THE EFFECT OF EGG SIZE AND RAPIDITY OF HATCHING ON GROWTH AND REPRODUCTIVE PERFORMANCE

By

CLETIS WILLIAMS

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THESIS AND ABSTRACT APPROVED:

George F. Godfrey
Thesis Adviser

R. B. Thompson
Faculty Representative

D. C. McIntosh
Dean of the Graduate School

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INTRODUCTION

The consumer's demand for broilers is increasing yearly. To meet this increased demand, broiler producers are growing broilers throughout the year. This practice in turn has brought about a demand for broiler chicks at all seasons of the year. A regulation of the National Poultry Improvement Plan requires that eggs being set during the months June through November inclusive weigh a minimum of 1 10/12 ounces each. As most hatchery flocks are replaced yearly, hatcherymen have a problem of obtaining sufficient hatching eggs which meet this weight requirement. It is believed by some broiler producers that chicks hatched from eggs weighing less than 1 10/12 ounces grow as satisfactorily as do chicks hatched from larger eggs.

Hatcherymen have observed that chicks may hatch from eggs from the twentieth through the twenty-second day of incubation. It appears that those chicks which emerge early are more vigorous. Hatcherymen have often asked whether early-emerging chicks have any advantage in growth over late-emerging chicks at broiler age.

As these questions were asked by the hatcherymen and broiler producers of Oklahoma, this investigation was undertaken.

The objectives of this investigation are the following:

1. To determine the effect of egg size on growth and reproductive performance.
2. To determine the effect of rapidity of hatching on growth and reproductive performance.

3. To determine the effect of egg size on rapidity of hatching.

REVIEW OF THE LITERATURE

Because this investigation deals with several problems the review of the literature will be divided into the following parts: the effect of egg size on growth, the effect of egg size on egg production, the effect of emergent period on growth, the effect of emergent period on reproductive performance, and factors affecting length of incubation.

The Effect of Egg Size on Growth

Benjamin (1920) found that a significant postive correlation exists between egg size and the size of the chick hatched from the egg. Halbersleben and Mussehl (1922), Upp (1927), Waters (1931), Graham (1932), and Munro and Kosin (1940) added further evidence that chick weight and egg weight are closely and postively correlated. The correlations between egg weight and chick weight obtained by these workers range from 0.83 to 0.95. Jull and Quinn (1925), and Hays and Sanborn (1929) have shown that chicks hatched from eggs of yearling hens tend to have a higher mean weight than chicks hatched from pullet eggs. This is probably because the eggs from yearling hens tend to be heavier than those of pullets. Galpin (1938) reported a seasonal fluctuation in the dependence of chick weight upon egg weight. The highest correlation between these two variables was found in March and April, while the lowest was found in July. These seasonal changes in the dependence of hatching weight on egg weight have been interpreted by Galpin as the expression of a varying maternal metabolism, the changes in the metabolic rate being related to thyroid activity. Penquite and Milby (1941) found that chicks from hens fed low levels of protein were larger and the chicks from hens fed high levels of protein were smaller than would be expected on the basis of egg size alone. They concluded that about 12 percent of the variation in chick weight at hatching time is due to factors other than variation in egg weight. They obtained a correlation between egg weight and chick weight of 0.94. Skoglund and Tomhave (1949) reported that the initial weight of the chick increases as the weight of the egg increases. Byerly (1932) concluded that the rate of growth of the chick embryo depends upon an inherent growth rate. This inherent growth rate is probably identical for all breeds. The rate of growth of the embryo was shown by Byerly to be modified in direct proportion to egg size.

Benjamin (1920) reported that the significant postive correlation between the size of the egg and chick weight persists for a period of 128 weeks of age. Hays and Sanborn (1929) reported that in Rhode Island Reds the weight difference at day-old persisted at 4 weeks of age, when the chicks from the large eggs were 26.9 percent heavier than the chicks from small eggs in the extreme classes. At the age of 21 weeks they found that this weight difference in chicks had disappeared. They further found that the hatching date of Rhode Island Reds ranging over 49-day period affected the weight of chicks throughout most of the growing season. The difference in mean hatching weight of the chicks in the first and last hatches was not striking, but early hatched chicks were 12.90 percent heavier at 2 weeks of age, 28.79 percent heavier at 4 weeks of age, 21.70 percent heavier at 16 weeks of age and 17.12 percent heavier at 21 weeks of age than the late hatched chicks. Skoglund and Tomhave (1949) obtained results which show that chicks produced from eggs weighing 27 to 30 ounces per dozen were heavier at 12 weeks of age than chicks from smaller eggs. In this study no statistical analysis was made. They found that broilers produced from eggs weighing at least 22 ounces per dozen grew satisfactorily.

