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## CORRELATION BETWEEN EXTERNAL BODY CHARACTERS AND ANNUAL EGG- PRODUCTION IN WHITE LEGHORN FOWLS



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†As of May 1, 1922.

\*In cooperation with School of Veterinary Medicine, A. and M. College of Texas.

\*\*In cooperation with United States Department of Agriculture.

## CORRELATION BETWEEN EXTERNAL BODY CHARACTERS AND ANNUAL EGG-PRODUCTION IN WHITE LEGHORN FOWLS

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By

R. M. SHERWOOD.

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The selection of fowls for egg-production, from an examination of their external body characters, has been practiced for several years. There are, however, few published data to show which characters should receive the greatest emphasis in these selections. It is possible that a great amount of such practice is empirical. It was to provide such data that studies were started at the Texas Agricultural Experiment Station on the correlation between annual egg-production and those external body characters upon which selection is usually based. This Bulletin reports the results of the study of ten of these characters, namely, color of shanks, color of beak, pliability of pubic bones, handling quality, number of primary wing feathers molted, body weight, width of pelvic arch, capacity, depth of body, and length of keel.

### REVIEW OF LITERATURE.

Blakeslee and Warner<sup>1</sup> published data showing a high negative correlation between the per cent of yellow in the ear lobes of White Leghorn fowls, as observed October 19th to 21st, and the number of days since laying. They also found a high negative correlation between the per cent of yellow in the ear lobes and the number that were laying when the observations were made. This means that the hens with the yellow lobes were not laying when the observations were taken, and had not been laying for some time. Their data also indicate a high negative correlation between the per cent of yellow in the ear lobes and the egg-production for September and October. This negative correlation means that low egg-production was associated with a high per cent of yellow in the lobes. The writers say concerning the relation between the color of lobes and annual egg-production that, "A distinct correlation with color seems to show in the yearly average but is largely an indirect one. It is generally only the best birds—those that make the large yearly records—that are laying in October. Therefore, any method that selects the laying birds at this season will select at the same time the birds laying above average throughout the year, and consequently give high yearly totals."

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<sup>1</sup>Blakeslee, A. F., and Warner, D. E., 1915, Correlation between egg laying and yellow pigment in the domestic fowl. Science N. S. 41: 432-434.

Blakeslee and Warner<sup>2</sup> also presented data showing a negative correlation between annual egg-production and color of ear lobes, shanks, and beak. These workers found that "Hens with a higher yearly average may be obtained by selecting those that are pale in all parts—ear lobes and beak as well as in legs—than if only one of these parts is considered."

Harris, Blakeslee, and Warner<sup>3</sup> showed a correlation between yellow color in the ear lobes of White Leghorn fowls and annual egg-production of  $-.5816 \pm .0253$  in 1913-1914 and  $-.6271 \pm .0252$  in 1914-1915.

Dougherty<sup>4</sup> found a negative correlation between annual egg-production and color of shanks, beak, and vent. To quote him: "The data presented indicate that shank color and beak color are somewhat more reliable to use for summer culling and grading than vent color. This is perhaps due to the fact that yellow pigment leaves and returns to the vent more rapidly than it does to the shanks or beak."

Palmer and Kempster<sup>5</sup> studied the physiology of the yellow pigment and reached the following conclusions: "The fading of the yellow pigment from the ear lobes, beak, shanks, etc., of hens of the Leghorn and American breeds during fecundity is due to the fact that fecundity deflects the normal path of excretion of the xanthophyll from these parts of the skin to the egg yolk. The xanthophyll deposited in the epidermis of the above-named parts gradually disappears as the result of the natural physiological change in the structure of the skin. The thicker the epidermis, the more slowly will the xanthophyll disappear. It is impossible to restore xanthophyll to the skin of hens as long as fecundity exists, no matter how large an excess of pigment is fed. Adipose tissue also fails to take up the xanthophyll from the food during laying even on rations rich in xanthophyll, the pigment being excreted wholly in the egg yolk. The fading of the ear lobes, beak, and shanks of the Leghorn and American breeds of hens as the result of laying is an index of continuous fecundity only—not heavy laying."

