

THE EFFECTS OF BEEF LIVER ON THE GROWTH  
OF CATFISH AND GOLDFISH

by

MARION ISABELL CAMPBELL

B. S., Kansas State Teachers College, Pittsburg, 1924

---

A THESIS

submitted in partial fulfillment of the requirements

for the degree of

MASTER OF SCIENCE

KANSAS STATE AGRICULTURAL COLLEGE

1930

## TABLE OF CONTENTS

INTRODUCTION .....	page 2
REVIEW OF LITERATURE .....	3
METHODS .....	4
DISCUSSION .....	8
SUMMARY .....	18
ACKNOWLEDGMENTS .....	19
BIBLIOGRAPHY .....	20
PLATES .....	21

## INTRODUCTION

In experiments worked out by Edward Schneberger, under the direction of Dr. Minna E. Jewell in 1928-29 at the Kansas State Agricultural College, fish fed a diet containing liver gained more in growth than those fed a non-liver diet. These results suggested the following questions:

1. Is liver just a desirable source of protein in the diet of catfish and goldfish or is some other growth factor contained in it?

2. Is the amount of liver a factor in the rate of growth of catfish and goldfish?

These studies were made under the direction of Dr. Edward J. Wimmer of the Kansas State Agricultural College under the auspices of the Zoology Department of the Kansas State Agricultural College.

#### REVIEW OF LITERATURE

The field of fish nutrition is comparatively new. Liver has always been a favorite food among hatchery people, because fish eat it readily and it has fulfilled the requirements of an adequate diet.

Pearse (1925) worked out the chemical composition of certain fresh water fishes and found the body to contain an average of 2.44 per cent nitrogen for the year. This would be supplied by the protein content of the food.

McCay, Bing and Dilley (1927), of the Animal Nutrition Department of Cornell University, found that if eastern brook trout were fed a diet containing more than 10 per cent protein, supplied by casein, some other factors besides the protein, carbohydrates, minerals, and vitamins A, B, and D were necessary for normal growth.

In another report, McCay and Dilley (1927) showed evidence of a thermolabile factor responsible for the growth of trout which is found in fresh liver and which they called Factor H. As low as 5 per cent raw liver added to the diet exerted a marked influence on the growth

of trout. Control experiments showed it to be neither vitamins A, B, C, D, or E.

Forbes (1888) by examination of the stomach contents of Ictalurus punctatus found that they consumed a diet of one-fourth vegetable matter. In the fish examined, the animal food eaten consisted of Mollusca, insect larvae, and pieces of fish.

Doze (1925) states that the channel catfish is well adapted to pond life. The Kansas State Hatchery at Pratt is the only hatchery in the United States that distributes channel catfish.

Schneberger (Manuscript, 1929), in experiments on the vitamin content of fish foods, showed that raw liver in the diet of catfish and goldfish produced the greatest gain.

In studying the vitamin D requirements of fish, Alexander (Manuscript, 1929) found that fish fed a raw liver diet gained 57 per cent over those fed on a non-liver diet.

#### METHODS

The catfish, Ictalurus punctatus (Rafinesque), and the common goldfish, Crassius auratus (Linnaeus), were used in this experiment. The catfish were furnished by the State Hatchery at Pratt, Kansas, and the goldfish were purchased

from Grassyforks Hatchery, Martinsville, Indiana. Both species were from the spring hatching of 1929.

The fish were kept in wooden troughs six feet long, one foot wide, and one foot deep. Running water from the College supply was kept at a depth of about eight inches in the troughs. At the beginning of the experiment, fifty catfish and fifty goldfish were placed in each trough. Each trough was fitted with four baskets of one-fourth inch mesh galvanized wire, 18"x12"x12". Twenty-five fish were placed in each basket, the catfish being kept at the end of the tank nearest the inlet. The tanks were numbered 1, 2, 3, and 4. The baskets in each tank were lettered from the water entrance A, B, C, and D in each trough.

The experiment on the catfish started October 14, 1929, and the goldfish were introduced on October 24, 1929. The fish were weighed and measured at the beginning of the experiment, and grouped so that the average length of the fish was the same for the A baskets; and in the same manner the lengths of B, C, and D were alike. The fish in the A baskets ranged in length from 47 mm. to 53 mm.; those of B from 53 to 65 mm.; C from 34 to 37 mm.; and D 37 to 41 mm.

The fish were weighed and measured each month and the average weight and length of the survived fish computed. Each fish was measured from the most anterior point to the base of the caudal fin. In measuring the catfish, each

fish was held in a wet towel in a tray of water while measuring with a pair of dividers so that there would be a minimum amount of contact between the hand and the fish. Each goldfish was transferred from a pan of water into a measuring device, the receptacle of which was glass kept wet with water so that there was no rough surface to injure the scales of the fish.

The fish in each basket were weighed collectively. For the first three months the fish were placed in a damp cloth bag while being weighed. The weighing was done every week for two months, but the weights fluctuated so much, showed no gain or loss, and fungus attacks on the fish became so serious it seemed advisable to weigh the fish but once a month at the time the measuring was done. The use of the cloth bag was discontinued in the weighing process the fourth month. Instead, the fish were placed in a wire basket in a jar of water on the scales. Then, after weighing, the fish, by means of the basket, were placed in a one part to 2,000 solution of copper sulphate for two minutes so as to disinfect any injury received during the measuring process.

