THE CORRELATION BETWEEN THE EGG PRODUCTION OF THE VARIOUS PERIODS OF THE YEAR IN THE RHODE ISLAND RED BREED OF DOMESTIC FOWL

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INTRODUCTION

This paper has for its purpose the consideration of the correlation between the egg records of various periods of the year in the Rhode Island Red breed of domestic fowl. Such correlations have already been determined and are in part published for the White Leghorn breed (HARRIS, BLAKESLEE and WARNER 1917; HARRIS, BLAKESLEE, WARNER and KIRKPATRICK 1917; HARRIS, BLAKESLEE and KIRKPATRICK 1917, 1918). In the discussion of the present investigation, we shall assume a knowledge of the results of these earlier studies, particularly that on the correlation between the records of various periods in the White Leghorn (HARRIS, BLAKESLEE and KIRKPATRICK 1918).

In addition to the general biological importance of the knowledge of the interrelationship between the physiological activities of the organisms of a population at various periods, such as will result from the determination of these correlations, the investigations have a potential practical significance. The existence of a correlation between the records of the individ-

ual months and the record of the year as a whole is the basis upon which the possibility of the prediction of the record of groups of birds for longer periods from the measured record of a short period of time must rest. In the case of the White Leghorn fowl, such prediction has been shown to be possible with a high degree of accuracy¹ (HARRIS, KIRKPATRICK and BLAKESLEE 1921; HARRIS, KIRKPATRICK, BLAKESLEE, WARNER and CARD 1921). It is, therefore, important to determine whether correlations of a similar magnitude also exist in breeds other than the White Leghorn. The investigation of the correlation existing in an individual flock is also a matter of considerable practical interest. Our earlier correlations, both those deduced from the Storrs series (HARRIS and others, loc. cit.) and from the Vineland series (HARRIS and LEWIS 1921) were based upon series of birds which were submitted by widely scattered breeders. There is a possibility of the correlations deduced in these cases being considered as due to the heterogeneity of materials thus assembled. This point can be settled only by determining correlations for individual flocks and comparing these with correlations deduced from contest samples drawn from many flocks. It is evident that if the methods of prediction of egg production are to be commercially applied, the practical use must be made in individual flocks. It is, therefore, economically essential to determine whether correlations are found in individual flocks similar to those which have been demonstrated in contest series.

It must not be inferred that we are oblivious to the many biological factors, extrinsic as well as intrinsic, upon which fecundity depends. Certain of these factors, such as time of maturity and broodiness, have been especially emphasized by one of us (GOODALE 1918 a, b, 1920). The great labor of calculation renders it impossible to treat all of the variables simultaneously. The analysis must, therefore, proceed step by step. Ultimately we hope to study in greater statistical detail the interrelationship of the various factors which for the moment must be left out of account.

The present paper on the Rhode Island Red breed is one of a series to be devoted to the more important breeds. A general comparison of results is reserved until the detailed presentation of the constants for each of the breeds is completed.

¹ While it is possible to make predictions for groups of birds, which are highly accurate on the average, it must not be inferred that it is possible to apply these equations to the prediction of the production of specific individuals.

MATERIALS

The materials upon which this study is based are the egg records for the pullet year made by the Rhode Island Red flocks at the MASSACHUSETTS AGRICULTURAL EXPERIMENT STATION for the laying years 1912-1913 to 1918-1919. Records made by birds that died or became pathological are omitted. The foundation stock, 1912-1913, came mainly, but not exclusively, from a single breeder. In 1915-1916, considerable new blood was added. During the period under consideration, breeding experiments dealing with egg production were going on, but aside from this fact, the flocks are a fair sample of what might be obtained from trap-nest records on any commercial poultry farm of similar size. Every care has been taken to keep the daily records accurately and to maintain all controllable environmental factors uniform.

In order to secure as many checks as possible on the trustworthiness of the constants it has seemed desirable to treat the materials in three groups. We have, therefore, determined the correlations for the 443 birds of 1915-1916, for the 442 birds of 1916-1917 and finally for all the birds of the seven years.

PRESENTATION AND ANALYSIS OF DATA

*The correlation between the record of the individual months
and annual production*

The correlation between the production of the individual months of the year and the annual egg record for the series for the two individual years, 1915-1916 and 1916-1917 appear in table 1. The correlations for the whole period, 1912-1919, are given in the first section of table 2.

It is clear that the correlations are of a substantial magnitude and statistically significant in comparison with their probable errors throughout. They are thus in full general agreement with the results obtained from the White Leghorn birds exhibited at the INTERNATIONAL EGG LAYING CONTEST at Storrs, Connecticut.

The constants indicate, therefore, that the production of any individual month should furnish a reasonably satisfactory basis for the prediction of the annual egg production of the Rhode Island Red fowl just as it has been shown to be in the case of the White Leghorn fowl.

It is interesting to note from the difference column in table 1 that the differences between the correlation coefficients deducted for the two different years are in general small. Five of them are less than twice as large as their probable errors. In view of the fact that less than five

TABLE 1

Correlation between the egg production of twelve individual months and total annual egg production.

MONTHS	CORRELATIONS		DIFFERENCE (1916-1917) -(1915-1916)	DIFF. E _{diff.}
	1915-1916	1916-1917		
November.....	.3245 ± .0287	.4357 ± .0255	+ .1112 ± .0384	2.90
December.....	.4887 ± .0244	.6646 ± .0179	+ .1759 ± .0302	5.82
January.....	.5753 ± .0214	.5910 ± .0209	+ .0157 ± .0299	0.53
February.....	.5092 ± .0237	.5937 ± .0208	+ .0845 ± .0315	2.68
March.....	.5020 ± .0240	.5763 ± .0214	+ .0743 ± .0321	2.31
April.....	.5522 ± .0223	.4427 ± .0258	- .1095 ± .0341	3.21
May.....	.5255 ± .0232	.4798 ± .0247	- .0457 ± .0353	1.29
June.....	.5395 ± .0227	.5460 ± .0225	+ .0065 ± .0320	0.20
July.....	.5585 ± .0221	.5623 ± .0219	+ .0038 ± .0311	0.12
August.....	.6021 ± .0204	.5522 ± .0223	- .0499 ± .0302	1.65
September.....	.5374 ± .0228	.6321 ± .0193	+ .0947 ± .0299	3.17
October.....	.3978 ± .0270	.4979 ± .0241	+ .1001 ± .0362	2.77

TABLE 2

Comparison of correlation between the egg production of the twelve individual months and total annual egg production in the Rhode Island Red and the White Leghorn breeds.

