

Factors Influencing Egg Production

I. The Influence of Maturity upon Egg Production in S. C. White Leghorns

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SUMMARY

1. A consistent correlation existed between early maturity and high winter egg production in all four years.
2. The correlation between maturity and winter egg production was shown, in graph form, to be negative.
3. Early maturity had a direct negative rectilinear prediction value with winter egg production.
4. Maximum winter egg production was obtained when birds matured in less than 220 days.
5. Very little if any relationship existed between maturity and spring egg production.
6. Great variation in the relation of maturity and total egg production existed from year to year.
7. Maturity bore a high curvilinear correlation with total annual egg production. The mode of this curve was 190 days for maturity and 225.5 eggs for total production while the means were 196.83 days and 204.99 eggs, respectively.
8. The variation in the correlation between maturity and total egg production was due to: First, too few numbers; second, only a sample of the entire population was used; third, the correlation found between maturity and total egg production was curvilinear; fourth, environmental conditions, such as a low protein ration, which retarded development tended to confuse the interpretation of results.
9. In order to secure maximum total egg production, S. C. White Leghorns should mature in 160 to 210 days

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I. The Influence of Maturity upon Egg Production in S. C. White Leghorns

BY C. W. KNOX

Maturity in poultry is one of the few factors which has been analyzed statistically for its influence upon egg production. Early maturity has long been considered by poultry investigators as an important criterion of winter and total annual egg production. Very few investigators have attempted to analyze this influence in a specific manner, altho a number of them have made statistical studies of it.

Considerable attention has been given by many investigators to the influence of maturity upon winter and total egg production for the "pullet year." Practically all agree that there is a high negative correlation between maturity and winter egg production, the early maturing birds being the better producers. Considerable variation and some disagreement have been found where maturity and total egg production were considered. The present investigation gives a possible reason for this diversity of opinion. Very few investigators have attempted to give an optimum number of days to maturity, which is of considerable importance from a practical standpoint. Still fewer investigators have analyzed the influence of maturity upon spring production, or upon rate of production. With these different factors in mind, the present investigation was undertaken.

Some of the investigators calculated the winter production from the date of the first egg whether it was laid in July or in February. Others figured production from Oct. 1 to March 1 inclusive, regardless of whether the pullets had started to lay that month or not. All ended the winter production with March 1. In this study, winter production was figured as the total number of eggs from the date of first egg to Feb. 28 inclusive.

RESUME OF PREVIOUS LITERATURE

Rice (17), who was one of the first to investigate this subject, reported that there was an important relationship between early maturity, rate and persistency of egg production. He made no attempt at a complete or statistical analysis.

In one of the outstanding investigations of the relative egg-producing powers of pullets based upon the length of the maturing period, the work of Kempster (10) indicates conclusively that early maturing pullets produce a much larger number of eggs during the "pullet year." Later investigations by Kempster, and Henderson (11) verified the former's conclusion.

Kennard (13) in 1921 showed that not only did the early

maturing pullets lay a larger number of eggs at less cost with a consequent greater profit per bird, but they also laid fewer small eggs, gained more weight and suffered less mortality than did the later maturing females.

Hurst (8) in 1921 pointed out that early maturity in Leg-horns and Wyandottes has an important bearing upon egg production. He further stated that early maturity is associated with heavy egg yields.

A year later Goodale (4) stated that 10 years of experience demonstrated that time lost by pullets in starting to lay is never made up but is a mortgage for all time on the profits of the flock.

Hays and Bennett (5) in 1923 obtained a correlation of -0.4380 ± 0.0134 between early maturity and annual egg production during the "pullet year" for Rhode Island Reds. This negative correlation found by many investigators means that the earlier a pullet matures, the greater number of eggs she will lay for the particular period or periods correlated.

In 1923 Dunn (3) published a preliminary report in which he stated that the average number of eggs laid in the first four winter months is an approximate index of the maturity of the pullets, since, other things being equal, there is a high correlation between the maturity of the pullets and their winter egg production.

Jul (9) in 1924 reported an experiment in which he divided 40 pullets into six classes according to ages in days when laying commenced. From the data obtained he found a correlation of -0.295 ± 0.097 between total egg production and age at maturity.

The same year Buster (1) reported that where 1171 pullets were segregated into two lots, one early maturing and one late maturing, the early maturing birds had an average egg production for a five-month period of 48.5 eggs, while the late maturing birds averaged 24.4 eggs for the same period. He further stated that when the eggs were sold the early maturing birds returned 86.5 cents per pullet more than the later ones for the five-month period.

The work of Hays et al (6) gave a correlation of -0.6061 ± 0.0151 between age at first egg (maturity) and winter egg production. In this study 803 Rhode Island Red pullets were used. The mean age at maturity was 210.96 days.

In a correlation study covering a period of six years, Kempster (12) ascertained that there was a significant correlation each year between sexual maturity and annual egg production. This is probably the most extensive investigation on this particular subject that has been reported up to the present time.

Lippincott et al (15) reported a positive correlation of $+0.359 \pm 0.076$ between age at first egg and total production. They also stated that this result was not supported by the available data

on the culled birds and was contrary to the results of other investigators. No explanation of this disagreement could be offered. It is interesting to note that the 60 birds which were culled at the end of 240 days required 20.05 ± 3.86 days longer to mature than did those which were retained because of their superior egg production.

In 1926 Parkhurst (16) found a correlation of $-.585 \pm .069$ between maturity and eggs to March 1 in 1923-24 and $-.4803 \pm .062$ in 1924-25. He also obtained a correlation of $-.249 \pm .099$ between days to first egg and total egg production in 1923-24. This investigation was conducted with S. C. White Leghorns in both years.

Hervey and Decker (7) pointed out that pullets which come into production in October are regarded as the most profitable in the flock. Experience has proved that it is not the time of hatching but the time of maturity that is the determining factor in the prospective value of the individual bird for contest purposes. Individuals that begin to lay under 200 days from their hatching dates represent a minority in a given population, irrespective of the month of incubation; yet their maturity indicates that they are the birds with the highest production during the first laying year. Hervey and Decker obtained a correlation of $-.2764 \pm .0320$ between maturity and first year egg production.