Habersleben and Mussehl (1922) found that at 35 days of age chicks from large eggs had no weight advantage over chicks hatched from small eggs. Upp (1927) reported that day-old chick weight of Rhode Island Reds was an unreliable index of the chick weight when two, four or twelve weeks of age. He observed that rate of growth was in most cases independent of chick size at hatching. Callenbach (1934), using Barred Plymouth Rocks and White Leghorns, found no relation between pullet chick weight and subsequent body weight at 3, 8 and 16 weeks of age, or at sexual maturity. McClung and Smith (1949), using White Wyandottes, obtained a postive correlation which was non-significant between egg weight and 12-week weight. Working with turkeys, Scott and Phillips (1936) observed that egg weight is highly correlated with day-old weight, but not with subsequent weight except for the two-week weight of the males. Hays and Sanborn (1929) have shown that the age of the dam affects the growth of the progeny. They found that the weight of chicks from hens was 5.01 percent heavier than chicks from pullets. It is well known that eggs from hens are generally heavier than those of pullets, and therefore chicks from hens would be expected to be heavier than those hatched from pullet eggs. At 4 and 16 weeks of age the chicks from hens were 8.62 and 6.97 percent heavier respectively than the chicks hatched from pullets. At 21 weeks of age there was no significant difference in weight between the two groups.

The Effect of Egg Size on Egg Production

There is no information regarding the effect of size of the egg from which the pullet hatches and egg production. As Funk and Kempster (1934) have shown that dams which lay large eggs tend to produce daughters which also lay large eggs, a discussion of the relationship of egg production and egg size should be included.

Atwood (1923) found that heavy layers laid eggs at least as large as the average for the breed or strain. Parkhurst (1925) reported no significant correlation between the 365-day record and the mean egg weight for that period. Atwood and Clark (1930) confirmed the findings of Parkhurst. They found that a bird which lays a large number of eggs is as likely to lay large eggs as small ones. Bennion and Warren (1933) reported that the higher producing birds maintained a larger mean weekly egg size throughout the year than did lower producing birds. Marble (1930) found that high egg production is accompanied by decreased egg size due to increased length of cycle. Low egg production is accompanied by decreased egg size due to lack of vigor. He concluded that the maximum egg size in any group studied was obtained from those birds laying approximately the mean production of that group.

The Effect of Emergent Period on Growth

Hays (1941) could not show any relation between length of incubation and body weight of pullets at six months of age; but he did find that cockerels, which emerged early, were slightly heavier at six months of age than those which emerged later. He also was unable to find any relation between length of incubation and body weight of pullets at sexual maturity, or at the end of the first laying year. Henderson and Champion (1948) observed the relationship between the incubation period for chicks of several breeds and the weight of the chicks at 8 weeks of age. They found that chicks emerging first showed a tendency to be heavier at 8 weeks of age than those emerging last, but in only one group was the correlation sufficiently high to be significant. However, egg size and age of eggs were controlled variables in their experiment.

The Effect of Emergent Period on Reproductive Performance

Hays (1941) found that very early emerging pullets are likely to be slightly earlier in reaching sexual maturity than late emerging ones. He found that more eggs before March first may be expected from early emerging pullets. As the length of incubation period increases, Hays found that there was a consistent decline in annual egg production. It is possible that this difference in egg production, as shown by Hays, is due to the difference that he has observed in sexual maturity. He also observed that early emerging pullets are likely to be more persistent layers than late emerging pullets. Smyth et al. (1949) were unable to find any important difference in the egg production of early hatching pullets and late hatching pullets for the first six months of production.