MONTHS	CORRELATIONS		DIFFERENCE (R.I.R.) - (W.L.)	DIFF. E _{diff.}
	Rhode Island Red 1912-1913 to 1918-1919	Storrs White Leghorn 1911-1912 to 1916-1917		
November.....	.4678 ± .0130	.4040 ± .0132	+ .0638 ± .0185	3.45
December.....	.5991 ± .0106	.5244 ± .0114	+ .0747 ± .0156	4.79
January.....	.6349 ± .0099	.5062 ± .0117	+ .1287 ± .0153	8.41
February.....	.5720 ± .0112	.5360 ± .0112	+ .0360 ± .0158	2.28
March.....	.5553 ± .0115	.5769 ± .0105	- .0216 ± .0156	1.38
April.....	.4761 ± .0128	.5469 ± .0110	- .0708 ± .0169	4.19
May.....	.4401 ± .0134	.5904 ± .0102	- .1503 ± .0169	8.89
June.....	.5173 ± .0122	.6496 ± .0091	- .1323 ± .0152	8.70
July.....	.5361 ± .0118	.6711 ± .0086	- .1350 ± .0146	9.25
August.....	.5682 ± .0112	.6700 ± .0087	- .1018 ± .0142	7.17
September.....	.5940 ± .0107	.6526 ± .0090	- .0586 ± .0140	4.19
October.....	.4742 ± .0129	.5251 ± .0114	- .0509 ± .0172	2.96

hundred birds are involved in each series and that these birds have been subject to the differences in conditions of two years, the agreement may be considered excellent. This will be shown in another way later.

While a more detailed comparison between breeds is reserved until those other than the Rhode Island Red and the White Leghorn may be taken into account, it is interesting to compare in a wholly preliminary

way the results (hitherto unpublished) obtained from the data for White Leghorn birds as observed at Storrs during the six years 1911 to 1917. These are laid beside the series of Rhode Island Red birds observed at Amherst during the period 1912 to 1919 in table 2. The differences are in general much larger than those between the two series of Rhode Island Red birds compared above, and suggest that the two breeds may differ in their correlations. This furnishes an additional reason for the carrying out of a series of comparative studies on this problem.

For purposes of prediction we must pass from measures of interrelationship in terms of correlation to those expressed in terms of regression equations.

TABLE 3

Regression equations for the prediction of annual total egg production from monthly egg records.

MONTHS	REGRESSION EQUATIONS		
	1915-1916	1916-1917	1912-1913 to 1918-1919
November e_1	$E=116.853+2.174 e_1$	$E=116.653+2.600 e_1$	$E=118.050+2.794 e_1$
December e_2	$E=108.366+2.406 e_2$	$E=95.301+3.274 e_2$	$E=106.027+2.987 e_2$
January e_3	$E=97.114+2.695 e_3$	$E=95.751+2.921 e_3$	$E=95.609+3.104 e_3$
February e_4	$E=91.093+2.551 e_4$	$E=89.727+3.342 e_4$	$E=88.828+3.249 e_4$
March e_5	$E=66.974+3.079 e_5$	$E=42.661+4.452 e_5$	$E=58.396+3.880 e_5$
April e_6	$E=50.253+4.062 e_6$	$E=53.619+4.046 e_6$	$E=60.015+3.895 e_6$
May e_7	$E=61.579+3.832 e_7$	$E=65.176+4.141 e_7$	$E=73.194+3.579 e_7$
June e_8	$E=74.667+3.915 e_8$	$E=76.134+5.048 e_8$	$E=78.474+4.233 e_8$
July e_9	$E=84.414+3.920 e_9$	$E=91.883+4.459 e_9$	$E=90.035+3.903 e_9$
August e_{10}	$E=87.999+4.046 e_{10}$	$E=100.595+3.597 e_{10}$	$E=94.704+3.929 e_{10}$
September e_{11}	$E=101.996+3.076 e_{11}$	$E=99.090+4.015 e_{11}$	$E=101.666+3.754 e_{11}$
October e_{12}	$E=113.621+2.574 e_{12}$	$E=115.121+3.644 e_{12}$	$E=116.928+3.402 e_{12}$

This is essential not merely for purposes of testing the possibilities of prediction but for verifying the validity of the correlation coefficient as applied to the particular data in hand, the validity of the product-moment method of determining closeness of interrelationship depending upon linearity of regression.

The linear regression equations for the two years 1915-1916 and 1916-1917 appear in table 3. These equations are represented graphically in diagrams 1 to 3.

On these diagrams the results for the two years are laid side by side. The figures show: (1) a reasonable agreement of the results obtained for the two different years; and (2) a reasonable agreement of the empirical annual mean production of birds laying various numbers of eggs in

the individual months of the year with the fitted straight lines. Taking the series as a whole, the closeness of agreement, as judged by inspection, merely, would seem to be very comparable with that obtained from the two-years production of White Leghorn birds, submitted by a large num-

DIAGRAM 1.—Regression of annual production on monthly production.

ber of breeders in the INTERNATIONAL EGG LAYING CONTEST at Storrs (HARRIS, BLAKESLEE and KIRKPATRICK 1918, figures 2-5). While it can not be asserted that regression is strictly linear, these results indicate

unmistakably that prediction of the annual record of the Rhode Island Red fowl might be made with a relatively high degree of precision from the recorded performance of any individual month, just as has been shown to be possible in the case of the White Leghorn breed (HARRIS, KIRKPATRICK, BLAKESLEE, WARNER and CARD 1921).

DIAGRAM 2.—Regression of annual production on monthly production.

DIAGRAM 3.—Regression of annual production on monthly production.

The regression equations for the whole series of material, 1912 to 1919, are given in the final section of table 3.

These are not represented graphically in the present paper but will be given in a subsequent publication in which the results for Rhode Island Red birds studied in two different localities will be compared.

The correlation between the record of the individual month and that of the other eleven months of the year

Because of the fact that the production of each individual month of the year is included in the annual total production, the correlations between the productions of the individual months and the annual production must be expected to be positive in sign, and to some extent misleading as measures of the biological interrelationships between the different periods of the same year. This criticism will not apply to the correlations between the productions of the individual months and the total productions of the other eleven months of the year.

Calculating as we have in the White Leghorn series the correlation between the egg records of the individual months and the records of the remaining 11 months of the year, we obtain the results set forth in table 4.

These constants are lower throughout than those which have been deduced for the relationship between monthly production and annual production. This is shown clearly by diagram 4 in which the correlations for the production of each individual month and the production for the remaining 11 months of the year are compared with the correlations for

TABLE 4

Correlation between the monthly egg production and the record of the remaining eleven months of the year.