Correlation between standard score and annual egg-production was studied in connection with the Vineland Egg Laying Contest.<sup>6</sup> The tables published show correlations\* of  $.015 \pm .054$  for Plymouth Rocks, of  $-.022 \pm .085$

<sup>2</sup>Blakeslee, A. F., and Warner, D. E., 1915, Correlation between egg laying and yellow pigment in the domestic fowl. *Amer. Nat.* 49: 360-368.

<sup>3</sup>Harris, J. A., Blakeslee, A. F., and Warner, D. E., in consultation with Kirkpatrick, W. F., 1917, the correlation between body pigmentation and egg-production in the domestic fowl. *Genetics* 2: 36-77.

<sup>4</sup>Dougherty, J. E., 1918, Suggestions for increasing egg-production in a time of high feed prices. California Agricultural Experiment Station Circular 197, 8 pp.

<sup>5</sup>Palmer, L. S., and Kempster, H. L., 1919. The physiological relation between fecundity and natural yellow pigmentation of certain breeds of fowls. *Jour. Biol. Chem.* 39: 313-330.

<sup>6</sup>Jackson, H. W., and Curtis, G. M., compilers, 1920. Profitable culling and selective flock breeding. 120 pp., Quincy, Illinois: Reliable Poultry Journal Publishing Company.

\*These correlations were worked out by the author from the tables referred to above. The data do not support the conclusions drawn by the compilers in respect to the importance of standard score.



for Rhode Island Reds, of  $-.096 \pm .059$  for Wyandottes, and of  $-.063 \pm .029$  for Leghorns. In all of these cases there is a small negative correlation but the correlation is so small in relation to its probable error\* that it cannot be considered significant. A negative correlation, in this case, between standard score and annual egg-production would indicate that the low-scoring birds were the better layers.

Correlation between body weight and annual egg-production was also studied in connection with the Vineland Egg Laying Contest.<sup>7</sup> One table published gives data for Plymouth Rocks, Rhode Island Reds, and Wyandottes, while a second table deals with Leghorns and other light breeds. Since both tables contain data for breeds of different weights it is impossible to make a complete analysis of them. The data in the first table tend to show a slight advantage in egg-production for the average—or standard—weight fowls over the heavier and the lighter ones. The second table shows that a few of the very lightest fowls were not good layers. If these few were discarded, data on the remaining birds would show no significant correlation between annual egg-production and the deviation of the weight of these birds from standard weight. The data presented in their tables do not support all of the conclusions drawn by the compilers.

#### METHODS OF SECURING AND TABULATING DATA.

One hundred and twenty-eight S. C. White Leghorn hens, of similar breeding, constituted the stock used in this study. They were hatched in February and March, 1920, but since limited rations were given while on range during the summer they did not develop to standard weight.

The term "annual egg-production," as used in this study, refers to the egg-production of these fowls from October 1, 1920, to September 30, 1921. This was their first laying year. The observations and measurements were made near the end of this laying period, but in no case were the egg records consulted at the time of making the observations and measurements.

Color of shank and color of beak, as observed September 20-22, 1921, are tabulated in four classes as follows: class 1 is very pale; class 2 has a slight tint; class 3 is light yellow; and class 4 is deep yellow.

Observations on pliability of pubic bones were also made September 20-22, 1921, and are tabulated in three classes. Class 1 is rigid; class 2 is somewhat pliable; and class 3 is very pliable.

Handling quality, as observed September 20-22, 1921, in-

<sup>7</sup>Jackson, H. W., and Curtis, G. M., compilers, 1920, Profitable culling and selective flock breeding. 120 pp. Quincy, Illinois: Reliable Poultry Journal Publishing Company.

