1-1-1914

Some Factors Affecting the Weight, Composition and Hatchability of Hen Eggs

Horace Atwood

Follow this and additional works at: [https://researchrepository.wvu.edu/
wv_agricultural_and_forestry_experiment_station_bulletins](https://researchrepository.wvu.edu/wv_agricultural_and_forestry_experiment_station_bulletins)

Digital Commons Citation

Atwood, Horace, "Some Factors Affecting the Weight, Composition and Hatchability of Hen Eggs" (1914). *West Virginia Agricultural and Forestry Experiment Station Bulletins*. 145.
https://researchrepository.wvu.edu/wv_agricultural_and_forestry_experiment_station_bulletins/145

This Bulletin is brought to you for free and open access by the Davis College of Agriculture, Natural Resources And Design at The Research Repository @ WVU. It has been accepted for inclusion in West Virginia Agricultural and Forestry Experiment Station Bulletins by an authorized administrator of The Research Repository @ WVU. For more information, please contact ian.harmon@mail.wvu.edu.

West Virginia University Libraries

3 0802 100896117 3

West Virginia University Agricultural Experiment Station

MORGANTOWN, W. VA.

POULTRY DEPARTMENT

Some Factors Affecting the Weight, Composition and Hatchability of Hen Eggs

A View at the Agricultural Experiment Station Farm Showing Poultry Buildings and Yards.

BY
HORACE ATWOOD

The Bulletins and Reports of this Station will be mailed free to any citizen of West Virginia upon written application. Address Director of Agricultural Experiment Station, Morgantown, West Virginia.

THE STATE OF WEST VIRGINIA

Educational Institutions

THE STATE BOARD OF CONTROL

JAMES S. LAKIN, President.....Charleston, W. Va.
W. M. O. DAWSON, Treasurer.....Charleston, W. Va.
J. M. WILLIAMSON.....Charleston, W. Va.

The State Board of Control has the direction of the financial and business affairs of the state educational institutions.

THE STATE BOARD OF REGENTS

M. P. SHAWKEY, State Superintendent of Schools,
PresidentCharleston, W. Va.
GEORGE S. LAIDLEY.....Charleston, W. Va.
ELLIOTT NORTHCOTT.....Huntington, W. Va.
EARL W. OGELBAY.....Wheeling, W. Va.
J. B. FINLEY.....Parkersburg, W. Va.

The State Board of Regents has charge of all matters of a purely scholastic nature concerning the state educational institutions.

The West Virginia University

THOMAS EDWARD HODGES, LL.D.,.....President

Agricultural Experiment Station Staff

E. Dwight Sanderson, B.S. Agr.,.....Director
Bert H. Hite, M.S.,.....Vice-Director and Chemist
W. E. Rumsey, B.S. Agr.,.....State Entomologist
N. J. Giddings, M.S.,.....Plant Pathologist
Horace Atwood, M.S. Agr.,.....Poultryman
W. H. Alderman, B.S. Agr.,.....Horticulturist
I. S. Cook Jr., B.S. Agr.,.....Agronomist
L. M. Peairs, M.S.,.....Research Entomologist
*O. M. Johnson, B.S. Agr.,.....Farm Management
Paul B. Bennetch, B.S. Agr.,.....Dairy Husbandry
C. A. Lueder, D.V.M.,.....Veterinary Science
†L. I. Knight, Ph.D.,.....Plant Physiologist
A. L. Dacy, B.Sc.,.....Associate Horticulturist
Frank B. Kunst, A.B.,.....Assistant Chemist
Charles E. Weakley Jr.,.....Assistant Chemist
J. H. Berghuis-Krak, B.Sc.,.....Assistant Chemist
Hubert Hill, B.S., M.S.,.....Assistant Chemist
Anthony Berg, B.S.,.....Assistant Plant Pathologist
E. C. Auchter, B.S. Agr.,.....Assistant Horticulturist
L. F. Sutton, B.S., B.S. Agr.,.....Assistant Horticulturist
R. R. Jeffries, B.S. Agr.,.....Assistant Horticulturist
W. B. Kemp, B.S. Agr.,.....Assistant Agronomist
Henry Dorsey,.....Assistant Agronomist
E. L. Andrews, B.S. Agr.,.....Assistant in Poultry Husbandry
*C. H. Scherffius,.....In Charge of Tobacco Experiments
O. M. Kile, B.S. Agr.,.....Editor
W. J. White,.....Bookkeeper
M. A. Stewart,.....Librarian

*In co-operation with U. S. Department of Agriculture.

†In co-operation with the University of Chicago.

Some Factors Affecting the Weight, Composition and Hatchability of Hen Eggs

By HORACE ATWOOD

The highest success in keeping poultry cannot be attained unless the little chickens that are reared each year develop into thrifty vigorous individuals. Without this early thrift and vigor the mature fowls never become efficient producers either of eggs or of flesh. They will neither fatten well nor lay well, and instead of being profitable they will be a financial burden, and the enterprise will be unsuccessful. Consequently it is of first importance to know how to produce chickens that are constitutionally strong.

In this bulletin the few experiments that have been performed are reported largely for the purpose of calling attention to the importance of the subject and as a record of progress. Only one or two phases of the subject have been touched upon, and these not exhaustively.

Large Eggs versus Small Eggs for Hatching.

In bulletin No. 124 of this Station are recorded experiments showing that chickens hatched from heavy eggs are heavier and more thrifty than chicks hatched from eggs lighter in weight. This result, too, has been confirmed recently by investigations conducted by the New York State College of Agriculture at Cornell University, so the general proposition that one should use large heavy eggs for incubating purposes may be accepted as an established fact. It is therefore a matter of importance to know when the heaviest eggs are laid and how fowls should be fed and handled in order that they may lay large heavy eggs best suited for hatching.

Seasonal Variation in the Weight of Eggs.

That there is a variation in the average weight of eggs according to the season of the year when they are laid was observed by the author in an experiment performed in 1899-

1900 and reported in bulletin No. 71 of this Station. At that time, however, its significance was not appreciated. The following table from the publication referred to shows the weight of eggs laid by two lots of fowls, one lot supplied liberally with green food, and the other lot with a scanty supply:

Fowls When Receiving Green Food.

LOT I	Number of eggs	Weight of eggs (lbs.)	Weight of eggs per hundred (lbs.)
Period 1—July-August, 1899.....	660	74.5	11.28
2—Aug.-Sept.	680	76.5	11.25
3—Sept.-Oct.	945	112.5	11.90
4—Oct.-Nov.	1,020	122.0	11.96
5—Nov.-Dec.	675	83.5	12.37
6—Dec.-Jan.	290	35.7	12.32
7—Jan.-Feb.	330	42.0	12.72
8—Feb.-March	930	114.0	12.26
9—March-April	1,595	201.5	12.63
10—April-May	1,600	185.7	11.61
11—May-June	1,542	174.4	11.31
12—June-July	1,185	131.2	11.07
Total	11,452	1,353.5	
Average weight of 100 eggs.....			11.89

Fowls When Not Receiving Green Food.

LOT II	Number of eggs	Weight of eggs (lbs.)	Weight of eggs per hundred (lbs.)
Period 1—July-Aug., 1899.....	710	79.5	11.19
2—Aug.-Sept.	865	96.0	11.09
3—Sept.-Oct.	610	70.0	11.47
4—Oct.-Nov.	710	81.5	11.48
5—Nov.-Dec.	385	45.5	11.81
6—Dec.-Jan.	355	44.2	12.46
7—Jan.-Feb.	90	12.0	13.33
8—Feb.-March	735	96.0	13.06
9—March-April	975	117.0	12.00
10—April-May	994	118.8	11.24
11—May-June	1,400	158.6	11.33
12—June-July	1,210	147.2	12.16
Total	9,039	1,066.3	
Average weight of 100 eggs.....			11.88

LIBERAL FEEDING VERSUS SCANTY FEEDING AS AFFECTING WEIGHT AND HATCHABILITY OF EGGS.