MONTHS	CORRELATIONS		
	1915-1916	1916-1917	1912-1913 to 1918-1919
November.....	.1822 ± .0310	.2990 ± .0292	.3218 ± .0149
December.....	.3110 ± .0289	.5256 ± .0232	.4456 ± .0133
January.....	.4046 ± .0268	.4341 ± .0260	.4866 ± .0127
February.....	.3385 ± .0284	.4593 ± .0253	.4347 ± .0135
March.....	.3649 ± .0279	.4797 ± .0247	.4441 ± .0133
April.....	.4467 ± .0257	.3484 ± .0282	.3733 ± .0143
May.....	.4153 ± .0265	.3831 ± .0274	.3330 ± .0148
June.....	.4306 ± .0261	.4632 ± .0252	.4192 ± .0137
July.....	.4483 ± .0256	.4665 ± .0251	.4271 ± .0136
August.....	.4937 ± .0242	.4314 ± .0261	.4577 ± .0131
September.....	.3951 ± .0270	.5223 ± .0233	.4763 ± .0128
October.....	.2563 ± .0299	.3846 ± .0273	.3554 ± .0145

these months and the annual production. The result shows, however, that the correlation between the individual months of the year and the annual total is not due primarily to the inclusion of the individual month in the second variable of the correlation. The constants show clearly that birds which are superior in any individual month of the year, also, on the average, show superiority in the other 11 months of the year.

DIAGRAM 4.—Comparison of correlation between monthly production and annual production (solid dots) and between monthly production and the production of the remaining eleven months of the year (circles).

The correlation between the annual production and the deviation of the productions of the individual months from their probable values

In a study of the White Leghorn fowl (HARRIS, BLAKESLEE and KIRKPATRICK 1918, p. 46-49) the value of a coefficient showing the relationship between a variable and the deviation of a dependent variable from its probable value (HARRIS 1909) as a means of analyzing the interrelationship between the records of major and minor periods has been demonstrated.

The correlations between the annual record of the birds and the deviations of the contributions of the individual months to this annual record from their probable value appear in table 5 and are represented graphically in diagram 5.

These constants are also in excellent general agreement with those obtained from the first-year performance of the White Leghorn breed as exhibited at Storrs. The correlations show that November, December, January, February, August, September and October make relatively larger contributions to the annual production of superior birds than might be expected from the average results for the flocks as a whole. March, April, May and June make relatively far smaller contributions

to the annual production of highly superior birds than might be expected from the average records. The relation of July production to annual

DIAGRAM 5. Correlation between annual production and monthly production (solid dots), and correlation between annual production and the deviation of monthly production from its probable value.

production is somewhat questionable since it falls sometimes in one category and sometimes in the other.

While the coefficient for February is positive in all three series, it is numerically very small.

These results furnish another form of expression for the biological fact that during the months of March, April and May all birds are laying at about their maximum capacity. Large annual superiority cannot, therefore, depend primarily upon increased production in these months but must depend upon either precocious laying (November, December and January) or persistently continued laying (August, September and October), or upon both.

*The correlation between the records of the individual months
of the same year*

Earlier studies (HARRIS and others, loc. cit.) have shown that in the White Leghorn there is a significant positive correlation between the records of each of five of the individual months of the first year and the records of each of the other eleven months of the first year. It has also been shown (HARRIS and LEWIS 1922) that there is in general a positive correlation between the records of the twelve individual months of the first year and the twelve individual months of the second year in the White Leghorn fowl.

TABLE 5

Correlation between annual egg production and the deviation of the monthly records from their probable value.

MONTH	CORRELATIONS		
	1915-1916	1916-1917	1912-1913 to 1918-1919
November.....	+ .1893 ± .0309	+ .2667 ± .0298	+ .3003 ± .0151
December.....	+ .2781 ± .0296	+ .3439 ± .0283	+ .3471 ± .0146
January.....	+ .2543 ± .0300	+ .1915 ± .0309	+ .2766 ± .0153
February.....	+ .0066 ± .0320	+ .1027 ± .0317	+ .0275 ± .0166
March.....	- .4205 ± .0264	- .5814 ± .0212	- .4623 ± .0131
April.....	- .5261 ± .0232	- .6986 ± .0164	- .5951 ± .0107
May.....	- .4433 ± .0258	- .5307 ± .0230	- .5211 ± .0121
June.....	- .2138 ± .0306	- .2350 ± .0303	- .2748 ± .0153
July.....	+ .0021 ± .0320	+ .0639 ± .0319	- .0386 ± .0166
August.....	+ .1660 ± .0312	+ .1841 ± .0310	+ .1147 ± .0164
September.....	+ .2587 ± .0299	+ .3264 ± .0287	+ .2770 ± .0153
October.....	+ .2287 ± .0304	+ .3125 ± .0289	+ .2922 ± .0152

We have now to consider the possible correlations between the records of the individual months of the first year in the three groups of Rhode Island Red birds under consideration.

The constants appear in tables 6 and 7. In table 6 the upper entry of the group of three represents the correlation coefficient for the 442 birds studied in 1916-1917 while the second entry gives the correlation coefficient for the 443 birds studied in 1915-1916. The third entry gives the difference and the probable error of the difference between these two coefficients obtained by taking $(1916-1917) - (1915-1916)$. In table 7 the first of the three entries gives the correlation coefficients for the 1658 birds representing the whole period 1912 to 1919. The second and third entries represent the differences between the correlation as deduced from this larger series and those derived from the series for 1916-1917 and 1915-1916, respectively. These differences are so taken that the sign shows whether the single-year series gives a larger (positive sign) or a smaller (negative sign) correlation.

We now have to consider the consistency in the correlations deduced for the two years. This may be tested in three ways. First, we may determine the difference in the average value of the possible correlations between the individual months of the year in the two years for which constants are available.² Second, we may compare the homologous constants individually with regard to their probable errors. Finally, we may determine the magnitude of the correlations between the homologous correlations in the two years.

Consider first the difference in the mean values of the two series. We have

For 1916-1917,	$.2448 \pm .0694$
For 1915-1916,	$.1960 \pm .0638$
Difference	$.0488 \pm .0275$

The average of the coefficients for 1916-1917 is slightly larger than that for 1915-1916, but the difference is only about twice as large as its probable error and cannot be asserted to be definitely significant.

For purposes of more critical comparison we must turn to the individual constants. The comparison of the individual coefficients for the two years has been made in table 6. Here the probable errors of the differences have been calculated in the usual manner.