The author (14) in 1927 obtained a correlation in White Plymouth Rocks of $-.51 \pm .06$ between total egg production and maturity. This negative correlation was considerably higher than that found by most of the other investigators. This condition was due, no doubt, to the kind of birds used in the experiments. The work was done with White Plymouth Rocks which were exceedingly late maturing as contrasted with the early maturing White Leghorn stock used by the other investigators.

In a later investigation, Buster (2) found that maturity is a good gauge of potential egg-laying ability of Single Comb White Leghorn pullets in commercial flocks. He also states that the earlier maturing pullet possesses greater vitality and produces a greater revenue.

Upp and Thompson (18) in 1927 found that early sexual maturity was associated with high egg production. They also observed that early maturing birds, altho lighter in weight when beginning to lay, were able to overcome this disadvantage during the laying year.

MATERIAL AND METHODS

The present investigation is an analysis of the records from Single Comb White Leghorns covering a period of four years. These records were compiled from 150 pullets in 1924-25, 223 in 1925-26, 120 in 1926-27, and 191 in 1927-28. This investigation

was started in order to analyze the data statistically by the use of multiple correlation methods but upon closer scrutiny it was found that this was not feasible for four reasons. First, part of the data were curvilinear rather than rectilinear; second, more information in some aspects could be obtained by treating the data graphically; third, any existing relationship could be adequately demonstrated by a graph representing the component groups; fourth, a graph will show optimum conditions for winter or total egg production.

All of the publications up to the present time, including the writer's, where correlation studies were used, presuppose rectilinearity. Graphic representation shows that many times this supposition is erroneous, especially in the case of maturity vs. annual egg production. This may account, in part at least, for the varying correlations obtained by different investigators and in some cases by the same author where several year's work was compiled. Because of this fitting of curvilinear data to rectilinear analysis, no accurate indication can be made of optimum maturity and greatest egg production. With this in mind the present investigation is presented graphically, which gives the extreme and optimum conditions.

The results secured each year are presented separately and those for all four years are compiled in a final summary. The data for each year are divided into four groups: The frequency distributions, the relation of maturity to winter egg production, its relation to spring egg production and to total annual production. Then a summary is presented of the four years for each part.

The frequency distributions should be used in connection with the graphs in order to know the number of individuals in each group. This will help to explain some discrepancies owing to the small numbers in some of the groups.

Maturity is taken as the number of days elapsing between the date of hatch and the date that the first egg was laid. The range in days to maturity which is necessary for maximum winter egg production is termed the optimum.

Maximum winter egg production is arbitrarily taken as 50 eggs or over. Winter egg production is also arbitrarily calculated as the number of eggs produced from the date of the first egg to March 1. Some of the earliest maturing females started to produce in July, in which case the number of eggs was counted from July to March 1. Therefore, some of these birds had as much as nine months' production, while others had only one month, or less, if they started to lay after Feb. 1.

Spring production is the sum of the production for the months of March, April, May and June.

Total production is the sum of the eggs laid in 365 days. It is also known as the annual production of the birds.

MATURITY AS COMPARED WITH WINTER PRODUCTION IN 1924-25

The records of 150 S. C. White Leghorns were used for the year 1924-25 and are presented in the following graphs. Figure 1 is concerned with the frequencies.

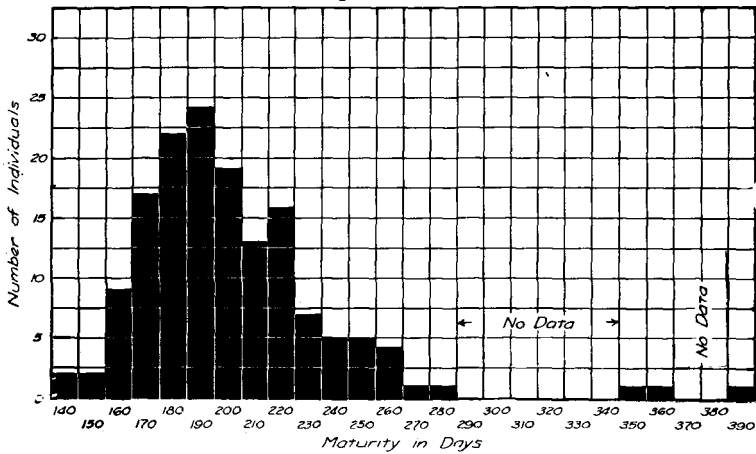


Fig. 1. Frequency distribution of maturity, 1924-25.

The graph (fig. 1) clearly shows the maturity mode for 1924-25 to be 190 days. It also shows the range of maturity in class intervals of 10 days. The average (mean) days to maturity was 201.27 days.

Figure 2 shows the relation of maturity to winter egg production for the year 1924-25.

This graphic representation in fig. 2 shows clearly that there is a very high negative rectilinear relation between early maturity and winter egg production, which would fit it admirably for ordinary rectilinear correlation studies.

It is readily seen from this graph that, in general, the earlier a bird matures the greater will be her winter production. The slight variations from this rule are probably due to the small numbers of individuals found in the particular group, or groups, which apparently disagree.

MATURITY AS COMPARED WITH SPRING PRODUCTION IN 1924-25

The correlation of maturity with spring production is depicted in fig. 3.

From this graph (fig. 3) it is apparent that very little if any relation exists between early maturity and spring production as

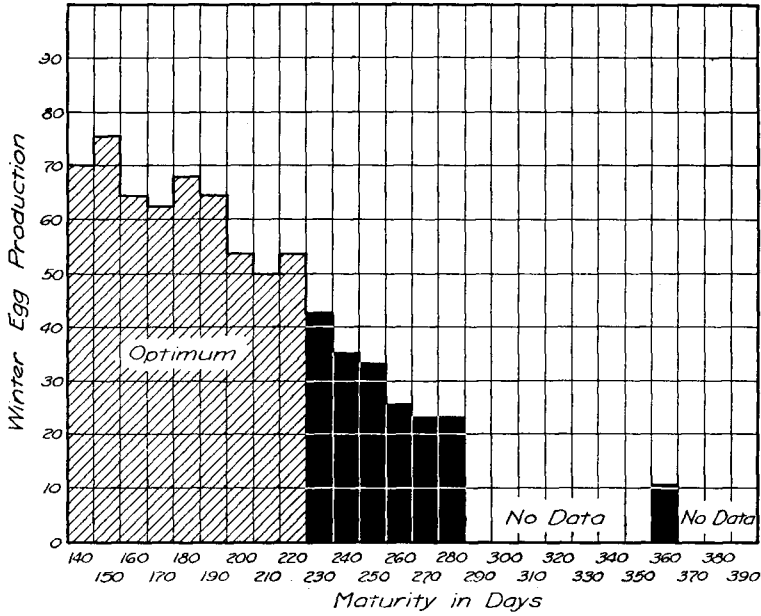


Fig. 2. Maturity and winter egg production, 1924-25.