EXPERIMENTS CONDUCTED IN 1911-1912.

On August 1, 1911 an experiment was begun with six lots of fowls to determine the effect of liberal versus scanty feeding, upon the number and weight of eggs produced and their hatchability. This experiment was continued for two years with the same fowls. The eggs from each lot of fowls were weighed regularly two or three times per week in bulk, and the following tables give the weight of the fowls, the amount of food consumed, the number of eggs laid and their weight (in grams) for each month of the year:

Pens 3, 4, 7 and 8 contained pullets, and pens 5 and 6 one year old hens. All pens were fed a moistened mash containing corn meal, wheat bran, wheat middlings and beef scrap. In the afternoon they were fed whole grain scattered in the straw litter that covered the floors of the houses. Pens 3, 4 and 5 were fed liberally for egg production, while pens 6, 7 and 8 were fed the same materials, but less liberally, so that few eggs were produced during the winter months. Due to the liberal feeding of pens 3 and 4 during the fall months, several of the pullets moulted at the approach of cold weather, thus materially reducing their winter egg production. After April 10th, pens 6 and 7 were also fed in a normal manner, and pen 8 after May 28th.

The following table shows the weights of each lot of 20 females and one male at the beginning of the test and at different times throughout the year:

Weight of Fowls in Feeding Experiments.
(Weight in pounds.)

	Pen 3	Pen 4	Pen 5	Pen 6	Pen 7	Pen 8
Aug. 1, 1911.....	50.5	49.	79.	77.	49.	49.5
Aug. 24, 1911.....	56.	56.5			54.	55.5
Sept. 1, 1911.....	60.	59.	74.	67.	57.	59.
Oct. 1, 1911.....	65.	67.	70.	63.5	58.	59.
Nov. 1, 1911.....	75.5	74.5	74.	61.5	63.	63.5
Dec. 1, 1911.....	77.5	76.5	76.5	61.5	66.5	69.
Jan. 1, 1912.....	78.5	77.5	80.5	66.	66.	67.5
March 1, 1912.....	83.5	77.	90.5	69.25	66.5	66.5
April 11, 1912.....	89.5	87.5	93.5	66.5	68.5	63.5
Aug. 1, 1912.....	79.75	80.	80.	68.5	70.75	65.

The table shows that of the fowls fed liberally there was a fairly uniform increase in weight from the beginning of the experiment until April 11th, then there was a decrease, showing that fowls are heaviest during the period of maximum egg production. The mature fowls fed scantily, pen 6, never weighed as much as at the beginning of the experiment while the two pens of pullets fed scantily gradually increased in weight.

The following table shows the pounds of feed consumed during the year by each lot of 21 fowls:

*Feed Consumed by Each Pen of Fowls.
(Weight in pounds.)*

	Pen 3	Pen 4	Pen 5	Pen 6	Pen 7	Pen 8
Corn	304.5	309.5	297.5	241.5	240.5	188.5
Wheat	215.	215.	205.	185.	185.	115.
Oats	382.	387.	375.	299.	298.	242.
Corn meal	176.6	176.6	181.6	136.6	139.6	130.6
Wheat bran	176.6	176.6	181.6	136.6	139.6	130.6
Wheat middlings	126.	126.	125.	101.	108.	95.
Cottonseed meal	22.	22.	23.	16.	19.	15.
Ground oats	62.6	62.6	56.6	51.6	51.6	51.6
Beef scrap	61.	61.	61.	47.	47.	45.
Total	1,526.3	1,536.3	1,506.3	1,214.3	1,228.3	1,013.3

The fowls fed liberally consumed during the year an average of 72.5 pounds of grain and beef scrap each, while those fed scantily each consumed 54.8 pounds of the same feeding stuff.

The following tables show the number and total weight, in grams, of the eggs laid each month by each pen of fowls; the average weight of the eggs each month, and the average weight of all the eggs laid by each pen for the year.

*Number and Weight of Eggs Laid by Each Pen.
(Weight in grams.)*

MONTH	PEN 3			PEN 4			PEN 5		
	Eggs Laid	Total Weight	Average Weight	Eggs Laid	Total Weight	Average Weight	Eggs Laid	Total Weight	Average Weight
Aug., 1911.....							252	14,365	57.0
Sept.	16	646	40.4	57	2,380	41.7	114	6,271	55.0
Oct.	32	1,533	47.9	46	2,047	44.5	47	2,649	56.4
Nov.	151	7,727	51.2	60	3,164	52.7	6	351	58.5
Dec.	188	10,293	54.7	168	9,143	54.4	30	1,916	63.8
Jan., 1912....	53	2,990	56.4	151	8,666	57.4	20	1,236	61.8
Feb.	194	11,481	59.2	232	13,743	59.2	166	10,119	60.9
Mar.	452	26,976	59.6	444	26,256	59.1	386	24,006	62.2
Apr.	459	26,849	58.5	407	23,673	58.1	408	24,805	60.8
May	463	26,392	57.0	438	24,820	56.6	415	24,502	59.0
June	477	26,809	56.2	477	27,062	56.7	426	24,923	58.5
July	309	17,214	55.7	275	15,072	54.8	243	13,668	56.2
Total	2,794	158,910		2,755	156,026		2,513	148,811	
Average ..			56.8			56.6			59.2

The total number of eggs produced by pens 3, 4 and 5 was 8062. The total weight of these eggs was 463,747 grams. The average weight of the eggs for the year was 57.5 grams.

MONTH	PEN 6			PEN 7			PEN 8		
	Eggs Laid	Total Weight	Average Weight	Eggs Laid	Total Weight	Average Weight	Eggs Laid	Total Weight	Average Weight
Aug., 1911.....	223	12,609	56.5						
Sept.	50	2,746	54.9				17	664	39.1
Oct.	5	309	61.8				22	1,102	50.1
Nov.							28	1,484	53.0
Dec.				9	431	47.9	27	1,426	52.8
Jan., 1912....	1	58	58.0	5	243	48.6	4	232	58.0
Feb.	98	6,062	61.8	139	7,967	57.3	150	9,036	60.2
March	81	4,874	60.1	28	1,562	55.7	75	4,278	57.0
April	305	17,946	58.8	305	17,526	57.4	231	13,071	56.6
May	449	25,945	57.8	484	28,219	58.3	310	17,464	58.0
June	462	26,150	56.6	484	28,103	58.0	398	22,842	57.4
July	273	15,109	55.3	301	16,797	55.8	189	10,584	56.0
Total	1,947	111,808		1,755	100,848		1,422	82,183	
Average ..			57.4			57.4			56.9

The total number of eggs produced by pens 6, 7 and 8 was 5,144. The total weight of these eggs was 294,839 grams. The average weight of the eggs for the year was 57.3 grams.

Number of Eggs Laid. The three pens of fowls fed liberally, laid 8062 eggs and those fed scantily laid 5144. This shows the importance of liberal feeding in the economical production of eggs. It takes a certain amount of feed to maintain the warmth of the fowls, to repair and build up their systems, and to supply energy for their normal activity. These requirements must be met before any of the nutritive materials can be used for the formation of eggs.

The two pens of pullets fed liberally averaged 138.7 eggs each, while the pen of yearling hens fed liberally laid only 125.6 eggs each, showing that the greatest egg production is to be expected during the pullet year.

