

MASSACHUSETTS
AGRICULTURAL EXPERIMENT STATION

BULLETIN No. 286

JUNE, 1932

Types of Intensity
In Rhode Island Reds

By F. A. Hays and Ruby Sanborn

Dhananjayrao Gadgil Library



GIPE-PUNE-047515

Intensity or rate of laying is one of the very important inherited characters affecting annual egg production in poultry. Various methods have been used for measuring intensity, and there is an increasing need for more information concerning the relative merits of the different measures as well as for definite data concerning the relation of intensity to other traits affecting fecundity. Interrelations between the rate of laying in three different seasons and the relative values of six short-time measures of intensity are considered in this report.

MASSACHUSETTS STATE COLLEGE
AMHERST, MASS.

7351:75-9171.7391

47515 G2

TYPES OF INTENSITY IN RHODE ISLAND REDS

By F. A. Hays, Research Professor of Poultry Husbandry, and
Ruby Sanborn, Research Assistant in Poultry Husbandry

INTRODUCTION

Intensity or rate of laying is recognized as of vital importance in breeding for high fecundity. Various methods have been used for measuring intensity, and there is an increasing need for more information concerning the relative merits of the different measures as well as for definite data concerning the relation of intensity to other traits affecting fecundity.

Hurst (1921) measured intensity on a percentage basis during three periods into which he divided the pullet laying year. He called the period from first pullet egg to March first, the winter period; that from March first to July first, the spring period; and that from July first to the end of the laying year, the autumn period. By dividing the number of eggs laid in a period by the days making up the period, he obtained the intensity on a percentage basis. He states that the annual egg record depends upon high intensity during these three periods, and places the dividing line between genetic high and low intensity at 30 per cent. This worker does not report upon the relative importance of the three periods or upon their possible relation to each other.

Dryden (1921) used the two highest months in the pullet year as a measure of intensity. He found it possible to increase annual production by selection on this basis.

Goodale and Sanborn (1922) offer as measures of intensity the egg records of individual months, the production in the initial cycle, and the production during the inter-broody periods. No attempt is made, however, to discover their relative importance. Harris and Goodale (1922) studied the correlation between individual monthly production and production for the remainder of the year in Rhode Island Reds. Their data indicate that production during January shows the most intimate correlation.

Hays and Sanborn (1927) report the correlation between four measures of intensity and annual egg production. These data show the following values for r : first 60 days vs. remainder of the year, $+0.3082 \pm 0.0121$; mean winter clutch size vs. annual record, $+0.3544 \pm 0.0117$; net winter rate vs. annual record, $+0.4769 \pm 0.0104$; and annual rate vs. annual record, $+0.7106 \pm 0.0066$. These writers conclude that mean winter clutch size is the most specific measure of intensity considered.

This report is concerned with clutch size in periods throughout the year as a measure of intensity. Data are presented to show the correlation between mean winter and mean spring clutch size, between mean winter and mean summer clutch size, and between mean spring and mean summer clutch size. The relation of clutch size during these three periods to four heritable characteristics affecting fecundity is shown by means of the coefficient of correlation. The mean clutch size during the individual months of March, April and May is also shown in relation to the four heritable traits. Finally, the correlations between mean clutch size during six intervals of time and annual production are presented.

Character of Birds Used

All Rhode Island Red pullets hatched during the five hatching seasons of 1925 to 1929 are included in these studies if their egg records appeared to be normal. These birds were carried in a number of different projects as follows: non-broody, high fecundity, egg size, variability in production, and intensity in relation to feather pigmentation. The number of individual birds concerned is 1695, except for those reported in Technical Bulletin 11, where the number is 2560 in studies concerned with mean winter clutch size.

In calculating the correlations, the entire range in age at first egg is included, only individuals exhibiting a pause of four days or more are included in the pause population, only individuals going broody during the pullet year are used in the broody studies, and the entire range is included in the persistency studies. All regressions are tested for linearity by Blakeman's (1905) test. Pearson's (1911) correction for the correlation ratio did not significantly alter the size of this constant in these data and is therefore not used.

A. INTERRELATIONS BETWEEN CLUTCH SIZE

Whether or not the appearance of high intensity in a bird during a particular period is a good criterion that such a bird is likely to be an intense layer in other periods of the year may be shown best by means of the coefficient of correlation. Consideration will be given to the following relations: Correlation between winter and spring clutch, correlation between winter and summer clutch and correlation between spring and summer clutch.

