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PROTEIN REQUIREMENTS OF GROWING CHICKS

by

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A THESIS

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Fulfilment of the Requirements for the Degree of
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TABLE OF CONTENTS

	<u>Page</u>
ACKNOWLEDGMENT	
INTRODUCTION	1
SCOPE OF THE WORK	1
PRELIMINARY TESTS	2
EXPERIMENTAL SERIES No.1 (California)	
Stock	2
Equipment	3
Rations	3
Methods	4
Experiments	4
Rate of Growth	5
Mortality	6
General Observations	6
Bone Analysis	7
EXPERIMENTAL SERIES No.2 (Alberta)	
Stock	9
Equipment and Method of Use	9
Rations	12
Methods	14
Rate of Growth	16
Variability in Growth Rate	19
Mortality and General Health	20
Food Consumption	22
Economy of Gains	22
Protein Retention Tests	23
SUMMARY AND CONCLUSIONS	25
BIBLIOGRAPHY	27
APPENDIX (Tables and Charts)	

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PROTEIN REQUIREMENTS OF GROWING CHICKS

Introduction

The main object of this investigation was to determine the maximum protein utilization in growing chicks during the early stages of life. The percentage of protein included in the majority of chick rations has heretofore been determined largely by empirical methods based on the experience of poultry men, and by chemical and biological analysis of food stuffs, rather than by experimental evidence of the protein requirements of the birds themselves. It was felt therefore that a measurement of protein retention under optimum conditions of growth should yield some information of fundamental importance which would assist in establishing definite feeding standards for growing chicks.

Scope of the Work

In order to secure maximum protein retention it was essential to get maximum growth, that is, maximum tissue formation in the chicks. This necessitated numerous experiments and involved many adjustments, not only of protein content, but of mineral and vitamin content of the rations, so as to maintain health and promote normal development. Two formulae were finally evolved which were found to give a higher rate of growth than so far reported anywhere in the literature for White Leghorn chicks. These were then used as a basis for the metabolism test to determine protein retention.

Preliminary Tests

A preliminary series of experiments was carried out at the University of California extending throughout June, July and August 1929, mainly to determine the range of protein content within which the most rapid growth could be secured, and the highest and lowest levels of protein that could be fed with safety and give reasonable increases in weight. These experiments also served to perfect the equipment and the technique necessary for control of brooding conditions, and for accurate measurement of intake and output of protein, so that the final test could be carried out with as little error and delay as possible.

EXPERIMENTAL SERIES No. 1 (California)

Stock

For the preliminary series of experiments, day-old White Leghorn chicks were used from the Station flock at the University of California in Berkeley, Cal. No selection was made, either among the chicks themselves or among the parent stock, for size, vigor or other qualities, except that no weak or crippled birds were used.

In some of the late hatches the pens of chicks were supplemented with cross-breds, as pure Leghorns were not available in sufficient numbers. These cross-breds were mostly Leghorn x Minorca and Leghorn x Ancona. However, it was concluded that the significance of the results would not be impaired by including them along with the purebreds, as their

average weekly weights, their range in weight and the variation in weight as measured by Standard Deviation and Coefficient of Variation, were closely comparable with these measurements in Leghorns, in the same pen and fed on the same ration.

Equipment

All chicks were kept for the first three weeks in storage battery brooders, heated by electricity and provided with thermostatic control. Each compartment measured three feet square and accommodated 20-25 chicks. The floors were of 1/2" wire mesh, and metal pans were provided underneath to collect and remove the droppings. Dry mash and water were supplied in metal pans suspended on the outside of the pens, and were available to the chicks only through the mesh of the side walls of the brooder. At three weeks the chicks were transferred to 4 x 6 pens on the floor of the brooder room, the heat necessary being supplied by small electric brooders. Mash was provided in hoppers placed inside the pens, and all hoppers were covered with wire netting to prevent waste.

Rations

Table I gives the percentage composition of the four mash mixtures fed to the various pens in this series of tests. Analysis of these mixtures gave total protein (N x 6.25) approximately 11%, 19%, 30% and 38% respectively.

The entire ration in every case was fed in the form of a dry mash mixture, no whole grain and no supplement other than water being provided.

TABLE I

RATIONS. PENS I - 2 - 3 - 4.

Experimental Series No. 1, (California).

	<u>PEN I</u>	<u>PEN 2,2A</u>	<u>PEN 3,3A,3B</u>	<u>PEN 4,4B</u>
Protein Supplement (Beef Scrap 1/3 (Fish Meal 1/3 (Dried Skim Milk 1/3	5	30	55	80
Alfalfa Leaf and Blossom Meal	5	5	5	5
Cod Liver Oil	2	2	2	2
Mineral Mixture (Bone Meal 60 (CaCO ₃ 20 (NaCl 20	5	5	5	5
Grain Mixture (Yellow Corn 2/3 (Wheat 1/3	83	58	33	8
	100	100	100	100

Methods

All chicks were weighed individually, daily for the first three weeks, then at weekly intervals up to six weeks, at which time records were discontinued and typical individuals from each pen were killed and examined. As it was found to be impossible to weigh every chick at the same hour every day and as no consistent increase in weight could be detected from day to day, (due in all probability to varying amounts of material in the digestive tract) conclusions were finally based on weekly increases only.

Food consumption was measured by recording daily additions and weighing back the residue at the time weekly weights of the chicks were taken.

Experiments

The first lot of chicks, hatched, June 3, 1929, was divided into four pens and placed on rations containing 5%, 30%, 55%, and 80% respectively of the protein supplement mixture as shown in Table I. On June 10, a second lot of chicks was hatched and these were used to repeat the tests with the 55% and 80% protein supplement, as it was felt that the optimum for rapid growth, especially in the early stages of life, lay rather in the higher than the lower levels of protein content. It soon became evident however, that the chicks on 80% supplement were lagging behind, and that the original pen on 30% was not only making the most rapid growth but was thriving better than either the 55% or the 80% pen. On June 17, therefore a third lot of chicks was hatched and these were used to compare the results of the 30% and the 55% protein rations.

Rate of growth

Table II sets forth for all pens in this series the weekly weights of chicks, and for the four pens in the first lot, weekly weights and food consumption, together with economy of gains expressed in grams of food per gram of gain in live weight, weekly and for the whole period of six weeks. Figure I illustrates by means of graphs the growth rates for all pens, average weight in grams being plotted against age in weeks.

From these it will be seen that of the four rations used, the one containing 30% protein supplement gave the highest rate of growth, the chicks attaining a weight of 329.9 grams in 6 weeks, as compared with 299.1 for the 55% ration, 224.0 for the 80% ration, only 162.6 for the 5% ration. The 30% ration was also the most economical in promoting growth, the average food for gram gain amounting to only 2.55 grams throughout the period, as compared with 2.75 for the 55% ration and 3.73 for the 80%. Pen I on 5% protein made such slow growth that even with an average food consumption considerably lower than in any of the other pens, it required 3.95 grams of food to produce a gram of gain.

It will be noted that in the second and third lots of chicks, the rate of growth was slower than for corresponding pens in the first lot on identical rations. This is in accordance with the findings of Upp and Thompson (1), and with the general experience of poultry keepers, that late hatched chicks make poorer gains than early hatched chicks, although the fundamental cause has not yet been ascertained. With these chicks, weather conditions were in all probability

TABLE II
RATE OF GROWTH
FOOD CONSUMPTION
AND
ECONOMY OF GAINS
 (Experimental Series No. 1, California)

TABLE II
RATE OF GROWTH
FOOD CONSUMPTION
AND
ECONOMY OF GAINS
 (Experimental Series No. 1, California).

Hatched	Age Wks.	<u>PEN 1 (5%)[#]</u>					<u>PEN 2 (30%)</u>				
		No. of Chicks	Ave. Live Wt. Grams	Ave. Gain Grams	Ave. Food Cons. Grams	Gram Food Per Gram Gain	No. of Chicks	Live Wt. grams	Ave. Gain grams	Ave. Food Cons. grams	Gram Food Per Gram Gain
June 3 1929	1/7	15	34.1	-	-	-	15	33.3	-	-	-
	1	15	42.1	8.0	20.7	2.58	15	49.9	16.6	26.3	1.59
	2	15	57.5	15.4	49.0	3.18	15	82.5	32.6	65.6	2.01
	3	14	79.4	21.9	71.4	3.26	15	129.1	46.6	101.3	2.17
	4	14	103.4	24.0	79.3	3.30	15	182.2	53.1	123.0	2.31
	5	14	127.2	23.8	114.3	4.80	15	234.6	52.4	193.3	3.69
	6	14	162.6	35.4	175.0	4.94	15	329.9	95.3	246.7	2.59
			128.5	509.7	3.95			296.6	756.2	2.55	

Hatched	Age Wks.	<u>PEN 3 (55%)</u>					<u>PEN 4 (80%)</u>				
		No. of Chicks	Ave. Live Wt. Grams	Ave. Gain Grams	Ave. Food Cons. Grams	Gram Food Per Gram Gain	No. of Chicks	Ave. Live Wt. Grams	Ave. Gain Grams	Ave. Food Cons. Grams	Gram Food Per Gram Gain
	1/7	16	33.7	-	-	-	15	32.9	-	-	-
	1	16	52.3	18.6	25.9	1.39	15	47.9	15.0	21.7	1.44
	2	16	79.4	27.1	60.9	2.25	12	69.0	21.1	66.3	3.14
	3	16	126.1	46.7	101.9	2.18	12	100.2	31.2	103.8	3.33
	4	16	157.9	31.8	125.0	3.93	11	137.2	37.0	125.5	3.39
	5	16	216.3	58.4	181.3	3.10	9	182.0	44.8	165.6	3.69
	6	15	299.1	82.8	236.0	2.85	9	224.0	42.0	231.1	5.50
			265.4	731.0	2.75		191.1	714.0	3.73		

Hatched	Age Wks.	<u>Pen 2A (30%)</u>	
		No. of Chicks	Live Wt. grams
June 10 1929	1/7	24	35.6
	1	24	44.1
	2	21	72.7
	3	21	121.1
	4	21	163.2
	5	20	220.8
	6	20	277.9

Hatched	Age Wks.	<u>PEN 3A (55%)</u>		<u>PEN 4A (80%)</u>	
		No. of Chicks	Live Wt. Grams	No. of Chicks	Live Wt. Grams
	1/7	25	35.8	26	35.7
	1	25	48.6	26	46.5
	2	25	70.4	22	60.8
	3	25	115.9	20	91.8
	4	25	153.6	16	115.6
	5	25	221.9	14	157.9
	6	25	278.6	13	191.8

Hatched	Age Wks.	<u>PEN 3B (55%)</u>	
		No. of Chicks	Live Wt. grams
	1/7	24	35.7
	1	24	43.1
	2	20	68.0
	3	20	103.2
	4	20	131.8
	5	19	183.3
	6	19	246.1

[#] Figures in brackets indicate percentage of protein supplement used.

^{**} Average Weight, percentage gain and average food consumption are based on total number of chicks surviving at end of six weeks.