It may be convenient to examine the frequency distribution of the differences. This is given in table 8. This shows that 19 of the 66 differences are negative, while 47 are positive in sign. This indicates clearly

² We deal with the correlations deduced for two individual years because we are not certain of the method of computing the probable error of the difference if the constants for the two individual years were compared with those for the whole period 1912 to 1919. It is for this reason that probable errors are not given for the differences in table 7.

TABLE 6
Correlations between the records of the individual months of the year

	NOVEMBER e_1	DECEMBER e_2	JANUARY e_3	FEBRUARY e_4	MARCH e_5	APRIL e_6	MAY e_7	JUNE e_8	JULY e_9	AUGUST e_{10}	SEPTEMBER e_{11}	OCTOBER e_{12}
November e_1		$+.4509 \pm .0256$ $+.5750 \pm .0215$ $-.1241 \pm .0334$	$+.0776 \pm .0319$ $+.1332 \pm .0315$ $-.0556 \pm .0448$	$+.1685 \pm .0312$ $-.0649 \pm .0319$ $+.2334 \pm .0446$	$+.1414 \pm .0314$ $+.0202 \pm .0320$ $+.1211 \pm .0449$	$+.0935 \pm .0318$ $+.0369 \pm .0320$ $+.0566 \pm .0451$	$+.1205 \pm .0316$ $+.0347 \pm .0320$ $+.0858 \pm .0450$	$+.1507 \pm .0314$ $+.0257 \pm .0320$ $+.1250 \pm .0448$	$+.1927 \pm .0309$ $+.0664 \pm .0319$ $+.1263 \pm .0444$	$+.1299 \pm .0315$ $+.0872 \pm .0318$ $+.0427 \pm .0448$	$+.1782 \pm .0311$ $+.0303 \pm .0320$ $+.1479 \pm .0446$	$+.0801 \pm .0319$ $-.0092 \pm .0320$ $+.0893 \pm .0452$
December e_2	$+.4509 \pm .0256$ $+.5750 \pm .0215$ $-.1241 \pm .0334$		$+.5551 \pm .0222$ $+.4763 \pm .0248$ $+.0788 \pm .0333$	$+.3604 \pm .0279$ $+.0387 \pm .0320$ $+.3217 \pm .0425$	$+.2344 \pm .0303$ $+.0930 \pm .0318$ $+.1414 \pm .0439$	$+.1005 \pm .0318$ $+.0986 \pm .0317$ $+.0019 \pm .0449$	$+.1233 \pm .0316$ $+.0382 \pm .0320$ $+.0851 \pm .0450$	$+.2023 \pm .0308$ $+.0653 \pm .0319$ $+.1370 \pm .0443$	$+.2559 \pm .0300$ $+.0418 \pm .0320$ $+.2141 \pm .0438$	$+.2104 \pm .0307$ $+.0971 \pm .0317$ $+.1133 \pm .0441$	$+.2388 \pm .0302$ $+.0966 \pm .0318$ $+.1423 \pm .0439$	$+.1970 \pm .0308$ $+.0664 \pm .0319$ $+.1306 \pm .0444$
January e_3	$+.0776 \pm .0319$ $+.1332 \pm .0315$ $-.0556 \pm .0448$	$+.5551 \pm .0222$ $+.4763 \pm .0248$ $+.0788 \pm .0333$		$+.5704 \pm .0216$ $+.4152 \pm .0265$ $+.1552 \pm .0342$	$+.2933 \pm .0293$ $+.2220 \pm .0305$ $+.0712 \pm .0423$	$+.0257 \pm .0321$ $+.1598 \pm .0312$ $-.1341 \pm .0448$	$+.0406 \pm .0320$ $+.0704 \pm .0319$ $-.0298 \pm .0452$	$+.1183 \pm .0316$ $+.0682 \pm .0319$ $+.0501 \pm .0449$	$+.1624 \pm .0312$ $+.0839 \pm .0318$ $+.0785 \pm .0446$	$+.1312 \pm .0315$ $+.1608 \pm .0312$ $-.0296 \pm .0444$	$+.1852 \pm .0310$ $+.1364 \pm .0315$ $+.0488 \pm .0441$	$+.2424 \pm .0302$ $+.1659 \pm .0312$ $+.0764 \pm .0434$
February e_4	$+.1685 \pm .0312$ $-.0649 \pm .0319$ $+.2334 \pm .0446$	$+.3604 \pm .0279$ $+.0387 \pm .0320$ $+.3217 \pm .0425$	$+.5704 \pm .0216$ $+.4152 \pm .0265$ $+.1552 \pm .0342$		$+.4405 \pm .0259$ $+.4206 \pm .0264$ $+.0199 \pm .0369$	$+.1350 \pm .0315$ $+.2417 \pm .0302$ $-.1066 \pm .0436$	$+.0878 \pm .0318$ $+.1285 \pm .0315$ $-.0408 \pm .0448$	$+.1681 \pm .0312$ $+.0781 \pm .0319$ $+.0900 \pm .0446$	$+.1811 \pm .0310$ $+.1049 \pm .0317$ $+.0761 \pm .0444$	$+.0880 \pm .0318$ $+.1616 \pm .0312$ $-.0737 \pm .0446$	$+.1860 \pm .0310$ $+.1554 \pm .0313$ $+.0305 \pm .0440$	$+.2366 \pm .0303$ $+.1736 \pm .0311$ $+.0630 \pm .0434$
March e_5	$+.1414 \pm .0314$ $+.0202 \pm .0320$ $+.1211 \pm .0449$	$+.2344 \pm .0303$ $+.0930 \pm .0318$ $+.1414 \pm .0439$	$+.2933 \pm .0293$ $+.2220 \pm .0305$ $+.0712 \pm .0423$	$+.4405 \pm .0259$ $+.4206 \pm .0264$ $+.0199 \pm .0369$		$+.3185 \pm .0288$ $+.3560 \pm .0280$ $-.0375 \pm .0402$	$+.3286 \pm .0286$ $+.2021 \pm .0307$ $+.1265 \pm .0420$	$+.2873 \pm .0294$ $+.1631 \pm .0312$ $+.1241 \pm .0429$	$+.2128 \pm .0306$ $+.1610 \pm .0312$ $+.0519 \pm .0437$	$+.2510 \pm .0301$ $+.1747 \pm .0311$ $+.0764 \pm .0432$	$+.2534 \pm .0300$ $+.1078 \pm .0317$ $+.1457 \pm .0436$	$+.2031 \pm .0308$ $+.1253 \pm .0315$ $+.0778 \pm .0441$
