

7351:75-371.7391

47505 G3

MASSACHUSETTS

AGRICULTURAL EXPERIMENT STATION

---

BULLETIN No. 301

NOVEMBER, 1933

---

# Characteristics of Non-Broody and Intense Broody Lines of Rhode Island Reds

By F. A. Hays

Dhananjayrao Gadgil Library



GIPE-PUNE-047505

The practical poultryman is interested in decreasing broodiness in his laying flock. The data presented here show to what extent this can be accomplished by ordinary selection methods without the use of tested males. There is included also a comparison of fecundity characters and of egg records of non-broody and broody lines.

---

MASSACHUSETTS STATE COLLEGE  
AMHERST, MASS.

# CHARACTERISTICS OF NON-BROODY, AND INTENSE BROODY LINES OF RHODE ISLAND REDS

By F. A. Hays, Research Professor of Poultry Husbandry

## INTRODUCTION

American breeds of poultry such as the Plymouth Rock, Rhode Island Red and Wyandotte normally exhibit a considerable degree of broodiness. Within recent years, however, the development of flocks for high fecundity has greatly reduced the amount of broodiness in these birds so that some flocks compare very favorably with Leghorns in freedom from broodiness. For example, the Massachusetts Agricultural Experiment Station flock of Rhode Island Reds has been reduced from 90 per cent broody in 1913 to about 14 per cent broody in the pullet year at the present time. A similar change has taken place in many flocks of the American breeds throughout the world.

The lowering of egg production by loss of time during broody periods is widely recognized. Goodale, Sanborn and White (1920) showed very definitely that Rhode Island Red females lose from 11 to 66 days in non-productive broody periods during the pullet laying year. Hays and Sanborn (1927) pointed out a net correlation of  $.5630 \pm .0097$  between total days broody and annual production during the pullet year. Jull (1932, p. 228) states that 494 Rhode Island Reds at the U.S. Animal Husbandry Experiment Farm that were non-broody in the pullet year averaged 204.78 eggs compared with 477 that showed broodiness and averaged 179.65 eggs.

This report concerns itself with two lines of Rhode Island Reds bred for non-broodiness and intense broodiness, respectively, for the nine-year period of 1923 to 1931. Care was taken to avoid close matings so that with few exceptions matings no closer than cousins were made. It was necessary to introduce males and females occasionally from the production-bred flock in order to avoid close matings. Mating pens in the two lines were generally made up in part of tested hens and cocks and in part of untested pullets and cockerels. Breeding stock was selected in both lines for similarity in all traits affecting fecundity, except broodiness. The non-broody line was selected constantly for freedom from broodiness and the broody line for intense broodiness. All female breeders in the non-broody line were free of broodiness in their pullet year and all dams in the broody line exhibited broodiness the first year.

## EXPERIMENTAL RESULTS

The most important inherited characters affecting egg production are age at sexual maturity, winter pause, intensity, broodiness and persistency. These five, according to Hays and Sanborn (1927, loc. cit.), are responsible for about 75 per cent of the variation in annual production in Rhode Island Reds.

### 1. Age at First Egg

Data on 1207 broody Rhode Island Red pullets hatched from 1916 to 1925 at this Station show that the regression of total days broody during the first laying year on age at first egg was not strictly linear. The correlation ratio was found to be  $.1552 \pm .0189$  and positive in nature. The magnitude of this constant is too small to indicate any significant association between age at sexual maturity and total days broody.

Table 1 gives the percentage of broody daughters in the two lines each year together with the means for the experimental period.

In general the non-broody line showed a greater absolute decrease in mean age

at first egg throughout the period than did the broody line. The differences in mean age at sexual maturity for the two lines are not significant, however, according to Fisher's (1930, p. 106) method for measuring the differences in means.

The coefficient of variation decreased slightly in both lines as the experiment progressed. For the entire period the variation amounted to 12.3 per cent in the non-broody line and 11.12 per cent in the broody line. These are insignificant differences and the variability in both lines was probably due largely to environmental factors as Hays (1932) points out.