TABLE II

RATE OF GROWTH
FOOD CONSUMPTION
AND
ECONOMY OF GAINS

(Experimental Series No. 1, C)

PEN 3 (55%)

Age Wks.	No. of Chicks	Ave. Live Wt. Grams	Ave. Gain Grams	Ave. Food Cons. Grams	Gram Food Per Gram Gain	No. Chicks
1/7	16	33.7	-	-	-	15
1	16	52.3	18.6	25.9	1.39	15
2	16	79.4	27.1	60.9	2.25	12
3	16	126.1	46.7	101.9	2.18	12
4	16	157.9	31.8	125.0	3.93	11
5	16	216.3	58.4	181.3	3.10	9
6	15	299.1	82.8	236.0	2.85	9
265.4 731.0 2.75						

PEN 3A (55%)

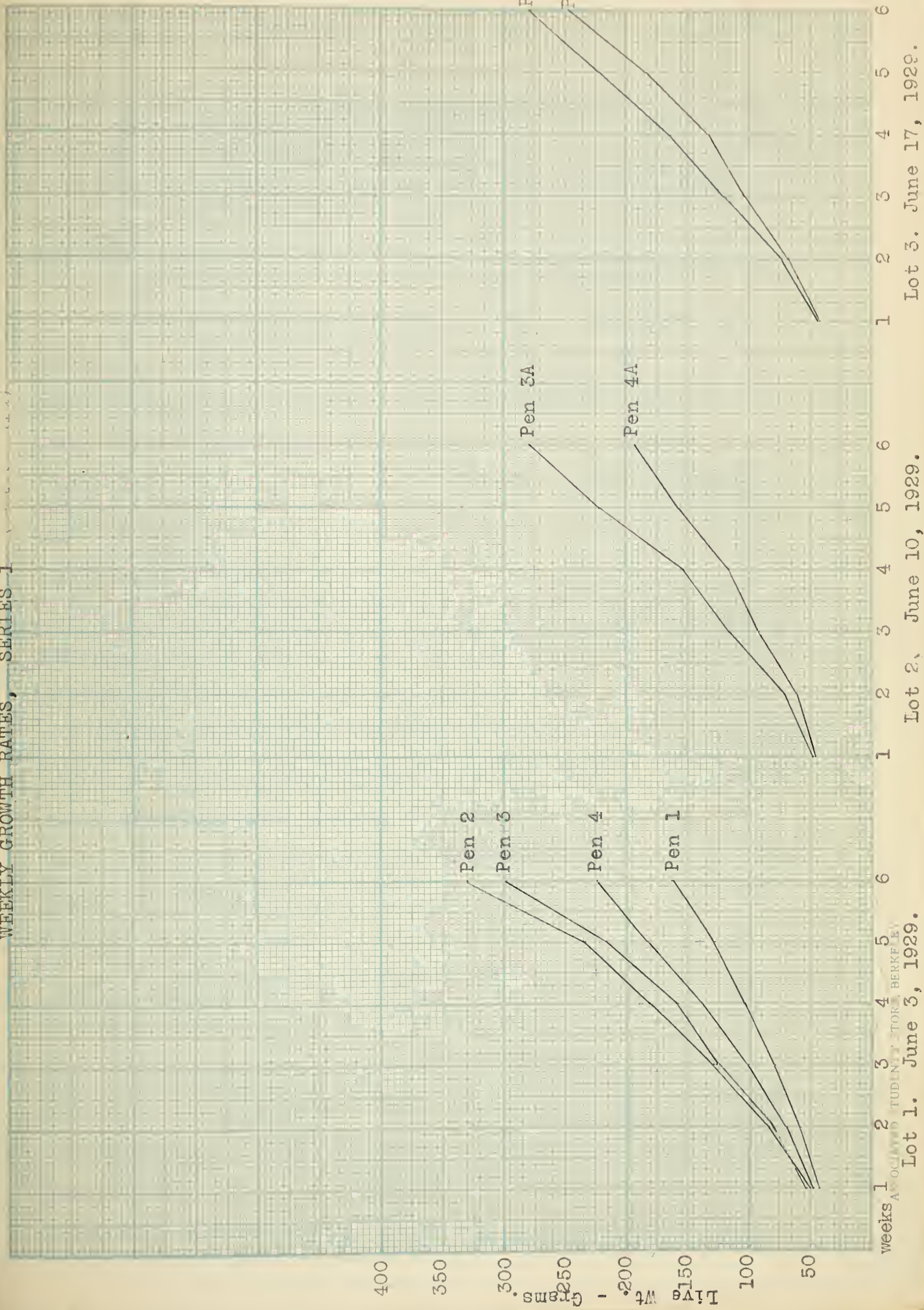
1/7	25	35.8				26
1	25	48.6				26
2	25	70.4				22
3	25	115.9				20
4	25	153.6				16
5	25	221.9				14
6	25	278.6				13

PEN 3B (55%)

1/7	24	35.7			
1	24	43.1			
2	20	68.0			
3	20	103.2			
4	20	131.8			
5	19	183.3			
6	19	246.1			

Fig. 1.

WEEKLY GROWTH RATES, SERIES 1



weeks 1 2 3 4 5 6
A. O. JAMES, TUDLINGTON, BERKELEY

Lot 1. June 3, 1929.
Lot 2. June 10, 1929.

Lot 3. June 17, 1929.

responsible, as the outside temperature towards the latter part of June remained consistently high, and for several hours a day on many occasions reached 90°- 95° in the brooding room.

Mortality

Mortality in the first lot was practically nil except in the high protein pen. The only death in Pen I was due to injury. In the second lot the mortality was 50% in the 80% protein pen and nil in the pen on 55% protein. In the third lot, mortality was high in both pens, but was probably due to the excessive heat, as in the corresponding pens in earlier hatches only one death occurred (Pen 3, 55% protein).

General Observations

In general health and vigor, results appeared to vary according to the amount of protein in the ration. Pen 4 (80% protein supplement) showed highest mortality, severest rickets and poorest feathering. In rate of feathering, and in general health and vigor, Pen I excelled all the others. In this pen there was also total absence of any signs of leg weakness, while this symptom appeared to some extent in all of the other pens, its incidence being in direct proportion to the protein content of the ration.

Subsequent studies have suggested that the high mortality, severe rickets and general unthriftiness in the high protein pens were due, not so much to the excessive protein or to the corresponding low content of yellow corn, but to an excess of minerals or to a disproportion in the amount of calcium and phosphorus present. Mussehl et al (2) in a report of experiments on mineral metabolism in growing chicks, present data which indicate that excess

mineral elements are detrimental to growth and injurious to health. Bethke (3) reports experiments which demonstrate that "the addition of excessive amounts of lime (4.5%) in the form of calcium carbonate, limestone or oyster shell, to a ration containing cod liver oil and approximately 5% bone meal, caused slower and more uneven growth, and increased mortality." Bethke et al (4) also show that calcium carbonate requirements for optimum growth amount to 2%.

A chemical analysis was not made of the various ingredients of the rations used in this series, but if an estimate of the calcium and phosphorus content of the protein and mineral supplements were based on analysis of similar foods used in later experiments, it would run as follows:

	<u>Ca.</u>	<u>P.</u>	<u>Ratio Ca:P</u>
Pen 1	1.29	.47	2.74
2	2.58	1.19	2.17
3	3.86	1.91	2.02
4	5.14	2.63	1.95

On this basis the ration of Pen 4 contained an equivalent of 12.5% total calcium carbonate, and it is reasonable to suppose that even if such an excess were not in itself injurious, it would at best tend to crowd out other elements more important in promoting growth, and thus reduce the efficiency of the ration.

Bone Analysis

Table III shows the results of examination and analysis of tibiae from a number of typical chicks from each of the pens in the first two lots of this series of experiments. It will be noted that the percentage of ash is highest in the

TABLE III

ANALYSIS OF TIBIAE

Experimental Series No.1, (California)

Pen No.	% Protein Supp.	No. of Birds	Ave. Live Wt. grams	Wt. of Tibia grams	% of Total Wt. of Chick	Ave. Length of Tibia cm.	Wt. per cm. grams	Analysis			
								Water of	Dry Matter of	Ash	% Ash of Dry Wt.
4	80	6	253.3	1.40	.55	5.10	.27	39.28	32.74	27.98	46.07
4A	80	13	191.8	.96	.50	4.52	.21	42.80	26.02	31.18	54.51
3	55	12	333.4	2.00	.59	5.50	.36	41.53	32.23	26.24	44.88
3A	55	25	278.6	1.59	.57	5.12	.31	43.69	28.17	28.14	49.98
2	30	12	366.8	2.05	.56	6.00	.34	40.04	33.67	26.29	43.84
1	5	11	192.4	.93	.48	5.28	.176	33.17	40.69	26.14	39.10

pens in which rickets were most prevalent and most severe, (pens 3 and 4). In these it approximates the normal for chicks of six weeks of age. It is possible that the low ash content of tibiae from chicks in Pens 1 and 2 (low protein) is due simply to a deficiency of calcium and phosphorus in the diet. The rations of Pen 3 and 4 carried the same amount of mineral supplement, but on account of the high percentage of animal protein they contained, were of course much richer in these mineral elements.

On the other hand, the greater incidence of rickets in the pens on high protein diets may have been due to a disproportion in the calcium: phosphorus ratio. Recent figures of Bethke et al (5) indicate that the ratio of calcium and phosphorus is of great importance in securing normal bone development, and that the optimum ratio of these two elements lies between 3:1 and 4:1, at which relationship requirements for the anti-rachitic factor are at a minimum. It will be seen from the above figures for estimated mineral content that this ratio most nearly approaches the optimum in the low protein diets, and decreases as the protein content rises, so that in Pen 4 it is considerably removed from the ideal.

It will be noted that although the ash content of tibiae varies consistently with the protein level in the ration, the figure for chicks in Pen 4 is considerably lower than that for Pen 4A on the same ration. This is probably accounted for by the fact that not all of the birds from Pen 4 were included in the analysis, while in Pen 4A all the survivors were examined, thus giving a truer value for the average.

EXPERIMENTAL SERIES No. 2 (Alberta).

In the winter of 1929 a series of experiments was undertaken at the University of Alberta, to continue the investigation of the protein requirements of chicks, and to determine the actual maximum protein retention.

Stock

As a basis for the work, fifty pure-bred single-comb White Leghorn pullets were set aside, to be used as parent stock for the chicks required. These birds were selected for size, type and evidence of health and vigor, from the Experiment Station flock of the Provincial Poultry Plant at Oliver, Alta. These birds were divided into three separate pens, and each pen was mated with a cockerel of good size and type. The birds were then identified by means of numbered leg-bands, and were trap-nested throughout the laying year. The eggs were marked as collected, so that the parentage of every chick could be recorded at hatching, and pedigree records could be compiled for future reference. Chicks were removed from the incubators as soon as possible after hatching, and were shipped to the University as required throughout the winter.

Equipment and Method of Use

All chicks were reared for the first six weeks (that is, for the duration of the test) in electric battery brooders which were installed in the animal room of the Department of Bio-Chemistry. This room is steam heated and well ventilated, and equipped with electric light and running water. These facilities insured efficient control of heat, light, air and

moisture throughout the whole series of experiments. It was also possible by making use of the electric light to give a constant feeding day to all pens, lights being turned on at dusk and turned out every night at nine o'clock. In the morning the lights were turned on at 8.30, until the season was sufficiently advanced to make this unnecessary. The chicks therefore had a fairly constant feeding day of 12-1/2 hours throughout.

During the course of the experiment three different types of electric battery brooders were used, in an attempt to find one which would meet the requirements for perfect control of all the factors under consideration. Brooder No. 1 used for the first lot of chicks was of the same type as the one employed in the preliminary tests in California. This proved satisfactory for heat regulation and for the general comfort of the birds, but at the third week it was noticed that some of the larger birds could not pass their heads through the mesh of the side walls to reach the mash and water, and consequently were being starved. This fact accounts for the drop in gains and in food consumption, which appears at three weeks in the records for the pens in the first lot of this series.

To overcome this difficulty the birds in these pens were moved at three weeks to brooder No. 2, one which was equipped with adjustable openings on the sides, thus making it possible for all the birds to feed comfortably until the end of the experiment. In this new equipment each brooding compartment consisted of two 2 x 2 1/2 ft. sections connected by means of an adjustable

opening. Heating elements were placed in one section only, so that the birds had more freedom in choice of temperature. The mash and water pans were also constructed in such a way as practically to eliminate the possibility of waste.