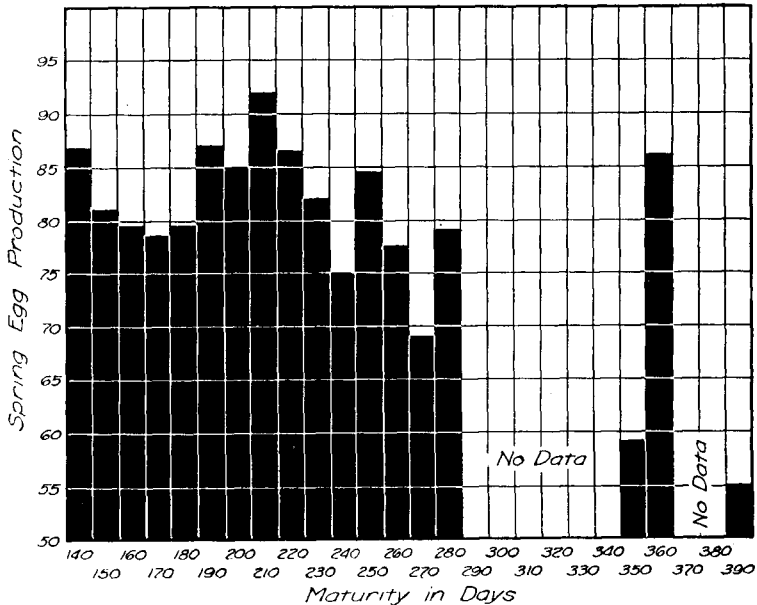


Fig. 3. Maturity versus spring production, 1924-25.

measured by the sum of the production of the birds for March, April, May and June, altho there does seem to be a greater number of 80 to 90 egg averages in the earlier maturing groups.

MATURITY AS COMPARED WITH ANNUAL EGG PRODUCTION IN 1924-25

Most investigators have agreed that early maturity is correlated with annual egg production but to a lesser extent than with winter egg production. Figure 4 presents in graphic form the relation of maturity to annual egg production.

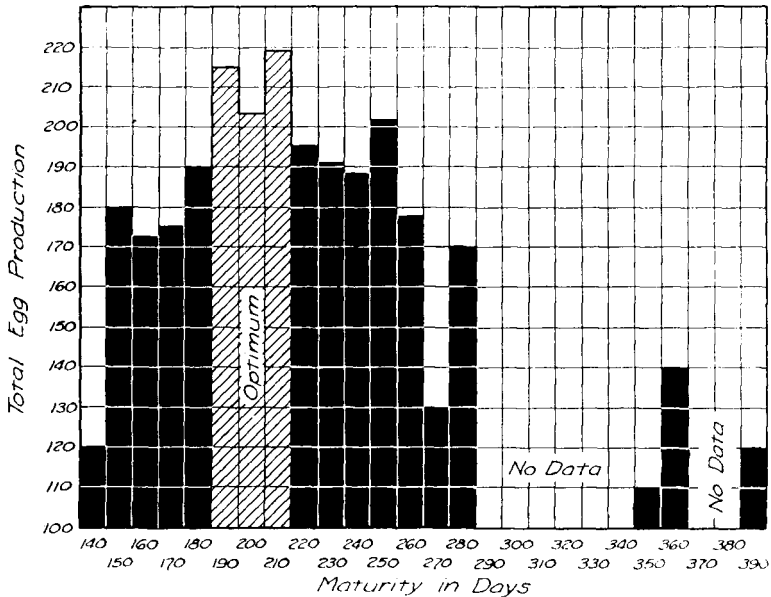


Fig. 4. Maturity versus annual production, 1924-25.

It is shown in fig. 4 that maturity is closely correlated with total annual production. All investigators up to the present time, including the writer, have fitted data of this type to rectilinear correlation. This may account, at least in part, for the variation of correlation coefficients which were found by various investigators. Since this graph shows very strong evidence of curvilinear correlation rather than rectilinear, it also clearly demonstrates that there is an optimum time for birds to mature, which is between 190 and 210 days.

As far as the writer has been able to ascertain there have been no previous reports treating such data in a curvilinear correlation or giving the optimum number of days to maturity within which range the greatest egg production can be expected.

MATURITY AS COMPARED WITH WINTER EGG PRODUCTION IN 1925-26

Records were kept on 223 S. C. White Leghorns for the year 1925-26. Figure 5 gives the distribution of the number of individuals in each class of maturity in days.

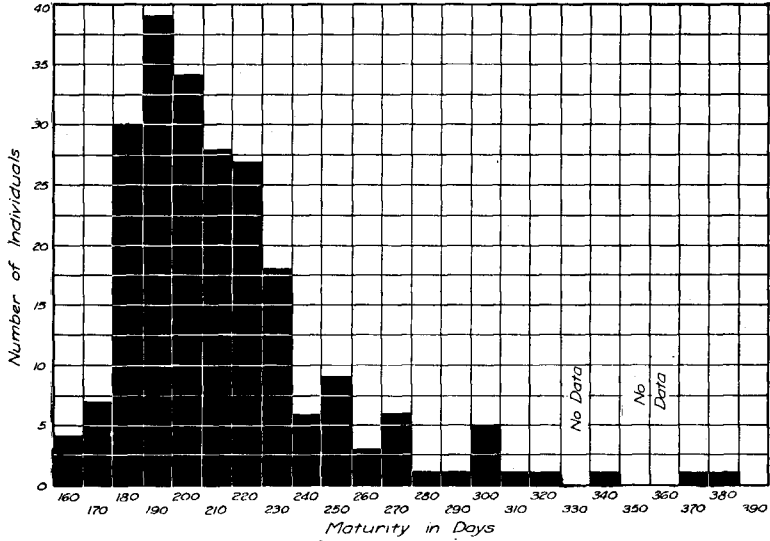


Fig. 5. Frequencies for 1925-26.