TABLE 1. MEAN AGE AT FIRST EGG IN NON-BROODY AND BROODY LINES.

Year	Non-Broody Line				Broody Line			
	Number of Birds	Mean Age at First Egg (Days)	P.E. of Mean	Coefficient of Variability	Number of Birds	Mean Age at First Egg (Days)	P.E. of Mean	Coefficient of Variability
1923	14	220.93	6.27	.1574	27	209.41	4.32	.1594
1924	5	215.00	3.82	.0590	21	205.48	3.79	.1255
1925	60	184.35	1.32	.0823	29	195.07	1.93	.0787
1926	12	182.33	4.23	.1199	26	202.96	2.35	.0871
1927	26	173.31	1.90	.0828	38	189.63	2.36	.1141
1928	40	205.98	1.90	.0870	34	201.50	2.13	.0913
1929	33	203.27	2.41	.1012	32	202.72	2.42	.1002
1930	33	179.45	2.94	.1394	24	204.83	2.85	.1011
1931	44	188.55	1.81	.0941	28	209.89	2.17	.0808
Total or Mean	267	191.34	.97	.1230	259	201.70	.94	.1112

## 2. Winter Clutch Size

Mean winter clutch size has been shown to be an inherited trait and is a satisfactory measure of intensity. Intensity has also been shown to be one of the most variable characters in the flock studied (Hays, 1932, loc. cit.). Goodale et al. (1920, loc. cit.) reported lower initial egg production in a flock of broody birds where the degree of broodiness was low (1.90 periods) than in a flock of broody birds with a high degree of broodiness (5.39 periods). In the Massachusetts Agricultural Experiment Station flock from 1916 to 1925, a total of 1188 birds showing broodiness had a mean winter clutch size of 2.96 while 2679 individuals not showing broodiness in their pullet year had a mean winter clutch size of 2.50. These facts indicate an association between broodiness and winter intensity. The correlation between degree of broodiness and winter intensity amounts to  $+.2548 \pm .0186$  according to Hays and Sanborn (1932 a).

Table 2 presents the mean winter clutch size by years in the non-broody and broody lines, together with their coefficients of variation and the grand means of the two lines.

There was a significant increase in intensity in both lines throughout the period. There was not, however, a change of any consequence in the variability as measured by the coefficient of variation. The high variability in winter clutch size may probably be due largely to its complex mode of inheritance, as the writer has pointed out elsewhere.

Contrary to earlier observations, mean clutch size was slightly greater in the non-broody line. The flocks hatched in 1924 and 1925 were the only exceptions. The differences in clutch size for the two lines were checked by Fisher's method, and it was found that the two lines are not significantly different in intensity.

The fact that the two lines showed about the same clutch size throughout the

nine-year period indicates that the linkage between broody genes and high intensity genes is sufficiently weak to allow much crossing over, so that non-broody birds with high intensity occur frequently and were selected as breeders in this experiment. Such a condition exists abundantly in Leghorns which may have had a similar evolutionary history.

TABLE 2. MEAN WINTER CLUTCH SIZE IN NON-BROODY AND BROODY LINES.

Year	Non-Broody Line				Broody Line			
	Number of Birds	Mean Clutch Size (Eggs)	P. E. of Mean	Coefficient of Variability	Number of Birds	Mean Clutch Size (Eggs)	P. E. of Mean	Coefficient of Variability
1923	14	2.71	.25	.5426	27	2.44	.12	.3822
1924	5	2.86	.41	.4448	21	2.90	.11	.2460
1925	60	3.29	.16	.5490	29	3.67	.22	.4670
1926	12	3.63	.21	.2945	26	3.39	.14	.3176
1927	26	4.37	.29	.4889	38	3.24	.16	.4490
1928	40	3.40	.14	.3775	34	3.28	.14	.3487
1929	33	2.79	.13	.3992	32	2.77	.12	.3779
1930	33	4.44	.20	.3801	24	4.19	.22	.3883
1931	44	4.36	.19	.4134	28	3.56	.26	.5689
Total or Mean	267	3.64	.07	.4946	259	3.26	.06	.4436

### 3. Winter Pause Duration

Winter pause represents a period of non-production between November first and March first of the pullet year. Hays and Sanborn (1927, loc. cit.) have shown the net correlation between total days broody and winter pause duration to be  $-.1609 \pm .0245$ , which indicates a slight tendency for high intensity of broodiness to be associated with short winter pause.

