A STUDY OF SELECTIONS FOR THE VARIATION AND INHERITANCE OF THE SIZE, SHAPE AND COLOR OF HENS' EGGS

A THESIS

PRESENTED TO THE FACULTY OF THE GRADUATE SCHOOL OF CORNELL UNIVERSITY

FOR THE DEGREE OF

DOCTOR OF PHILOSOPHY

BY

EARL WHITNEY BENJAMIN

1914, 1920

A STUDY OF SELECTIONS FOR THE VARIATION AND INHERITANCE OF THE SIZE, SHAPE AND COLOR OF HENS' EGGS

A THESIS

PRESENTED TO THE FACULTY OF THE GRADUATE SCHOOL OF CORNELL UNIVERSITY

FOR THE DEGREE OF

DOCTOR OF PHILOSOPHY

BY

EARL WHITNEY BENJAMIN

1914, 1920

CONTENTS

A STUDY OF SELECTIONS FOR THE SIZE, SHAPE, AND COLOR OF HENS' EGGS

A STUDY OF SELECTIONS FOR THE SIZE, SHAPE, AND COLOR OF HENS' EGGS[1]

EARL W. BENJAMIN

The study here reported was conducted from the spring of 1911 until 1919, with the purpose of determining the results that may be obtained by selecting the breeding stock of the domestic fowl, and the eggs for hatching, in order to change the size, shape, and color of the eggs produced by the offspring. There is a certain type of egg which especially meets the desires of the respective customers in various markets. It is usually not practicable to grade the eggs closely, and it becomes necessary to select and develop the flocks so that the proportion of eggs unsatisfactory to the customer may be reduced to the minimum.

The wholesale trade of the New York City market requires the size and shape of the eggs to be such that the eggs are not crowded, but fit snugly, in the fillers of the commercial thirty-dozen cases; this means an egg about $2\frac{3}{8}$ inches long and $1\frac{3}{4}$ inches wide, and usually weighing from 2 to $2\frac{1}{8}$ ounces when fresh. Shipping only the eggs of proper size and shape insures less breakage, better appearance, and a resulting higher sale value. The New York City market has a special demand for white-shell eggs and will sometimes pay from eighteen to twenty cents a dozen more for eggs having chalk-white shells than for those varying from cream-tinted to brown.

REVIEW OF LITERATURE

The study of the external characters of eggs seems to date from a comparatively recent period, and even at the present time the published data with respect to these characters are very meager.

Tradition tells us (in Horace, Lib. II, st. 4) that the eggs of pullets are longer than those of hens, and that pullets' eggs produce a larger proportion of male chicks than do hens' eggs. This tradition has been developed until many persons believe that long eggs produce cockerels and round eggs produce pullets when incubated.

[1] This study completes the work reported in part in a thesis presented by the writer to Cornell University in 1912 for the degree of master of science in agriculture, and continued in a thesis presented to Cornell University in 1914 in partial fulfillment of the requirements for the degree of doctor of philosophy.

The size and shape of the egg is shown by Curtis (1911 a)[2] and by Surface (1912) to be due partly to the structure of the oviduct, which may probably be considered an inherited character as claimed by Newton (1893–96). This is in accordance with the view of Thompson (1908). This physical influence on the size and shape of the egg described by Thompson (1908) is denied by Horwood (1909), but without convincing evidence.

The shape of the egg seems to depend on its size, according to Curtis (1914 a). The same author shows good correlations between the two dimensions of eggs, and between either of these dimensions and the weight. This agrees with the conclusions of Pearl and Curtis (1916).

Curtis (1914 a) claims that the larger eggs are due to a greater relative deposition of egg white, while Atwood (1914) finds indications contrary to this.

The size of the egg seems to be affected by the feed, according to Atwood (1914), and the same author shows a marked seasonal fluctuation in the weight of eggs laid, the weight gradually increasing from July to February and decreasing from March to July. This agrees with Curtis (1914 a) and with Féré (1898 b), who claim that the eggs are smaller at both the beginning and the end of the litter. Rice, Nixon, and Rogers (1908) and Riddle (1911) show a striking effect of the amount of food consumed on the number of eggs produced. According to these workers, both the amount of food consumed and the number of eggs produced seem to be variable factors agreeing in their seasonal fluctuations with the size of the egg, as just noted. Curtis (1914 a) also shows a gradual reduction in size for the successive eggs in the clutch. Hadley (1919) shows a monthly fluctuation in the egg weight of thirty-nine White Plymouth Rocks which corresponds closely with the monthly numerical production. He finds also that the percentage increase in egg weight during the two modal months of increased production (April and September) is positively indicative of the relative annual numerical production of the respective birds.

According to Curtis (1914 a), the size of the eggs increases as the bird matures. Curtis states also that the variations among the eggs produced by individuals were not so great as the variations in the flock's production, and seemed to diminish as the birds matured. This agrees with the

[2] Dates in parenthesis refer to *Bibliography*, page 310.

results obtained in a study of the number of leaves to a whorl in Ceratophyllum made by Pearl, Pepper, and Hagle,[3] and in a later study for egg shape made by Pearl (1909). Similar variations in sparrows' eggs have been observed also by Pearson (1902 b).

Stewart and Atwood (1909) report that chicks hatched from pullets' eggs are not so large nor so vigorous as those hatched from the eggs of hens two and three years old. Atwood (1914) mentions this fact as showing that chicks hatched from larger eggs are larger and more vigorous than others. It would seem that there is danger here of attributing any possible defect of the embryo due to the immaturity of the parent, to the smaller size of the egg, which also is due to the immaturity of the parent. The writer does not see proof that a smaller egg produces a smaller and weaker chick irrespective of the maturity and condition of the parent.

Pearl and Curtis (1916) found that the two characters size and shape, as measured by weight, length, and breadth, show different degrees of variability, ranging from the most variable to the least variable in the order named. Pearl and Curtis were able also to strengthen their previous conclusions that the index and the weight are negatively correlated. They found that dwarf or abnormal eggs do not occur more frequently at the beginning or at the end of the litter than at other times. During the eight years previous to their study, 5.15 per cent of all the birds kept at the Maine experiment station produced one or more dwarf eggs, and only 3.5 per cent of this 5.15 per cent produced more than two dwarf eggs.

Abnormal types of eggs have been reported also by Von Nathusius (1895), Féré (1897 and 1898 b), Herrick (1899, a and b), Hargitt (1899 and 1912), Parker (1906), Patterson (1911), Glaser (1913), Curtis (1914 b), Chidester (1915), and Weimer (1918). Some of the abnormalities reported might, of course, prove to be inherited, especially such as the double yolks found by Glaser (1913); however, since this publication is concerned with normal eggs, further discussion of rare monstrosities may be omitted.

The coloration of the shells of eggs has long been a subject of interest to oölogists. According to Newton (1893–96), older birds usually lay darker-shell eggs. Newton says that some of the color is applied to the

[3] Variation and differentiation in Ceratophyllum. By Raymond Pearl, Olive M. Pepper, and Florence J. Hagle. Carnegie Inst. Pub. no. 58: 1–136. 1907.

shell early in its development, while some is added later — as is indicated by the lighter shade of an egg that has been laid prematurely, due to some excitement. The intensifying of the pigment with the age of the bird is supposed to continue until she has attained her full vigor, when the tint begins to decline gradually. Newton believes that except for individual differences the pigment is fairly constant in supply.

Sorby (1875) found seven substances which in various mixtures are supposed to produce all eggshell colors. These substances were oorhodeine, oocyan, banded oocyan, yellow ooxanthine, rufous ooxanthine, a substance giving narrow absorption-bands in the red, and lichnoxanthine. They are said to be closely connected with either haemoglobin or bile pigments.

M'Aldowie (1886) and many others have advanced theories as to the cause of variation in eggshell color. The general opinion seems to be that the color is very unstable and variations do occur frequently, and that general tints or colors are inherited. Horwood (1909) gives it as his opinion that coloration of the shells of birds' eggs has absolutely no connection with mendelian principles.

According to Surface (1912), the color of eggshells is probably added from glands in the vagina or adjoining parts of the oviduct, and it may reasonably be supposed that a function of this nature would be inherited. Such a supposition agrees with the results of Benjamin (1912 and 1914), which are discussed later in this report.

All these studies, made by various workers, show conclusively that with respect to many characters, including size, shape, and color, there is a characteristic type of egg to be accredited to each individual, and that some degree of inheritance has been found to exist.

METHODS OF INVESTIGATION

The investigation described in this memoir was begun, in the spring of 1911, by selecting fifty eggs for hatching for each of the following nine characters — three characters being grouped in each of three selection studies:

Size selections	Shape selections	Color selections
Large	Long	Chalk-white
Medium	Normal	Cream-tinted
Small	Round	Brown-tinted

The eggs were selected from three-year-old Single Comb White Leghorn hens, and an effort was made to get eggs from hens that consistently laid the type of egg selected. The Single Comb White Leghorn breed was used for the study because, first, it is the commonest breed in New York State, and secondly, because it was desired to study these commercial characters of eggs by the use of commercial breeds, and the Leghorn predominates on commercial egg farms in the United States. The birds used were from the high-producing trap-nested stock of the well-established Cornell strain.

SIZE CHARACTER

The basis for selecting eggs for the size character was weight. A Harvard balance, equipped with a slide reading to 10 grams in tenths, was used early in the work, but this was later replaced by a special direct-reading balance (fig. 7).[4] Exact weights were used at first, but later the weights were recorded in 2-gram classes and could be transferred directly for use in the correlation tables. Eggs weighing more than 50 grams and not more than 52 grams were recorded as 51 grams in weight and were grouped in the 50–52-gram class in the correlation tables.

The eggs were weighed as soon as possible after they were laid, in order to avoid any serious losses due to evaporation. When it was necessary to hold them for some time before weighing, they were kept packed and in a cool, rather moist, place. After January, 1913, the eggs were held in an artificially cooled room at a temperature of from 32° to 40° F.

The eggs selected for incubation each year were weighed, as well as all the eggs produced by any of the hens in the size-character studies. In the early part of the work the eggs selected for incubation were also measured and their length and breadth recorded.

Just before hatching, the eggs were placed in pedigree trays. The trays used in 1911 were so constructed that it seemed advisable to put into one compartment all the eggs produced by the same hen. If more than one egg in a compartment hatched, it was necessary to use the average of all the hatched eggs in that compartment, in order to calculate the average type of egg which hatched. This gave a fairly accurate result because, as a rule, all the eggs laid by the same hen are of the same general type. However, as this method allowed the possibility of some error,

[4] This balance was imported by Cornelius Kahlen, New York City.

FIG. 7. SPECIALLY DESIGNED DIRECT-READING BALANCE FOR WEIGHING EGGS AND CHICKS

all incubated eggs were individually pedigreed after 1911. For the 1912 and 1913 hatches, the compartments of the pedigree trays were made small enough to hold just one egg, and thus it was possible to know from which egg each chick hatched. In the 1914 hatch and after that time, the chicks were satisfactorily hatched in cloth bags.

The day-old chicks were weighed on the same direct-reading egg scales as were used for the eggs. After this first weighing the chicks were individually weighed every four weeks on a special type of milk balance, by which the weights could be accurately estimated to 1/100 pound. When these weights were transformed to grams, as was done for some of the correlation tables, the calculation was made by means of the formula, 1 pound = 453.6 grams. In the early part of the work a separate record was made of the vigor of the chicks.

SHAPE CHARACTER

The basis for selecting eggs for shape was the index figure obtained by dividing the greatest width of the egg by its greatest length and

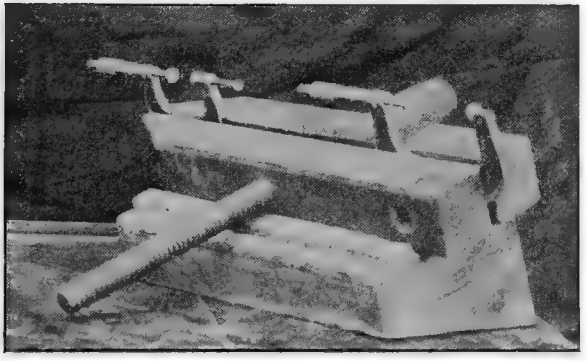

FIG. 8. SPECIALLY DESIGNED RATCHET MICROMETERS HELD BY WOODWORKING CLAMP, FOR EGG MEASUREMENTS

multiplying the result by 100. The measurements were made by specially constructed ratchet micrometers with a $\frac{1}{2}$-inch face (fig. 8).[5] One micrometer was adjusted for the egg length and one for the egg width.

[5] These were manufactured by Brown & Sharpe, Providence, Rhode Island.

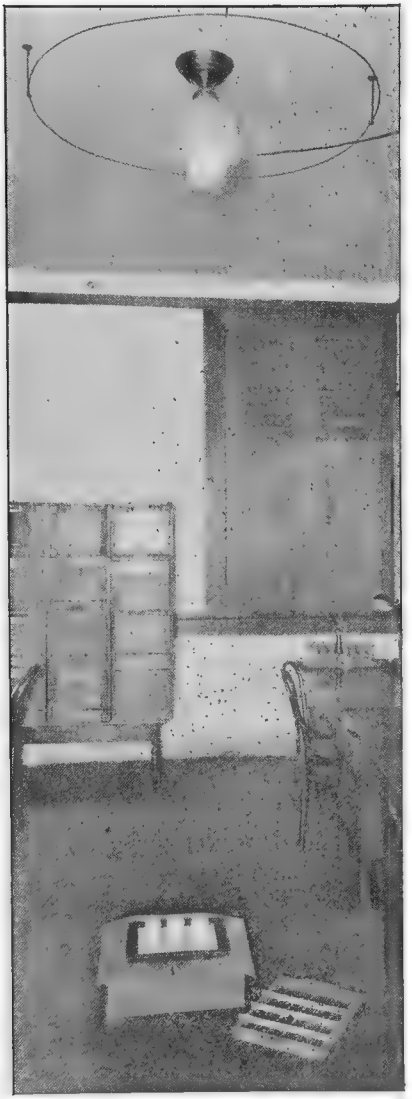

FIG. 9. LIGHT, AND FRAME FOR HOLDING EGGS, AS USED FOR THE SHADOW PHOTOGRAPHIC PROCESS

The wire circle around the light was used early in the work to hold a curtain for preventing reflection of light from the sidewalk. The eggs are shown as they are placed on the film ready for exposure. At the right is shown the frame used for arranging the eggs in their proper positions

The micrometers were held in a woodworking clamp to prevent error due to expansion which might result if they were warmed by being held in the hand of the operator.

All eggs incubated for the shape-character studies, or produced by hens in the shape-selection studies, were measured and the data recorded.

PHOTOGRAPHING THE EGGS FOR SIZE AND SHAPE STUDIES

It was thought desirable to have some sort of graphic representations of the eggs selected for size and shape, and to compare these with representations of the eggs that the pullets produced during the following year. Photography was the first method of representation considered. Since this was very expensive, however, the practice of allowing the shadows of the eggs to fall directly on sensitized photographic paper was adopted.[6] A sheet of sensitized paper, 9 by 11 inches in size, is slipped into the back of a specially constructed frame, where it is held securely by a wooden support. The sensitized paper is slipped in back of a sheet of stock film glued in the frame; this film, if kept clean, does not hinder the reproduction, reflects much of the diffused light, and thus prevents the blurring of the shadow.[7]

The eggs are placed on the film as shown in figure 9, and are held in

[6] It was necessary to use high-contrast paper for this work, in order to obtain distinct black and white tones.

[7] This stock film is the base used for photographic films before the gelatinous coating is applied. It is transparent.

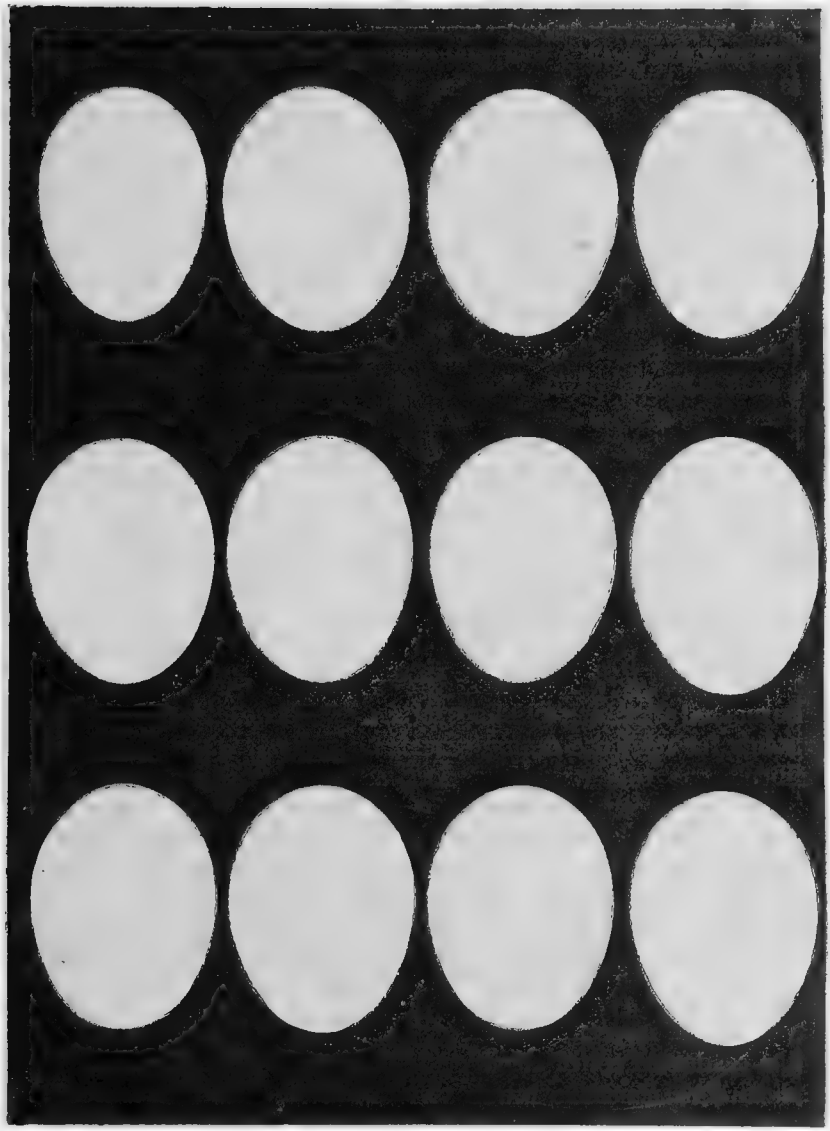

FIG. 10. PHOTOGRAPHIC STUDY OF SIZE AND SHAPE CHARACTERS

This shows the appearance of the sensitized paper after exposure under the eggs and subsequent development. A record is made at the time of the exposure, identifying each egg so that, if desired, it may be used later in a group with all other eggs laid by the same hen

place by small circles of stock film made by cutting strips of film about 3 inches long and $\frac{1}{8}$ inch wide and gluing the ends together. These film circles are transparent, thus casting no shadow, and are therefore much more suitable than if made of an opaque substance such as cardboard or metal. When the twelve eggs that are to be reproduced on each 9x11-inch sheet are placed on the film, they are arranged evenly by means of a separate frame shown in figure 9, which divides the 9x11-inch space into twelve equal parts. This frame is removed before the reproduction is made. After the frame with the eggs on it is in place under the light, the light is turned on for an exposure varying with its power and its distance from the eggs. In this study, a 200-candle-power tungsten light, with a special parallel-ray reflector, was used, about 9 feet distant from the eggs, and an exposure of just one minute was required. A red light was used when working with the sensitized paper.

After the exposed sheet has been developed, the eggs appear as white outlines on a black background (fig. 10). A key is arranged at the time when the exposure is made, whereby the numbers of the eggs reproduced are known, so that certain eggs can be cut out of the plate at any time, rearranged, and photographed.

COLOR CHARACTER

The method of making selections for the color character, and of recording the colors for reference during succeeding generations of the birds, was a difficult one to develop. Various schemes were contemplated and many of these were tried. Schemes of using color tops or wheels, various types of colorimeters, colored photography, and so forth, were considered, but were discarded as being too slow, expensive, or inaccurate. It is very difficult to match the color of an egg with that of any other surface. It was decided that if a system of matching colors was to be followed, in order to do the work rapidly the eggs must be matched to other eggs of standard colors.

By a careful inspection of all eggs produced on the plant for several days, a graduated set of colors containing about fifty tones from chalk-white to dark chocolate brown was obtained. The first seventeen of these tones were the only ones used in the experiment. The contents of these eggs were blown, and the shells were numbered consecutively and

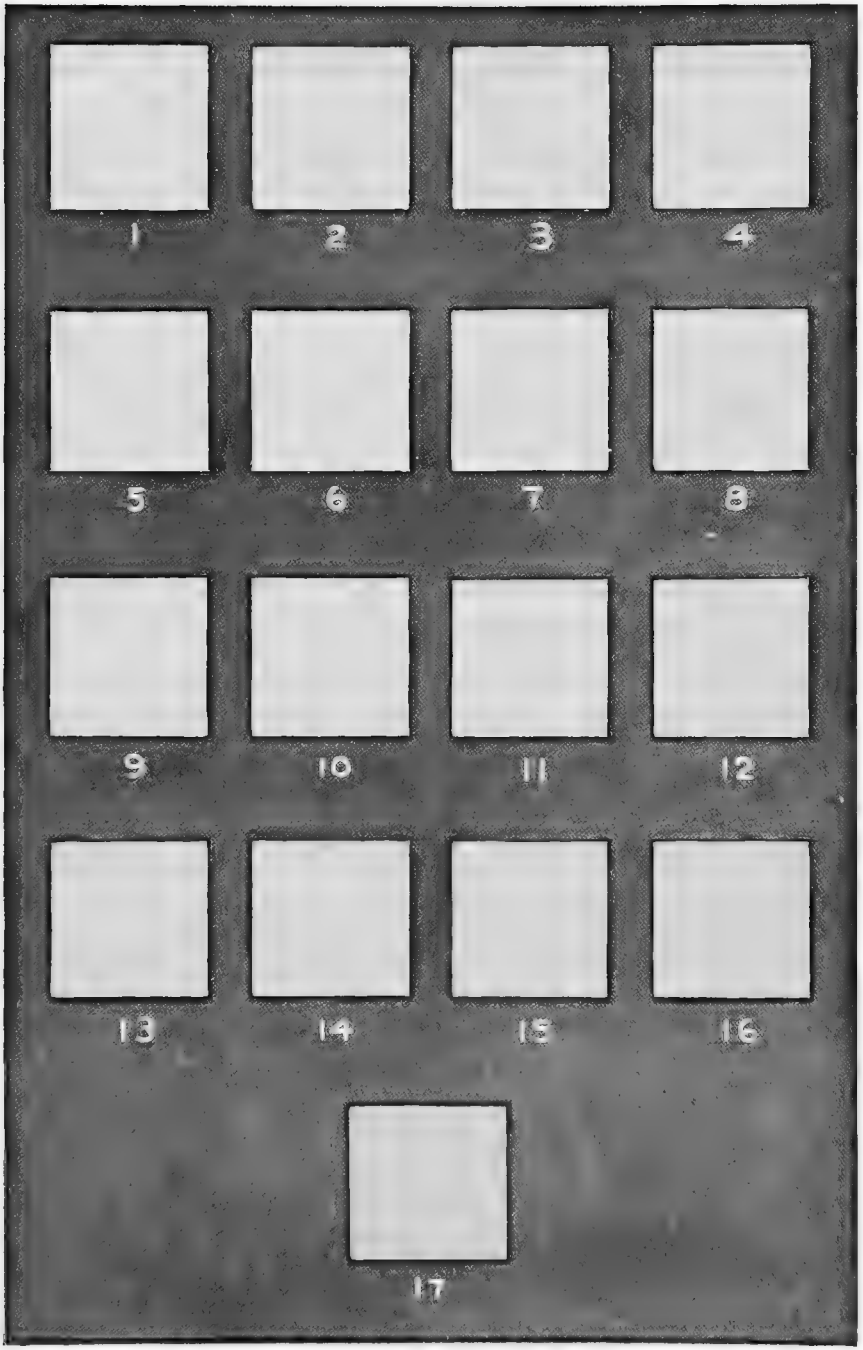
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17

Plate VII

KEY TO COLOR NOTATION USED FOR COLOR STUDIES OF EGGS

Color notation number	Equivalent in *Répertoire de Couleurs*	
	Plate	Ton (Tone)
1	1	1
2	11	1
3	11	2
4	11	3
5	2	1
6	10	1
7	10	2
8	9	3
9	9	4
10	312	1
11	312	2
12	67	1
13	36	1
14	68	1
15	68	2
16	68	3
17	68	4

arranged in a tray. These standard eggs were then carefully matched with their respective colors in *Répertoire de Couleurs*[8] (Plate VII).

The color of eggshells is not permanent and will fade considerably if exposed to the light for any great length of time. The practice was tried of coating the shells with various preparations intended to preserve their color, but this was not successful, as all these preparations contained so much color in themselves that the color of the shells thus coated was materially changed. The method finally followed was to use, as standards, eggs with the natural surface. The tray of eggs was kept covered with a black cloth except when in use, and the standard eggs were replaced with others of identical color at intervals varying with the length of time they were used.

A clear north light is necessary for accurate color selection, and one must have a trained eye in order to be sure of recording the correct color. The terms *chalk-white*, *cream-tinted*, and *brown-tinted* are used merely to designate the three groups of colors, in order to show the type of eggs selected for each lot. The color recording was done by one person early in the experiment and by another person later. A trial was made of color recording by several inexperienced persons on the same set of eggs for several succeeding days, and the percentage of error was found to be very slight. The same standard scale of colors was used thruout the work. The colors were numbered as shown in Plate VII, and these numbers were used in the correlations and other calculations.

METHODS COMMON TO STUDIES OF ALL THE CHARACTERS

The chicks used in this study were reared by standard methods, in colony houses with the other experimental chicks on the Cornell experimental farm. Previous to 1913 the mature birds were kept in a narrow house divided into nine pens, one pen for each of the nine characters. Under these conditions the one selected male bird for each pen was allowed freedom in the pen. During the 1913 breeding season and after, individual mating coops were installed, and individual mating was followed for the remainder of the experiment. New houses were used for the stock after 1913 (fig. 11). All feeding, trap-nesting, and other details of management

[8] Répertoire de couleurs. Published by La Société Française des Chrysanthémistes and René Oberthür, with the collaboration of Henri Dauthenay and others. 1905.

were conducted under the supervision of the manager of the Cornell poultry farm and in accordance with the usual practice on that farm.

The general plan was to save all the chicks until maturity and then save as many typical specimens from each group as could be satisfactorily housed. Usually about 120 females and 30 males were kept for the study of the three characters, size, shape, and color. When the surplus stock was culled each fall, an effort was made to save the birds

FIG. 11. TYPE OF HOUSE USED FOR STOCK AFTER 1913

representing the extremes of the types. If there were birds that had produced no chicks during the previous breeding season, these birds were usually culled. In cases in which nearly all the members of a certain family had developed only a medium quality for the character studied, the whole family was often culled to make room for more promising birds.

A large proportion of cockerels and pullets were usually saved for the first year, and these were culled fairly closely before being used as breeders during the succeeding years.

These methods of selection explain why so few records are actually available for the study of some of the characters.

In following the method of individual mating, each male to be mated with any females in the pen is retained in a coop. Whenever a female is removed from the trap nest, the attendant finds her band number on a posted list and learns the band number of the male with which she is to be mated. Before placing her in the mating coop, however, the work is further checked by looking for the hen number on a tag attached to the coop, and also by comparing the color of her band with the color of the male's band. The female is then placed in the coop and removed at the time of the next inspection of the trap nests. Usually about twelve mating coops were needed in each house.

Every egg laid by the mature birds is recorded as to either its size, its shape, or its color, in the same way as the original incubated eggs were recorded. This enables the investigator to compare the character of the egg incubated with the eggs which the resulting pullet produces. Many of the eggs from hens in the size and shape selections were also photographed, as previously explained.

RESULTS

The results of the investigation may properly be grouped into those concerned with the inheritance studies and those concerned with other related studies, the former being dealt with first.

INHERITANCE STUDIES

Variability of production due to differences between the parent types

An effort was made to determine to what extent the variability of a bird's production was dependent on the differences existing, for the particular character, in the respective dam and sire. The studies made in this regard are illustrated in tables 1 to 12, and a summary is given in table 13. In constructing these tables, the standard deviations for each of the three egg characters considered, for each respective year's production, were calculated, and these were correlated with the differences existing between the means of the respective egg character for all the eggs produced during the life of the respective dam, and as calculated for the respective sire.[9]

[9] The life mean for the sire was obtained by averaging his respective dam and sire. The character of the egg from which the first sires used in the study were hatched, was taken as the mean for these first sires. When a class is designated by one figure, that figure represents the upper limit of the class; when a class is designated by two figures, the upper figure is included in the class.

