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THE INFLUENCE OF STRAIN, PROTEIN LEVEL AND HOUSING DENSITY ON CORRELATIONS AMONG TRAITS OF LAYING HENS

A Dissertation

Presented to

the Graduate Council of

The University of Tennessee

In Partial Fulfillment

of the Requirements for the Degree

Doctor of Philosophy

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by

Saravanam Srinivasan

August 1972

DEDICATED TO

DR. O. E. GOFF

AND MY PARENTS

1040178

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ABSTRACT

Data collected during the Twelfth, Thirteenth and Fourteenth Tennessee Random Sample Laying tests (1969-1971) were analyzed by computing conventional product-movement coefficients of correlation among production variables for each strain and treatment subclass in each test to determine the magnitude of these relationships. Then various coefficients of correlation between income over feed and chick cost and other production variables for each strain, protein level and cage-density subclass in each test were computed and subjected to tests of homogeneity.

There were strain differences and treatment differences in many of the correlations calculated, as indicated by the tests of homogeneity. It was obvious from the results that both sample size and magnitude of correlations being compared play a part in determining the outcome of tests of homogeneity. Correlations larger than .9 which were very similar in value were frequently declared nonhomogeneous even when sample sizes were quite large. In many instances, smaller correlations were declared homogeneous, even though appreciably different from one another.

Although comparison of correlation estimates was not a stated objective of these random sample tests, the results of this empirical study indicate that consideration of homogeneity (or lack of it) among separate estimates is essential if one is to draw valid conclusions

concerning correlation between variables, especially if investigation of correlation is a major objective of an experiment with quantitative variables such as those represented in the data from random sample laying tests.

No particular treatment combination, among those studied here, was consistently superior to any other in increasing correlations of income over feed and chick cost with other variables.

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CHAPTER I

INTRODUCTION

The relative importance of various production traits which determine profitability of a strain of egg laying chickens is a matter of great importance to breeders of such stocks. Hence, it is often of primary importance to know exactly the extent to which these various production traits influence one another or are related to one another. In the case of negative correlation between two traits, both of which need to be increased, selection for one trait may cause serious depression in the other. Thus, it is extremely important to know the magnitude and sign of various correlations in order to plan selection programs and mating systems.

Phenotypic correlations between different traits are the result of combination of genetic and environmental correlations. Genetic correlations may arise from pleiotropic action of genes and/or, temporarily, from disequilibrium among various combinations of the genes involved. Environmental correlations are a result of the fact that two or more traits develop in the same animal and are thus exposed to the same environmental deviation from the average environmental influence. At the present time breeders in the poultry industry are interested in all economically important traits and in the environmental and genetic effects on them.

Bartlett's test of homogeneity of variances is a familiar test of homogeneity used to ascertain the homogeneity (confidence with which

they can be considered to be estimates of the same population variance) of a group of separate sample estimates of variance. However, homogeneity of correlations is apparently given very little consideration by research workers. Homogeneity tests among phenotypic correlation coefficients are conducted to ascertain whether the sample correlations are estimates of the same population parameter or if the samples from which they were calculated actually came from different populations. Thus, it is extremely important to know the homogeneity or heterogeneity of correlation coefficients before combining separate estimates to obtain a single better estimate of the parameter ρ (rho).

Numerous studies have been conducted on means of various production traits of strains and other variables in the Random Sample Laying Tests (Nordskog, 1960, Nordskog and Kempthorne, 1960, Abplanalp *et al.*, 1962, Mackin, 1970). No published record of any previous study of phenotypic correlations among various production traits with the same objective as the present study was found in the literature available.

I. OBJECTIVE

The objective of this study was to determine the magnitude and homogeneity of coefficients of correlation among various production traits when calculated within different strains, within different protein levels and within different housing densities.

CHAPTER II

REVIEW OF LITERATURE

I. PRODUCTION TRAITS

Studies of egg production traits and other traits and of correlations among them have been reported by numerous research workers and have been reviewed by Jull (1940), Hutt (1949) and Lerner (1950). No attempt will be made to present an exhaustive review of these reports, but attention will be concentrated on production variables which determine the genetic-economic value of a breeding flock.

Egg Production and Egg Weight

Atwood (1923), Jull (1924), Lippincott et al. (1925), Atwood and Clark (1930), Hays (1944) and Fransworth (1956) found positive correlations between egg production and egg weight, but Parkhurst (1926), Atwood (1925), and Hogsett and Nordskog (1958) reported negative correlations between these traits. The relationship of the same traits was found to be nonlinear by Marbel (1930), Blyth (1952), Wyatt (1954), and Farnsworth and Nordskog (1955).

Egg Production and Body Weight of Birds

Considerable work has been done by investigators to determine the relationship between body weight and egg production. Sherwood (1922), Hervey and Lewis (1924), Atwood and Clark (1930), and King

(1961) reported positive correlation between these traits, but Jull (1924), and Platt (1927) found negative correlations.

Body Weight of Hen and Egg Weight

Atwood (1923), Atwood and Clark (1930), and Hogsett and Nordskog (1958) found significant positive correlations between body weight and egg weight, but Jull (1924), and King (1961) reported positive but non-significant relationship. Some other investigators (Marble, 1930; Wyatt, 1954; and Farnsworth and Nordskog, 1955) reported correlations between these traits to be nearly zero, slightly positive or even curvilinear.

Egg Production and Albumen Quality

The effectiveness of selection in improving albumen quality has been studied by several workers (Lorenz and Taylor, 1940; Knox and Godfrey, 1940). Knox and Godfrey (1938) found no relationship between egg production and albumen quality. Miller and Bearse (1937), Jeffrey (1941), Brant et al. (1953) and Johnson and Merritt (1955) reported highly significant negative correlations between these traits. However, King and Hall (1955) in their study over a period of four years of the New York Random Sample Test, found a nonsignificant correlation of -.1113 between egg production and Haugh units (a commonly used measure of albumen quality).

Egg Weight and Haugh Units

King (1961) found a correlation of .12 between 32-week egg weight and Haugh units.

Egg Quality Factors

Strain and breed differences have been established with respect to quality of albumen. Van Wagenen et al. (1937) surveyed the Western and Central New York standard egg laying tests and reported that eggs of Barred Plymouth Rocks and White Plymouth Rocks had significantly less firm albumen than did the eggs of other breeds in these tests.

Hall (1939) found no consistent breed differences among White Wyandottes, Barred Plymouth Rocks, Rhode Island Reds, and White Leghorns with respect to total weight of egg white, height of albumen, and percentage that weight of white made up of total egg weight.

Brant et al. (1953) in their survey of egg quality in two egg laying tests found small breed differences for albumen quality and shell thickness.

While there is some inconsistency in the findings of various workers, it appears that, in general, there are significant strain and breed differences with respect to several traits of economic importance. In spite of the fact that some early studies showed positive correlation between egg weight and number of eggs produced, most workers would agree that this correlation, as one would logically expect, is negative. Also, a positive correlation between egg weight and body weight is logical and generally accepted. Correlations of egg quality variables and other traits appear to be quite inconsistent and may be truly different, that is, not homogeneous, from sample to sample.

II. HOMOGENEOUS AND HETEROGENEOUS CORRELATIONS

A search of the literature indicates that the amount of work done in this area is limited. In the absence of any reports of studies specifically and primarily focused on the matter of homogeneity of correlations in poultry, a review will be given of certain basic textbook discussions of the subject and of certain experimental results which are relevant.

Examples of Homogeneity of Correlation Coefficients

Lush (1931) in his studies of steers on three feeding experiments calculated an average correlation coefficient value after testing for homogeneity of separate estimates and obtaining a chi-square value of 4.949. This value was not significant for four degrees of freedom in his steer experiment. Thus, it was statistically valid to combine the separate estimates to obtain a better estimate. In the ensuing four decades since this report was published many workers have reported pooled estimates of correlation derived from separate estimates which were not homogeneous.

Steel and Torrie (1960) pooled the coefficients of correlation between percent of resin content and percent of rubber content from data of Federer (1946). The correlation coefficients in the data ranged from .362 to .527 with a sample size of 50 for three strains. They obtained a nonsignificant chi-square value of 1.049 (two degrees of freedom) and, hence, declared the correlation coefficients to be homogeneous.

In testing the hypothesis $\rho_1 = \ldots = \rho_k$ (k = 3, sample size, 102) Ostle (1963) tested the homogeneity of correlation coefficients ranging from .632 to .775 and obtained a chi-square value of 4.439. With two degrees of freedom, the probability of a greater chi-square would be between .05 and .01. This probability is low enough to make pooling questionable, but if the probability of a greater chi-square is above the specified "significance" level, a pooled estimate of ρ (corresponding to the "average z") may appropriately be calculated.

In an example given by Snedecor (1965) about the test of significance of the difference between two correlations of gain with feed consumed by swine (source of data not mentioned), he concluded that the z's (transformed r's) were from a common population. The correlation coefficients considered in his studies were .87 calculated from a sample of five pigs and .56 calculated from a sample of twelve pigs.

Sokal and Rohlf (1969), to illustrate the test of homogeneity among correlation coefficients, considered the data of Brown and Comstock (1952). The data contained correlations between wing length and width of a band on the wing in females of ten populations of a species of butterfly. These samples were collected in different locations of the Caribbean area. The correlation coefficients ranged from .29 to .70, and sample size ranged from 17 to 100. In their illustration, a chi-square value of 15.26 was obtained (nine degrees of freedom). Their specified "significance" level was .05, hence, they declared the separate estimates to be homogeneous since the probability of a greater chi-square would be between .05 and .01.

Ezekiel and Fox (1959) developed and published graphs showing the observed correlations in the sample and true correlations and used the graphs in determining the reliability of observed correlations in their study of Fisher's methods.

Examples of Heterogeneity of Correlation Coefficients

Paterson (1939) tested the homogeneity of the yearly correlations between yield of wheat and size of seed for five years, 1914 through 1918, and obtained a chi-square value of 11.42 (four degrees of freedom), which indicated significant differences among the individual estimates of ρ, since the probability of a greater chi-square would be between .01 and .025.