1. Correlation Between Winter and Spring Clutch Size.

The mean winter clutch is obtained by dividing the number of eggs from first pullet egg to the end of February by the number of clutches represented. Mean spring clutch is calculated by dividing the total eggs laid during March, April and May by the number of clutches concerned. Class intervals of one were used, and the mean winter clutch size of each individual was paired against her mean spring clutch. This was done for 1695 individuals to obtain the following constants:

Number of birds.....	1695
Mean winter clutch.....	3.35
Winter clutch standard deviation.....	± 1.60
Mean spring clutch.....	4.07
Spring clutch standard deviation.....	± 2.21
Coefficient of correlation.....	+ .3854. ± 0139
Correlation ratio.....	.4171

The above constants show that although the mean spring clutch size was greater than the mean winter clutch size, the standard deviation for spring clutch shows it to be more variable than winter clutch. This fact may be genetically significant since the spring season is the normal period of laying in unimproved stock.

The regression of spring clutch size vs. winter clutch size is not strictly linear as shown by Blakeman's test. The correlation ratio, therefore, expresses the true relation and amounts to .4171. Using the squared value of the correlation ratio as a criterion of relationship as Ezekiel (1929) has suggested for the

correlation coefficient, the value .1740 appears. The interpretation is that about 17 per cent of the variability in spring clutch size may be accounted for as due to variability in winter clutch size. Such an association is certainly genetically significant though not very intimate.

2. *Correlation Between Winter and Summer Clutch Size.*

Mean summer clutch size represents the constant obtained by dividing the number of eggs laid from June first to the end of the 365-day laying year by the number of clutches involved. Records are available on 1682 birds, and winter clutch was paired against summer clutch for each bird with class intervals of one. The calculations show the following constants:

Number of birds.....	1682
Mean winter clutch.....	3.35
Winter clutch standard deviation.....	± 1.60
Mean summer clutch.....	3.04
Summer clutch standard deviation.....	± 1.60
Coefficient of correlation.....	+ .2829 ± .0151
Correlation ratio.....	.3091

Mean clutch size during the winter months is somewhat greater than during summer. The variability in summer clutch size is also greater than for winter clutch size. The lesser variability in size of clutch during winter shows that the flock is more uniform in winter than in summer production.

Regression of summer clutch size on winter clutch size is not strictly linear by Blakeman's test. The correlation ratio is therefore used to measure the association. The constant +.3091 expresses a less intimate association between winter clutch size and summer clutch size than was observed between winter clutch and spring clutch with a constant +.4171. The squared value of .3091 is .0955 showing that about 10 per cent of the variance in summer clutch size may be associated with variance in winter clutch. Winter clutch size may be said to have a value for selection purposes of about 10 per cent as affecting summer clutch size.

3. *Correlation Between Spring and Summer Clutch Size.*

The spring period of March, April and May is the normal laying period for the unimproved domestic hen. Flocks bred for high fecundity differ greatly from unimproved flocks in the distribution of egg laying during the pullet year. For example, the Massachusetts Agricultural Experiment Station flock hatched in 1913 laid about 29 per cent of the yearly average by the end of February. The flock hatched in 1930 averaged to lay about 36 per cent of its eggs before March first. Moreover, the actual mean length of the productive year has increased from about 240 days to 340 days. These changes have reduced the proportion of total eggs laid during the spring season and this section is chiefly concerned with possible inter-relations of intensity, between the spring and summer periods.

The coefficient of correlation between mean spring clutch and mean summer clutch was calculated on 1682 birds to discover if there is a significant association. The constants are presented below:

Number of birds.....	1682
Mean spring clutch.....	4.08
Spring clutch standard deviation.....	± 2.21
Mean summer clutch.....	3.04
Summer clutch standard deviation.....	± 1.60
Coefficient of correlation.....	$+.4593 \pm .0130$

Summer clutch shows the same coefficient of variation as spring clutch—about 53 per cent, compared with about 48 per cent for winter clutch. The fact should be observed, however, that the actual range in clutch size is ± 1.60 both during the winter and summer periods and ± 2.21 during the spring season.

Regression of summer clutch size on spring clutch size is linear by Blakeman's test. The magnitude of the correlation coefficient is greater than those shown in sections 1 and 2. Squaring r , the value .2110 appears which means that 21 per cent of the variance in summer clutch size is associated with variance in spring clutch size.

The data in sections 1, 2 and 3 on the inter-relationships of clutch size during the winter, spring and summer periods show significant correlations, yet the correlation is in no case sufficiently intimate to justify the use of clutch size in any one period as an accurate measure of intensity for the year. Hurst (1921 loc. cit.) made use of intensity throughout the year in his study of the genetics of egg production, and Hays and Sanborn (1927, loc. cit.) state that annual intensity should be adequately stressed in breeding for fecundity.