The following diets were fed to the fish:

# Diet No. 1 - to fish in Tank 1

## Basal Ration

Quick Quaker Oats	79 grams
Hogan's Salt Mixture	3 grams
Crisco	5 grams
Grape Fruit Juice	10 grams
Fleischman's Yeast	10 grams
Codliver Oil	4 grams
Water	190 grams

# Diet No. 2 - to fish in Tank 2

95 grams Basal Ration plus 5 grams ground raw  
beef liver

# Diet No. 3 - to fish in Tank 3

80 grams Basal Ration plus 20 grams ground raw  
beef liver.

# Diet No. 4 - to fish in Tank 4

60 grams Basal Ration plus 40 grams ground raw  
beef liver.

The oats, crisco, salt mixture and water were cooked together in a double boiler to the consistency of a thick paste. After the mixture had cooled the grape fruit juice, yeast, and codliver oil were added so that the thermolabile vitamins would not be destroyed. The liver was ground to a pulp in a food grinder, then added to the basal ration and the whole thoroughly mixed. The fish were fed twice a day at regular periods. The amount fed was the maximum amount eaten by any one group.

## DISCUSSION

Catfish were selected because they are carnivorous feeders, and goldfish, being largely herbivorous, were chosen so that one would be a check on the other in determining the effects of the liver and non-liver diets. The fish in Tank 1, being fed the basal ration only, were a control on the other groups which were fed the same diet plus liver. By placing the fish in small groups of 25 each, with one group averaging larger than the other, the question of size as affected by the diet was more accurately determined.

Table I shows the average lengths in millimeters of the surviving fish. This was computed by subtracting, each month, the total length of those that had died since the previous measuring from the total lengths at the last measuring, thus obtaining the total length of the surviving fish. Then the average length was determined. In this way, the apparent growth or loss due to the death of large or small fish was minimized.

The growth of the fish of any basket can be observed in the table, in the horizontal arrangement; a comparison of the fish in each tank from the diagonal, and a comparison of the fish in the various tanks from the vertical.

All of the fish in Tank 1 died on December 17 from some unknown cause. They were found the next morning, rigor had

Table I. Average Lengths in Millimeters of Survived Fish.

		: Oct. 13-24	: Nov. 16	: Dec. 15	: Jan. 12		: Feb. 8-13	: Mar. 8	: Apr. 4	: May 3	: Gain	: Percent Gain
Tank 1		:	:	:	:	:	:	:	:	:	:	:
Catfish	A:	50.48	50.88	50.90 <sup>1</sup>	:	:	:	51.00 <sup>3</sup>	50.29	50.52	-.48	-.83
	B:	56.64	56.84	56.40	:	:	:	56.38	56.87	59.07	2.24	4.2
Goldfish	C:	35.20	36.70	36.10	:	39.96 <sup>2</sup>	:	40.76	39.87	41.10	1.60	1.7
	D:	37.40	39.20	38.70	:	39.88	:	40.87	41.67	44.27	1.14	2.8
											1.30	3.47
											4.39	11.0
Tank 2		:	:	:	:	:	:	:	:	:	:	:
Catfish	A:	50.48	51.68	51.59	51.60	52.24	:	51.80	52.15	53.00	2.52	5.03
	B:	56.64	57.20	57.60	57.75	58.21	:	58.60	59.21	58.79	2.15	3.84
Goldfish	C:	35.20	37.80	36.80	38.40	40.04 <sup>4</sup>	40.82 <sup>4</sup>	42.26	42.61	45.45	4.84	13.74
	D:	38.00	40.20	40.60	41.10	41.70 <sup>4</sup>	38.00 <sup>5</sup>	38.77	35.22	41.72	4.63	11.08
											3.70	9.75
											-3.72	9.7
Tank 3		:	:	:	:	:	:	:	:	:	:	:
Catfish	A:	50.48	52.00	52.00	52.04	53.00	:	53.17	53.22	53.33	2.85	5.66
	B:	56.68	57.84	58.20	58.80	59.70	:	59.18	60.54	61.29	4.61	8.1
Goldfish	C:	35.20	38.75	38.40	40.90	41.90	:	47.10	48.82	55.28	20.08	57.07
	D:	38.00	41.10	43.30	44.40	47.86	:	51.10	54.90	60.72	22.72	58.78
Tank 4		:	:	:	:	:	:	:	:	:	:	:
Catfish	A:	50.48	52.60	52.50	52.28	52.79	:	52.81	53.06	53.73	3.25	6.43
	B:	56.68	58.52	58.60	59.40	59.62	:	59.50	60.75	61.25	4.57	8.08
Goldfish	C:	35.20	39.40	41.00	43.50	48.71	:	48.45	51.70	59.11	23.91	67.92
	D:	38.00	42.28	45.10	45.80	45.30	:	51.09	54.04	61.09	23.09	60.76

<sup>1</sup> All fish in Tank 1 died December 17.