\*The probable error, as used here is the ordinary mathematical term for the amount which the result is apt to vary, due to chance alone, and does not refer to any error or uncertainty of measurement or calculation.

cluded the pliability and thickness of the skin. In the tabulation, class 1 represents a thick and poor handling skin; class 2, a medium quality; and class 3, a thin, pliable skin free from fatty deposits.

The number of primary wing feathers molted was determined on October 4, 1921, and is stated in figures in the table.

The fowls were weighed on October 4, 1921, the weight being stated in ounces in the tables.

The width of pelvic arch was obtained by measuring the distance between the tips of the pubic bones. This measurement was taken September 20-22, 1921. A pair of calipers was used and the distances, read from a finely divided scale, are stated in figures in the tables.

Capacity, as studied in this work, is the caliper measurement from the tip of one pubic bone to the back point of the keel. This measurement was taken September 20-22, 1921. The hens were held in the same position in each case and all precautions were taken to get the exact distance between these points.

The depth of body is the caliper measurement from the upper joint of the femur to the back point of the keel. This measurement was made September 20-22, 1921.

Length of keel is the caliper measurement between the two extreme points of the lower edge of the keel. This measurement was taken June 28-30, 1921.

In tabulating the ratios of width of pelvic arch, depth of body, and capacity to weight it was necessary to use the measurements made September 20-22, 1921, with the weights taken on October 4, 1921. These ratios and the ratio of length of keel to weight were used because the correlation between weight and egg-production was not significant and it is clear that weight is related to width of pelvic arch, depth of body, capacity, and length of keel in any group of birds of similar type. By correlating these ratios with the egg-production the factor of weight is eliminated and it can be shown whether there is any correlation between annual egg-production and the variations of these characters due to other causes than weight.

## RESULTS.

Table 1 gives the mean, or average, and the standard deviation, which is the commonly used measure of variability, for the several characters studied. Tables 2-19 are the correlation tables for the different characters. Table 20 gives a summary of the correlations obtained in Tables 2-19.

TABLE 1.—Mean and Standard Deviation for the Several Characters Studied

CHARACTER	MEAN	STANDARD DEVIATION
ANNUAL EGG-PRODUCTION.....	127.131±2.534	42.50±1.792
COLOR OF SHANKS.....	1.984±.054	.90±.038
COLOR OF BEAKS.....	2.125±.059	.99±.042
PLIABILITY OF PUBIC BONES.....	1.938±.043	.73±.031
HANDLING QUALITY.....	1.992±.041	.69±.029
NUMBER OF PRIMARY WING FEATHERS MOLTED.....	5.086±.154	2.58±.109
BODY WEIGHT.....	51.031±.379	6.36±.268
WIDTH OF PELVIC ARCH.....	13.125±.156	2.62±.110
RATIO OF PELVIC ARCH TO WEIGHT.....	25.813±.334	5.60±.236
CAPACITY.....	24.602±.225	3.78±.159
RATIO OF CAPACITY TO WEIGHT.....	48.203±.448	7.52±.317
DEPTH OF BODY.....	39.531±.178	2.99±.126
RATIO OF DEPTH OF BODY TO WEIGHT.....	77.828±.444	7.44±.314
LENGTH OF KEEL.....	39.625±.136	2.29±.096
RATIO OF LENGTH OF KEEL TO WEIGHT.....	79.141±.546	9.16±.386