It is clear that no correlation exists for these characters. This statement, of course, has reference to the first generation only. This result does not show that when comparing the mean characters for the several offspring from a certain mating, one may not find a variability depending on the difference between the same characters for the respective dam and sire.

TABLE 1. STANDARD DEVIATION OF EGG SIZE (WEIGHT IN GRAMS) DURING FIRST YEAR OF PRODUCTION, SUBJECT; DIFFERENCE BETWEEN EGG-SIZE LIFE MEAN FOR DAM AND FOR SIRE, RELATIVE

Coefficient of correlation = .012 ± .052

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	
1.0–1.5			1		2					1													4
1.5–2.0	2	1			1		1	2		1		1											9
2.0–2.5	4	2		2		4	2	1	7	4	2	2	3										33
2.5–3.0	11	5	3	2	1	7	2	8	3	3	2	1	4									1	53
3.0–3.5	6	3	3	4		1	7	5	2	7		6	1	1	1								47
3.5–4.0	3	2	1	1			2	1	1	3	1		1						1				17
4.0–4.5			1			1	1																3
4.5–5.0																							0
5.0–5.5																							0
5.5–6.0										1													1
6.0–6.5																							1
6.5–7.0																							0
7.0–7.5							1																1
	26	13	10	9	4	13	16	17	13	20	5	10	9	1	1	0	0	0	1	0	0	1	169

TABLE 2. STANDARD DEVIATION OF EGG SIZE DURING SECOND YEAR OF PRODUCTION, SUBJECT; DIFFERENCE BETWEEN EGG-SIZE LIFE MEAN FOR DAM AND FOR SIRE, RELATIVE

Coefficient of correlation = — .28 ± .08

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	
1.5–2.0						1	1													2
2.0–2.5			1			2	2	2	1	2	2								1	18
2.5–3.0	2	3	1	2	1	2	2	4	4	2	1	3								27
3.0–3.5	2	2	2	1					3											10
3.5–4.0								1		1										2
4.0–4.5		1				1														2
	4	6	4	3	1	6	5	7	8	5	3	3	0	0	0	0	0	0	1	56

TABLE 3. STANDARD DEVIATION OF EGG SIZE DURING THIRD YEAR OF PRODUCTION, SUBJECT; DIFFERENCE BETWEEN EGG-SIZE LIFE MEAN FOR DAM AND FOR SIRE, RELATIVE

Coefficient of correlation = .13 ±.12

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	
1.5–2.0								1												1
2.0–2.5		1		1							1									3
2.5–3.0		1		1		4		2	1	3	1									13
3.0–3.5	1	1						1				2							1	6
3.5–4.0					1			1	2											4
4.0–4.5																				0
4.5–5.0																				0
5.0–5.5								1												1
5.5–6.0									1											1
	1	3	0	2	1	4	0	6	4	3	2	2	0	0	0	0	0	0	1	29

TABLE 4. STANDARD DEVIATION OF EGG SIZE DURING FOURTH YEAR OF PRODUCTION SUBJECT; DIFFERENCE BETWEEN EGG-SIZE LIFE MEAN FOR DAM AND FOR SIRE, RELATIVE

Coefficient of correlation = — .16 ± .20

	1	2	3	4	5	6	7	8	9	10	11	12	
2.0–2.5				1						1	1		3
2.5–3.0				1		1					1		3
3.0–3.5								2		1			3
3.5–4.0													0
4.0–4.5	1											1	2
	1	0	0	2	0	1	0	2	0	2	2	1	11

TABLE 5. STANDARD DEVIATION OF EGG SHAPE DURING FIRST YEAR OF PRODUCTION, SUBJECT; DIFFERENCE BETWEEN EGG-SHAPE LIFE MEAN FOR DAM AND FOR SIRE, RELATIVE

Coefficient of correlation = .18 ± .08

	.01	.02	.03	.04	.05	.06	.07	.08	.09	.10	.11	.12	.13	.14	.15	.16	.17	.18	
1.0–1.5			1																1
1.5–2.0				1		1	1						1						4
2.0–2.5	1	4	3	1		1	1	1			1	1		1				1	16
2.5–3.0	4	2	2	3	2	1	1		2		2		3	1		1			24
3.0–3.5	1	2			1		2				2		1					2	11
3.5–4.0		1		2		2		1			4								10
4.0–4.5						1		1											2
4.5–5.0								1				1							2
	6	9	6	7	3	6	5	4	2	0	9	2	5	2	0	1	0	3	70

TABLE 6. STANDARD DEVIATION OF EGG SHAPE DURING SECOND YEAR OF PRODUCTION, SUBJECT; DIFFERENCE BETWEEN EGG-SHAPE LIFE MEAN FOR DAM AND FOR SIRE, RELATIVE

Coefficient of correlation = .14 ± .10

	.01	.02	.03	.04	.05	.06	.07	.08	.09	.10	.11	.12	.13	.14	.15	.16	.17	.18	
0.5–1.0		1																	1
1.0–1.5																			0
1.5–2.0						1	1												2
2.0–2.5		2	1	1	1	1							1						7
2.5–3.0	1		1			2	1	1					1					1	8
3.0–3.5	3		1		1		1				1					1			8
3.5–4.0	1										1		1						3
4.0–4.5				1										1					2
4.5–5.0																			0
5.0–5.5				1															1
	5	3	3	3	2	4	3	1	0	0	2	0	3	1	0	1	0	1	32

TABLE 7. STANDARD DEVIATION OF EGG SHAPE DURING THIRD YEAR OF PRODUCTION, SUBJECT; DIFFERENCE BETWEEN EGG-SHAPE LIFE MEAN FOR DAM AND FOR SIRE, RELATIVE

Coefficient of correlation = .13 ± .18

	.01	.02	.03	.04	.05	.06	.07	.08	.09	.10	.11	.12	.13	.14	
2.0–2.5				1		1									2
2.5–3.0	2			1	1	1								1	6
3.0–3.5			1										1		2
3.5–4.0	1		1			1									3
4.0–4.5															0
4.5–5.0															0
5.0–5.5															0
5.5–6.0															0
6.0–6.5															0
6.5–7.0								1							1
	3	0	2	2	1	3	0	1	0	0	0	0	1	1	14

TABLE 8. STANDARD DEVIATION OF EGG SHAPE DURING FOURTH YEAR OF PRODUCTION, SUBJECT; DIFFERENCE BETWEEN EGG-SHAPE LIFE MEAN FOR DAM AND FOR SIRE, RELATIVE

Coefficient of correlation = .45 ± .20

	.01	.02	.03	.04	.05	.06	.07	.08	.09	.10	.11	.12	.13	.14	
1.5–2.0	1														1
2.0–2.5				2		1									3
2.5–3.0	1														1
3.0–3.5			2											1	3
3.5–4.0						1		1							2
	2	0	2	2	0	2	0	1	0	0	0	0	0	1	10

TABLE 9. STANDARD DEVIATION OF EGG COLOR DURING FIRST YEAR OF PRODUCTION, SUBJECT; DIFFERENCE BETWEEN EGG-COLOR LIFE MEAN FOR DAM AND FOR SIRE, RELATIVE

Coefficient of correlation = .13 ± .05

	0.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0	5.5	6.0	6.5	7.0	7.5	8.0	8.5	9.0	9.5	10.0	10.5	11.0	
0.25–0.50	2			2																			4
0.50–0.75	1	1	4	1	1				1														9
0.75–1.00	9	5	2	2	1			3	3														25
1.00–1.25	9	7	7	3	1	2		1	7														37
1.25–1.50	4	5	5	4		1	1	2	8	3													33
1.50–1.75	2	3	2	3	1	7	1		2														21
1.75–2.00			3		3	1	1		2	1													11
2.00–2.25	3	3		2		1		1														1	11
2.25–2.50				1	1																		2
2.50–2.75	1			1	1		1																4
2.75–3.00	2	1			1																		4
3.00–3.25		1	1			1	1																4
3.25–3.50		1	1																1				3
3.50–3.75	1	1		1																			3
3.75–4.00																							0
4.00–4.25									1														1
4.25–4.50																							0
4.50–4.75																							0
4.75–5.00									1														1
5.00–5.25																							0
5.25–5.50																							0
5.50–5.75																							0
5.75–6.00				1																			1
	34	28	25	21	10	13	5	7	25	4	0	0	0	0	0	0	0	0	1	0	0	1	174

TABLE 10. STANDARD DEVIATION OF EGG COLOR DURING SECOND YEAR OF PRODUCTION, SUBJECT; DIFFERENCE BETWEEN EGG-COLOR LIFE MEAN FOR DAM AND FOR SIRE, RELATIVE

Coefficient of correlation = .43 ± .07

	0.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0	5.5	6.0	6.5	7.0	7.5	8.0	8.5	9.0	9.5	
0.25–0.50				1																1
0.50–0.75	1																			1
0.75–1.00	4	3																		7
1.00–1.25	2	3	2		2				1											10
1.25–1.50		3	1	2		2	1		2											11
1.50–1.75		3		1			1	2	2											9
1.75–2.00	1			1		1	1		1											5
2.00–2.25			1	1		2			3											7
2.25–2.50	1					1			1											3
2.50–2.75		2						1		1										4
2.75–3.00	1						1													2
3.00–3.25		1						1												2
3.25–3.50	1						1													2
3.50–3.75																				0
3.75–4.00	1																			1
4.00–4.25									1											1
4.25–4.50																				0
4.50–4.75					1															1
4.75–5.00																				0
5.00–5.25																				0
5.25–5.50																				0
5.50–5.75																			1	1
	12	15	4	6	3	6	5	4	11	1	0	0	0	0	0	0	0	0	1	68

TABLE 11. STANDARD DEVIATION OF EGG COLOR DURING THIRD YEAR OF PRODUCTION, SUBJECT; DIFFERENCE BETWEEN EGG-COLOR LIFE MEAN FOR DAM AND FOR SIRE, RELATIVE

Coefficient of correlation = .52 ± .13

	0.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0	5.5	6.0	6.5	7.0	7.5	8.0	8.5	9.0	9.5	
0.50–0.75									1											1
0.75–1.00	2	1	1																	4
1.00–1.25	1								2											3
1.25–1.50	1			1					1											3
1.50–1.75								1	1											2
1.75–2.00							1		1											2
2.00–2.25																				0
2.25–2.50																				0
2.50–2.75		1																		1
2.75–3.00							1													1
3.00–3.25						1														1
3.25–3.50				1																1
3.50–3.75							1													1
3.75–4.00																				0
4.00–4.25																				0
4.25–4.50																				0
4.50–4.75																				0
4.75–5.00																				0
5.00–5.25																			1	1
	4	2	1	2	0	1	3	1	6	0	0	0	0	0	0	0	0	0	1	21

TABLE 12. STANDARD DEVIATION OF EGG COLOR DURING FOURTH YEAR OF PRODUCTION, SUBJECT; DIFFERENCE BETWEEN EGG-COLOR LIFE MEAN FOR DAM AND FOR SIRE, RELATIVE

Coefficient of correlation = .55 ± .15

	0.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0	5.5	6.0	6.5	7.0	7.5	8.0	8.5	9.0	9.5	
1.00–1.25		1							4											5
1.25–1.50																				0
1.50–1.75	1																			1
1.75–2.00							1													1
2.00–2.25																				0
2.25–2.50							1													1
2.50–2.75																				0
2.75–3.00																				0
3.00–3.25																				0
3.25–3.50							1													1
3.50–3.75																				0
3.75–4.00																			1	1
	1	1	0	0	0	0	3	0	4	0	0	0	0	0	0	0	0	0	1	10

TABLE 13. SUMMARY OF CORRELATIONS BETWEEN STANDARD DEVIATION OF EGG CHARACTERS DURING EACH OF THE FIRST FOUR YEARS OF PRODUCTION, SUBJECT, AND DIFFERENCE BETWEEN RESPECTIVE LIFE MEANS FOR DAM AND FOR SIRE, RELATIVE

Selection	Year of production	Coefficient of correlation	$\frac{r}{Er}$	Number of individuals
Size	First	.012± .052	0.23	169
	Second	−.28 ± .08	3.50	56
	Third	.13 ± .12	1.08	29
	Fourth	.16 ± .20	0.80	11
Shape	First	.18 ± .08	2.25	70
	Second	.14 ± .10	1.40	32
	Third	.13 ± .18	0.72	14
	Fourth	.45 ± .20	2.25	10
Color	First	.13 ± .05	2.60	174
	Second	.43 ± .07	6.14	68
	Third	.52 ± .13	4.00	21
	Fourth	.55 ± .15	3.67	10

Inheritance of mean egg type

The correlations shown in tables 14 to 22 and summarized in tables 23 and 24 indicate a distinct positive relation between the mean type of either or both parents and the production of the offspring. In table 23 it is seen that $\frac{r}{Er}$ for the sire ranges from 3 to 18; for the dam, from 4 to 22; and for the average of both parents, from 8 to 39. In table 24 it is seen that $\frac{r}{Er}$ ranges, for size, from 4 to 10; for shape, from 3 to 8; and for color, from 18 to 39.

TABLE 14. TOTAL AVERAGE SIZE (WEIGHT IN GRAMS) OF PRODUCTION OF THE OFFSPRING, SUBJECT; SIZE RECORD FOR SIRE, RELATIVE

Coefficient of correlation = .36 ± .04

	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	
36											1										1
38																					0
40																					0
42																					0
44																					0
46																				1	1
48	3				2	2			1	1	1		1							1	12
50	4					3			2	2	3	1	2								17
52	2					2				3	5	5	6		1	1	1			2	28
54					2	3			2	4	7	2	3	1		1	2	1		5	33
56	2				1	2	2		5	2	4	1	3			1	2	1		6	32
58	1					1			1	2	2		1	1		3	1	1		9	23
60							1		1	1	1		3							4	11
62	1															1		1		2	5
64														1			1			3	5
66														1		1	1	1			4
68																					0
70																					0
72																					0
74									1												1
	13	0	0	0	5	13	3	0	13	15	24	9	19	4	1	8	8	5	0	33	173

TABLE 15. TOTAL AVERAGE SIZE OF PRODUCTION OF THE OFFSPRING, SUBJECT; SIZE RECORD FOR DAM, RELATIVE

Coefficient of correlation = .22 ± .05

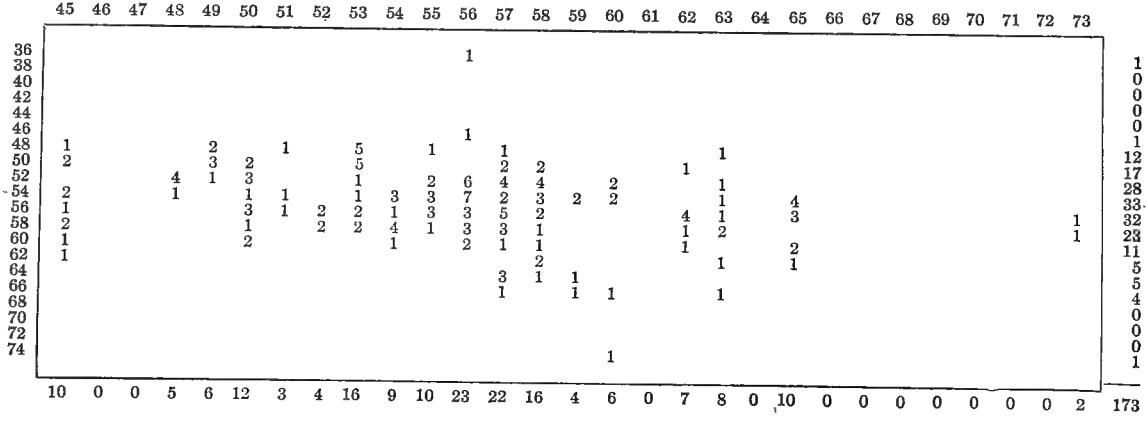

TABLE 16. TOTAL AVERAGE SIZE OF PRODUCTION OF THE OFFSPRING, SUBJECT; AVERAGE SIZE RECORD FOR SIRE AND DAM, RELATIVE

Coefficient of correlation = .42 ± .04

	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	
36												1														1
38																										0
40																										0
42																										0
44																										0
46																1										1
48	1				1	3	1	1	1	2		1								1						12
50	1		2			1	1		4	6	1			1												17
52			1					1	2	6	2	10	1	2	1	1	1									28
54						1	1	1	1	1	5	7	6		4	4	2									33
56							3	1	2	3	1	5	1	6	4	3	2	1								32
58						1	2			1	3	2	1	4	2	2	2	2							1	11
60							1			2		1		2	1	3	1		1							23
62	1														1		1				1					5
64															2	1	3		1							5
66															2											4
68																										0
70																										0
72																										0
74													1													1
	3	0	3	0	1	6	9	4	10	21	12	27	10	15	17	15	12	3	2	1	1	0	0	0	1	173

TABLE 17. TOTAL AVERAGE SHAPE OF PRODUCTION OF THE OFFSPRING, SUBJECT; SHAPE RECORD FOR SIRE, RELATIVE

Coefficient of correlation = .21 ± .07

	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	
54																					1				1
56	1																								1
58																									0
60																									0
62																									0
64																									0
66											1		2				1			1				1	6
68						1					1		1			1				1					5
70											1		1			3	1			3	1	4		3	17
72											4		2			4	1			3		6		3	23
74											1						3			2		1		2	9
76					1											1	1			1	2	2			8
78											2					1								1	4
80																						1		1	2
	1	0	0	0	1	1	0	0	0	0	10	0	6	0	0	10	7	0	0	11	4	14	0	11	76

TABLE 18. TOTAL AVERAGE SHAPE OF PRODUCTION OF THE OFFSPRING, SUBJECT; SHAPE RECORD FOR DAM, RELATIVE

Coefficient of correlation = .47 ± .06

	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	
54										1														1
56	1																							1
58																								0
60																								0
62																								0
64																								0
66			1				1				1	2		1										6
68											2	2		1										5
70							1			3	1	2		5	3			1			1			17
72			1							3	2	2		7	2			1		3			1	23
74										1		1		2	1					1	2		1	9
76										3		1		2						1	1			8
78										1										1		2		4
80															1					1				2
	1	0	2	0	0	0	2	0	0	12	6	10	0	18	7	0	0	2	7	3	4	0	2	76

TABLE 19. TOTAL AVERAGE SHAPE OF PRODUCTION OF THE OFFSPRING, SUBJECT; AVERAGE SHAPE RECORD FOR SIRE AND DAM, RELATIVE

Coefficient of correlation = .49 ± .06

	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	
54																1							1
56	1																						1
58																							0
60																							0
62																							0
64																							0
66											1	1	1	2	1								6
68									1		1			2		1							5
70									1				1		1	5	4	3		1	1		17
72											1	1	3	2	2	4	5	3	1	1			23
74														1		2	1	3	1			1	9
76									1							3	1	3					8
78																2	2						4
80																				2			2
	1	0	0	0	0	0	0	0	3	0	3	2	5	7	4	18	13	12	2	4	1	1	76

TABLE 20. TOTAL AVERAGE COLOR OF PRODUCTION OF THE OFFSPRING, SUBJECT; COLOR RECORD FOR SIRE, RELATIVE

Coefficient of correlation = .53 ± .03

	2.0	2.5	3.0	3.5	4.0	4.5	5.0	5.5	6.0	6.5	7.0	7.5	8.0	8.5	
1.0–1.5		3			2	3				1					9
1.5–2.0		5			5	1	2			2					15
2.0–2.5		9	1		6	5	1			11					33
2.5–3.0	2	10	2	1	8	7				8					38
3.0–3.5	1	5	2		1	6	1		2	1					19
3.5–4.0		2	3		3	11	3			2					24
4.0–4.5		1	1		2	5	1			2					12
4.5–5.0		2				7	2			1					12
5.0–5.5	1	1		1	1		1			1					6
5.5–6.0		1				1				1					3
6.0–6.5														2	2
6.5–7.0					1				1	3		3			8
7.0–7.5									3	4	6	13			26
7.5–8.0		1				1	1		2	2		1			8
8.0–8.5															0
8.5–9.0								1							1
	4	40	9	2	29	47	12	1	8	39	6	17	0	2	216

TABLE 21. TOTAL AVERAGE COLOR OF PRODUCTION OF THE OFFSPRING, SUBJECT; COLOR RECORD FOR DAM, RELATIVE

Coefficient of correlation = .67 ± .03

	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0	5.5	6.0	6.5	7.0	7.5	8.0	
1.0–1.5			6	3											9
1.5–2.0			8	2	1	2					2				15
2.0–2.5		5	10	7	3	2	1	3	1					1	33
2.5–3.0	1	3	7	9	4	2	4	1	3		4				38
3.0–3.5	2	1	2	4		2		2	2	1	2			1	19
3.5–4.0			4	7	5	2	2	2	2						24
4.0–4.5		1		6	1	1	1		1		1				12
4.5–5.0		1	1	3	2		1	2	1		1				12
5.0–5.5			1		1	1			1		2				6
5.5–6.0			1				1				1				3
6.0–6.5								1	1						2
6.5–7.0									1		1	4	2		8
7.0–7.5			1				1					8	11	5	26
7.5–8.0			1	1	1							2	1	2	8
8.0–8.5															0
8.5–9.0				1											1
	3	11	42	43	18	12	11	11	13	1	14	14	14	9	216

TABLE 22. TOTAL AVERAGE COLOR OF PRODUCTION OF THE OFFSPRING, SUBJECT; AVERAGE COLOR RECORD FOR SIRE AND DAM, RELATIVE

Coefficient of correlation = .79 ± .02

	2.5	3.0	3.5	4.0	4.5	5.0	5.5	6.0	6.5	7.0	7.5	
1.0–1.5	3	2	1	2	1							9
1.5–2.0	3	4	1	2	4		1					15
2.0–2.5	7	2	7	1	10	4		1	1			33
2.5–3.0	6	2	6	8	13	2			1			38
3.0–3.5	1	3	2	7	3	1		2				19
3.5–4.0		3	3	11	7							24
4.0–4.5	1	1		4	4	2						12
4.5–5.0			4	5	1	1			1			12
5.0–5.5				2	3		1					6
5.5–6.0		1			1				1			3
6.0–6.5									1	1		2
6.5–7.0					1				3	1	3	8
7.0–7.5					1		1		2	5	17	26
7.5–8.0	1			2					2	2	1	8
8.0–8.5												0
8.5–9.0				1								1
	22	18	24	45	49	10	3	3	12	9	21	216

TABLE 23. SUMMARY OF CORRELATIONS BETWEEN TOTAL AVERAGE CHARACTERS OF PRODUCTION OF THE OFFSPRING, SUBJECT, AND AVERAGE CHARACTERS OF PARENTS, RELATIVE

Correlated parentage	Character studied	Coefficient of correlation	$\frac{r}{Er}$	Number of individuals
Sire	Size	.36± .04	9	173
	Shape	.21± .07	3	76
	Color	.53± .03	18	216
Dam	Size	.22± .05	4	173
	Shape	.47± .06	8	76
	Color	.67± .03	22	216
Average of sire and dam	Size	.42± .04	10	173
	Shape	.49± .06	8	76
	Color	.79± .02	39	216

TABLE 24. SUMMARY GIVEN IN TABLE 23 ARRANGED ACCORDING TO CHARACTERS

Character	Correlated parentage	Coefficient of correlation	$\frac{r}{Er}$	Number of individuals
Size	Sire	.36±.04	9	173
	Dam	.22±.05	4	173
	Sire and dam	.42±.04	10	173
Shape	Sire	.21±.07	3	76
	Dam	.47±.06	8	76
	Sire and dam	.49±.06	8	76
Color	Sire	.53±.03	18	216
	Dam	.67±.03	22	216
	Sire and dam	.79±.02	39	216

All of these correlations are significant, especially since they arise from a random population. From the results of this study, it would appear that the quality of either the male or the female parent will affect the type of egg to be produced by the offspring, with the female having slightly greater influence. A certain character is of much greater influence if possessed by both individuals than if possessed by either one alone. This does not agree with some results obtained by Pearl (1912, and 1915 a and b) in dealing with quantity of production, and it does not show quite the conditions found by Goodale (1918), who also worked with the quantity factor; it does agree fairly closely, however, with the general opinion prevailing among poultrymen.

The results for the whole experiment relative to the mean character of the progeny in relation to the respective characters of the sire and the dam, are charted in figures 12 to 17. References to *large*, *small*, *round*, *long*, *brown*, or *white* parents or progeny relate to the quality of the eggs produced by those birds, not to the size, shape, or color of the birds. The terms *large* and *small* refer, respectively, to means of the sizes of eggs produced during the birds' lifetime, of 56 grams or more, and of less than 56 grams; the terms *round* and *long* refer to means of the index figures of the eggs produced during the birds' lifetime, of 72 or more, and of less than 72, respectively; and the terms *brown* and *white* refer to means of the color of eggs produced during the birds' lifetime, of 3 or higher,

and of lower than 3, respectively. The exact means for the various groups shown in figures 12 to 14 are given in table 25:

TABLE 25. MEAN CHARACTERS OF BIRDS AVAILABLE FOR USE IN CALCULATING DATA FOR FIGURES 12 TO 14

Character type	Mating	Mean character for sire	Mean character for dam	Mean character for progeny
Size	Large sire and small dam	59.6	51.5	54.3
	Small sire and large dam	51.7	60.6	53.9
	Large sire and large dam	60.3	59.6	57.2
	Small sire and small dam	51.7	51.7	51.6
Shape	Round sire and long dam	73.0	69.3	71.5
	Long sire and round dam	67.0	75.4	72.5
	Round sire and round dam	73.0	76.0	75.0
	Long sire and long dam	65.4	69.1	71.0
Color	Brown sire and white dam	4.81	2.34	3.00
	White sire and brown dam	2.11	4.78	3.27
	Brown sire and brown dam	4.56	4.55	3.75
	White sire and white dam	2.34	2.19	2.60

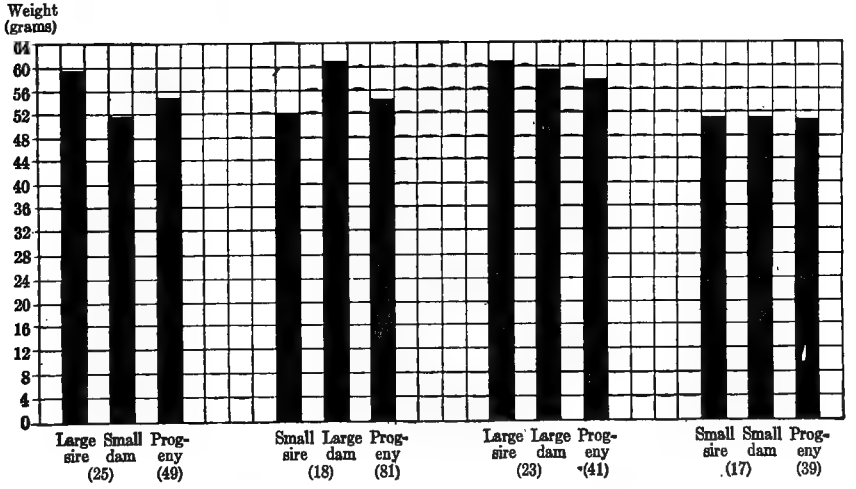

FIG. 12. MEAN SIZE CHARACTERS OF SIRES, DAMS, AND PROGENY IN ALL MATINGS
The figures in parenthesis designate the numbers of birds available for the respective calculations

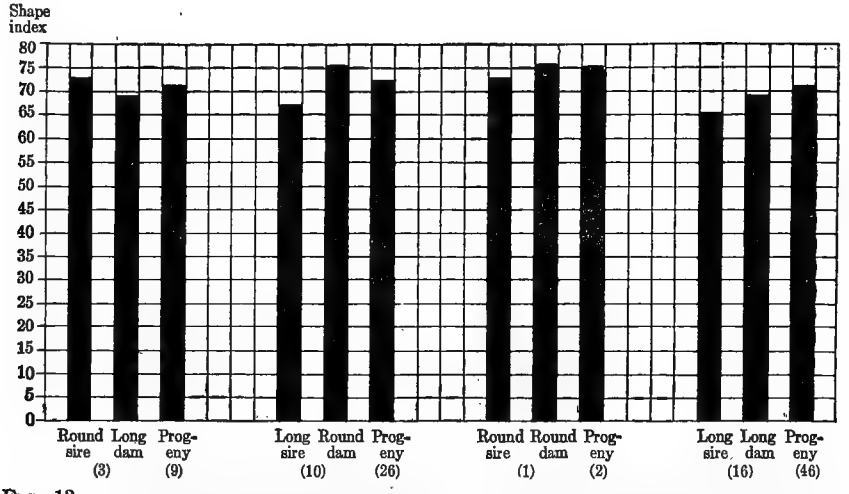

FIG. 13. MEAN SHAPE CHARACTERS OF SIRES, DAMS, AND PROGENY IN ALL MATINGS
The figures in parenthesis designate the numbers of birds available for the respective calculations

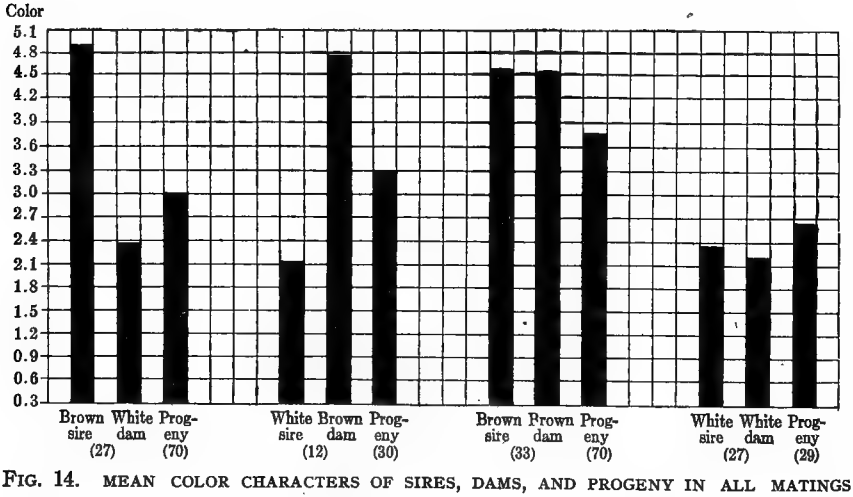

FIG. 14. MEAN COLOR CHARACTERS OF SIRES, DAMS, AND PROGENY IN ALL MATINGS
The figures in parenthesis designate the numbers of birds available for the respective calculations

It is seen in figures 12 to 14 that in every instance in which one extreme character has been mated with another, the progeny have dis-

played a character between the two. In most instances in which the sire and the dam were both of the same extreme character, the progeny displayed a character nearer to normal than either of the parents. In the case of small size, however, this tendency was reversed, and the character for the progeny from two small parents was of a still smaller type. In this case it is probable that the effect of the size of body was to limit the size of the eggs (Benjamin, 1914).