Table 3 presents the mean winter pause length by years for all birds in the two lines. In general the non-broody line appears to exhibit a shorter pause than the broody line. Tested by Fisher's method the two series of means differ significantly.

TABLE 3. MEAN WINTER PAUSE DURATION IN NON-BROODY AND BROODY LINES.

Year	Non-Broody Line				Broody Line			
	Number of Birds	Mean Pause (Days)	P. E. of Mean	Coefficient of Variability	Number of Birds	Mean Pause (Days)	P. E. of Mean	Coefficient of Variability
1923	14	11.00	2.53	1.7432	27	30.37	3.23	.8102
1924	5	8.60	3.60	1.2701	21	30.00	4.29	.9479
1925	60	30.55	1.72	.6388	29	26.62	2.91	.8442
1926	12	10.67	1.70	.7687	26	22.42	2.68	.8949
1927	26	15.88	2.24	1.0587	38	13.32	1.92	1.2939
1928	40	8.60	1.16	1.1301	34	16.59	2.24	1.1210
1929	33	19.67	2.30	.9694	32	21.44	2.52	.9752
1930	33	12.27	2.04	1.3559	24	17.83	2.92	1.1539
1931	44	11.48	1.97	1.6344	28	15.68	2.97	1.4719
Total or Mean	267	16.76	.79	1.1146	259	20.96	.96	1.0667

The proportion of pause and non-pause birds shown by the detailed data was 1 non-pause to 1.72 pause birds in the non-broody line compared with 1 non-pause to 1.91 pause birds in the broody line. There were four families in the non-broody line in which no daughters with pause occurred and only one family in the broody line that showed no pause daughters. Contrary to earlier observations, the effect of breeding for non-broodiness in this experiment has been to reduce winter pause duration.

#### 4. Annual Persistency

Annual persistency is arbitrarily terminated with 365 days as a maximum. In those birds which stopped laying for 30 days or more after March first but before the close of their 365-day laying year, persistency was less than 365 days. High persistency is the most important of all inherited characters in relation to annual production, according to Hays and Sanborn (1927, loc. cit.). The net correlation between persistency and annual egg production in Rhode Island Reds is  $+0.7501 \pm 0.063$ . It is important, therefore, to discover possible relations between broodiness or non-broodiness and persistency of laying.

Although the non-broody line showed higher average persistency than the broody line in seven of the nine experimental years, the differences in the two lines were found to be of questionable significance when tested by Fisher's method for determining the significance of differences in a series of means. It is probable, therefore, that the two lines are essentially alike in persistency.

TABLE 4. ANNUAL PERSISTENCY IN NON-BROODY AND BROODY LINES.

Year	Non-Broody Line				Broody Line			
	Number of Birds	Mean Persistency (Days)	P. E. of Mean	Coefficient of Variability	Number of Birds	Mean Persistency (Days)	P.E. of Mean	Coefficient of Variability
1923	14	324.21	6.87	.1170	27	296.74	7.29	.1900
1924	5	333.40	7.24	.0723	21	329.86	7.58	.1578
1925	60	336.60	3.06	.1052	29	335.97	5.65	.1352
1926	12	322.75	9.50	.1518	26	328.54	5.59	.1295
1927	26	339.15	5.61	.1268	38	327.87	5.79	.1631
1928	40	332.13	4.29	.1223	34	325.65	6.93	.1856
1929	33	312.42	5.39	.1478	32	336.88	4.33	.1085
1930	33	347.79	3.14	.0779	24	291.83	6.90	.1716
1931	44	337.11	4.48	.1319	28	270.79	7.80	.2265
Total or Mean	267	333.33	1.67	.1225	259	317.07	2.32	.1759

#### 5. Absence of Broodiness in the Pullet Year

The results of selection for freedom from broodiness in one line and for intense broodiness in another line are summarized in Table 5.