TABLE 2.—Correlation between Annual Egg-production and Color of Shanks

COLOR OF SHANKS	ANNUAL EGG-PRODUCTION												TOTALS
	30	50	70	90	110	130	150	170	190	210	230	250	
1	....	....	....	3	3	3	14	9	6	3	2	1	44
2	....	2	3	10	11	12	7	5	1	....	....	....	51
3	1	1	3	9	5	2	2	1	....	....	....	....	24
4	....	....	3	4	1	....	....	....	....	....	....	....	9
TOTALS.....	2	3	9	26	20	17	23	15	7	3	2	1	128

$$r = -.622 \pm .037$$

TABLE 3.—Correlation between Annual Egg-production and Color of Beak

COLOR OF BEAK	ANNUAL EGG-PRODUCTION												TOTALS
	30	50	70	90	110	130	150	170	190	210	230	250	
1	....	....	....	3	2	8	13	8	4	3	2	1	44
2	....	2	1	5	8	5	7	5	3	....	....	....	36
3	1	1	5	13	7	4	3	2	....	....	....	....	36
4	1	....	3	5	3	....	....	....	....	....	....	....	12
TOTALS.....	2	3	9	26	20	17	23	15	7	3	2	1	128

$$r = -.603 \pm .038$$

TABLE 4.—Correlation between Annual Egg-production and Pliability of Pubic Bones.

PLIABILITY OF PUBIC BONES	ANNUAL EGG-PRODUCTION												TOTALS
	30	50	70	90	110	130	150	170	190	210	230	250	
1	1	....	5	10	7	3	2	2	....	....	....	....	39
2	1	3	4	12	9	11	12	5	2	....	....	....	60
3	....	....	....	4	4	3	9	8	5	3	1	1	38
TOTALS.....	2	3	9	26	20	17	23	15	7	3	2	1	128

$$r = +.472 \pm .046$$

TABLE 5.—Correlation between Annual Egg-production and Handling Quality

HANDLING QUALITY	ANNUAL EGG-PRODUCTION												TOTALS
	30	50	70	90	110	130	150	170	190	210	230	250	
1	1	1	4	11	7	3	2	2					31
2	1	2	5	11	9	10	16	8	5				67
3				4	4	4	5	5	2	3	2	1	30
TOTALS.....	2	3	9	26	20	17	23	15	7	3	2	1	128

$$r = +.431 \pm .048$$

TABLE 6.—Correlation between Annual Egg-production and Number of Primary Wing Feathers Molted

Number of Primary Wing Feathers Molted	ANNUAL EGG-PRODUCTION												TOTALS
	30	50	70	90	110	130	150	170	190	210	230	250	
0				2			3	2	2	2	1	1	13
1					1	1	2						4
2							2	1		1			4
3				1		1	2	2	1		1		8
4		1		4	2	2	5	2	1				17
5				3	5	5	2	4	3				22
6		1	3	2	3	3	2	1					15
7		1	3	9	3	3	3	2					24
8	1		2	2	5	2	1						13
9	1			2	1		1						5
10			1	1				1					3
TOTALS.....	2	3	9	26	20	17	23	15	7	3	2	1	128

$$r = -.522 \pm .043$$

TABLE 7.—Correlation between Annual Egg-production and Body Weight

BODY WEIGHT	ANNUAL EGG-PRODUCTION											TOTALS	
	30	50	70	90	110	130	150	170	190	210	230		250
34				1									1
36													0
38				1									1
40				2		1							4
42		1			1		2	3					7
44			1	1	1	1	1	1			1		7
46			1	2		1	2		1				7
48			2	4	3	4	5		2	1	1	1	23
50	1			3	2	2	2	2					12
52	1	1	1	7	4	4	5	1	2				26
54			2	1	2	1	1	2	1				10
56					2	2	2	2	1				9
58			1	3		1	3			1			9
60		1	1	1	3			2		1			9
62													0
64					1								1
66													0
68								1					1
70													0
72													0
74													0
76													0
78													0
80													0
82					1								1
TOTALS.....	2	3	9	26	20	17	23	15	7	3	2	1	128