Weight of Eggs. The eggs laid by pen 3 in September averaged 40.4 grams each, and there was a gradual increase in weight until during March, when the eggs averaged 59.6 grams each. Then there was a slight but gradual decrease until the close of the first year when the eggs averaged for the last month only 55.7 grams. This variation is also plainly evident in pens 4 and 5 and to a certain extent in the case of the pens fed scantily. In the case of pens 6, 7 and 8, variations in the liberality of their food supply introduced another factor influencing the weight of the eggs.

The records for the years 1899-1900 and 1911-1912 both show that the heaviest eggs are laid during February, March and April. The reason for this may not be clearly evident, but it certainly throws additional light on the subject and explains why early hatched chickens are almost universally considered more hardy and vigorous than those hatched later in the season.

Scanty Feeding Reduces Size of Egg. Coming now to the influence of scanty feeding on the size of the eggs, the tables show that the average weight of the eggs laid during the year, by the fowls fed liberally was 57.5 grams, and the average for the other fowls was 57.3 grams. This is only a slight decrease, but it must be remembered that pens 6 and 7 were fed liberally after April 10th, and pen 8 after May 28th.

During the month of March, the eggs from pens 1, 2 and 3 averaged 60.3 grams each, while the eggs from the other pens averaged 57.6 grams, or a decrease of about $4\frac{1}{2}$ per cent, so we may safely conclude that scanty feeding reduces slightly the size of the eggs.

Hatchability of Eggs and Vigor of Chicks.

The eggs in this experiment were incubated in Cyphers 390-egg size incubators. Whenever two or more incubators were used the eggs from each lot of fowls were uniformly distributed among the machines, so that any variation during the hatching period would affect each lot of eggs alike. The incubators were operated in the usual manner, and the variations in the temperature of the egg chambers were very slight.

The following table gives the essential details of the first hatch:

HATCH 1—March 22, 1912.

	Fowls fed heavily	Fowls fed scantily
Number of eggs incubated.....	845	94
Tested out April 5th.....	288	54
Per cent "fertile" eggs.....	65.9	42.6
Unhatched	101	9
Number of chicks.....	456	31
Per cent hatch of "fertile" eggs.....	81.9	77.5
Per cent hatch of all eggs incubated....	53.9	32.9

The eggs from the fowls fed scantily were less strongly fertilized than the others and a slightly less number of the fertile eggs hatched.

Both lots of chicks, together with 373 others of the same age were placed in an Arenburg brooder and brooded in one flock. The experimental chicks were not marked, so there is no record of the mortality of each lot. A record was kept, however, of the deaths occurring among the entire 860 chicks. There were 8 deaths during the first three days after the chickens were placed in the brooder. These were undoubtedly weak or defective chickens. Of the 852 remaining, there was only one death until they were removed to colony houses at twelve weeks of age. This shows plainly that all the chickens in this flock from whatever source were remarkably strong and healthy.

HATCH 2—April 9, 1912.

	Fowls fed heavily	Fowls fed scantily
Number of eggs incubated.....	200	93
Tested out April 18th.....	12	13
Per cent "fertile" eggs.....	94	86
Unhatched	23	6
Number of chicks.....	165	74
Per cent hatch of "fertile" eggs.....	87.7	92.5
Per cent hatch of all eggs incubated....	82.5	79.5
Deaths to June 15th.....	12	0
Per cent mortality.....	7.3	0

In this hatch, also the eggs from the fowls fed scantily were not so fertile as those from the other lot of fowls. The fertile eggs however, hatched somewhat better, the net result being that a slightly greater percentage hatched from the eggs laid by the fowls fed liberally.

The mortality was greater in the chicks hatched from eggs laid by the fowls fed liberally. The chicks were brooded in a Cornell gasoline brooder.

HATCH 3—April 20, 1912.

	Fowls fed heavily	Fowls fed scantily
Number of eggs incubated.....	377	239
Tested out May 5th.....	28	32
Per cent "fertile" eggs.....	92.6	86.6
Unhatched	52	22
Number of chicks.....	297	185
Per cent hatch of "fertile" eggs.....	85.1	89.3
Per cent hatch of all eggs incubated....	78.7	77.4
Weight of 100 chicks just hatched (lbs.)	8.77	8.38
Per cent mortality first six weeks.....	3.8	1.6

In this hatch the eggs from the fowls fed liberally were somewhat more fertile, but the fertile eggs did not hatch quite so well as the eggs from the other lot, the final result being that there was practically the same percentage of chicks from both lots of eggs.

	Fowls fed heavily	Fowls fed scantily
Number of eggs incubated.....	189	185
Tested out May 13th.....	23	23
Per cent "fertile" eggs.....	87.8	87.6
Unhatched	20	19
Number of chicks.....	146	143
Per cent hatch of "fertile" eggs.....	87.9	88.2
Per cent hatch of all eggs incubated....	77.8	77.3
Weight of 100 chicks just hatched (lbs.)	8.58	8.73
Per cent mortality first six weeks.....	4.1	0.

Both lots of eggs hatched practically the same. The mortality however, was slightly greater in the chicks hatched from eggs laid by the heavily fed pen of fowls, although the deaths in this lot were few. The chicks were brooded in one flock in a Cornell gasoline brooder.

HATCH 5—May 22, 1912.

	Fowls fed heavily	Fowls fed scantily
Number of eggs incubated.....	393	390
Tested out June 1st.....	78	46
Per cent "fertile" eggs.....	80.2	88.2
Unhatched	50	32
Number of chicks.....	265	312
Per cent hatch of "fertile" eggs.....	84.1	90.7
Per cent hatch of all eggs incubated....	67.4	80.0
Weight of 100 chicks just hatched (lbs.)	8.92	8.80
Per cent mortality first three weeks....	1.5	2.9

The eggs laid by the fowls that had been fed scantily were more fertile and hatched considerably better than those laid by the other lot of fowls. The chicks were toe-marked and brooded with about 500 others of the same age in an Arenburg brooder. During the first three weeks the mortality was somewhat greater in the case of the chicks hatched from the eggs from the fowls that had been fed scantily. In both cases, however the death loss was low.

Summary of 1911-1912 Incubating and Brooding Experiments.

The tests indicate that when fowls are fed too scantily the fertility of the eggs will be low, but those which are fertile seem to hatch practically as well as the fertile eggs laid by the fowls fed heavily. Hatch 5 indicates that after fowls have been laying heavily for a considerable length of time their eggs are less fertile and do not hatch so well as eggs laid by fowls which are just reaching or have reached their maximum egg production for the season. There seems to be no great difference in the vigor of the chicks from the two lots of fowls, although what difference there is seems to be in favor of the chicks from the fowls fed scantily, except in the case of the last hatch.

EXPERIMENTS CONDUCTED IN 1912-1913.

The experiment begun August 1st, 1911 with six pens of fowls was continued for the second year with the same fowls and on the same general plan, pens 3, 4 and 5 being fed liberally, and pens 6, 7 and 8 being fed scantily.