The relative effect of the sire and the dam is shown clearly in figures 15 to 17. In figure 15 it is seen that small size is predominant over large size. The sire will transmit small size to the progeny much more strongly than large size. In the instance in which both parents are large, only 58.6 per cent of the progeny possess the "large" character; but when

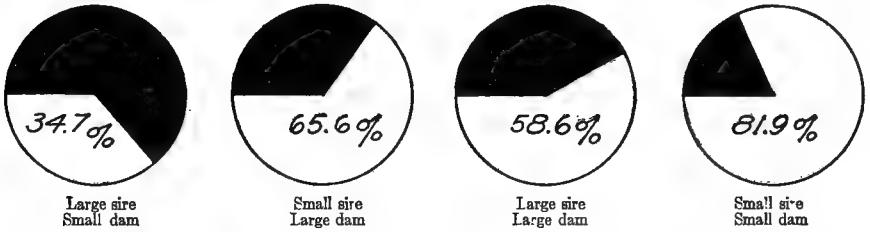

FIG. 15. RELATION OF PROGENY SIZE CHARACTERS TO SIRE AND DAM
The white area in each case designates the proportion of progeny showing the same character as that of the sire

both parents are small, 81.9 per cent of the progeny possess the "small" character. The two parents appear here to have about equally strong influence in transmitting the "small" character. The predominance of the small size may be due to the additional physiological factors involved by the size of the dam's body restricting the size of egg which can possibly be produced, without regard to any inherited tendencies. A hen with a large body can produce a small egg, but a hen with a small body cannot so readily produce a large egg.

The question of the inheritance of egg shape may not be entirely free from the physiological complications involved in the study of egg size. This opinion is borne out by figure 16. The dam seems to have nearly 60 per cent of the influence on the progeny. The fact that the two long parents have a somewhat higher percentage of the progeny following their type than do the two round parents, would lead to the theory that

the length character is somewhat predominant over the width; otherwise one would expect to find more than 50 per cent of round progeny when both sire and dam are round.

Both the size and the shape of the egg seem to be about equally transmitted to the progeny by the dams and by the sires. These two factors

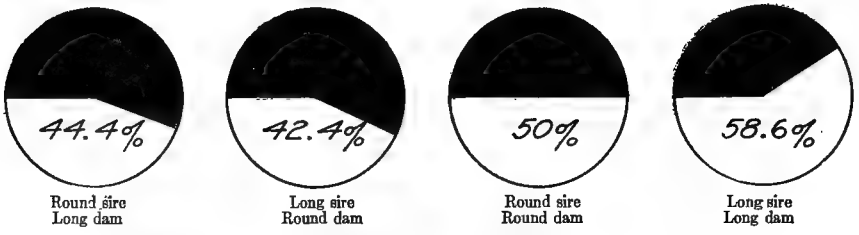

FIG. 16. RELATION OF PROGENY SHAPE CHARACTERS TO SIRE AND DAM
The white area in each case designates the proportion of progeny showing the same character as that of the sire

appear, however, to be independent, as is shown by an entire lack of correlation between them (Benjamin, 1912). Such a condition as is found here is the reverse of what might be expected if the results obtained by other workers (Pearl and Curtis, 1916) on Barred Plymouth Rocks were borne out with the strain of White Leghorns used in these experi-

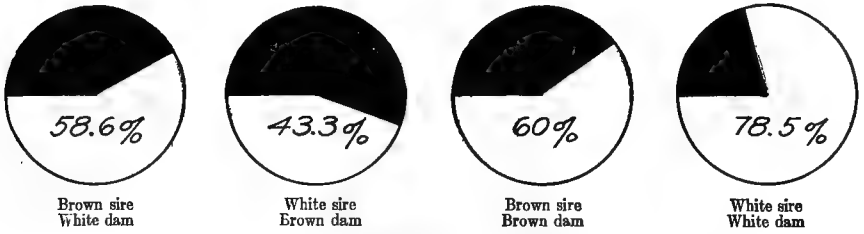

FIG. 17. RELATION OF PROGENY COLOR CHARACTERS TO SIRE AND DAM
The white area in each case designates the proportion of progeny showing the same character as that of the sire

ments. Pearl and Curtis found the index figure and the weight of eggs to be negatively correlated.

The study of the color inheritance (fig. 17) shows about equal influences of sire and dam. When both parents are of the "white" character, they seem to be able to transmit their character more definitely than when

both are of the "brown" character, but this difference is not great. Neither color and neither parent seem to have a predominance.

These results are an accumulation of data from six different years, with all the variations in conditions that must always occur. Hence the facts shown can apparently be accepted as giving undoubted evidence of the inheritance of the characters in question.

Relation of egg incubated to mean egg type of bird hatched

The correlations shown in tables 26 to 49, and summarized in tables 50 and 51, show a general relationship between the particular type of egg incubated and the type of egg produced by the chick hatched, both for the separate years of the bird's production and for its life mean.[10] $\frac{r}{Er}$ is much less significant for these studies than for the studies of the relation existing between the mean productions of parents and progeny. Apparently the particular type of egg incubated has some effect on the type of egg which the offspring will produce, but not so much effect as the mean production of the hen which laid that incubated egg.

In this study the coefficient of correlation for the size character, as shown in table 50, is of greater significance than that for the other characters, as is the case in all of the work here reported. The shape character shows a fair degree of correlation.

The color character exhibits a peculiar condition. The correlations with the pullets' eggs incubated, for the first and second years, are insignificant; the third-year correlation is based on too few individuals to be of much value; and the life-mean correlation shows a distinct negative coefficient. This condition is probably due to the great irregularity that exists in the coloration of successive eggs laid by most individuals. Sufficient proof is not at hand to warrant the conclusion that a negative correlation actually exists for this character, but it is believed that such a negative or insignificant correlation may be expected, due to the irregularity of the material.

[10] The terms *pullet* and *hen*, as used in this memoir, refer to female birds during their first season of production and during their later seasons of production, respectively.

TABLE 26. MEAN SIZE (WEIGHT IN GRAMS) OF FIRST YEAR'S PRODUCTION OF BIRDS, SUBJECT; SIZE OF PULLETS' EGGS FROM WHICH RESPECTIVE BIRDS WERE HATCHED, RELATIVE

Coefficient of correlation = .40 ± .063

	45	47	49	51	53	55	57	59	61	63	65	
46			1									1
48	1	2	2		2		2					9
50	1	1	5		2	1		1				11
52	1		1	1	4	1		2	1			11
54		1	1		5		3	1				11
56			1	3	2	3	4	3			1	17
58			2	1	4	1	1	1	2			12
60				1		2			1			4
62					1	1	1					3
64						1						1
66								1				1
	3	4	13	6	20	10	11	9	4	0	1	81

TABLE 27. MEAN SIZE OF SECOND YEAR'S PRODUCTION OF BIRDS, SUBJECT; SIZE OF PULLETS' EGGS FROM WHICH RESPECTIVE BIRDS WERE HATCHED, RELATIVE

Coefficient of correlation = .37 ± .103

	47	49	51	53	55	57	59	61	
50	1			1					2
52		1							1
54	1	1				2		1	5
56		1		3		1	1	1	7
58			1		2	1	1	1	6
60		1		2	1	1	1		6
62					1	1			2
64				1		1	1		3
66									0
68									0
70							1		1
	2	4	1	7	4	7	5	3	33

TABLE 28. MEAN SIZE OF THIRD YEAR'S PRODUCTION OF BIRDS, SUBJECT; SIZE OF PULLETS' EGGS FROM WHICH RESPECTIVE BIRDS WERE HATCHED, RELATIVE

Coefficient of correlation = .30 ± .131

	47	49	51	53	55	57	59	61	
50		1							1
52	1	1				1			3
54				1		2		1	5
56	1			1			1		3
58				2	2				4
60		1				2			3
62				1					1
64						1			1
66									0
68									0
70									0
72									0
74							1		1
	2	3	0	5	2	6	3	1	22

TABLE 29. MEAN SIZE OF FOURTH YEAR'S PRODUCTION OF BIRDS, SUBJECT; SIZE OF PULLETS' EGGS FROM WHICH RESPECTIVE BIRDS WERE HATCHED, RELATIVE

Coefficient of correlation = .50 ± .191

	47	49	51	53	55	57	59	
50	1							1
52								0
54		1		1				2
56							1	1
58								0
60						1		1
62								0
64						1		1
66								0
68				1				1
	1	1	0	2	0	2	1	7

TABLE 30. MEAN SIZE OF LIFE PRODUCTION OF BIRDS, SUBJECT; SIZE OF PULLETS' EGGS FROM WHICH RESPECTIVE BIRDS WERE HATCHED, RELATIVE

Coefficient of correlation = .37 ± .065

	45	47	49	51	53	55	57	59	61	63	65	
46			1									1
48	1	1	2		2		2					8
50	1	1	3		1	1		1				8
52	1		2	1	3	1		1				9
54		2	1		7		3	1	1			15
56			2	2	2	1	3	3	1		1	15
58			1	2	4	3		1	2			13
60			1	1		1	1	1	1			6
62						2						2
64					1	1	1					3
66												0
68												0
70												0
72												0
74								1				1
	3	4	13	6	20	10	10	9	5	0	1	81

TABLE 31. MEAN SIZE OF FIRST YEAR'S PRODUCTION OF BIRDS, SUBJECT; SIZE OF HENS' EGGS FROM WHICH RESPECTIVE BIRDS WERE HATCHED, RELATIVE

Coefficient of correlation = .31 ± .065

	45	47	49	51	53	55	57	59	61	63	65	67	69	
36							1							1
38														0
40														0
42														0
44	1													1
46			1		1									2
48			1	1	1		1							4
50			3	2			3							8
52				3	2	3	2	5		1	1			17
54		2		3	2	1	4	2	2		1	1	2	20
56	1			2	2	1	2	4			1	1	1	15
58					3	2	2			1			1	9
60				1		1	1			2				5
62				1										1
64							1	1		1		1		4
66										1				1
	2	2	5	13	11	8	17	12	2	6	3	3	4	88

TABLE 32. MEAN SIZE OF SECOND YEAR'S PRODUCTION OF BIRDS, SUBJECT; SIZE OF HENS' EGGS FROM WHICH RESPECTIVE BIRDS WERE HATCHED, RELATIVE

Coefficient of correlation = .46 ± .099

	45	47	49	51	53	55	57	59	61	63	65	67	
50		1		1	2		1						5
52			1			1							2
54	1						1						2
56				1		1					1		3
58				2	1	2			1				6
60	1			1							1		3
62		1											1
64					1					3			4
66													0
68										1		1	2
70						1							1
	2	2	1	5	4	5	2	0	1	4	2	1	29

TABLE 33. MEAN SIZE OF THIRD YEAR'S PRODUCTION OF BIRDS, SUBJECT; SIZE OF HENS' EGGS FROM WHICH RESPECTIVE BIRDS WERE HATCHED, RELATIVE

Coefficient of correlation = .65 ± .123

	45	47	49	51	53	55	57	59	61	63	65	
52	1	1										2
54											1	1
56				1	1							2
58									1			1
60					1						1	2
62												0
64										1		1
66										1		1
	1	1	0	1	2	0	0	0	1	2	2	10

TABLE 34. MEAN SIZE OF LIFE PRODUCTION OF BIRDS, SUBJECT; SIZE OF HENS' EGGS FROM WHICH RESPECTIVE BIRDS WERE HATCHED, RELATIVE

Coefficient of correlation = .34 ± .063

	45	47	49	51	53	55	57	59	61	63	65	67	69	71	73	75	
36							1										1
38																	0
40																	0
42																	0
44																	0
46		1															1
48			2		2												4
50	1		2	3			4										10
52		1		1	2	3	3	5		1	1						17
54		1		1	3	1	4	2	1			1	2				16
56			1	4	1		2	4	1		1	1	1				16
58	1				1	3		1			1		1				8
60				1	2		1	1		1							6
62				1			1	1		2							5
64																	0
66						2			1	1		1				1	6
	2	3	5	11	11	9	16	14	3	5	3	3	4	0	0	1	90

TABLE 35. MEAN SHAPE OF FIRST YEAR'S PRODUCTION OF BIRDS, SUBJECT; SHAPE OF PULLETS' EGGS FROM WHICH RESPECTIVE BIRDS WERE HATCHED, RELATIVE

Coefficient of correlation = .39 ± .106

	68	69	70	71	72	73	74	75	76	77	78	79	80	
64			1											1
66	1					1								2
68		1		1						1				3
70					1				1	2				4
72		2			3	2	1	2						10
74				1			2			1	1		1	6
76							1							1
78							1							1
80									1					1
	1	3	1	2	4	3	5	2	2	4	1	0	1	29

TABLE 36. MEAN SHAPE OF SECOND YEAR'S PRODUCTION OF BIRDS, SUBJECT; SHAPE OF PULLETS' EGGS FROM WHICH RESPECTIVE BIRDS WERE HATCHED, RELATIVE

Coefficient of correlation = .23 ± .192

	69	70	71	72	73	74	75	76	77	
68	1		1	1		1				4
70		1		1				1	1	4
72	1			1						2
74										0
76							1			1
	2	1	1	3	0	1	1	1	1	11

TABLE 37. MEAN SHAPE OF LIFE PRODUCTION OF BIRDS, SUBJECT; SHAPE OF PULLETS' EGGS FROM WHICH RESPECTIVE BIRDS WERE HATCHED, RELATIVE

Coefficient of correlation = .43 ± .102

	68	69	70	71	72	73	74	75	76	77	78	79	80	
66	1		1			1								3
68		1												1
70				1	1		1		1	2				6
72		2			3	2	1	1		1				10
74				1			1	1		1	1		1	6
76							1							1
78							1							1
80									1					1
	1	3	1	2	4	3	5	2	2	4	1	0	1	29

TABLE 38. MEAN SHAPE OF FIRST YEAR'S PRODUCTION OF BIRDS, SUBJECT; SHAPE OF HENS' EGGS FROM WHICH RESPECTIVE BIRDS WERE HATCHED, RELATIVE

Coefficient of correlation = .34 ± .083

	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	77+	
54														1					1
56																			0
58																			0
60																			0
62																			0
64																			0
66	1						1		2		1								5
68									1	1	1	1	2		1				7
70							1	1				1	1		2				6
72		1		1	1		1			2	1	3	2	1		2	2		17
74								1					2	1	2	1	1		8
76												1			2		1		4
78											1					1	1		3
80																		1	1
	1	1	0	1	1	0	3	2	3	3	4	6	7	3	7	4	5	1	52

TABLE 39. MEAN SHAPE OF SECOND YEAR'S PRODUCTION OF BIRDS, SUBJECT; SHAPE OF HENS' EGGS FROM WHICH RESPECTIVE BIRDS WERE HATCHED, RELATIVE

Coefficient of correlation = .47 ± .101

	67	68	69	70	71	72	73	74	75	76	77	
66	1		1	1	1							4
68			1									1
70		1			1	1				1	1	5
72						1		1	2	2		6
74	1						2	1	1		1	6
76					1		1			1	1	4
78							1					1
	2	1	2	1	3	2	4	2	3	4	3	27

TABLE 40. MEAN SHAPE OF THIRD YEAR'S PRODUCTION OF BIRDS, SUBJECT; SHAPE OF HENS' EGGS FROM WHICH RESPECTIVE BIRDS WERE HATCHED, RELATIVE

Coefficient of correlation = .52 ± .142

	69	70	71	72	73	74	75	76	77	
54	1									1
56										0
58										0
60										0
62										0
64										0
66	1									1
68					1					1
70					1		1	1	1	4
72							1		1	2
74		1		1					1	3
	2	1	0	1	2	0	2	1	3	12

TABLE 41. MEAN SHAPE OF LIFE PRODUCTION OF BIRDS, SUBJECT; SHAPE OF HENS' EGGS FROM WHICH RESPECTIVE BIRDS WERE HATCHED, RELATIVE

Coefficient of correlation = .31 ± .084

	61 or less	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	77+	
54														1					1
56																			0
58																			0
60																			0
62																			0
64									1										1
66	1						1		1		1						1		5
68									1		1	1							3
70					1		1	1		1		2	2		3	1			12
72		1		1			1			2	1	2	1	1	1	2	3		16
74								1				1	3		1				6
76											1		1		2		1		5
78														1		1	1		3
80																		1	1
	1	1	0	1	1	0	3	2	3	3	4	6	7	3	7	4	6	1	53

TABLE 42. MEAN COLOR OF FIRST YEAR'S PRODUCTION OF BIRDS, SUBJECT; COLOR OF PULLETS' EGGS FROM WHICH RESPECTIVE BIRDS WERE HATCHED, RELATIVE

Coefficient of correlation = —.12 ± .07

	1	2	3	4	5	6	7	
1.0–1.5	1	2	3	1				7
1.5–2.0	1	7	3	2			1	14
2.0–2.5	7	8	3					18
2.5–3.0	4	12	2	4		1		23
3.0–3.5	6	3	1	3	1			14
3.5–4.0	1	1	1					3
4.0–4.5	1	1	2					4
4.5–5.0	3	3	1		1			8
5.0–5.5	1		2					3
5.5–6.0	2		2					4
6.0–6.5								0
6.5–7.0								0
7.0–7.5	1	1						2
	28	38	20	10	2	1	1	100

TABLE 43. MEAN COLOR OF SECOND YEAR'S PRODUCTION OF BIRDS, SUBJECT; COLOR OF PULLETS' EGGS FROM WHICH RESPECTIVE BIRDS WERE HATCHED, RELATIVE

Coefficient of correlation = .002 ± .105

	1	2	3	4	5	6	7	
1.0– 1.5			1					1
1.5– 2.0	1	2						3
2.0– 2.5	1	4						5
2.5– 3.0	2	2	1	1			1	7
3.0– 3.5	3	2	1	1				7
3.5– 4.0	2	1						3
4.0– 4.5		3	1	1				5
4.5– 5.0			1					1
5.0– 5.5	2	1						3
5.5– 6.0								0
6.0– 6.5	1		2					3
6.5– 7.0	1							1
7.0– 7.5		1						1
7.5– 8.0								0
8.0– 8.5								0
8.5– 9.0								0
9.0– 9.5								0
9.5–10.0								0
10.0–10.5			1					1
	13	16	8	3	0	0	1	41

TABLE 44. MEAN COLOR OF THIRD YEAR'S PRODUCTION OF BIRDS, SUBJECT; COLOR OF PULLETS' EGGS FROM WHICH RESPECTIVE BIRDS WERE HATCHED, RELATIVE

Coefficient of correlation = .57 ± .15

	1	2	3	4	
1.5–2.0	1				1
2.0–2.5					0
2.5–3.0		2			2
3.0–3.5		1		1	2
3.5–4.0	1	1			2
4.0–4.5		1			1
4.5–5.0					0
5.0–5.5					0
5.5–6.0				1	1
	2	5	0	2	9

TABLE 45. MEAN COLOR OF LIFE PRODUCTION OF BIRDS, SUBJECT; COLOR OF PULLETS EGGS FROM WHICH RESPECTIVE BIRDS WERE HATCHED, RELATIVE

Coefficient of correlation = — .26 ± .06

	1	2	3	4	5	6	7	
1.0–1.5	1	2	2					5
1.5–2.0	1	6	2		2			11
2.0–2.5	5	6	3				1	15
2.5–3.0	5	11	2	5		1		24
3.0–3.5	5	4	1	2	1			13
3.5–4.0	2	4	3					9
4.0–4.5	1	1	2	1				5
4.5–5.0	3	3	1		1			8
5.0–5.5	2		2					4
5.5–6.0	2		1					3
6.0–6.5								0
6.5–7.0								0
7.0–7.5	1	1						2
7.5–8.0			1					1
	28	38	20	8	4	1	1	100

TABLE 46. MEAN COLOR OF FIRST YEAR'S PRODUCTION OF BIRDS, SUBJECT; COLOR OF HENS' EGGS FROM WHICH RESPECTIVE BIRDS WERE HATCHED, RELATIVE

Coefficient of correlation = .20 ± .08

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	
1.0–1.5			1																		1
1.5–2.0	2	2	4	1																	9
2.0–2.5	1	3	3	2		1															10
2.5–3.0	5	3	3	3		2															16
3.0–3.5	1	2	1	1	1	1															7
3.5–4.0	3	2			1																6
4.0–4.5	1	1	2	2	1																7
4.5–5.0	1				1																2
5.0–5.5		1	2																	1	4
5.5–6.0															1						1
6.0–6.5																					0
6.5–7.0	1																				1
7.0–7.5																					0
7.5–8.0			1																		1
8.0–8.5																					0
8.5–9.0		1																			1
	15	15	17	9	4	4	0	0	0	0	0	0	0	0	1	0	0	0	0	1	66

TABLE 47. MEAN COLOR OF SECOND YEAR'S PRODUCTION OF BIRDS, SUBJECT; COLOR OF HENS' EGGS FROM WHICH RESPECTIVE BIRDS WERE HATCHED, RELATIVE

Coefficient of correlation = .31 ± .10

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	
1.0–1.5	1																				1
1.5–2.0		1	1																		2
2.0–2.5	1	2	3	1		1															8
2.5–3.0				1																	1
3.0–3.5			2			1															3
3.5–4.0	2																				2
4.0–4.5				1		1															2
4.5–5.0		1	1	1																1	4
5.0–5.5			1		1																2
5.5–6.0					1																1
6.0–6.5																					0
6.5–7.0															1						1
7.0–7.5																					0
7.5–8.0																					0
8.0–8.5																					0
8.5–9.0	1																				1
	5	4	8	4	2	3	0	0	0	0	0	0	0	0	1	0	0	0	0	1	28

TABLE 48. MEAN COLOR OF THIRD YEAR'S PRODUCTION OF BIRDS, SUBJECT; COLOR OF HENS' EGGS FROM WHICH RESPECTIVE BIRDS WERE HATCHED, RELATIVE

Coefficient of correlation = .17 ± .20

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	
1.0–1.5	1																				1
1.5–2.0			1																		1
2.0–2.5						1															1
2.5–3.0			1																		1
3.0–3.5																					0
3.5–4.0		1																			1
4.0–4.5				1											1					1	3
4.5–5.0			1																		1
5.0–5.5					1																1
5.5–6.0																					0
6.0–6.5																					0
6.5–7.0																					0
7.0–7.5			1																		1
	1	1	4	1	1	1	0	0	0	0	0	0	0	0	1	0	0	0	0	1	11

TABLE 49. MEAN COLOR OF LIFE PRODUCTION OF BIRDS, SUBJECT; COLOR OF HENS' EGGS FROM WHICH RESPECTIVE BIRDS WERE HATCHED, RELATIVE

Coefficient of correlation = .28 ± .08

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	
1.0–1.5			1																		1
1.5–2.0	1	1	3	1																	6
2.0–2.5	2	4	4	1																	11
2.5–3.0	5	3	3	2		2															15
3.0–3.5	1	2		2		2															7
3.5–4.0	3	2		1	1																7
4.0–4.5	1	1	2	2	1																7
4.5–5.0	1	1	1		2																5
5.0–5.5			3																		3
5.5–6.0																					0
6.0–6.5															1					1	2
6.5–7.0																					0
7.0–7.5																					0
7.5–8.0	1		1																		2
8.0–8.5																					0
8.5–9.0		1																			1
	15	15	18	9	4	4	0	0	0	0	0	0	0	0	1	0	0	0	0	1	67

TABLE 50. SUMMARY OF CORRELATIONS BETWEEN CHARACTER-MEANS FOR PRODUCTION FOR SEPARATE YEARS AND FOR LIFE, SUBJECT, AND CHARACTERS FOR PARENT EGGS INCUBATED FROM PULLETS OR FROM HENS, RELATIVE

Character	Year of production (means for)	Pullets' eggs incubated			Hens' eggs incubated		
		Coefficient of correlation	$\frac{r}{Er}$	Number of individuals	Coefficient of correlation	$\frac{r}{Er}$	Number of individuals
Size	First	.40 ±.063	6.3	81	.31±.065	4.8	88
	Second	.37 ±.103	3.6	33	.46±.099	4.6	29
	Third	.30 ±.131	2.3	22	.65±.123	5.3	10
	Fourth	.50 ±.191	2.6	7	.....	....	.....
	Life	.37 ±.065	5.7	81	.34±.063	5.4	90
Shape	First	.39 ±.103	3.7	29	.34±.083	4.1	52
	Second	.23 ±.192	1.2	11	.47±.101	4.7	27
	Third	.....	....	.....	.52±.142	3.7	12
	Life	.43 ±.102	4.2	29	.31±.084	3.7	53
Color	First	−.12 ±.07	1.7	100	.20±.08	2.5	66
	Second	.002±.105	0.02	41	.31±.10	3.1	28
	Third	.57 ±.15	3.8	9	.17±.20	0.8	11
	Life	−.26 ±.06	4.3	100	.28±.08	3.5	67

TABLE 51. SUMMARY OF $\frac{r}{Er}$ FROM TABLE 50

Year of production	Character	$\frac{r}{Er}$	
		Pullets' eggs incubated	Hens' eggs incubated
First	Size	6.3	4.8
	Shape	3.7	4.1
	Color	1.7	2.5
Second	Size	3.6	4.6
	Shape	1.2	4.7
	Color	0.02	3.1
Third	Size	2.3	5.3
	Shape	.....	3.7
	Color	3.8	0.8
Life	Size	5.7	5.4
	Shape	4.2	3.7
	Color	4.3	3.5

The summary in table 51 groups the figures for the factor of significance, $\frac{r}{Er}$, according to years and life means. There is a more significant correlation between the life mean of the offspring production and the type of parent egg incubated, than between the production of any of the separate years and the incubated egg. This means that the egg incubated affects the mean type of egg produced during the whole life of the bird hatched, to a greater extent than it affects the pullet-year production or the production of any other single year.

There is a strong correlation, as shown in tables 52 to 54, when a study is made of the relationship between the individual eggs incubated and all

TABLE 52. SIZE (WEIGHT IN GRAMS) OF EGGS LAID BY BIRDS, SUBJECT; SIZE OF EGGS FROM WHICH RESPECTIVE BIRDS WERE HATCHED, RELATIVE

Coefficient of correlation = .458 ± .007

	46	48	50	52	54	56	58	60	62	64	66	68	70	72	74	
28–30		1														1
30–32						1										1
32–34	1															1
34–36	3	1														4
36–38	4	6			2											12
38–40	3	6									1					10
40–42	2	8	1	5						1	5					22
42–44	10	8	3	27		2	2			1						53
44–46	41	32	11	63	3	3	9				5					167
46–48	68	45	23	82	28	12	30			3	11					302
48–50	77	108	32	89	32	30	76		4	5	44	1				498
50–52	45	155	39	41	45	70	124		8	11	76					614
52–54	26	129	65	29	79	98	110		29	25	137	8				735
54–56	15	69	79	25	143	120	91		51	27	153	12		1		786
56–58	3	42	45	24	129	87	65	1	104	35	157	1			1	694
58–60	1	24	28	17	75	50	59		74	59	94	4			1	486
60–62		6	33	13	28	36	38	1	38	46	79	2				320
62–64	1	6	10	2	15	28	35		30	116	31					274
64–66			6	1	5	17	22		17	85	16					169
66–68						1	4		1	49	1				1	57
68–70			1			1	1			19						22
70–72							1			13						14
72–74					1	1				3						5
74–76										2	1					3
	300	646	376	418	585	557	667	2	356	500	811	28	0	1	3	5,250

the individual eggs produced by the respective birds hatched. The factor $\frac{r}{Er}$ equals, for size, shape, and color, respectively, 65, 20, and 16. This is significant and suggests the same relative degrees of inheritance as are found in other studies in this investigation.