$$r = +.009 \pm .060$$

TABLE 8.—Correlation between Body Weight and Width of Pelvic Arch

WIDTH OF PELVIC ARCH	BODY WEIGHT																							TOTALS		
	34	36	38	40	42	44	46	48	50	52	54	56	58	60	62	64	66	68	70	72	74	76	78		80	82
7						1																				1
8				1	1	1		2	1				1													7
9								2	2	2	1															5
10				1				2	2	2		1	1	2	1											9
11							1	4	2	2	2															8
12				1	3		2	4	2	7	5	1	2	1	1											24
13							2	2	3	1	1	1	1	1	1											15
14	1				3	2	1	2	2	5	1	2	1	1		1									1	17
15			1	1		2	1	2	2	6	1	1	1	1												17
16							1	2	2	2	3	1	1	1	1				1							13
17								1				3	1	1	1											7
18						1					1			2												4
19												1														1
TOTALS.....	1	0	1	4	7	7	7	23	12	26	10	9	9	9	0	1	0	1	0	0	0	0	0	0	1	128

$$r = +.216 \pm .057$$

TABLE 9.—Correlation between Annual Egg-production and Width of Pelvic Arch

WIDTH OF PELVIC ARCH	ANNUAL EGG-PRODUCTION												TOTALS
	30	50	70	90	110	130	150	170	190	210	230	250	
7					1								1
8			1	3		1	1	1					7
9				3			1						5
10			1	3		2		2	1				9
11			1	3	1		3						8
12		2	2	4	6	4	1	3	2				24
13	2		2	1	2	2	5		1				15
14				1	5	1	3	3	1		2	1	17
15				6	2	3	4	1	1				17
16			1	1	1	3	3	2	1	1			13
17				1	2		1	2		1			7
18		1	1					1		1			4
19							1						1
TOTALS.....	2	3	9	26	20	17	23	15	7	3	2	1	128

$$r = +.210 \pm .057$$

TABLE 10.—Correlation between Annual Egg-production and the Ratio of Width of Pelvic Arch to Weight

RATIO OF WIDTH OF PELVIC ARCH TO WEIGHT	ANNUAL EGG-PRODUCTION											TOTALS	
	30	50	70	90	110	130	150	170	190	210	230		250
13				1									1
15				1	1								2
17				6	1		1	1	1				10
19			2	1	1	3	1	1					9
21			2	1	3	2	1	1					10
23		1	1	3	3	2	4	1	1				16
25	2		1	1	3	2	5	2	3				19
27			1	1	2	1	1	4		1			11
29		2		6	4	5	1	2		1	1	1	23
31				1	2	1	4	1	1		1		11
33			2			1	4	1					8
35				1			1		1	1			4
37				1									1
39				1									1
41				1				1					2
TOTALS.....	2	3	9	26	20	17	23	15	7	3	2	1	128

$$r = +.178 \pm .053$$



TABLE 11.—Correlation between Body Weight and Capacity

CAPACITY	BODY WEIGHT																	TOTALS
	34	36	38	40	42	44	46	48	50	52	54	56	58	60	62	64	66	
15					1				1									2
16								1										1
17					1	1		1										3
18							1		1									3
19							1	1										2
20								3	1	1								5
21				1	2	1		1	1	1	1							8
22			1	1	1			2		5	1		1					12
23							1	1	1	1	2		1					7
24				2	1	1	1	6	2	2	1	1	2	2				21
25						2	3	3		2	1	1	1					13
26	1							1	1	4	2	1	1	2				13
27					1	2		1	4	2		3	1					13
28								1		2	1	2		1				6
29									4	1	1	1						6
30								1		2		1						2
31													2		1	1		7
32										1		1						2
33											1						1	2
TOTALS.....	1	0	1	4	7	7	7	23	12	26	10	9	9	9	0	1	0	128