<sup>2</sup> Other goldfish entered February 13 in C and D.

<sup>3</sup> Other catfish entered March 8 in A and B.

<sup>4</sup> C and D were combined February 13.

<sup>5</sup> Other fish placed in D February 13.

set in and they were heavily covered with mucous. An analysis of the water and fish gave no clue. The water, however, had been running continuously, so that any foreign substance may have been washed out. The goldfish were replaced on February 13 with 25 goldfish obtained at the same time as those used in this problem and which had been used in another experiment. They had been fed an adequate diet consisting of the basal ration of this experiment plus 20 per cent by weight of ground liver. They were placed in basket C of Tank 1. A similar group of 25 goldfish which had been fed on a similar diet plus iodine, were placed in basket D of Tank 1 and fed Diet Number 1. At the same time, due to a heavy mortality, the remaining fish in baskets C and D of Tank 2 were combined into basket C; and 25 goldfish which had been fed on a diet of a commercial Grassy-fork Natural Fish Food were placed in basket D and fed Diet Number 2. On March 8, the catfish were replaced in Tank 1 in baskets A and B by catfish of a similar age from the Pratt Hatchery.

The mortality in Tanks 2 and 3 was greater among the goldfish than among the catfish, but not so great in Tank 3 as in Tank 2. Few catfish in any group died.

The growth of the goldfish was more rapid than that of the catfish, but this may have been due to the approaching maturity of the goldfish.

By a chemical analysis, it was found that the basal ration contained 4.56 per cent protein ( $N \times 6.25$ ) and the liver 21.06 per cent protein ( $N \times 6.25$ ). Computation from this determination indicates that Diet Number 1 contains 4.56 per cent protein; Diet Number 2, 5.68 per cent protein; Diet Number 3, 8.65 per cent protein; Diet Number 4, 11.25 per cent protein.

Diet Number 1, although it is adequate in vitamins, minerals, and fats, but containing no liver, produced small gain in all groups to which it was fed. The catfish gained 0.16 per cent over the first two months, and 2.05 per cent for the second group of fish added in March, and the goldfish 3.3 per cent and 6.91 per cent for the same corresponding periods. Diet Number 2, containing 5 per cent liver, gave a marked gain of 4.38 per cent in the catfish and 19.01 per cent in the goldfish. The difference in protein content between these two diets was only 1.12 per cent ( $N \times 6.25$ ), but Diet Number 2 produced approximately twice the gain among the catfish as Diet Number 1, and over three times as great a gain in the goldfish.

Diet Number 3 with 20 per cent liver produced a gain of 7.93 per cent in the catfish and 58.58 per cent in the goldfish. For the catfish, this is only a slightly greater gain over Diet Number 4 with 40 per cent liver which gain was 7.29 per cent or a difference of 0.68 per cent. The

opposite effect is true among the goldfish, the 40 per cent liver producing the greater gain, 64.2 per cent, or 5.62 per cent more than Diet Number 3.

If the protein were the essential factor, Diet Number 4, having approximately twice as much protein as Diet Number 2, should have produced twice as great a gain.

Table II shows that the gain in length of goldfish on Diet Number 4 was almost three times that of those on diet Number 2. This would indicate that there is some other growth factor other than protein in liver. Diet Number 3 produced a slightly greater gain among the catfish than Diet Number 4. This seems to signify that less than 40 per cent liver in the diet was an adequate amount for catfish or that for the catfish a sufficient amount of the growth factor is contained in a diet of 20 per cent liver.

A graphical representation of Tables I and II is given in Figures 1, 2, and 3. All of the curves show less growth during December, January, and February. This was the quiescent period for fish. Not as much food was eaten as during the spring months. The catfish appeared to be more susceptible to weather changes than the goldfish. This might have been due to the catfish not being accustomed to an environment that would permit a maximum amount of activity during the winter months.

Table II. Average Lengths in Millimeters of Survived Fish.

	Oct. 13-24	Nov. 16	Dec. 15	Jan. 12	Feb. 8	Mar. 8	Apr. 4	May 3	Gain	Per Cent Gain
Tank 1										
Catfish A-B	53.56 <sup>1</sup>	53.86	53.65			53.69 <sup>3</sup>	53.58	54.79	.09	1.1
Goldfish C-D	36.30 <sup>1</sup>	37.95	37.40		39.92 <sup>2</sup>	40.8	40.8	42.68	1.14	2.76
Tank 2										
Catfish A-B	53.56	54.44	54.59	54.55	55.2	55.2	55.68	55.89	2.33	4.38
Goldfish C-D	36.60	39.00	38.70	39.75	39.91	40.5	38.91	43.56	6.96	19.01
Tank 3										
Catfish A-B	53.56	54.92	55.10	55.42	56.35	56.17	56.88	57.81	4.25	7.93
Goldfish C-D	36.60	39.92	40.85	42.6	44.88	49.2	51.86	58.00	21.40	58.58
Tank 4										
Catfish A-B	53.58	55.56	55.55	55.84	56.2	56.15	56.9	57.49	3.91	7.29
Goldfish C-D	36.60	40.34	43.05	44.65	47.50	49.77	52.87	60.10	23.50	64.2

<sup>1</sup> Died December 17.<sup>2</sup> Added February 13.<sup>3</sup> Entered March 8

A study of these figures shows that there was no significant difference in growth between the average of the larger fish and the average of the smaller fish fed any of the diets.