B. SHORT-TIME MEASURES OF INTENSITY IN RELATION TO FECUNDITY TRAITS

Table 1 is presented to set forth the correlation between six short-time measures of intensity and four characteristics affecting annual egg production and the correlation between each measure and annual egg record.

Winter Clutch Size

The coefficient of correlation between mean winter clutch and age at first egg is $-.2273 \pm .0103$. Regression of winter clutch size on age at first egg is strictly non-linear according to Blakeman's test. Therefore, the correlation ratio of .7475 expresses the true relation between these two characters. Squaring the constant .7475 gives .5588 which indicates that about 56 per cent of the variance in winter clutch size is due to variance in age at sexual maturity. In other words, the data show that early sexual maturity is intimately associated with large winter clutch size.

Winter clutch size shows a non-linear relation to length of winter pause. The correlation ratio shows, however, that the two are actually correlated. The constant is .1297 indicating by its squared value of .0168 that about 2 per cent of the variability in winter clutch size is due to variability in pause duration.

The degree of broodiness measured by the number of days spent without production while broody during the pullet year is associated with large winter clutch size. There is a positive correlation constant of $.2205 \pm .0186$. The regression is non-linear and the correlation ratio is .2548. Hays and Sanborn (1927 loc. cit.) have already shown that the mean winter clutch size is greater in broody than in non-broody birds.

TABLE 1.—CORRELATIONS BETWEEN INTENSITY AND INHERITED CHARACTERS AFFECTING FECUNDITY; ALSO BETWEEN INTENSITY AND ANNUAL EGG PRODUCTION.

	WINTER CLUTCH (First egg to March 1)	SPRING CLUTCH (March, April, May)	MARCH CLUTCH	APRIL CLUTCH	MAY CLUTCH	SUMMER CLUTCH (June to end of laying year)
AGE AT FIRST EGG:						
Correlation Coefficient	-0.2273 ± .0103	+0.0322 ± .0164	+0.0366 ± .0164	-0.106 ± .0164	+0.0035 ± .0165	-0.0481 ± .0164
Correlation Ratio	.7475					
WINTER PAUSE, DAYS:						
Correlation Coefficient	-0.0674 ± .0145	+0.0729 ± .0197	-0.0352 ± .0199	+0.0052 ± .0199	+0.0351 ± .0199	+0.1112 ± .0197
Correlation Ratio	.1297	.3596				.1678
TOTAL BROODY DAYS:						
Correlation Coefficient	+0.2205 ± .0186	+0.0025 ± .0361	+0.0234 ± .0363	-0.0197 ± .0361	+0.0386 ± .0361	+0.2627 ± .0336
Correlation Ratio	.2548					.3531
PERSISTENCY:						
Correlation Coefficient	+0.1692 ± .0130	+0.1529 ± .0160	+0.0673 ± .0163	+0.1155 ± .0162	+0.1122 ± .0163	+0.1640 ± .0160
Correlation Ratio	.1927					.2078
ANNUAL PRODUCTION:						
Correlation Coefficient	+0.3544 ± .0117	+0.4559 ± .0130	+0.2824 ± .0151	+0.3268 ± .0147	+0.3198 ± .0148	+0.3958 ± .0139
Correlation Ratio	.4214	.5024	.3023	.3975	.3498	.4238

Persistency is associated with winter clutch size in a positive manner and regression is not linear. The coefficient of correlation is $+.1692 \pm .0130$ and the correlation ratio is .1927. The latter constant squared gives .0371 as the amount of variance in persistency associated with variance in winter clutch size.

Spring Clutch Size

Since the spring season of March, April and May may be considered the normal laying period in the Temperate Zone, it is important to discover if the intensity of laying at this time is associated with any of the four other characters affecting egg yield.

Table 1 shows that the correlation between age at first egg and mean spring clutch is negligible. In other words, the age at which the pullet begins to lay shows no relation to her spring intensity. The relation is linear, however.

The regression of spring clutch size on winter pause duration is distinctly non-linear by Blakeman's test. The correlation ratio shows that there is a positive relation amounting to .3596. Using the squared value of .3596 the constant .1293 is obtained, showing the percentage of associated variability between length of winter pause and size of spring clutch in 1156 birds with winter pause. This association between duration of pause and subsequent rate of laying is considered later in this report in connection with total days broody and summer rate of laying.

Total days broody during the pullet laying year is independent of spring clutch size in Table 1. This appears in contrast to the significant positive correlation between total days broody and mean winter clutch, already considered.

Table 1 shows a linear correlation between spring clutch and persistency of $+.1539 \pm .0160$. This supplements the observation reported by Hays and Sanborn (1926) that intense winter layers are more likely to be persistent layers.