$$r = +.468 \pm .047$$

TABLE 12.—Correlation between Annual Egg-production and Capacity

CAPACITY	ANNUAL EGG-PRODUCTION												TOTALS
	30	50	70	90	110	130	150	170	190	210	230	250	
15				1				1					2
16			1										1
17					1		2						3
18						2			1				3
19				1			1						2
20				3				1				1	5
21		1	1	4	1			1					8
22	1		1	4	1	2	2				1		12
23	1					1	2	1	2				7
24			1	5	4	2	5	3	1				21
25			2	3		2	3	2	1	1			13
26		1		3	3	1	2	2	1				13
27			2		2	2	3	3			1		13
28				1		2	1	1	1				6
29			1	1	3	1							6
30						1		1					2
31					2	1	2	1		1			7
32					1					1			2
33		1			1								2
TOTALS.....	2	3	9	26	20	17	23	15	7	3	2	1	128

$$r = +.093 \pm .059$$

TABLE 13.—Correlation between Annual Egg-production and the Ratio of Capacity to Weight

RATIO OF CAPACITY TO WEIGHT	ANNUAL EGG-PRODUCTION											TOTALS	
	30	50	70	90	110	130	150	170	190	210	230		250
29				1									1
31													0
33			1										1
35						1	1	1	1				4
37				2	1								3
39			2	3	1	1		1					8
41	1			3	2	1	5	1				1	14
43				4	3	1		1					9
45	1			1		1		1	2		1		7
47			2	1	1	1	6	1					12
49		2	1	1	5	3	4	3	3				22
51					2			1		1			4
53			1	4	2	2	3	1					14
55		1	1	3	2	3	1			1			12
57			1	1		1	1	2					6
59				1	1	1	1	1	1				6
61						1					1		2
63													0
65							1	1					2
67													0
69													0
71													0
73													0
75													0
77				1									1
TOTALS.....	2	3	9	26	20	17	23	15	7	3	2	1	128

$$r = +.100 \pm .059$$

TABLE 14.—Correlation between Body Weight and Depth of Body

DEPTH OF BODY	BODY WEIGHT																										TOTALS
	34	36	38	40	42	44	46	48	50	52	54	56	58	60	62	64	66	68	70	72	74	76	78	80	82		
31				1																						1	
32																										0	
33						1																				1	
34								2																		2	
35			1		1	2		1	1																	7	
36	1			1	3		1	2		2				1												11	
37				1	1		2	4	2	1			1													12	
38					2		1	2	3	3																13	
39				1			1	1	1	5	1	2	1	1												15	
40							2	4	3	2			2	3												16	
41						1			6	6	2	4	2													21	
42								1	1	4	1			1												8	
43								1		3	3		2													9	
44									1	1		1		1												4	
45										1		1	1	2		1		1								7	
46																										0	
47																										0	
48																										0	
49																								1		1	
TOTALS.....	1	0	1	4	7	7	7	23	12	26	10	9	9	9	0	1	0	1	0	0	0	0	0	0	1	128	

$$r = +.645 \pm .035$$

TABLE 15.—Correlation between Annual Egg-production and Depth of Body

DEPTH OF BODY	ANNUAL EGG-PRODUCTION												TOTALS
	30	50	70	90	110	130	150	170	190	210	230	250	
31				1									1
32					1								0
33													1
34				1			1						2
35			1	1	2		1	1			1		7
36		1	1	5	2		1	1					11
37				4	1	3	1	2	1				12
38			1	2	2	3	3	2					13
39	1		4	4	1	2		1	2				15
40		1		3	4	1	4	1	1	1			16
41			1	3	3	6	6				1	1	21
42					1	1	2	2	2				8
43			1			1	3	2	1	1			9
44	1			1			1	1					4
45		1		1	2			2		1			7
46													0
47													0
48					1								0
49													1
TOTALS.....	2	3	9	26	20	17	23	15	7	3	2	1	128

$$r = +.174 \pm .058$$

TABLE 16.—Correlation between Annual Egg-production and the Ratio of Depth of Body to Weight.