The second lot of chicks was housed in brooder No. 1 throughout, the feeding difficulty being overcome by removing the pans from the outside and placing them inside the compartment, at the first sign of trouble. To prevent waste, wire netting was placed above and in contact with the mash, so that the birds could reach the food but were unable to scratch it out.

For the third lot of chicks, a third brooder was installed, similar in size and type to brooder No. 1, but provided with adjustable openings for feeding. In this equipment however, some difficulty was encountered in preventing wastage of food due to the construction of the pans, and records of mash consumption for pens 13, 14, 15 and 20 accordingly appear slightly higher than those of the pens in brooder 2, where the feeding equipment was more efficient.

At the end of the test with the pens in brooder No. 2, it was decided to adapt this brooder for use as a metabolism cage in measuring protein retention. Heating units were installed in both sections of the compartments and one section only was used for each test pen. As a preliminary trial, pens 14 and 20 were moved at four weeks from brooder No. 3 into these cages, and accurate records taken of intake and output of nitrogen, over measured periods.

Pens 22 and 23, the test pens for protein retention, were housed throughout the six-weeks period in these metabolism cages.

Rations

Table IV gives the chemical analysis of the protein and mineral supplements used in this series of experiments, and Table V the percentage composition of the various diets in which these supplements were employed. Emphasis is laid upon Ca:P ratio, because, as already pointed out, this factor has been shown to be highly significant in securing normal growth and calcification of bone.

The rations for pens 7, 8 and 9 in the second lot of this series, are identical with those of pens 1, 2 and 3 in the first lot, except for an increase in mineral supplement in pen 7. While in all cases the calcium: phosphorus ratio was kept at exactly the same level, it was concluded when the second lot was hatched that possibly with only 20% protein supplement the minerals added for Pen I were not sufficient to provide the optimum total. In the second and third lots therefore, mineral additions were made to the ration for the pens on 20% protein supplement, so as to bring the total calcium and phosphorus up to the same level as in the 40% pens. The marked increase in growth of the chicks in Pens 7 and 13 over those in Pen I, amply demonstrates the beneficial effect of this increase.

The pens on 60% protein supplement received a higher total of minerals than the other two, but as the phosphorus could not have been reduced without removing some of the protein supplement, the only means by which the calcium: phosphorus

TABLE IV

Experimental Series No. 2

PARTIAL CHEMICAL ANALYSIS OF FOOD STUFFS USED IN RATIONS.

	<u>%</u> Crude Protein	<u>%</u> Total Ash	<u>%</u> Ca.	<u>%</u> P.	<u>Ca:P.</u> Ratio
	(N x 6.25)				
Fish Meal	72.5	16.26	5.61	3.13	1.8
Beef Scrap	50.0	26.13	8.62	4.61	1.9
Dried Milk	38.0	7.08	1.16	.89	1.3
Bone Meal			21.49	11.11	1.9
Limestone Flour			39.55		
Alfalfa Meal		8.62	.91	.21	4.3

TABLE V

PERCENTAGE COMPOSITION
OF RATIONS

Lots 1, 2, 3 & 4, Series 2, (Alberta).

Dec. 6, 1929									
Lot 1	<u>PEN 1</u>			<u>PEN 2</u>			<u>PEN 3</u>		
Yellow Cornmeal	20			20			20		
Alfalfa Leaf-and-Blossom Meal	5			5			5		
Wheat Bran	5			5			5		
Salt (NaCl)	1			1			1		
Cod Liver Oil	<u>1</u>			<u>1</u>			<u>1</u>		
	32			32			32		
(1)		<u>Ca.</u>	<u>P.</u>		<u>Ca.</u>	<u>P.</u>		<u>Ca.</u>	<u>P.</u>
Protein Supp.	20	1.05	.59	40	2.10	1.17	60	3.14	1.76
CaCO ₃ Flour	2	.79		4	1.58		6	2.37	
Fine Oatmeal	46			24			2		
	100	1.84	.59	100	3.68	1.17	100	5.51	1.76
		Ratio			Ratio			Ratio	
		3.12:1			3.14:1			3.13:1	
	<u>PEN 4</u>								
		<u>Ca.</u>	<u>P.</u>	<u>Ratio</u>					
Yellow Cornmeal	45								
Fine Oatmeal	15								
Wheat Bran	5								
Alfalfa Leaf-and-Blossom Meal	5								
Protein Supp.	25	1.31	.73						
CaCO ₃ Flour	2.5	.99							
Cod Liver Oil	1.5								
Salt (NaCl)	1								
	100	2.30	.73	3.15					
Dec. 30, 1929									
Lot 2	<u>PEN 7</u>			<u>PEN 8</u>			<u>PEN 9</u>		
		<u>Ca.</u>	<u>P.</u>		<u>Ca.</u>	<u>P.</u>		<u>Ca.</u>	<u>P.</u>
Basal (as in pens 1-2-3)	32			32			32		
Protein Supp.	20	1.05	.59	40	2.10	1.17	60	3.14	1.76
Calcium Carbonate (2)	4	1.58		4	1.58		6	2.37	
Bone Meal	5	1.07	.56	-			-		
Fine Oatmeal	39			24			2		
	100	3.70	1.15	100	3.68	1.17	100	5.51	1.76
		Ratio			Ratio			Ratio	
		3.21			3.14			3.13	

TABLE V (Continued)

PERCENTAGE COMPOSITION
OF RATIONS
Lots 1, 2, 3 & 4, Series 2, Alberta.

Lot 2 (Continued)

	PEN 10 (Decreasing proportions of Protein Supplement)						
	Week	1	2	3	4	5	6
Basal (as in pens 1-2-3)		32	32	32	32	32	32
Protein Supp.		60	50	40	30	20	10
Calcium Carbonate		6	5	4	4	4	4
Bone Meal		-	-	-	2.5	5	8
Fine Oatmeal		2	13	24	31.5	39	46
		100	100	100	100	100	100

Chemical Analysis of Pen 10 Rations:

		% in Ration		
		Ca.	P.	Ratio
1st Week	Protein Supp. 60%	3.14	1.76	
	Calcium Carbonate	2.37		
	6	5.51	1.76	3.13
2nd Week	Protein Supp. 50%	2.62	1.47	
	Bone Meal	-		
	Calcium Carbonate	1.98		
	5	4.60	1.47	3.13
3rd Week	Protein Supp. 40%	2.10	1.17	
	Bone Meal	-		
	Calcium Carbonate	1.58		
	4	3.68	1.17	3.14
4th Week	Protein Supp. 30%	1.57	.88	
	Bone Meal	2.5	.28	
	Calcium Carbonate	4	1.58	
	4	3.69	1.16	3.2
5th Week	Protein Supp. 20%	1.05	.59	
	Bone Meal	5	.56	
	Calcium Carbonate	4	1.58	
	4	3.70	1.15	3.2
6th Week	Protein Supp. 10%	.52	.29	
	Bone Meal	8	.88	
	Calcium Carbonate	4	1.58	
	4	3.82	1.17	3.3

TABLE V (Cont.)

PERCENTAGE COMPOSITION
OF RATIONS

Lots 1-2-3-4, Series 2 (Alberta)

Lot 3 (Hatched Feb 14, 1930)

Pens 13, 14 and 15, same as pens 7, 8, 9, respectively
Pen 20, same as Pen 4

Lot 4 (Hatched March 8, 1930)

Pen 22, same as Pen 4 (Protein Supp. 25%)
Pen 23, same as Pen 8 (" " 40%)

(1) Protein Supplement in all pens of this series consisted of the following mixture:

Pilchard Meal (Crude Prot. 72.5%)	50
Beef Scrap (Crude Prot. 50%)	25
Powdered Skim Milk (Crude Prot. 38%)	25
	100

Analysis of the mixture
is as follows:

	<u>Protein</u>	<u>Ca.</u>	<u>P.</u>	<u>Ca:P Ratio</u>
	%	%	%	
Pilchard Meal	36.3	2.80	1.56	
Beef Scrap	12.5	2.15	1.15	
Skim Milk	9.5	.29	.22	
	58.3	5.24	2.93	1.8: 1

(2) Made from a marble grit analysing 39.55% Calcium, and free from Magnesium.

granular form instead of as a powder, and no silica grit was given. In studies of the mechanism and function of grit, Buckner, Martin & Peter (6) found that when fed in addition to a grain, mash and buttermilk ration, grit did not materially change the rate of growth in White Leghorns up to 30 weeks of age, and did not influence egg production up to eight months. Bethke and Kennard (7) also found no benefit from the feeding of granite grit up to twelve weeks and concluded that its value lay in providing a source of essential minerals if the ration was otherwise deficient in these. It was concluded therefore that the rate of growth would not be materially influenced by omitting hard grit from the ration, and furthermore that feeding would be simplified and the risk of introducing other minerals from impurities in the grit would be eliminated.

Methods

All chicks were weighed individually as soon as received and were distributed in groups, made up in such a way that the average weight and the range in weight were as nearly alike as possible in each. Weights were then taken individually for all chicks at weekly periods from date of hatching. Food consumption was also recorded weekly for each pen, the residue in the pans being weighed back and recorded at the time the chicks were weighed.

Some apparent discrepancies appear as between the different lots, in the records of growth and food consumption for the first week. These are due principally to the fact that the chicks in Lots I and 2 were not fed for 24 hours after date of hatching, those in Lot 3 were fed as soon as hatched, and those in Lot 4

were not fed for 48 hours. The first week therefore was not of constant length throughout the series and the rate of growth and amount of food consumed in this period might reasonably be expected to vary accordingly.

Data were compiled showing the results secured in growth, food consumption and economy of gains for all pens in this series, and are set forth in both tabular and graphical form. Average weekly live weight as shown in these tables was based on total number of surviving chicks in each pen at the end of the six weeks period. Average weekly food consumption was computed by deducting weekly from the total for each pen, the estimated amount eaten by the chicks which died, on the basis of the relation of their weight at time of death to the total weight of the chicks in the pen. In this way reasonably accurate figures could be secured to compare percentage increase in live weight and average weekly food consumption on the different diets.