Factors Affecting Length of Incubation Period

As this is a study involving rapidity of hatching and its effect on growth and reproductive performance, some consideration should be given to normal variation of incubation period as well as factors which may affect rapidity of hatching.

Normal Variation in Incubation -- Bergtold (1917) defines length of incubation as being the number of days or weeks necessary to completely hatch the young. He lists the incubation period of the domestic hen as 21 days. Byerly (1933) reported that eggs from hen vary in duration of incubation from 480 hours (20 days) to 522 hours (21 3/4 days). Romanoff et al. (1932) state that in commercial incubators the peak of a hatch is reached at about the twentieth day of incubation. Olsen and Winton (1941) found that 90 percent of the chicks hatch between the twentieth and twenty-first day of incubation, but there may be a difference of as much as 40 hours between the first and last chick to emerge. Smyth and Howes (1949), studying the inheritance of length of incubation period, observed that in their original stock the first chick hatched after 20 days and 4 hours of incubation, while the last one hatched after 21 days and 20 hours of incubation.

In a discussion of incubation periods of birds, Bergtold (1917) states that the true incubation period varies little with each species or subspecies under optimum conditions. He finds that the true length of incubation can be shortened artificially with extreme difficulty, but may be prolonged with ease. He concludes that a bird's temperature determines or fixes the true length of its incubation period, and that only an abiding change in the birds temperature can permanently alter the true length of its incubation period. Although Bergtold believes the true or specific length of incubation is a deep-seated, inelastic and persistently unchanging character, Smyth and Howes (1949) have been able, by selection, to lengthen the average incubation period of the hen by 20 hours.

Variations in Development of Embryos of Hen's Eggs

Nicolaides (1933) observed, through cytological studies, that the blastoderms of eggs laid by high hatching hens are further advanced at the time of laying than those laid by hens of low hatchability, regardless of the time of laying. Hays and Nicolaides (1934) confirmed these findings. Taylor and Gunns (1935) did not find the size of the embryo to be correlated with the hatchability of the dam. They did observe that the first egg in a cycle of consecutively produced eggs contained a larger embryo than other eggs of the cycle. They concluded that one major cause of differences in embryo size appears to be the length of time the egg is retained in the oviduct. McNally and Byerly (1936) reported that embryos from fresh fertile eggs, after being incubated for 48 hours, showed a variation in development of from 9 to 26 somites. The average number of somites of embryos increases with the length of time between eggs of a cycle. In eggs from individual hens, the number of somites increases with egg weight when eggs weigh above a minimum value for the hen at that time. Neel (1942) confirmed the work of Nicolaides (1933) and Hays and Nicolaides (1934). He also found that rate of embryo development appears to decrease with the age of the hen.

Egg Size -- Bergtold (1917) found that egg size, within the Avian Class, is loosely related to the true length of incubation. Byerly (1933), reported that large eggs generally require a longer incubation period than do small eggs. His reasoning is that the heavier the egg, the more growth in proportion to egg weight that must be made after eighteen days of incubation to bring the chick at hatching time to its usual percentage of egg weight, and hence a longer incubation period is required. Huggins and Huggins (1941) state that previously presented evidence would indicate that there is a general postive correlation between egg weight and length of incubation. Olsen (1942), using turkey eggs, found that small eggs required 3 to 4 hours less time to hatch than large eggs.

Hays (1941) could not show the length of incubation period to be affected by weights of eggs in 430 dams studied.

Egg Storage and Incubation Period -- Wood (1905) observed that fresh eggs hatch earlier and that the chicks from them are stronger than those from older eggs. Waite (1919) reported that the deterioration in hatching quality of eggs with age is slight up to the sixth or seventh day but after this period the rate of deterioration is very much accelerated and varies almost directly with age. Byerly (1933) and Funk (1934) found that duration of incubation varied directly with the length of storage period. Funk (1934) reported that eggs which were held from fourteen to twenty-one days required from 14 to 18 hours longer incubation than did those which were held for less than eight days.