RATIO OF DEPTH OF BODY TO WEIGHT	ANNUAL EGG-PRODUCTION												TOTALS
	30	50	70	90	110	130	150	170	190	210	230	250	
59					2								2
61													0
63				1									1
65			1										1
67			1	1	3			1					6
69				3	1	1	2	2					9
71			1	2	1	1	2						7
73			2	1	4	2	2	1					12
75		1		4	3	1	1	1	3	2			16
77		1		4	2	4		1	1				13
79	1		2	2	1	3	6	2			1		18
81				2			2	2	1				7
83	1			1	1	3	2	1	1	1			11
85		1	2				2	1			1	1	8
87				1	1		3	1					6
89				3				1	1				5
91					1		1						2
93						1		1					2
95													0
97						1							1
99													0
101													0
103													0
105				1									1
TOTALS.....	2	3	9	26	20	17	23	15	7	3	2	1	128

$$r = +.149 \pm .058$$

TABLE 17.—Correlation between Body Weight and Length of Keel

LENGTH OF KEEL	BODY WEIGHT																								TOTALS	
	34	36	38	40	42	44	46	48	50	52	54	56	58	60	62	64	66	68	70	72	74	76	78	80		82
33							1			1																2
35	1				1					3	1															4
37				2	2	4	1	5		1	1	1	1	2												22
39				2	1	2	3	10	5	12	1	3	3	1		1		1								45
41			1		3		1	5	5	7	5	3	5	2												37
43						1	1	2	2	1	2	2		4												15
45							1			1														1		3
TOTALS.....	1	0	1	4	7	7	7	23	12	26	10	9	9	9	0	1	0	1	0	0	0	0	0	0	1	128

$$r = +.384 \pm .051$$

TABLE 18.—Correlation between Annual Egg-production and Length of Keel

LENGTH OF KEEL	ANNUAL EGG-PRODUCTION												TOTALS
	30	50	70	90	110	130	150	170	190	210	230	250	
33				1	1								2
35			1	1	1			1					4
37		1	2	4	4	2	5	2	1		1		22
39	1		5	13	6	6	7	4	2	1			45
41	1	1	1	6	5	7	6	6	3		1		37
43		1		1	2	1	4	2	1	2		1	15
45					1	1	1						3
TOTALS.....	2	3	9	26	20	17	23	15	7	3	2	1	128

$$r = +.208 \pm .057$$

TABLE 19.—Correlation between Annual Egg-production and the Ratio of Length of Keel to Weight

RATIO OF LENGTH OF KEEL TO WEIGHT	ANNUAL EGG-PRODUCTION												TOTALS
	30	50	70	90	110	130	150	170	190	210	230	250	
55					1								1
57													0
59								1					1
61			1										1
63					3								3
65				1									1
67			1		1		2			1			5
69			1	1	2			1	1				5
71		2		1	2	2	1	2	1				11
73				4		1	2			1			8
75			1	1	3	1	2	2	1				11
77	1		2	5	2	2	1	1	1				15
79	1			1	3	2	3		1				11
81			1	4	1	3	5	2					16
83				1			1	1	1				4
85			1	2	1		1	2			1		8
87				1		4					1		7
89			1						1			1	3
91						1	2			1			4
93					1		1	2					4
95							1	1					2
97		1		1			1						3
99					1	1							2
101													0
103				1									1
105				1									1
TOTALS.....	2	3	9	26	20	17	23	15	7	3	2	1	128

