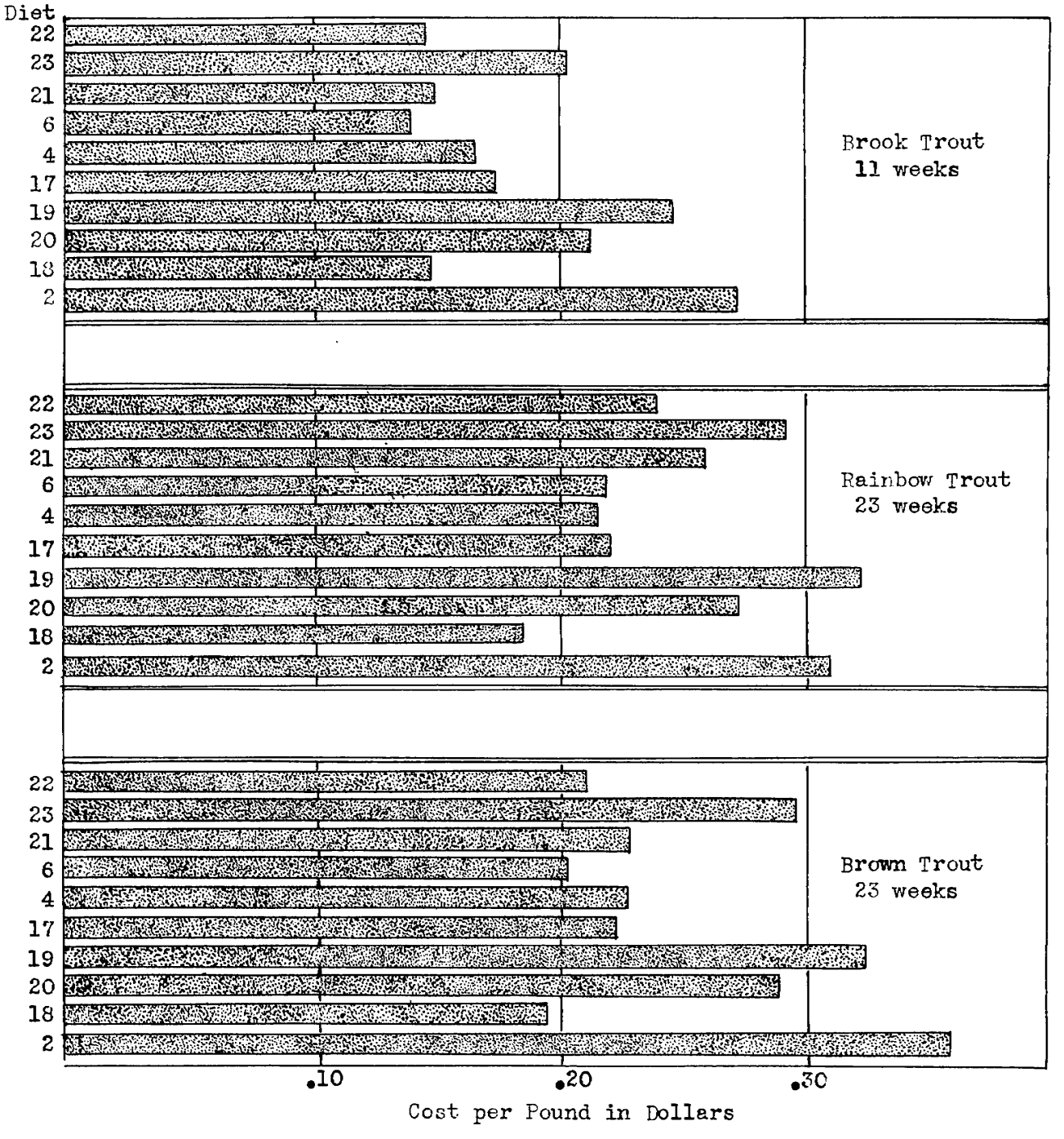


Figure 11. Cost Per Pound to Rear

Bars represent cost of rearing one pound of trout



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December 15, 1937

APPENDIX TO REPORT NO. 446

OUTLINE OF TROUT FEEDING EXPERIMENTS IN PROGRESS AT BENTON HARBOR. 1937.

On September 21, 1937 the trout which were being used in the feeding experiment at Wolf Lake were transferred to concrete raceways at Benton Harbor. Rainbow and brown trout receiving diets 2, 4, 6, 17 and 20 were continued on these diets. Diets 18, 19, 21, 22, and 23 were discontinued because of a poor growth or mortality record. The fish which had been receiving these diets were put into one lot and equal samples by weight placed on new diets, 27, 28, 29, 30, and 31. The ten raceways were divided by placing a screen at the middle; the rainbows occupy the upper half and the browns the lower, so that only one diet is fed to the fish in each raceway.