In the non-broody line the proportion of non-broody birds varied from about 60 to 92 per cent: in the broody line the proportion ranged from about 4 to 50 per cent. The detailed data show that no non-broody families were obtained in the broody line, except in 1923 when 40 per cent of the families were entirely non-broody. In the non-broody line the percentage of non-broody families ranged from 28.6 to 66.7 with a mean of about 50. The data do not show progress either in eliminating broodiness or intensifying broodiness in the nine-year period.

There are three possible reasons for failure to make progress: (1) Small numbers of birds were used; (2) breeding pens were made up in part of genetically untested pullets and cockerels; and (3) there was no phenotypical record on the males.

The first two difficulties may be easily met, but the progeny test offers the only partial solution of the third difficulty.

These data as well as other records of the Station flock indicate that broodiness is a trait which it is very difficult to eliminate completely. As pointed out elsewhere, a female should not be classed as non-broody because she does not become broody during her first or second laying year; for it is not uncommon for broodiness to manifest itself during the third laying year or even later. Trap-nesting may also tend to discourage the instinct in some individuals. In order to eliminate this character in any line of birds, it would at least be necessary to trap-nest all female breeders throughout their productive life and to select male breeders entirely on the progeny test after all daughters have completed at least two laying years. Such a breeding scheme is expensive and is of questionable economic value.

TABLE 5. BIRDS NON-BROODY IN THE PULLET YEAR.

Year	Non-Broody Line			Broody Line		
	Total Number of Birds	Non-Broody Birds		Total Number of Birds	Non-Broody Birds	
		Number	Per cent		Number	Per cent
1923.....	14	11	78.57	27	13	48.15
1924.....	5	1	20.00	21	1	4.76
1925.....	60	35	58.33	29	0	.....
1926.....	12	9	75.00	26	1	3.85
1927.....	26	24	92.31	38	19	50.00
1928.....	40	24	60.00	34	5	14.71
1929.....	33	30	90.91	32	10	31.25
1930.....	33	26	78.79	24	0	.....
1931.....	44	34	77.27	28	4	14.29
Total or Mean	267	194	72.66	259	53	20.46

## 6. Age at Onset of Broodiness

A number of workers have pointed out the fact that the broody instinct may not appear during the first laying year and yet may appear in later years with considerable intensity. Goodale et al. (1920, loc. cit.) have shown that broodiness appears earlier in the first laying year in more intensely broody lines. On the same basis it might be assumed that deferred broodiness may be associated with low degree of broodiness. Management may be a factor in deferred broodiness, as Punnett and Bailey (1920) indicate.

In Table 6 the non-broody line alone is studied. The table includes the percentage of non-broody daughters (pullet-year record) from dams free of broodiness during their first laying year only; from dams free of broodiness for two laying years but exhibiting the trait in the third or later years; and from dams never observed to be broody in three or more laying years. Such a tabulation considers the phenotypical behavior of the dams only and gives no consideration to the male ancestry. The phenotypical nature of the daughters is reported for the pullet laying year alone, which does not correctly classify a considerable proportion. The data do show, however, in a general way the relative effectiveness of breeding from females with different degrees of deferred broodiness and from apparently non-broody individuals in developing a line free of broodiness in the pullet year.

TABLE 6 — NON-BROODY DAUGHTERS (PULLET-YEAR RECORD) FROM DIFFERENT CLASSES OF DAMS.