The comparable coefficients of variability, calculated on the basis of unit classes, for the eggs used in compiling tables 52 to 54 are: for size (table 52), 20 per cent; for shape (table 53), 10 per cent; for color (table 54), 74 per cent. The greater irregularity in the color of eggs as compared

TABLE 53. SHAPE OF EGGS LAID BY BIRDS, SUBJECT; SHAPE OF EGGS FROM WHICH RESPECTIVE BIRDS WERE HATCHED, RELATIVE

Coefficient of correlation = .204 ± .01

	64	66	68	70	72	74	76	78	80	
54– 56								1		1
56– 58										0
58– 60						1	1			2
60– 62				6	1	3	2	2		14
62– 64	2			21	1	7	7	8		46
64– 66				65	6	24	16	16		127
66– 68				146	17	71	58	34		326
68– 70				132	38	222	152	80		624
70– 72			1	143	44	310	196	146		840
72– 74				97	80	397	175	211		961
74– 76				39	43	355	122	148		707
76– 78				21	13	175	59	29		307
78– 80				5	4	48	4	10		71
80– 82				1		9	3	4		17
82– 84				1		9		1		11
84– 86						3				3
86– 88						1				1
88– 90										0
90– 92						1		1		2
92– 94				1						1
94– 96				2						2
96– 98										0
98–100						1	1			2
	2	0	1	680	247	1,637	796	701	1	4,065

with the other characters undoubtedly accounts for the results in this one correlation with the pullets' eggs incubated. The coefficients of correlation for the study of the mean production with the hens' eggs are positive for all characters and years. The color correlation is about as significant as the shape correlation.

TABLE 54. COLOR OF EGGS LAID BY BIRDS, SUBJECT; COLOR OF EGGS FROM WHICH RESPECTIVE BIRDS WERE HATCHED, RELATIVE

Coefficient of correlation = .145 ± .009

	1	2	3	4	5	6	7	8	
1	143	238	40	182	175	117	10	33	938
2	396	298	168	188	206	107	26	16	1,405
3	215	174	173	183	227	56	42	31	1,101
4	68	119	137	110	173	32	33	14	686
5	27	71	62	85	86	24	12	22	389
6	15	44	47	47	41	8	12	21	235
7	7	18	28	31	21	7	1	6	119
8	12	14	26	44	17	2	1	14	130
9	1	5	18	15	26		2	16	83
10	4	5	26	20	19	3	2	7	86
11	1	2	21	19	30	7	3	8	91
12	1		19	5	10	2			37
13	1	6	8	9	11	2		2	39
14		1	16		6				23
15			2		1				3
16	1								1
17					1				1
	892	995	791	938	1,050	367	144	190	5,367

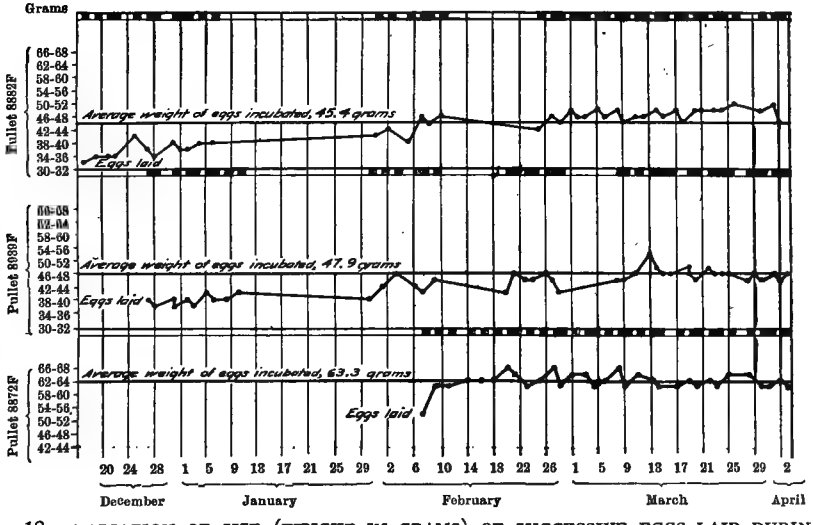

FIG. 18. VARIATION OF SIZE (WEIGHT IN GRAMS) OF SUCCESSIVE EGGS LAID DURING EARLY PULLET PRODUCTION

The squares blocked in black indicate the days on which eggs were laid by the respective pullets

Relation of eggs incubated to types of eggs produced by the respective birds hatched

Some further features of the relationship existing between the types of eggs incubated and the egg types produced by the respective birds hatched, are shown in figures 18 to 25. These figures represent only a small part of the available material resulting from the study, and are used here merely to show typical conditions.

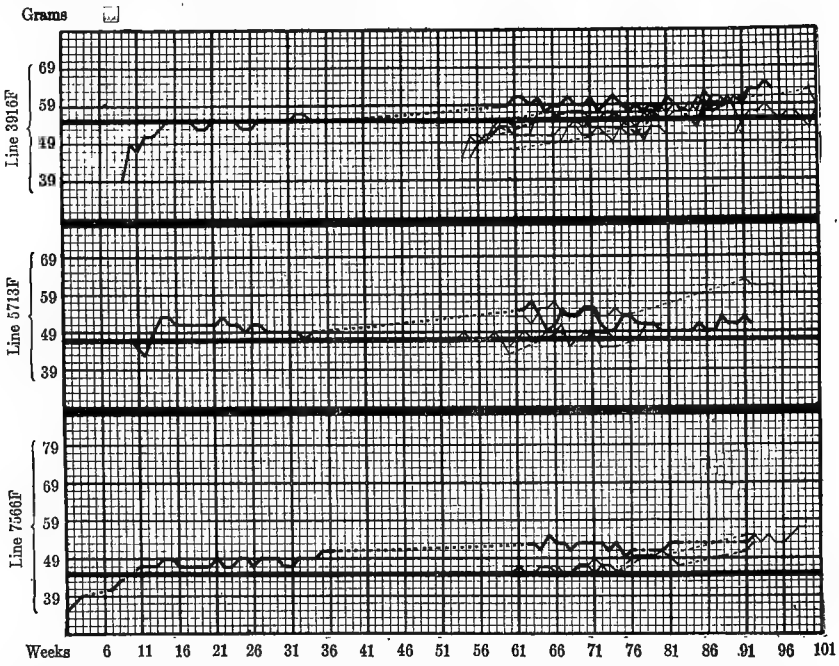

FIG. 19. VARIATION OF SIZE (WEIGHT IN GRAMS), BY WEEKLY AVERAGES, OF EGGS PRODUCED BY DAM FOR TWO YEARS AND BY PROGENY DURING EARLY PULLET PRODUCTION

The heavy horizontal line in each division represents the character of the parent egg incubated; the heavy curve represents the production of the chick hatched; the light curve represents the production of the progeny of the chick. The dotted lines indicate that no eggs were produced during the periods which they cover

Pullets 8882F and 8939F, illustrated in figure 18, are from small eggs, but pullet 8872F is from a large egg. It is evident that the tendency is for a pullet to produce eggs of the same size as the egg from which she was hatched. Sometimes small eggs are obtained from hens that

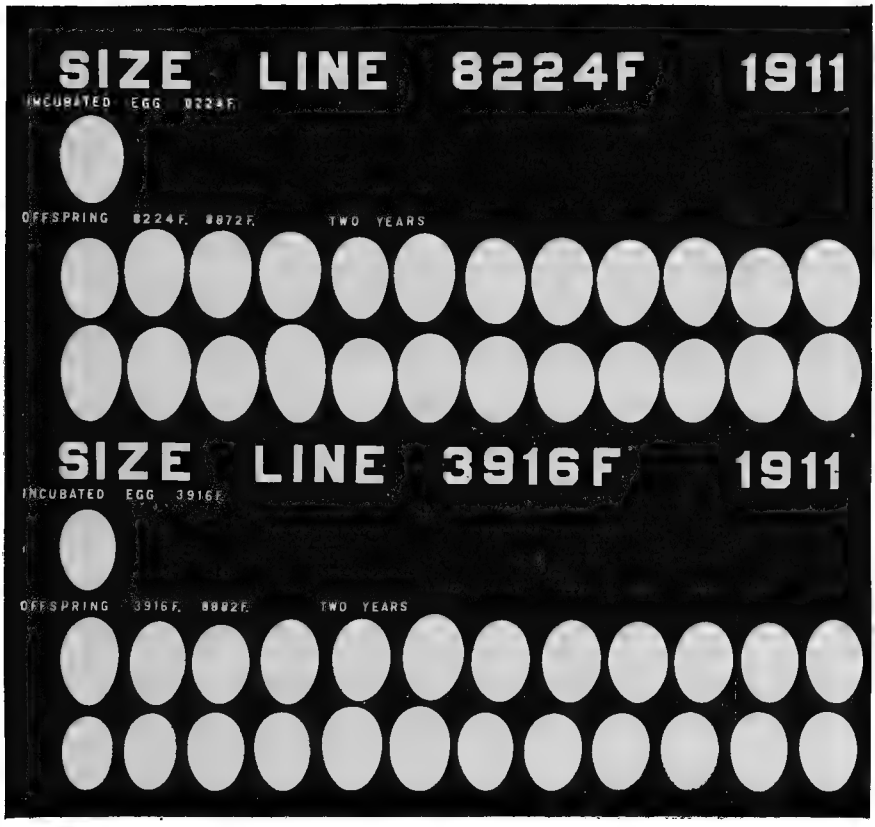

FIG. 20. SHADOW PHOTOGRAPHIC RECORD OF RELATION BETWEEN SIZE OF EGG INCUBATED AND SIZE OF EGGS PRODUCED BY THE RESULTANT CHICK

Each row of progeny production shows twelve eggs, which were selected at regular intervals during the respective year's production. All eggs were photographed each year, but only twelve eggs for each year could be represented in this group

ordinarily lay large eggs, and vice versa; this probably accounts for the low correlation in studies of mixed flocks, while the study of separate matings shows more definite results. The heavy curve for line 3916F in figure 19 represents the record for the bird whose early pullet daily record is shown as 8882F in figure 18.

The photographic record, figure 20, shows the relative sizes of eggs produced by line 8224F, one of the largest lines, and by line 3916F, one of the smallest lines. The difficulty of observing the fine differences in size, except by careful measurements, is seen from this figure. Under line 3916F is shown another record of the production of 8882F.

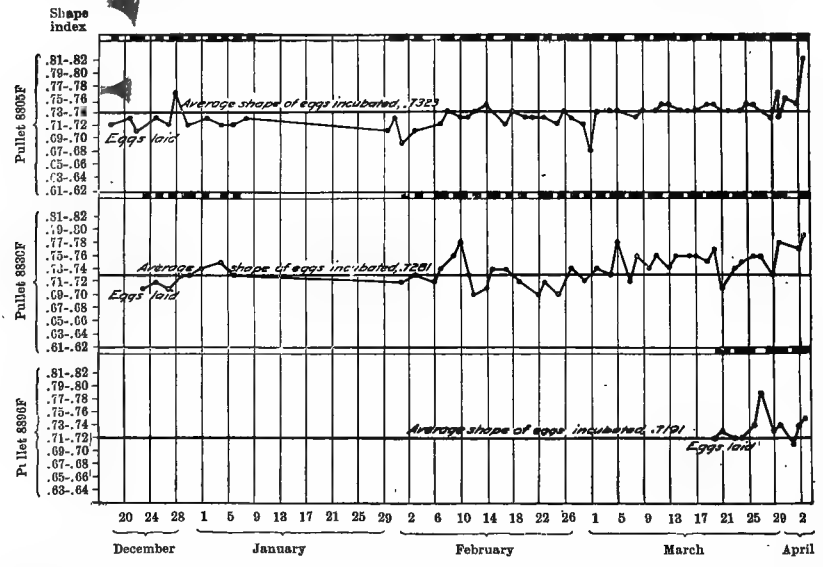

FIG. 21. VARIATION OF SHAPE OF SUCCESSIVE EGGS LAID DURING EARLY PULLET PRODUCTION

The squares blocked in black indicate the days on which eggs were laid by the respective pullets

In figures 21 and 22 are shown the daily and weekly fluctuations of shape. A photographic record of two of the first-year inheritance results for the shape character is shown in figure 23. Both of the lines shown in figure 23 are shown also in figure 22. Neither the shape nor the size of

eggs has a large coefficient of variability, and this fact is reflected in the curves and in the photographic record.

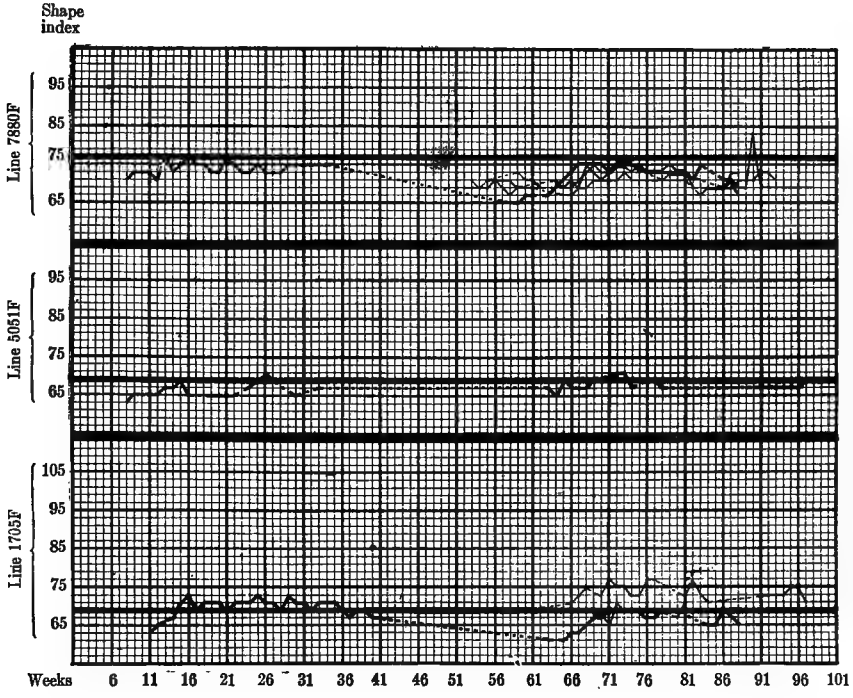

FIG. 22. VARIATION OF SHAPE, BY WEEKLY AVERAGES, OF EGGS PRODUCED BY DAM FOR TWO YEARS AND BY PROGENY DURING EARLY PULLET PRODUCTION

The heavy horizontal line in each division represents the character of the parent egg incubated; the heavy curve represents the production of the chick hatched; the light curve represents the production of the progeny of the chick. The dotted lines indicate that no eggs were produced during the periods which they cover

The color character has a much higher coefficient of variability, as may be observed from figures 24 and 25. The pullets included in figure 24 were all of the brown-egg type, but in figure 25 both brown-egg and white-egg types are shown. In these figures there seems to be a tendency for the type of egg produced by the original pullet hatched, and her later offspring, to resemble the original egg incubated. The writer can explain the negative or practically zero correlation for the color character in the

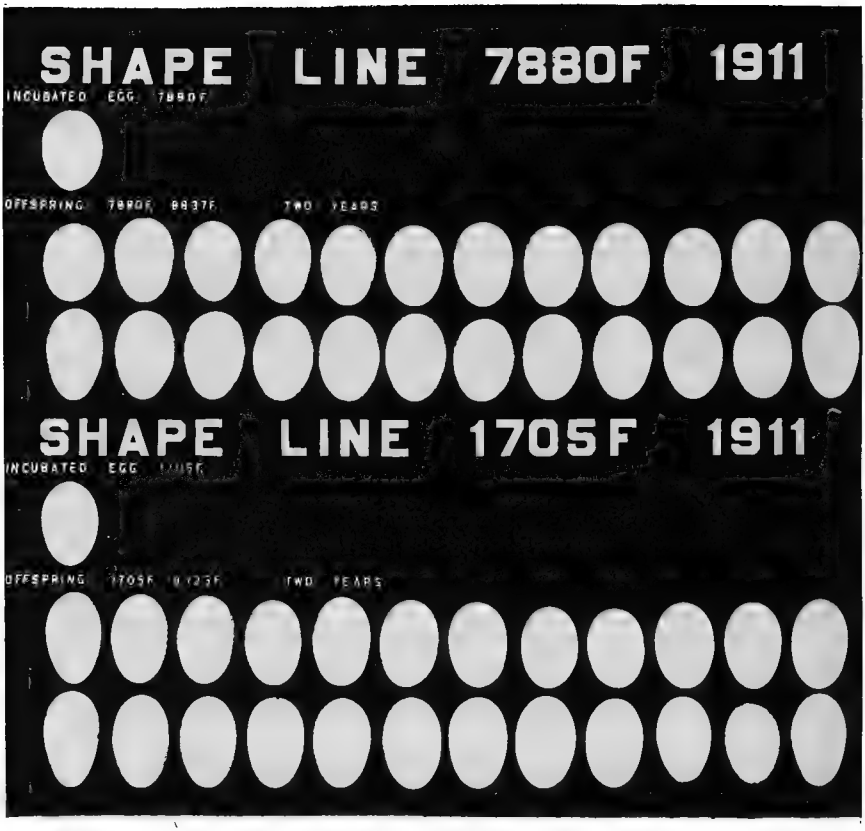

FIG. 23. SHADOW PHOTOGRAPHIC RECORD OF RELATION BETWEEN SHAPE OF EGG INCUBATED AND SHAPE OF EGGS PRODUCED BY THE RESULTANT CHICK

Each row of progeny production shows twelve eggs, which were selected at regular intervals during the respective year's production. All eggs were photographed each year, but only twelve eggs for each year could be represented in this group

data previously reviewed, only by the high coefficient of variability and the probability that many abnormal eggs are incubated instead of the normal type for the respective dam.

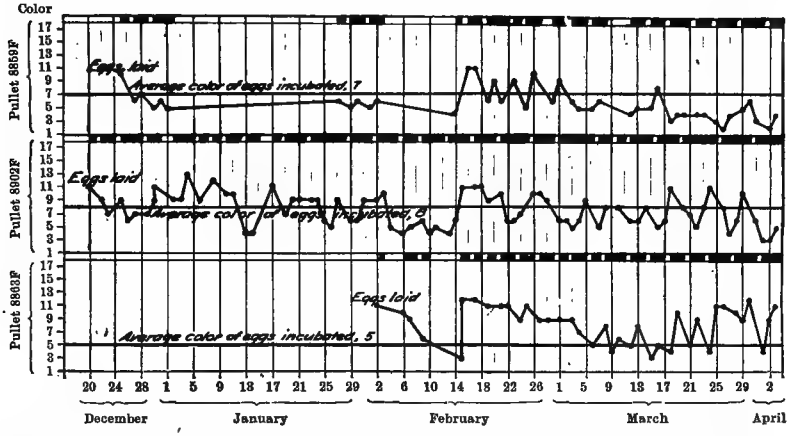

FIG. 24. VARIATION OF COLOR OF SUCCESSIVE EGGS LAID DURING EARLY PULLET PRODUCTION

The squares blocked in black indicate the days on which eggs were laid by the respective pullets

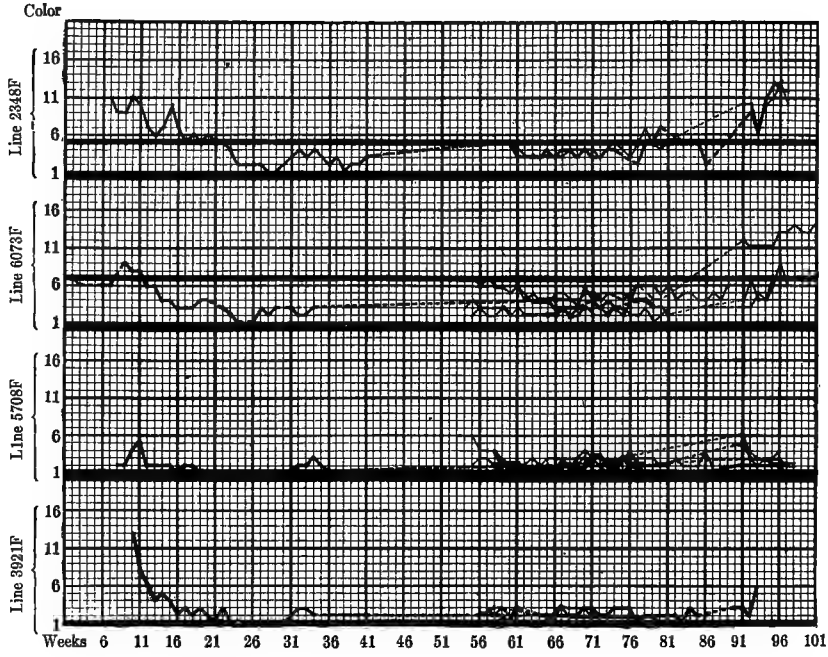

FIG. 25. VARIATION OF COLOR, BY WEEKLY AVERAGES, OF EGGS PRODUCED BY DAM FOR TWO YEARS AND BY PROGENY DURING EARLY PULLET PRODUCTION

The heavy horizontal line in each division represents the character of the parent egg incubated; the heavy curve represents the production of the chick hatched; the light curve represents the production of the progeny of the chick. The dotted lines indicate that no eggs were produced during the periods which they cover

MISCELLANEOUS STUDIES

A few studies were made in addition to those relating solely to the degree of inheritance existing for the size, shape, and color characteristics. These are discussed in the following pages.

Relationship of size and shape of eggs

A study was made of a mixed assortment of pullets' eggs (table 55), which showed practically a zero correlation. This does not agree with results reported by Pearl and Curtis (1916). Some individuals, and some different strains and breeds, may possess characteristics the reverse of those of the strain of Single Comb White Leghorns used in these experiments.

TABLE 55. SIZE (WEIGHT IN GRAMS) OF PULLETS' EGGS, SUBJECT; SHAPE OF RESPECTIVE EGGS, RELATIVE

Coefficient of correlation = —.035 ± .035

	.62	.63	.64	.65	.66	.67	.68	.69	.70	.71	.72	.73	.74	.75	.76	.77	.78	.79	.80	.81	.82	.83	.84	.85	.86	
30–32							1																			1
32–34												1														1
34–36													2		2											4
36–38		1										1		5	1	1										9
38–40								1	2	2	2		1	1	1											10
40–42					1			1	4		1	3	1	1			1		1							14
42–44								2		2		1	1	3	1		1									11
44–46							1				3	3	4	2	4			1								18
46–48								1	1	3	5	5	2	5	4	5	2									33
48–50								2	2	2	3	3	7	4	6	6	4									39
50–52						1	2	2	4	6	5	3	9	4	6	4	4			1						51
52–54				1		3	2	5	6	9	8	6	8	6	8	4	1	3								70
54–56						1	2	5	4	7	7	5	8	6		2										47
56–58	1							2		2	1	1			2				1							10
58–60												1	1													2
60–62										1		2	1	1	5	2	2									14
62–64						1		2			3	1	2	2	1	1										13
64–66										1	3	1	1	1						1					1	9
66–68									2		1	2														5
68–70																										0
70–72																										0
Above 72	1																									1
	2	1	0	1	1	6	8	23	25	35	42	39	48	41	41	25	15	4	2	2	0	0	0	0	1	362

Incubation effects of egg type

In the 1911 hatch the incubation records of the eggs were studied in relation to the egg type. These studies, as shown in tables 56 and 57, do not indicate any definite relationship between egg type and incubation record.

TABLE 56. A STUDY OF EGG TYPES AND INCUBATION RECORDS

Type of eggs incubated	Per cent of infertile eggs for each character	Per cent of total infertile eggs	Per cent of dead germs for each character	Per cent of total dead germs	Per cent hatched for each character	Per cent of total chicks hatched
Large	6	11	54	10.5	40	12
Medium	4	7	68	13	28	8
Small	8	14	40	8	52	15
Long	6	11	54	10.5	40	12
Normal	8	14	54	10.5	38	11
Round	16	29	58	11	23	8
Brown-tinted	4	7	54	10.5	42	13
Cream-tinted	4	7	70	14	23	8
Chalk-white	0	0	58	11	42	13

TABLE 57. RELATION OF SIZE OF EGGS INCUBATED TO THEIR INCUBATION RECORDS

Weight of eggs incubated (grams)	Infertile eggs		Dead germs		Chicks hatched		Total number of eggs
	Number	Per cent	Number	Per cent	Number	Per cent	
42–44	2	22	4	44	3	33	9
44–46	0	.....	6	60	4	40	10
46–48	1	4	8	30	18	67	27
48–50	1	7	7	44	8	50	16
50–52	1	4	14	56	10	40	25
52–54	3	4	46	66	21	30	70
54–56	2	3	37	60	23	37	62
56–58	2	3	40	61	24	36	66
58–60	4	7	30	57	19	36	53
60–62	3	7	22	50	19	43	44
62–64	5	14	23	62	9	24	37
64–66	3	13	14	58	7	29	24
66–68	1	20	3	60	1	20	5
68–70	0	.....	1	100	0	.....	1
70–72	0	.....	0	.....	0	.....	0
72–74	0	.....	1	100	0	.....	1
Total	28	.....	256	.....	166	.....	450

In table 57 the eggs incubated were grouped according to size and incubation results, in order to see whether any effect on the incubation record exists. No definite effect is shown by the data available here.

Relative variability of the productions of successive years

The standard deviation for all the eggs produced each year by each of the available hens was studied, in order to learn whether there is an approach to a definite egg type for the eggs produced by a hen as she becomes older. The data from this study are collected in figures 26 and

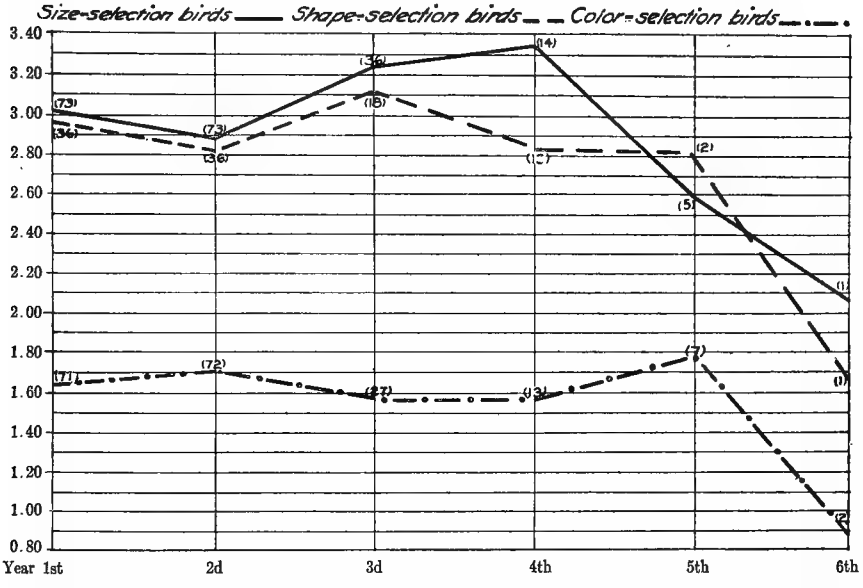

FIG. 26. STANDARD DEVIATIONS FOR SUCCESSIVE YEARS, GROUPED AS TO CHARACTER
The figures in parenthesis designate the number of birds available for the respective calculations

27. In figure 26 the studies are segregated into the three character groups. The reduction of the number of birds available for study in the fifth and sixth years makes the data for these years of doubtful value, altho the number of eggs used for each bird is in each case sufficient to make the standard deviation of real value.