Kosin et al. (1952) in their study involving eight different breed types of chickens, to investigate the influence of weight of hatching eggs on weight gain of chicks hatching from them, pooled the correlation coefficients for males and females separately by years for 1947, 1948 and 1949. Their 1949 correlations for males and females resulted in chi-square values of 34.67 and 78.62, respectively (seven degrees of freedom), which indicated significant differences among the individual estimates of ρ, since the probability of a greater chi-square would be beyond .005. The coefficients of correlation in their data from males and females ranged from .71 to .96 and .71 to .97, respectively. The sample size in males and females ranged from 28 to 75 and 30 to 75, respectively.

Thus the tests of homogeneity of sample correlation coefficients which Kosin et al (1952) either did not conduct or, at least, did not

mention, indicate that the sample values should not have been pooled as the authors did for their publication. This is only one example, but it is typical of many published reports of invalidly pooled correlation coefficients.

CRANES CREST

CHAPTER III

EXPERIMENTAL PROCEDURE

I. SOURCE AND DESCRIPTION OF DATA

Data used for this study were obtained from the Twelfth, Thirteenth, and Fourteenth Tennessee Random Sample Laying Tests.

Each of the tests was initiated by securing hatching eggs of each strain (entry) to be entered. Three cases of eggs were seucred from each breeder farm. Strains in each of the tests were subjected to uniform management practices during the incubation, growing, and laying periods. When the chicks were one day of age, they were sexed, wing banded, and vaccinated against Newcastle disease and infectious bronchitis. During the first ten weeks in the brooder house, infrared heat lamps served as the heat source. The pullets were moved to a growing shelter when they were ten weeks of age. Newcastle and infectious bronchitis vaccinations were repeated at 70 and 140 days. When they were approximately 12 weeks of age, all brids were vaccinated against fowl pox. A coccidiostat was used in the starter and grower diets. At 20 weeks of age all pullets were debeaked. The chicks of the Twelfth and Thirteenth tests received a 22-percent protein starter diet until they were housed at 147 days and 141 days of age, respectively. The chicks of the Fourteenth Test also received a 22-percent protein starter diet until they were 10 weeks of age (Table I).

TABLE I

STARTER AND GROWER DIETS

Feedstuff	Starter BR1[a]	Grower GR8[a]	Grower GR6[a]
	Lbs.	Lbs.	Lbs.
Yellow corn	638.00	883.75	718.75
Alfalfa meal, 17%	25.00	50.00	50.00
Fish meal	25.00	---	25.00
Vitamin mix	6.00	6.00	6.00
Defluorinated rock phosphate	15.00	20.00	15.00
Ground limestone	6.00	10.00	10.00
Salt	4.80	5.00	5.00
Manganese sulfate	0.20	0.25	0.25
Soybean oil meal, 50%	255.00	---	145.00
Coccidiostat Premix	25.00	25.00	25.00
	1,000.00	1,000.00	1,000.00
Calculated to contain:			
Crude protein, percent	21.95	10.18	17.59
Productive energy, C/lb.	957.00	1,012.00	966.00
C/P (Calorie:protein ratio)	43.60	99.41	59.92
Metabolizable energy C/lb.	1,365.00	1,443.00	1,382.00
Metabolizable energy C/P ratio	62.19	141.75	78.57
Methionine, percent	0.363	0.194	0.309
Cystine, percent	0.329	0.172	0.265
Lysine, percent	1.251	0.377	0.928
Calcium, percent	0.894	1.100	1.057
Phosphorus, percent	0.681	0.612	0.636
Available phosphorus, percent	0.435	0.435	0.421
Manganese, mg./lb.	32.210	34.570	37.080
Vitamin A, I.U./lb.	5,349.000	8,217.000	7,966.000
Vitamin D, I.C.U./lb.	340.000	340.000	340.000
Riboflavin, mg./lb.	3.050	2.900	3.100
Niacin, mg./lb.	28.440	27.470	28.430
Pantothenic acid, mg./lb.	6.710	5.950	6.570
Choline, mg./lb.	761.020	462.800	654.200

[a]Minerals and vitamin content calculated to equal or exceed requirements as given by National Research Council.

A cage laying house was employed throughout these tests. The pullets were all housed in cages 8" x 16", where they remained for 360 days of production. In the Twelfth and Thirteenth tests, one-half of the mature pullets of each entry was housed at the rate of one bird per cage, while the other half of each entry was housed at the rate of two birds per cage. Thus, entries in these tests were divided into eight lots at housing, four lots of 15 pullets each with one bird per cage and four lots of 30 pullets each with two birds per cage. At housing, all pullets received a laying diet containing 17.2 percent protein (Table II). When the house production reached 50 percent, two lots of each of the one-bird and two-birds-per-cage groups were placed on a diet of 13.4 percent protein (EL 38, Table II) with the other lots remaining on the 17.2-percent protein diet. In the Fourteenth Test all the mature pullets were housed at the rate of two birds per cage. At 10 weeks of age, each entry was divided into four pens, and two pens of each entry were placed on a 17.6-percent protein grower diet and the other two pens on a 10.2-percent protein diet (Table I, page 11). At 20 weeks of age, 60 pullets of each entry from each of the two protein treatment levels were placed in laying cages. The remaining pullets were continued on the two treatments to 24 weeks of age at which time 60 pullets of each entry from each protein treatment level were housed in laying cages. All tests were terminated when the birds were approximately 500 days of age. In each test this age was attained during the first 12 days of August of the respective years. There were 14 strains, one of which was the Kentville-Cornell control stock, in each test.

TABLE II

LAYER DIETS

Feedstuff	Hi-Protein Layer LR3[a]	Low-Protein Layer EL38[a]
	Lbs.	Lbs.
Yellow corn	669.75	762.25
Alfalfa meal, 17%	50.00	50.00
Fish meal	25.00	25.00
Vitamin mix	5.00	5.00
Defluorinated rock phosphate	15.00	15.00
Ground limestone	60.00	60.00
Salt	5.00	5.00
Manganese sulfate	0.25	0.25
Soybean oil meal, 50 %	170.00	77.50
Coccidiostat premix	---	---
	1,000.00	1,000.00
Calculated to contain:		
Crude protein, percent	17.19	13.39
Productive energy, C/lb.	911.00	940.00
C/P (Calorie:protein ratio)	53.02	70.20
Metabolizable energy C/lb.	1,280.00	1,315.00
Metabolizable energy C/P ratio	74.45	98.20
Methionine, percent	0.297	0.250
Cystine, percent	0.266	0.203
Lysine, percent	0.923	0.643
Calcium, percent	2.957	2.939
Phosphorus, percent	0.621	0.584
Available phosphorus, percent	0.417	0.406
Manganese, mg./lb.	36.700	35.660
Vitamin A, I.U./lb.	7,123.000	7,262.000
Vitamin D, I.C.U./lb.	1,342.000	1,342.000
Riboflavin, mg./lb.	2.931	2.870
Niacin, mg./lb.	20.680	20.630
Pantothenic acid, mg./lb.	5.440	5.090
Choline, mg./lb.	631.450	529.700

[a]Minerals and vitamin content calculated to equal or exceed requirements as given by National Research Council.

Description of Variables and Variable Names

The variables considered in assessing relationships were: eggs-per-pullet-housed (E/P), market weight of hens (MW), egg weight (EW), and Haugh units (HU).

The variables considered in the homogeneity study were: income over feed and chick cost (IOFCC), percent hen-day production (PHDP) after 50 percent production, market weight of hens (MW), percent mortality (PM), pounds of feed per dozen of eggs (PF/DE), one bird per cage with 17.2-percent (high) protein laying diet (D1P1), one bird per cage with 13.4-percent (low) protein laying diet (D1P2), two birds per cage with 17.2-percent (high) protein laying diet (D2P1), two birds per cage with 13.4-percent (low) protein laying diet (D2P2), 10 to 20 weeks growing period with 17.6-percent (high) protein growing diet (G1P1), 10 to 20 weeks growing period with 10.2-percent (low) protein growing diet (G1P2), 10 to 24 weeks of growing period with 17.6-percent (high) protein growing diet (G2P1), and 10 to 24 weeks of growing period with 10.2-percent (low) protein growing diet (G2P2).

Data Collection

Traits considered in this study were measured on a per-lot basis. Eggs per pullet housed was calculated as the total number of eggs produced divided by the total number of pullets housed. Percent hen-day production was calculated by multiplying by 100 the ratio of average number of eggs laid per hen to the average number of days each hen had spent in the laying house. Market weight of the hen was the live body weight at the end of the test period.

Percent mortality was determined by multiplying by 100 the ratio of total number of dead birds per lot to the total number of birds housed per lot.

Feed consumed was determined each month for each pen. The total weight of eggs, in grams, laid on one day each week was recorded for each lot, permitting calculation of the amount of feed required to produce a unit weight of eggs. The eggs used to obtain the above weights were then sized into classes of: peewee, medium, large and extra large and over in order to obtain the size distribution. The weights in ounces per dozen of eggs for each of the above size categories were: under 17, 17-19, 20-22, 23-25, 26 and over, respectively. The Haugh unit score was calculated using the average albumen height and average egg weight for each lot, according to the widely used Haugh-unit formula.

The income over feed and chick cost was calculated. The prices of feed, eggs, market hens and chicks used to calculate costs and income were local prices and assumed to be representative of the local situation at that particular time. The chick price was obtained from each breeder as the price per chick in lots of 1,000 day-old pullet chicks. All hens were sold at the termination of each test at the market price per pound existing at that time. Feed consumption during the growing period was calculated by determining the average weight of pullets at housing and multiplying this weight by six, the estimated pounds of feed required to produce a pound of egg-type pullet at 140 days of age. The cost of the feed consumed during the laying period plus the value of

feed consumed during the growing period and cost of the day-old chicks was the feed and chick cost for each of the three tests.