For the final two pens, which were used in the metabolism test, the experimental procedure was as follows:

As with the other pens, the chicks were weighed when placed in the brooder, and then at weekly intervals for six weeks. Dry mash was weighed in each day as required, and the residue weighed back at the time the chicks were weighed. In addition the excreta, which were collected in pans beneath the wire floors of the compartment were removed at the time the food was measured, then dried over a water bath for two or three days and weighed. The total collection was then immediately ground fine, sampled and

TABLE VI
RATE OF GROWTH
FOOD CONSUMPTION
AND
ECONOMY OF GAINS

TABLE VI
RATE OF GROWTH
FOOD CONSUMPTION
AND
ECONOMY OF GAINS

PEN 1 (20%) [#]											PEN 2 (40%)					PEN 3 (60%)					PEN 4 (25%)											
Age Wks.	No. of Chicks	Ave. Live Wt. Grams	% Gain	Ave. Food Cons. Grams	Grams Food Per Gram Gain	No. of Chicks	Ave. Live Wt. Grams	% Gain	Ave. Food Cons. Grams	Grams Food Per Gram Gain	Age Wks.	No. of Chicks	Ave. Live Wt. Grams	% Gain	Ave. Food Cons. Grams	Grams Food Per Gram Gain	No. of Chicks	Ave. Live Wt. Grams	% Gain	Ave. Food Cons. Grams	Grams Food Per Gram Gain	Age Wks.	No. of Chicks	Ave. Live Wt. Grams	% Gain	Ave. Food Cons. Grams	Grams Food Per Gram Gain	No. of Chicks	Ave. Live Wt. Grams	% Gain	Ave. Food Cons. Grams	Grams Food Per Gram Gain
Lot 1 Hatched Dec. 6, 1929.																																
1/7	15	34.4	--	--		19	34.2	--	--		1/7	20	34.1	--	--		9	33.8	--	--												
1	15	48.2	40.1	26.6		19	53.0	54.9	25.4		1	20	56.0	64.2	21.6		9	52.1	54.1	29.2												
2	15	77.1	59.9	55.1		19	96.2	81.5	70.0		2	15	96.9	73.0	90.1		9	95.5	83.3	80.2												
3	15	105.8	37.2	75.1		19	144.0	49.6	99.2		3	15	143.0	47.6	126.6		9	141.2	47.8	95.5												
4	15	156.3	47.7	123.1		18	211.6	46.9	150.0		4	13	205.4	43.6	200.7		9	224.6	59.1	190.0												
5	15	230.3	47.3	176.6		18	303.9	43.6	187.0		5	13	285.4	38.9	243.9		9	325.2	44.8	271.7												
6	15	317.2	37.7	196.3		18	416.1	36.9	231.0		6	13	383.1	34.2	284.6		9	445.6	37.0	296.7												
Gain = 282.8					652.8	2.31	Gain = 381.9				762.6	2.00	Gain = 349.0					967.5	2.77	Gain = 411.8				963.3	2.34							
Lot 2 Hatched Dec. 30, 1929.																																
PEN 7 (20%)											PEN 8 (40%)					PEN 9 (60%)					PEN 10 (60 --- 10%)											
1/7	17	33.8	--	--		16	34.0	--	--		1/7	15	33.8	--	--		16	33.8	--	--												
1	17	56.8	68.0	32.1		16	58.8	72.9	21.9		1	15	55.1	63.0	27.1		16	56.8	68.0	30.6												
2	17	86.9	53.0	83.9		16	99.9	69.9	82.5		2	15	86.8	57.5	88.1		16	90.2	58.8	78.1												
3	17	141.5	62.8	128.6		16	164.3	64.5	175.3		3	14	136.2	56.9	168.6		16	141.5	56.8	120.0												
4	17	197.7	39.7	164.7		16	223.6	36.1	185.6		4	14	171.9	26.2	207.9		16	206.6	46.0	179.1												
5	17	285.6	44.5	227.4		16	319.1	42.7	239.7		5	14	246.6	43.5	280.0		16	306.2	48.2	242.2												
6	17	370.0	29.6	305.9		16	441.3	38.3	325.0		6	14	343.4	39.2	328.6		16	417.1	36.2	325.0												
Gain = 336.2					942.6	2.80	Gain = 407.3				1030.0	2.53	Gain = 309.6					1100.3	3.55	Gain = 383.3				975.0	2.54							
Lot 3 Hatched Feb. 14, 1930.																																
PEN 13 (20%)											PEN 14 (40%)					PEN 15 (60%)					PEN 20 (25%)											
1/7	18	37.2	--	--		16	37.4	--	--		1/7	18	38.2	--	--		17	39.3	--	--												
1	18	57.1	53.5	43.1		16	62.8	67.9	48.1		1	18	59.7	56.3	46.7		17	61.1	55.5	34.5												
2	18	91.2	59.7	105.0		16	106.2	69.1	120.6		2	17	93.3	56.3	108.9		17	105.3	72.3	107.1												
3	18	137.2	50.4	135.9		16	159.1	49.8	138.8		3	15	126.8	35.9	149.4		16	157.6	49.7	123.7												
4	18	206.8	50.7	177.7		16	243.3	52.9	190.0		4	15	184.9	45.9	200.0		16	239.8	52.1	190.9												
5	18	294.4	42.3	223.6		16	338.4	39.1	225.3		5	15	257.6	39.3	225.6		16	331.4	38.2	210.6												
6	18	374.7	27.3	270.3		16	425.3	25.6	231.9		6	15	339.2	31.7	292.6		16	407.9	23.1	226.3												
Gain = 337.5					955.6	2.83	Gain = 387.9				954.7	2.46	Gain = 301.0					1023.2	3.40	Gain = 368.6				893.1	2.42							

Figures in brackets indicate percentage of protein supplement used.

[#]Average weight, percentage gain and average feed are based on total number of chicks surviving at end of six weeks.

analysed for total nitrogen. Meantime the mash mixture had been chemically analysed and nitrogen content recorded. Total intake and output of nitrogen could thus be measured for each weekly period, and the percentage retention calculated.

No adjustment was made for lag in digestion, as food consumption was almost continuous and defecation was found to occur at comparatively short intervals throughout the entire day.

After the fourth week, the samples of excreta became too unwieldy for accurate measurement, and the test periods were shortened to three days and four days, the results for these two short periods being combined to give the weekly totals.

Records of all data were continued on Pen 22 up to the end of the eighth week. This was done principally as a check on results secured for protein retention, which in both pens was found to rise unaccountably in the sixth week of the test. The birds in Pen 23 were removed at the end of the sixth week and records discontinued as there appeared some cases of leg weakness among them and several chicks died.

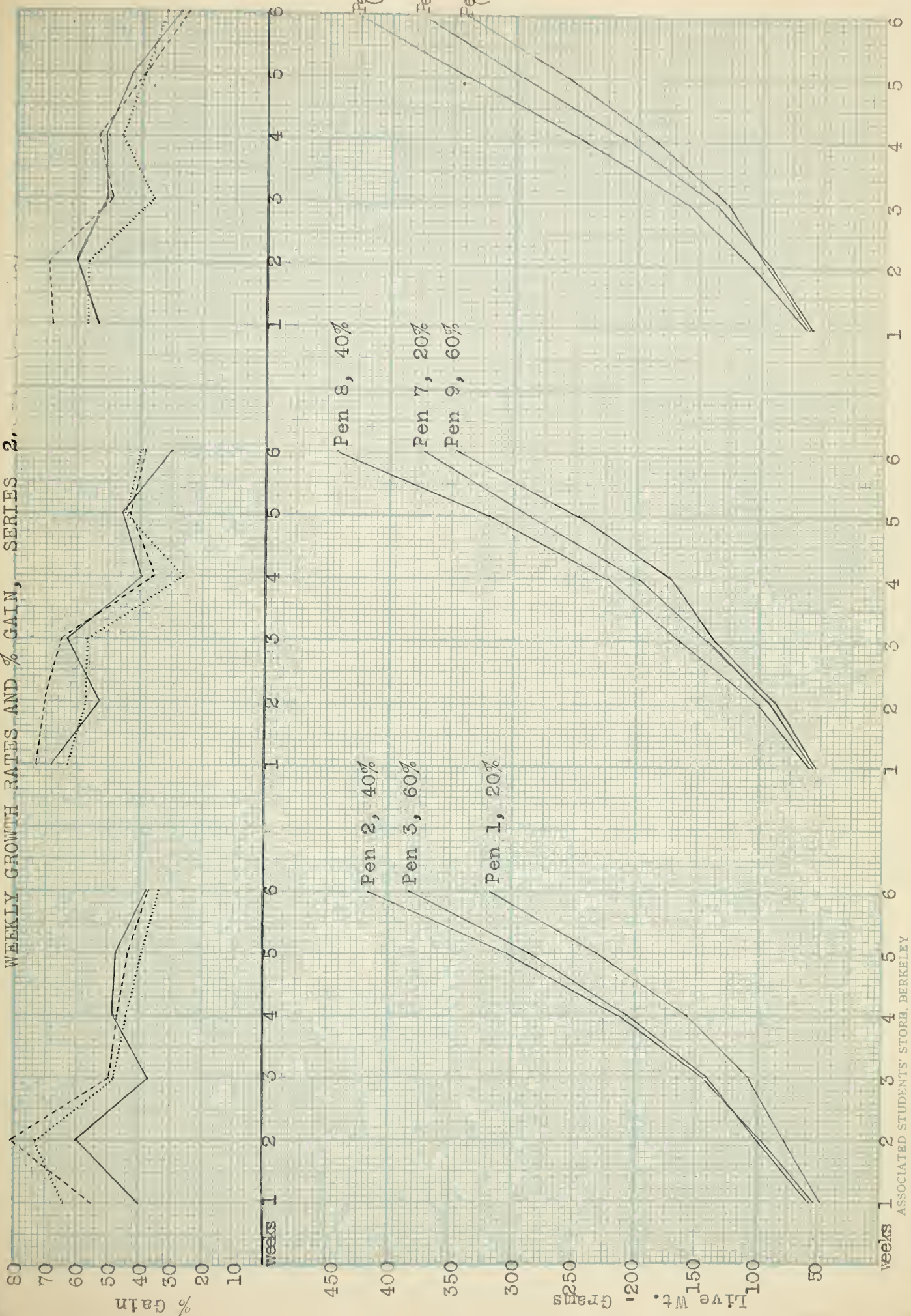
Rate of Growth

In Table VI are set forth the weekly weights and percentage gain for all pens in the first three lots of this series. Figure 2 illustrates graphically these values for the three groups of pens on 20%, 40% and 60% protein supplement.

In the first lot, hatched December 6, 1929 it will be noted that the average rate of growth in Pen I (20% protein) fell considerably below the level of the other two. In both the second and third hatches, when the mineral content of the

..... 60%

WEEKLY GROWTH RATES AND % GAIN, SERIES 2.



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Lot 1. Dec. 6, 1929.

Lot 2. Dec. 30, 1929.

Lot 3. Feb. 14, 1930.

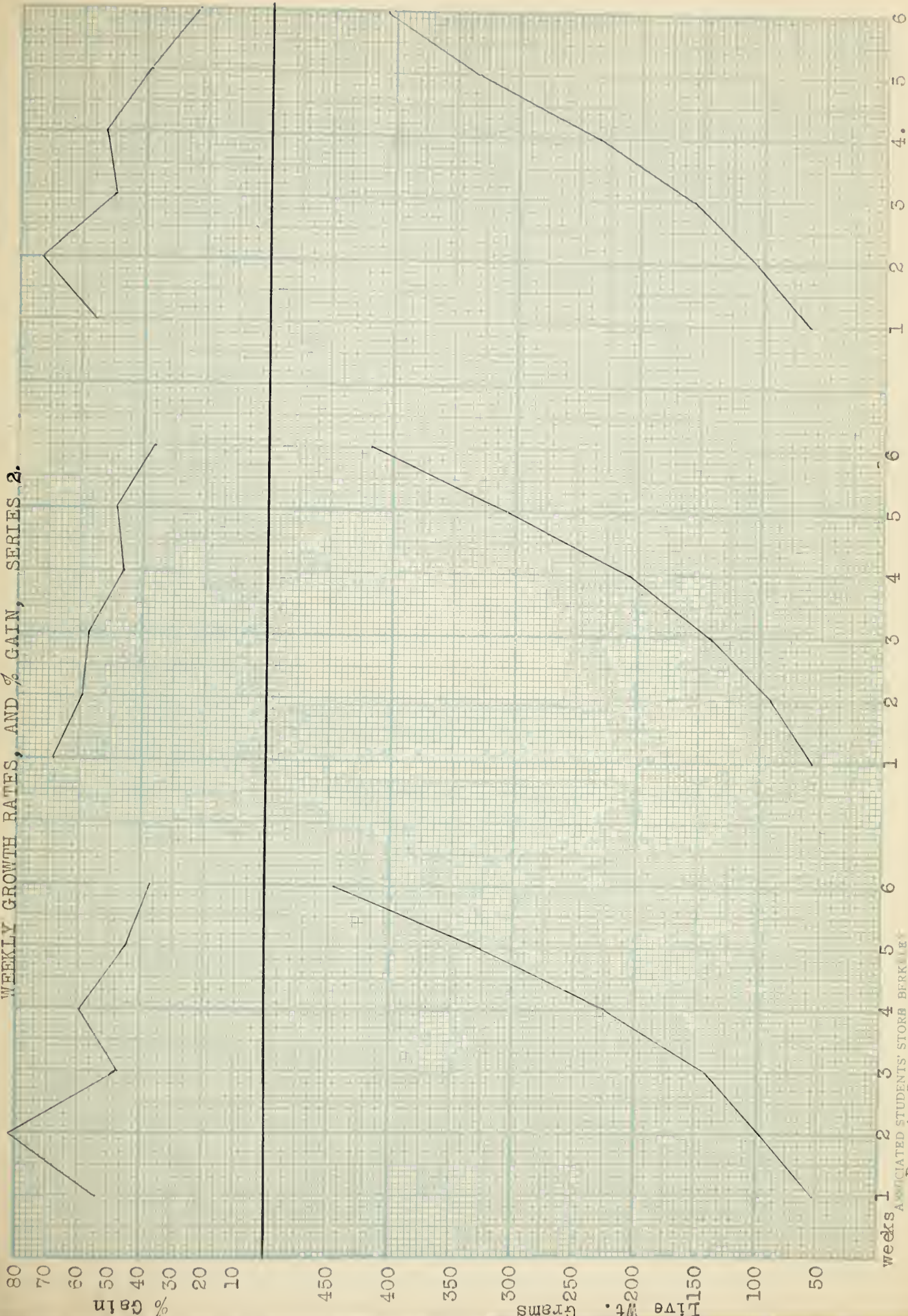
20% pens was increased, the rate of growth excelled that of the 60% pen, and the average weight at six weeks was more than 50 grams higher than in the original 20% pen.