Mean spring clutch size is independent of age at sexual maturity. The relation of spring clutch size to winter pause duration is fairly intimate though non-linear. The degree of broodiness measured by non-productive broody periods is independent of spring clutch size. The regression of persistency on spring clutch size is linear and of some significance.

March Clutch Size

The usefulness of a short-time measure of intensity is clearly evident provided such a measure accurately depicts the intensity for a long period. Mean clutch size during March may be considered as a possibility.

Table 1 shows no correlation between March clutch size and age at first egg, duration of winter pause, total days broody in the broody population or annual persistency. Clearly the rate of laying in March is independent of the four inherited characters just mentioned. The regression of March clutch size on the four above-mentioned characters is strictly linear by Blakeman's test.

April Clutch Size

The correlation coefficient indicates complete independence between mean clutch size during the month of April and age at first egg, duration of winter pause and total days broody. The regression is strictly linear in all cases.

The correlation between April clutch size and annual persistency is of low degree and the regression is linear. The amount of variance in April clutch size

associated with variance in persistency is only .0133 and is far too small to be of significance. These data, therefore, point to no association between the four inherited traits considered and April clutch size.

May Clutch Size

Table 1 shows no significant correlation between May clutch size and the three inherited characters, age at first egg, winter pause duration and total days broody. The correlation coefficient of $+.1122 \pm .0163$ between May clutch size and persistency is of very small magnitude and of little significance. Blakeman's test shows that the relation between May clutch size and the four inherited traits is linear. The general statement seems justified; that clutch size during the three spring months is practically independent of the four inherited characters considered essential to high annual egg production.

Summer Clutch Size

The period from June first to the end of the 365-day laying year is often a period of low production in improved flocks. During this time mortality is likely to be high, many birds may stop laying because of broodiness, others lay at a low rate and still others do not persist in laying to the end of their year. Information regarding the possible relation of clutch size at this season to inherited fecundity traits should be of considerable value.

Table 1 indicates by means of the insignificant value of r , that age at first egg and summer clutch size are independent. The same relation has already been indicated between age at first egg and spring clutch in contrast to a significant value of $-.7475$ between age at first egg and winter clutch size.

There is a small non-linear correlation between duration of winter pause and summer clutch size. The value of the constant is $+.1678$ indicating to a small degree the tendency for a long winter pause to enable the bird to lay at a slightly higher rate in summer.

Regression of days broody on size of summer clutch is non-linear and positive. The correlation ratio .3531 gives the true relation. This value is of considerable significance and indicates that the inter-broody periods tend to be periods of heavy laying. This agrees with the previous observation that winter pause duration is correlated with size of spring clutch. These data indicate that a period of non-production is likely to be followed by large clutches.

Persistency does not show a linear regression on summer clutch size. Using the correlation ratio to express the correlation, the positive value .2078 is obtained. Such a constant shows that intense layers tend to a small degree to be persistent layers.

In general, the study of the relations of six short-time measures of intensity to inherited characters affecting fecundity shows the following significant correlations: Winter clutch and early sexual maturity, spring clutch and duration of winter pause, summer clutch and duration of winter pause, winter clutch and days broody, summer clutch and days broody, winter clutch and persistency, spring clutch and persistency and summer clutch and persistency.

C. SHORT-TIME MEASURES OF INTENSITY IN RELATION TO ANNUAL EGG PRODUCTION

Table 1 also includes the correlation coefficients showing the relation between six measures of intensity and annual egg records.

The regression of annual egg production on winter clutch size is distinctly non-linear by Blakeman's test. The correlation ratio with a value of .4214 supplies a true measure of association. The magnitude of this constant squared is .1776 showing that 18 per cent of the variance in annual production is due to variance in winter intensity. For selection purposes, winter clutch size does furnish a significant criterion of annual egg record.

Annual production does not show linear regression on spring clutch by Blake-man's test. Therefore, the correlation ratio of .5024 with a positive sign expresses the true relationship. By squaring this constant .2524 is obtained to express the amount of variance in annual production that may be attributed to variance in spring clutch. Spring clutch size has, therefore, a high value in selecting for intensity.

The three months: March, April and May, making up the spring season all show non-linear regression of production on clutch size. In these data, April clutch size appears to be the most significant with a correlation of .3975, followed by May with .3498 and March with .3023. No single month in the spring season appears to give as good a measure of intensity as the combined three months.