The income from eggs laid was determined by using the market price for small, medium, and large eggs as quoted on the Chicago market. Prices quoted were those paid to the first receiver, 80 percent Grade A. The total eggs, in dozens, of each size produced was multiplied by the average price per dozen for the year, giving the income from eggs. Since the market reports gave no quotation for peewee size eggs, this price was determined by subtracting the average difference in price between small and medium sizes from the price paid for small eggs. The income from eggs produced by birds of each stock was determined as the gross income from eggs credited to that stock minus the percentage of income lost due to eggs having blood and meat spots of any size.

II. METHODS OF ANALYSIS

The approach taken in the analysis of these data was first to compute coefficients of correlation among production variables for each strain and treatment subclass in each test to determine the magnitude of these relationships. Then various coefficients of correlation between income over feed and chick cost and other production variables for each strain, protein level, and cage density subclass in each test were computed and subjected to tests of homogeneity.

Correlation coefficients were conventional product-moment coefficients computed by the new Statistical Analysis System of Barr and

Goodnight (1970). Tests of homogeneity were conducted as described by Fisher (1950).

Procedures for Conducting Tests of Homogeneity

1. Each correlation coefficient (r) is transformed to z. where $z = \log_e (1 + r)/(1 - r)$.

2. Each z is weighted (multiplied) by its mean square $(n_i - 3)$, where n_i = the sample size and 3 is a constant.

3. The sum of weighted z's is divided by the sum of weights, $\Sigma (n_i - 3)$, to obtain $\bar{z}_w$ (average z).

To test the hypothesis that sample correlations are estimates of a common population correlation, each squared deviation $(\bar{z}_w - z_i)^2$ is multiplied by $(n_i - 3)$ and added to obtain a chi-square value. $\Sigma (\bar{z}_w - z_i)$ is distributed as chi-square with $(k - 1)$ degrees of freedom when k normal variates (z's) are all estimates of the same population mean but have different variances.

In Table III, correlation coefficients among traits studied are identified by strain number in all the tests. Each strain number thus indicates that a correlation coefficient was found between the traits considered, and the location of the strain number in the table shows the category of that correlation coefficient, viz., highly significant ($P < .01$), significant ($.01 < P < .05$), positive but nonsignificant ($P > .05$) and negative but nonsignificant. In cases where significant and highly significant correlation were negative, the minus sign follows the strain number in parentheses.

TABLE III

CLASSIFICATION OF STRAINS BASED UPON COEFFICIENTS OF CORRELATION AMONG PRODUCTION TRAITS (TWELFTH, THIRTEENTH AND FOURTEENTH TESTS)

Traits Correlated	Strains Identified by Types of Correlations*			
	Highly Significant (P < .01)	Significant (.01 < P < .05)	Positive (P > .05)	Negative (P > .05)
E/P and EW[a]				
12th test		5	1,2,4,6,9,11,13,14	3,7,8,10,12
13th test			1-7,9-11,14	8,12,13
14th test		1(-)	4,5,7,10,12	2,3,6,8,9,11,13,14
E/P and MW[b]				
12th test	11(-)	8	1,4,5,7,9,14	2,3,6,10,12,13
13th test			1,4,5,7,8,10,13	2,3,6,9,11,12,14
14th test			6,8,14	1-5,7,9-13
MW and EW[c]				
12th test			1-5,7,9,10,13,14	6,8,11,12
13th test			1,3-5,10-14	2,6-9
14th test		5(-)	1-4,8,9,12,14	6,7,10,11,13

TABLE III (continued)

Traits Correlated	Strains Identified by Types of Correlations*			
	Highly Significant (P < .01)	Significant (.01 < P < .05)	Positive (P > .05)	Negative (P > .05)
EW and HU[d]				
12th test			1,3,4,8,10,14	2,5-7,9,11-13
13th test		4(-)	1,3,6,7,10-13	2,5,8,9,14
14th test		5	1-3,6-10,12	4,11,13,14

*Sign of coefficient of correlation is in parentheses.

[a]Eggs per pullet housed and average egg weight.

[b]Eggs per pullet housed and market weight of hens.

[c]Market weight of hens and average egg weight.

[d]Average egg weight and average Haugh units.

CHAPTER IV

RESULTS AND DISCUSSION

I. PRODUCTION TRAITS

Egg Production and Average Egg Weight

Strains were found to differ from one another with respect to the relationship between the traits E/P and EW in all three tests. It was interesting to note that correlations between these two traits in the Regional control stock were positive in the Twelfth and Thirteenth tests but negative in the Fourteenth test. Significant positive and negative correlations, respectively, were found in strain five (which was the heaviest strain in the Twelfth test) and in strain one (which was medium in body weight in the Fourteenth test). The correlation coefficients in lightweight strains were negative for these two traits in the Twelfth and Thirteenth tests and positive in the Fourteenth test. Another interesting feature observed was that strains eight and twelve showed negative coefficients of correlation between these two traits in the Twelfth and Thirteenth tests, and these strains were from the same breeder farm. Thus, these strains of the same breeder farm exhibited the same sign for this correlation in these two tests (Table III, page 18).

These results with respect to positive correlations agree generally with the results of Atwood (1923), Lippincott *et al*. (1925),

Atwood and Clark (1930), Hays (1944), and Farnsworth (1956), who found positive coefficients of correlation between these two traits in the birds they studied also. Similarly, the negative correlation coefficients are in general agreement with those reported by Parkhurst (1925), Atwood (1925), and Hogsett and Nordskog (1958).

The results show that some strains produced more large eggs while others produced more small eggs or fewer large eggs. The r's between these two traits were positive in all three tests except for treatment D2P2 in the Thirteenth test when strains were combined (Tables IV and V). There were highly significant correlations between these two traits in treatment D1P1 and D1P2 and a significant correlation in treatment D2P1 in the Twelfth test. Thus, the study showed strain and treatment differences in sign and magnitude of the coefficients of correlation between these two traits.

Egg Production and Market Weight of Hens

Some positive and some negative coefficients of correlation were found between E/P and MW in all three tests. Strains eight and eleven in the Twelfth test yielded significant and highly significant positive and negative correlations, respectively, between these two traits, but the same strains exhibited negative and positive relationships, respectively, between eggs per pullet housed and average egg weight. These results indicate that strain eleven produced more large eggs with decreased body weight or fewer eggs with increased body weight. Strain eight produced more small eggs or fewer large eggs, and, as egg

TABLE IV

COEFFICIENTS OF CORRELATION AMONG ECONOMIC TRAITS BY TREATMENTS WITH ALL STRAINS COMBINED (TWELFTH AND THIRTEENTH TESTS)

Test Traits	Eggs per Pullet Housed				Average Egg Weight			
	D1P1[a]	D1P2[b]	D2P1[c]	D2P2[d]	D1P1	D1P2	D2P1	D2P2
Average Egg Weight								
Twelfth	0.67**	0.77**	0.55*	0.47				
Thirteenth	0.33	0.08	0.18	-0.39				
Market Weight of Hens								
Twelfth	-0.13	-0.26	-0.58*	-0.51*	0.10	0.12	0.06	-0.02
Thirteenth	0.07	-0.20	-0.02	-0.40	0.06	0.42	-0.20	-0.03
Average Haugh Units								
Twelfth	-0.19	-0.31	-0.09	-0.29	-0.08	-0.29	-0.28	-0.02
Thirteenth	-0.43	-0.05	0.08	-0.30	-0.33	-0.02	-0.38	-0.10

[a]One bird per cage and 17.2-percent protein laying diet.

[b]One bird per cage and 13.4-percent protein laying diet.

[c]Two birds per cage and 17.2-percent protein laying diet.

[d]Two birds per cage and 13.4-percent protein laying diet.

TABLE V

COEFFICIENTS OF CORRELATION AMONG PRODUCTION TRAITS BY TREATMENTS WITH ALL STRAINS COMBINED (FOURTEENTH TEST)

Traits	Eggs per Pullet Housed				Average Egg Weight			
	G1P1[a]	G1P2[b]	G2P1[c]	G2P2[d]	G1P1	G1P2	G2P1	G2P2
Average Egg Weight	0.08	0.19	0.32	0.18				
Market Weight of Hen	-0.57*	-0.39	-0.38	-0.51*	-0.26	-0.12	-0.20	-0.04
Average Haugh Units	-0.50	-0.23	-0.09	-0.39	0.06	-0.25	-0.06	0.17

*Significant ($P < 0.05$).

[a]10 to 20 weeks growing period and 17.6-percent protein growing diet.

[b]10 to 20 weeks growing period and 10.2-percent protein growing diet.

[c]10 to 24 weeks growing period and 17.7-percent protein growing diet.

[d]10 to 24 weeks growing period and 10.2-percent protein growing diet.

production increased, body weight increased also in this strain (Table III, page 18).

The positive relationship found agrees generally with those of Sherwood (1922), Hervey and Lewis (1924), Atwood and Clark (1930) and King (1961). Similarly, the negative relationship observed is in close agreement with the results of Jull (1924) and Platt (1927). The preference of light or heavy birds rests with the breeders. Breeders vary considerably in this respect, but economic considerations make it appear that light-bodied hens should be preferred at the present time.

The r's between these two traits were negative in all three tests when all strains were combined (Tables IV and V, pages 22 and 23). Some of the treatments in the Twelfth and Fourteenth tests exhibited significant negative correlations. This again indicated strain and treatment differences in correlations calculated.

Market Weight of Hen and Average Egg Weight

Analyses yielded both positive and negative correlations between these traits. Strain five in the Fourteenth test exhibited a significant negative correlation (Table III, page 18). This is a unique result of the present study since no previous studies have reported negative coefficients of correlation between these characteristics. The studies of Jull (1924) and King (1961) showed a positive but nonsignificant relationship. Atwood (1923), Atwood and Clark (1930), and Hogsett and Nordskog (1958) found significant positive correlations. The negative relationship found here was unexpected and difficult to explain.