The curves in Figure 2 illustrating weekly percentage increase in weight for the pens in Lot I, indicate a fairly constant rise up to the second week, then a gradual decline to the end of the six weeks period. The rise between the first and second week is quite marked in the lot hatched December 6 and is present to a certain degree in the February 14 lot. The fact that there is a drop instead of a rise in all pens hatched on December 30th, may be due to the fact that on the night of January 4th, the temperature of the room fell to a very low level. The birds became chilled, and may have suffered a temporary set-back in growth. In the first lot the sharp decline from the second to the third week may be accounted for by the feeding difficulties already described. Between the third and fourth weeks there is a compensating rise in the curve, followed by a gradual decline to the end of the period.

The fact that the corresponding curves for the second lot drop most rapidly between the third and fourth week and those for the third lot between the second and third week, cannot be accounted for except by temporary environmental conditions.

In Figure 3 are shown the growth and percentage increase curves for Pens 4 and 20 (25% protein supplement) on the so-called "normal" ration. It will be noted that Pen 4 made the highest gains of any pen in the series, reaching an average of 445.6 grams at six weeks. The curves for weekly rate of increase in both Pen

WEEKLY GROWTH RATES, AND % GAIN, SERIES 2.



weeks 1 2 3 4 5 6
 ASSOCIATED STUDENTS' STORE BERKALIE
 PeP 4. Dec. 6, 1929. Prot. Supp. 25%
 PeP 10. Dec. 30, 1929. Prot. Supp. 80% -- 10%
 PeP 20, Feb. 14, 1930. Prot. Supp. 25%



4 and Pen 20 display the sharp rise at two weeks that is to be found in most of the other pens, and the drop at three weeks common to all but the pens of Lot 2 hatched December 30th.

In comparing the rate of growth of the chicks on this "normal" ration with those of the rations designed for comparison of results on different protein levels, it will be seen that the results are more nearly approximated by those of the 40% pens, rather than by those of the 20% pens, and that there is a much wider difference in favor of the "normal" ration (which contains 25% protein) than might be attributed to a difference of 5% in protein supplement. The factor responsible for the superiority of the 25% ration is probably the higher content of yellow cornmeal (45%, as compared with 20%) and the consequent greater richness of the food in Vitamin A.

Figure 3 also gives the growth curves for Pen 10, which received decreasing proportions of protein supplement from 60% the first week, reduced by 10% each week down to 10% in the sixth week. The results in growth on this system of feeding are highly satisfactory, but do not quite equal those of the "normal" ration nor of the pens on 40% protein supplement. It is possible that if the yellow corn content had been made up to the level of that in Pen 4, equally rapid growth might have been secured. Optimum results may however, have been impossible due to the necessity for adjustment of the digestive system to the sudden change each week in the composition of the mash.

The curve illustrating weekly percentage increase in weight for Pen 10 shows a more even and gradual decline during

the six weeks than those for any of the other pens in the entire series of experiments.

Variability in Growth Rate

It will be noted that in spite of the fact that all the chicks in these experiments were of the same breed and strain and were hatched from a small group of selected parents, there is a very wide variation in rate of growth even between individuals in the same pen and fed on the same rations. Tables attached hereto giving individual weekly weights of all birds used in these experiments indicate how wide is the range of weight in each pen. The lowest figure at six weeks for any pen (170 grams) is to be found in Pen 9 (60% protein supplement) while individuals of 500 grams occur at every protein level included. It is to be noted, however, that in none of the pens on 40% protein supplement, and in none on the "normal" ration were there any birds weighing less than 300 grams at six weeks.

While variability in growth rate is highest in the pens on very high protein, there is still a wide enough range of difference even in the most uniform groups, to suggest the operation of a heritable factor for "growth impulse", or ability to utilize protein for the formation of tissue. Data are being compiled from records of growth of the birds used in these experiments, which may throw some light on the question of the possible inheritance of a factor or factors determining just how rapidly a bird may be expected to grow or to what ultimate size it may attain under a given set of conditions. Such data should be of

supplementing value in these present studies of what the optimum conditions are which will enable a bird to realize most fully its inherent potentialities for growth.

Mortality and General Health

Mortality in all pens of these three lots was negligible except in those on 60% protein supplement. This is in agreement with the results secured in the preliminary series of experiments herein reported, and appears to support the theory that very high levels of protein not only do not promote rapid growth but are actually injurious to health. As indicated before, however, excessive mineral content, together with a correspondingly low proportion of feeding stuffs of high caloric value, may be partly responsible for poor results with the high protein rations.

In strength of bone, growth of feathers and constitutional vigor, the birds on the "normal" ration appeared to be somewhat superior to the others, although all apparently developed normally, except those on 60% protein. These latter were unkempt in appearance and less active and vigorous than the others. The feces were abnormally moist, and this condition was accompanied by excessive thirst and high food consumption.

No evidence of rickets was observed in any of the pens in the first three lots of chicks, and no tail-picking or cannibalism occurred throughout the entire series.

There was observed, however, in one chick (No. 123 in Pen 7) a peculiar type of paralysis which occurred at about three weeks of age and lasted for ten days, after which it spontaneously disappeared.

The disease was characterised by a weakening of the leg muscles which caused the bird to walk on its hocks, the toes being curled in and apparently paralysed. The chick was otherwise in normal health and its appetite was good, although it had some difficulty in reaching the mash and water and was frequently crowded aside by the others.



Figure 4



Figure 5

Figures 4 and 5 illustrate the symptoms described. Norris et al (8) suggest this disease is due to the absence of a hitherto unrecognised vitamin thought to exist in milk. As the ration on which this chick was fed contain 5% dried milk this theory appears feasible only if the vitamin in question

is one which is destroyed by dehydration and is therefore not present except when liquid milk is used.

A number of cases of this same type of paralysis have recently been reported from various flocks in the Province of Alberta and data are being assembled as to the feeding and brooding conditions in each case, in an effort to trace the cause. Cultures from various organs so far have yielded no bacterial growth, and the question of the responsibility of the food remains an open one.

Food Consumption

Records of average food consumption, weekly and for the entire period are shown in Table VI. In comparing the figures for the pens on the three levels of protein it will be noted that average food consumption increases with protein content - or possibly with mineral content, which in the first lot followed the protein level. The possibility of the influence of mineral content is suggested also by the fact that the 20% pen in the second lot consumed more food per chick, and also per gram of chick, than the 20% pen in the first lot, the only difference in the ration for these two pens being a higher mineral level in the second lot.

Economy of Gains

In efficiency in promoting growth (expressed in grams of food per gram of gain) the 40% ration is much superior to the other two, in all three lots. The pens on 20% protein used slightly more food per gram of gain, with the 60% pens in all

cases considerably behind the others.

With the "normal" ration the efficiency is equal to that in the 40% protein pens with the exception of Pen 2, which is unaccountably low in food per gram gain.

Pen 10, on decreasing amounts of protein, made slightly less economical gains than the pens on "normal" rations, the food consumed per gram of gain being on a par with the pens on 40% protein.

Protein Retention Tests

In Table VII are set forth the figures for weekly growth and food consumption for the two pens used in determining protein retention.

The results in growth are not so satisfactory as in the pens on the same diets in earlier hatches. This may be accounted for in either of two ways: (1) By the fact that the pens were too small and were not fitted with automatic heat control, so that the chicks became overheated. (2) The chicks used were taken at random from a large hatch of eggs from the Station flock of White Leghorns, as no chicks from the specially selected breeding pen were available at the time. If this latter factor is responsible for the poorer gains in these two pens, it strengthens the theory of the presence of a hereditary factor governing rate of growth.

Table VIII gives a summary of the results of tests for protein retention in Pen 22, which received the "normal" ration containing 25% protein supplement. The total protein (N x 6.25) in this mash amounted to 22.1%, giving weekly figures for total protein consumed as set forth in column 5. Total protein excreted

TABLE VII

WEEKLY GROWTH AND FOOD CONSUMPTION

Pens 22 and 23

Experimental Series No. 2 (Alberta)

Lot 4,
Hatched March 8, 1930.

Age Wks.	<u>PEN 22 (25%)</u>				<u>PEN 23 (40%)</u>			
	No. of Chicks	Ave. Wt. Grams	Percent Gain	Ave. Food 10 Chicks Grams.	No. of Chicks	Ave. Wt. Grams	Percent Gain	Ave. Food 9 Chicks Grams.
0	12	33.8	-	-	11	32.7	'	-
1	12	56.1	65.9	27.5	11	58.8	79.8	31.2
2	12	94.1	67.7	83.6	11	99.4	69.0	80.5
3	10	148.1	57.3	104.5	11	158.0	58.9	118.7
4	10	213.4	44.1	149.5	9	230.5	45.9	181.7
5	10	288.9	35.4	175.0	9	284.7	23.5	186.7
6	10	399.0	38.1	265.0	9	397.8	39.7	262.2
	Gain = 365.2			805.1	Gain = 365.1			861.0

Food per gram gain, 2.20 gms.

Foodper gram gain, 2.36 gms.

TABLE VIII

PROTEIN RETENTION
Pen 22
Protein Supplement 25%

Age Days	Length of Period Days	No. of Chicks	Total Food Con- sumed grams	Protein Consumed # grams	Weight of Excreta grams	Percent Protein in Excreta	Total Protein in Excreta grams	Total Protein Retained grams	Age in Weeks	Percent Protein Retained
7	5	12	320	70.72	102.13	35.44	36.15	34.57	1	48.88
14	7	12	920	203.32	296.55	42.15	124.99	34.13	2	38.52
21	7	10	1045	230.95	387.46	41.12	159.32	71.63	3	31.01
28	7	10	1495	330.40	557.61	35.69	199.01	131.39	4	39.77
32	4	10	900	198.90	418.49	36.06	159.90)			
35	3	10	850	187.85	316.68	40.37	127.84)	108.01	5	27.92
39	4	10	1400	309.40	484.71	37.12	179.92)			
42	3	10	1250	276.25	424.61	38.50	163.47)	242.26	6	41.36
46	4	10	1700	375.70	553.46	38.50	213.08)	162.62		
49	3	9	1195	264.10	415.76	38.75	161.11)	102.99	7	41.51
54	6	9	2180	481.78	685.76	38.94	267.03)	214.75		
56	2	9	890	196.69	320.33	41.50	132.93)	63.76	8	41.05

Based on analysis of 22.1% Protein (Nx6.25)

in corresponding periods is based on total dry weight of excreta and percentage protein ($N \times 6.25$) in the sample, and is listed in column 8.