$$r = +.120 \pm .059$$

TABLE 20.—Summary of Correlations for Characters Studied

CHARACTERS CORRELATED	CORRELATION
COLOR OF SHANKS—ANNUAL EGG-PRODUCTION.....	— .622 ± .037
COLOR OF BEAK—ANNUAL EGG-PRODUCTION.....	— .603 ± .038
PLIABILITY OF PUBIC BONES.....	+ .472 ± .046
HANDLING QUALITIES—ANNUAL EGG-PRODUCTION.....	+ .431 ± .048
NUMBER OF PRIMARY WING FEATHERS MOLTED—ANNUAL EGG-PRODUCTION.....	— .522 ± .043
BODY WEIGHT—ANNUAL EGG-PRODUCTION.....	+ .009 ± .060
WIDTH OF PELVIC ARCH—BODY WEIGHT.....	+ .216 ± .057
WIDTH OF PELVIC ARCH—ANNUAL EGG-PRODUCTION.....	+ .210 ± .057
RATIO OF WIDTH OF PELVIC ARCH TO WEIGHT—ANNUAL EGG-PRODUCTION.....	+ .178 ± .058
CAPACITY—BODY WEIGHT.....	+ .468 ± .047
CAPACITY—ANNUAL EGG-PRODUCTION.....	+ .093 ± .059
RATIO OF CAPACITY TO WEIGHT—ANNUAL EGG-PRODUCTION.....	+ .100 ± .059
DEPTH OF BODY—BODY WEIGHT.....	+ .645 ± .035
DEPTH OF BODY—ANNUAL EGG-PRODUCTION.....	+ .174 ± .058
RATIO OF DEPTH OF BODY TO WEIGHT—ANNUAL EGG-PRODUCTION.....	+ .149 ± .058
LENGTH OF KEEL—BODY WEIGHT.....	+ .384 ± .051
LENGTH OF KEEL—ANNUAL EGG-PRODUCTION.....	+ .208 ± .057
RATIO OF LENGTH OF KEEL TO WEIGHT—ANNUAL EGG-PRODUCTION.....	+ .120 ± .059

## CONCLUSIONS.

1. The data obtained in this study show a strong negative correlation between color of shanks and annual egg-production, and also a strong negative correlation between color of beak and annual egg production. This means that the fowls that laid the low number of eggs had the greatest amount of yellow in their shanks and beaks. This is in agreement with the results of other workers and with common culling practices.

2. There is a strong positive correlation between pliability of pubic bones and annual egg-production. This supports the practice in culling of picking the hens with pliable pubic bones as the high producers.

3. There is a correlation of  $+ .431 \pm .048$  between handling quality and annual egg-production. These findings are in agreement with the practice in culling of selecting the hen with the thin pliable skin as the hen that has laid the large number of eggs.

4. This study indicates a strong negative correlation between the number of primary wing feathers molted and annual egg-production. Here, again, common culling practices are supported; the early molting fowls averaged much poorer in egg-production than did those molting late.

5. This work shows no correlation between the weight of the fowls and annual egg production, nor between the deviation from either standard or average weight and annual egg-production.

6. There is a strong positive correlation between capacity and weight, and between depth of body and weight. A smaller positive correlation is shown between length of keel



and weight. A still smaller positive correlation exists between width of pelvic arch and weight.

7. No distinctly significant correlation is shown between capacity, depths of body, width of pelvic arch, length of keel, and the ratios of capacity, depth of body, width of pelvic arch, and length of keel to weight, on the one hand and annual egg production on the other. In each case the correlation in relation to its probable error is small. The author is unable to find published data on these characters as related to annual egg-production, but his findings indicate that too much emphasis is being placed upon these characters in common culling practices.

8. The characters reported upon divide themselves into two classes, namely, physiological and anatomical. The physiological characters include color of shanks, color of beak, pliability of pubic bones, handling quality, and the number of primary wing feathers molted. With each of these characters the correlation with annual egg-production is large. They range from  $.431 \pm .048$  to  $.622 \pm .037$ . The anatomical characters, which include the weight of fowl, width of pelvic arch, capacity, depth of body, and length of keel, show no distinctly significant correlation with annual egg-production. The correlations range from  $.009 \pm .60$  to  $.210 \pm .057$ . The fact that there is such a distinct difference in the size of the correlations for the two classes of characters shows that the classification is not an arbitrary one but is based upon a real fundamental difference and that egg-production itself is largely a physiological rather than an anatomical character. It appears that, in common culling practices, much more emphasis should be placed upon the physiological characters than upon the anatomical ones.