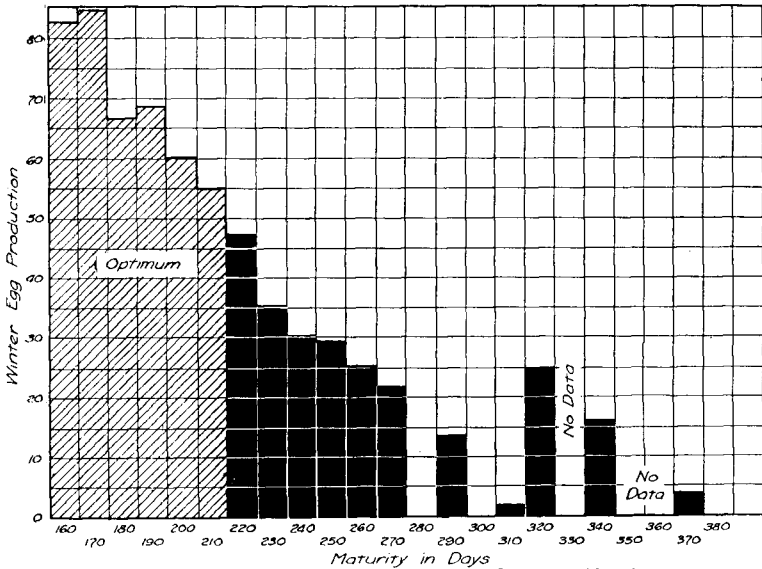


Fig. 6. Maturity versus winter egg production, 1925-26.

Figure 5 shows that the mode to maturity is 190 days, as in the previous year. The range was smaller, varying from 160 to 380 days, thus showing some improvement over the previous year's breeding in regard to early maturity. The average (mean) days to maturity (212.02) did not indicate this improvement, being but slightly more than in 1924-25, which, no doubt, was due to the method of feeding. In the spring of this year, the birds were fed a ration restricted in its protein content, which considerably retarded their sexual development.

Figure 6 again demonstrates that early maturity bears a very high rectilinear correlation with winter egg production. In this case, the birds maturing under 220 days laid more than 50 eggs before March 1. This was the same as for the year previous as all birds maturing under 220 days laid this number of eggs. Therefore, the relation of maturity and winter egg production expressed the same relationship in 1925-26 as in the previous year.

*MATURITY AS COMPARED WITH SPRING PRODUCTION
IN 1925-26*

The graph in fig. 7 shows the relation of maturity with spring egg production.

There seems but slight relation between early maturity and spring production. Practically the same lack of a definite trend

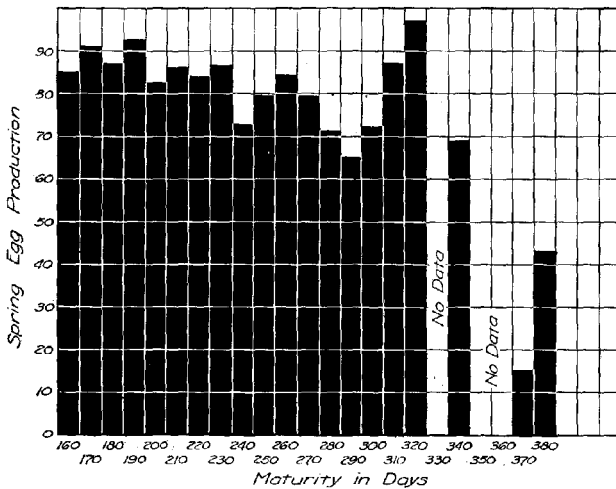


Fig. 7. Maturity versus spring production, 1925-26.

was found in 1925-26 between maturity and spring egg production as in the previous year. It may be noted that there was a very slight but not consistent downward trend between maturity and spring production after the 230 day group had been reached.

MATURITY AS COMPARED WITH ANNUAL PRODUCTION IN 1925-26

As previously stated, the birds' development was retarded in 1925-26, making the pullets come into maturity almost a month later and seriously influencing total egg production. Figure 8 shows this condition, and also the relation of maturity to annual production for the year.

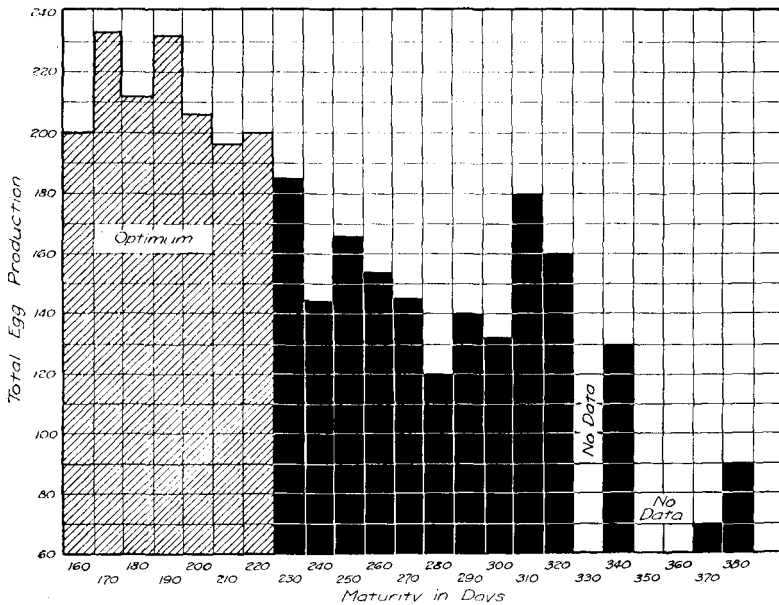


Fig. 8. Maturity versus annual egg production, 1925-26.

In considering annual egg production for 1925-26, there were no 120, 130, 140, and 150 egg groups. This condition was due to retarded sexual development brought about by the feeding of a low protein ration. These groups are the fore-part of the curve showing curvilinear correlation of maturity in days with total egg production. As the fore part of the curve expresses positive correlation, it is only reasonable to expect that the greater the number of these groups not entering into the data, the greater would be the negative correlation as expressed by the latter part of the curve. If a statistical analysis had been

made from these data it would have been strongly negative and would have agreed with the results of most of the other investigators. The previous year's work shows curvilinearity as it includes a wider range from the modal class of 190 days.