In figure 6 are shown curves for average weekly weight, weekly percentage increase in growth and weekly percentage retention of protein for Pen 22. The latter two curves are included on the same chart to show their relationship to each other, and all are extended to the end of the eighth week. The protein retention curve, which would be expected to follow the increase in weight curve throughout, unaccountably takes a sharp rise at the sixth week while the other continues to fall, and at the eighth week there is a wide divergence between them.

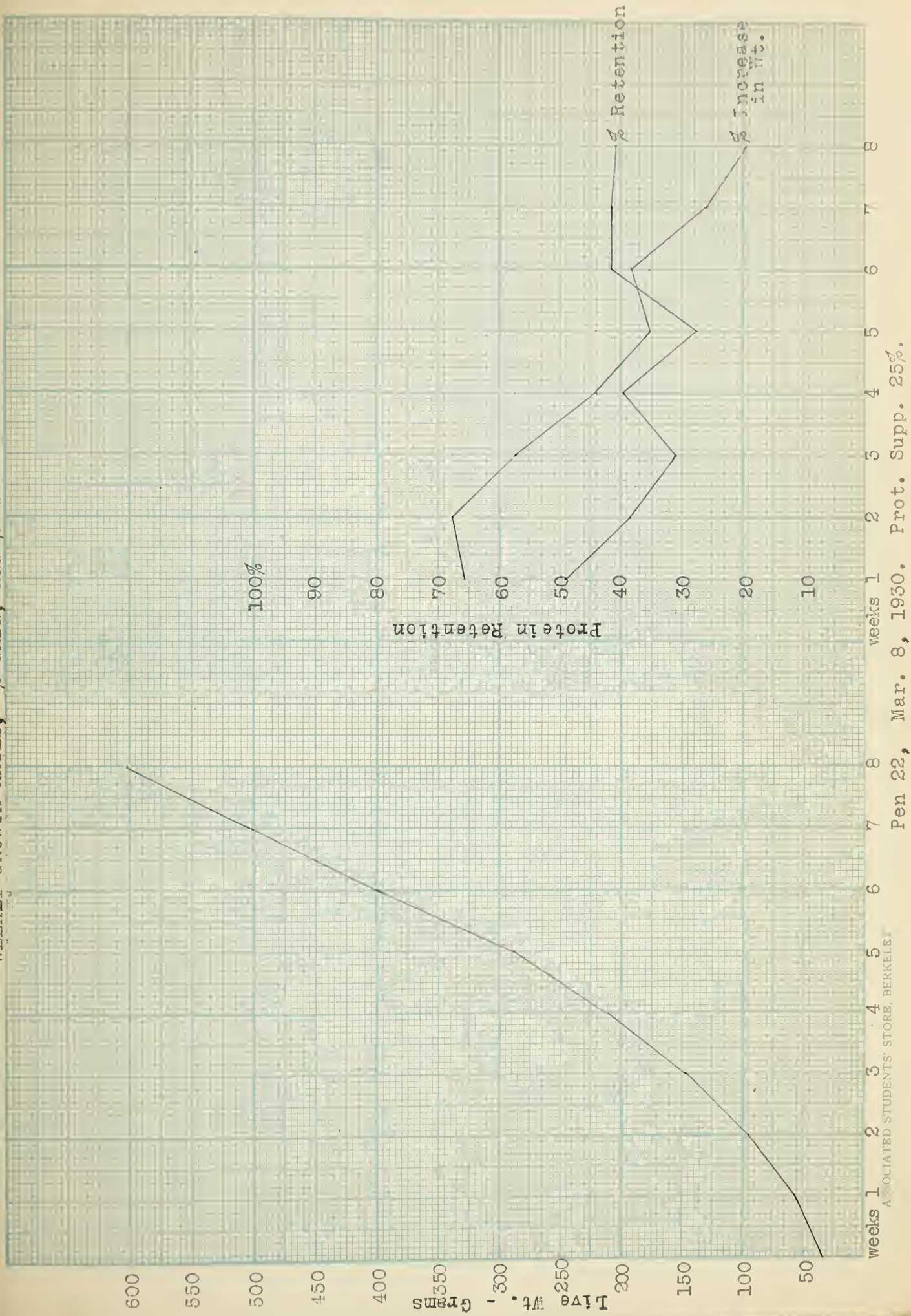
Table IX and figure 7 give similar data for Pen 23, on the ration with 40% protein supplement (analysis 29.3% protein), but do not include data beyond the sixth week.

The values for protein retention are somewhat similar to those of Pen 22, except that they begin at a higher level and drop more rapidly to the fifth week. At this point protein retention rises as in Pen 22 but is accompanied by a corresponding increase in percentage gain.

In Pen 23 also, the protein retention is somewhat lower throughout the test period than it is in Pen 22, indicating the possibility that, at least within certain limits, the efficiency of protein utilization decreases with an increase of protein supplement in the ration.

Fig. 6.

WEEKLY GROWTH RATES, % GAIN, AND % RETENTION OF PROTEIN.



Pen 22, Mar. 8, 1930. Prot. Supp. 25%.

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TABLE IX

PROTEIN RETENTION

Pen 23

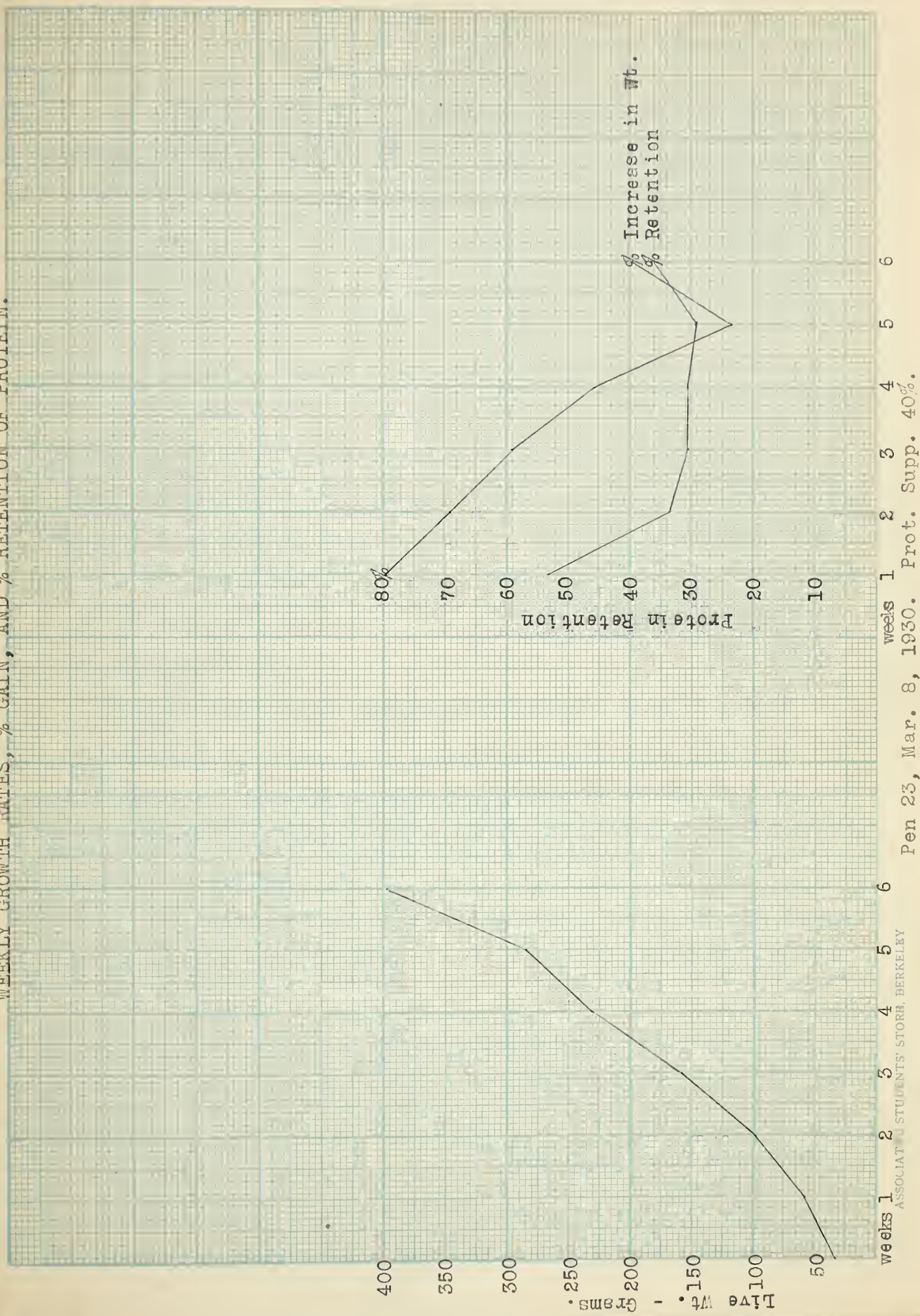
Protein Supplement 40%

Age Days	Length of Period Days	No. of Chicks	Total Food Consumed grams	Protein Consumed # grams	Weight of Excreta grams	Percent Protein in Excreta	Total Protein in Excreta grams	Total Protein Retained grams	Age in Wks	Percent Protein Retained
7	5	12	370	108.41	139.81	36.25	50.68	57.73	1	53.25
14	7	12	910	266.63	410.82	42.94	176.41	90.22	2	33.83
21	7	11	1200	351.60	614.40	39.69	243.86	107.74	3	30.64
28	7	9	1635	479.06	727.63	45.56	331.51	147.55	4	30.80
32	4	9	950)	492.24	408.94	44.06	180.18)	143.89	5	29.23
35	3	9	730)		343.21	49.00	168.17)			
39	4	9	1360)	691.48	547.71	42.56	233.10)	253.27	6	36.63
42	3	9	1000)		434.10	47.25	205.11)			

Based on analysis of 29.3% protein (Nx6.25)

Fig. 7

WEEKLY GROWTH RATES, % GAIN, AND % RETENTION OF PROTEIN.



SUMMARY AND CONCLUSIONS.

1. Preliminary tests of protein requirements for Leghorn chicks, demonstrated that of the four levels of protein supplement used in the experimental diets, the lowest (5%) gave extremely slow growth up to six weeks of age, but good health and low mortality, the highest (80%) gave only slightly better growth, together with poor feathering, high incidence of leg weakness, and high mortality. The two intermediate diets gave satisfactory growth and good health, with the pens on 30% attaining a slightly higher level in all tests than those on 55% supplement.

The ration with 30% supplement was also the most economical in promoting growth, requiring an average of 2.55 grams to produce one gram of gain, as compared with 2.75 for the 55%, 3.73 for the 80% and 3.95 for the 5% ration, in the pens of the first lot of chicks used.

In all but the pen on 5% protein, a certain amount of leg weakness was observed, which appeared to increase in extent and in severity with increase in protein content of the ration, and was the immediate or apparent cause of the high mortality in the pens on 60% supplement.

2. A second series of experiments, in which protein supplement levels of from 20% to 60% were used, indicated that the optimum for growth lay between 25% and 40% for the first six weeks of life. In these tests it was also found that the total mineral content of the diet, and more particularly the ratio of calcium to phosphorus, were of high significance in securing normal calcification of bone, good general development and rapid growth. A maximum average weight of 445.6 grams at six weeks was attained by a pen fed a 25% protein supplement, containing calcium and phosphorus in the proportion of 3.15:1.