April e_6	$+.0935 \pm .0318$ $+.0369 \pm .0320$ $+.0566 \pm .0451$	$+.1005 \pm .0318$ $+.0986 \pm .0317$ $+.0019 \pm .0449$	$+.0257 \pm .0321$ $+.1598 \pm .0312$ $-.1341 \pm .0448$	$+.1350 \pm .0315$ $+.2417 \pm .0302$ $-.1066 \pm .0436$	$+.3185 \pm .0288$ $+.3560 \pm .0280$ $-.0375 \pm .0402$		$+.4699 \pm .0250$ $+.4819 \pm .0246$ $-.0120 \pm .0351$	$+.3563 \pm .0280$ $+.3925 \pm .0271$ $-.0362 \pm .0390$	$+.2758 \pm .0296$ $+.3053 \pm .0291$ $-.0295 \pm .0415$	$+.1939 \pm .0309$ $+.2666 \pm .0298$ $-.0727 \pm .0429$	$+.2760 \pm .0296$ $+.1943 \pm .0308$ $+.0818 \pm .0428$	$+.1841 \pm .0310$ $+.0847 \pm .0318$ $+.0994 \pm .0444$
May e_7	$+.1205 \pm .0316$ $+.0347 \pm .0320$ $+.0858 \pm .0450$	$+.1233 \pm .0316$ $+.0382 \pm .0320$ $+.0851 \pm .0450$	$+.0406 \pm .0320$ $+.0704 \pm .0319$ $-.0298 \pm .0452$	$+.0878 \pm .0318$ $+.1285 \pm .0315$ $-.0408 \pm .0448$	$+.3286 \pm .0286$ $+.2021 \pm .0307$ $+.1265 \pm .0420$	$+.4699 \pm .0250$ $+.4819 \pm .0246$ $-.0120 \pm .0351$		$+.4612 \pm .0253$ $+.5206 \pm .0234$ $-.0595 \pm .0344$	$+.3204 \pm .0288$ $+.4193 \pm .0264$ $-.0988 \pm .0391$	$+.2622 \pm .0299$ $+.3492 \pm .0281$ $-.0870 \pm .0410$	$+.3028 \pm .0291$ $+.2201 \pm .0305$ $+.0827 \pm .0422$	$+.1603 \pm .0313$ $+.0932 \pm .0318$ $+.0672 \pm .0446$
June e_8	$+.1507 \pm .0314$ $+.0257 \pm .0320$ $+.1250 \pm .0448$	$+.2023 \pm .0308$ $+.0653 \pm .0319$ $+.1370 \pm .0443$	$+.1183 \pm .0316$ $+.0682 \pm .0319$ $+.0501 \pm .0449$	$+.1681 \pm .0312$ $+.0781 \pm .0319$ $+.0900 \pm .0446$	$+.2873 \pm .0294$ $+.1631 \pm .0312$ $+.1241 \pm .0429$	$+.3563 \pm .0280$ $+.3925 \pm .0271$ $-.0362 \pm .0390$	$+.4612 \pm .0253$ $+.5206 \pm .0234$ $-.0595 \pm .0344$		$+.4117 \pm .0266$ $+.4605 \pm .0253$ $-.0488 \pm .0367$	$+.3206 \pm .0288$ $+.4839 \pm .0245$ $-.1632 \pm .0378$	$+.3620 \pm .0279$ $+.2958 \pm .0292$ $+.0662 \pm .0404$	$+.2120 \pm .0306$ $+.0892 \pm .0318$ $+.1228 \pm .0442$
July e_9	$+.1927 \pm .0309$ $+.0664 \pm .0319$ $+.1263 \pm .0444$	$+.2559 \pm .0300$ $+.0418 \pm .0320$ $+.2141 \pm .0438$	$+.1624 \pm .0312$ $+.0839 \pm .0318$ $+.0785 \pm .0446$	$+.1811 \pm .0310$ $+.1049 \pm .0317$ $+.0761 \pm .0444$	$+.2128 \pm .0306$ $+.1610 \pm .0312$ $+.0519 \pm .0437$	$+.2758 \pm .0296$ $+.3053 \pm .0291$ $-.0295 \pm .0415$	$+.3204 \pm .0288$ $+.4193 \pm .0264$ $-.0988 \pm .0391$	$+.4117 \pm .0266$ $+.4605 \pm .0253$ $-.0488 \pm .0367$		$+.4122 \pm .0266$ $+.5493 \pm .0224$ $-.1371 \pm .0348$	$+.3963 \pm .0270$ $+.3799 \pm .0274$ $+.0164 \pm .0385$	$+.1502 \pm .0314$ $+.1418 \pm .0314$ $+.0084 \pm .0444$
August e_{10}	$+.1299 \pm .0315$ $+.0872 \pm .0318$ $+.0427 \pm .0448$	$+.2104 \pm .0307$ $+.0971 \pm .0317$ $+.1133 \pm .0441$	$+.1312 \pm .0315$ $+.1608 \pm .0312$ $-.0296 \pm .0444$	$+.0880 \pm .0318$ $+.1616 \pm .0312$ $-.0737 \pm .0446$	$+.2510 \pm .0301$ $+.1747 \pm .0311$ $+.0764 \pm .0432$	$+.1939 \pm .0309$ $+.2666 \pm .0298$ $-.0727 \pm .0429$	$+.2622 \pm .0299$ $+.3492 \pm .0281$ $-.0870 \pm .0410$	$+.3206 \pm .0288$ $+.4839 \pm .0245$ $-.1632 \pm .0378$	$+.4122 \pm .0266$ $+.5493 \pm .0224$ $-.1371 \pm .0348$		$+.5205 \pm .0234$ $+.3942 \pm .0271$ $+.1263 \pm .0358$	$+.2813 \pm .0295$ $+.1784 \pm .0310$ $+.1029 \pm .0428$
September e_{11}	$+.1782 \pm .0311$ $+.0303 \pm .0320$ $+.1479 \pm .0446$	$+.2388 \pm .0302$ $+.0966 \pm .0318$ $+.1423 \pm .0439$	$+.1852 \pm .0310$ $+.1364 \pm .0315$ $+.0488 \pm .0441$	$+.1860 \pm .0310$ $+.1554 \pm .0313$ $+.0305 \pm .0440$	$+.2535 \pm .0300$ $+.1078 \pm .0317$ $+.1457 \pm .0436$	$+.2760 \pm .0296$ $+.1943 \pm .0308$ $+.0818 \pm .0428$	$+.3028 \pm .0291$ $+.2201 \pm .0305$ $+.0827 \pm .0422$	$+.3620 \pm .0279$ $+.2958 \pm .0292$ $+.0662 \pm .0404$	$+.3963 \pm .0270$ $+.3799 \pm .0274$ $+.0164 \pm .0385$	$+.5205 \pm .0234$ $+.3942 \pm .0271$ $+.1263 \pm .0358$		$+.4205 \pm .0264$ $+.3513 \pm .0281$ $+.0692 \pm .0386$
October e_{12}	$+.0801 \pm .0319$ $-.0092 \pm .0320$ $+.0893 \pm .0452$	$+.1970 \pm .0308$ $+.0664 \pm .0319$ $+.1306 \pm .0444$	$+.2424 \pm .0302$ $+.1659 \pm .0312$ $+.0764 \pm .0434$	$+.2366 \pm .0303$ $+.1736 \pm .0311$ $+.0630 \pm .0434$	$+.2031 \pm .0308$ $+.1253 \pm .0315$ $+.0778 \pm .0441$	$+.1841 \pm .0310$ $+.0847 \pm .0318$ $+.0994 \pm .0444$	$+.1603 \pm .0313$ $+.0932 \pm .0318$ $+.0672 \pm .0446$	$+.2120 \pm .0306$ $+.0892 \pm .0318$ $+.1228 \pm .0442$	$+.1502 \pm .0314$ $+.1418 \pm .0314$ $+.0084 \pm .0444$	$+.2813 \pm .0295$ $+.1784 \pm .0310$ $+.1029 \pm .0428$	$+.4205 \pm .0264$ $+.3513 \pm .0281$ $+.0692 \pm .0386$	