(Non-Broody Line Only)

Year	Dams Not Broody until the Second Year				Dams Not Broody until the Third Year or Later				Dams Not Broody in Three or More Years			
	No. Daughters				No. Daughters				No. Daughters			
	of	Total	Non-Broody		of	Total	Non-Broody		of	Total	Non-Broody	
	Dams	No.	No.	Per cent	Dams	No.	No.	Per cent	Dams	No.	No.	Per cent
1923	0				1	5	5	100.00	1	9	6	66.67
1924	0				0				2	5	1	20.00
1925	1	13	5	38.46	5	30	17	56.67	3	17	13	76.47
1926	0				2	12	9	75.00	0			
1927	1	4	3	75.00	2	10	10	100.00	2	12	11	91.67
1928	1	7	4	57.14	2	15	6	40.00	4	18	14	77.78
1929	1	10	9	90.00	2	13	11	84.62	3	10	10	100.00
1930	1	2	1	50.00	4	15	10	66.67	3	16	15	93.75
1931	2	20	18	90.00	2	13	8	61.54	3	11	8	72.73
Total or Mean	7	56	40	71.43	20	113	76	67.26	21	103	80	77.67

In the nine-year period reported, the seven dams free of broodiness for only the first year gave daughters about 71 per cent of which were non-broody the first year. There was, however, considerable fluctuation in individual years, with a minimum of 38 per cent and a maximum of 90 per cent. The number of dams in this class is very small, but the data do appear to indicate some progress in eliminating broodiness by this method of selection. The fact should be stressed in this connection that only one dam of the seven gave an entire family of non-broody daughters. This particular hen (K 917) was kept only until February 2 of her second laying year, and up to that time she had not gone broody; consequently she may not be correctly classified.

Twenty dams were free of broodiness for two laying years but exhibited the trait in the third year. Considerable fluctuation is seen from year to year in the percentage of non-broodiness in daughters of these dams, but there was no progressive increase in non-broody daughters as the experiment continued. The detailed records show that nine of these dams gave no broody daughters and that the eleven remaining dams gave varying proportions of broody and non-broody daughters. From the standpoint of eliminating broodiness, this group of dams was greatly superior to the preceding group which was free of broodiness in the pullet year only.

Twenty-one dams were never observed to be broody in three or more laying years. This group might reasonably be assumed to lack one or both of the broody factors. This group of females, when mated to the same males that were used on the previous two classes of hens, gave a somewhat higher percentage of non-broody daughters. Thirteen of these dams gave no broody daughters, and the remaining eight gave varying proportions of broody and non-broody daughters.

By Fisher's method, the mean percentages of non-broody daughters from the three classes of dams do not show significant differences. Such a result might be anticipated because of the small numbers involved.

From the genetic standpoint, however, the data show that the ability to transmit non-broodiness increased with deferred broodiness in dams and can be significantly increased by selection of hens for breeding that have not gone broody in the first three or more laying years.

### 7. Degree of Broodiness Measured by Number of Broody Periods

One of the most satisfactory measures of degree or intensity of broodiness is the number of distinct broody periods during the laying year. In the studies reported here, degree of broodiness was recorded on all individuals during the pullet laying year, which begins with the first egg laid and ends 365 days later.

Table 7 gives the mean number of broody periods each year for the two lines throughout the experiment and the mean for the entire experimental period. This table includes only individuals that became broody and not the entire population.

The data in table 7 show very clearly that the degree of broodiness was higher in the broody line. Without exception, year after year, the mean number of broody periods per broody bird was smaller in the non-broody line. There was also a slight tendency for degree of broodiness to decrease in succeeding generations in the non-broody line. The broody line, however, does not exhibit a significant change in degree of broodiness.

The coefficients of variation for the two lines do not indicate a decrease in variability throughout the experiment. This fact suggests that degree of broodiness is affected by environmental influences, although at the present time there is no definite information as to just what these environmental factors may be.

The mean number of broody periods for the two lines in the nine year period was  $2.63 \pm .16$  and  $3.99 \pm .11$ . The difference amounts to  $1.36 \pm .19$  and is clearly significant. The data in table 7 as a whole show that the degree of broodiness in the non-broody line was distinctly less than in the broody line.