Economy of gains was greatest with the pens on the 40% supplement ration, which utilised only 2.00 to 2.53 grams of food per gram of gain, although those on the 25% ration were almost equally satisfactory from this point of view, the food per gram gain ranging from 2.34 to 2.54 grams. The pens on 20% supplement consumed an average of from 2.31 to 2.83 grams of food per gram of gain, but the pens on 60% supplement showed much lower efficiency, the averages of the three pens being 2.77, 3.55 and 3.40 grams of food per gram of gain, respectively.

3. Tests for determination of maximum protein retention were applied to pens of chicks on the rations containing 25% and 40% protein supplement respectively. Results secured indicate that the efficiency of protein utilization is highest during the first week of life and decreases gradually up to the end of the fifth week. In both pens there appeared an unaccountable increase of retention at the sixth week, which was maintained during the seventh and eighth week in the pen on 25% supplement. Comparison of results for these two pens also suggests that protein utilization is more efficient on the lower than on the higher levels of protein content.

Results of these tests are, however, by no means conclusive, and frequent repetition of the experiments with the use of different levels of protein, will be necessary before a definite statement can be made as to what is the maximum protein retention at different periods, and what particular level of protein in the ration is necessary to make this maximum retention possible.

BIBLIOGRAPHY

1. Upp, Ches.W. and Thompson, R.B., "Influence of Time of Hatch on....Rate of Growth of Chicks", Okla.A.& M. College Bull. 167, Oct. 1927.
2. Mussehl, F.E., Blish,M.J. and Ackerson, C.W., "Mineral Metabolism of the Growing Chick", Poultry Science, Vol. VI, 5, 1928.
3. Bethke, R.M., Ohio Exp.Sta. Bull. July-August, 1927.
4. Bethke, R.M., Kennard, D.C., Kick,C.H. and Zinzalien,G. "The Calcium:Phosphorus Relationship in the Nutrition of Growing Chicks". Poultry Science, Vol.VIII, 5, 1929.
5. Buckner, G.D., Martin, J.H. and Peter A.M., "Concerning the Growth of Chickens Raised without Grit", Poultry Science, Vol. V, 5, 1926.
6. Bethke, R.M. and Kennard, D.C., "Does the Growing Chick Require Grit?" Poultry Science, Vol.V, 6, 1926.
7. Norris, L.C., Heuser, G.F. and Wilgus, H.S.Jr., "Is the Chief Value of Milk for Feeding Poultry due to the Presence of a New Vitamin?" Poultry Science, Vol.IX, 2, 1930.

The tables hereto appended set forth individual weekly live weights, average weekly weight of the pen, and percentage weekly gain, for pens in Series 2, 3 and 4, Alberta.

INDIVIDUAL WEEKLY LIVE WEIGHTS in GRAMS.

PEN I
Protein Supplement 20%

		1929 Dec.	Dec.	Dec.	Dec.	1930 Jan.	Jan.	Jan.
Date		7	13	20	27	3	10	17
Age in Days		1	7	14	21	28	35	42
<u>Chick No.</u>	<u>Sex</u>							
74	M	35	47.5	72	89	124	175	280
15	F	31	46.0	85	114	167	245	335
58	M	34.5	44.5	82	119	211	315	396
85	F	32.5	47	63	92	135	195	250
32	F	35	49.5	77	92	123	185	270
79	M	32.5	41.5	65	98	140	210	290
29	M	37.5	46	57	81	129	200	310
53	F	35.5	50	81	117	174	255	335
60	F	34	45	72	89	110	140	180
23	M	33.5	48	74	107	170	260	340
76	M	37.5	56.5	90	98	168	260	350
3	M	36	49	92	144	195	285	400
38	F	34.5	48.5	77	113	161	237	315
80	M	34	50.5	90	136	214	310	420
87	F	33.5	53.5	79	99	123	182	287
Total Weight		516.5	723.0	1156	1588	2344	3454	4758
No. of Chicks		15	15	15	15	15	15	15
Average Wt.		34.4	48.2	77.1	105.8	156.3	230.3	317.2
% Gain			40.1%	59.9	37.2	47.7	47.3	37.7

INDIVIDUAL WEEKLY LIVE WEIGHTS IN GRAMS.

PEN 2
Protein Supplement 40%

	1929				1930		
Date	Dec. 7	Dec. 13	Dec. 20	Dec. 27	Jan. 3	Jan. 10	Jan. 17
Age in Days	1	7	14	21	28	35	42

<u>Chick No.</u>	<u>Sex</u>							
41	F	34	45.5	81	125	170	242	340
17	F	36	55.5	104	155	225	327	445
49	F	35.5	60.5	121	164	254	353	465
84	M	36	55.5	118	171	254	312	435
46	F	29	43.5	71	125	182	252	350
24	F	34.5	52.5	93	144	206	292	383
61	M	34.5	58.5	122	164	247	375	510
86	M	35.5	58.0	93	137	206	305	425
90	M	35	53.5	94	139	192	282	410
88	M	34	55.0	90	143	215	300	405
22	F	32.5	57.0	108	175	260	392	505
5-	F	33	59.5	122	178	251	365	465
36	M	35	53.5	94	153	245	352	475
31	F	37	61.0	118	166	235	325	430
14	M	32.5	41.0	63	103	155	255	385
78	F	30.5	48.5	76	100	162	230	310
48	M	37	54.0	84	138	190	270	400
68	M	34	42.0	80	113	160	242	350
81		36.5	49.5	82	102	D. Dec. 27.		

Total Weight	652.0	1004.0	1814	2695			
Total No. of Chicks	19	19	19	19			
Average Wt.	34.3	52.8	95.5	141.8			
Total Weight	615.5	954.5	1732	2593	3809	5471	7490
Survivors	18	18	18	18	18	18	18
Average Wt.	34.2	53.0	96.2	144.0	211.6	303.9	416.1
% Gain	-	54.9	81.5	49.6	46.9	43.6	36.9

INDIVIDUAL WEEKLY LIVE WEIGHTS IN GRAMS.

PEN 3
Protein Supplement 60%

Date	1929				1930			
	Dec. 7	Dec. 13	Dec. 20	Dec. 27	Jan. 3	Jan. 10	Jan. 17	
Age in Days	1	7	14	21	28	35	42	
<u>Chick No.</u>	<u>Sex</u>							
26	M	35.5	58	119	170	262	380	500
77	M	34.5	62	106	142	207	297	425
89	?	36.5	55.5	D. Dec. 20	-	-	-	-
55	M	36.5	62.5	98	124	183	276	410
96	M	38	60.5	102	147	233	330	450
6	F	32.5	56.5	102	154	203	290	360
57	M	32.5	46	74	101	148	200	300
34	?	29	44.5	D. Dec. 19	0	-	-	-
25	?	30	50.5	D. Dec. 16	-	-	-	-
8	F	30	53	104	160	233	304	395
71	M	31.5	49.5	70	113	167	235	315
1	F	34	58.5	110	158	224	308	385
28	F	36	62	102	148	214	297	395
95	M	34.5	53.5	99	157	218	287	385
73	?	33.5	52	94	102	D. Dec. 27	-	-
91	F	36	58	89	147	185	242	310
59	?	31.5	50.5	D. Dec. 19	-	-	-	-
70	?	36.5	47	D. Dec. 18	-	-	-	-
11	?	29.5	50.5	65	84	D. Dec. 27	0	-
7	F	31.5	48	85	139	193	272	350
Total Weight		699.5	1078.5	1419	2046			
No. of Chicks		20	20	15	15			
Average Wt.		33.5	53.9	94.6	136.4			
Total Weight		443.0	728	1260	1860	2670	3718	4980
Survivors		13	13	13	13	13	13	13
Average Wt.		34.1	56.0	96.9	143.0	205.4	285.4	383.1
% Gain		-	64.2	73.0	47.6	43.6	38.9	34.2

Date	Description	Amount	Balance
1901	Jan 1		
1902	Feb 1		
1903	Mar 1		
1904	Apr 1		
1905	May 1		
1906	Jun 1		
1907	Jul 1		
1908	Aug 1		
1909	Sep 1		
1910	Oct 1		
1911	Nov 1		
1912	Dec 1		
Total			

INDIVIDUAL WEEKLY LIVE WEIGHTS IN GRAMS.

PEN 4
Normal Ration

		1929				1930		
		Dec.	Dec.	Dec.	Dec.	Jan.	Jan.	Jan.
Date		7	13	20	27	3	10	17
Age in Days		1	7	14	21	28	35	42
<u>Chick No.</u>	<u>Sex</u>							
66	F	34	53	96	141	215	302	385
30	M	29.5	47.5	83	137	223	325	440
2	F	36.5	51.5	76	143	220	310	415
75	M	39	55.5	120	141	222	353	495
51	M	34	54.5	95	133	227	350	475
39	M	36	61.5	128	175	273	360	520
45	M	29	50.5	98	145	250	347	490
21	M	33	51	88	132	216	335	460
92	F	33.5	43.5	76	124	175	245	330
Total Weight		304.5	468.5	860.0	1271	2021	2927	4010
No. of Chicks		9	9	9	9	9	9	9
Average Wt.		33.8	52.1	95.5	141.2	224.6	325.2	445.6
% Gain		-	54.1	83.3	47.8	59.1	44.8	37.0

INDIVIDUAL WEEKLY LIVE WEIGHTS IN GRAMS.

Pen 7
Protein Supplement 20%

	1929 Dec.	1930 Jan.	Jan.	Jan.	Jan.	Feb.	Feb.	
Date	31	6	13	20	27	3	10	
Age in Days	1	7	14	21	28	35	42	
<u>Chick No.</u>	<u>Sex</u>							
99	F	31	65	110	175	225	370	475
196	M	33	57	85	150	218	330	435
311	F	33	56	88	153	202	267	340
142	F	30	57	98	165	222	320	405
320	F	34	55	85	145	224	325	410
114	F	38	58	96	165	245	365	463
193	M	36	52	76	125	174	215	270
146	M	31	50	68	100	132	180	240
183	F	33	47	67	105	130	180	242
173	F	35	55	82	125	175	265	345
278	F	33	60	92	142	185	260	335
108	F	35	60	90	140	198	270	342
227	F	36	57	82	132	190	293	372
110	M	38	67	102	174	268	400	516
123	M	34	55	75	115	138	190	278
275	M	33	60	93	145	207	295	385
101	M	32	55	88	150	227	330	437
Total Weight	575	966	1477	2406	3360	4855	6290	
No. of Chicks	17	17	17	17	17	17	17	
Average Wt.	33.8	56.8	86.9	141.5	197.7	285.6	370.0	
% Gain	-	68.0	53.0	62.8	39.7	44.5	29.6	

INDIVIDUAL WEEKLY LIVE WEIGHTS IN GRAMS.

PEN 8
Protein Supplement 40%

	1929	1930					
	Dec.	Jan.	Jan.	Jan.	Jan.	Feb.	Feb.
ate	31	6	13	20	27	3	10
ge in Days	1	7	14	21	28	35	42

Chick No. Sex

250	F	37	57	83	135	192	270	375
293	M	36	55	100	170	240	335	445
222	M	33	60	100	165	232	312	410
147	M	32	55	95	160	230	345	488
208	F	31	55	99	162	224	320	430
249	M	36	60	107	180	257	377	525
244	M	34	52	85	140	195	286	410
136	F	33	58	105	176	205	312	412
211	M	31	65	100	170	237	340	460
106	F	34	63	86	145	170	240	355
267	M	36	56	98	170	245	350	490
276	M	33	60	111	185	248	350	485
194	F	33	55	95	142	200	285	410
98	F	31	62	122	182	237	330	447
295	M	38	63	100	172	220	323	453
133	M	36	64	112	175	245	330	465

Total Weight	544	940	1598	2629	3577	5105	7060
No. of Chicks	16	16	16	16	16	16	16
Average Wt.	34.0	58.8	99.9	164.3	223.6	319.1	441.3
% Gain	-	72.9	69.9	64.5	36.1	42.7	38.3

INDIVIDUAL WEEKLY LIVE WEIGHTS IN GRAMS.