The average weight of the surviving fish was computed in the same manner as the average lengths. These results are given in Table III for the fish in each basket, while Table IV shows the average weights of the surviving catfish as a group and goldfish as a group as affected by the different diets. Figures 4, 5, and 6 show the weights in grams of the catfish, while figures 7, 8, and 9 the weights of the goldfish. In both a gain in weight paralleled the gain in length. Again, the goldfish gained more than the catfish. The catfish fed Diet Number 1 gained 13.6 per cent over the first period and lost 18.8 per cent over the second period. This probably means that the first group of catfish were storing fat for their growth was only 0.16 per cent. The second group lost 18.8 per cent in weight but gained 2.05 per cent in length, which may be explained by a loss of the surplus fat and its transformation into body tissue.

Diet Number 1 produced a loss in weight of 95 per cent in the first group of goldfish and a 20 per cent gain in the second group.

Table III. Average Weights in Grams of Survived Fish

	:Nov. 4:	:Nov.17:	:Dec.15:	:Jan.12:	Feb. 8	:Mar. 8:	:Apr. 4:	:May 3	:Gain	:Gain Per Cent
Tank 1	:	:	:	:	:	:	:	:	:	:
Catfish A:	1.9	1.8	1.7 <sup>1</sup>	:	:	1.9 <sup>3</sup>	1.7	1.7	-.2 and .2	- 10.5
B:	2.5	2.5	2.3	:	:	2.6	2.6	2.8	-.2 and .2	- 8 and 7.6
Goldfish C:	1.9	1.8	1.5	:	2.5 <sup>2</sup>	2.5	2.5	2.7	-.4 and .2	- 21 and 8
D:	2.3	2.2	2.4	:	2.5	2.6	2.2	3.3	.8 and 1	32 and 4.3
Tank 2	:	:	:	:	:	:	:	:	:	:
Catfish A:	2.0	2.0	2.0	2.0	2.0	2.2	2.2	2.3	.3	15
B:	2.7	2.6	2.6	2.7	2.7	2.9	3.0	3.1	.4	14.8
Goldfish C:	1.9	2.0	2.0	2.2	2.8 <sup>4</sup>	2.8 <sup>4</sup>	3.2	3.8	4.1	9 and 1.3
D:	2.4	2.6	2.6	3.1	2.8 <sup>4</sup>	2.0 <sup>5</sup>	2.2	2.4	2.8	4 and .8
Tank 3	:	:	:	:	:	:	:	:	:	:
Catfish A:	2.2	2.1	2.1	2.3	2.4	2.2	2.2	2.4	0.2	9.09
B:	2.9	2.7	2.9	2.9	3.2	3.2	3.4	3.6	.7	24.1
Goldfish C:	2.1	2.0	2.7	3.1	3.7	5.0	5.8	7.5	5.4	252.3
D:	2.6	2.7	3.3	4.4	4.9	6.2	8.0	9.8	7.2	276.8
Tank 4	:	:	:	:	:	:	:	:	:	:
Catfish A:	2.1	2.1	3.0	3.0	2.2	2.2	2.2	2.6	.4	19.04
B:	2.8	2.4	2.1	2.1	3.0	3.1	3.2	3.4	.6	21.43
Goldfish C:	2.1	2.3	2.8	3.4	4.2	5.2	6.5	9.0	6.9	328.5
D:	2.4	2.8	3.1	4.0	4.9	5.6	6.7	9.0	6.6	275.0

<sup>1</sup> All fish in Tank 1 died December 17.

<sup>2</sup> Other goldfish entered February 13 in C and D.

<sup>3</sup> Other catfish entered March 8 in A and B.

<sup>4</sup> C and D were combined February 13.

<sup>5</sup> Other fish placed in D February 13.

Table IV. Average Weight in Grams of Survived Fish.

	:Nov. 4:	:Nov.16:	:Dec. 15:	:Jan.12:	:Feb. 8:	:Mar. 8:	:Apr. 4:	:May 3 :	:Gain :	:Per Cent Gain :		
Tank 1	:	:	:	:	:	:	:	:	:	:		
Catfish A-B:	2.2	2.1	2.5 <sup>1</sup>	:	:	2.7 <sup>3</sup>	2.1	2.2	.3	-5	13.6	-18.8
Goldfish C-D:	2.1	2.0	1.9	:	2.5 <sup>2</sup>	2.5	2.3	3.0	.2	+5	-95	20
-----												
Tank 2	:	:	:	:	:	:	:	:	:	:	:	:
Catfish A-B:	2.3	2.3	2.3	2.3	2.3	2.5	2.6	2.7	.4	:	17.39	:
Goldfish C-D:	2.2	2.3	2.3	2.6	2.4 <sup>4</sup>	2.7 <sup>5</sup>	3.1	2.4	:	.2	:	9.9
-----												
Tank 3	:	:	:	:	:	:	:	:	:	:	:	:
Catfish A-B:	2.5	2.4	2.5	2.6	2.8	2.7	2.8	3.5	1.0	:	40	:
Goldfish C-D:	2.3	2.3	3.7	3.2	4.3	5.6	6.9	8.6	:	6.3	:	273.9
-----												
Tank 4	:	:	:	:	:	:	:	:	:	:	:	:
Catfish A-B:	2.4	2.2	2.5	2.5	2.5	2.6	2.7	3.0	.6	:	25	:
Goldfish C-D:	2.2	2.5	2.9	3.7	4.5	5.4	6.6	9.0	:	6.8	:	309.9

<sup>1</sup> All fish in Tank 1 died December 17.