The following table shows the kind and amount of feed consumed by each lot of fowls for the twelve months under consideration:

*Feeds Consumed by Fowls From August, 1912, to July, 1913.
(Weight in pounds.)*

	Pen 3	Pen 4	Pen 5	Pen 6	Pen 7	Pen 8	Total
Corn	475.2	473.5	476.4	277.5	304.0	280.5	
Oats	475.2	473.5	476.4	277.5	304.0	280.5	
Corn meal	166.5	168.6	158.8	106.4	106.7	121.8	
Wheat bran	103.3	103.8	96.4	61.7	69.3	73.9	
Wheat middlings	145.5	151.8	146.8	93.4	94.7	85.8	
Beef scrap	87.3	87.8	83.4	59.7	51.8	64.4	
Fresh meat and bone..	51.0	41.6	41.6	41.6	35.2	41.6	
Cottonseed meal	10.9	11.0	9.0	7.0	8.0	5.0	
Gluten meal	12.0	16.8	12.0	12.0	12.0	33.8	
Sprouted oats	47.7	48.7	48.7	48.7	48.7	48.7	
Oil meal	21.8	21.6	21.1	15.6	12.4	16.0	
Milk	(290)	(290)	(290)	(290)	(290)	(290)	
Shredded alfalfa	21.8	21.6	20.8	15.6	12.4	16.0	
Total	1,618.2	1,620.3	1,591.4	1,016.7	1,059.2	1,068.0	7,973.8

Total pens 3, 4 and 5.....4,829.9

Total pens 6, 7 and 8.....3,143.9

Weight of Fowls in Each Pen by Months.

	1 9 1 2					1 9 1 3							
	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	April.	May	June	July	Average
Pen 3	79.7	84.0	77.2	75.0	79.5	86.0	92.2	98.5	100.5	97.0	96.0	88.5	87.8
Pen 4	80.0	83.0	80.2	80.5	79.5	85.2	92.7	97.5	95.5	86.2	90.7	90.2	86.8
Pen 5	80.0	85.0	78.7	77.0	78.2	85.0	90.7	97.5	95.5	93.0	93.7	87.5	86.8
Pen 6	68.5	71.0	61.2	54.5	63.0	73.0	82.7	76.0	71.2	66.5	64.5	59.0	67.6
Pen 7	70.7	69.0	65.0	58.0	66.0	81.7	87.0	80.0	74.0	65.5	68.0	65.0	70.8
Pen 8	65.0	68.0	58.5	58.5	72.7	74.7	81.2	74.0	69.2	63.7	64.7	58.5	67.4
Average	73.9	76.6	70.1	67.2	73.1	80.9	87.7	87.2	84.3	78.6	79.6	74.8	

Average weight of pens 3, 4 and 5.....87.1 lbs.

Average weight of pens 6, 7 and 8.....68.6 lbs.

This table shows that the liberally fed fowls remained heavier throughout the year; also that the fowls were heavier during the months of January, February, March and April than at any other time.

The following table shows the number of eggs laid by each pen of fowls for each month in the year:

Total Number of Eggs Laid. by Months.

	Pen 3	Pen 4	Pen 5	Pen 6	Pen 7	Pen 8	Total
August, 1912	287	245	167	157	152	85	1,093
September	203	195	156	64	69	42	729
October	67	39	44		1	2	153
November	1				1		2
December	8	1		3		19	31
January, 1913	13	35	32	33	64	46	223
February	57	75	55	77	83	110	457
March	314	357	339	191	180	209	1,590
April	379	406	379	161	183	175	1,683
May	399	359	376	157	113	138	1,542
June	360	347	344	215	159	234	1,659
July	336	315	286	153	121	145	1,356
Total	2,424	2,374	2,178	1,211	1,126	1,205	10,518

The above table shows that the heaviest production was during the months of March, April, May and June. Comparing this with the average weights shown in the preceding table it is seen that fowls reach their maximum weight slightly before they reach their maximum production.

Disregarding the results for December, on account of the small number of eggs laid that month, the table shows that the average weight of the eggs during January, February and March is greater than at any other time of the year. This result is in complete harmony with former findings.

The Following Table Shows the Total Weight, in Grams, of all the Eggs Laid for Each Month in the Year, and the Average Weight of Eggs:

Month	Pen 3	Pen 4	Pen 5	Pen 6	Pen 7	Pen 8	Total	Average weight of eggs
August, 1912	16,608	14,063	9,835	8,736	8,451	4,852	62,545	57.2
September ..	12,072	11,457	9,395	3,731	3,877	2,381	42,913	58.8
October	4,039	2,268	2,714		57	96	9,174	59.9
November ..	61				51		112	56.0
December ..	491	58		206		1,148	1,903	61.4
Jan., 1913...	782	2,045	1,830	2,097	3,960	3,003	13,717	61.5
February ...	3,520	4,329	3,148	4,800	5,180	6,685	27,562	60.3
March	19,064	21,785	20,938	11,252	10,546	12,348	95,933	60.3
April	22,599	24,075	23,512	9,003	10,361	9,904	99,454	59.1
May	23,038	20,856	20,614	8,566	6,208	7,522	86,804	56.3
June	20,606	20,071	20,716	11,767	9,009	13,089	95,258	57.4
July	19,315	18,343	16,903	8,446	6,809	8,261	78,137	57.6
Total	142,095	139,350	129,605	68,604	64,569	69,289	613,512	
Total eggs laid	2,424	2,374	2,178	1,211	1,126	1,205		
Av. weight of eggs	58.6	58.7	59.5	56.6	57.3	57.5		

The table also shows that the scanty feeding of pens 6, 7 and 8 materially reduced the size of the eggs. Pens 3, 4 and 5 laid 6,767 eggs, weighing 411,050 grams or an average of 58.92 grams each, while pens 6, 7 and 8 laid 3,542 eggs weighing 202,462 grams or an average of 57.41 grams. This makes an average difference of 1.51 grams per egg throughout the year.

Increase in Weight of Egg Due to Age of Fowls.

During the first year of the test the eggs from pens 3, 4 and 5 had an average weight of 57.5 grams. During the second year the eggs had an average weight of 58.92 grams or an increase, due apparently to the increased age of the fowls, of 1.4 grams per egg. This indicates the importance of breeding only from mature stock. The results for the two years from pens 6, 7 and 8 are not strictly comparable as these pens were fed liberally a portion of the time during the first year of the test.

During the first year of the test, the eggs from pens 3 and 4, pullets, averaged respectively, 56.8 and 56.6 grams. The eggs from the yearling hens, pen 4, however, averaged 59.2 grams or, in other words, they averaged about $2\frac{1}{2}$ grams apiece heavier than the eggs laid by pullets.

Average Weight of Eggs, in Grams, for Each Month of the Year.

	Pen 3	Pen 4	Pen 5	Pen 6	Pen 7	Pen 8
August, 1912.....	57.87	57.40	58.89	55.64	55.60	57.08
September	59.46	58.76	60.22	58.30	56.19	56.69
October	60.28	58.15	61.68		57.00	48.00
November	61.00				51.00	
December	61.38	58.00		68.66		60.42
January, 1913.....	60.15	58.42	57.18	63.54	61.87	65.28
February	60.00	57.72	57.23	62.33	62.41	60.77
March	60.71	61.02	61.76	58.91	58.59	59.08
April	59.63	59.30	62.03	55.91	56.61	56.59
May	57.73	58.09	60.63	54.56	54.93	54.50
June	57.40	57.84	60.22	54.73	56.66	55.93
July	57.48	58.23	59.10	55.20	56.76	56.97

ADDITIONAL EXPERIMENTS CONDUCTED IN 1913.

To continue the study of liberal versus scanty feeding upon the hatchability of the eggs and the vigor of the chicks three hatches were carried out in the spring of 1913 by Mr. Stuart A. Cody, Assistant Poultryman. The details of these tests follow:

Incubation Tests.

On April 10, 1913, 366 eggs laid by pens 3, 4 and 5 and 353 eggs laid by pens 6, 7 and 8 were placed in Cyphers incubators. The following table shows the details of the hatch:

TEST 1—April 10, 1913.