TABLE 7.— BROODY PERIODS FOR BROODY BIRDS

Year	Non-Broody Line				Broody Line			
	Number of Birds	Mean Number of Broody Periods	P. E. of Mean	Coefficient of Variability	Number of Birds	Mean Number of Broody Periods	P. E. of Mean	Coefficient of Variability
1923	3	2.67	.37	.3535	14	3.07	.31	.5567
1924	4	3.75	.28	.2211	20	5.25	.30	.3851
1925	25	2.80	.33	.8806	29	4.17	.25	.4878
1926	3	2.00	.32	.4083	25	5.96	.40	.5033
1927	2	1.00	.00	.0000	19	2.11	.17	.5315
1928	16	2.75	.31	.6618	29	4.03	.29	.5655
1929	3	2.33	.73	.8081	22	3.59	.37	.7206
1930	7	2.57	.54	.8278	24	3.42	.26	.5599
1931	10	2.20	.39	.8332	24	3.54	.26	.5405
Total or Mean	73	2.63	.16	.7746	206	3.99	.11	.6033

### 8. Degree of Broodiness in Daughters from Various Classes of Mothers

The intensity of broodiness in all daughters from mothers with varying degrees of broodiness is considered to throw light on the inheritance of degree of broodiness. The broody line alone was used in these studies and the dams showed from one to eleven broody periods during their first laying year. Table 8 presents the detailed data.

The mean number of broody periods in all daughters from dams ranging in degree of broodiness from one to eleven broody periods showed a rather consistent increase as would be expected in an inherited character. The mean number of broody periods in daughters from the eleven different classes of dams when fitted to a straight line showed the difference in number of broody periods between all daughters of hens broody once and those broody eleven times to be 1.20 periods. Tested by the  $X^2$  test for goodness of fit the straight line was found to fit the data.



The conclusion seems justified, therefore, that degree of broodiness measured by number of broody periods in the first laying year behaves very definitely as an inherited character. The mode of inheritance has not been worked out as yet.

TABLE 8. DEGREE OF BROODINESS IN DAUGHTERS FROM DIFFERENT CLASSES OF DAMS.

Dams' Broody Periods	Daughters			
	Number of Birds	Mean Number of Broody Periods	P. E. of Mean	Coefficient of Variability
1	31	2.23	.27	.9863
2	46	2.04	.18	.8775
3	31	3.55	.35	.8094
4	18	2.89	.41	.8855
5	33	4.21	.37	.7456
6	18	3.72	.34	.5790
7	22	3.36	.40	.8339
8	9	3.89	.67	.7613
9	10	1.10	.34	1.4345
10	21	5.57	.33	.4016
11	14	3.29	.39	.6651

### 9. Laying House Mortality

Low mortality in the laying house is highly desirable from every standpoint. In Table 9 the percentage of females that died during their first laying year is recorded yearly in the non-broody and broody lines. The two lines do not show a significant difference in mortality. Considering the small number of birds used, the mortality rates in the two lines tended to be similar in the same year. The means of the two lines for the entire experimental period are almost identical. The data in Table 9 furnish no evidence of any relation between mortality rate in the laying house and the presence or absence of broodiness.

TABLE 9. LAYING HOUSE MORTALITY IN NON-BROODY AND BROODY LINES.

Year	Non-Broody Line			Broody Line		
	Total Number of Birds	Died in Laying House		Total Number of Birds	Died in Laying House	
		Number	Per cent		Number	Per cent
1923	21	5	23.81	40	9	22.50
1924	10	5	50.00	51	25	49.02
1925	81	18	22.22	47	12	25.53
1926	18	3	16.67	34	2	5.88
1927	42	13	30.95	71	28	39.44
1928	48	5	10.42	46	8	17.39
1929	70	24	34.29	50	10	20.00
1930	67	24	35.82	44	16	36.36
1931	60	13	21.67	43	10	23.26
Total or Mean	417	110	26.38	426	120	28.17

### 10. Winter Egg Production

Winter egg production includes the number of eggs laid by each individual from her first pullet egg up to March first. There is an intimate correlation  $+ .6214 \pm .0142$  between winter production and annual production in Rhode Island Reds (Hays, Sanborn and James, 1924). Table 10 records the mean winter egg production in the two lines throughout the experiment.