Regression of annual production on summer clutch size is non-linear and the correlation ratio is .4238. This constant squared gives .1796 as the part of the variance in annual record associated with variance in summer clutch. This constant indicates that summer clutch size is of somewhat less importance than spring clutch size for the flock studied in so far as annual egg records are concerned. There is a possibility that spring clutch size has been reduced by the methods of selecting for high winter intensity and for greater persistency.

In a general sense, no one of the six short-time measures of intensity may be considered as an accurate criterion of the clutch size for the year. For the flock studied, spring clutch size is the best short-time measure. These data suggest that eight distinct types of intensity may occur:

<i>Winter</i>	<i>Spring</i>	<i>Summer</i>
High	High	High
High	High	Low
High	Low	High
Low	High	High
High	Low	Low
Low	Low	High
Low	High	Low
Low	Low	Low

Section A shows that high spring and high summer intensity are more likely to occur together than high winter and high spring or high winter and high summer. The same section also presents a significant correlation for intensity between any two of these seasons. In selecting breeders for maximum intensity, therefore, the clutch size throughout the first laying year offers the only reliable guide.

PRACTICAL APPLICATIONS

In breeding a flock for high intensity, the starting point is the selection as breeders of those females laying in large clutches in March, April and May. The next step is the selection of breeders with large spring clutch size and in addition winter clutch size of not under three eggs. Because of the intimate correlation between early sexual maturity and large winter clutch, it is also important that breeders carry early maturity. The third and final step in selection for high intensity is the addition of high summer intensity from June first to the close of the laying year. In order to establish uniform high intensity throughout the pullet laying year it is necessary to employ yearling breeders that exhibit large clutch size in winter, spring and summer.

SUMMARY

Intensity during three seasons of the pullet laying year is considered. Winter clutch size measures the intensity from first pullet egg to March first. Spring clutch size covers the period from March first to June first. Summer clutch size includes the time interval beginning June first and continuing to the close of the 365-day laying year.

March clutch size, April clutch size and May clutch size are each studied as possible short-time measures.

Winter clutch size and spring clutch size show a non-linear relation and the correlation ratio between the two is .4171.

Winter clutch size and summer clutch size also show a non-linear relation with a correlation ratio of .3091.

Spring clutch size and summer clutch size show a linear relation to each other and a coefficient of correlation of $+.4593 \pm .0130$.

Winter clutch size is correlated to a high degree with age at first egg.

The degrees of correlation between winter clutch size and winter pause duration, winter clutch size and days broody and winter clutch size and persistency are very moderate but slightly significant.

Spring clutch size shows non-linear regression on winter pause duration with a correlation ratio of .3596.

March clutch size, April clutch size and May clutch size are independent of age at first egg, winter pause duration, total days broody and persistency.

Summer clutch size is independent of age at sexual maturity, moderately correlated with winter pause duration and persistency and correlated to the extent of .3531 with total days broody.

As a criterion of annual egg production, the six short-time measures rank in the following order determined by the degree of correlation: spring clutch, summer clutch, winter clutch, April clutch, May clutch and March clutch.

In general, clutch size seems to increase somewhat following either a winter period of non-production or a broody period.

The mean clutch size for the flock studied was: winter, 3.35; spring, 4.07; and summer, 3.04.

The most significant short-time measure of intensity is spring clutch size, but no short-time measure of intensity is as accurate as the mean clutch size for the entire year.

REFERENCES

- Blakeman, J. 1905. On tests of linearity of regression in frequency distribution. *Biometrika* 4:332-350.
- Dryden, James. 1921. Egg-laying characteristics of the hen. *Oreg. Agr. Exp. Sta. Bul.* 180.
- Ezekiel, M. 1929. Meaning and significance of correlation coefficients. *Amer. Econ. Rev.* 19: 246-250.
- Goodale, H. D. and Ruby Sanborn. 1922. Changes in egg production in the Station flock. *Mass. Agr. Exp. Sta. Bul.* 211.
- Harris, J. Arthur and H. D. Goodale. 1922. The correlation between the egg production of the various periods of the year in the Rhode Island Red breed of domestic fowl. *Genetics* 7: 446-465.
- Hays, F. A. and Ruby Sanborn. 1926. Annual persistency in relation to winter and annual egg production. *Mass. Agr. Exp. Sta. Tech. Bul.* 9.
- Hays, F. A. and Ruby Sanborn. 1927. Intensity or rate of laying in relation to fecundity. *Mass. Agr. Exp. Sta. Tech. Bul.* 11.
- Hurst, C. C. 1921. The genetics of egg production in White Leghorns and White Wyandottes. *Natl. Poultry Jour.* Sept. 2 to Dec. 9.
- Pearson, K. 1911. On a correction to be made to the correlation ratio. *Biometrics* 8: 254-256.
-