TABLE 7

Correlations between the records of the individual months of the year in the whole series, and comparison of these constants with those for two individual years.

	NOVEMBER e_1	DECEMBER e_2	JANUARY e_3	FEBRUARY e_4	MARCH e_5	APRIL e_6	MAY e_7	JUNE e_8	JULY e_9	AUGUST e_{10}	SEPTEMBER e_{11}	OCTOBER e_{12}
November e_1		$+.5039 \pm .0124$ $-.0530$ $+.0711$	$+.2044 \pm .0159$ $-.1267$ $-.0711$	$+.1344 \pm .0163$ $+.0340$ $-.1994$	$+.1399 \pm .0163$ $+.0015$ $-.1196$	$+.0719 \pm .0165$ $+.0216$ $-.0350$	$+.0365 \pm .0166$ $+.0840$ $-.0018$	$+.0933 \pm .0165$ $+.0575$ $-.0676$	$+.1495 \pm .0162$ $+.0432$ $-.0831$	$+.1680 \pm .0161$ $-.0381$ $-.0807$	$+.1724 \pm .0161$ $+.0058$ $-.1421$	$+.1219 \pm .0164$ $-.0418$ $-.1311$
December e_2	$+.5039 \pm .0124$ $-.0530$ $+.0711$		$+.5597 \pm .0114$ $-.0046$ $-.0835$	$+.2527 \pm .0155$ $+.1076$ $-.2140$	$+.2262 \pm .0158$ $+.0082$ $-.1332$	$+.1018 \pm .0164$ $-.0013$ $-.0033$	$+.0338 \pm .0166$ $+.0895$ $+.0044$	$+.0904 \pm .0165$ $+.1119$ $-.0251$	$+.1208 \pm .0164$ $+.1351$ $-.0790$	$+.1387 \pm .0163$ $+.0717$ $-.0416$	$+.2027 \pm .0159$ $+.0362$ $-.1061$	$+.1898 \pm .0160$ $+.0072$ $-.1234$
January e_3	$+.2044 \pm .0159$ $-.1267$ $-.0711$	$+.5597 \pm .0114$ $-.0046$ $-.0835$		$+.5260 \pm .0120$ $+.0444$ $-.1109$	$+.2943 \pm .0152$ $-.0010$ $-.0722$	$+.1259 \pm .0163$ $-.1002$ $+.0339$	$+.0405 \pm .0166$ $+.0001$ $+.0299$	$+.0987 \pm .0164$ $+.0196$ $-.0305$	$+.1382 \pm .0163$ $+.0242$ $-.0543$	$+.1786 \pm .0161$ $-.0474$ $-.0178$	$+.2357 \pm .0157$ $-.0505$ $-.0994$	$+.2476 \pm .0156$ $-.0052$ $-.0816$
February e_4	$+.1344 \pm .0163$ $+.0340$ $-.1994$	$+.2527 \pm .0155$ $+.1076$ $-.2140$	$+.5260 \pm .0120$ $+.0444$ $-.1109$		$+.4212 \pm .0137$ $+.0192$ $-.0006$	$+.2075 \pm .0159$ $-.0724$ $+.0342$	$+.1061 \pm .0164$ $+.0183$ $+.0225$	$+.1315 \pm .0163$ $+.0366$ $+.0534$	$+.1378 \pm .0163$ $+.0432$ $-.0329$	$+.1442 \pm .0163$ $-.0562$ $+.0174$	$+.2075 \pm .0159$ $-.0216$ $-.0521$	$+.1988 \pm .0159$ $+.0378$ $-.0252$
March e_5	$+.1399 \pm .0163$ $+.0015$ $-.1196$	$+.2262 \pm .0158$ $+.0082$ $-.1332$	$+.2943 \pm .0152$ $-.0010$ $-.0722$	$+.4212 \pm .0137$ $+.0192$ $-.0006$		$+.3849 \pm .0141$ $-.0664$ $-.0289$	$+.2439 \pm .0156$ $+.0847$ $-.0418$	$+.2113 \pm .0159$ $+.0760$ $-.0482$	$+.1594 \pm .0162$ $+.0534$ $+.0016$	$+.2063 \pm .0159$ $+.0447$ $-.0316$	$+.1934 \pm .0160$ $+.0601$ $-.0856$	$+.1710 \pm .0161$ $+.0321$ $-.0456$
April e_6	$+.0719 \pm .0165$ $+.0216$ $-.0350$	$+.1018 \pm .0164$ $-.0013$ $-.0033$	$+.1259 \pm .0163$ $-.1002$ $+.0339$	$+.2075 \pm .0159$ $-.0724$ $+.0342$	$+.3849 \pm .0141$ $-.0664$ $-.0289$		$+.4399 \pm .0134$ $+.0299$ $+.0420$	$+.3285 \pm .0148$ $+.0278$ $+.0640$	$+.2414 \pm .0156$ $+.0344$ $+.0639$	$+.2054 \pm .0159$ $-.0115$ $+.0613$	$+.2032 \pm .0159$ $+.0728$ $-.0090$	$+.1061 \pm .0164$ $+.0780$ $-.0214$
May e_7	$+.0365 \pm .0166$ $+.0840$ $-.0018$	$+.0338 \pm .0166$ $+.0895$ $+.0044$	$+.0405 \pm .0166$ $+.0001$ $+.0299$	$+.1061 \pm .0164$ $-.0183$ $+.0225$	$+.2439 \pm .0156$ $+.0847$ $-.0418$	$+.4399 \pm .0134$ $+.0299$ $+.0420$		$+.4765 \pm .0128$ $-.0153$ $+.0442$	$+.3570 \pm .0145$ $-.0365$ $+.0623$	$+.2750 \pm .0153$ $-.0128$ $+.0742$	$+.1897 \pm .0160$ $+.1131$ $+.0304$	$+.0829 \pm .0165$ $+.0774$ $+.0102$
June e_8	$+.0933 \pm .0165$ $+.0575$ $-.0676$	$+.0904 \pm .0165$ $+.1119$ $-.0251$	$+.0987 \pm .0164$ $+.0196$ $-.0305$	$+.1315 \pm .0163$ $+.0366$ $-.0534$	$+.2113 \pm .0159$ $+.0760$ $-.0482$	$+.3285 \pm .0148$ $+.0278$ $+.0640$	$+.4765 \pm .0128$ $-.0153$ $+.0442$		$+.4561 \pm .0131$ $-.0444$ $+.0044$	$+.3943 \pm .0140$ $-.0736$ $+.0896$	$+.2972 \pm .0151$ $+.0648$ $-.0013$	$+.1605 \pm .0160$ $+.0515$ $-.0713$
July e_9	$+.1495 \pm .0162$ $+.0432$ $-.0831$	$+.1208 \pm .0164$ $+.1351$ $-.0790$	$+.1382 \pm .0163$ $+.0242$ $-.0543$	$+.1378 \pm .0163$ $+.0432$ $-.0329$	$+.1594 \pm .0162$ $+.0534$ $+.0016$	$+.2414 \pm .0156$ $+.0344$ $+.0639$	$+.3570 \pm .0145$ $-.0365$ $+.0623$	$+.4561 \pm .0131$ $-.0444$ $+.0044$		$+.4626 \pm .0130$ $-.0505$ $+.0866$	$+.3568 \pm .0145$ $+.0395$ $+.0231$	$+.1553 \pm .0160$ $-.0051$ $-.0135$
August e_{10}	$+.1680 \pm .0161$ $-.0381$ $-.0807$	$+.1387 \pm .0163$ $+.0717$ $-.0416$	$+.1786 \pm .0161$ $-.0474$ $-.0178$	$+.1442 \pm .0163$ $-.0562$ $+.0174$	$+.2063 \pm .0159$ $+.0447$ $-.0316$	$+.2054 \pm .0159$ $-.0115$ $+.0613$	$+.2750 \pm .0153$ $-.0128$ $+.0742$	$+.3943 \pm .0140$ $-.0736$ $+.0896$	$+.4626 \pm .0130$ $-.0505$ $+.0866$		$+.4387 \pm .0134$ $+.0818$ $-.0445$	$+.2592 \pm .0155$ $+.0221$ $-.0809$
September e_{11}	$+.1724 \pm .0161$ $+.0058$ $-.1421$	$+.2027 \pm .0159$ $+.0362$ $-.1061$	$+.2357 \pm .0157$ $-.0505$ $-.0994$	$+.2075 \pm .0159$ $-.0216$ $-.0521$	$+.1934 \pm .0160$ $+.0601$ $-.0856$	$+.2032 \pm .0159$ $+.0728$ $-.0090$	$+.1897 \pm .0160$ $+.1131$ $+.0304$	$+.2972 \pm .0151$ $+.0648$ $-.0013$	$+.3568 \pm .0145$ $+.0395$ $+.0231$	$+.4387 \pm .0134$ $+.0818$ $-.0445$		$+.4082 \pm .0138$ $+.0123$ $-.0570$
October e_{12}	$+.1219 \pm .0164$ $-.0418$ $-.1311$	$+.1898 \pm .0160$ $+.0072$ $-.1234$	$+.2476 \pm .0156$ $-.0052$ $-.0816$	$+.1988 \pm .0159$ $+.0378$ $-.0252$	$+.1710 \pm .0161$ $+.0321$ $-.0456$	$+.1061 \pm .0164$ $+.0780$ $-.0214$	$+.0829 \pm .0165$ $+.0774$ $+.0102$	$+.1605 \pm .0162$ $+.0515$ $-.0713$	$+.1553 \pm .0162$ $-.0051$ $-.0135$	$+.2592 \pm .0155$ $+.0221$ $-.0809$	$+.4082 \pm .0138$ $+.0123$ $-.0570$	