<sup>2</sup> Other goldfish entered February 13 in C and D.

<sup>3</sup> Other catfish entered March 8 in A and B.

<sup>4</sup> C and D were combined February 13.

<sup>5</sup> Other fish placed in D February 13.

Diet Number 2 produced a greater gain in weight among the catfish than among the goldfish. The gain in weight of the catfish being 17.39 per cent, and for the goldfish 9.9 per cent.

Diet Number 3 gave an increase in weight of 40 per cent for the catfish or 22.61 per cent more than that of Diet Number 2. This diet (Number 3) gave an increase in weight of 273.9 per cent in the goldfish or twenty-eight times the increase of those fed Diet Number 2. These fish also seemed more mature than the goldfish fed diets 1 and 2.

Diet Number 4 did not produce as great a gain in weight among the catfish as Diet Number 3, being 25 per cent. This was parallel to the gain in length. The goldfish made a great gain in weight of 309.9 per cent or twenty-six per cent more than those fed Diet Number 3. Figures 4 to 9 show that the greatest increase in weight was during the spring months. Catfish in Tanks 1, 3, and 4 show a decrease in weight at the beginning of the experiment, but all made a rapid gain in growth probably due to the change to the experimental diets, and to using up their surplus fat. Groups II and IV show the most constant weight. Group III shows the most fluctuations in weight and the greatest increase in February after the severe cold weather and a period of decreased feeding.

The greatest gain in both weight and length for any one month was during April. The experiment was terminated May 2, the beginning of the season when fish make their most rapid growth. Therefore, it probably would have been better to have continued the experiment throughout the year.

The fish fed diets 1 and 2 seemed to be more subject to changes in temperature. The diseases were more pronounced and the mortality higher when the fish were not eating.

It was impossible, during the time allotted to the experiment to devise a method of keeping an individual record of the length and weight of each fish.

It is apparent from the preceding results that both goldfish and catfish make more rapid growth gains on a liver diet than on a non-liver diet. Those fed a liver diet were also more healthy looking than the others. The 20 per cent and 40 per cent liver diets produced practically the same amount of gain. Twenty per cent liver added to the diet would, therefore, be a sufficient amount. This is in accord with the results of McCay and Dilley working with trout.

#### SUMMARY

1. The purpose and methods of the experiment are set forth and explained.

2. The results of the experiment show that catfish fed a diet containing 20 per cent liver gain 0.68 per cent

in length and 15 per cent in weight over those fed a 40 per cent liver diet, and 5.8 per cent in length and 58 per cent in weight over those fed a non-liver diet. Goldfish fed on a 40 per cent liver diet gain 2.1 per cent in length and 26 per cent in weight over those fed a diet with 20 per cent liver, and 57.29 per cent in length and 328 per cent in weight over those fed a non-liver diet.

3. A diet of 20 per cent by weight of liver is shown to be adequate for catfish. The goldfish increase in length and weight in proportion to the amount of liver added.

4. There appears to be no difference in the growth of the larger fish as compared with the smaller fish fed on the different diets.

5. Evidence is shown indicating the presence of a growth promoting factor in raw beef liver. This confirms the findings of McCay and Dilley in experiments on the effects of liver diets on trout.

#### ACKNOWLEDGMENTS

The author is indebted to Dr. Minna E. Jewell of the Kansas State Agricultural College who suggested the problem and planned the diets, and to Mr. Alva Clapp, State Fish and Game Warden for providing the channel catfish used in the experiment.

## BIBLIOGRAPHY

- Alexander, Jean  
1929. The effect of vitamin D on the growth of fish.  
Unpublished, K.S.A.C.
- Bing, F. C.  
1927. A progressive report upon feeding experiments  
with brook trout fingerlings at the Connecticut  
State Fish Hatchery, Burlington, Connecticut.  
Trans. Amer. Fish. Soc., 57:266-272.
- Doze, J. B.  
1925. The barbed trout of Kansas.  
Trans. Amer. Fish. Soc., 55:167-183.
- Forbes, S. A.  
1888. Studies of the food of fresh water fishes.  
Bull. of Ill. State Lab. of Nat. Hist., 2:434-  
473.
- McCay, C. M., Bing, F. C., and Dilley, W. S.  
1927. The effects of variations in vitamins, protein,  
fat and minerals in the diet upon the growth  
and mortality of eastern brook trout.  
Trans. Amer. Fish. Soc., 57:240-257.
- McCay, C. M., Dilley, W. E.  
1927. Factor H in the nutrition of trout.  
Trans. Amer. Fish. Soc., 57:250-257.
- Pearse, A. S.  
1925. The chemical composition of certain fresh water  
fishes.  
Ecology, 6:1-16.
- Schneberger, Edward  
1929. The effects of vitamins B and G on the growth  
of fish.  
Unpublished, K.S.A.C.