Positive coefficients of correlation between these two traits were observed in the Twelfth and Thirteenth tests except for trestment D2P1 in the Thirteenth test in which it was negative (Table IV, page 22). The r's in the Fourteenth test were all negative (Table V), page 23). Similar to the previous study, this indicated the strain and treatment differences in correlations calculated.

Egg Production and Average Haugh Units

The coefficients of correlation between E/P and HU in all three tests were negative (Tables IV and V, pages 22 and 23). These results agree generally with the results of Miller and Bearse (1937), Jeffrey (1941), Brant et al. (1953), and Johnson and Merritt (1955), who found highly significant negative correlations between egg production and albumen quality.

Average Egg Weight and Haugh Units

The coefficients of correlation between average egg weight and Haugh units also were both positive and negative (Table III, page 18). Strain three in the Thirteenth test and strain five in the Fourteenth test exhibited significant negative and positive relationships, respectively (Table III, page 18). The negative correlations found here are in disagreement with the finding of King (1961). The r's between these two traits were negative in all three tests except for G2P2 in the Fourteenth test when strains were combined (Tables IV and V, pages 22 and 23). These findings contradicted the findings in Table III, page 18 and are in disagreement with that of King (1961).

Haugh units are calculated by considering weight of eggs and albumen height. The traits EW and HU should exhibit positive correlation, according to King (1961). The results of Brant et al. (1953) show that breeds entered in laying tests have small breed differences with respect to albumen quality and shell thickness. The breeders are interested, in addition to total egg production in the production of quality eggs. Hence, the negative correlation observed connot be used as a guide in selection and mating systems since it is a phenotypic correlation. If genetic correlations also are negative, then breeders must produce desirable stocks by crossing inbred lines appropriately selected for two such negatively correlated traits. In developing such inbred lines for crossing, selection emphasis in each line should be placed on a specified trait.

In Random Sample tests, generally entries are of economically high ranking stocks which are characterized by high rates of lay, intermediate egg size and rather small body size. They are ranked using income over feed costs as the criterion. Economically, it would seem sound to select for the smallest bird which lays the largest eggs, but, biologically, this course of action is of questionable effectiveness because of the generally positive relationships between egg weight and body weight. Line or strain crossing appears to be the most effective system for producing stocks possessing optimum compromise combinations of performance levels for these economically important but negatively correlated traits.

II. TESTS OF HOMOGENEITY

Coefficients of Correlation Among Production Traits by Strains, All Treatment Combinations Combined

Abbreviations of variable names. Abbreviations, as listed below, were used to denote correlation coefficients tested for homogeneity:

1. Income over feed and chick cost, IOFCC
2. Eggs per pullet housed, E/P
3. Percent hen-day production, PHDP
4. Market weight of hens, MW
5. Percent mortality, PM
6. Pounds of feed per dozen of eggs, PF/DE
7. Average egg weight, EW
8. Average Haugh units, HU

Coefficients of Correlation Between IOFCC and E/P

Twelfth test. The correlation coefficients in strains 3, 4, 8, and 12 were homogeneous while those in strains 3, 4, 5, 8, 12, and 13 were heterogeneous (Table VI). The correlation coefficients in the homogeneous group ranged from .93 to .95, thus exhibiting a maximum difference of .02 among them. The sample size ranged from 140 to 148. The magnitude and sign of these correlation coefficients are presented in Table VI. The coefficients in strains 3 and 4 were significant at the .05 level of probability while those of strains 8 and 12 were positive but nonsignificant. Since these nonsignificant correlation coefficients

TABLE VI

RESULTS OF TESTS OF HOMOGENEITY AMONG COEFFICIENTS OF CORRELATION BETWEEN INCOME OVER FEED AND CHICK COST AND EGGS-PER-PULLET HOUSED (TWELFTH TEST)

Type of Correlation	Coefficients of Correlation[a]
Homogeneous	.95(3), .95(4), .94(8), .93(12) .95(4), .96(5), .94(8) .96(5), .94(8), .96(13) .99(6), .99(9), .99(11) .82(7), .87(14) .94(8), .92(10), .93(12)
Heterogeneous	.95(3), .95(4), .96(5), .94(8)[b] .95(3), .95(4), .93(12), .96(13)[c]
**Highly Significant	.996(2), .988(6), .993(9), .990(11)
*Significant	.95(3), .95(4), .96(5), .96(13)
NS Nonsignificant Positive	.65(1), .82(7), .94(8), .92(10), .93(12), .87(14)

[a] Strain number is in parentheses.

[b] Each coefficient of correlation is homogeneous with .95, i.e., not significantly different from it.

[c] Each coefficient of correlation is homogeneous with .95, i.e., not significantly different from it.

** ($P < .01$).

* ($.01 < P < .05$).

NS ($P > .05$).

are homogeneous with significant r's, they must have probabilities of chance occurrence very close to .05, which is indeed the case. These were found to be .06 and .07. Thus, one could easily estimate rather accurately the levels of probability of chance occurrence of any r in a homogeneous set if he knows the level of probability of chance occurrence of any single r in that set. Among the coefficients from strains 3, 4, 5, 8, 12, and 13 each r was homogeneous with some of the others, but as a total group they were heterogeneous. The difference among the heterogeneous coefficients of large magnitude was .03 (.93 to .96). Following the results of homogeneity tests strictly, then, one would have to say that a correlation coefficient of .96 should not be pooled with r's which are more than .03 smaller. A similar situation prevailed with the other heterogeneous set (Table VI, page 28). The correlation coefficient of strains 5, 8, and 13, when separated from the total heterogenous set, were homogeneous after reducing the range below .03 which was the range in the total heterogeneous set. A difference of .05 existed among homogeneous r's of a somewhat smaller magnitude in that r's ranging from .82 to .87 proved to be homogeneous according to the test.

The remainder of the correlation coefficients which did not appear in homogeneous groups in Table VI were heterogeneous, or significantly different from one another. They were .65 and .996 in strains 1 and 2, respectively. The correlation coefficient of .99 could theoretically never be averaged or pooled with any other r of less magnitude, even though only .01 smaller.

Thirteenth test. The r's of .90 and .87 in strains 1 and 13, respectively, were homogeneous (Table VII). Because of a difference of .03 between .97 and .94, the whole group was heterogeneous though it contained r's of .96 and .95, indicating that the .97 should not be pooled with r's which were as much as .03 smaller. The same situation was observed in the results from the Twelfth test. The r's of .98 and .97 were homogeneous. The correlation coefficients of .96 and .97 in strains 6 and 12, respectively, were not homogeneous with r of .95, according to the test. The correlation coefficient of .99 was not homogeneous with any r as much as .01 smaller. These results were typical throughout these homogeneity tests with respect to large correlation coefficients (0.9 or larger). Groups of such coefficients from small samples have to be practically identical in magnitude in order to be declared homogeneous. Sets of correlation coefficients which were not presented in Table VII were heterogeneous ones.

Fourteenth test. The correlation coefficients of .83, .79, and .82 in strains 1, 5, and 7, respectively, and .62 and .61 in strains 6 and 8, respectively, were homogeneous (Table VIII). The difference of .13 between the homogeneous correlation coefficients of .19 and .06 of strains 10 and 14, respectively, was the largest difference between homogeneous correlations found in this study. Sokal and Rohlf (1969) have shown homogeneity among correlation coefficients exhibiting a difference of 0.41, with a small sample size. Table VIII shows the sets of homogeneous correlation coefficients, which were positive nonsignificant r's, except for -.70 and -.65 in strains 2 and 13, respectively.

TABLE VII

RESULTS OF TESTS OF HOMOGENEITY AMONG COEFFICIENTS OF CORRELATION BETWEEN INCOME OVER FEED AND CHICK COST AND EGGS-PER-PULLET HOUSED (THIRTEENTH TEST)

Type of Correlation	Coefficients of Correlation[a]
Homogeneous	.90(1), .87(13) .96(2), .96(6), .95(7), .94(9) .99(3), .99(10), .99(11), .99(8) .98(4), .97(12) .96(6), .97(12)
Heterogeneous	.96(2), .96(6), .95(7), .94(9), .97(12)[b] .96(6), .95(7), .97(12)[c]
**Highly Significant	.99(3), .98(4), .99(8), .99(10), .99(11), .996(14)
*Significant	.96(2), .96(6), .95(7), .94(9), .97(12)
NSSignificant Positive	.90(1), .70(5), .87(13)

[a]Strain number is in parentheses.

[b]Each coefficient of correlation is homogeneous with .96, i.e., not significantly different from it.

[c]Each coefficient of correlation is homogeneous with .96, i.e., not significantly different from it.

**($P < .01$).

*($.01 < P < .05$).

NS($P > .05$).

TABLE VIII

RESULTS OF TESTS OF HOMOGENEITY AMONG COEFFICIENTS OF CORRELATION BETWEEN INCOME OVER FEED AND CHICK COST AND EGGS-PER-PULLET HOUSED (FOURTEENTH TEST)

Type of Correlation	Coefficients of Correlation[a]
Homogeneous	.83(1), .79(5), .82(7) .62(6), .61(8) .19(10), .06(14) -.70(12), -.65(13)
Heterogeneous	.98(2), .96(4) .79(5), .62(6) .82(7), .61(8) -.99(3), -.37(9), -.70(12), -.65(13)
**Highly Significant	.98(2), -.99(3), .999(11)
*Significant	.96(4)
NSNonsignificant	
Positive	.83(1), .79(5), .62(6), .82(7), .61(8), .19(10), .06(14)
Negative	-.37(9), -.70(12), -.65(13)

[a]Strain number is in parentheses.

**($P < .01$).

*($.01 < P < .05$).

NS($P > .05$).