In figure 27 the data for the three characters are combined both by a weighted and by an ordinary average. This figure does not show the definite tendency toward a reduction in the variability which is claimed by some other investigators (Pearl, 1909), altho if the data for the fifth and sixth years could be given as much value in this discussion as is given to the data for the first four years, a straight line fitted to the curve would show a distinct reduction in the standard deviation. The unweighted averages are shown in figure 27 because if it can be considered that the standard deviations calculated for the respective character

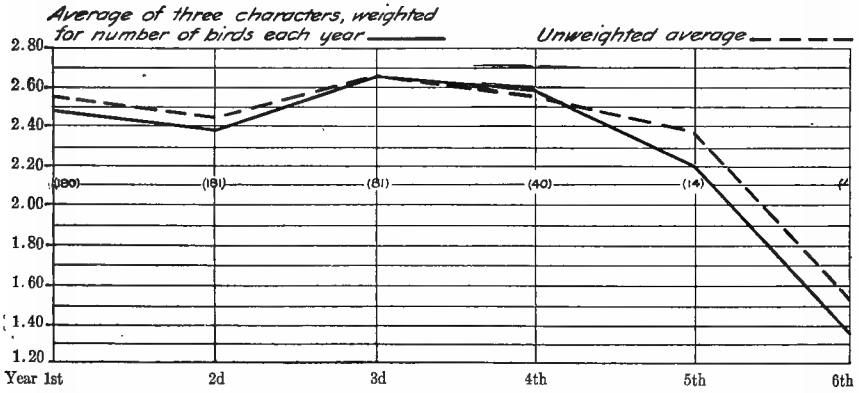

FIG. 27. STANDARD DEVIATIONS OF ALL CHARACTERS FOR SUCCESSIVE YEARS
The figures in parenthesis designate the number of birds available for the respective calculations

groups are based on a sufficient number of individuals to be trustworthy, none of these characters should be handicapped in the average if it happened that a less number of individuals were available for that particular character than for the others. This is especially true since this is a comparison of standard deviations based on a grouping according to classes of widely different values.

Variations in types of eggs produced during successive months and years

The study of the variations of eggs produced during successive months and years was carried on with birds that began to lay in different months, as noted in table 58.

The time of beginning to lay is varied enough in the data used here to nearly eliminate seasonal effects.

TABLE 58. PERCENTAGE OF EACH YEAR'S FLOCK BEGINNING TO LAY IN THE RESPECTIVE MONTHS FROM NOVEMBER TO JUNE, INCLUSIVE

Month when laying began	Percentage of year's flock that began laying in respective months					
	First year of production	Second year of production	Third year of production	Fourth year of production	Fifth year of production	Sixth year of production
November	0.3	1.1	.....	.....	5.6	.....
December	21.7	8.6	.....	2.6	.....	.....
January	29.6	28.0	6.2	2.6	5.6	.....
February	28.2	28.4	28.4	43.6	33.3	20.0
March	11.2	22.6	46.9	48.6	49.9	80.0
April	9.0	9.7	18.5	2.6	5.6	.....
May	.....	1.1	.....	.....	.....	.....
June	.....	0.5	.....	.....	.....	.....

Size character

The variations in the mean size of the eggs produced during the successive months by the size-selection birds are shown in figures 28 to 31. These curves are made up by calculating the mean for the first month's production of the first year, the second month's production of the first year, and so on for the succeeding months and years for each hen used, and then finding the mean for all available hens at each period. Data for eleven months of each year were available for a sufficient number of birds to make the figures reasonably reliable.

The size of the eggs produced by pullets increases fairly regularly during the year, but no real increase in the size of the eggs produced during the later years of production can be observed. It may seem that this statement is disproved by figure 30, but a glance at figure 28 shows that the size of the first year's production increases so rapidly that it causes the mean size to increase slightly.

All seasonal effects are eliminated in these studies, the birds being arranged in accordance with the month when they began laying each year, irrespective of the particular month which that happened to be. It would seem that the wide fluctuations after the ninth month in figure 28, and after the seventh month in figure 29, may be due to the fact that too few birds were available for study; but an apparent tendency for the size of the egg to increase rapidly near the end of the laying season is observed.

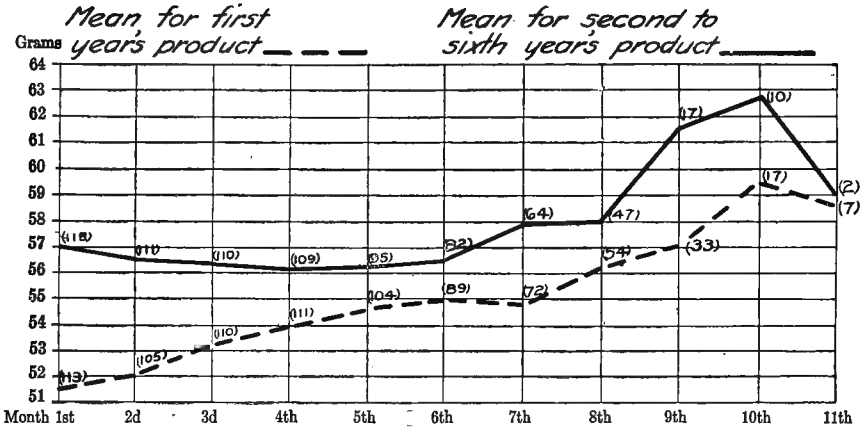

FIG. 28. MONTHLY VARIATION IN SIZE OF EGGS PRODUCED DURING A PERIOD OF SIX YEARS

The figures in parenthesis designate the number of birds available for the respective calculations

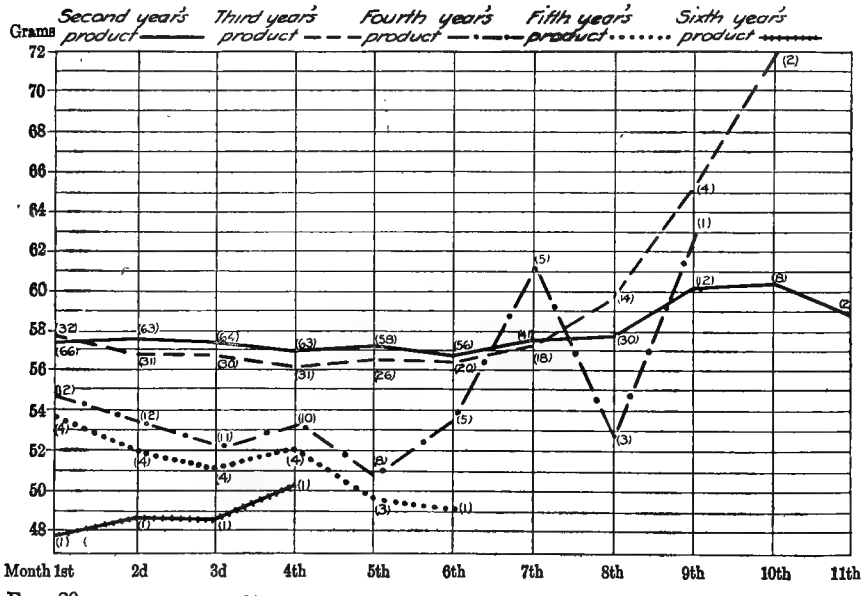

FIG. 29. MONTHLY VARIATION IN SIZE OF EGGS PRODUCED DURING A PERIOD OF SIX YEARS

The figures in parenthesis designate the number of birds available for the respective calculations

It should be noted that the individuals whose data are used for the later months of the year, shown in figures 28, 29, and 30, are those that laid during the longest period and were very likely to be the highest producers (Rice, 1914). This would indicate an agreement with Curtis

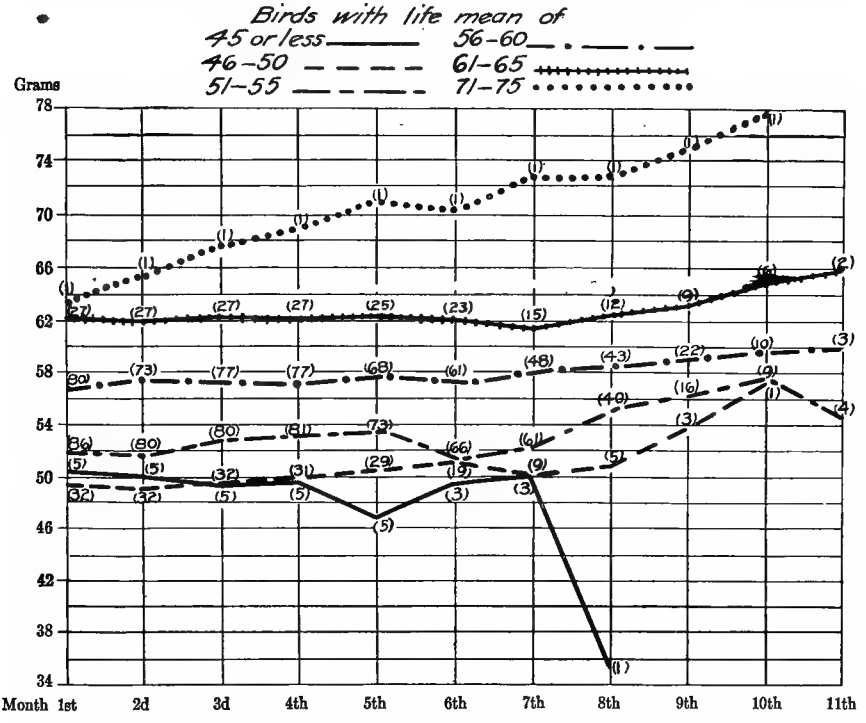

FIG. 30. MONTHLY VARIATION IN SIZE OF EGGS PRODUCED DURING A PERIOD OF SIX YEARS

The figures in parenthesis designate the number of birds available for the respective calculations
The curve representing the birds having a life mean of 45 or less does not lie entirely within that range because the whole six-years data on which the life mean is based is not available in monthly means for this chart

(1914 a) and Hadley (1919) to the effect that the conditions causing the production of a great many eggs will also cause the production of large eggs. In order to see whether the results shown in figures 28, 29, and 30 were due to the selection of high-producing birds from the low producers, as suggested above, figure 31 was constructed for five individuals which

began laying in December and continued laying for about the same period as the others (until August). No material difference can be observed between the types of curves shown in figure 31, and those shown in figures 28, 29, and 30. There seems, then, to be no marked error due to the possible selection of birds in the study of the random flocks, and it is probable that the curves for heavy producers are not materially different from those for lower producers.

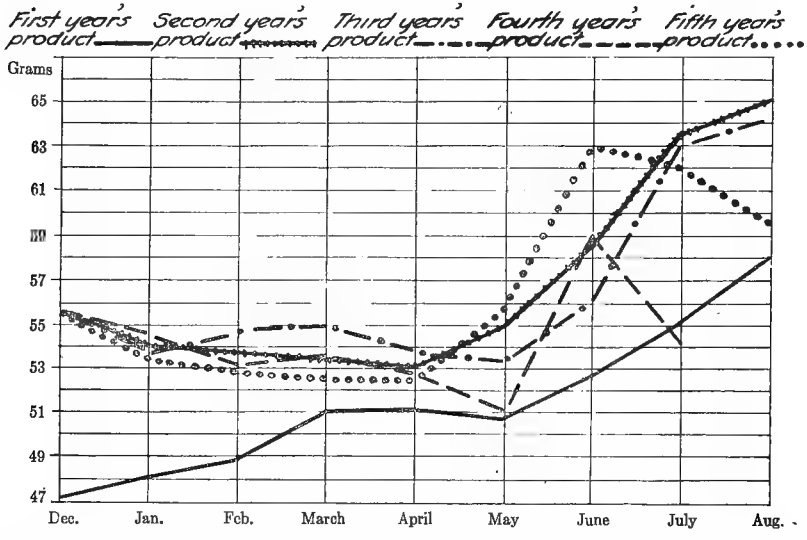

FIG. 31. MEAN MONTHLY SIZE RECORDS FOR FIVE NORMAL INDIVIDUALS FOR A PERIOD OF FIVE YEARS

After the great increase in the size of the eggs from the first to the second year, there seems to be a gradual decrease in the size of the eggs produced during successive years. This last statement does not agree with the results of Curtis (1914 a).

No decreased size of the eggs produced at the beginning and at the end of the litter is observed, as claimed by Féré (1898 b) and Curtis (1914 a), and there is no appreciable difference in the variations for the birds laying large, medium, and small eggs (fig. 30).

Shape character

In order to study the relative monthly and yearly shapes of eggs produced, the data for shape selection were prepared for figures 32 to 35 in the same way that the data for size selection were prepared for figures 28 to 31. There is shown a tendency for the eggs produced each year, even in the pullet year, to have a gradually increasing index until the fifth or sixth month of production, after which this index gradually decreases until the season's production ceases (fig. 32).

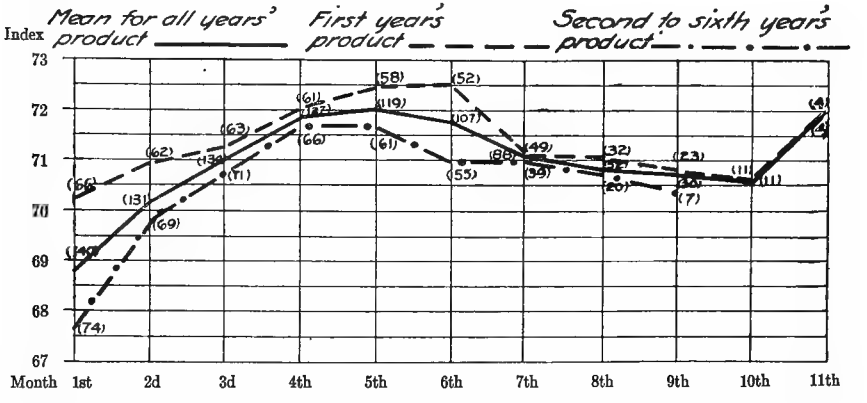

FIG. 32. MONTHLY VARIATION IN SHAPE OF EGGS PRODUCED DURING A PERIOD OF SIX YEARS

The figures in parenthesis designate the number of birds available for the respective calculations

According to figure 32, the eggs produced during the pullet year are of practically the same shape as those produced in later years. The difference may be considered insignificant. The reader should be warned against erroneous interpretation of the fifth and sixth years' production shown in figure 33, because of the very few individuals available for study for those years.

As indicated in figure 34, there seems to be no radical difference between the variation of the groupings according to the life means of the birds. Where slight differences are shown, these may usually be considered as being due to an insufficient number of individuals available for study.

The five birds recorded in figure 35 showed no distinct character different from those shown in figures 32 to 34.

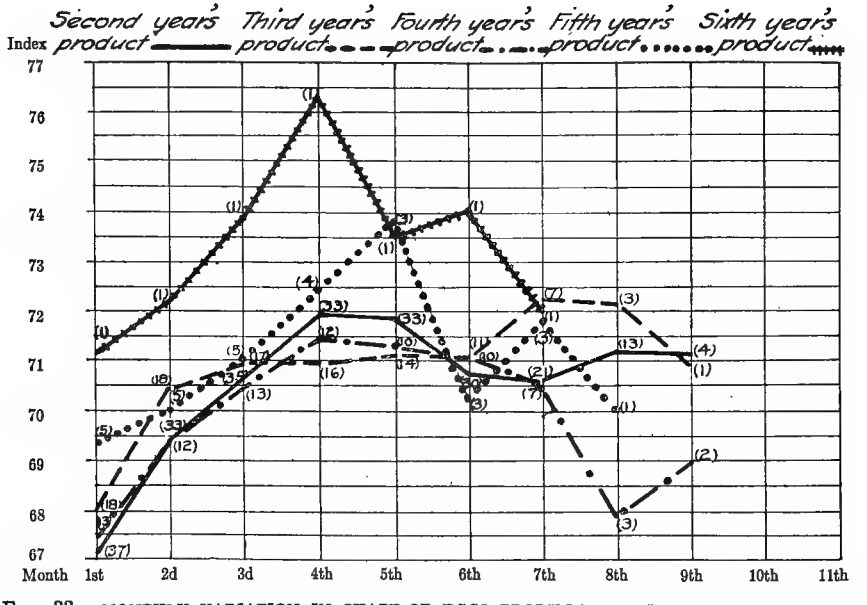

FIG. 33. MONTHLY VARIATION IN SHAPE OF EGGS PRODUCED DURING A PERIOD OF SIX YEARS

The figures in parenthesis designate the number of birds available for the respective calculations

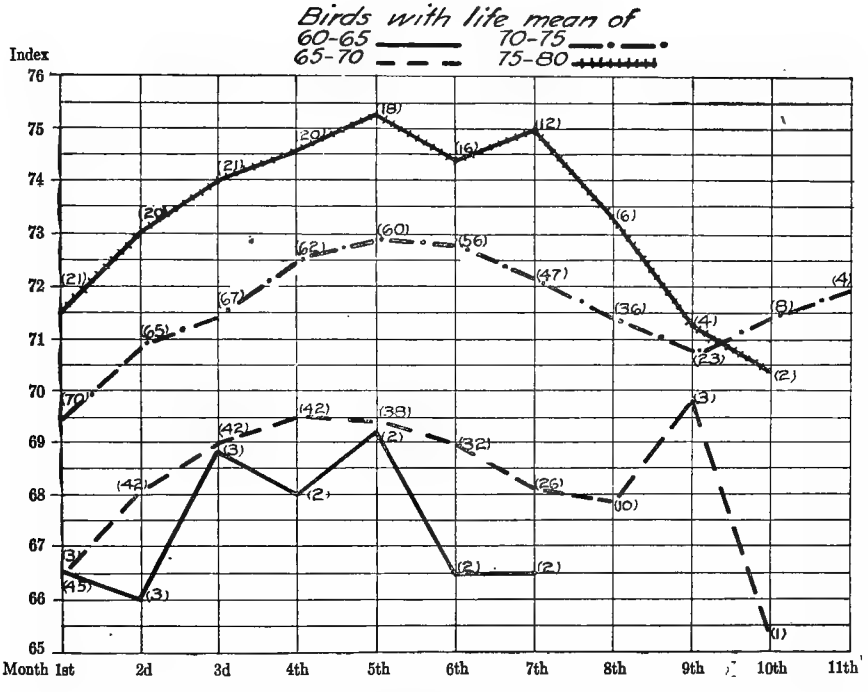

FIG. 34. MONTHLY VARIATION IN SHAPE OF EGGS PRODUCED DURING A PERIOD OF SIX YEARS

The figures in parenthesis designate the number of birds available for the respective calculations
The curve representing the birds having a life mean of 60–65 does not lie entirely within that range because the whole six-years data on which the life mean is based is not available in monthly means for this chart

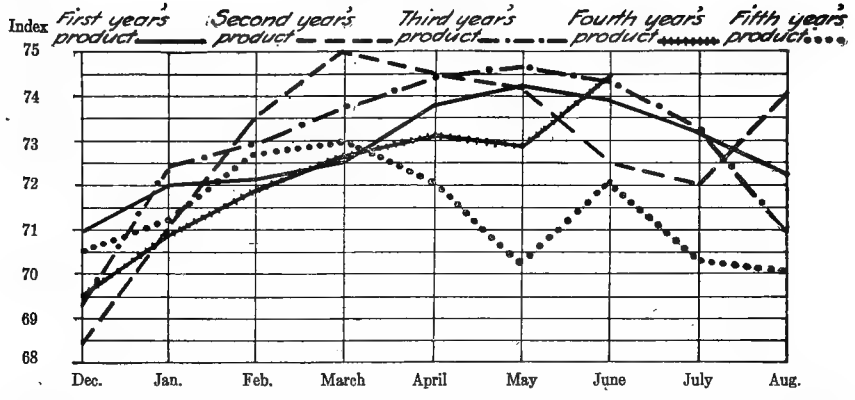

FIG. 35. MEAN MONTHLY SHAPE RECORDS FOR FIVE NORMAL INDIVIDUALS FOR A PERIOD OF FIVE YEARS

These results do not agree with deductions to be gained from Curtis (1914 a) or from Thompson (1908). It would appear from these results that the tension of the oviduct wall may gradually relax during the first five or six months of the bird's production each year, and then increase again as the season closes, causing at first a rounding of the egg and later a lengthening.

Color character

The study of the monthly production as to the variations of color is summarized in figures 36 to 39. There is a definitely increased amount of pigment in the eggs produced by the hens after their pullet year as compared with their first year's production (fig. 36). There is a distinct tendency for the eggs to become whiter as the production continues for the first five or six months, and then to become more tinted again toward the end of the season's production. It would seem that the amount of pigment is decreased during the period of most abundant egg production.

As shown in figure 37, there is no distinct and gradual increase in the pigmentation of the eggs from the second to the sixth year's production, but during each year when enough birds are available for the data to be considered of value, there is a tendency for the same monthly fluctuations as are exhibited in figure 36. The grouping of the birds according to their life means in figure 38 shows the same monthly fluctuations as were previously observed.

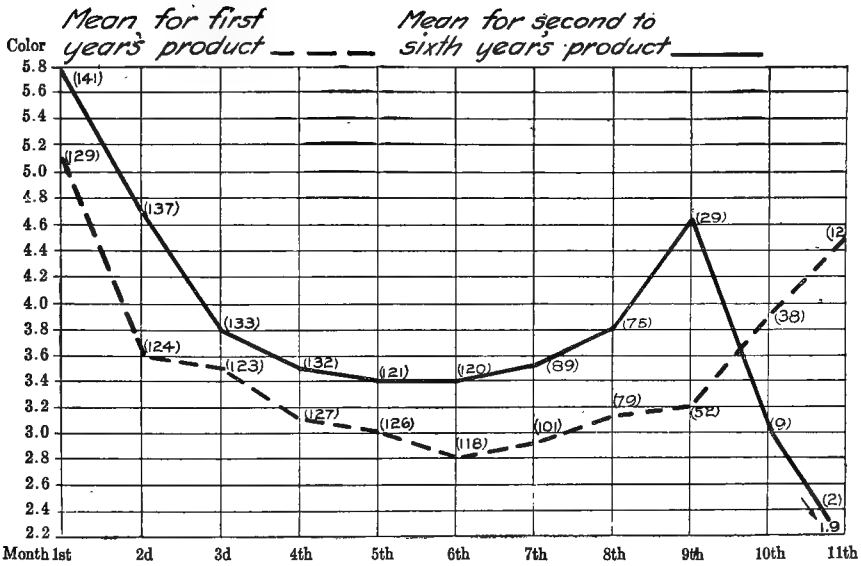

FIG. 36. MONTHLY VARIATION IN COLOR OF EGGS PRODUCED DURING A PERIOD OF SIX YEARS

The figures in parenthesis designate the number of birds available for the respective calculations

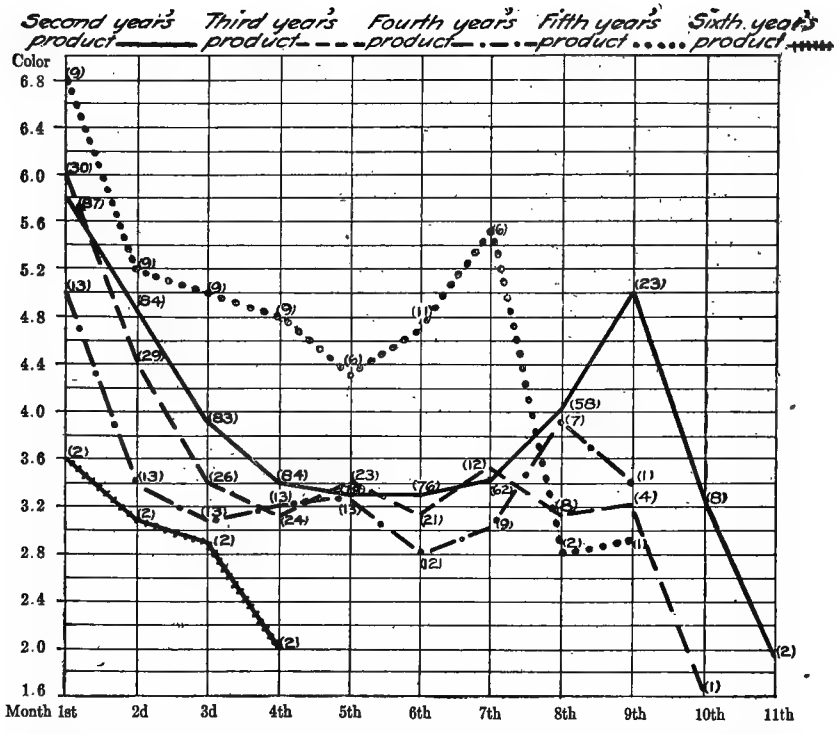

FIG. 37. MONTHLY VARIATION IN COLOR OF EGGS PRODUCED DURING A PERIOD OF SIX YEARS

The figures in parenthesis designate the number of birds available for the respective calculations

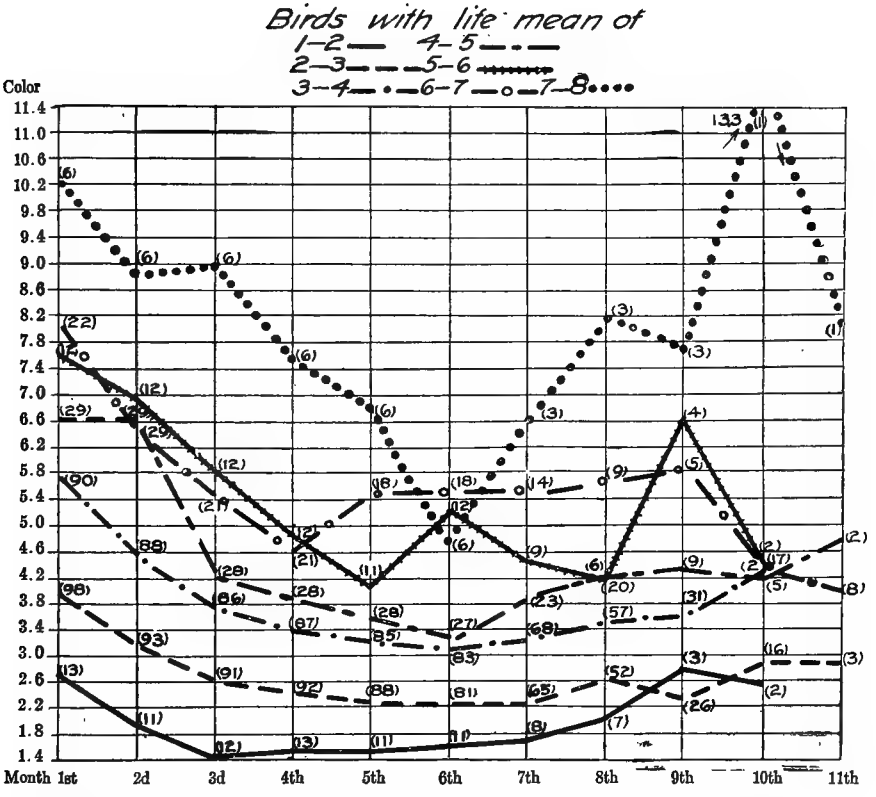

FIG. 38. MONTHLY VARIATION IN COLOR OF EGGS PRODUCED DURING A PERIOD OF SIX YEARS

The figures in parenthesis designate the number of birds available for the respective calculations

The results of this study agree in general with the findings of other workers, already discussed.

The record of five individuals in figure 39 agrees in general with the records in figures 36 to 38.

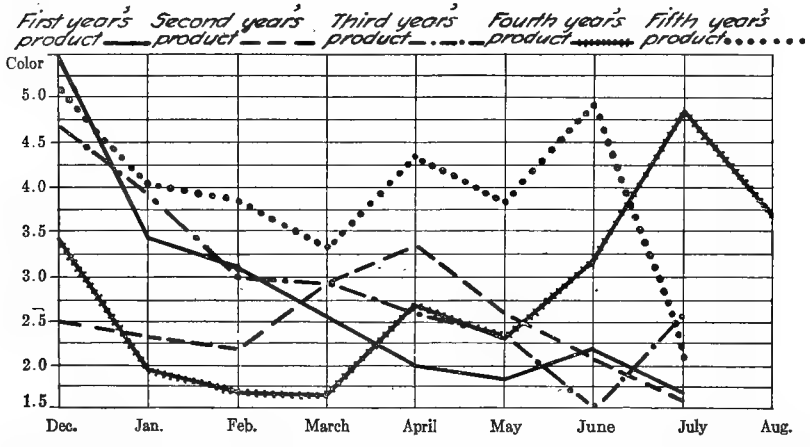

FIG. 39. MEAN MONTHLY COLOR RECORDS FOR FIVE NORMAL INDIVIDUALS FOR A PERIOD OF FIVE YEARS

Variations in types of successive individual eggs

An opportunity is furnished by figures 18, 21, and 24 (pages 243, 246, and 249) to observe how the types of successive eggs may be affected by the general type of the bird and the rate of laying.

In figure 18 it may be noted that in nearly every instance when two or more eggs are laid on successive days, the size gradually diminishes until the bird rests for one or more days, when the size of the next egg is again larger. This agrees with many more charts constructed for this same character, and is in entire accordance with Curtis (1914 a).

A study of figure 21, which agrees in general with other charts constructed for the shape character but not reproduced here, reveals the fact that in a large proportion of the instances when two or more eggs are laid in succession, the egg laid later is rounder than the one laid earlier. About 60 per cent of the cases showed an increase in the index, 25 per cent showed no change, and 15 per cent showed a decrease. This condition may

result from the less tension exerted by the oviduct wall on the second egg when it closely follows an earlier one. After the bird has rested for a day or two, the oviduct wall regains its tension and the next egg is longer.