Fig 1.

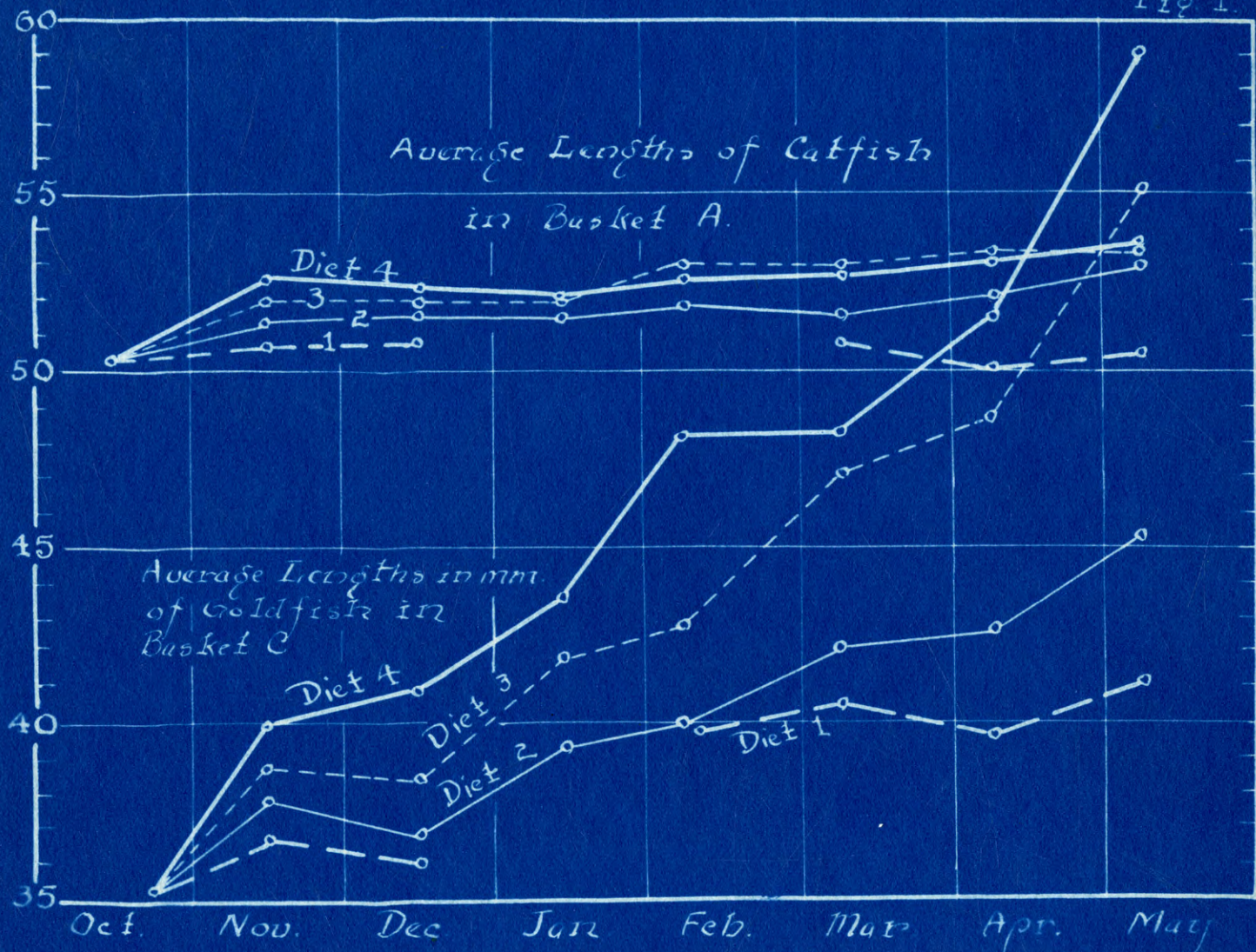


Fig. 2.