that the series for 1916-1917 is slightly more highly correlated than that for 1915-1916. In further evidence of this fact we may note that these are only four groups, each of 0.05 range, of negative differences, wherear there are seven such groups of positive differences.

Considering the relation of the individual differences to their probable errors, as calculated by the usual formula, we have the frequency distribution shown in table 9. Here the frequencies of the various ratios to their probable errors are shown in groupings of unit range, the signs are those of the differences.

TABLE 8

DIFFERENCE IN COR- RELATION (1916-1917) - (1915-1916)	FREQUENCY
-.151 to -.200	1
-.101 to -.150	4
-.051 to -.100	6
-.001 to -.050	8
+.001 to +.050	7
+.051 to +.100	21
+.101 to +.150	15
+.151 to +.200	1
+.201 to +.250	2
+.251 to +.300	
+.301 to +.350	1
Total	66

TABLE 9

RATIO TO PROBABLE ERROR AND SIGN OF DIFFERENCE	FREQUENCY
-4.001 to -5.000	1
-3.001 to -4.000	2
-2.001 to -3.000	4
-1.000 to -2.000	5
-0.000 to -1.000	7
+0.000 to +1.000	6
+1.001 to +2.000	19
+2.001 to +3.000	11
+3.001 to +4.000	7
+4.001 to +5.000	2
+5.001 to +6.000	1
+6.001 to +7.000	
+7.001 to +8.000	1
Total	66

We note that there are only five classes of negative ratios whereas there are eight classes of positive ratios. Again, it is clear that the frequency of large ratios is greater in the positive series. For example, there are only three cases in which the difference is over three times as large as its probable error in the negative differences, whereas there are eleven such cases in the positive differences. There are only seven cases in which the difference is more than twice as large as its probable error in the negative differences, whereas there are 22 such cases in the positive differences. It is clear, therefore, that the 1916-1917 series is somewhat more highly correlated than the 1915-1916 series.³

³ There was less disease in the flock during 1916-1917, and the range conditions were better for the growing birds than in 1915-1916. This may, or may not, be the reason for the differences in correlation.