Incubation Temperature and Incubation Period -- In natural incubation, as shown by Huggins (1941), there is no one absolute temperature, but a range of temperatures through which an egg can develop normally, and the young hatch. Under artificial incubation conditions using forced draft incubators, egg temerature should vary little. Phillips and Brooks (1923) have shown that temperatures above the optimum resulted in an early hatch. Barott (1937) reported that the higher the temperature, the greater was the energy metabolism, consequently the more rapid the development of the chick and the earlier the hatch. The length of incubation period varied from 19½ days at 103.5°F. to about 23½ days at 96°F. At 100°F. hatching took place at about 20¼ days. Romanoff et al. (1932)

state that the time of hatch is most influenced by extremes of temperature during the first week of incubation. They also found that low temperature has a more pronounced influence in delaying the hatch than high temperature in shortening the hatch. They found the range of distribution of the hatch to be noticeably wide only under a prolonged exposure to an unfavorable temperature. Romanoff and Faber (1933) found that hatching occurred one-half day or so earlier than usual at high temperature, and was very irregular and delayed for about two days at low temperature.

Hormonal Control of Incubation Period -- Wheeler and Hoffman (1948) reported that chicks from hens fed varying levels of thyroprotein in their diets required longer periods of incubation. They conclude that delayed hatching may be due to: (1) reduced rate of embryonic development as a result of a deficient maternal hormone, or (2) ineffective functioning of the chick thyroid during the last half of incubation.

Factors Which May Influence Incubation Period -- There are factors which have been shown to have an affect upon the growth of the embryo at various stages. Although no workers have shown these factors to have an influence on incubation period, it may well be that these factors have some influence.

Romanoff (1929, 1930) observed that the growth of the embryo was somewhat hastened at high humidity, and retarded at low humidity.

Cruz and Romanoff (1944) reported that the early growth of the embryo is accelerated by exposure to oxygen concentration above 21 percent. Meshew (1949) showed that the hatching weight of chicks and poults incubated in an atmosphere containing 25.5 percent oxygen was slightly higher than those incubated under normal atmospheric conditions. The average two-week weight of chicks receiving additional oxygen during incubation was slightly higher than the average two-week weights of chicks which did not receive additional oxygen.

Romanoff (1930) obtained results which indicate that moderate amounts of carbon dioxide (about 0.4 percent) stimulates the growth of the embryo during the first few days of incubation. Increasing amounts of carbon dioxide resulted in slow growth and early embryo mortality.

EXPERIMENTAL PROCEDURE

As the New Hampshire breed is noted for broiler production, it was selected for this study. Eggs used in this investigation were obtained from the Oklahoma Station strain of New Hampshires. Four trials were conducted to study the effect of egg size and rapidity of hatching on growth and reproductive performance. Trial 1, which included 10 groups of eggs, was hatched between February 5 and 14, 1949; Trial 2, which included 5 groups of eggs, was hatched between April 26 and 30, 1949; Trial 3, which included 2 groups of eggs, was hatched November 26, 1949; and Trial 4, composed of but one group, was hatched February 2, 1950.

Trials 1 and 2 were conducted in the following manner. The eggs were obtained from a flock mating. Each egg was pedigreed as to the hen's number and the date it was laid. The eggs were gathered twice daily, then sorted into holding trays. The eggs were held at desirable holding temperatures for four days as this was considered the average number of days eggs are held before being brought to the hatchery. As Byerly (1933) has shown egg size to be a factor affecting length of incubation, each egg was weighed to the nearest half gram. After being weighed the eggs were trayed and placed into a modern incubator. Instructions of the manufacturer were followed in the operation of the incubator. On the eighteenth day the eggs were candled and each fertile egg placed in an individual basket for hatching. A cardboard tag, secured to each basket by wire clips, was used to record data pertinent to the egg involved.

Seven emergent periods spaced eight hours apart were established; the first beginning at 3:00 P.M. on the twentieth day of incubation and the last period concluding at 3:00 P.M. the twenty-second day of incubation. At the end of each emergent period, the hatcher was opened and each basket was checked for a chick. If a chick had emerged, the emergent period was marked on the tag attached to the basket. Opening of the hatcher did not greatly effect temperature, as the drop in temperature was usually less than 2 degrees. At the end of the last emergent period, the chicks were removed from the baskets, weighed and wingbanded.