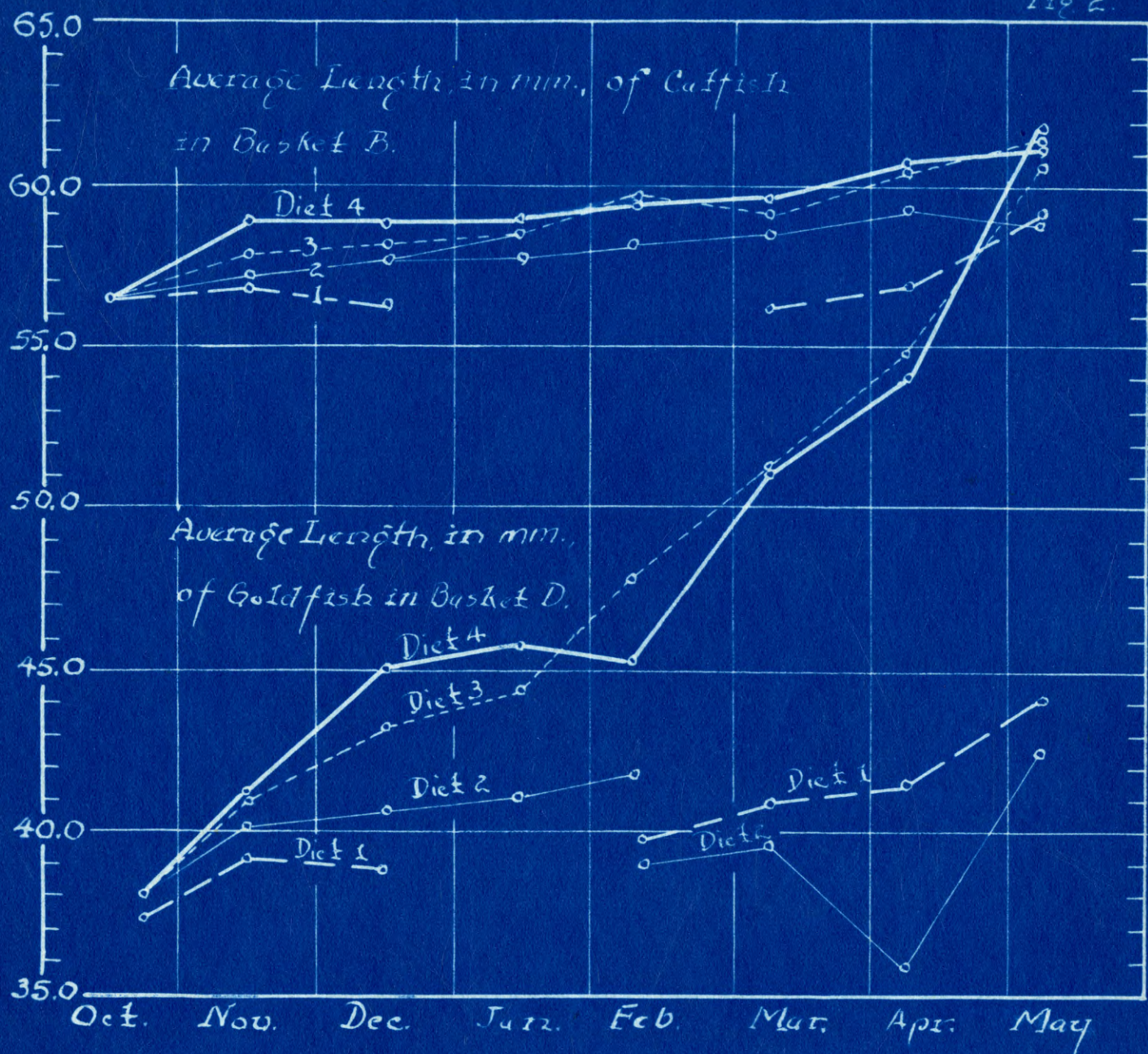
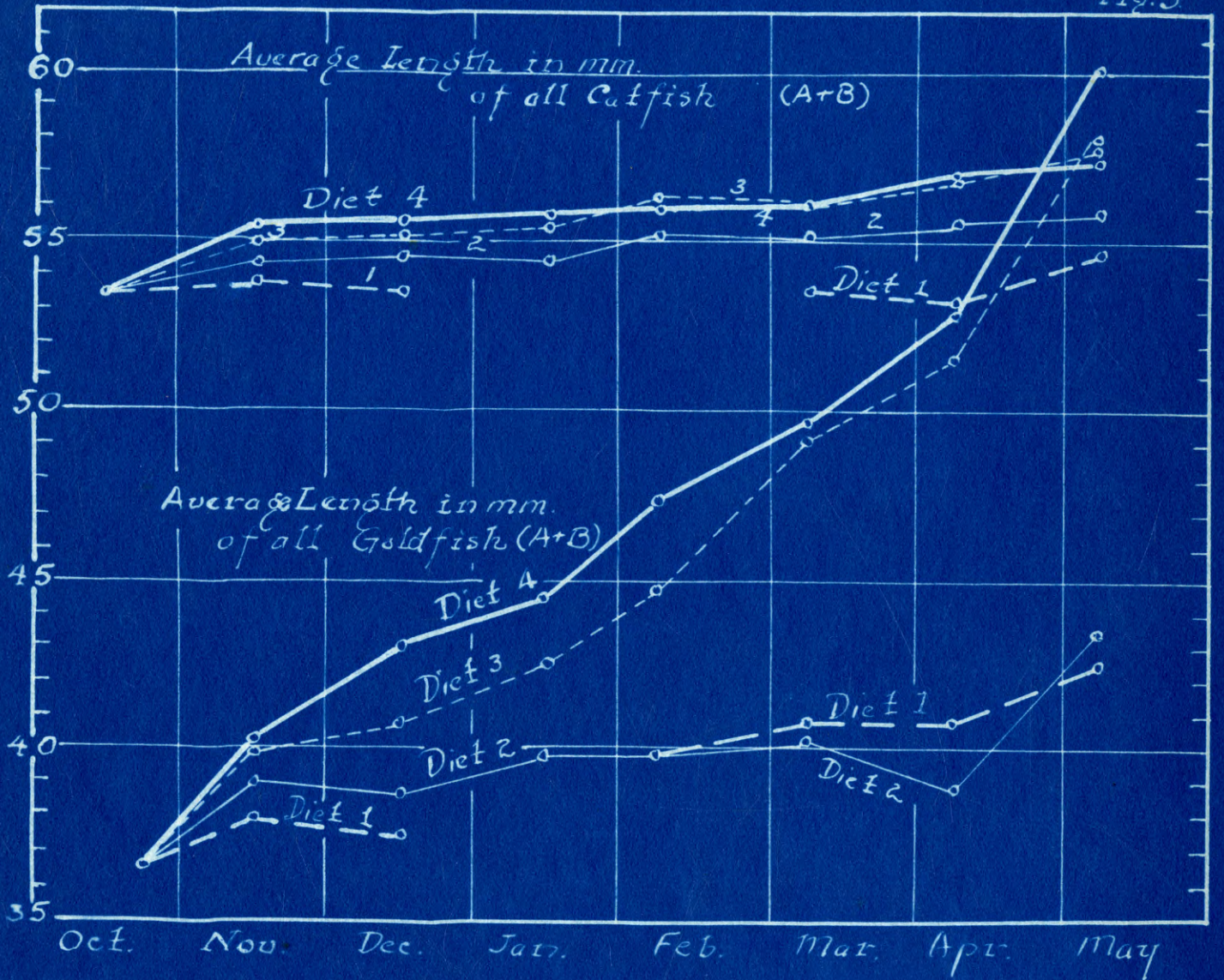