DIAGRAM 6.—Distribution of magnitudes of correlations between the records of individual months and the records of subsequent months of the same year.

The foregoing analysis demonstrates that the correlation between the individual months of the 1916-1917 series is on the whole slightly higher than that for the 1915-1916 series. As a measure of the general consistency of the two systems of coefficients we may determine the correlation

DIAGRAM 7.—Distribution of magnitudes of correlations between the records of individual months and the records of antecedent months of the same year.

between the homologous coefficients for the two years. We deduce from the ungrouped data in table 6

$$r = .9181 \pm .0130$$

This coefficient is very large indeed, and indicates a very close similarity between the coefficients measuring the relationship between the same combinations of months in the two years. It shows clearly that the correlations between the individual months do not differ in a merely haphazard manner but that there are definite and relatively rigid biological laws underlying these interrelationships.

When further data are available we shall have occasion to consider the relative magnitudes of the correlations between the correlations when birds of the same breed are compared at the same Station in different years, when the correlations for the same breed are compared at different Stations, and finally, when the correlations for different breeds are compared at the same Station or different Stations.

We now turn to a comparison of the magnitudes of the coefficients for the different combinations of months among themselves.

The reader will, of course, have noted that the mean value of the correlations is not large. It is only 0.244 for the series for 1916-1917, 0.196 for the series for 1915-1916, and 0.228 for the series for 1912 to 1919. The correlation between the series of correlations for the two years shows, however, that the coefficients for the different combinations of months differ among themselves. The significance of these differences in the magnitudes of the coefficients may best be brought out by graphic presentation.

The constants are divided into two series, the first (diagram 6) showing the relationship between the record of each month and that of each subsequent month, the second showing the correlation between the record of each month and that of each antecedent month (diagram 7).

On these diagrams, the verticals represent the subsequent or the antecedent months of the year as the case may be. The magnitude of the correlation between the production of any month (as indicated by the lettering on the lines connecting the dots for this month) and that of the months of the year is indicated on the scale of ordinates on the vertical for the antecedent or subsequent month in question.

In the preparation of these diagrams, it has seemed desirable to smooth out in so far as possible the probable errors of random sampling by using the averages of two independently determined constants. The values represented are the averages of the two series of correlations deduced from the 1915-1916 and the 1916-1917 series. The distribution of the several months between the two sections of the diagrams has been determined by clearness of presentation merely.

These diagrams show that in the Rhode Island Red as in the White Leghorn breed of poultry we may recognize the existence of two laws underlying the interrelationship between the productions of the individual months of the first year. These laws have been stated (HARRIS, BLAKESLEE and KIRKPATRICK 1918, p. 70-71) as follows:

"First, the correlation between the egg production of the individual months tends to become smaller as the months considered are more widely separated in time.

"Second, there is a more intimate correlation between the egg production of the autumn and winter months at the beginning and end of the contest year than between the egg production of these months and the productions of the spring and summer months."

Referring to the diagrams for details, we note from diagram 6 that for November, December, January and February production there is at first a rapid decline in the magnitude of the correlations with successively later subsequent months until a minimum value is reached for the production of the month under consideration and that of April or May. There is then an increase in the correlations for the production of these months and those of the months of June, July, August, September and October. The correlations for March are an exception to the other four months represented on this figure, in that correlation decreases as the successive months are more widely separated. This is also true for all of the months, April to August, represented on the second section of diagram 6.

Turning to the relationship between the egg production of individual months and that of preceding months, we note from diagram 7 that the correlations between January, February and March production and the production of preceding months decreases as the months become more widely separated in time. The correlations for April, May, June, July, August and September show a slight increase for the relationship between the production of these months and that of the earlier months of the year. The curve of the correlations of October production with that of the earlier months illustrates in a striking manner the existence of the two laws.

The comparison of the results for the Rhode Island Red breed with other breeds of poultry is reserved until the other constants, computed but not yet published, are available.

RECAPITULATION

This paper presents the results of a statistical analysis of the monthly egg records for the pullet year of 1658 Rhode Island Reds as recorded at the MASSACHUSETTS AGRICULTURAL EXPERIMENT STATION, Amherst, Massachusetts.

The following problems are considered:

1. The correlation between monthly record and annual production. The coefficients are shown to have a material positive value ranging from 0.325 to 0.634 in the 36 determinations made. The average values are $\bar{r}=0.5094$ for 1915-1916, $\bar{r}=0.5479$ for 1916-1917, and $\bar{r}=0.5363$ for 1912 to 1919.

These coefficients are of about the same order of magnitude as those already demonstrated for White Leghorn fowl (HARRIS and others, 1917, 1918). The regression of annual egg production on monthly egg production is, roughly speaking, linear. Prediction of annual egg production of groups of birds may therefore be made with relative ease from the records of an individual month by the use of equations of the type computed and shown to be effective for the White Leghorn breed (HARRIS, KIRKPATRICK and BLAKESLEE 1921; HARRIS, KIRKPATRICK, BLAKESLEE, WARNER and CARD 1921).

2. The correlation between monthly record and the total record of the other eleven months of the year. These values are, as might be expected, lower than those for the relationship between monthly production and annual production. They are, however, positive in sign and statistically significant throughout. They show, therefore, that the correlations between the records of the individual months and annual total is not due primarily to the inclusion of the record of the individual month under consideration in the annual total.

3. The correlation between the annual record and the deviation of the production of the individual months from their probable value. These coefficients show that the several months of the year differ greatly in their relative contribution to the annual egg record of unusual birds.

4. The correlation between the record of the individual months of the same year. All possible values of the correlation between the records of the individual months of the first year have been determined for two years individually and for the records for the entire period 1912 to 1919.

These coefficients are on the average small. The average value of the correlation is $\bar{r}=0.196$ for 1915-1916, $\bar{r}=0.244$ for 1916-1917, and $\bar{r}=0.228$ for the entire period, 1912 to 1919. The coefficients for the different permutations of months differ widely among themselves. This is shown by the fact that there is a correlation of .918 between the system of coefficients for 1915-1916, and that for 1916-1917. In their distribution the coefficients show the existence of two laws. First, the coefficient between the egg production of the individual months tends to become smaller as the months considered are more widely separated in time.

Second, there is a more intimate correlation between the egg production of the autumn and winter months at the beginning and end of the pullet year than between the egg production of these months and the productions of the spring and summer months. These two laws of the distribution of the magnitude of the correlations are to some extent mutually obscuring.

The foregoing conclusions are in general agreement with those already drawn for White Leghorns. Detailed comparisons between the more important commercial breeds will be made in a subsequent paper.

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