The egg color, for the birds that were studied in this regard, seemed to be gradually intensified in eggs laid on successive days (fig. 24). About 50 per cent of the cases showed an intensification of color, 25 per cent showed no change, and 25 per cent showed a decrease of color.

Variations in types of eggs produced in different calendar months

Since it is known that the commercial eggs received in the markets vary somewhat from month to month as to their average size and color, and possibly as to their shape, it was thought well to ascertain what information could be obtained on this point from the data at hand. These variations for size, shape, and color, respectively, are illustrated in figures 40, 41, and 42.

The results shown in figure 40 do not agree with those of Hadley (1919), but tend instead to agree in general form with figures 28, 29, and 30.

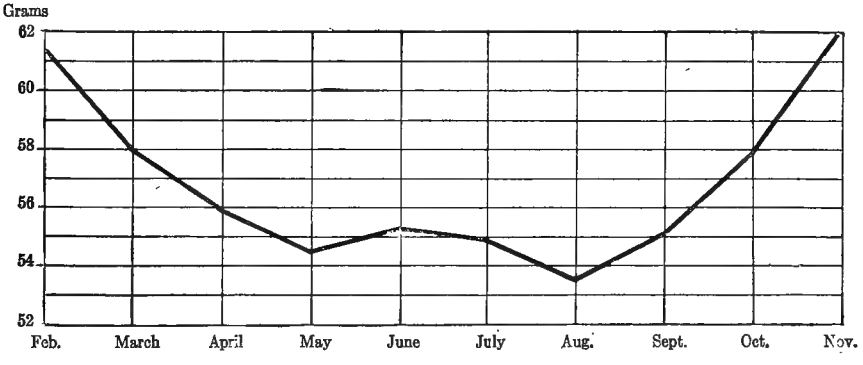

FIG. 40. MEAN MONTHLY VARIATION IN SIZE OF EGGS PRODUCED IN CERTAIN CALENDAR MONTHS FOR A PERIOD OF SIX YEARS. RECORD OF TEN INDIVIDUALS BEGINNING TO LAY IN FEBRUARY

No increase of egg size during the period of heavier production can be observed here, as found by Hadley (1919) with White Plymouth Rocks.

The results shown in figures 41 and 42 agree closely with the results previously obtained for mixed flocks, and need no further comment here.

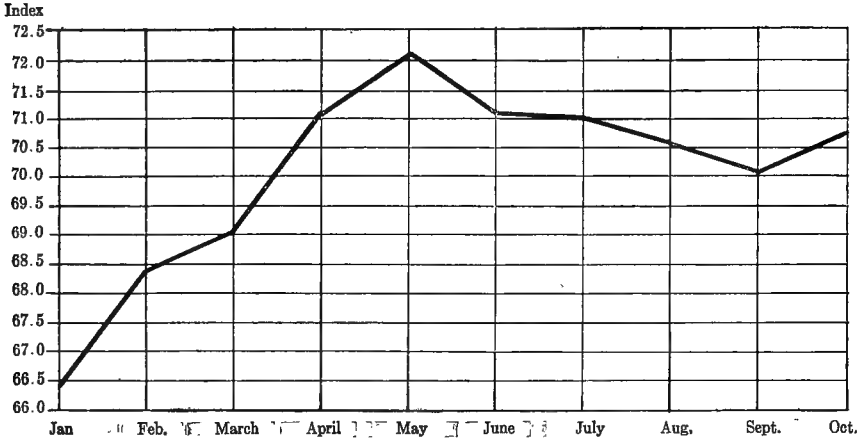

FIG. 41. MEAN MONTHLY VARIATION IN SHAPE OF EGGS PRODUCED IN CERTAIN CALENDAR MONTHS FOR A PERIOD OF SIX YEARS. RECORD OF TEN INDIVIDUALS BEGINNING TO LAY IN JANUARY

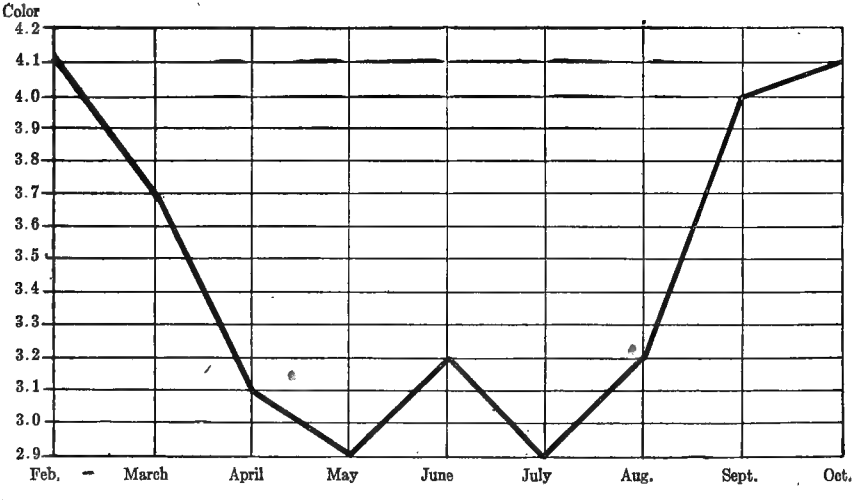

FIG. 42. MEAN MONTHLY VARIATION IN COLOR OF EGGS PRODUCED IN CERTAIN CALENDAR MONTHS FOR A PERIOD OF SIX YEARS. RECORD OF TEN INDIVIDUALS BEGINNING TO LAY IN FEBRUARY

Relation between vigor of the chick and size of the egg from which it was hatched

In 1911–12 a separate record of the vigor of the chicks, as well as of their weight, was made for the first forty weeks of their lives. The vigor was recorded in four classes: Very Poor (V.P.), Poor (P), Good (G), Very Good (V.G.). Correlation tables such as table 59 were constructed

TABLE 59. VIGOR OF CHICKS AT THE AGE OF FOUR WEEKS, SUBJECT; WEIGHT (IN GRAMS) OF EGGS FROM WHICH THE RESPECTIVE CHICKS WERE HATCHED, RELATIVE

Coefficient of correlation = .381 ± .064

	44–46	46–48	48–50	50–52	52–54	54–56	56–58	58–60	60–62	62–64	64–66	
V. P.				1								1
P.	1	3			1	1	1		1	1		9
G.		5		1	6	5	4	3	1	2		27
V. G.				5	4	8	8	2	8	4	4	43
	1	8	0	7	11	14	13	5	10	7	4	80

for each four weeks of the chicks' lives. A summary of the results of the correlation tables (space for which cannot be taken here) is given in table 60. In this table the respective weight correlations also are shown.

TABLE 60. SUMMARY OF COEFFICIENTS OF CORRELATION FOUND IN STUDYING THE RELATION OF THE WEIGHT AND VIGOR OF THE CHICKS, SUBJECT, AND THE WEIGHT OF THE EGGS FROM WHICH THE RESPECTIVE CHICKS WERE HATCHED, RELATIVE

Age of chick	Coefficient of correlation		Number of individuals
	Chick vigor	Chick weight	
1 day	.....*	.844± .021	82
4 weeks	.381± .064	.461± .060	80
8 weeks	.331± .066	.311± .067	82
12 weeks	.334± .069	.362± .068	75
16 weeks	.338± .070	.380± .068	72
20 weeks	.159± .077	.263± .073	73
24 weeks	.176± .077	.308± .072	73
28 weeks	.174± .081	.296± .077	65
32 weeks	.296± .080	.509± .064	61
36 weeks	.075± .087	.392± .074	60
40 weeks	.110± .093	.397± .079	51

*The vigor was not recorded at the one-day-old period, because it was impossible to designate the different classes at this early age.

In recording the data for these vigor studies, a special effort was made to be sure that the record for vigor was made independently of the record

for weight. Of course these two factors are likely to be very closely associated. The weight correlations are much more distinct than those for vigor during most of the year. The vigor correlations decreased after the early weeks, until some very severe winter weather just previous to the thirty-sixth week's recording. After the thirty-sixth week, however, abnormally early spring weather prevailed, the vigor of all birds improved wonderfully, and the correlation entirely disappeared.

From the observations just noted, it seems that the test of the vigor of a chick, that is to say, when the size of the parent egg is of real benefit, comes during the season of greatest hardship to the birds. The weights are not affected by the seasonal conditions quite so definitely as is the vigor.

Relation between male and female weights for chicks of the same age

During the first forty weeks of the 1911 hatch, and the first seventy-six weeks of the 1912 hatch, the male and female weights were averaged

TABLE 61. CONSTANTS REPRESENTING X IN THE FORMULA: FEMALE WEIGHT : MALE WEIGHT :: X : 1

1911 offspring		1912 offspring	
Age	Constant	Age	Constant
		1 day	.97
4 weeks	.89	4 weeks	.72
8 weeks	.91	8 weeks	.84
12 weeks	.81	12 weeks	.86
16 weeks	.78	16 weeks	.88
20 weeks	.75	20 weeks	.87
24 weeks	.75	24 weeks	.*
28 weeks	.88	28 weeks	.95
32 weeks	.89	32 weeks	.91
36 weeks	.92	36 weeks	.95
40 weeks	.90	40 weeks	.94
		44 weeks	.85
		48 weeks	.83
		52 weeks	.89
		56 weeks	.84
		60 weeks	.81
		64 weeks	.82
		68 weeks	.85
		72 weeks	.82
		76 weeks	.83

* No male weights were obtained at this age in 1912.

separately, and for each four-weeks period a figure was obtained to represent x in the following ratio:

Female weight : male weight :: x : 1

A list of all such constants obtained is shown in table 61. In studying correlations for the weeks shown in table 61 for the 1911 offspring, and for the one-day-old period of the 1912 offspring, the male weights were multiplied by their respective constants and used with the female weights. After the above periods, and for all other offspring, no male weights were used. These constants correspond rather closely to the constant 0.93 representing the same ratio for human stature in mature persons, found by Galton.[11]

Relation between size of the chick and size of the egg from which it was hatched

A preliminary study was made of the 1911 and 1912 offspring, before the records for the later years were available, to determine the relation between the size of the chick and the size of the egg from which it was

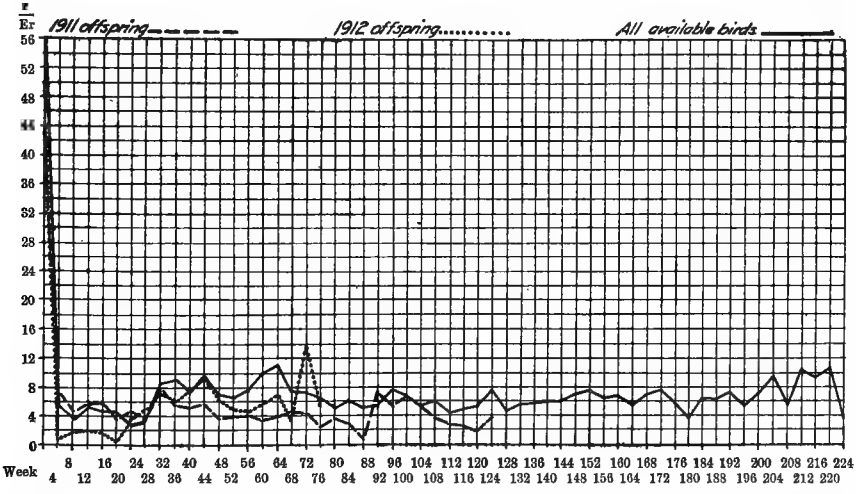

FIG. 43. GRAPHIC RECORD OF $\frac{r}{Er}$ FOR 1911 OFFSPRING, 1912 OFFSPRING, AND ALL BIRDS AVAILABLE DURING THE PERIOD OF THE EXPERIMENT

Sizes of birds at four-weeks periods during their life, subject; sizes of eggs from which the respective chicks were hatched, relative

[11] Galton, Francis. Natural inheritance, p. 78. 1889.

hatched (Benjamin, 1912 and 1914). The coefficients of correlation for these preliminary studies are summarized in table 62 and in figure 43.

TABLE 62. SUMMARY OF PRELIMINARY STUDIES TO DETERMINE THE RELATION BETWEEN SIZE OF THE CHICK AND SIZE OF THE EGG FROM WHICH IT WAS HATCHED

Age of chicks	1911 offspring			1912 offspring		
	Coefficient of correlation	$\frac{r}{Er}$	Number of individuals	Coefficient of correlation	$\frac{r}{Er}$	Number of individuals
1 day	.844±.021	40.19	82	.745±.017	43.82	308
4 weeks	.461±.060	7.68	80	.024±.050	0.48	179
8 weeks	.311±.067	4.64	82	.074±.058	1.28	134
12 weeks	.362±.068	5.32	75	.099±.059	1.68	125
16 weeks	.380±.068	5.59	72	.088±.063	1.40	110
20 weeks	.263±.073	3.60	73	.046±.069	0.67	96
24 weeks	.308±.072	4.28	73	.301±.082	3.67	56
28 weeks	.296±.077	3.84	65	.363±.076	4.78	59
32 weeks	.509±.064	7.95	61	.401±.055	7.29	108
36 weeks	.392±.074	5.30	60	.350±.058	6.03	104
40 weeks	.397±.079	5.03	51	.420±.057	7.37	96
44 weeks	.458±.081	5.65	44	.506±.052	9.73	92
48 weeks	.355±.090	3.94	43	.378±.062	6.10	88
52 weeks	.353±.089	3.97	44	.328±.066	4.97	83
56 weeks	.355±.089	3.99	44	.310±.067	4.63	82
60 weeks	.306±.092	3.33	44	.367±.067	5.48	80
64 weeks	.340±.090	3.78	44	.405±.064	6.33	77
68 weeks	.370±.089	4.16	43	.246±.071	3.46	79
72 weeks	.363±.089	4.08	43	.331±.025	13.24	78
76 weeks	.224±.098	2.29	43	.409±.075	5.45	56
80 weeks	.315±.093	3.39	43			
84 weeks	.276±.095	2.91	43			
88 weeks	.066±.103	0.64	43			
92 weeks	.549±.073	7.52	42			
96 weeks	.441±.083	5.31	42			
100 weeks	.492±.079	6.23	42			
104 weeks	.441±.084	5.25	42			
108 weeks	.356±.093	3.83	40			
112 weeks	.270±.099	2.73	40			
116 weeks	.222±.102	2.18	40			
120 weeks	.164±.104	1.58	40			
124 weeks	.337±.095	3.55	40			
128 weeks	.368±.093	3.96	40			

In both years the value r seems to have been higher during cold weather, which occurred, for the 1911 offspring, from the thirtieth to the forty-fourth week and from the ninety-second to the one-hundredth week, and for the 1912 offspring from the thirtieth to the forty-fourth week. This seems to be due to the fact that the larger, stronger birds were

able to withstand the severe winter weather relatively better than the smaller birds from the smaller eggs.

A similar tendency may be noted for the $\frac{r}{Er}$ to increase during the first winter, in the curve representing all birds in figure 43, but no definite increase in this factor can be observed for any of the later winters. No definite tendency can be seen toward an increase or a decrease in the factor $\frac{r}{Er}$ as the birds become older after the fourth week. The factor $\frac{r}{Er}$ at the one-day age is very large, as might be expected.

From the fourth week to the twentieth week of the 1912 offspring, it will be noticed that the coefficient of correlation is very low. The only explanation of this is that it may be due to an error in taking the weights. The balance used was rather heavy, and the hundredths of pounds had to be estimated. It is possible that the flapping and jumping of the larger, more vigorous chicks caused their weight to be underestimated, thus tending to reverse the correlation. In spite of these few discrepancies, it will be noted that the correlation is always positive and in most cases significant.

The studies that were made on all available birds during the entire experiment are shown in tables 63 to 119, and are summarized in figure 43 (page 271) and in table 120.

TABLE 63. SIZE (WEIGHT IN GRAMS) OF BIRDS AT AGE OF 1 DAY, SUBJECT; SIZE OF EGGS FROM WHICH RESPECTIVE CHICKS WERE HATCHED, RELATIVE

Coefficient of correlation = .73 ± .013

	44	46	48	50	52	54	56	58	60	62	64	66	68	70	
23–25			1												1
25–27		7	7												14
27–29		8	17	6	8	1	1		1						42
29–31		5	15	17	20	16	6	2	1						82
31–33	1		3	11	26	39	21	6	2						109
33–35		2	1	11	12	19	26	22	5	4					102
35–37			1	2	5	4	14	24	23	10	1				84
37–39		1			3	13	6	10	8	10	7	2			60
39–41						4	3	7	9	8	7	4			42
41–43						2	3	3	6	3	4	4	1		26
43–45								1	1			2	1		5
45–47														1	1
47–49								1			1				2
49–51													1	1	2
51 or more				1											1
	1	23	45	48	74	98	80	76	56	35	20	12	3	2	573

TABLE 64. SIZE OF BIRDS AT AGE OF 4 WEEKS, SUBJECT; SIZE OF EGGS FROM WHICH RESPECTIVE CHICKS WERE HATCHED, RELATIVE

Coefficient of correlation = .20 ± .037

	44	46	48	50	52	54	56	58	60	62	64	66	68	70	
20- 30		1	1		2				1						5
30- 40						1	1		1						3
40- 50			1		3	4	4	1	2	1					16
50- 60			1	1	1		2	1							6
60- 70		1	1	2	2	5	1	1	6						19
70- 80		1	2	1		2		2	1	2					11
80- 90			4	2	1	2	1	2	3						15
90-100		1	5	7	7	10	6	5	4	1	1	1			48
100-110		2	1	2	4	8	5	5	3	5	2			1	38
110-120	1	1	1	2	4	10	9	7	4	2	3	2	1		47
120-130			1		2	3	5	5	4	4	1			1	26
130-140				1	5	4	5	6	1		1	2	1	2	28
140-150					2	1	1	3	1	2	1	1			12
150-160				1	1	1	1				1	1			6
160-170						1		2	1	1					5
170-180				1	1			2							4
180-190					1										1
190-200						1		1		1					3
200-210							1	1							2
210-220															0
220-230									1						1
230-240							1								1
240-250			1				1								2
	1	7	19	20	36	53	44	44	33	19	10	7	2	4	299

TABLE 65. SIZE OF BIRDS AT AGE OF 8 WEEKS, SUBJECT; SIZE OF EGGS FROM WHICH RESPECTIVE CHICKS WERE HATCHED, RELATIVE

Coefficient of correlation = .14 ± .038

	44	46	48	50	52	54	56	58	60	62	64	66	68	70	
80–100			1												1
100–120			2												2
120–140					1		1	1							3
140–160		2	1				2		3						8
160–180			2		1	4	1	2	3	1	1	1			16
180–200			1	1	4	3	2	1	2	2	2			1	19
200–220			2	5	1	6	4	1	3	2					24
220–240	1		2	4	4	7	4	4	2	2	1	1			32
240–260		3	2	3	3	9	2	7	4			1			34
260–280		1	2	3	6	8	7	4	1	1					33
280–300		1		2	4	2	5	4	3	5	2	1	1	1	31
300–320			1	2	5	1	6	7	2	1	3	2	2		32
320–340			1	1		6	4	3	1	1	1	1		2	21
340–360			1		1	2	2	5	3	1	1				16
360–380			1		5	3	3	4	3	3					22
380–400					1	1	1	1	1						5
400–420				1											1
420–440					1										1
440–460						1									1
	1	7	19	22	37	53	44	44	31	19	11	7	3	4	302

TABLE 66. SIZE OF BIRDS AT AGE OF 12 WEEKS, SUBJECT; SIZE OF EGGS FROM WHICH RESPECTIVE CHICKS WERE HATCHED, RELATIVE

Coefficient of correlation = .20 ± .040

	44	46	48	50	52	54	56	58	60	62	64	66	68	70	
300–320					1	1	1		2			1			6
320–340									1						1
340–360		1		2	2	3		1	2	1					12
360–380		1	1	1		3			2						8
380–400				1	1	2		2							6
400–420			1	1	1	3	2	1	1	1			1	1	13
420–440		2	1		1	2	2	2	1	1					12
440–460		2	3	1	6	1	2			1	1				17
460–480	1		1	1	1	2		2	3	1					12
480–500			3	2	2	3	5	3	1		1				20
500–520			1						1						2
520–540			1	2	3	2	4	2	3	1				1	19
540–560						8	6	6	1	1	1	1		1	25
560–580				1	1	3		3	5	2	2		1		18
580–600			2		5	2	3			1		2			15
600–620			1	2	1	5	2	3	1		1				16
620–640		1	1	1	1	2	3	4	1						14
640–660					1		3	2		1					7
660–680				1	2			1		1	1	2			8
680–700				1	1	2	2	1	2		3	1			13
700–720						1	2	1	2						6
720–740					1		1	1		3	1				7
740–760										1					1
760–780								1		1					2
780–800					1					1					2
	1	7	16	17	32	45	38	36	29	18	11	7	2	3	262

TABLE 67. SIZE OF BIRDS AT AGE OF 16 WEEKS, SUBJECT; SIZE OF EGGS FROM WHICH RESPECTIVE CHICKS WERE HATCHED, RELATIVE

Coefficient of correlation = .19 ± .040

	44	46	48	50	52	54	56	58	60	62	64	66	68	70	
360– 400												1			1
400– 440			1	1			3	1		1					7
440– 480				2		1	1		3						7
480– 520				2		2		1	1						6
520– 560		1		2	3	3		3	1						13
560– 600		1			1	2		1	2	1			1		9
600– 640		1	1	2	2	1	4	4		1					16
640– 680	1	2	1		1	2	1	3	1						12
680– 720			2	2	2	2	2	2			2			1	15
720– 760		1	2	1	2	4	2		3	2					17
760– 800			2	1	3	4	2	2		1	1			1	17
800– 840			1	4		5	3	3	3	2		1			22
840– 880			2	2	3	5	4	2	1				1		20
880– 920		1	2		4	4	3	6	9		1				30
920– 960					1	3	7	3		3	2	1			20
960–1000			1	1	2	2	1	2							9
1000–1040			1		2	1	1	1	1	1					8
1040–1080					1	1	1	1		3	4	1			12
1080–1120							3	2		1	1	1			8
1120–1160							2			1		1			4
1160–1200					2		1	1							4
1200–1240										1					1
1240–1280					1										1
	1	7	16	20	30	42	41	38	25	18	11	6	2	2	259

TABLE 68. SIZE OF BIRDS AT AGE OF 20 WEEKS, SUBJECT; SIZE OF EGGS FROM WHICH RESPECTIVE CHICKS WERE HATCHED, RELATIVE

Coefficient of correlation = .18 ± .040

	44	46	48	50	52	54	56	58	60	62	64	66	68	70	
400– 500			1					1							2
500– 600				1			1		3						5
600– 700				3	3		2	1	1						10
700– 800	1			3		3	1	4	1	2		1	1		17
800– 900		7	3	5	4	5	5	5	6	3				1	44
900–1000		1	2	5	9	13	10	10	3		5	1		1	60
1000–1100			4	5	3	12	8	5	9	1	4	2	1		54
1100–1200			1	2	5	6	2	8	8	4	2	3	2		43
1200–1300			2		2	1	6	4	4	1	1	2			23
1300–1400							1	1							2
1400–1500					1										1
	1	8	13	24	27	40	36	39	35	11	12	9	4	2	261

TABLE 69. SIZE OF BIRDS AT AGE OF 24 WEEKS, SUBJECT; SIZE OF EGGS FROM WHICH RESPECTIVE CHICKS WERE HATCHED, RELATIVE

Coefficient of correlation = .15 ± .066

	46	48	50	52	54	56	58	60	62	64	66	68	70	
600– 700		1					1							2
700– 800				1				1						2
800– 900				1										1
900–1000					1	3	1	3	1	1				10
1000–1100	3	2	2	1	2	3	1	2			1		1	18
1100–1200	1	1	3	4	7	1	4		1	2		1		25
1200–1300		1	3	4	4	6	4	7		1				30
1300–1400		2	1	1	4	2	5	6	2	1	2	1		27
1400–1500		1			2	1	2	2	1	3	3			15
1500–1600				2		1	2							5
1600–1700						3								3
1700–1800								1						1
1800–1900				1										1
	4	8	9	15	20	20	20	22	5	8	6	2	1	140

TABLE 70. SIZE OF BIRDS AT AGE OF 28 WEEKS, SUBJECT; SIZE OF EGGS FROM WHICH RESPECTIVE CHICKS WERE HATCHED, RELATIVE

Coefficient of correlation = .12 ± .039

	44	46	48	50	52	54	56	58	60	62	64	66	68	70	
600– 700				1					1						2
700– 800			1					1							2
800– 900				1				1	2						4
900–1000			1	3	6	2	1		2	1		1			17
1000–1100		3		2		6	3	3	5	2			1		25
1100–1200	1	2	2	4	9	10	6	10	6		1			2	53
1200–1300		3		5	4	6	6	8	6	1	4	1	2	1	47
1300–1400			6	6	5	11	7	3	6	1	3	1	1	1	51
1400–1500			1	1	4	7	6	6	5	2	3	2	1		38
1500–1600				1	1	2	5	5	2	1		3			20
1600–1700			2	1	1	1	2	1	3	1		1			13
1700–1800			1		2	2	1	2							8
1800–1900					1				1	2					4
1900–2000							1	1							2
2000–2100															0
2100–2200															0
2200–2300									1						1
	1	8	14	25	33	47	38	41	40	11	11	9	5	4	287

TABLE 71. SIZE OF BIRDS AT AGE OF 32 WEEKS, SUBJECT; SIZE OF EGGS FROM WHICH RESPECTIVE CHICKS WERE HATCHED, RELATIVE

Coefficient of correlation = .31 ± .036

	44	46	48	50	52	54	56	58	60	62	64	66	68	70	
700– 800			1	1					1						3
800– 900				1											1
900–1000	1		1	2	1	1		1							7
1000–1100		2		3		1	1		2	2					11
1100–1200		1		1	7	4	1	5	2			1	1		23
1200–1300		1	1	2	6	6	7	9	3		2			1	38
1300–1400		3	3	7	5	10	4	2	10		1		2		47
1400–1500			3	5	5	11	10	6	8	1	2	2		2	55
1500–1600			4	4	4	9	5	6	3	2	1	1			39
1600–1700		1			3	4	8	2	4	2	2	1	1	1	29
1700–1800			1		1	2		6	2		1	2			15
1800–1900							2	2	2	1	1	1			9
1900–2000								1		1	1		1		4
2000–2100												1			1
2100–2200									1	2					3
2200–2300								1							1
	1	8	14	26	32	48	38	41	38	11	11	9	5	4	286

TABLE 72. SIZE OF BIRDS AT AGE OF 36 WEEKS, SUBJECT; SIZE OF EGGS FROM WHICH RESPECTIVE CHICKS WERE HATCHED, RELATIVE

Coefficient of correlation = .33 ± .037

	44	46	48	50	52	54	56	58	60	62	64	66	68	70	
700– 800	1								1						2
800– 900															0
900–1000				2	1										3
1000–1100			1	1	1	1		1							5
1100–1200		2		1	3	3	1		3	1					14
1200–1300		3		6	3	3	4	7	2	1			1		30
1300–1400			3	4	3	7	7	8	4	1	3	1	1		42
1400–1500		2	5	5	8	9	6	6	6	1					48
1500–1600		1	1	5	5	7	7	4	6	2	3	2	1	2	46
1600–1700			1	1	1	10	6	7	3	1		2	1	1	34
1700–1800			1		3	2	4	1	3		2				16
1800–1900						2	3	4	4		2	3			18
1900–2000			1					2		1		1	1		6
2000–2100										1	1				2
2100–2200								1	1						2
2200–2300										1					1
	1	8	13	25	28	44	38	41	33	10	11	9	5	3	269

TABLE 73. SIZE OF BIRDS AT AGE OF 40 WEEKS, SUBJECT; SIZE OF EGGS FROM WHICH RESPECTIVE CHICKS WERE HATCHED, RELATIVE

Coefficient of correlation = .28 ± .038

	46	48	50	52	54	56	58	60	62	64	66	68	70	
900–1000								1						1
1000–1100			1	1										2
1100–1200			2											2
1200–1300	1	1	2	6	3		2	3						18
1300–1400	3	1	6	6	9	6	4	7	1			1		44
1400–1500	3	3	4	6	10	7	10	7	3	4	3	1		61
1500–1600		6	8	3	12	7	10	1	1	2		1	1	52
1600–1700			3	5	6	6	6	5	2	1			2	36
1700–1800		2		5	4	5	3	7	1	1	2			30
1800–1900					3	2	2	1	1	1	2		1	13
1900–2000							2	3	1					6
2000–2100											1			1
2100–2200														0
2200–2300							1		1					2
2300–2400								1						1
	7	13	26	32	47	33	40	36	11	9	8	3	4	269