After hatching the chicks were placed in brooders and fed a ration considered adequate for good growth. The chicks were weighed at 2, 4, 6, 8, 10 and 12 weeks of age. At 4 weeks of age Trial 2 chicks were vaccinated with live virus Newcastle vaccine.

In Trial 3 only egg weight and growth were considered. In this trial eggs were collected for eleven days before being incubated. The eggs were weighed to the nearest tenth of a gram, set in the incubator, candled at 18 days, and then each fertile egg was placed in a separate basket for hatching. The chicks were weighed at weekly intervals until 12 weeks of age. At 4 weeks of age the chicks were vaccinated with live virus Newcastle vaccine.

In Trial 4 the eggs were collected for seven days. At the end of seven days, the eggs were weighed to the nearest tenth of a gram and placed in the incubator. The eggs were placed in the incubator at the same time of day as in Trials 1 and 2. On the eighteenth day the eggs were transferred to individual baskets. The same emergent periods were used as in Trials 1 and 2. In this trial at the end of each emergent period those chicks which had hatched were removed from the baskets. As soon as the chicks had been weighed and wing-banded, they were placed in the brooder house where feed and water were available. This procedure was followed because of the possibility that any advantage chicks gained by emerging early might be lost while they remained in the incubator to the end of the hatch. All night lights were used for the first week in order that chicks placed in the brooders at night could find feed and water.

To study the effects of egg size and emergent period on reproductive performance, pullets from Trials 1 and 2 were used. At twelve weeks of age the pullets were placed on bermuda grass ranges. While on range the birds were fed growing mash and grain. At twenty weeks of age the pullets were housed. Trial 1 pullets were housed June 30, 1949, in two 20 by 20 foot straw loft pens. Trial 2 pullets were housed September, 1949, in a 32 by 32 foot straw loft pen. At housing the pullets were weighed and leg-banded. The birds were fed laying mash, free choice, and a grain mixture in the litter. The pullets received morning lights from early fall until spring. Pullets in Trial 1 were trapnested eleven months and pullets in Trial 2 eight months. No culling was done at any time. Mortality rates from all causes were considered. Age of sexual maturity and the number of eggs laid were the only factors considered under reproductive performance in this study. Two methods of calculating egg production were used. The first method included the egg production of only those birds alive at the end of the study; the second method included the egg production of all birds housed.

Pullets in Trial 1 contacted Newcastle in November, 1949, while pullets in Trial 2 were immune due to previous vaccination.

Simple correlation coefficients were obtained using the formula of Chambers (1946) in order to determine if any relation exists between egg size and growth to 12 weeks of age, and egg size and reproductive performance. This same method of analysis was used to determine any possible relationship between emergent period and growth to 12 weeks of age and reproductive performance.

RESULTS

Effect of Egg Size on Growth

A total of 693 male and 735 female chicks were hatched in four different trials and grown to twelve weeks of age in order to determine the effect of egg size on growth. In general, little relationship exists between egg size and growth at twelve weeks of age. The results of these trials are shown in tables 1, 1a, 2, 2a, 3, 3a, 4, 4a, 5 and 5a. All data were divided into 5 gram egg-weight classes with the totals for all classes included. This was done in order to minimize the advantage early emerging chicks gain in growth, as was indicated by the findings of Hays (1941) and Henderson and Champion (1948).

For the totals in all trials a highly significant positive correlation was obtained between egg size and day-old chick weight for both sexes. Within the 5 gram egg-weight classes highly positive correlations were found except where the number of chicks involved were small, indicating that chicks from large eggs are larger at hatching time than chicks from small eggs.

Positive highly significant correlations for the totals were obtained between egg size and growth for both sexes at one, two, and three weeks of age except for the females in Trial 1. No explanation can be given for the non-significant value found in Trial 1 females except one of statistical interpretation. It might be due to the "one-in-twenty" of sampling probability. Within the 5 gram egg-weight classes both positive and negative correlations were found indicating that within a small egg size range there was little relationship between egg size and growth at these ages.