MATURITY AS COMPARED WITH WINTER PRODUCTION IN 1926-27

The records of 120 S. C. White Leghorns were used in this year for the study of the influence of maturity upon egg production. Figure 9 gives the number of individuals in each maturity group.

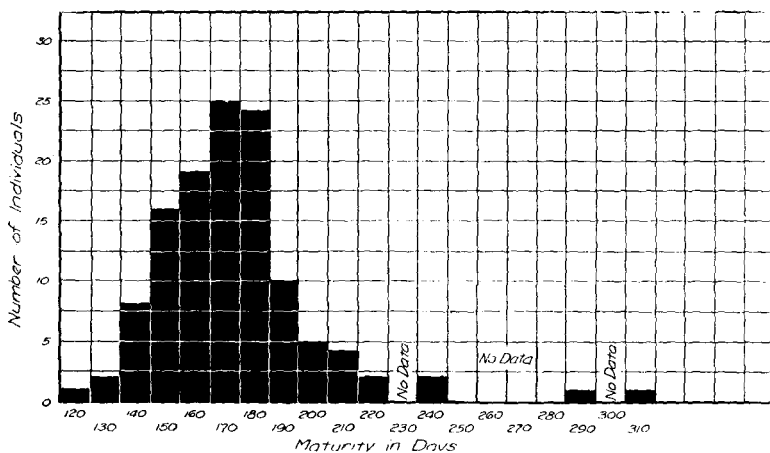


Fig. 9. Frequency distribution, 1926-27.

This graph shows the mode to be 170 days, which is considerably earlier than the two previous years. The range in days to maturity is also less, being 60 days less than in 1924-25 and 30 days less than in 1925-26. The average (mean) days to maturity was 173.08 days.

It can be readily seen from fig. 10 that the station flock showed considerable improvement in the production of females of uniform maturity. Figure 10 shows a strong negative rectilinear relationship between maturity and winter egg production. This is in accord with the preceding year's work and with the results of other investigators.

MATURITY AS COMPARED WITH SPRING PRODUCTION IN 1926-27

The spring months of 1927 were exceedingly unfavorable for egg production in this state, therefore fig. 11 shows a considerably lower production. This condition was influenced largely by such environmental factors as heavy rainfall and disease.

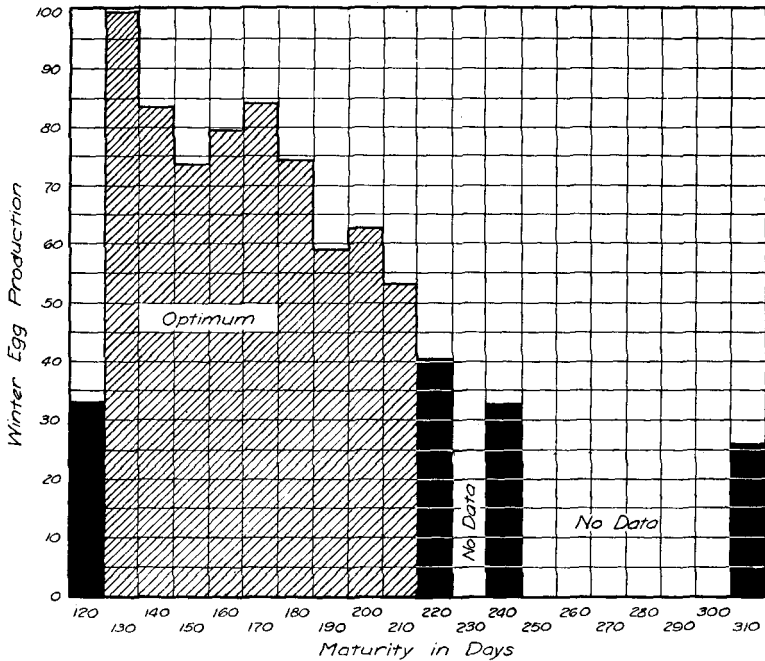


Fig. 10. Maturity versus winter production, 1926-27.

There was, seemingly, no evidence of any relationship between maturity and spring production for 1926-27. The high production shown in the groups taking 290 and 310 days respectively to mature is insignificant since it is due to only one individual in each case.

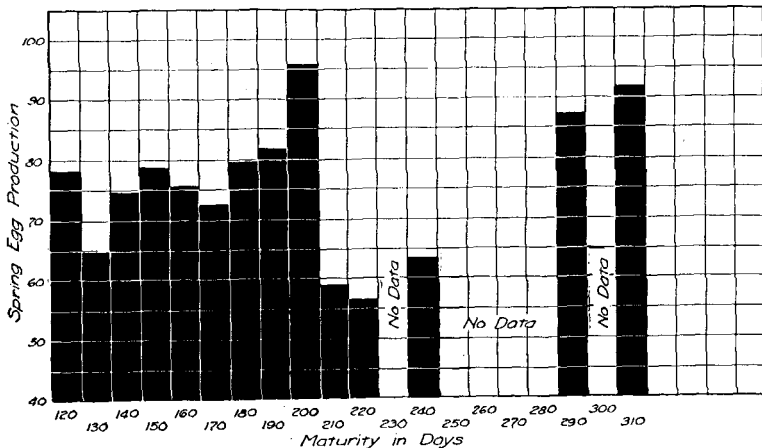


Fig. 11. Maturity versus spring production, 1926-27.

MATURITY AS COMPARED WITH ANNUAL PRODUCTION IN 1926-27

Figure 12 illustrates in graphic form the relation of days to maturity with total annual egg production. This graph also shows the effect of the unfavorable spring conditions, the egg production being lower for this period than in the two years preceding and the following year.

Since only 8 percent of the White Leghorn population for this year reached sexual maturity after 200 days, and because it appears in this graph that the earlier a bird matured the fewer eggs she laid, it follows that there is a positive rectilinear relationship between maturity and total egg production. This would agree with Lippincott et al (15) but would disagree with nearly all of the other investigators.