Coefficients of Correlation Between IOFCC and PHDP

Twelfth test. The correlation coefficients of .81, .82, and .86 in strains 1, 2, and 4, respectively, and .81, .75, and .77 in strains 1, 6, and 10, respectively, were homogeneous. However, when these two sets were considered together, they were heterogeneous (Table IX), as were the correlation coefficients of .82, .86, .75, and .77 in strains 2, 4, 6, and 10, respectively. The maximum difference observed among the homogeneous r's was .16.

Thirteenth test. The correlation coefficients of .82, .80, and .88 in strains 4, 6, and 12, respectively, were heterogeneous (Table X) with a maximum difference of .08 among them, but r's of .82 and .88 were homogeneous. Strains 2, 9, and 14 yielded r's of approximately the same magnitude. The correlation coefficient of .99 was not homogeneous with any other correlations of lesser magnitude. The other correlation coefficients presented in Table X range from .11 to .98. A difference of .06 was maximum among homogeneous correlations in the .8 series. Again, as in other tests, r's of magnitudes approaching 1.0 were not homogeneous with other r's of very nearly the same magnitude.

Fourteenth test. A maximum difference of .14 was observed in the homogeneous set of correlation coefficients .21, .27, .33, and .35 in strains 5, 9, 10, and 11, respectively, while the heterogeneous set of r's, .46, .37, .52, .33, and .35 in strains 6, 7, 8, 10 and 11, respectively, showed a maximum difference of .19 among them. After regrouping, this heterogeneous set became four homogeneous sets as shown

TABLE IX

RESULTS OF TESTS OF HOMOGENEITY AMONG COEFFICIENTS OF CORRELATION BETWEEN INCOME OVER FEED AND CHICK COST AND PERCENT HEN-DAY PRODUCTION (TWELFTH TEST)

Type of Correlation	Coefficients of Correlation[a]
Homogeneous	.81(1), .82(2), .86(4) .81(1), .75(6), .77(10) .81(1), .82(2), .77(10) .89(3), .86(4) .75(6), .77(10), .68(12) .41(7), .57(8) .57(8), .68(12) .97(5), .98(11), .98(13)
Heterogeneous	.81(1), .82(2), .86(4), .75(6), .77(10)[b] .82(2), .86(4), .75(6), .77(10)[c]
**Highly Significant	.98(11)
*Significant	.97(5), .94(9), .98(13)
NSNonsignificant Positive	.81(1), .82(2), .89(3), .86(4), .75(6), .41(7), .57(8), .77(10), .68(12), .27(14)

[a]Strain number is in parentheses.

[b]Each coefficient of correlation is homogeneous with .81.

[c]Each coefficient of correlation is homogeneous with .82, i.e., not significantly different from it.

**($P < .01$).

*($.01 < P < .05$).

NS($P > .05$).

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TABLE X

RESULTS OF TESTS OF HOMOGENEITY AMONG COEFFICIENTS OF CORRELATION BETWEEN INCOME OVER FEED AND CHICK COST AND PERCENT HEN-DAY PRODUCTION (THIRTEENTH TEST)

Type of Correlation	Coefficients of Correlation[a]
Homogeneous	.99(2), .99(9), .99(14) .93(3), .95(13) .82(4), .80(6)
Heterogeneous	.82(4), .80(6), .88(12)[b]
**Highly Significant	.99(2), .995(7), .99(9), .98(10), .99(14)
*Significant	.95(13)
NSNonsignificant Positive	.83(1), .93(3), .82(4), .11(5), .80(6), .69(8) .72(11), .88(12)

[a]Strain number is in parentheses.

[b]Each coefficient of correlation is homogeneous with .82, i.e., not significantly different from it.

**($P < .01$).

*($.01 < P < .05$).

NS($P > .05$).

in Table XI. A set ranging from .37 to .52 was homogeneous, while one ranging from .35 to .52, only .02 greater range, was heterogeneous, according to the test.

Coefficients of Correlation Between IOFCC and MW

Twelfth test. The test showed that the r's of -.67 and -.62 in strains 1 and 6, respectively, were homogeneous (Table XII). Another set, having a maximum difference of .15, containing the r's of -.46, -.42 and -.31 in strains 3, 10, and 12, respectively, also was homogeneous. The correlation coefficients not presented within the homogeneous sets were heterogeneous (Table XII).

Thirteenth test. The correlation coefficients of .53, .54, .38, and .62 in strains 1, 4, 7, and 10, respectively, were heterogeneous with a maximum difference of .24 among them, but a difference of .15 or less among the r's of .53, .54 and .38 made these three a homogeneous subset of the larger heterogeneous set (Table XIII).

Fourteenth test. The test showed homogeneity among correlation coefficients of -.77, -.74 and -.69 in strains 1, 5, and 14, respectively (Table XIV). The heterogeneous set of r's of -.44, -.35, -.56, -.48, and -.57 when regrouped yielded a homogeneous subset of r's of -.44, -.56, -.48, and -.57. Correlation coefficients not presented within the homogeneous sets were heterogeneous. Strain 7 had a highly significant r of .99 which was not homogeneous with any of the smaller values with which it might be grouped in homogeneity tests.

TABLE XI

RESULTS OF TESTS OF HOMOGENEITY AMONG COEFFICIENTS OF CORRELATION BETWEEN INCOME OVER FEED AND CHICK COST AND PERCENT HEN-DAY PRODUCTION (FOURTEENTH TEST)

Type of Correlation	Coefficients of Correlation[a]
Homogeneous	.95(1), .95(4) .21(5), .27(9), .33(10), .35(11) .37(7), .33(10), .35(11) -.01(13), -.02(14)
Heterogeneous	.46(6), .37(7), .52(8), .33(10), .35(11)[b] .37(7), .52(8), .27(9)[c]
*Significant	.95(1), -.94(3), .95(4)
NSNonsignificant	
Positive	.71(2), .21(5), .46(6), .37(7), .52(8), .27(9), .33(10), .35(11)
Negative	-.38(12), -.01(13), -.02(14)

[a]Strain number is in parentheses.

[b]Each coefficient of correlation is homogeneous with .46.

[c]Each coefficient of correlation is homogeneous with .37, i.e., not significantly different from it.

*(.01 < P < .05).

NS(P > .05).

TABLE XII

RESULTS OF TESTS OF HOMOGENEITY AMONG COEFFICIENTS OF CORRELATION BETWEEN INCOME OVER FEED AND CHICK COST AND MARKET WEIGHT OF HENS (TWELFTH TEST)

Type of Correlation	Coefficients of Correlation[a]
Homogeneous	-.67(1), -.62(6) -.02(2), -.17(14) -.46(3), -.42(10), -.31(12)
Heterogeneous	.92(5), .98(7) -.46(3), -.62(6) -.97(11), -.92(13)
**Highly Significant	.98(7)
*Significant	-.97(11)
NSNonsignificant	
Positive	.53(4), .92(5), .83(8), .72(9)
Negative	-.67(1), -.02(2), -.46(3), -.62(6), -.42(10), -.31(12), -.92(13), -.17(14)

[a]Strain number is in parentheses.

**($P < .01$).

*($.01 < P < .05$).

NS($P > .05$).

TABLE XIII

RESULTS OF TESTS OF HOMOGENEITY AMONG COEFFICIENTS OF CORRELATION BETWEEN INCOME OVER FEED AND CHICK COST AND MARKET WEIGHT OF HENS (THIRTEENTH TEST)

Type of Correlation	Coefficients of Correlation[a]
Homogeneous	.53(1), .54(4), .38(7) .54(4), .62(10) -.30(3), -.35(11) -.01(5), -.19(14) -.32(12), -.19(14)
Heterogeneous	.53(1), .54(4), .38(7), .62(10)[b] -.90(2), -.62(9) -.62(9), -.35(11)
*Significant	.95(8)
NSNonsignificant	
Positive	.53(1), .54(4), .38(7), .62(10), .08(13)
Negative	-.90(2), -.30(3), -.01(5), -.89(6), -.62(9), -.35(11), -.32(12), -.19(14)

[a]Strain number is in parentheses.

[b]Each coefficient of correlation is homogeneous with .53, i.e., not significantly different from it.

*(.01 < P < .05).

NS(P > .05).

TABLE XIV

RESULTS OF TESTS OF HOMOGENEITY AMONG COEFFICIENTS OF CORRELATION BETWEEN INCOME OVER FEED AND CHICK COST AND MARKET WEIGHT OF HENS (FOURTEENTH TEST)

Type of Correlation	Coefficients of Correlation[a]
Homogeneous	-.77(1), -.74(5), -.69(14) -.44(2), -.56(6), -.48(9), -.57(10) -.35(4), -.48(9) -.74(5), -.69(14) -.56(6), -.48(9), -.57(10)
Heterogeneous	-.44(2), -.35(4), -.56(6), -.48(9), -.57(10)[b] -.99(7), -.77(1) .89(3), .60(13)
**Highly Significant	-.99(7)
NSNonsignificant	
Positive	.89(3), .40(8), .27(12), .60(13)
Negative	-.77(1), -.44(2), -.35(4), -.74(5), -.56(6), -.48(9), -.57(10), -.06(11), -.69(14)

[a]Strain number is in parentheses.

[b]Each coefficient of correlation is homogeneous with -.44, i.e., not significantly different from it.

**($P < .01$).

NS($P > .05$).

Coefficients of Correlation Between IOFCC and PM

Twelfth test. The correlation coefficients of -.57, -.53, and -.54 in strains 1, 9, and 12, respectively, were homogeneous, but these were not homogeneous with r's of -.68 and -.67. The r's of -.53, -.67, and -.54 of strains 9, 11, and 12 were homogeneous (Table XV).

Thirteenth test. The study showed a maximum difference of .15 between the r's of -.52 and -.37 (Table XVI). This result falls in line with that of the Fourteenth test with respect to IOFCC and PHDP, where the .5 and the .3 series showed homogeneity with a difference of .15 or less. The negative nonsignificant r's in strains 9 and 12 were -.87 and -.80, and these were not homogeneous.