TABLE 74. SIZE OF BIRDS AT AGE OF 44 WEEKS, SUBJECT; SIZE OF EGGS FROM WHICH RESPECTIVE CHICKS WERE HATCHED, RELATIVE

Coefficient of correlation = .34 ± .035

	46	48	50	52	54	56	58	60	62	64	66	68	70	
1000–1100					1			1						2
1100–1200			1	2	1			1						5
1200–1300	3	1	4	4	3	2	2	4	1					24
1300–1400	1	3	5	11	9	3	4	6				1		43
1400–1500	3	3	8	4	15	8	8	4	3	1	1		1	59
1500–1600		3	4	4	9	8	9	5	1	3	1	1	2	50
1600–1700		2	2	6	5	3	8	7	1	3	2	1		40
1700–1800			1	1	2	8	1	6	3		1	1	1	25
1800–1900						2	2	1	1	2	2			10
1900–2000					1		1		1					3
2000–2100														0
2100–2200							1	1						2
	7	12	25	32	46	34	36	36	11	9	7	4	4	263

TABLE 75. SIZE OF BIRDS AT AGE OF 48 WEEKS, SUBJECT; SIZE OF EGGS FROM WHICH RESPECTIVE CHICKS WERE HATCHED, RELATIVE

Coefficient of correlation = .27 ± .039

	46	48	50	52	54	56	58	60	62	64	66	68	70	
900–1000				1										1
1000–1100			1	1			1	1						4
1100–1200	1	1	5	2		2	1	3				1		16
1200–1300	4		6	2	11	6	4	5	2					40
1300–1400		2	5	12	7	5	9	3	4	2	1		2	52
1400–1500	2	6	5	6	12	6	7	7		2	2	1		56
1500–1600		3	2	2	10	7	5	9	1	1		2	1	43
1600–1700				4	1	5	6		3	1	3		1	24
1700–1800				1	3	2	1	6		2				15
1800–1900					1					1	1			3
1900–2000							2							2
2000–2100								1	1					2
	7	12	24	31	45	33	36	35	11	9	7	4	4	258

TABLE 76. SIZE OF BIRDS AT AGE OF 52 WEEKS, SUBJECT; SIZE OF EGGS FROM WHICH RESPECTIVE CHICKS WERE HATCHED, RELATIVE

Coefficient of correlation = .25 ± .039

	46	48	50	52	54	56	58	60	62	64	66	68	70	
900–1000				1										1
1000–1100			3					2						5
1100–1200	1	1	4	3	1	1	3	4	1	1				20
1200–1300	4		2	8	5	5	7	2	3			1	1	38
1300–1400	1	4	8	3	22	8	4	6	1	1	1	1	1	61
1400–1500		5	4	10	11	9	7	8	2	2	1	1	1	61
1500–1600		3	1	2	6	6	7	4	1	2	1			33
1600–1700				3	1	3	4	3	2	1	1			18
1700–1800				2	2	2	3	4		2	2		1	18
1800–1900														0
1900–2000														0
2000–2100							1	1						2
2100–2200									1					1
	6	13	22	32	48	34	36	34	11	9	6	3	4	258

TABLE 77. SIZE OF BIRDS AT AGE OF 56 WEEKS, SUBJECT; SIZE OF EGGS FROM WHICH RESPECTIVE CHICKS WERE HATCHED, RELATIVE

Coefficient of correlation = .28 ± .039

	46	48	50	52	54	56	58	60	62	64	66	68	70	
700– 800												1		1
800– 900														0
900–1000														0
1000–1100			5	1			1	2						9
1100–1200	2	1	1	3	6	5	2	3	1					24
1200–1300	4	2	6	11	7	5	4	6	1	1			1	48
1300–1400		6	3	4	15	7	10	5	2	2	1		2	57
1400–1500		2	5	10	10	3	4	9	1		1	1		46
1500–1600		1	1	1	8	7	9	4	1	2	1	1		36
1600–1700		1		2		7	2	1	1	2	1			17
1700–1800			1		2		3	2		2	2		1	13
1800–1900								1	3					4
1900–2000														0
2000–2100														0
2100–2200							1	1	1					3
	6	13	22	32	48	34	86	34	11	9	6	3	4	258

TABLE 78. SIZE OF BIRDS AT AGE OF 60 WEEKS, SUBJECT; SIZE OF EGGS FROM WHICH RESPECTIVE CHICKS WERE HATCEHD, RELATIVE

Coefficient of correlation = .37 ± .037

	46	48	50	52	54	56	58	60	62	64	66	68	70	
700– 800					1									1
800– 900			1											1
900–1000				2				1						3
1000–1100			6	1		1								8
1100–1200	3	2	3	5	3	1	2	4	2					25
1200–1300	2	1	3	7	8	2	5	3					1	32
1300–1400	1	2	4	5	13	9	4	5	1	2	2			48
1400–1500		5	3	5	6	8	9	8	3			1		48
1500–1600		1	2	5	9	2	6	5		3			2	35
1600–1700		2		1	5	7	6	3			1	1		26
1700–1800					2	3	3	1	2	1	2		1	15
1800–1900				1		1		1	2	3	1			9
1900–2000									1					1
2000–2100							1							1
2100–2200														0
2200–2300								1						1
	6	13	22	32	47	34	36	32	11	9	6	2	4	254

TABLE 79. SIZE OF BIRDS AT AGE OF 64 WEEKS, SUBJECT; SIZE OF EGGS FROM WHICH RESPECTIVE CHICKS WERE HATCHED, RELATIVE

Coefficient of correlation = .40 ± .036

	46	48	50	52	54	56	58	60	62	64	66	68	70	
800– 900				1	1									2
900–1000			1				1							2
1000–1100			3	2										5
1100–1200	1	1	3	2	5	1	1	3	1					18
1200–1300	4	3	3	8	9	7	3	4	1	1			1	44
1300–1400	1	2	6	6	13	8	10	7	2	4			1	60
1400–1500		5	3	5	9	6	6	4	2	1	2	1		44
1500–1600		2	1	3	4	6	7	5			1	1		30
1600–1700				3	4	3	5	4	1		2		2	24
1700–1800					2	2	2	2			1			9
1800–1900				1				2	3	3				9
1900–2000														0
2000–2100						1		1	1					3
2100–2200							1							1
	6	13	20	31	47	34	36	32	11	9	6	2	4	251

TABLE 80. SIZE OF BIRDS AT AGE OF 68 WEEKS, SUBJECT; SIZE OF EGGS FROM WHICH RESPECTIVE CHICKS WERE HATCHED, RELATIVE

Coefficient of correlation = .30 ± .039

	46	48	50	52	54	56	58	60	62	64	66	68	70	
800– 900			1											1
900–1000					2									2
1000–1100			4	1	1		1	2						9
1100–1200	2	2	3	2	2	2	4	1			1			19
1200–1300	3	1	5	5	12	3	4	4	1					38
1300–1400	1	1	3	8	9	6	3	3	3	2			1	40
1400–1500		2	4	7	4	7	6	3	1	3	2	1	1	41
1500–1600		4	1	5	9	4	5	6	3	1		1		39
1600–1700		2		2	6	8	8	4		1	1		1	33
1700–1800					1	2	4	4	1	1	2			15
1800–1900		1						1						2
1900–2000				1	1	1	1	1	1				1	7
2000–2100														0
2100–2200														0
2200–2300									1					1
2300–2400								1						1
	6	13	21	31	47	33	36	30	11	8	6	2	4	248

TABLE 81. SIZE OF BIRDS AT AGE OF 72 WEEKS, SUBJECT; SIZE OF EGGS FROM WHICH RESPECTIVE CHICKS WERE HATCHED, RELATIVE

Coefficient of correlation = .29 ± .040

	46	48	50	52	54	56	58	60	62	64	66	68	70	
800– 900			1											1
900–1000		1			1									2
1000–1100				2	1									3
1100–1200	3		6		4	1		2						16
1200–1300	1	1	3	1	6	2	4	1	1	1				21
1300–1400	2	2	6	5	7	7	7	4	2	1	1	1	2	47
1400–1500		3	4	8	9	7	6	4		2	1			44
1500–1600		3		6	8	3	7	10	4	3		1		45
1600–1700		2		4	6	6	4	2	1	2	1		2	30
1700–1800		1		4	2	4	3	6			1			21
1800–1900					1	2	2		2		1			8
1900–2000						1					1			2
2000–2100					1									1
2100–2200							1							1
2200–2300														0
2300–2400														0
2400–2500								1	1					2
	6	13	20	30	46	33	34	30	11	9	6	2	4	244

TABLE 82. SIZE OF BIRDS AT AGE OF 76 WEEKS, SUBJECT; SIZE OF EGGS FROM WHICH RESPECTIVE CHICKS WERE HATCHED, RELATIVE

Coefficient of correlation = .26 ± .043

	46	48	50	52	54	56	58	60	62	64	66	68	70	
900–1000		1						1						2
1000–1100			2	1	1									4
1100–1200			1		1				1					3
1200–1300	1		4		5	2	2	1			1	1		17
1300–1400	3	2	5	3	10	6	5	3	1	1			1	40
1400–1500	2	4	3	8	4	4	10	7		1	2			45
1500–1600		2		4	4	7	6	4	1	2		1		31
1600–1700		1	2	3	6	3	3	4	3	2			1	28
1700–1800		1		5	3	5	2	2	1	2	1		1	23
1800–1900				2	3	1	2	4		1				13
1900–2000					1	3	2		1					7
2000–2100						1			1					2
2100–2200					2						2			4
2200–2300								1						1
2300–2400							1		1					2
2400–2500														0
2500–2600														0
2600–2700								1						1
	6	11	17	23	40	32	33	28	10	9	6	2	3	223

TABLE 83. SIZE OF BIRDS AT AGE OF 80 WEEKS, SUBJECT; SIZE OF EGGS FROM WHICH RESPECTIVE CHICKS WERE HATCHED, RELATIVE

Coefficient of correlation = .24 ± .048

	46	48	50	52	54	56	58	60	62	64	66	68	70	
900–1000				1										1
1000–1100		1	2											3
1100–1200			1		2				1					4
1200–1300	1		4	2	2		2	1	1		1		1	15
1300–1400	2		2	3	9	2	7	6	1	1		1	1	35
1400–1500	1	2	1	4	4	5	5	5			1			28
1500–1600	1	1		2	2	5	4	2	1	1				19
1600–1700			2	2	5	1	4	2	3	1				20
1700–1800		1		5	4	5		2		2	1		1	21
1800–1900				1	2	1	2	4		3		1		14
1900–2000		1				3			1		1			6
2000–2100						2	2	1						5
2100–2200					2				2					4
2200–2300											1			1
2300–2400							1							1
2400–2500														0
2500–2600								1						1
	5	6	12	20	32	24	27	24	10	8	5	2	3	178

TABLE 84. SIZE OF BIRDS AT AGE OF 84 WEEKS, SUBJECT; SIZE OF EGGS FROM WHICH RESPECTIVE CHICKS WERE HATCHED, RELATIVE

Coefficient of correlation = .33 ± .054

	46	48	50	52	54	56	58	60	62	64	66	68	70	
900–1000				1										1
1000–1100														0
1100–1200					2									2
1200–1300			3		1									4
1300–1400	1			1	3	1	2	1	1			1		11
1400–1500		2	3	3	3	4	3	1						19
1500–1600	2	1	1	2	4	5	1	4	1		1			22
1600–1700		1		2	1	3	1	3	1			1		13
1700–1800				2	3	2	2	3	1	3				16
1800–1900		1		2	3	1	2	2		1			1	13
1900–2000					3	5	1	2	1	2				14
2000–2100					1	1	1		1		1			5
2100–2200							1				1			2
2200–2300									1					1
2300–2400														0
2400–2500							1	1						2
	3	5	7	13	24	22	15	17	7	6	3	2	1	125

TABLE 85. SIZE OF BIRDS AT AGE OF 88 WEEKS, SUBJECT; SIZE OF EGGS FROM WHICH RESPECTIVE CHICKS WERE HATCHED, RELATIVE

Coefficient of correlation = .30 ± .057

	46	48	50	52	54	56	58	60	62	64	66	68	70	
900–1000				1										1
1000–1100														0
1100–1200			1											1
1200–1300					1	1								2
1300–1400			2	1	1			1						5
1400–1500	1				2		2	3	1		1	1		11
1500–1600	1	3	2	4	3	6	1	2	1		1			24
1600–1700			3	1	3	3	3	2	1	1				17
1700–1800		1		3	2	2	2	3	1	2				16
1800–1900					4	5	2							11
1900–2000				1	1	1	3	2					1	9
2000–2100		1		1	3	1		1	2	1	1			11
2100–2200											1			1
2200–2300								1	2	1				4
2300–2400														0
2400–2500							1							1
2500–2600														0
2600–2700								1						1
	2	5	8	12	20	19	14	16	8	5	4	1	1	115

TABLE 86. SIZE OF BIRDS AT AGE OF 92 WEEKS, SUBJECT; SIZE OF EGGS FROM WHICH RESPECTIVE CHICKS WERE HATCHED, RELATIVE

Coefficient of correlation = .30 ± .055

	46	48	50	52	54	56	58	60	62	64	66	68	70	
1200–1300			1	1										2
1300–1400			2		1			2	1					6
1400–1500	1	1	1	1	5	2	2	1				1		15
1500–1600	1	2		3	7	4	3	5			1			26
1600–1700		1	1	2		2	3	1	2	2				14
1700–1800	1		2	3	4	4	2	3	1	2	1			23
1800–1900				1	3	2	2	1				1		10
1900–2000				1	2	2	1	1	1				1	9
2000–2100					1	3	1	2		1				8
2100–2200						1			1	1	1			4
2200–2300		1							1		1			3
2300–2400														0
2400–2500							1		1					2
2500–2600								1						1
	3	5	7	12	23	20	15	17	8	6	4	2	1	123

TABLE 87. SIZE OF BIRDS AT AGE OF 96 WEEKS, SUBJECT; SIZE OF EGGS FROM WHICH RESPECTIVE CHICKS WERE HATCHED, RELATIVE

Coefficient of correlation = .40 ± .051

	46	48	50	52	54	56	58	60	62	64	66	68	70	
1100–1200			1											1
1200–1300	1													1
1300–1400		1	1	3	3	2		2	2					14
1400–1500	1	1	2	4	6	4	2	3						23
1500–1600	1	2	1	2	5	3	4	4			1			23
1600–1700			1	3	3	3	2	4	2	3	1	1		23
1700–1800					3	5		1		1		1		11
1800–1900					3		4							7
1900–2000						2		2	1		1		1	7
2000–2100						1	1		2		1			5
2100–2200		1								2				3
2200–2300							1							1
2300–2400							1	1	1					3
	3	5	6	12	23	20	15	17	8	6	4	2	1	122

TABLE 88. SIZE OF BIRDS AT AGE OF 100 WEEKS, SUBJECT; SIZE OF EGGS FROM WHICH RESPECTIVE CHICKS WERE HATCHED, RELATIVE

Coefficient of correlation = .35 ± .055

	46	48	50	52	54	56	58	60	62	64	66	68	70	
1100–1200			1	1										2
1200–1300	1		2	1	1	1		2						8
1300–1400	1			2	3	1	1	3	1					12
1400–1500	1	3	1	3	7	5	2	1	2			1		26
1500–1600		1	1	2	3	2	5	3		1	2	1		21
1600–1700			1		3	1	2	3	2					12
1700–1800				2	3	3	2			3				13
1800–1900					2	2	1	2					1	8
1900–2000						1	1	1	1		1			5
2000–2100						1			1	2				4
2100–2200		1									1			2
2200–2300									1					1
2300–2400														0
2400–2500							1							1
	3	5	6	11	22	17	15	15	8	6	4	2	1	115

TABLE 89. SIZE OF BIRDS AT AGE OF 104 WEEKS, SUBJECT; SIZE OF EGGS FROM WHICH RESPECTIVE CHICKS WERE HATCHED, RELATIVE

Coefficient of correlation = .32 ± .057

	46	48	50	52	54	56	58	60	62	64	66	68	70	
1000–1100			1											1
1100–1200	1		1	1				1						4
1200–1300			1		3	2	1	3	1					11
1300–1400		1	1	1	5	1	2		1					12
1400–1500	1	2	1	4	3	5	2	1	1		1	1		22
1500–1600	1			2	3	1	2	5	1	1				16
1600–1700		1	1	2	2	1	2	3		2	1	1		16
1700–1800				1	4	4	3	1		2	1			16
1800–1900						1	1		1					3
1900–2000					1			1	1				1	4
2000–2100		1				2				1				4
2100–2200									2					2
2200–2300							1				1			2
	3	5	6	11	21	17	14	15	8	6	4	2	1	113

TABLE 90. SIZE OF BIRDS AT AGE OF 108 WEEKS, SUBJECT; SIZE OF EGGS FROM WHICH RESPECTIVE CHICKS WERE HATCHED, RELATIVE

Coefficient of correlation = .34 ± .056

	46	48	50	52	54	56	58	60	62	64	66	68	70	
1000–1100			1					1						2
1100–1200	1		2					1						4
1200–1300				1	2	2		1	1					7
1300–1400	1			2	7	3	1	3	1					18
1400–1500		2	2	2	4	3	2	1				1		17
1500–1600	1	2	1	4	1	1	3	3	2	1	1			20
1600–1700				2	4	2	2	2		1	1			14
1700–1800					2	1	4	1	1	2		1	1	13
1800–1900					1	3	1	2	1		1			9
1900–2000		1							1	2				4
2000–2100						1								1
2100–2200						1			1		1			3
2200–2300														0
2300–2400							1							1
	3	5	6	11	21	17	14	15	8	6	4	2	1	113

TABLE 91. SIZE OF BIRDS AT AGE OF 112 WEEKS, SUBJECT; SIZE OF EGGS FROM WHICH RESPECTIVE CHICKS WERE HATCHED, RELATIVE

Coefficient of correlation = .25 ± .060

	46	48	50	52	54	56	58	60	62	64	66	68	70	
900–1000			1											1
1000–1100			1											1
1100–1200									1					1
1200–1300	1		1		1			3	1					7
1300–1400		1		3	5	5	1	1	1			1		18
1400–1500	1	2	2	4	6	1	2	3	1	2				24
1500–1600	1	1	1	1	2	3	3	4		1	2	1		20
1600–1700				1	3	1	3	1		1	1		1	12
1700–1800				2	4	3	1	1						11
1800–1900						2	3	1	2	2				10
1900–2000		1				1		1	1					4
2000–2100														0
2100–2200									1		1			2
2200–2300														0
2300–2400							1							1
	3	5	6	11	21	16	14	15	8	6	4	2	1	112

TABLE 92. SIZE OF BIRDS AT AGE OF 116 WEEKS, SUBJECT; SIZE OF EGGS FROM WHICH RESPECTIVE CHICKS WERE HATCHED, RELATIVE

Coefficient of correlation = .28 ± .059

	46	48	50	52	54	56	58	60	62	64	66	68	70	
1000–1100			1						1					2
1100–1200		1	1	1		1								4
1200–1300				1	1			2						4
1300–1400	1			2	3	3	2	2	1		1	1		16
1400–1500		1	3	1	3	1		3	2					14
1500–1600	2	1	1	3	9	3	3	2		2				26
1600–1700		1		2	2	1	4	2		2	1			15
1700–1800					1	3	1	1		1		1		8
1800–1900				1	2	2	1		1		1		1	9
1900–2000		1				1	2	3	2	1				10
2000–2100														0
2100–2200						1					1			2
2200–2300														0
2300–2400							1							1
2400–2500									1					1
	3	5	6	11	21	16	14	15	8	6	4	2	1	112

TABLE 93. SIZE OF BIRDS AT AGE OF 120 WEEKS, SUBJECT; SIZE OF EGGS FROM WHICH RESPECTIVE CHICKS WERE HATCHED, RELATIVE

Coefficient of correlation = .29 ± .059

	46	48	50	52	54	56	58	60	62	64	66	68	70	
1000–1100									1					1
1100–1200			1	2										3
1200–1300		1	3		1	1					1			7
1300–1400	1			1	2			3		1				8
1400–1500	1	1			3	2	2	1	2	1		1		14
1500–1600	1	2	2	4	9	5	2	4		1				30
1600–1700				3	4	1	2	5	1	2	1	1		20
1700–1800					1	1	2				1		1	6
1800–1900		1				2	2	1						6
1900–2000					1	1	3		1					6
2000–2100						1			1		1			3
2100–2200										1				1
2200–2300						1			1					2
2300–2400									1					1
	3	5	6	10	21	15	13	14	8	6	4	2	1	108

TABLE 94. SIZE OF BIRDS AT AGE OF 124 WEEKS, SUBJECT; SIZE OF EGGS FROM WHICH RESPECTIVE CHICKS WERE HATCHED, RELATIVE

Coefficient of correlation = .41 ± .054

	46	48	50	52	54	56	58	60	62	64	66	68	70	
1100–1200					2				1					3
1200–1300			2	1	1									4
1300–1400	2	3	2	1	1	1	1		1					12
1400–1500		1	1	1	5	1		5	1	1				16
1500–1600	1			2	6	3	1	2	1	2		1		19
1600–1700			1	5	2	6	4	4		2		1		25
1700–1800					3	3	3	1			2		1	13
1800–1900		1				1	2	2	1		1			8
1900–2000					1		1	1	1					4
2000–2100										1				1
2100–2200							1				1			2
2200–2300									2					2
	3	5	6	10	21	15	13	15	8	6	4	2	1	109

TABLE 95. SIZE OF BIRDS AT AGE OF 128 WEEKS, SUBJECT; SIZE OF EGGS FROM WHICH RESPECTIVE CHICKS WERE HATCHED, RELATIVE

Coefficient of correlation = .33 ± .069

	45	47	49	51	53	55	57	59	61	63	65	67	
1200–1300	1		1	2	2				1				7
1300–1400			2		3			2	1		1		9
1400–1500		3	1	2	2	1	4	2		1			16
1500–1600	1			1	1	3	2	1	1			1	11
1600–1700			1		3	3		1	2		1		11
1700–1800						1	3			2			6
1800–1900								1					1
1900–2000		1			1		2	1	1		1		7
2000–2100						1		1		1	1		4
2100–2200					1		1						2
2200–2300									1				1
	2	4	5	5	13	9	12	9	7	4	4	1	75

TABLE 96. SIZE OF BIRDS AT AGE OF 132 WEEKS, SUBJECT; SIZE OF EGGS FROM WHICH RESPECTIVE CHICKS WERE HATCHED, RELATIVE

Coefficient of correlation = .42 ± .074

	45	47	49	51	53	55	57	59	61	63	65	
1100–1200			1									1
1200–1300				1	2						1	4
1300–1400		2	1		2			1	1			7
1400–1500		1	1			1				1		4
1500–1600	1				2	3	2	3				11
1600–1700					2	1	1		3			7
1700–1800				1	2	1	4			1		9
1800–1900		1						1		1	1	4
1900–2000					1		1					2
2000–2100						1		2		1		4
2100–2200							1				1	2
2200–2300												0
2300–2400											1	1
	1	4	3	2	11	7	9	7	4	4	4	56

TABLE 97. SIZE OF BIRDS AT AGE OF 136 WEEKS, SUBJECT; SIZE OF EGGS FROM WHICH RESPECTIVE CHICKS WERE HATCHED, RELATIVE

Coefficient of correlation = .44 ± .077

	45	47	49	51	53	55	57	59	61	63	65	
1000–1100			1									1
1100–1200												0
1200–1300												0
1300–1400	1	1	1			1		1			1	6
1400–1500	1	1	1									3
1500–1600				1	1		1	1		1		5
1600–1700			1		4	1	1					7
1700–1800		1		1	1	1		2	2		1	9
1800–1900		1			1	1	1	1		1		6
1900–2000						1	2	1		2	1	7
2000–2100							1					1
2100–2200					1	1		1				3
2200–2300											1	1
2300–2400							1		1			2
	2	4	4	2	8	6	7	7	3	4	4	51

TABLE 98. SIZE OF BIRDS AT AGE OF 140 WEEKS, SUBJECT; SIZE OF EGGS FROM WHICH RESPECTIVE CHICKS WERE HATCHED, RELATIVE

Coefficient of correlation = .41 ± .071

	45	47	49	51	53	55	57	59	61	63	65	
1100–1200			1									1
1200–1300												0
1300–1400				1					1			2
1400–1500			2		2				1		1	6
1500–1600	2	2				1		2				7
1600–1700						1	2	2		1		6
1700–1800		1		1	6	1	3		1			13
1800–1900			1	1	3		1	1			1	8
1900–2000		1				1	3		1			6
2000–2100						2		1		2		5
2100–2200								1			1	2
2200–2300							1	1		1	1	4
2300–2400												0
2400–2500							1					1
2500–2600									1			1
	2	4	4	3	11	6	11	8	5	4	4	62

TABLE 99. SIZE OF BIRDS AT AGE OF 144 WEEKS, SUBJECT; SIZE OF EGGS FROM WHICH RESPECTIVE CHICKS WERE HATCHED, RELATIVE

Coefficient of correlation = .44 ± .074

	45	47	49	51	53	55	57	59	61	63	65	
1100–1200							1					1
1200–1300			1	1					1			3
1300–1400					1							1
1400–1500					1			1				2
1500–1600	2	2	1		2		2	2			1	12
1600–1700		1	2		1	1	2					7
1700–1800				2	1	1	1	2				7
1800–1900					3	1	1				1	6
1900–2000					1	1	1	1				4
2000–2100								2	1		1	4
2100–2200							1			1	1	3
2200–2300							1			1		2
2300–2400							1					1
2400–2500												0
2500–2600									1			1
	2	3	4	3	10	4	11	8	3	2	4	54

TABLE 100. SIZE OF BIRDS AT AGE OF 148 WEEKS, SUBJECT; SIZE OF EGGS FROM WHICH RESPECTIVE CHICKS WERE HATCHED, RELATIVE

Coefficient of correlation = .49 ± .070

	45	47	49	51	53	55	57	59	61	63	65	
1200–1300			2									2
1300–1400					1			1	1			3
1400–1500	2	1			2		2	2				9
1500–1600			1	3	4	1	3	1			1	14
1600–1700		2	1		1			1				5
1700–1800							2	1			1	4
1800–1900					2	3	1					6
1900–2000							2	1			1	4
2000–2100							1	1	1		1	4
2100–2200										1		1
2200–2300										1		1
2300–2400												0
2400–2500												0
2500–2600												0
2600–2700												0
2700–2800									1			1
	2	3	4	3	10	4	11	8	3	2	4	54

TABLE 101. SIZE OF BIRDS AT AGE OF 152 WEEKS, SUBJECT; SIZE OF EGGS FROM WHICH RESPECTIVE CHICKS WERE HATCHED, RELATIVE

Coefficient of correlation = .52 ± .068

	45	47	49	51	53	55	57	59	61	63	65	
1200–1300			1									1
1300–1400	2			1				1				4
1400–1500		1			4	1	1	1	1			9
1500–1600		2	1	1	2		2	2			1	11
1600–1700			1	1	3	1	4	1			2	13
1700–1800							2					2
1800–1900						2	1	1	1			5
1900–2000								2		1		3
2000–2100										1		1
2100–2200							1				1	2
2200–2300									1			1
	2	3	3	3	9	4	11	8	3	2	4	52

TABLE 102. SIZE OF BIRDS AT AGE OF 156 WEEKS, SUBJECT; SIZE OF EGGS FROM WHICH RESPECTIVE CHICKS WERE HATCHED, RELATIVE

Coefficient of correlation = .50 ± .078

	45	47	49	51	53	55	57	59	61	63	65	
1100–1200			1									1
1200–1300				1	1							2
1300–1400	2		1		1		1		1			6
1400–1500		1			3	1	1	1				7
1500–1600		2		1		1	2	2			2	10
1600–1700			1	1			3				1	6
1700–1800					2		1	1				4
1800–1900						1		1	1			3
1900–2000										1		1
2000–2100										1		1
2100–2200									1			1
	2	3	3	3	7	3	8	5	3	2	3	42

TABLE 103. SIZE OF BIRDS AT AGE OF 160 WEEKS, SUBJECT; SIZE OF EGGS FROM WHICH RESPECTIVE CHICKS WERE HATCHED, RELATIVE

Coefficient of correlation = .48 ± .072

	45	47	49	51	53	55	57	59	61	63	65	
1300–1400	1		1	1	1		1					5
1400–1500	1	1	1		3			1	1			8
1500–1600		1		1	2		2				3	9
1600–1700		1	1	1	1	1	3	4				12
1700–1800					1	1	3					5
1800–1900					1	1		1				3
1900–2000						1		2		1		4
2000–2100							1		1	1		3
2100–2200												0
2200–2300							1		1		1	3
	2	3	3	3	9	4	11	8	3	2	4	52