	No. eggs incubated	No. unfertile eggs	% of eggs unfertile	No. chicks hatched	% hatched of all eggs incubated	% hatched fertile eggs
Pen 3	107	32	29.9	66	61.7	88.0
Pen 4	109	10	9.1	81	74.3	81.8
Pen 5	144	37	25.7	88	61.1	82.2
Total	360	79	21.9	235	65.3	83.6
Pen 6	106	18	16.9	78	73.6	88.6
Pen 7	111	54	48.6	45	40.5	78.9
Pen 8	136	14	10.1	105	77.2	86.0
Total	353	86	24.3	228	64.5	85.4

The above table shows that there was practically no difference in the average fertility or hatchability of the eggs from the fowls fed heavily or scantily. There is considerable variation, however, in the results from the different pens, due, probably in large measure, to variations in the vigor of the males.

The chicks were weighed when removed from the incubators. The chicks hatched from eggs laid by fowls fed liberally weighed 8.80 lbs. per hundred chicks, while chicks from the fowls fed scantily weighed at the rate of 8.40 lbs. per hundred.

The chicks were toe-marked and placed with about 700 other chicks in an Arenburg brooder, and a record was kept of their mortality until June 26th. Up to that time 11.9% of the chicks from the fowls fed heavily, and 10.9% of the chicks from the fowls fed scantily, had died.

Eggs from the liberally and scantily fed fowls were placed in Cyphers incubators June 9, 1913. The following table shows the details of the hatch:

TEST 2—June 9, 1913.

Lot	No. eggs incubated	No. unfertile eggs	% of eggs unfertile	No. chicks hatched	% hatched of all eggs incubated	% hatched fertile eggs
Lot I—Fed liberally...	512	97	18.9	238	46.4	57.3
Lot II—Fed scantily...	251	29	11.5	79	31.4	35.6

The table shows that the eggs from the fowls fed scantily did not hatch nearly so well as the eggs from the other lot of fowls. This result may have been due, however, to the fact that through oversight, the ventilators in the machine containing the eggs from the fowls fed scantily, remained closed throughout the hatch, while the ventilators in the other machine were kept open.

The chicks from the liberally fed fowls weighed, when removed from the incubator, 8.76 lbs. per hundred chicks, and 7.91 lbs. per hundred in the case of the other lot.

The chicks were marked and placed in a hot water pipe-brooder house and a record was kept of all deaths due to weakness or disease until the chicks were eight weeks old. During that time 36.5% of the chicks died from lot I or from eggs laid by fowls fed liberally, and 27.8% of the other chicks. The mortality in both cases was high.

TEST 3—July 11, 1913.

Lot	No. eggs incubated	No. unfertile eggs	% of eggs unfertile	No. chicks hatched	% hatched of all eggs incubated	% hatched fertile eggs
Lot I—Fed liberally...	297	110	37.0	117	39.3	62.5
Lot II—Fed scantily...	98	29	29.6	28	28.5	40.6

The table shows that the eggs from lot II did not hatch so well as those from lot I. The chicks were weighed when taken from the incubator. Those from lot I weighed 8.09 lbs. per hundred chicks, and those from lot II 8.12 lbs. per hundred.

A record was kept of the mortality of these chicks until September 30th. At that time 29.9% of the chicks from lot I and 64.3% of the chicks from lot II had died from various causes.

Conclusions Concerning Hatchability of Eggs and Weight of Chicks.

The following table brings together the results obtained during the two years:

Hatch	% Fertile Eggs		% Hatched of all Eggs Incubated		% Hatched of Fertile Eggs	
	Liberally fed	Scantily fed	Liberally fed	Scantily fed	Liberally fed	Scantily fed
No. 1—1912	65.9	42.6	53.9	32.9	81.9	77.5
No. 2—1912	94.0	86.0	82.5	79.5	87.7	92.5
No. 3—1912	92.6	86.6	78.7	77.4	85.1	89.3
No. 4—1912	87.8	87.6	77.8	77.3	87.9	88.2
No. 5—1912	80.2	88.2	67.4	80.0	84.1	90.7
No. 1—1913	83.1	75.7	65.3	64.5	83.6	85.4
No. 2—1913	81.1	88.5	46.4	31.4	57.3	35.6
No. 3—1913	63.0	70.4	39.3	28.5	62.5	40.6

With a single exception, (hatch 5-1912), the eggs from the fowls fed liberally produced a larger number of chicks from a given number of eggs incubated than was the case with the eggs from fowls fed scantily and the exception itself is more apparent than real, for in May 1912, when the hatch in question was made, the scantily fed fowls were laying practically as well as those fed liberally.

The following table indicates the relative mortality:

Hatch	Weight of Chicks per hundred		% Mortality	
	Liberally fed	Scantily fed	Liberally fed	Scantily fed
No. 2—1912			7.3	0
No. 3—1912	8.77	8.38	3.8	1.6
No. 4—1912	8.58	8.73	4.1	0
No. 5—1912	8.92	8.80	1.5	2.9
No. 1—1913	8.80	8.40	11.9	10.9
No. 2—1913	8.76	7.91	36.5	27.8
No. 3—1913	8.09	8.12	29.9	64.3

If the hatch of 1912 be disregarded, as pens 6 and 7 were being fed in a normal manner at the time that hatch was made, it is evident from the table that the chicks hatched from eggs laid by the fowls fed liberally averaged somewhat heavier than those hatched from the other eggs.

Mortality of Chicks. In some cases there was a slightly greater mortality among chicks from the liberally fed fowls, but too much stress should not be placed on these figures, as so many uncontrollable factors may have intervened as to have vitiated the results

SEASONAL VARIATION IN THE COMPOSITION OF HEN EGGS.

Inasmuch as there seems to be a seasonal variation in the weight of eggs it is of interest to observe whether there is any seasonal variation in their composition or in the relative proportions of the different parts. The following tables are the results of analyses performed by Mr. K. H. Knudsen, formerly Assistant Chemist of the Experiment Station. The eggs analyzed were taken from pen 3 previously mentioned. The methods used in these analyses are described on page 100 and following, of this bulletin.

Composition of Yolks.

Date	% of total egg in wet yolk	% of total egg in dry yolk	% phosphoric acid in dry yolk	% phosphoric acid in wet yolk	Weight of one egg	% water in yolk
Oct. 8, 1911....		13.53	2.62	1.36		48.14
Oct. 14, 1911....		12.81	2.61	1.35		48.15
Oct. 16, 1911....		13.08	2.58	1.30		49.44
Oct. 21, 1911....		15.99	2.62	1.37		47.90
April 9, 1912...	29.65	15.07	2.68	1.39	59.75	47.98
April 11, 1912...	31.65	16.25	2.62	1.35	58.48	48.60
April 24, 1912...	29.80	15.38	2.66	1.37	54.77	48.38
Average	30.35	14.59	2.63	1.35	57.66	48.39

The average per cent of the total egg that is dry yolk, for the four analyses performed in October 1911, is 13.85, while the average for the three analyses performed in April is 15.56.

Although these analyses are too few in number to allow any definite conclusions to be drawn, still, the figures indicate that the yolks of eggs are relatively heavier in respect to the total egg, in the spring than in the fall. This point should be studied further.

There seems to be no other striking difference between the fall and spring analyses, except that the average per cent of phosphoric acid in the dry yolk was 2.607 for October and 2.653 for April. This matter also should be studied further.

Composition of Whites.

Date	% of total egg in wet white	% of total egg in dry white	% phosphoric acid in dry white	% phosphoric acid in wet white	Weight of one egg	% water in white
Oct. 8, 1911....		7.55				87.04
Oct. 14, 1911....		9.08				84.82
Oct. 16, 1911....		8.83				85.24
Oct. 21, 1911....		8.12				85.90
April 9, 1912...	59.02	6.87	.32	.037	59.75	88.37
April 11, 1912...	56.43	7.64	.26	.035	58.48	86.46
April 24, 1912...	59.26	7.66	.26	.034	54.77	87.07
Average	58.24	7.96	.28	0.35	57.66	86.41

In this table the most striking feature is the high relative proportion of the weight of the dry white to the weight of the total egg, in the fall and in the spring. The average per cent for October was 8.395, while for April it was slightly more than one per cent less or 7.390. This is in accord with the results shown in the preceding table.