Fourteenth test. The study showed homogeneity among r's with a maximum difference of .15 among them (-.40 to -.25) in the group from strains 2, 3, 6, and 12 (Table XVII). Since tests discussed earlier have shown homogeneity of correlations with a difference of .15 for correlations of magnitudes in the vicinity of .5 and .3, it was expected that correlations of smaller magnitudes could have larger differences among them and still be declared homogeneous. The highly significant and very similar coefficients -.997 and -.986 in strains 7 and 10 were not homogeneous. Thus, it appears that r's of near 1.0 can seldom be declared homogeneous with smaller correlation coefficients, unless sample sizes are much different from those involved in the present study.

TABLE XV

RESULTS OF TESTS OF HOMOGENEITY AMONG COEFFICIENTS OF CORRELATION BETWEEN INCOME OVER FEED AND CHICK COST AND PERCENT MORTALITY (TWELFTH TEST)

Type of Correlation	Coefficients of Correlation[a]
Homogeneous	-.57(1), -.53(9), -.54(12)
	-.93(2), -.96(4)
	-.68(3), -.70(5), -.70(7), -.67(11), -.68(14)
	-.68(3), -.67(11), -.68(14)
	-.68(3), -.54(12)
	-.96(4), -.96(6)
	-.78(8), -.78(10), -.67(11), -.68(14)
	-.53(9), -.67(11), -.54(12)
	-.54(12), -.68(14)
Heterogeneous	-.57(1), -.68(3), -.53(9), -.67(11), -.54(12), -.68(14)[b]
	-.68(3), -.70(5), -.70(7), -.67(11), -.54(12), -.68(14)[c]
	-.70(5), -.70(7), -.78(8), -.78(10), -.67(11), -.68(14)[d]
	-.78(10), -.67(11), -.68(14)[e]
*Significant	-.96(4), -.96(6)
NSNonsignificant Negative	-.57(1), -.93(2), -.68(3), -.70(5), -.70(7), -.78(8), -.53(9), -.78(10), -.67(11), -.54(12). -.12(13), -.68(14)

[a]Strain number is in parentheses.

[b]Each correlation coefficient is homogeneous with -.57.

[c]Each correlation coefficient is homogeneous with -.68.

[d]Each correlation coefficient is homogeneous with -.70.

[e]Each correlation coefficient is homogeneous with -.78, i.e., not significantly different from it.

*(.01 < P < .05).

NS(P > .05).

TABLE XVI

RESULTS OF TESTS OF HOMOGENEITY AMONG COEFFICIENTS OF CORRELATION BETWEEN INCOME OVER FEED AND CHICK COST AND PERCENT MORTALITY (THIRTEENTH TEST)

Type of Correlation	Coefficients of Correlation[a]
Homogeneous	-.49(1), -.52(4), -.38(10), -.37(11), -.51(13) -.80(2), -.80(12) -.995(3), -.995(14) -.16(5), -.25(7), -.23(8) -.25(7), -.23(8), -.38(10), -.37(11)
Heterogeneous	-.87(9), -.80(12) -.995(3), -.97(6)
**Highly Significant	-.995(3), -.995(14)
*Significant	-.970(6)
NSNonsignificant Negative	-.49(1), -.80(2), -.52(4), -.16(5), -.25(7), -.23(8), -.87(9), -.38(10), -.37(11), -.80(12) -.51(13)

[a]Strain number is in parentheses.

**($P < .01$).

*($.01 < P < .05$).

NS($P > .05$).

TABLE XVII

RESULTS OF TESTS OF HOMOGENEITY AMONG COEFFICIENTS OF CORRELATION BETWEEN INCOME OVER FEED AND CHICK COST AND PERCENT MORTALITY (FOURTEENTH TEST)

Type of Correlation	Coefficients of Correlation[a]
Homogeneous	-.53(1), -.40(3) -.27(2), -.40(3), -.32(6), -.25(12) .69(8), 68(14) .25(9), .20(13)
Heterogeneous	-.997(7), -.986(10) -.99(10), -.83(11)
**Highly Significant	-.997(7), -.986(10)
NSNonsignificant	
Positive	.004(4), .69(8), .25(9), .20(13), .68(14)
Negative	-.53(1), -.27(2), -.40(3), -.67(5), -.32(6) -.83(11), -.25(12)

[a]Strain number is in parentheses.

**($P < .01$).

NS($P > .05$).

Coefficients of Correlation Between IOFCC and PF/DE

Twelfth test. Among the homogeneous groups of correlation coefficients those of .06 and .27 in strains 4 and 7, respectively, with a difference of .21 between them (Table XVIII), had the greatest difference found between homogeneous correlation coefficients. The difference of .02 between r's of -.93 and -.91 in strains 11 and 13, respectively, and the maximum difference found between homogeneous correlation coefficients larger than .9 of .03 make the results of homogeneity tests with correlations between these variables very similar to those with other variables discussed earlier. The r of .99 was not homogeneous with any smaller r's.

Thirteenth and Fourteenth tests. The results of the tests of homogeneity applied to the coefficients of correlation calculated from the data from the Thirteenth and Fourteenth tests are tabulated in Tables XIX and XX. In general, the results are so similar to those previously discussed that there is no point in belaboring the matter further. Correlation coefficients larger than .9 are declared non-homogeneous with very small differences between them, whereas, those of smaller magnitudes are declared homogeneous with considerably more difference between them.

Coefficients of Correlation Between IOFCC and EW

The results of the tests of homogeneity among coefficients of correlation between these two variables are presented in Tables XXI, XXII and XXIII for the Twelfth, Thirteenth, and Fourteenth tests,

TABLE XVIII

RESULTS OF TESTS OF HOMOGENEITY AMONG COEFFICIENTS OF CORRELATION BETWEEN INCOME OVER FEED AND CHICK COST AND POUNDS OF FEED PER DOZEN OF EGGS (TWELFTH TEST)

Type of Correlation	Coefficients of Correlation[a]
Homogeneous	.07(1), .06(4), .10(8) -.94(2), -.93(11) .06(4), .27(7), .10(8) -.62(5), -.69(6) .53(9), .49(14) -.85(10), -.84(12) -.93(11), -.91(13)
Heterogeneous	-.94(2), -.99(3) .27(7), .53(9)
**Highly Significant	-.99(3)
*Significant	-.94(2)
NSNonsignificant Positive	.07(1), .06(4), .27(7), .10(8), .53(9), .49(14) -.62(5), -.69(6), -.85(10), -.93(11), -.84(12), -.91(13)

[a]Strain number is in parentheses.

**($P < .01$).

*($.01 < P < .05$).

NS($P > .05$).

TABLE XIX

RESULTS OF TESTS OF HOMOGENEITY AMONG COEFFICIENTS OF CORRELATION BETWEEN INCOME OVER FEED AND CHICK COST AND POUNDS OF FEED PER DOZEN OF EGGS (THIRTEENTH TEST)

Type of Correlation	Coefficients of Correlation[a]
Homogeneous	-.96(1), -.96(3), -.96(6) -.47(2), -.59(9) -.89(10), -.91(8) -.91(8), -.89(10), -.90(13) -.89(10), -.85(11)
Heterogeneous	-.89(10), -.85(11), -.91(8), -.90(13)[b] -.96(6), -.91(8) -.986(12), -.997(14)
**Highly Significant	-.986(12), -.997(14)
*Significant	-.96(1), -.96(3), -.96(6)
NSNonsignificant Negative	-.47(2), -.89(4), -01(5), -.25(7), -.91(8), -.59(9), -.89(10), -.85(11), -.90(13)

[a]Strain number is in parentheses.

[b]Each correlation coefficient is homogeneous with -.89, i.e., not significantly different from it.

**($P < .01$).

*($.01 < P < .05$).

NS($P > .05$).

TABLE XX

RESULTS OF TESTS OF HOMOGENEITY AMONG COEFFICIENTS OF CORRELATION BETWEEN INCOME OVER FEED AND CHICK COST AND POUNDS OF FEED PER DOZEN OF EGGS (FOURTEENTH TEST)

Type of Correlation	Coefficients of Correlation[a]
Homogeneous	-.95(1), -.94(10) -.67(2), -.55(8) -.89(4), -.89(14) -.41(5), -.55(8) -.55(8), -.43(9)
Heterogeneous	-.55(8), -.67(2), -.41(5)
**Highly Significant	-.99(13)
*Significant	-.95(1), -.97(7), -.94(10)
NSNonsignificant	
Positive	.80(3), .59(6), .20(11)
Negative	-.67(2), -.89(4), -.41(5), -.55(8), -.43(9), -.03(12), -.89(14)

[a]Strain number is in parentheses.

**($P < .01$).

*($.01 < P < .05$).

NS($P > .05$).

TABLE XXI

RESULTS OF TESTS OF HOMOGENEITY AMONG COEFFICIENTS OF CORRELATION BETWEEN INCOME OVER FEED AND CHICK COST AND AVERAGE EGG WEIGHT (TWELFTH TEST)

Type of Correlation	Coefficients of Correlation[a]
Homogeneous	-.04(1), -.04(13), -.04(14). .04(2), .11(4), .19(7) .36(6), .19(7) -.23(8), -.39(12)
Heterogeneous	.39(11), .36(6), .19(17)[b]
*Significant	.97(5)
NSNonsignificant	
Positive	.04(2), .11(4), .36(6), .19(7), .77(9), .39(11)
Negative	-.04(1), -.93(3), -.23(8), -.59(10), -.39(12), -.04(13), -.04(14)

[a]Strain is in parentheses.

[b]Each coefficient of correlation is homogeneous with .39, i.e., not significantly different from it.

*(.01 < P < .05).

NS(P > .05).