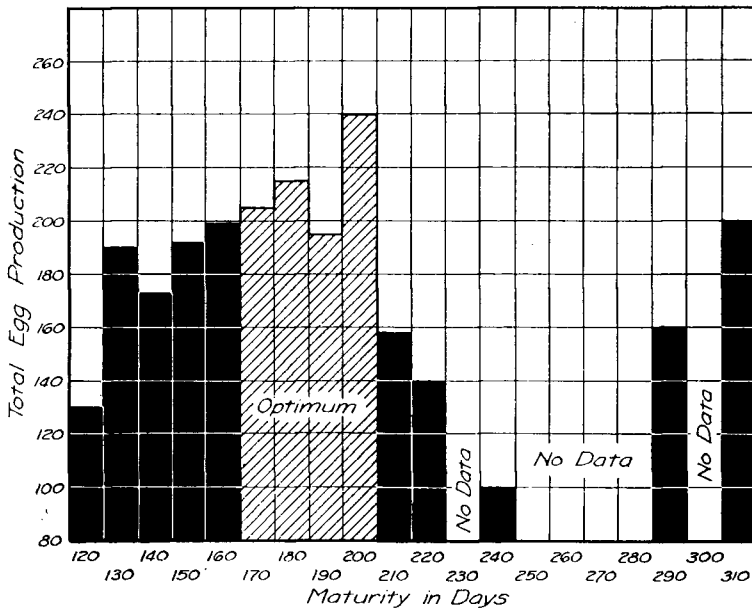


Fig. 12. Maturity versus annual production, 1926-27.

MATURITY AS COMPARED WITH WINTER PRODUCTION IN 1927-28

Considerable selection was made during 1927-28 before July 1. In the three previous years a slight amount of selection was made but not enough to interfere materially with the interpretation of results. This year the selection probably had considerable influence, since approximately 50 percent of the birds were culled before July 1, leaving a selected group of 191 pullets.

Since the previous year's work showed that the earlier a bird

matured the more eggs she would lay before March 1, it is only reasonable to expect that birds culled before July 1 would be those pullets that had shown slow maturity. This selection would therefore have considerable effect upon the frequency distribution of the population, which is clearly shown in fig. 13.

The graph in fig. 13 shows that due to selection only 9.4 percent of the 191 pullets matured later than 210 days. It is also shown that the mode for maturity for 1927-28 is 200 days, and the range in days is 150, considerably less than in previous years, a condition due in part, no doubt, to selection. The average (mean) days to maturity was 190.31.

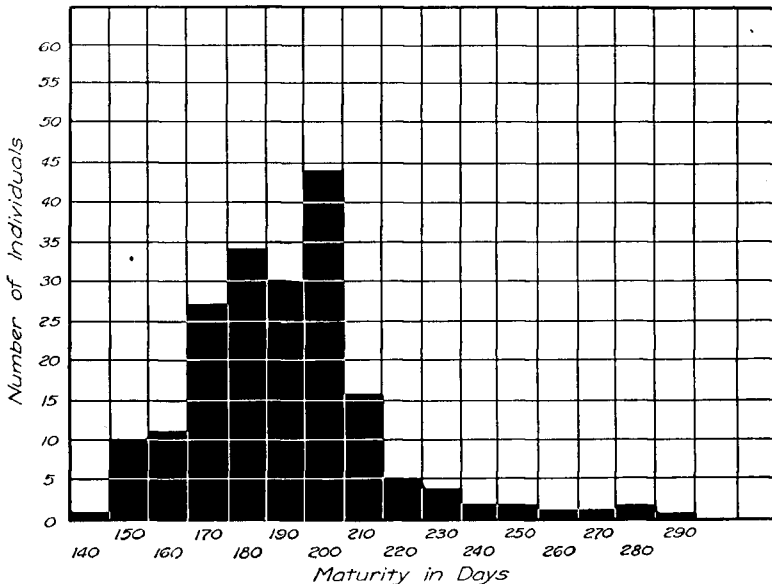


Fig. 13. Frequencies for 1927-28.

Figure 14 shows the relation of maturity of these 191 selected birds to winter production.

Even tho considerable selection had been made, practically no change in the relation of maturity with winter egg production was found. The graph in fig. 14 shows essentially that the earlier a bird matures the greater number of eggs she will produce before March 1. This result is similar to those of 1924-25, 1925-26 and 1926-27; and also to those of other investigators.

MATURITY AS COMPARED WITH SPRING PRODUCTION IN 1927-28

Since the pullets for this year were a selected group, it is reasonable to expect that their production for the four spring

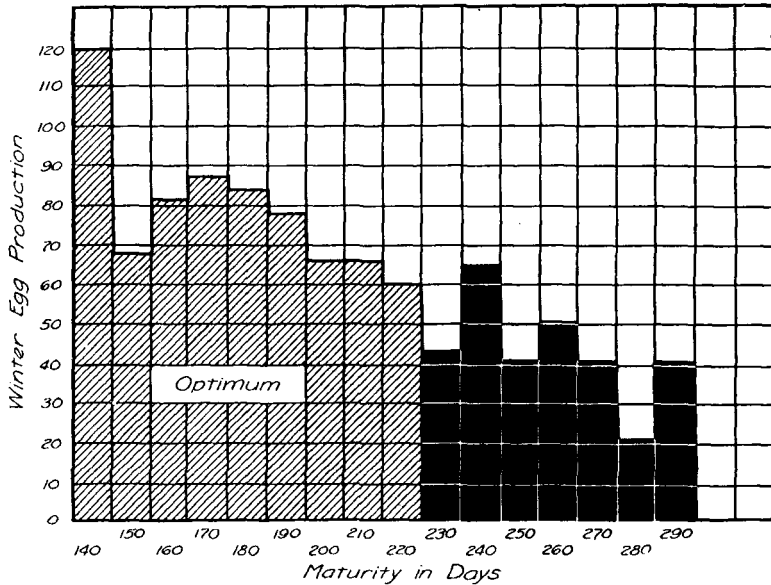


Fig. 14. Maturity versus winter production, 1927-28.

months would be fairly uniform. This is exactly the case as shown by the graph in fig. 15.