Composition of Shell.

Date	% of total egg that is wet shell	% of total egg that is dry shell	% phosphoric acid in dry shell	% phosphoric acid in wet shell	Weight of one egg	% water in shell
Oct. 8, 1911....		10.01				
Oct. 14, 1911....		10.57	.29	.27		
Oct. 16, 1911....		10.91				
Oct. 21, 1911....		10.45	.27	.26		
April 9, 1912...	11.15	9.40	.28	.24	59.75	15.40
April 11, 1912...	11.70	10.15	.31	.27	58.48	13.24
April 24, 1912...	10.95	9.57	.30	.26	54.77	13.74
Average	11.27	10.15	.29	.26	57.66	14.13

In this table the only figures available for October and April are in reference to the per cent of the total egg that is dry shell. The average for October is slightly greater than for April.

Conclusions.

Although the analyses are too few to justify drawing definite conclusions, yet the results indicate that during spring when hens are laying well, and when the eggs are heavier than at any other time of the year, then the dry matter of the yolk constitutes a greater percentage of the total weight of the egg than in the fall when the fowls are laying less liberally. This may be an additional reason why early hatched chickens are more vigorous than those hatched later, for it is reasonable to suppose that the larger the yolk the more perfectly nourished will be the embryo.

THE INFLUENCE OF CERTAIN RATIONS ON THE SIZE AND COMPOSITION OF HEN EGGS.

The question often arises whether the amount of phosphorus in a ration for laying hens affects either the number of eggs laid, their size, or their composition.

If a lack of sufficient phosphorus causes a diminution in the phosphorus content of the eggs produced, this possibly may be one reason why late hatched chicks are less thrifty than those hatched earlier in the season. It is conceivable that a fowl during the normal resting period while moulting and before beginning to lay, stores up a supply of phosphorus in the body which is drawn upon to supplement the amount assimilated from the ration, thus providing the early laid eggs with a liberal supply of the necessary phosphorized materials present in the yolk substances, and that, later in the season, the available stored-up body phosphorus having been used up, the eggs may be less abundantly supplied with these essential compounds, with the effect that the resulting chickens are less perfectly nourished and consequently are weaker. In the absence of a sufficient supply of phosphorus it is conceivable, also, that even though the composition of the phosphorized yolk substances remain unchanged, the relative amount of yolk may be diminished thus weakening the chick. To study this matter a feeding experiment was carried out, and many eggs analyzed by Professor H. K. Knudsen, formerly Assistant Chemist of the Station.

Rations Rich and Poor in Phosphorus Fed to Laying Hens.

This experiment was started February 17, 1912 and was continued until August 1st, with two lots of Single Comb White Leghorn fowls, each consisting of ten pullets and one cockerel.

Both lots were fed dry mash, in hoppers, consisting of a mixture of bolted corn meal and gluten flour. The whole grain consisted of rice fed *ad libitum* in hoppers. In addition to the rice and mash, pen 1 received granulated bone and mica crystal grit *ad libitum*; pen 2, instead of granulated bone received oyster shell.

The following tables show the composition of the feeding stuffs employed and the amounts consumed:

Feeding Stuffs	% Nitrogen	% ash	% phosphoric acid
Granulated bone	4.13	64.45	23.83
Gluten flour	12.9	.66	.41
Corn meal	1.38	.60	.20
Rice	1.23	.80	.34
Oyster shell	Only a trace of phosphorus		

Pen	Granulated bone (pounds)	Mica crystal grit (pounds)	Rice (pounds)	Corn meal (pounds)	Gluten flour (pounds)	Oyster shell (pounds)
Pen 1	49	9.25	244	77	18	
Pen 2		9.	212	80	19	19

The following table shows the egg production by months, the weight of the eggs, and the average weight in grams.

Month	PEN 1			PEN 2		
	Eggs laid	Total weight (grams)	Aver. weight (grams)	Eggs laid	Total weight (grams)	Aver. weight (grams)
Feb. (17)	56	3,078	54.9	30	1,696	56.5
March	136	7,430	54.6	82	4,610	56.2
April	162	8,518	52.6	100	5,483	54.8
May	174	9,280	53.3	82	4,363	53.2
June	158	8,391	53.1	69	3,704	53.6
July	70	3,688	52.7	23	1,219	53.
Total	756	40,385		386	21,075	
Average			53.4			54.6

The above table shows that pen 1, which received granulated bone laid almost twice as many eggs as pen 2 with oyster shell. It must be remembered, however, that the grain part of the ration was selected with particular reference to its low phosphorus content. Also it must be remembered that the granulated bone contained 4.13% nitrogen which might have had some effect in stimulating the greater egg production of pen 1, but as the gluten flour supplied to both lots of fowls was very rich in nitrogen, it is entirely probable that enough protein was available from this source for both flocks.

The following tables show the results of analyses made of eggs laid by each lot of fowls:

Composition of Yolks.

YOLK OF PEN NO. 1.

Date	% of total egg in wet yolk	% of total egg in dry yolk	% phosphoric acid in dry yolk	% phosphoric acid in wet yolk	Weight of one egg	% water in yolk	Number eggs in sample
Feb. 26, 1912.....	28.85	15.00	2.60	1.35	56.85	48.02	2
March 1, 1912.....	30.56	16.05	2.59	1.36	53.18	47.47	6
March 5, 1912.....	31.26	15.85	2.66	1.35	54.82	49.28	12
March 11, 1912.....	29.93	15.43	2.64	1.36	53.96	48.58	5
April 9, 1912.....	30.88	15.89	2.64	1.36	53.98	48.54	6
April 11, 1912.....	32.53	16.56	2.63	1.33	53.75	49.12	6
April 20, 1912.....	31.52	16.25	2.67	1.36	52.66	48.84	6
April 24, 1912.....	30.78	15.64	2.66	1.35	51.83	49.17	6
Average	30.79	15.83	2.64	1.35	53.88	48.63	

YOLK OF PEN NO. 2.

Feb. 26, 1912.....	29.12	15.46	2.66	1.41	60.77	46.92	2
March 1, 1912.....	31.23	15.78	2.64	1.33	58.02	49.48	6
March 5, 1912.....	29.40	15.01	2.64	1.35	57.48	48.96	9
March 11, 1912.....	29.24	14.82	2.59	1.31	53.42	49.34	5
April 9, 1912.....	30.78	15.63	2.68	1.36	54.80	49.21	6
April 11, 1912.....	32.00	16.35	2.57	1.31	54.00	48.88	6
April 20, 1912.....	30.29	15.27	2.63	1.32	54.25	49.71	6
April 24, 1912.....	28.25	14.48	2.67	1.36	53.57	48.88	6
Average	30.04	15.35	2.63	1.34	55.79	48.92	6

Composition of Whites.

WHITE OF PEN NO. 1.

Date	% of total egg in wet white	% of total egg in dry white	% phosphoric acid in dry white	% phosphoric acid in wet white	Weight of one egg	% water in white	Number eggs in sample
Feb. 26, 1912.....	57.88	8.23	.30	.043	56.85	85.77	2
March 1, 1912.....	52.77	7.33	.27	.037	53.18	86.11	6
March 5, 1912.....	55.58	6.78	.28	.034	54.82	87.80	12
March 11, 1912.....	58.02	7.00	.28	.034	53.96	87.93	5
April 9, 1912.....	57.46	7.07			53.98	87.98	6
April 11, 1912.....	55.53	7.08	.31	.040	53.75	87.25	6
April 20, 1912.....	56.25	6.90	.24	.029	52.66	87.73	6
April 24, 1912.....	56.88	7.08	.26	.032	51.83	87.55	6
Average	56.30	7.18	.28	.036	53.88	87.27	

WHITE OF PEN NO. 2.