The data show that the non-broody line gave higher winter egg production throughout the experiment. By Fisher's method, the two series of nine mean winter records differ significantly. The weighted means for the nine-year period are also significantly different. In this experiment the non-broody line gave a winter egg production more than twelve eggs greater than the broody line.

TABLE 10. WINTER EGG PRODUCTION IN NON-BROODY AND BROODY LINES.

Year	Non-Broody Line				Broody Line			
	Number of Birds	Mean of Winter Egg Record	P. E. of Mean	Coefficient of Variability	Number of Birds	Mean of Winter Egg Record	P. E. of Mean	Coefficient of Variability
1923	14	61.00	5.22	.4869	27	52.37	2.43	.3582
1924	5	68.00	6.77	.3277	21	58.10	2.23	.2644
1925	60	73.52	2.16	.3376	29	73.90	3.05	.3348
1926	12	81.33	4.14	.2593	26	54.58	1.92	.2687
1927	26	99.04	2.65	.2015	38	83.39	2.68	.2931
1928	40	74.40	2.13	.2685	34	72.29	1.94	.2314
1929	33	68.67	3.00	.3722	32	70.41	2.68	.3175
1930	33	101.24	3.67	.3106	24	82.04	3.14	.2778
1931	44	90.91	2.29	.2481	28	65.93	2.65	.3166
Total or Mean	267	81.42	1.14	.3382	259	69.08	.97	.3372

### 11. Annual Egg Production

Annual egg records represent the number of eggs laid by each individual from her first pullet egg to a date 365 days later. In this experiment the two lines are considered first as made up of broody and non-broody individuals and second as entire populations. As stated earlier in this report, the attempt is being made to develop the two lines for similarity in all characters except broodiness. In section 3, however, the two lines are shown to differ in winter pause. In age at first egg, winter clutch size, and persistency the two lines do not differ significantly. Table 11 presents the condensed data.

Both lines were made up of broody and non-broody individuals in the pullet laying year. The 194 non-broody individuals in the non-broody line averaged  $212.21 \pm 2.01$  eggs per year for the experimental period, compared with  $184.94 \pm 3.08$  eggs for the 53 non-broody birds in the broody line. This is a significant difference and indicates that the two lines differed in their egg-laying ability aside from degree of broodiness.

Considering the broody individuals in the two lines, 73 in the non-broody line averaged  $203.41 \pm 2.94$  eggs compared with  $177.50 \pm 1.48$  for the 206 birds in the broody line. In the case of these two groups of birds, the difference in mean annual production may be attributed in large part to differences in degree of broodiness.

When all birds in the two lines are considered, the data show that the mean annual egg production of the non-broody line excelled that of the broody line in every year reported. The mean for the entire experimental period for the 267 birds in the non-broody line was  $209.81 \pm 1.67$  and for the 259 birds in the broody line,  $179.02 \pm 1.34$ . The actual difference in this case was  $30.79 \pm 2.14$  eggs. By Fisher's method, the probability of obtaining chance differences in annual egg production as great as those reported in the nine-year period is zero. The data clearly indicate that the non-broody line was distinctly superior to the broody line from the standpoint of annual egg production.

TABLE 11. MEAN ANNUAL EGG PRODUCTION IN BROODY AND NON-BROODY LINES.