As in the previous results, very little relation is discernible

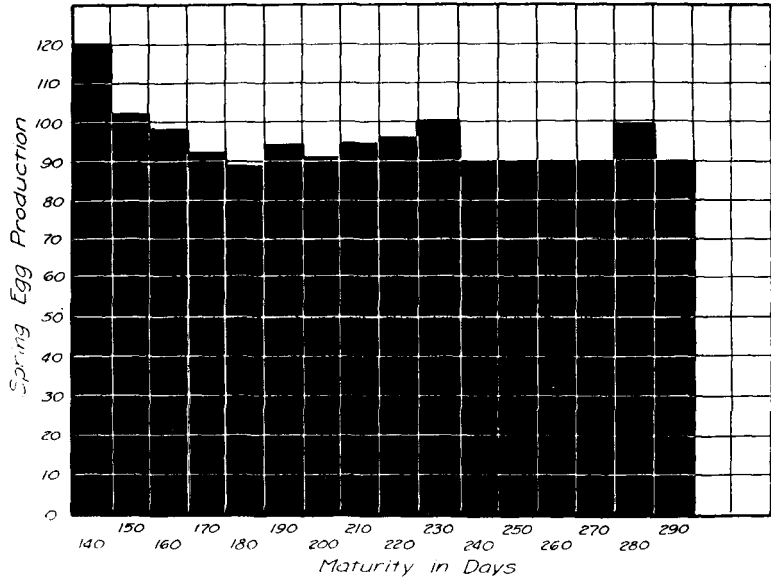


Fig. 15. Maturity versus spring production, 1927-28.

between maturity and spring egg production for this year. This agrees with the relationship shown in previous years, except, of course, the production is considerably higher because of selection.

MATURITY AS COMPARED WITH TOTAL EGG PRODUCTION IN 1927-28

Figure 16 shows the distribution of the maturity groups in 10-day intervals and total egg production.

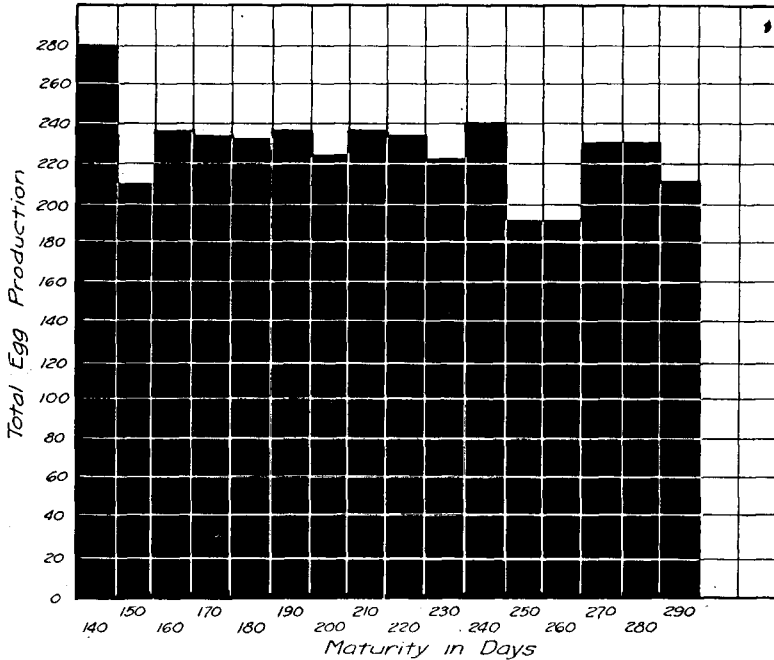


Fig. 16. Maturity versus total egg production, 1927-28.

Again, owing to selection, the pullets are much more uniform and do not show the correlation as well as those of other years. It is interesting to note, however, that of these 191 selected birds, 90.6 percent matured in the early groups, that is, before 220 days had elapsed between the date of hatching and the date of first egg. This indirectly shows that in general the early maturing birds are the higher producers. The results agree substantially with those of other investigators.

MATURITY AS COMPARED WITH WINTER PRODUCTION FOR FOUR YEARS

The compiled four-year data were taken from the records of

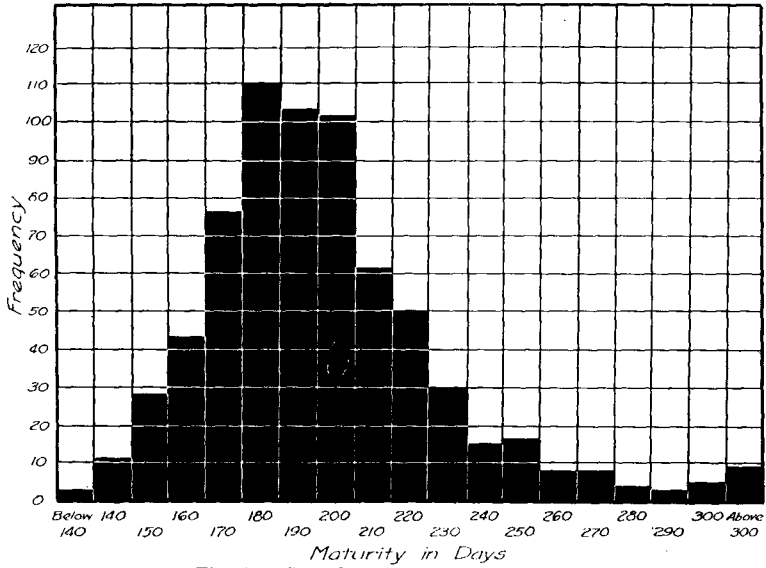


Fig. 17. Compiled four years frequency.

684 S. C. White Leghorns. The frequency distribution of the days to maturity and the number of individuals in each group are given in fig. 17.

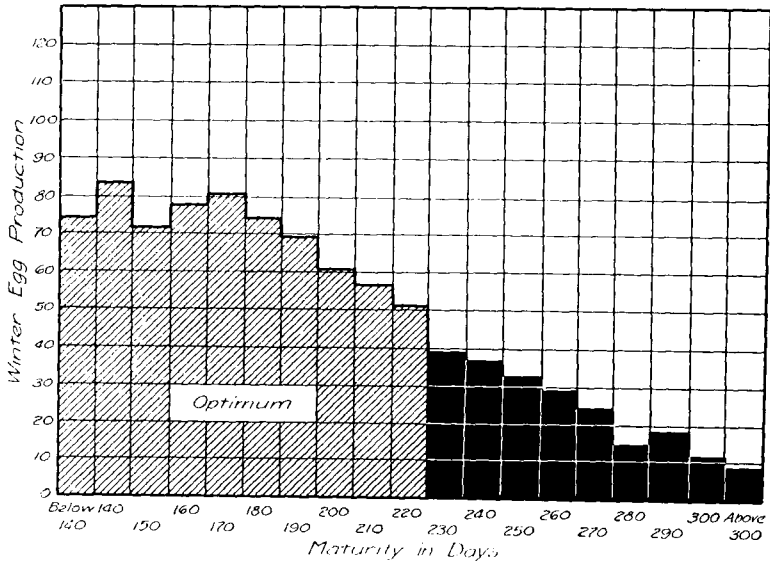


Fig. 18. Maturity versus winter production compiled.