Feb. 26, 1912.....	60.64	8.33	.27	.036	60.77	86.50	2
March 1, 1912.....	55.92	7.08	.27	.034	58.02	87.34	6
March 5, 1912.....	58.80	7.54	.29	.037	57.48	87.18	9
March 11, 1912.....	58.33	7.15	.29	.036	53.42	87.75	5
April 9, 1912.....	57.39	7.14	.31	.039	54.80	87.56	6
April 11, 1912.....	55.71	6.99	.29	.036	54.00	87.45	6
April 20, 1912.....	58.56	7.28	.29	.036	54.25	87.57	6
April 24, 1912.....	60.45	7.82	.24	.031	53.57	87.07	6
Average	58.23	7.42	.28	.036	55.79	87.30	

Composition of Shells.

SHELLS OF PEN NO. 1.

Date	% of total egg in wet shells	% of total egg in dry shells	% phosphoric acid in dry shells	% phosphoric acid in wet shells	Weight of one egg	% water in shells	Number eggs in sample
Feb. 26, 1912.....	11.26	10.10	.29	.26	56.85		2
March 1, 1912.....	10.69	9.97	.32	.30	53.18		6
March 5, 1912.....	11.85	10.41	.30	.26	54.82	14.43	12
March 11, 1912.....	12.04	9.90	.31	.25	53.96	17.82	5
April 9, 1912.....	11.36	9.79	.32	.28	53.98	13.90	6
April 11, 1912.....	11.78	10.21	.29	.25	53.75	13.33	6
April 20, 1912.....	11.38	9.76	.29	.24	52.66	16.98	6
April 24, 1912.....	11.65	10.17	.29	.25	51.83	12.76	6
Average	11.50	10.04	.30	.26	53.88	14.87	

SHELLS OF PEN NO. 2.

Feb. 26, 1912.....	9.54	8.47	.27	.24	60.77		2
March 1, 1912.....	11.52	9.76	.28	.24	58.02	15.23	6
March 5, 1912.....	11.02	9.55	.27	.23	57.48	13.32	9
March 11, 1912.....	11.75	9.93	.31	.26	53.42	15.55	5
April 9, 1912.....	11.36	9.44	.29	.24	54.80	16.91	6
April 11, 1912.....	11.40	9.81	.28	.24	54.00	14.51	6
April 20, 1912.....	10.83	9.40	.28	.24	54.25	13.17	6
April 24, 1912.....	11.26	9.85	.29	.25	53.57	12.30	6
Average	11.08	9.53	.28	.24	55.79	14.43	

The Yolks.

Taking up first the composition of the yolks of the eggs from pens 1 and 2, the table shows that both the wet and dry yolks of the eggs laid by pen 1 constituted a larger proportion of the total egg substance than was the case in pen 2. The average for pen 1 gives 30.79 per cent of the total weight of the eggs that were wet yolks, and 30.04 for pen 2. This is a variation of 2.4 per cent, and indicates that when there is a lack of sufficient phosphorus in the ration, the size of the yolk will be diminished. Also, there seems to be slightly more phosphorus in the dry matter itself, where the fowls received an abundant supply of phosphorus in the ration.

The eggs from pen 2 that were analyzed, averaged slightly heavier than those from pen 1. This is in harmony with the table on page 92.

The Whites.

Inasmuch as the yolks from pen 1 were relatively heavier than the yolks from pen 2, one would naturally expect the whites from pen 1 to be relatively lighter than those from pen 2. The tables show this to be the case, as the wet whites average 56.30 per cent of the total weight of the eggs in the case of pen 1 and 58.23 per cent in the case of pen 2. As the analyses of yolk, white and shells were all direct determinations this gives a check upon the accuracy of the analytical results.

The percentage of phosphorus in the whites is identical in both instances, but the percentage of moisture in the whites from pen 2 is slightly greater.

The Shells.

..

Somewhat contrary to what might be expected the shells of the eggs laid by the fowls fed granulated bone, were some-

what heavier in proportion to the total weight of the eggs than was the case with the eggs laid by the fowls fed oyster shell. This variation was practically 5 per cent of the dry weight of the shell.

There was .30 per cent phosphoric acid in the dry shells of pen 1 and .28 per cent in the shells of pen 2. This is a difference of two parts in thirty or 6.66 per cent. This would indicate that some of the tri-calcium phosphate of the granulated bone was used for shell material. Whether this increased amount of phosphorus laid down in the shell can be assimilated by the developing embryo remains for future experiments to determine. It is known however, that a considerable quantity of calcium carbonate is removed from the shell by the embryo during its development and enters directly into the tissues and structure of the chick.

Does the Ordinary Grain Ration Contain Sufficient Phosphorous?

In connection with this investigation it is of interest to determine whether a ration for egg production consisting of grain only, contains sufficient phosphorus for maximum egg production. For our purposes let us select wheat, since this grain contains somewhat more phosphorus than corn. In round numbers a fowl will consume about 70 pounds of grain per year. According to the generally accepted tables, wheat contains .85* per cent phosphoric acid. Consequently seventy pounds of wheat would contain .595 of a pound of phosphoric acid.

The table on page 77 shows that pen 3 laid during the year 158,910 grams of eggs. As there were 20 layers in that pen each hen laid an average of 7,945.5 grams of eggs.

The average of all analyses of eggs laid by pen 1 showed that they contained .47 per cent of phosphoric acid. Making the necessary calculation it is seen that a fowl laying as well as the fowls in pen 3 would require in the course of a year 37.34 grams phosphoric acid for use solely in egg building. This is equivalent to .082 of a pound or slightly more than one-seventh of that contained in the 70 pounds of wheat.

As far as the writer is aware there are no tables showing the average digestibility of phosphoric acid in the various feeding stuffs. At least no experiments along this line have been performed with poultry, but these figures would indicate that there is enough phosphoric acid in the ordinary grains

*Lanes' and Gilbert's Tables.

for all the requirements of fowls. Other experiments tend to show however, that the phosphorus in a ration consisting entirely of grain, has a very low digestibility and that fowls have great difficulty in getting enough phosphorus for their needs from this source.

In bulletins No. 149 and 171 of the New York Agricultural Experiment Station, are recorded the results of experiments by W. P. Wheeler in feeding rations wholly of vegetable origin as compared with rations partly of animal origin. The latter of course, containing much larger amounts of phosphorus than the rations wholly of vegetable origin. The following quotations are from the publications referred to.

"The rations in which from 40 to 50 per cent of the protein was supplied by animal food gave in every trial, (with chicks, pullets, cockerels and ducklings) more economical results than the contrasted rations in which most of the protein came from vegetable sources"

"Although it was found possible, when using a large number of foods in contrasted rations of these kinds, to have the ordinary groups of organic compounds in approximately equal proportions, there was always a much larger amount of mineral matter in the one ration, owing to the bone of the animal meal. Consequently there was sometimes nearly three times as much phosphorus in the one ration as in the other. Calculating all the phosphorus as phosphoric acid there was in the animal meal ration fed to chicks and hens generally about 3.9 per cent of phosphoric acid, while in the ration of vegetable origin there was about 1.4 per cent. In the contrasted rations for ducklings there were 4.0 per cent, and 1.9 per cent of phosphoric acid respectively."