Fig. 3



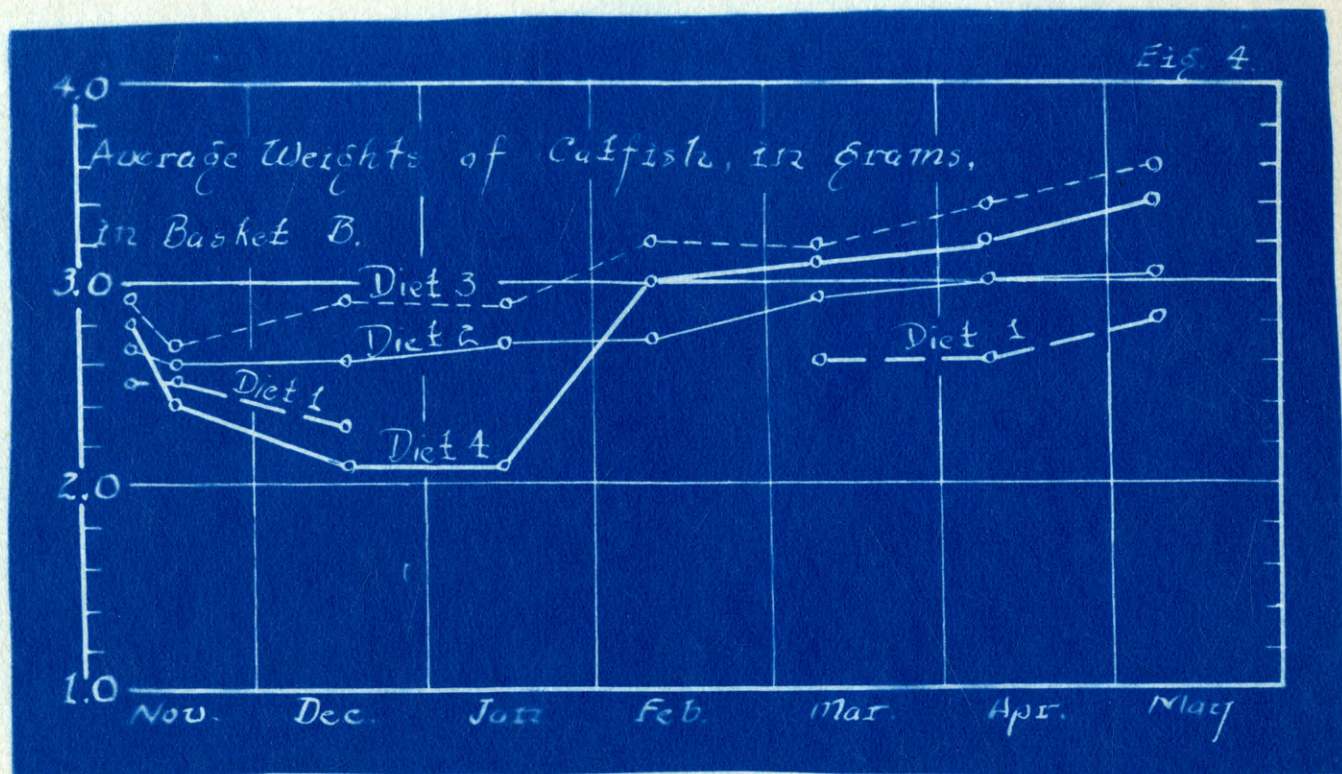


Fig. 5.