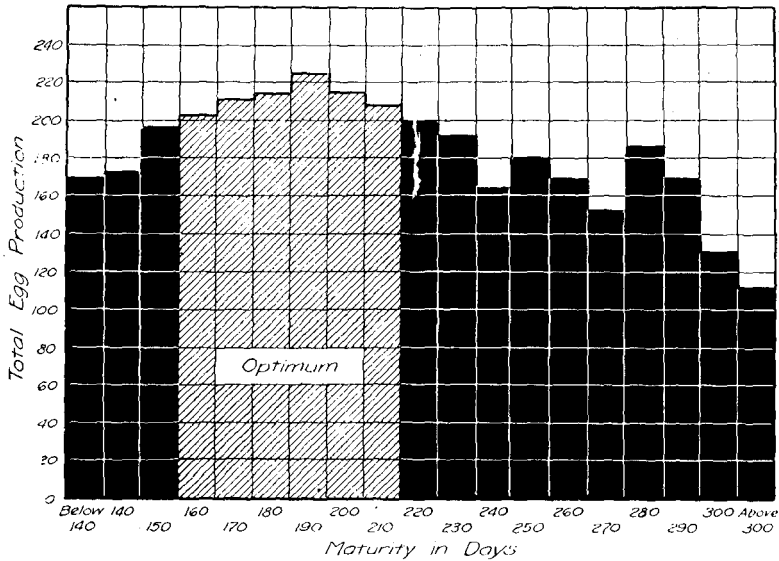


Fig. 20. Maturity versus total egg production; four years data compiled.

The extreme classes, those that matured in less than 140 days, and those that took longer than 300 days, were placed together.

The graph in fig. 20 demonstrates the curvilinear relationship of maturity and total egg production. As far as the writer has been able to ascertain there has been no mention of this fact in other publications. This curvilinearity accounts for the seeming discrepancies between the results of various investigators and for the greater portion of the variation of the correlation coefficients found by them.

Since Lippincott et al. (15) were the only investigators to find a positive correlation between maturity and annual egg production, it will be interesting to note how their data compare with these curvilinear data.

The writer took the liberty of compiling the data of Lippincott et al. (15) into the average production for each class. Then the corresponding averages and classes were calculated from the present work and the results of the two compared and shown in table I.

TABLE I. COMPARISON OF MATURITY WITH EGG PRODUCTION

Days to maturity		151-175	176-200	201-225	226-250	251-275
Data of Lippincott et al. (15)	No. of ind.	12	32	10	4	2
	Average egg prod.	150	167	205	188	200
From present data	Average egg prod.	206	218	202	173	167
	No. of ind.	147	315	140	31	20

This comparison, altho only a close approximation, shows that Lippincott and his collaborators agree essentially with the

present data, since the production in each of the classes used follows a similar curvilinear trend as in this investigation, with the exception of the last class. Here, too few individuals were used to make the difference significant, only two individuals being in this group. The two sets of data compare favorably altho Lippincott et al. (15) obtained a positive correlation, whereas the present data taken in its entirety would show a negative correlation. The specific reason for the difference is, no doubt, the fact that the data of Lippincott et al. (15) were taken from the first part of the curve illustrated in fig. 20, and would therefore show a positive rectilinear correlation, a similar condition to that found in 1926-27 of this study.

The writer (14) working with White Plymouth Rocks, was one of those who obtained a higher negative correlation — $.51 \pm .06$, than most of the other investigators. In checking the data, it was noted that the White Plymouth Rocks mature late, having a mean of 278.27 ± 3.68 days, and therefore the data had been taken from that part of the curve which showed a downward or pronounced negative rectilinear correlation.

The variation in rectilinear correlation coefficients between maturity and total egg production found by different investigators is due, at least in part, to the pronounced curvilinear effect of maturity upon total egg production.

Table II shows the improvement made in the station flock during the last four years. This table gives the means and their probable errors for days to maturity, winter egg production, spring egg production and total egg production. Table III gives the standard deviations with their probable error for the data.

TABLE II. MEANS

Years	No. of ind.	Maturity	Winter prod.	Spring prod.	Total prod.
1924-25	150	201.27 \pm 2.04 days	55.33 \pm 1.27 eggs	83.23 \pm 0.86 eggs	193.15 \pm 2.37 eggs
1925-26	120	212.02 \pm 2.14 "	53.20 \pm 1.66 "	84.80 \pm 1.11 "	198.70 \pm 3.13 "
1926-27	223	173.08 \pm 1.21 "	72.98 \pm 1.14 "	76.44 \pm 1.17 "	196.97 \pm 2.09 "
1927-28	191	190.31 \pm 1.19 "	73.72 \pm 1.01 "	93.61 \pm 0.68 "	230.42 \pm 1.49 "
Total	684	196.83 \pm 0.78 "	62.66 \pm 0.62 "	85.52 \pm 0.51 "	204.99 \pm 1.10 "

TABLE III. STANDARD DEVIATIONS

Years	No. of ind.	Maturity	Winter prod.	Spring prod.	Total prod.
1924-25	150	36.00 \pm 1.44 days	23.15 \pm 0.90 eggs	15.58 \pm 0.61 eggs	43.06 \pm 1.67 eggs
1925-26	120	34.82 \pm 1.52 "	26.98 \pm 1.17 "	18.02 \pm 0.78 "	50.82 \pm 2.21 "
1926-27	223	26.89 \pm 0.86 "	25.20 \pm 0.80 "	25.96 \pm 0.83 "	46.22 \pm 1.48 "
1927-28	191	24.43 \pm 0.84 "	20.75 \pm 0.72 "	13.87 \pm 0.48 "	30.53 \pm 1.05 "
Total	684	30.25 \pm 0.55 "	23.93 \pm 0.44 "	19.63 \pm 0.36 "	42.62 \pm 0.78 "

Altho at first glance table II shows very little improvement, conditions warrant the statement that considerable progress has been made. The standard deviation in days to maturity has decreased from 36.99 ± 1.44 days in 1924-25 to 26.80 ± 0.86 in 1926-27 and 24.43 ± 0.84 days in 1927-28. The means of days