"By using bone ash in another series of experiments the amount of phosphorus was made to equal and sometimes to slightly exceed that in the animal food ration, although all the organic matter was still derived from vegetable food. There was in the animal food ration fed to chicks, phosphorus equivalent to about 3.9 per cent of phosphoric acid and in the contrasted rations about 4 per cent. The animal food ration for ducklings contained about 3.6 per cent of phosphoric acid, and the vegetable food ration about 4.0 per cent. Both rations for laying hens contained about 3.6 per cent of phosphoric acid. Practically the same relative amounts of protein, fats and carbohydrates existed in the contrasted rations. The vegetable food ration, thus supplemented by the mineral matter of bone ash, when fed to chicks proved fully equal to the ration containing animal meal so far as rapidity of growth was concerned. In economy it was even somewhat superior,

for considerably less food was required for equal results. For laying hens the rations were equal in efficiency for several months, but the ration containing animal food proved somewhat more enduring in its effects. With ducklings the ash-supplemented ration of vegetable food proved decidedly inferior to the corresponding ration containing animal food."

"From these results it appears that rations containing a necessary amount of protein and having the relation of the ordinary constituents considered satisfactory, may be inferior because of a lack of mineral matter, probably phosphates."

Further Experiments Concerning the Phosphorus Content of Poultry Rations.

This test was begun January 3rd., 1913, with two lots of Single Comb White Leghorn pullets, each lot containing fifteen pullets and one cockerel, and was continued for 135 days. The pullets were from a late hatch and were just beginning to lay, when the test began.

The following table shows the average weight of the fowls at the beginning of the test and at various times during the test:

Weight of Fowls (Pounds).

Month	Pen 1	Pen 2
January 3	4.00	4.17
February 1	3.92	4.09
March 1	3.88	4.12
April 1	3.66	3.75
May 17	3.36	3.39

Both pens decreased in weight during the test. One hen was removed from pen 1 March 31st., and another hen February 26th, both being out of condition.

Amount and Kind of Feed Consumed (Pounds).

Feed	Pen 1	Pen 2
Bone ash (grams).....	5,308	
Oyster shell (lbs.).....		9.5
Corn meal (lbs.).....	138	135
Gluten flour (lbs.).....	27.6	27
Rice (lbs.)	171	202

The following tables show the number of eggs laid and their average weight in grams:

Eggs Laid.

Month	Pen 1	Pen 2
January, 1913	49	23
February	31	14
March	68	102
April	148	137
May	72	59
Total	368	335

The above table shows that, in spite of the fact that two hens were removed from pen 1, yet the egg production was greater than in the case of pen 2.

Average Weight of Eggs (Grams).

	Pen 1	Pen 2
January, 1913	55.16	58.13
February	55.58	58.92
March	52.86	55.27
April	50.89	52.74
May	50.85	50.46
Average	53.07	55.10

The table shows that the eggs laid by pen 2 were slightly larger than those laid by pen 1.

The most striking thing in connection with this table is that there is a gradual decrease in the weight of the eggs. The eggs laid by pullets fed a normal ration, should gradually increase in size as the pullets get older, but in this case there has been a marked decrease showing that the size or weight of the egg depends upon the ration that the fowls receive.

In both instances what must be considered an abnormal ration was fed, and the results indicate that if a fowl is not properly nourished the size of the egg is decreased.

The fowls receiving the bone ash laid better than those fed oyster shells, but it is difficult to understand why the eggs laid by lot 2 should be heavier than those laid by the other lot of fowls, although this is in harmony with the previous year's results.

The results of these tests indicate that when laying hens are fed a ration too poor in phosphorus the relative size of the yolks of the eggs is reduced; the yolks and shells contain a slightly less percentage of phosphorus; and the total number of eggs laid is materially diminished.

During the course of a year, and under normal conditions there is phosphorus equivalent to about 37 grams of phosphoric acid present in the eggs laid by a hen. The ordinary grain ration fed to laying hens contains several times as much phosphorus as is found in the eggs produced.

This subject needs further study particularly with reference to the influence of small yolks and low phosphorus content of yolks and shells, upon the vigor of chicks hatched from such eggs.

METHODS USED IN ANALYZING EGGS.

Phosphoric Acid Content in Eggs.

The chemical composition of eggs is well known, yet the methods of analysis have been but meagerly discussed. As a method had to be adopted for use during the entire investigation in order to obtain comparable results and as each investigator seems to have had a method of his own, it was thought advisable to make some preliminary tests. The main difficulty consists in the elimination of the organic matter without causing a loss of the mineral constituents and this can be accomplished in a wet or dry way.

The wet methods depend on the oxidation of the organic matter by strong acids either alone or with some salt. Digestion with the following acids and salts were taken up: (1) Sulphuric acid and ammonium nitrate. (2) Nitric acid either alone or together with hydrochloric acid or bromine. In each case the digestions required a long time and gave unsatisfactory results. Sulphuric acid and ammonium nitrate will destroy the organic matter but the large amount of sulphates prevents the complete precipitation of the phosphoric acid. The sample went readily into solution with nitric acid, but on dilution and evaporation substances separated out which contained traces of phosphoric acid.

The well known method of Carius was then resorted to—digestion with nitric acid under pressure. The result obtained at 200 degrees C. to 220 degrees C. for four hours were entirely satisfactory, but it was thought best to try to find a less dangerous method. Burning the sample in oxygen in a bomb gave very encouraging results, but it was soon found it would require a bomb especially constructed and this method was abandoned.

The dry methods depend on the oxidation of the organic matter by salts rich in oxygen. This is brought about by mixing thoroughly the salt and sample and gently applying heat. After trying the chlorates, nitrates and peroxides of the alkali metals and alkaline earth metals, it was found that barium nitrate gave the best results. Three grams of the sample were weighed out and ground with six grams of barium nitrate. The mixture was then compressed in a short steel cylinder, the oil and readily volatile matter being absorbed by the barium nitrate. The sample was then carefully removed to a platinum crucible of about 60 cc capacity and placed over a Bunsen burner. Almost instantly combustion took place without smoke or odor. In the course of one minute the combustion was complete, leaving a white ash. The ash was then fused with sodium potassium carbonate in the same crucible. After the fusion was completed it was extracted with hot water and the barium carbonate filtered off. The solution was then acidified and treated as usual. The barium carbonate was dissolved in nitric acid and then concentrated to allow the bulk of the barium nitrate to crystalize out and be filtered off. The filtrate was always found to contain a small amount of phosphoric acid which was precipitated in the regular way and brought on the same filter as the main portion. It was not considered safe to titrate the phospho-molybdate, as it was noticed that free molybdic acid has a tendency to separate out, especially in cases where the barium nitrate had not been separated.

In the combustion it is very essential not to have a large excess of barium nitrate, also that the mixture be compressed into compact shape. The results obtained by this method checked very well with those obtained by the Carius method.

Preparing the Sample.

The shell, yolk and white were first separated. This was easily accomplished by hard boiling,—the loss of phosphates occasioned by the leaching effect of the water being very small.

The samples were then dried in a partial vacuum at the temperature of boiling alcohol.

GENERAL CONCLUSIONS.

The average weight of eggs varies from month to month, reaching the maximum in the early spring when the fowls are heaviest and laying most freely.

Eggs from White Leghorns do not reach their maximum weight until the hens are at least in their third laying season.

Scanty feeding reduces the number and size of eggs.

Liberal feeding increases the number and size of eggs.

Eggs from scantily fed fowls do not hatch as well as eggs laid by fowls fed more liberally.

The weight of eggs is reduced when fowls are fed a ration in which the necessary nutritive constituents are not present in proper amount or in proper proportions.