TABLE XXII

RESULTS OF TESTS OF HOMOGENEITY AMONG COEFFICIENTS OF CORRELATION BETWEEN INCOME OVER FEED AND CHICK COST AND AVERAGE EGG WEIGHT (THIRTEENTH TEST)

Type of Correlation	Coefficients of Correlation[a]
Homogeneous	.32(1), .19(3), .23(4), .27(5), .26(11) .32(1), .43(6) .43(6), .53(10) -.07(9), -.21(12) .53(10), .63(14)
Heterogeneous	.32(1), .19(3), .23(4), .27(5), .43(6), .26(11)[b]
**Highly Significant	.99(2)
NSNonsignificant	
Positive	.32(1), .19(3), .23(4), .27(5), .43(6), .90(7), .53(10), .26(11), .63(14)
Negative	-.84(8), -.07(9), -.21(12), -.60(13)

[a]Strain number is in parentheses.

[b]Each coefficient of correlation is homogeneous with .32, i.e., not significantly different from it.

**($P < .01$).

ns($P > .05$).

TABLE XXIII

RESULTS OF TESTS OF HOMOGENEITY AMONG COEFFICIENTS OF CORRELATION BETWEEN INCOME OVER FEED AND CHICK COST AND AVERAGE EGG WEIGHT (FOURTEENTH TEST)

Type of Correlation	Coefficients of Correlation[a]
Homogeneous	-.04(3), -.12(9) .43(7), .38(13) .20(8), .38(13) -.12(9), -.24(14) -.36(11), -.24(14) .29(12), .38(13) .38(13), .43(7), .29(12)
Heterogeneous	-.24(14), -.12(9), -.36(11)[b] -.70(2), -.55(6) -.24(14), -.04(3)
**Highly Significant	.999(10)
NS Nonsignificant	
Positive	.13(4), .86(5), .43(7), .20(8), .29(12), .38(13)
Negative	-.93(1), -.70(2), -.04(3), -.55(6), -.12(9), -.36(11), -.24(14)

[a]Strain number is in parentheses.

[b]Each coefficient of correlation is homogeneous with -.24, i.e., not significantly different from it.

**($P < .01$).

NS ($P > .05$).

respectively. Again, except for some variation in the differences between homogeneous correlation coefficients and between nonhomogeneous correlation coefficients, the results are very similar to those discussed earlier.

Coefficients of Correlation Between IOFCC and HU

Tables XXIV, XXV, and XXVI contain the results of tests of homogeneity among coefficients of correlation between these two variables calculated from the data of the Twelfth, Thirteenth, and Fourteenth tests, respectively. Again, the pattern displayed by the results is very similar to that shown for correlations involving other variables which were discussed earlier.

Sokal and Rohlf (1969) in their examination of the data of Brown and Comstock (1952) found homogeneity among correlation coefficients differing from one another by as much as .41, but their sample size ranged from 17 to 100 with an average of 42.3 as compared to the average of 143.64 and range of 129 to 153 in the present study. The sampel size in the steer experiment of Lush (1931) ranged from 4 to 15 with an average of 11.2, and his homogeneous r's ranged from .123 to .929. The homogeneous r's of Federer (1946) had a range of .17, and the sample size was 50. The example of Snedecor (1965) showed a maximum difference of .31 between homogeneous r's (.56 to .87) with an average sample size of 8.5. Ostle (1963) found r's of .63 and .78 to be homogeneous with a small sample size. The difference necessary for r's to be declared nonhomogeneous in the example of Paterson (1939) was .47 with an average sample size of 56. In the examples enumerated above and in the results

TABLE XXIV

RESULTS OF TESTS OF HOMOGENEITY AMONG COEFFICIENTS OF CORRELATION BETWEEN INCOME OVER FEED AND CHICK COST AND AVERAGE HAUGH UNITS (TWELFTH TEST)

Type of Correlation	Coefficients of Correlation[a]
Homogeneous	.79(1), .84(8), .82(14) .55(2), .50(4), .53(9) -.84(3), -.75(11) .50(4), .53(9) -.31(5), -.34(13) .30(7), .39(12) .53(9), .39(12)
Heterogeneous	.30(7), .09(10), .39(12)[b]
[NS]Nonsignificant	
Positive	.79(1), .55(2), .50(4), .30(7), .84(8), .53(9), .09(10), .39(12), .82(14)
Negative	-.84(3), -.31(5), -.93(6), -.75(11), -.34(13)

[a]Strain number is in parentheses.

[b]Each coefficient of correlation is homogeneous with .30, i.e., not significantly different from it.

[NS]($P > .05$).

TABLE XXV

RESULTS OF TESTS OF HOMOGENEITY AMONG COEFFICIENTS OF CORRELATION BETWEEN INCOME OVER FEED AND CHICK COST AND AVERAGE HAUGH UNITS (THIRTEENTH TEST)

Type of Correlation	Coefficients of Correlation[a]
Homogeneous	-.46(4), -.34(12), -.31(13), -.31(14) -.15(5), -.34(12), -.31(13), -.31(14) .55(6), .65(7), .68(11)
Heterogeneous	.92(3), .99(8), .98(9)
**Highly Significant	.99(8)
*Significant	-.98(9)
NSNonsignificant	
Positive	.28(1), .92(3), .55(6), .65(7), .68(11)
Negative	-.76(2), -.46(4), -.15(5), -.64(10), -.34(12), -.31(13), -.31(14)

[a]Strain number is in parentheses.

**($P < .01$).

*($.01 < P < .05$).

NS($P > .05$).

TABLE XXVI

RESULTS OF TESTS OF HOMOGENEITY AMONG COEFFICIENTS OF CORRELATION BETWEEN INCOME OVER FEED AND CHICK COST AND AVERAGE HAUGH UNITS (FOURTEENTH TEST)

Type of Correlation	Coefficients of Correlation[a]
Homogeneous	-.50(1), -.60(9) .08(3), .21(6) -.18(4), -.18(14) -.71(8), -.72(13)
Heterogeneous	.21(6), .29(11), .08(3)[b] -.50(1), -.18(4) -.02(2), .08(3), .21(6)
**Highly Significant	.98(5)
NSNonsignificant	
Positive	.02(2), .08(3), .21(6), .87(7), .57(10), .29(11), .93(12)
Negative	-.50(1), -.18(4), -.71(8), -.60(9), -.72(13), -.18(14)

[a]Strain number is in parentheses.

[b]Each correlation coefficient is homogeneous with .21, i.e., not significantly different from it.

**($P < .01$).

NS($P > .05$).

of the present study, it is obvious that the magnitude of coefficients of correlation and the sample sizes are both involved in determining homogeneity or heterogeneity among r's compared.

The variations in results from test to test in the present study can be attributed to differences in sample size. The Fourteenth test had an average sample size of 200.4 as compared to 146.6 in the Twelfth test, this undoubtedly accounts for variation in differences between homogeneous r's in view of the r's being of approximately the same magnitude. This is supported by the fictitious example calculated using the data of Lush (1931) (Table XXVII) wherein the mean square of 143.6 from the Twelfth test of the present study was used in place of Lush's value to obtain the chi-square value. With four degrees of freedom, the chi-square of 186.4 indicates singificant differences among the individual estimates of ρ since the probability of a greater chi-square value would be less than .005. The chi-square value actually obtained by Lush was 4.95, which indicated no significant differences among the individual estimates of ρ.

That the magnitude of the coefficients of correlation being compared plays a part in determining homogeneity or heterogeneity among them is supported by the data of Kosin et al. (1952), wherein the r's ranged from .71 to .96 with sample sizes ranging from 28 to 75 in males and from .71 to .97 with sample size from 30 to 75 in females (Table XXVIII). The chi-square values obtained were 36.13 for males and 78.30 for females (seven degrees of freedom), which indicated significant differences among the individual estimates of ρ since the probability of

TABLE XXVII

CHI-SQUARE VALUES FROM DATA OF INITIAL WEIGHT AND GAIN OF STEERS[a]

Coefficients of Correlation (n_i)	Transformed Values of r_i (z_i)	Mean Squares[b]	
		Lush Data	Twelfth Test
.93	1.65	1	143.6
.57	0.65	10	143.6
.46	0.50	6	143.6
.12	0.12	8	143.6
.32	0.34	11	143.6
	Chi-Square Values	4.95	186.4

[a]Data of Lush (1931).

[b]n_i - 3 values.

TABLE XXVIII

SIGNIFICANT CHI-SQUARE VALUES FROM DATA ON THE PREDICTABILITY OF BODY WEIGHT FROM EGG WEIGHT (1949 TRIAL)[a]

Mean Squares[b]		Coefficients of Correlation (r_i)		Transformed Values of r_i (z_i)	
Males	Females	Males	Females	Males	Females
71	72	.85	.84	1.26	1.22
64	57	.72	.65	0.91	0.78
72	66	.89	.97	1.42	2.09
55	42	.73	.71	0.93	0.89
25	27	.71	.80	0.89	1.10
31	50	.96	.93	1.95	1.66
55	41	.81	.72	1.13	0.91
38	40	.76	.88	1.00	1.38
		Chi-Square Values		36.13	78.30

[a]Data of Kosin et al. (1952).

[b]$n_i - 3$ values.

greater chi-square values would be less than .005 in both cases. Thus, in these cases, the pooled estimates of .80 and .88 for 435 males and 419 females, respectively, obtained by the authors (Kosin et al.) would not be better estimates of ρ.

Coefficients of Correlation Among Production Traits by Treatment Combination, All Strains Combined

The following abbreviations of treatments are used for discussion:

1. One bird per cage and 17.2-percent protein laying diet, hereafter referred to as D1P1.

2. One bird per cage and 13.4-percent protein laying diet, hereafter referred to as D1P2.

3. Two birds per cage and 17.2-percent protein laying diet, hereafter referred to as D2P1.

4. Two birds per cage and 13.4-percent protein laying diet, hereafter referred to as D2P2.

5. Ten to 20 weeks growing period and 17.6-percent protein drowing diet, hereafter referred to as G1P1.

6. Ten to 20 weeks growing period and 10.2-percent protein growing diet, hereafter referred to as G1P2.

7. Ten to 24 weeks growing period and 17.6-percent protein growing diet, hereafter referred to as G2P1.

8. Ten to 24 weeks growing period and 10.2-percent protein growing diet, hereafter referred to as G2P2.

Results using various treatment combinations as criteria for classifying the data, instead of using strains to classify the data, are

shown in Tables XXIX through XXXIV. In general, the same pattern prevails throughout these tables as was apparent in the earlier comparisons of r values calculated from each strain. Homogeneous r's of large magnitude differ from one another by much less than do homogeneous r's of small magnitude. The effect of sample size on homogeneity, as noted earlier, is also apparent in these tests conducted with r values calculated for treatment-combination groups rather than for strain groups as were the r's tested in Table VI, page 28, VII, VIII, pages 31 and 32, IX, X, pages 34 and 35, XI to XIV, pages 37-40, XV to XVII, pages 42-44, XVIII to XXIII, pages 46-51, and XXIV to XXVI, pages 53-55.