Year	Non-Broody Line						Broody Line					
	Non-Broody Birds		Broody Birds		Total Birds		Non-Broody Birds		Broody Birds		Total Birds	
	Number	Mean	Number	Mean	Number	Mean	Number	Mean	Number	Mean	Number	Mean
	Birds	Annual Egg Record	Birds	Annual Egg Record	Birds	Annual Egg Record	Birds	Annual Egg Record	Birds	Annual Egg Record	Birds	Annual Egg Record
1923.....	11	219.36	3	229.67	14	221.64	13	183.46	14	165.00	27	173.89
1924.....	1	199.00	4	183.25	5	186.40	1	162.00	20	163.40	21	163.33
1925.....	35	201.69	25	199.32	60	200.70	0	.....	29	183.24	29	183.24
1926.....	9	204.56	3	225.00	12	209.67	1	169.00	25	164.80	26	164.96
1927.....	24	214.25	2	225.00	26	215.08	19	192.79	19	184.16	38	188.48
1928.....	24	204.75	16	213.31	40	208.17	5	190.20	29	180.76	34	182.15
1929.....	30	193.43	3	179.67	33	192.18	10	177.00	22	186.91	32	183.81
1930.....	26	235.08	7	183.86	33	224.22	0	.....	24	180.83	24	180.83
1931.....	34	226.06	10	208.00	44	221.96	4	175.50	24	181.63	28	180.75
Total or Mean.....	194	212.21	73	203.41	267	209.81	53	184.94	206	177.50	259	179.02

NON-BROODY AND INTENSE BROODY LINES

### Summary

1. Two lines of Rhode Island Reds, bred for non-broodiness and broodiness, respectively, were carried through a nine-year period to study the nature of the broody instinct and its relation to fecundity.

2. These two lines proved to be essentially identical in age at sexual maturity, winter clutch size, and annual persistency.

3. The non-broody line exhibited a shorter winter pause than the broody line, and also more families free from pause.

4. The mean percentage of non-broody daughters, for the period of the experiment, was 72.66 in the non-broody line and 20.46 in the broody line.

5. Dams free from broodiness for three or more years gave a significantly greater proportion of non-broody daughters than was obtained from dams free from broodiness for one or two years only.

6. The data indicate that broodiness cannot be entirely eliminated by the selection of aged broody-free dams. It seems probable that the breeding test for males offers the only possible solution.

7. The two lines showed a distinct difference in degree of broodiness in broody individuals as measured by the number of broody periods. The non-broody line had  $2.63 \pm .16$  periods and the broody line  $3.99 \pm .11$  periods in this experiment.

8. Degree of broodiness is definitely inherited, as shown by the fact that daughters showed a definite and consistent increase in degree of broodiness as the number of broody periods of the dams increased.

9. No difference in mortality in the laying houses was observed in the two lines.

10. Mean winter egg production was about twelve eggs greater per individual in the non-broody line.

11. Annual egg records were significantly higher for non-broody birds in the non-broody line than for non-broody birds in the broody line.

12. Annual egg production of broody birds in the non-broody line was greater than that of broody birds in the broody line.

13. When all birds are considered, the average annual production was  $209.81 \pm 1.67$  eggs for the non-broody line as compared with  $179.02 \pm 1.34$  eggs for the broody line.

### References

- Fisher, R. A. 1930. Statistical methods for research workers. 3d ed. Oliver and Boyd, London.
- Goodale, H. D., Ruby Sanborn and Donald White. 1920. Broodiness in domestic fowl. Mass. Agr. Expt. Sta. Bul. 199.
- Hays, F. A., Ruby Sanborn and L. L. James. 1924. Correlation studies on winter fecundity. Mass. Agr. Expt. Sta. Bul. 220.
- Hays, F. A., and Ruby Sanborn. 1927. Net correlations of characters concerned in fecundity. Mass. Agr. Expt. Sta. Tech. Bul. 12.
- Hays, F. A., and Ruby Sanborn. 1932 a. Types of intensity in Rhode Island Reds. Mass. Agr. Expt. Sta. Bul. 286.
- Hays, F. A. 1932 b. Hereditary and environmental factors affecting variability in egg production. Mass. Agr. Expt. Sta. Bul. 289.
- Jull, M. A. 1932. Poultry breeding. John Wiley and Sons, New York.
- Punnett, R. C., and P. G. Bailey. 1920. Genetic studies in poultry.
11. Inheritance of egg color and broodiness. Jour. Genetics 10:277-292.