Both highly significant and significant correlations were obtained between egg size and growth for both sexes at four, five and six weeks of age for the totals in all trials except Trial 2 males and Trial 3 - 501, males and females. This indicates that with chicks from eggs with a 43 to 75 gram range there was some relationship between egg size and growth at these ages. The results within the 5 gram egg-weight classes vary. In general, little relationship was found to exist between egg size and growth at these ages.

After six weeks of age the results vary. Both significant and non-significant correlations were obtained between egg size and growth for the totals. The major effect of egg size on growth appears to have been overcome by six weeks of age in most of the trials.

At twelve weeks of age a positive correlation for all totals still exists between egg size and growth for both sexes except for Trial 3 - 501, females. Only with Trial 1 males and Trial 2 females were correlations statistically significant. By twelve weeks of age no apparent and consistent advantage appears to exist between egg size and growth.

Positive but non-significant correlations of 0.058 and 0.087 were obtained between egg size and growth at twenty weeks of age for females of Trials 1 and 2 respectively, indicating no relation between egg size and growth at this age.

Although there was little relationship between egg size and growth at twelve weeks of age, the range of egg weights involved affected the time required to overcome egg size. As was found in the 5 gram egg-weight classes, chicks from eggs with a small range in weight were able to overcome the influence of egg size within a shorter time than chicks from eggs with a large range in weight.

Effect of Egg Size on Reproductive Performance

A total of 323 pullets housed in two trials were trapnested in order to determine the effect of size of the egg from which the pullet hatched on reproductive performance. No apparent relationship exists between the size of the egg from which the pullet hatched and sexual maturity or egg production.

In Trial 1 a positive correlation of 0.006 and in Trial 2 a negative correlation of 0.117 were obtained between the size of the egg from which the pullet hatched and sexual maturity. The average age of sexual maturity for Trials 1 and 2 was 185 and 190 days respectively. This was probably a true difference in age of sexual maturity even though there was two months difference in date of hatch. The pullets in Trial 2 received artificial lights which gave them approximately the same length of day at age of sexual maturity as the pullets in Trial 1. Byerly and Knox (1946) have shown that artificial lights at the time of sexual maturity modifies the effect of time of hatch on age at sexual maturity.

A significant negative correlation of 0.212 was obtained between the size of the egg from which the pullet hatched and egg production of the surviving pullets, and a non-significant negative correlation of 0.089 was obtained between egg size from which the pullet hatched and egg production of all pullets housed for Trial 1. In Trial 2 non-significant positive correlations of 0.148 and 0.134 were obtained between egg size from which the pullet hatched and egg production of the surviving pullets and all pullets housed respectively. This indicates that in both trials little relation exists between size of the egg from which the pullet hatched and egg production. The average egg production on a hen-housed basis was 92 eggs for Trial 1 and 83 eggs for Trial 2 for periods of 11 and 8 months respectively.

Effect of Emergent Period on Growth

A total of 481 male and 506 female chicks were hatched in three trials and grown to twelve weeks of age in order to determine the effect of emergent period on growth. Early-emerging chicks showed little advantage in growth when they were left in the incubator until the twenty-second day of incubation, but they did show a slight advantage in growth when they were removed from the incubator soon after hatching and given feed and water. The results of these trials are shown in tables 6, 6a, 7, 7a, 8, 8a and 9. The data were divided into 5 gram egg-weight classes in order to minimize the effect that egg size has on emergent period (Byerly, 1933).

Within the 5 gram egg-weight classes both positive and negative correlations were obtained between egg size and emergent period. Only in Trial 1 males and in Trial 1 females was a significant positive correlation obtained in the 5 gram egg-weight classes. In general, there was no relation between egg size and emergent period within the 5 gram egg-weight classes.

In Trials 1 and 2 highly significant positive correlations were obtained between emergent period and day-old chick weight for the totals for both sexes. In Trial 4 negative correlations were found for the totals for both sexes. The differences that were found may be explained by the fact that chicks in Trial 4 were removed from the incubator soon after hatching and weighed, while those chicks in Trials 1 and 2 remained in the incubator until the twenty-second day before being weighed. Thus, the chicks in Trial 4 lost little weight while those in Trials 1 and 2 lost weight because of their prolonged stay in the incubator. Both positive and negative correlations were obtained between emergent period and day-old chick weight in the 5 gram egg-weight classes indicating little relationship between emergent period and day-old weight.