PEN 9
Protein Supplement 60%

	1929	1930					
Date	Dec.	Jan.	Jan.	Jan.	Jan.	Jan.	Feb.
	31	6	13	20	27	3	10
Age in Days	1	7	14	21	28	35	42

<u>Chick No.</u>	<u>Sex</u>							
167		33	62	66	D. Jan.16			
313	F	34	55	74	125	176	260	389
307	M	35	57	91	140	180	250	362
197	M	34	65	94	144	192	290	360
120	F	33	57	102	157	211	300	412
318	F	36	52	77	130	157	215	310
192	M	31	54	92	165	192	296	436
264	F	36	56	103	157	192	267	345
258	F	33	52	96	145	185	260	350
178	F	35	51	85	130	176	252	342
287	M	32	52	73	110	130	210	305
111	F	38	62	72	100	105	123	170
209	M	30	58	100	167	215	316	435
230	F	35	55	91	137	156	214	312
127	F	31	45	65	100	140	200	280

Total Weight	506	833	1281
No. of Chicks	15	15	15
Average Wt.	33.7	55.5	85.4

Total Weight	473	771	1215	1907	2407	3453	4808
Survivors	14	14	14	14	14	14	14
Average Wt.	33.8	55.1	86.8	136.2	171.9	246.6	343.4
% Gain	-	63.0	57.5	56.9	26.2	43.5	39.2

INDIVIDUAL WEEKLY LIVE WEIGHTS IN GRAMS.

PEN 10

Decreasing proportions of Protein
supplement 60 - 10%

	1929	1930					
Date	Dec.	Jan.	Jan.	Jan.	Jan.	Feb.	Feb.
	31	6	13	20	27	3	10
Age in Days	1	7	14	21	28	35	42

<u>Chick No.</u>	<u>Sex</u>							
296	M	32	57	100	160	237	335	450
269	M	33	56	85	142	208	315	440
270	F	33	56	80	135	180	275	375
256	F	33	47	78	125	176	268	350
116		36	70	124	155	242	345	455
259	F	33	47	75	119	180	290	410
322	F	31	47	72	115	160	240	335
245	?	33	52	95	152	236	340	460
210	M	33	56	97	140	200	310	445
315	F	37	57	75	115	160	250	325
291	M	36	62	95	145	218	335	465
241	M	36	50	68	110	170	245	345
279	M	33	67	98	165	248	355	495
117	F	37	73	127	205	275	388	511
260	F	34	47	86	136	190	268	348
234	M	30	65	89	145	226	340	465

Total Weight	540	909	1444	2264	3306	4899	6674
No of Chicks	16	16	16	16	16	16	16
Average Wt.	33.8	56.8	90.2	141.5	206.6	306.2	417.1
% Gain	-	68.0	58.8	56.8	46.0	48.2	36.2

INDIVIDUAL WEEKLY LIVE WEIGHTS IN GRAMS.

PEN 13
Protein Supplement 20%

	1930						
	Feb.	Feb.	Feb.	Mar.	Mar.	Mar.	Mar.
Date	14	21	28	7	14	21	28
Age in Days	0	1	2	3	4	5	6

<u>Chick No.</u>	<u>Sex</u>							
445	M	38	56	95	155	245	340	452
373	M	42	65	110	165	247	360	430
397	F	34	50	82	120	186	270	375
342	F	35	51	82	115	180	255	335
362	F	38	64	99	130	205	289	370
343	F	36	63	95	140	211	290	377
386	M	35	55	90	140	203	290	362
461	F	34	53	80	115	195	290	285
442	F	37	56	85	130	187	257	345
357	M	41	67	107	175	266	360	460
427	F	43	72	110	165	244	335	425
356	M	37	55	92	145	185	313	412
411	F	37	57	82	110	170	245	325
405	F	39	56	92	145	215	312	395
380	F	41	56	95	147	220	302	385
400	M	30	50	78	112	180	270	363
368	F	35	50	76	115	166	220	270
392	F	38	52	92	146	217	302	380

Total Weight	670	1028	1642	2470	3722	5300	6746
No. of Chicks	18	18	18	18	18	18	18
Average Wt.	37.2	57.1	91.2	137.2	206.8	294.4	374.7
% Gain	-	53.5	59.7	50.4	50.7	42.3	27.3

INDIVIDUAL WEEKLY LIVE WEIGHTS IN GRAMS.

PEN 14
Protein Supplement 40%

		1930 Feb.	Feb.	Feb.	Mar.	Mar.	Mar.	Mar.
Date		14	21	28	7	14	21	28
Age		0	1	2	3	4	5	6
<u>Chick No.</u>	<u>Sex</u>							
335	M	39	62	110	170	265	358	440
430	M	34	70	126	200	285	402	485
363	M	35	60	97	155	242	335	425
330	F	39	72	125	175	245	335	415
435	F	36	57	98	132	200	273	380
471	M	39	60	90	150	250	348	465
407	F	40	65	110	165	245	330	400
341	M	37	62	107	170	252	340	440
374	M	41	72	134	180	235	380	405
360	M	33	52	94	157	237	338	440
468	F	40	70	125	170	265	350	435
334	M	37	57	97	155	250	341	420
441	F	38	62	65	107	175	244	325
359	M	35	68	120	165	290	418	475
327	F	40	56	102	160	250	349	450
462	M	35	60	99	135	206	273	405
Total Weight		598	1005	1699	2546	3892	5414	6805
No. of Chicks		16	16	16	16	16	16	16
Average Wt.		37.4	62.8	106.2	159.1	243.3	338.4	425.3
% Gain		-	67.9	69.1	49.8	52.9	39.1	25.6

INDIVIDUAL WEEKLY LIVE WEIGHTS IN GRAMS.

PEN 15
Protein Supplement 60%

	1930 Feb.	Feb.	Feb.	Mar.	Mar.	Mar.	Mar.
ate	14	21	28	7	14	21	28
ge	0	1	2	3	4	5	6

<u>Chick No.</u>	<u>Sex.</u>							
345	M	40	65	105	135	205	280	365
351	F	40	56	74	95	120	175	232
458	F	38	52	84	95	140	200	295
337	M	35	61	97	132	185	273	360
467	M	40	67	120	163	255	332	415
388	F	37	57	92	140	197	280	360
429	F	33	56	95	145	215	298	365
406	?	33	55	90	D. Feb. 28			
350	F	41	65	73	100	135	175	235
379	?	39	54	D. Died Feb. 21				
451	F	36	58	100	150	220	298	377
348	M	35	60	87	120	190	275	352
448	F	42	57	92	135	202	285	362
366	M	36	60	83	100	160	215	315
414	?	40	53	80	D. Died Feb. 28			
470	F	41	60	95	143	205	285	370
377	M	41	65	94	120	155	217	310
354	M	38	57	99	130	190	275	375

Total Weight	685	1058	1570					
No of Chicks	18	18	17					
Average Weight	38.1	58.8	92.4					
Total Weight	573	896	1400	1903	2774	3863	5088	
Survivors	15	15	15	15	15	15	15	
Average Weight	38.2	59.7	93.3	126.8	184.9	257.6	339.2	
% Gain	-	56.3	56.3	35.9	45.8	39.3	31.7	

INDIVIDUAL WEEKLY LIVE WEIGHTS IN GRAMS

PEN 20

("Normal" Ration)

	1930 Feb.	Feb.	Feb.	Mar.	Mar.	Mar.	Mar.	
	14	21	28	7	14	21	28	
	0	1	2	3	4	5	6	
<u>Chick No.</u>	<u>Sex</u>							
26	M	46	77	133	200	280	390	475
49	F	39	62	102	156	217	293	360
25	M	39	62	102	176	255	360	450
71	F	39	61	115	170	247	332	390
33	M	40	55	94	146	235	342	435
55	F	39	60	103	160	235	325	390
13	F	37	61	100	152	235	336	425
54	F	36	56	102	150	232	282	340
46	F	41	54	75	105	162	226	300
17	?	35	52	74 D. Died Feb. 28				
59	M	39	65	130	162	262	363	435
70	F	42	68	124	170	252	365	420
98	F	36	60	102	150	235	332	420
95	F	34	53	90	135	205	273	335
47	M	41	58	95	157	254	362	450
73	F	42	62	117	176	270	358	425
44	M	39	64	101	157	261	363	477
Total Weight	664	1030	1759					
No. of Chicks	17	17	17					
Average Weight	39.1	60.6	103.5					
Total Weight	629	978	1685	2522	3837	5302	6527	
Survivors	16	16	16	16	16	16	16	
Average Weight	39.3	61.1	105.3	157.6	239.8	331.4	407.9	
Gain	-	55.5	72.3	49.7	52.1	38.2	23.1	

INDIVIDUAL WEEKLY LIVE WEIGHTS IN GRAMS

PEN 22

(Same Ration as 20, Normal
without Yeast)

		1930						
		Mar.	Mar.	Mar.	Mar.	Apr.	Apr.	Apr.
		10	15	22	29	5	12	19
in days		2	7	14	21	28	35	42
<u>Chick No.</u>	<u>Sex</u>							
53	F	34	50	84	115	175	260	370
55	?	30	42	55	D.			
52	M	35	65	95	140	190	255	360
51	F	38	64	123	195	245	315	440
54	F	36	51	75	115	175	245	340
18	F	32	55	92	135	185	250	350
60	M	31	55	86	135	196	252	310
62	M	36	60	103	170	256	337	475
37	M	32	50	88	148	225	305	430
71	M	34	59	97	160	240	335	460
05	M	30	52	98	168	247	335	455
07	?	31	47	39	D.			
Total Weight		399	650	1035				
No. of Chicks		12	12	12				
Average Weight		33.2	54.2	86.3				
Total Weight		338	561	941	1481	2134	2889	3990
Survivors		10	10	10	10	10	10	10
Average Weight		33.8	56.1	94.1	148.1	213.4	288.9	399.0
Gain		-	65.9	67.7	57.3	44.1	35.4	38.1

INDIVIDUAL WEEKLY LIVE WEIGHTS IN GRAMS.

PEN 23

(Same Ration as 14,
40% Protein)

	1930 Mar.	Mar.			Apr.	Apr.	Apr.
	10	15	22	29	5	12	19
in Days	2	7	14	21	28	35	42

<u>Chick No.</u>	<u>Sex</u>						
07		32	55	90	132	200	350
04		35	56	98	152	215	400
11		30	52	85	135	207	385
01		35	65	105	175	250	400
04		36	60	63	75	D. Died Mar. 29	
08		33	64	115	190	268	460
01		34	63	97	158	227	360
02		33	57	108	165	247	440
06		32	57	94	157	228	425
05		30	60	103	158	232	360
06		32	55	95	110	D. Died Mar. 29	

Total Weight	362	644	1053	1607			
No. of Chicks	11	11	11	11			
Average Weight	32.9	58.1	95.7	146.1			
Total Weight	294	529	895	1422	2074	2562	3580
Survivors	9	9	9	9	9	9	9
Average Weight	32.7	58.8	99.4	158.0	230.5	284.7	397.8
Gain	-	79.8	69.0	58.9	45.9	23.5	39.7

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