From the table showing the composition of the diets it will be noticed that each of the five new ones contains a portion of green buttermilk. This green buttermilk is a mixture of dehydrated cereal grasses and buttermilk. It is said to contain appreciable quantities of vitamins B, C, E and G, and carotene. Diet 31 contains no fresh meat whatsoever; the hope is that with the unusual vitamin content of the dry green buttermilk we may be able to rear fish without the addition of any fresh meat. At present (after ten weeks) there is no more mortality among the rainbows receiving this diet than any of the other rainbows; the browns, however, show a heavier mortality though the loss is small. Considering growth at

the end of six weeks the rainbows receiving diet 31 had increased in weight by a larger percentage than some of the rainbows on other diets. In other words, theirs was not the poorest growth exhibited. It is a different picture with the browns: they had actually lost weight, about two and one-half per cent.

Some brook trout which had been receiving diet 4 were transferred from Wolf Lake and continued on this same diet. About November 1 it was possible to take milt from about fifty per cent of the males in this group. The female gonads were only slightly developed.

The water supply for the raceways is taken from a small stream named Blue Creek. Numerous springs provide additional water along the course, but since the valley is quite wide along this stream the water from the springs has to flow over quite a flat marshy area before entering the stream proper.

Composition and Cost of Diets in Use at
Benton Harbor -- 1937

Ingredient	Cost Per Pound	Composition of Diets in Parts Per Hundred									
		2	4	6	17	20	27	28	29	30	31
Sheep Liver	$0.0850	100	50	...	50	50	...	40	...	40	...
Pork Melts	.0600	...	...	75	...	...	40	...	40	...	...
Fish Meal	.0300	...	16.7	8.3	13.3	...	20	20	35	35	40
Cottonseed Meal	.0240	...	16.7	8.3	13.3	13.3	...	...	...	...	...
Skimmilk Powder	.0560	...	16.7	8.3	13.3	13.3	...	...	...	...	...
Oatmeal	.0304	...	...	...	10.0	10.0	10	10	10	10	30
Grasshopper Meal	.1000	...	...	...	...	13.3	...	...	...	...	...
Green buttermilk	.0800	...	...	...	...	...	30	30	15	15	30
Water (Shown in % of rest of diet)	...	...	33.3	5.3	33.3	33.3	58.7	58.7	50.0	50.0	100.0
Cost per Pound		$.0850	.0608	.0542	.0602	.0695	.0570	.0670	.0495	.0595	.0451

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December 15, 1937

SECOND APPENDIX TO REPORT NO. 446

(Excerpts from letter by J. T. Wilkinson
dated December 12, 1937)

Continuation of the feeding experiments after Mr. Gilmore and I return to East Lansing, January 2, 1938, will require practically full time services of someone familiar with our procedure and equipment. I doubt if Mr. Thompson, although capable, should be asked to assume the extra duty of attending to the experimental work. Whoever is to do the work after January first should spend some time working with us before then. If an additional man is to be assigned to this work, I suggest it be Robert Hirsch who has worked at this station during our stay and has been in close enough contact with our work to require very little instruction. He has had no scientific training, but is a good worker; and with occasional guidance from Mr. Thompson, I believe, could do the job satisfactorily.

The original purpose of the trout feeding experiments in Michigan was to try to find a means of reducing the food cost of rearing fingerling trout in the State's hatcheries. Since facilities are available, I believe it would be wise to (1) check results of the various diets over longer periods of time in order (a) to determine cost to rear legal size fish on these diets as compared with liver; (b) to check effect of these diets ~~as eem~~ on egg and milt production; (c) to compare fertility; and (d) to study length of life with reference to rate of growth. (Should mark or tag fish of both sizes.) (2) to maintain a group of stock fish with

known dietary history for any special studies which may be deemed worthwhile.

A suggestion for an experimental program to be started in the 1938 season:

At this time I believe that there are some diets which can be recommended to hatchery men whereby the food cost of rearing fingerling trout can be reduced. At the same time I do not believe that we have arrived at the end of our search. I am sure that continued effort in the future will bring out new results and consequently more "efficient" diets for trout.

During 1938 I think some demonstration trout feeding experiments should be conducted by reliable persons in several of Michigan's hatcheries to demonstrate the value of some of the diets shown to be satisfactory in rearing trout fingerlings at Wolf Lake and at Benton Harbor. Not only the old diets but also some new ones can be included in these tests. This work should be undertaken by someone whose whole time can be devoted to the experimental work. I believe that such a program should be supervised from a central point so that final results can be compared.

INSTITUTE FOR FISHERIES RESEARCH

By James T. Wilkinson
Research Assistant