III. CONCLUSIONS

This empirical study of correlation coefficients calculated from random-sample-laying-test data has shown that effects such as strain and imposed treatment do influence the magnitude and homogeneity or heterogeneity of correlation coefficients obtained. Traditionally, research workers have concerned themselves more with the influence such effects have on means than with the influence they have on correlations. There has been a widespread tendency to combine separate estimates of ρ into a single estimate in the form of a pooled within-group correlation or as an average correlation calculated by transforming separate r values to Fisher's z, averaging the z values and then transforming the average z back to r. This combining of separate r values has been reported in many publications with no mention made of any consideration having been given to ascertaining if the combined r's are actually estimates of the

TABLE XXIX

RESULTS OF TESTS OF HOMOGENEITY AMONG COEFFICIENTS OF CORRELATION OF INCOME AND EGG PRODUCTION VARIABLES FOR VARIOUS TREATMENT COMBINATIONS (TWELFTH AND THIRTEENTH TESTS)

IOFCC* and Correlated Variables	Test	D1P1[a]	D1P2[b]	D2P1[c]	D2P2[d]
Eggs per Pullet Housed (E/P)					
Homogeneous r's	Twelfth		.98	.97	.97
	Thirteenth	.97		.96	.96
Heterogeneous r's	Twelfth	.95	.98	.97	.97
	Thirteenth	.97	.99	.96	.96
Percent Hen-Day Production (PHDP)					
Homogeneous r's	Twelfth	.93		.92	
			.84		.82
	Thirteenth	.90		.93	.90
		.90	.88		.90
Heterogeneous r's	Twelfth	.93	.84	.92	.82
	Thirteenth	.90	.88	.93	.90

[a]One bird per cage and 17.2-percent protein laying diet.

[b]One bird per cage and 13.4-percent protein laying diet.

[c]Two birds per cage and 17.2-percent protein laying diet.

[d]Two birds per cage and 13.4-percent protein laying diet.

*Income over feed and chick cost.

TABLE XXX

RESULTS OF TESTS OF HOMOGENEITY AMONG COEFFICIENTS OF CORRELATION OF INCOME, HEN WEIGHT AND MORTALITY FOR VARIOUS TREATMENT COMBINATIONS (TWELFTH AND THIRTEENTH TESTS)

IOFCC* and Correlated Variables	Test	D1P1[a]	D1P2[b]	D2P1[c]	D2P2[d]
Market Weight of Hen (MW)					
Homogeneous r's	Twelfth	-.31	-.32		
				-.63	-.56
	Thirteenth	-.11		-.23	
			-.44		-.54
Heterogeneous r's	Twelfth	-.31	-.32	-.63	-.56
	Thirteenth	-.11	-.44	-.23	-.54
Percent Mortality (PM)					
Homogeneous r's	Twelfth	-.60	-.46		-.47
	Thirteenth	-.63	-.48		
				-.23	-.26
Heterogeneous r's	Twelfth	-.60	-.46	-.05	-.47
	Thirteenth	-.63	-.48	-.23	-.26

[a]One bird per cage and 17.2-percent protein laying diet.

[b]One bird per cage and 13.4-percent protein laying diet.

[c]Two birds per cage and 17.2-percent protein laying diet.

[d]Two birds per cage and 13.4-percent protein laying diet.

*Income over feed anc chick cost.

TABLE XXXII

RESULTS OF TESTS OF HOMOGENEITY AMONG COEFFICIENTS OF CORRELATION OF INCOME AND HAUGH UNITS FOR VARIOUS TREATMENT COMBINATIONS (TWELFTH AND THIRTEENTH TESTS)

IOFCC* and Correlated Variables	Test	D1P1[a]	D1P2[b]	D2P1[c]	D2P2[d]
Average Haugh Units (HU)					
Homogeneous r's	Twelfth	-.39	-.35		
			-.35	-.16	-.28
		-.39			-.28
	Thirteenth	-.46			-.33
			.02	.03	
Heterogeneous r's	Twelfth	-.39	-.35	-.16	-.28
	Thirteenth	-.46	.02	.03	-.33

[a]One bird per cage and 17.2-percent protein laying diet.

[b]One bird per cage and 13.4-percent protein laying diet.

[c]Two birds per cage and 17.2-percent protein laying diet.

[d]Two birds per cage and 13.4-percent protein laying diet.

*Income over feed and chick cost.

TABLE XXXIII

RESULTS OF TESTS OF HOMOGENEITY AMONG COEFFICIENTS OF CORRELATION OF INCOME AND PRODUCTION VARIABLES FOR VARIOUS TREATMENT COMBINATIONS (FOURTEENTH TEST)

IOFCC* and Correlated Variables	G1P1[a]	G1P2[b]	G2P1[c]	G2P2[d]
Eggs per Pullet Housed (E/P)				
Homogeneous r's			.83	.79
Heterogeneous r's	.91	.55	.83	.79
Percent Hen-Day Production (PDHP)				
Homogeneous r's		.50	.54	
Heterogeneous r's	.87	.50	.54	.72
Market Weight of Hen (MW)				
Homogeneous r's	-.70	-.60		
		-.60	-.47	-.45
Heterogeneous r's	-.70	-.60	-.47	-.45
Percent Mortality (PM)				
Homogeneous r's		-.44	-.58	-.58
Heterogeneous r's	-.18	-.44	-.58	-.58

[a]10-20 weeks growing period and 17.6-percent protein growing diet.

[b]10-20 weeks growing period and 10.2-percent protein growing diet.

[c]10-24 weeks growing period and 17.6-percent protein growing diet.

[d]10-24 weeks growing period and 10.2-percent protein growing diet.

*Income over feed and chick cost.

TABLE XXXIV

RESULTS OF TESTS OF HOMOGENEITY AMONG COEFFICIENTS OF CORRELATION OF INCOME, FEED EFFICIENCY AND EGG QUALITY FOR VARIOUS TREATMENT COMBINATIONS (FOURTEENTH TEST)

IOFCC* and Correlated Variables	G1P1[a]	G1P2[b]	G2P1[c]	G2P2[d]
Pounds of Feed/Dozen of Eggs (PF/DE)				
Homogeneous r's		-.59	-.49	
Heterogeneous r's	-.87	-.59	-.49	-.72
Average Egg Weight (EW)				
Homogeneous r's		.61	.66	.67
Heterogeneous r's	.28	.61	.66	.67
Average Haugh Units (HU)				
Homogeneous r's		-.05	-.10	-.10
Heterogeneous r's	-.38	-.05	-.10	-.10

[a]10-20 weeks growing period and 17.6-percent protein growing diet.

[b]10-20 weeks growing period and 10.2-percent protein growing diet.

[c]10-24 weeks growing period and 17.6-percent protein growing diet.

[d]10-24 weeks growing period and 10.2-percent protein growing diet.

*Income over feed and chick cost.

same parameter. If determination of correlation is a major consideration in an investigation, homogeneity of separate r values should be given attention before combining them into a single estimate of ρ.

Both sample size and the magnitude of correlations being compared are involved in determining the outcome of homogeneity tests. This makes it necessary, in some instances, for a research worker to use practical considerations in deciding what valid conclusions may be drawn concerning correlation. For example, in the case of two correlations of .98 and .99 which are declared nonhomogeneous by a test of homogeneity, it makes little practical difference whether one chooses .98, .99 or a pooled value between them as an estimate of ρ. In such a case, it would be logical to choose as the best available estimate of ρ the r value calculated from the larger sample, especially if the sample sizes were greatly different. In the case of smaller correlations, homogeneity should be established before combining separate estimates into a single estimate.

It should be pointed out however, that no particular treatment combination consistently increased the magnitude of coefficients of correlation of income over feed and chick cost with other variables. Therefore, the results of this study do not justify recommending to breeders that they use any of the treatment combinations studied here in the hope of increasing effectiveness of their selection.

CHAPTER V

SUMMARY

Data collected during the Twelfth, Thirteenth and Fourteenth Tennessee Random Sample Laying tests (1969-1971) were analyzed by computing conventional product-movement coefficient of correlation among production variables for each strain and treatment subclass in each test to determine the magnitude of these relationships. Then various coefficients of correlation between income over feed and chick cost and other production variables for each strain, protein level and cage-density subcalss in each test were computed and subjected to tests of homogeneity.

There were strain differences and treatment differences in many of the correlations calculated, as indicated by the tests of homogeneity. It was obvious from the results that both sample size and magnitude of correlations being compared play a part in determining the outcome of tests of homogeneity. Correlations larger than .9 which were very similar in value were frequently declared nonhomogeneous even when sample sizes were quite large. In many instances, smaller correlations were declared homogeneous, even though appreciably different from one another.

Although comparison of correlation estimates was not a stated objective of these random sample tests, the results of this empirical study indicate that consideration of homogeneity (or lack of it) among

separate estimates is essential if one is to draw valid conclusions concerning correlation between variables, especially if investigation of correlation is a major objective of an experiment with quantitative variables such as those represented in the data from random sample laying tests.

No particular treatment combination, among those studied here, was consistently superior to any other in increasing correlations of income over feed and chick cost with other variables.

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VITA

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