TABLE 104. SIZE OF BIRDS AT AGE OF 164 WEEKS, SUBJECT; SIZE OF EGGS FROM WHICH RESPECTIVE CHICKS WERE HATCHED, RELATIVE

Coefficient of correlation = .43 ± .078

	45	47	49	51	53	55	57	59	61	63	65	
1200–1300			1									1
1300–1400	1				1		1		1			4
1400–1500	1	1			1			2			1	6
1500–1600		2		1	2	1	1	1				8
1600–1700			2	1	1	1	3	2			1	11
1700–1800					2		2				1	5
1800–1900					1	2	1					4
1900–2000							2	2	1	1		6
2000–2100								1				1
2100–2200									1		1	2
2200–2300										1		1
2300–2400												0
2400–2500												0
2500–2600							1					1
	2	3	3	2	8	4	11	8	3	2	4	50

TABLE 105. SIZE OF BIRDS AT AGE OF 168 WEEKS, SUBJECT; SIZE OF EGGS FROM WHICH RESPECTIVE CHICKS WERE HATCHED, RELATIVE

Coefficient of correlation = .50 ± .072

	45	47	49	51	53	55	57	59	61	63	65	
1100–1200			1									1
1200–1300												0
1300–1400	1											1
1400–1500	1	1	1		2		1	2	1		1	10
1500–1600		2		2	3		1	1			1	10
1600–1700					2		2	2				6
1700–1800			1			3	3				1	8
1800–1900					1		3	2				6
1900–2000						1			1	1		3
2000–2100							1					1
2100–2200											1	1
2200–2300									1	1		2
	2	3	3	2	8	4	11	7	3	2	4	49

TABLE 103. SIZE OF BIRDS AT AGE OF 172 WEEKS, SUBJECT; SIZE OF EGGS FROM WHICH RESPECTIVE CHICKS WERE HATCHED, RELATIVE

Coefficient of correlation = .52 ± .070

	45	47	49	51	53	55	57	59	61	63	65	
1200–1300			1		1							2
1300–1400	2			1	1		1		1			6
1400–1500		2			3		1	1				7
1500–1600		1	1	1	2		2	2			1	10
1600–1700								1			1	2
1700–1800			1			2	3	2		1	1	10
1800–1900					1	2		2				5
1900–2000							4		1			5
2000–2100										1		1
2100–2200												0
2200–2300											1	1
2300–2400									1			1
	2	3	3	2	8	4	11	8	3	2	4	50

TABLE 107. SIZE OF BIRDS AT AGE OF 176 WEEKS, SUBJECT; SIZE OF EGGS FROM WHICH RESPECTIVE CHICKS WERE HATCHED, RELATIVE

Coefficient of correlation = .44 ± .082

	45	47	49	51	53	55	57	59	61	63	65	
1000–1100		1	1									2
1100–1200												0
1200–1300												0
1300–1400	1											1
1400–1500	1			1	1			2			1	6
1500–1600		2	1		1		1	1			1	7
1600–1700				1	2	2		1		1	1	8
1700–1800							2	1				3
1800–1900			1		2	1	2		1	1		8
1900–2000						1	2	2	1			6
2000–2100							1	1			1	3
	2	3	3	2	6	4	8	8	2	2	4	44

TABLE 108. SIZE OF BIRDS AT AGE OF 180 WEEKS, SUBJECT; SIZE OF EGGS FROM WHICH RESPECTIVE CHICKS WERE HATCHED, RELATIVE

Coefficient of correlation = .37 ± .108

	45	47	49	51	53	55	57	59	61	63	65	
1000–1100			1									1
1100–1200												0
1200–1300											1	1
1300–1400					1							1
1400–1500	2	2					1	1				6
1500–1600				1	1							2
1600–1700			1				1	1			1	4
1700–1800			1	1	1			1		1		5
1800–1900					1		2				1	4
1900–2000						1	1	2		1		5
	2	2	3	2	4	1	5	5	0	2	3	29

TABLE 109. SIZE OF BIRDS AT AGE OF 184 WEEKS, SUBJECT; SIZE OF EGGS FROM WHICH RESPECTIVE CHICKS WERE HATCHED, RELATIVE

Coefficient of correlation = .52 ± .085

	45	47	49	51	53	55	57	59	61	63	65	
1100–1200			1									1
1200–1300												0
1300–1400	1			1								2
1400–1500	1	1						1				3
1500–1600		1					2					3
1600–1700			1		1		1	3		1	1	8
1700–1800				1	3	1						5
1800–1900					1		3			1		5
1900–2000						1	1	1				3
2000–2100											1	1
2100–2200							1	1				2
2200–2300								1				1
	2	2	2	2	5	2	8	7	0	2	2	34

TABLE 110. SIZE OF BIRDS AT AGE OF 188 WEEKS, SUBJECT; SIZE OF EGGS FROM WHICH RESPECTIVE CHICKS WERE HATCHED, RELATIVE

Coefficient of correlation = .60 ± .099

	45	47	49	51	53	55	57	59	
1300–1400	1			1					2
1400–1500									0
1500–1600								1	1
1600–1700		1	1						2
1700–1800					1		1		2
1800–1900						1	1	2	4
1900–2000							1		1
2000–2100					1		1		2
2100–2200						1		1	2
2200–2300							1	1	2
2300–2400							1		1
	1	1	1	1	2	2	6	5	19

TABLE 111. SIZE OF BIRDS AT AGE OF 192 WEEKS, SUBJECT; SIZE OF EGGS FROM WHICH RESPECTIVE CHICKS WERE HATCHED, RELATIVE

Coefficient of correlation = .59 ± .079

	45	47	49	51	53	55	57	59	61	63	
1200–1300			1								1
1300–1400											0
1400–1500	2										2
1500–1600				1							1
1600–1700			1				2				3
1700–1800		2						3			5
1800–1900				1	3		1	1			6
1900–2000					1	1	1				3
2000–2100						1	1			1	3
2100–2200					1		1	2			4
2200–2300							1				1
2300–2400								1			1
2400–2500							1				1
	2	2	2	2	5	2	8	7	0	1	31

TABLE 112. SIZE OF BIRDS AT AGE OF 196 WEEKS, SUBJECT; SIZE OF EGGS FROM WHICH RESPECTIVE CHICKS WERE HATCHED, RELATIVE

Coefficient of correlation = .48 ± .093

	45	47	49	51	53	55	57	59	61	63	
1200–1300			1								1
1300–1400											0
1400–1500							1	1			2
1500–1600	2	1			2						5
1600–1700		1			1			1			3
1700–1800				1	1		2	1			5
1800–1900			1		1			1			3
1900–2000				1		2	2	1			6
2000–2100							1	2			3
2100–2200							1			1	2
2200–2300											0
2300–2400											0
2400–2500											0
2500–2600											0
2600–2700							1				1
	2	2	2	2	5	2	8	7	0	1	31

TABLE 113. SIZE OF BIRDS AT AGE OF 200 WEEKS, SUBJECT; SIZE OF EGGS FROM WHICH RESPECTIVE CHICKS WERE HATCHED, RELATIVE

Coefficient of correlation = .56 ± .084

	45	47	49	51	53	55	57	59	61	63	
1000–1100			1								1
1100–1200											0
1200–1300											0
1300–1400	1										1
1400–1500		1					1				2
1500–1600		1		1	2						4
1600–1700	1		1		1		1	3			7
1700–1800								1			1
1800–1900					1		2	2			5
1900–2000				1		2	1	1			5
2000–2100					1						1
2100–2200							1				1
2200–2300							1				1
2300–2400										1	1
	2	2	2	2	5	2	7	7	0	1	30

TABLE 114. SIZE OF BIRDS AT AGE OF 204 WEEKS, SUBJECT; SIZE OF EGGS FROM WHICH RESPECTIVE CHICKS WERE HATCHED, RELATIVE

Coefficient of correlation = .66 ± .068

	45	47	49	51	53	55	57	59	61	63	
1100–1200			1								1
1200–1300											0
1300–1400	1	1									2
1400–1500	1										1
1500–1600		1	1		2			1			5
1600–1700				2	2	1	2	2			9
1700–1800							2	1			3
1800–1900							2				2
1900–2000						1		3			4
2000–2100					1		1				2
2100–2200										1	1
2200–2300							1				1
	2	2	2	2	5	2	8	7	0	1	31

TABLE 115. SIZE OF BIRDS AT AGE OF 208 WEEKS, SUBJECT; SIZE OF EGGS FROM WHICH RESPECTIVE CHICKS WERE HATCHED, RELATIVE

Coefficient of correlation = .49 ± .092

	45	47	49	51	53	55	57	59	61	63	
1100–1200			1								1
1200–1300	1										1
1300–1400											0
1400–1500											0
1500–1600			1	2	1			1			5
1600–1700		2			2		2	3			9
1700–1800	1					1	2	1			5
1800–1900					1		1				2
1900–2000					1	1	2	2		1	7
2000–2100											0
2100–2200											0
2200–2300											0
2300–2400											0
2400–2500							1				1
	2	2	2	2	5	2	8	7	0	1	31

TABLE 116. SIZE OF BIRDS AT AGE OF 212 WEEKS, SUBJECT; SIZE OF EGGS FROM WHICH RESPECTIVE CHICKS WERE HATCHED, RELATIVE

Coefficient of correlation = .68 ± .065

	45	47	49	51	53	55	57	59	61	63	
1100–1200			1								1
1200–1300											0
1300–1400	1										1
1400–1500	1	2									3
1500–1600					1	1	1				3
1600–1700			1	2	3		1	3			10
1700–1800					1			1			2
1800–1900						1	2				3
1900–2000							2	2			4
2000–2100							1	1		1	3
2100–2200											0
2200–2300											0
2300–2400											0
2400–2500							1				1
	2	2	2	2	5	2	8	7	0	1	31

TABLE 117. SIZE OF BIRDS AT AGE OF 216 WEEKS, SUBJECT; SIZE OF EGGS FROM WHICH RESPECTIVE CHICKS WERE HATCHED, RELATIVE

Coefficient of correlation = .66 ± .070

	45	47	49	51	53	55	57	59	61	63	
1200–1300			1								1
1300–1400	1	1			1						3
1400–1500	1			1	1		1				4
1500–1600		1			1		1				3
1600–1700				1	1		1	2			5
1700–1800			1				1	2			4
1800–1900						1	1	1			3
1900–2000							2	1			3
2000–2100						1		1			2
2100–2200										1	1
2200–2300							1				1
	2	2	2	2	4	2	8	7	0	1	30

TABLE 118. SIZE OF BIRDS AT AGE OF 220 WEEKS, SUBJECT; SIZE OF EGGS FROM WHICH RESPECTIVE CHICKS WERE HATCHED, RELATIVE

Coefficient of correlation = .69 ± .064

	45	47	49	51	53	55	57	59	61	63	
1200–1300			1								1
1300–1400	2	1									3
1400–1500		1		1	1	1					4
1500–1600					1		1	1			3
1600–1700					2		2	1			5
1700–1800				1			1	3			5
1800–1900			1				1	1			3
1900–2000						1	3	1			5
2000–2100											0
2100–2200										1	1
	2	2	2	2	4	2	8	7	0	1	30

TABLE 119. SIZE OF BIRDS AT AGE OF 224 WEEKS, SUBJECT; SIZE OF EGGS FROM WHICH RESPECTIVE CHICKS WERE HATCHED, RELATIVE

Coefficient of correlation = .40 ± .103

	45	47	49	51	53	55	57	59	61	63	
1100–1200			1								1
1200–1300								1			1
1300–1400		1		1							2
1400–1500	2				1		1	1			5
1500–1600		1		1	1	1	1	2			7
1600–1700					1		2	1			4
1700–1800					1		1	1			3
1800–1900			1			1	1			1	4
1900–2000							1	1			2
2000–2100							1				1
	2	2	2	2	4	2	8	7	0	1	30

TABLE 120. SUMMARY OF TABLES 63 TO 119. SIZE OF BIRDS AT FOUR-WEEKS PERIODS DURING THEIR LIFE, SUBJECT; SIZE OF EGGS FROM WHICH RESPECTIVE CHICKS WERE HATCHED, RELATIVE

Age of chicks	Coefficient of correlation	$\frac{r}{Er}$	Number of individuals
1 day	.73±.013	56.15	573
4 weeks	.20±.037	5.41	299
8 weeks	.14±.038	3.68	302
12 weeks	.20±.040	5.00	262
16 weeks	.19±.040	4.75	259
20 weeks	.18±.040	4.50	261
24 weeks	.15±.066	2.27	140
28 weeks	.12±.039	3.08	287
32 weeks	.31±.036	8.61	286
36 weeks	.33±.037	8.92	269
40 weeks	.28±.038	7.37	269
44 weeks	.34±.035	9.71	263
48 weeks	.27±.039	6.92	258
52 weeks	.25±.039	6.41	258
56 weeks	.28±.039	7.18	258
60 weeks	.37±.037	10.00	254
64 weeks	.40±.036	11.11	251
68 weeks	.30±.039	7.69	248
72 weeks	.29±.040	7.25	244
76 weeks	.26±.043	6.05	223
80 weeks	.24±.048	5.00	178
84 weeks	.33±.054	6.11	125
88 weeks	.30±.057	5.26	115
92 weeks	.30±.055	5.45	123
96 weeks	.40±.051	7.84	122
100 weeks	.35±.055	6.36	115
104 weeks	.32±.057	5.61	113
108 weeks	.34±.056	6.07	113
112 weeks	.25±.060	4.17	112
116 weeks	.28±.059	4.75	112
120 weeks	.29±.059	4.92	108
124 weeks	.41±.054	7.59	109
128 weeks	.33±.069	4.78	75
132 weeks	.42±.074	5.68	56
136 weeks	.44±.077	5.71	51
140 weeks	.41±.071	5.77	62
144 weeks	.44±.074	5.95	54
148 weeks	.49±.070	7.00	54
152 weeks	.52±.068	7.65	52
156 weeks	.50±.078	6.41	42
160 weeks	.48±.072	6.67	52
164 weeks	.43±.078	5.51	50
168 weeks	.50±.072	6.94	49
172 weeks	.52±.070	7.43	50
176 weeks	.44±.082	5.37	44

TABLE 120 (*concluded*)

Age of chicks	Coefficient of correlation	$\frac{r}{Er}$	Number of individuals
180 weeks	.37±.108	3.43	29
184 weeks	.52±.085	6.12	34
188 weeks	.60±.099	6.06	19
192 weeks	.59±.079	7.47	31
196 weeks	.48±.093	5.16	31
200 weeks	.56±.084	6.67	30
204 weeks	.66±.068	9.71	31
208 weeks	.49±.092	5.33	31
212 weeks	.68±.065	10.46	31
216 weeks	.66±.070	9.43	30
220 weeks	.69±.064	10.78	30
224 weeks	.40±.103	3.88	30

DISCUSSION OF RESULTS

The results of these studies are neither in entire accord nor in entire discord with any of the important studies of the same factors made by other workers. Up to the present time no extensive work has been reported on Single Comb White Leghorn material. So far as is known by the writer, no other study of these particular factors has been made with similar lines of inheritance over as long a period as is here reported.

The studies have been made with vitally important commercial factors in a commercial breed. It is especially incumbent on the eastern producer to excel in the production of these desired factors in order to compete with more distant production. Therefore the fact indicated by these studies, namely, that the characters in question are distinctly inherited, should be gratifying and encouraging to commercial poultrymen who have been working for years along these lines.

The inheritance of the characters studied seemed to be thru the medium of both the male and the female parent. The writer found no evidence of distinctly sex-linked factors, such as were observed by Pearl (1912) and by Hadley (1913). According to the writer's results, benefit to the flock can be gained for any of these inherited characters by adding either better males or better females to the flock.

The relation of an individual egg to the mean type produced by the parent bird, and the relation of the type of egg incubated to the mean

type produced by the progeny, point directly to an easy way of improving a commercial flock by careful selection of the eggs for hatching. The results of this investigation show that a study of all the eggs produced by the parent hen, such as would be possible only by trap-nesting, would be more dependable than a selection of the incubated eggs alone; but the latter method is found to be a possible way, as well as an easier and quicker way, of obtaining good results.

The fact that the size, the shape, or the color of eggs does not affect their incubation record, leaves the poultryman free to select his eggs for hatching according to his own preference without its affecting the percentage of hatch.

The old opinion that hens' eggs approach a definite standard, to which they adhere more uniformly as the bird becomes older, is not borne out by the results of these studies. From this work it seems that the variability of a hen's production does not decrease as the hen becomes older. If the indication shown here is a fact, it does away with one of the several arguments which the poultryman has for using hens' eggs instead of pullets' eggs for hatching. The work of Pearl (1909) with Plymouth Rocks does not show agreement with this theory.

There seem to be no gradual and consistent changes thruout the life of the bird for any of the three egg characters studied. Nearly all of the changes noted occur between the productions of the first and the second year. Since the eggs produced during the second year are nearer to the mean for the entire life production of a bird kept for from three to four years, it would be expected, and was found generally, that the eggs selected for incubation produced by hens two years old or older, gave more consistent correlations than those produced by pullets.

The positive relation of the size of the egg incubated to the size of the resultant chick and mature bird, is of value to poultrymen who are interested in the production of either poultry or eggs.

The inheritance of the characters studied is undoubtedly of the type of a Galton regression. Much further study is needed in order to properly analyze the unit factors, or physiological units, involved in the formation of the broad practical characters here observed. Until further results are available, however, the fact that certain general lines of inheritance are known gives breeders some evidence on which to base more work for the improvement of their flocks.

SUMMARY

The most important results obtained from the studies reported in this paper may be grouped into the following conclusions:

1. The variability of a bird's production for a certain character does not depend on the difference existing between that bird's parents for the same character.

2. Both the male and the female have a distinct and approximately equal effect on the type of egg produced by the progeny, but the combined effect of the two is much greater and is directly inherited by the progeny, as is shown by the type of egg produced.

3. A mating of two opposite extremes of character always caused the production of a medium character in the progeny.

4. A mating of two similar extremes of character usually caused the production of a character approaching normal, in the progeny.

5. It appears that small size and length of egg are dominant, while there seems to be no dominancy whatever for color.

6. The correlations between the type of egg incubated and the mean type produced during the life of the respective progeny, are positive in every instance and are significant except for the color character. These correlations are not so significant as those between the mean types of eggs produced by the parents and the respective progeny.

7. The color character is much more irregular than the size or the shape, and less reliance can be placed on the stability of any color type when selecting eggs for hatching.

8. It does not appear that any more reliance can be placed on the stability of the progeny type hatched from hens' eggs than on that hatched from pullets' eggs.

9. The type of egg incubated affects the mean type of egg produced during the life of the bird hatched, to a greater extent than it affects the pullet-year production or the production of any other single year.

10. A strong correlation exists between the types of eggs produced by individuals and the types of eggs from which these individuals were hatched.

11. There is no correlation between the size and the shape of eggs produced by the birds used in this experiment.

12. The size, the shape, and the color of the egg seem to have no effect on its incubation record.

13. No definite tendency is shown toward a reduction of the variability of type of eggs produced by individual birds during successive years.

14. During the pullet year the size of the eggs produced increases rapidly, but after the first year's production no appreciable change in the size of the eggs produced can be found.

15. There seems to be no perceptible and consistent difference between the shapes of eggs laid by pullets and those laid by hens.

16. There is a tendency for the eggs produced each year, even in the pullet year, to have a gradually increasing index until the fifth or the sixth month of production, after which this index gradually decreases until the season's production ceases.

17. The eggs produced by hens two years old or older, are more likely to be tinted, or are tinted darker, than the eggs produced by the same birds during their pullet year.

18. There is no gradual darkening of the shell pigment after the second year's production.

19. Each year there is a tendency for the eggs produced to gradually become whiter during the first five or six months of production, and then to become more tinted again toward the end of the production season.

20. The data presented show that when eggs are laid by an individual bird for two or more successive days, the eggs become successively smaller, have a larger index, and are more deeply tinted.

21. A distinct positive correlation is found between the size of the eggs incubated and the vigor of the respective chicks hatched, at various ages of the chicks. The correlation is especially significant during the period of severe weather conditions.

22. A constant figure to represent x in the ratio, female weight : male weight :: x : 1, was calculated for a part of the available material at various ages, and this figure was found to agree closely with Galton's constant for human stature of 0.93.

23. There is a significant positive correlation between the size of the eggs incubated and the size of the respective chicks hatched. This correlation persists during the life of the birds as far as it was studied; that is, during a period of 228 weeks.

24. All of the eggs produced by any one hen tend to be of a characteristic type as to size, shape, and color.

25. Certain individuals have the power to transmit their characters much better than do others.

26. The results of these studies indicate a condition of inheritance resembling a Galton regression, for all characters studied.

ACKNOWLEDGMENTS

The materials and equipment used for this study were supplied by the Department of Poultry Husbandry of the New York State College of Agriculture at Cornell University. The writer wishes to express his appreciation for these facilities and for the valuable advice furnished by Professor James E. Rice, of the Department. The helpful suggestions given by Dr. H. H. Love, of the Department of Plant Breeding at Cornell University, are also appreciated.

BIBLIOGRAPHY

ATWOOD, HORACE. Some factors affecting the weight, composition, and hatchability of hen eggs. West Virginia Univ. Agr. Exp. Sta. Bul. 145:71–102. 1914.

BENJAMIN, EARL W. A study of the inheritance and incubation effects of certain outside characters of eggs. Thesis for degree of M.S.A., Cornell University. (Unpublished.) 1912.

———— A study of the variation and inheritance of the size, shape, and color of eggs. Thesis for degree of Ph. D., Cornell University. (Unpublished.) 1914.

BUMPUS, HERMON C. The elimination of the unfit as illustrated by the introduced sparrow, Passer domesticus. Marine Biol. Lab. Wood's Holl, Massachusetts. Biol. lectures 1898:209–226. 1899.

CASTLE, W. E. The laws of heredity of Galton and Mendel, and some laws governing race improvement by selection. Amer. Acad. Arts and Sciences. Proc. 39:221–242. 1903.

CHIDESTER, F. E. An abnormal hen's egg. Amer. nat. 49:49–51. 1915.

CURTIS, MAYNIE R. The ligaments of the oviduct of the domestic fowl. Maine Agr. Exp. Sta. Ann. rept. 26(1910):1–20. 1911 a.

———— An accurate method for determining the weight of the parts of the eggs of birds. Maine Agr. Exp. Sta. Bul. 191:93–112. 1911 b.

———— A biometrical study of egg production in the domestic fowl. IV. Factors influencing the size, shape, and physical constitution of eggs. Arch. Entwicklungsmech. Organ. 39:217–327. (*Abstracted in* Factors influencing the size, shape, and physical constitution of the egg of the domestic fowl. Maine Agr. Exp. Sta. Bul. 228:105–136. 1914.) 1914 a.

———— Studies on the physiology of reproduction in the domestic fowl. VI. Double- and triple-yolked eggs. Biol. bul. 26:55–83. 1914 b.

ECKLES, C. H., AND REED, O. E. A study of the cause of wide variation in milk production by dairy cows. Univ. Missouri Agr. Exp. Sta. Research bul. 2:107–147. 1910.

FÉRÉ, CH. Note sur la puissance toxique et la puissance tératogène de la morphine sur le poulet. Soc. Méd. Hôp. Paris. Bul. et. mém. 14:ser. 3:608–617. 1897.

———— Deuxième note sur le développement et sur la position de l'embryon de poulet dans les oeufs à deux jaunes. Soc. Biol. [Paris]. Compt. rend., ser. 10:5:922. 1898 a.

———— Note sur le poids de l'oeuf de poule et sur ses variations dans les pontes successives. Journ. anat. et physiol. [Paris] 34:123–127. 1898 b.

GLASER, OTTO. On the origin of double-yolked eggs. Biol. bul. **24**: 175–186. 1913.

GOODALE, H. D. Inheritance of winter egg production. Science n. s. **47**:542–543. 1918.

GOWELL, G. M. Poultry experiments in 1900 and 1901. Maine Agr. Exp. Sta. Bul. 79:9–40. 1902.

HADLEY, PHILIP B. Studies on inheritance in poultry: I. The constitution of the White Leghorn breed. Rhode Island State Coll. Agr. Exp. Sta. Bul 155:149–216. 1913.

———— Egg-weight as a criterion of numerical production. Amer. Assn. Instr. and Invest. Poul. Husb. Journ. **5**:26–27. 1919.

HARGITT, CHARLES W. Some interesting egg monstrosities. Zool. bul. **2**:225–229. 1899.

———— Double eggs. Amer. nat. **46**:556–560. 1912.

HERRICK, F. H. A case of egg within egg. Science n. s. **9**:364. 1899 a.

———— Ovum in ovo. Amer. nat. **33**:409–414. 1899 b.

HORWOOD, A. R. The coloration of birds' eggs. Nature **82**:247. 1909.

LATTER, OSWALD H. The egg of Cuculus canorus. Biometrika **1**:164–176. 1901.

M'ALDOWIE, ALEXANDER M. Observations on the development and the decay of the pigment layer on birds' eggs. Journ. anat. and physiol. **20**:225–237. 1886.

MAIRS, THOMAS I. Some poultry experiments. Pennsylvania State Coll. Agr. Exp. Sta. Bul. 87:1–48. 1908.

NATHUSIUS, W. VON. Einschluss eines Hühner-Eies, Knorpel-, Knochen-, und Bindegewebe enthaltend. Arch. mikros. Anat. **45**:654–692. 1895.

NEWTON, A. A dictionary of birds, vols. 1–4. 1893–96.

PARKER, G. H. Double hens' eggs. Amer. nat. **40**:13–25. 1906.

PATTERSON, J. THOMAS. A double hen's egg. Amer. nat. **45**:54–59. 1911.

PEARL, RAYMOND. Studies on the physiology of reproduction in the domestic fowl. I. Regulation in the morphogenetic activity of the oviduct. Journ. exp. zool. **6**:339–359. 1909.

———— The mode of inheritance of fecundity in the domestic fowl. Journ. exp. zool. **13**:153–268. *Also*, Maine Agr. Exp. Sta., Bul. 205:283–394. 1912.

———— Mendelian inheritance of fecundity in the domestic fowl, and average flock production. Amer. nat. **49**:306–317. 1915 a.

———— Seventeen years selection of a character showing sex-linked mendelian inheritance. Amer. nat. **49**:595–608. 1915 b.

PEARL, RAYMOND, AND CURTIS, MAYNIE R. Studies on the physiology of reproduction in the domestic fowl. V. Data regarding the physiology of the oviduct. Journ. exp. zool. **12**:99–132. 1912.

———— Studies on the physiology of reproduction in the domestic fowl. XV. Dwarf eggs. Journ. agr. res. 6:977–1042. (*Abstracted in* Dwarf eggs of the domestic fowl. Maine Agr. Exp. Sta. Bul. 255:289–328. 1916.) 1916.

PEARSON, KARL. Variation of the egg of the sparrow (Passer domesticus). Biometrika 1:256. 1902 a.

———— Mathematical contributions to the theory of evolution. XI.—On the influence of natural selection on the variability and correlation of organs. Roy. Soc. London. Proc. 60:330–333. 1902 b.

———— Note on the separate inheritance of quantity and quality in cows' milk. Biometrika 7:548–550. 1910.

RICE, JAMES E. Methods of increasing production and improving the quality of eggs. New York State Dept. Agr. Cir. 54:1295–1315. 1912.

———— Breeding poultry for egg production. *In* The poultry industry in New York State. New York State Dept. Agr. Bul. 65:260–301. 1914.

RICE, JAMES E., NIXON, CLARA, AND ROGERS, CLARENCE A. The molting of fowls. Cornell Univ. Agr. Exp. Sta. Bul. 258:17–68. 1908.

RIDDLE, OSCAR. On the formation, significance, and chemistry of the white and yellow yolk of ova. Journ. morph. 22:455–491. 1911.

SORBY, H. C. On the colouring-matters of the shells of birds' eggs. Zool. Soc. London. Proc. 1875:351–365. 1875.

STEWART, J. H., AND ATWOOD, HORACE. Some factors influencing the vigor of incubator chickens. West Virginia Univ. Agr. Exp. Sta. Bul. 124:21–45. (Reference on p. 23–30.) 1909.

SURFACE, FRANK M. The histology of the oviduct of the domestic hen. Maine Agr. Exp. Sta. Bul. 206:395–430. 1912.

THOMPSON, D'ARCY WENTWORTH. On the shapes of eggs, and the causes which determine them. Nature 78:111–113. 1908.

TSCHERMAK, A. VON. Über Verfärbung von Hühnereiern durch Bastardierung und über Nachdauer dieser Farbänderung. Biol. Centbl. 35:46–63. 1915.

WALTHER, AD. R. Über den Einfluss der Rassenkreuzung auf Gewicht, Form, Glanz, und Farbe der Hühnereier. Landw. Jahrb. 46:89–104. 1914.

WEIMER, BERNAL R. A peculiar egg abnormality. Amer. Assn. Instr. and Invest. Poul. Husb. Journ. 4:78–79. 1918.

Memoir 29, *The Lecithin Content of Butter and its Possible Relationship to the Fishy Flavor*, the second preceding number in this series of publications, was mailed on December 23, 1919.