In Trials 1 and 2 positive correlations were obtained between emergent period and two week weight for the totals of both sexes except for Trial 2 females. After this time a majority of the correlations between emergent period and growth to ten weeks of age were negative except for Trial 2 males. In Trial 4 negative correlations were obtained from one week of age to 12 weeks of age for the totals of both sexes except for the males at four weeks of age. The chicks in Trial 4 were removed from the incubator soon after hatching and were given access to feed and water. Thus they were able to maintain the advantage gained by emerging early.

Non-significant positive correlations were obtained between emergent period and growth at 12 weeks of age for the totals for the males and females in Trial 1 and the males in Trial 2, and negative correlations were found for the totals of Trial 2 females and Trial 4 males and females. The correlations of Trial 2 and 4 females were significant. The difference observed here may be due to environmental factors influencing growth and the time the chicks were removed from the incubator. In general, early emerging chicks maintain a slight advantage in growth at twelve weeks of age, especially when they are given access to feed and water shortly after emerging from the shell.

At 20 weeks of age, as shown in table 9, pullets in Trial 1 showed little relation between emergent period and growth, while in Trial 2 the pullets which emerged early were larger than the pullets which emerged later.

Effect of Emergent Period on Reproductive Performance

A total of 323 pullets were housed in two trials and trapnested in order to determine the effect of emergent period on reproductive performance. Generally, pullets which emerge early reach sexual maturity sooner and lay a few more eggs than the pullets which emerge later. The relationship of emergent period to sexual maturity is shown in table 10, while the relationship of emergent period and egg production is shown in table 11.

The results of Trial 1 show little relationship between emergent period and sexual maturity, while the results of Trial 2 indicate that early emerging pullets mature earlier sexually than the later emerging pullets. The source of variation may be due to the environment under which the pullets were grown, or to the difference in the date of hatch. The pullets in Trial 2 were grown during the warmer part of the year and hatched two months later than Trial 1 pullets.

The egg production of all surviving pullets of both trials indicate that the early emerging pullets lay a few more eggs than the late emerging pullets. Based on the egg production of pullets housed larger differences of egg production were found between the early emerging pullets and the late emerging pullets. It is possible a part of the difference in egg production was due to the fact that early emerging pullets reached sexual maturity sooner than the late emerging pullets.

Effect of Egg Size on Emergent Period

There have been conflicting data concerning the effect of egg size on emergent period. Byerly (1933) reported that larger eggs generally require longer incubation periods. Hays (1949), using the mean egg weight of the first ten eggs laid during the hatching season as a measure of egg weight, could show no relation between egg size and length of incubation of 430 dams studied. The range of egg weights in Byerly's data was from 52 to 57 grams, while no range is given for Hay's data.

Table 12 shows the relation of emergent period and egg size. The egg weights in this study range from 46 to 75 grams with a mean egg weight of 61.14 ± 4.468 grams. The average emergent period was 4.500 ± 1.162. This corresponds to the first half of the twenty-first day of incubation. When the three trials were combined a highly significant positive correlation was obtained indicating that larger eggs require a longer period of incubation than do small eggs. Only in Trial 4 was a non-significant correlation found.

Within the 5 gram egg-weight classes as seen in tables 6, 6a, 7, 7a, 8, and 8a little variation in emergent period was found. As the mean egg weight increases for each 5 gram egg-weight class, there was a general increase in the mean emergent period for both sexes.

The results of these data tend to show that chicks from large eggs emerge later than do chicks from small eggs. This would confirm Byerly's (1933) finding but apparently the range of egg weights involved has a definite bearing on the results obtained.

Egg Weight and Sex Ratios

The results of this study, as shown in table 13, confirm those of Jull (1924), Jull and Quinn (1925), and Munro and Kosin (1940) showing that there is no apparent relation between egg weight and sex ratios. No significant chi square values were obtained in these data.

The data were further divided into two groups. Group 1 was composed of eggs weighing between 43 and 58.9 grams and Group 2, eggs weighing between 59 and 75 grams. Nonsignificant chi square values of 0.78 for Group 1 and 1.03 for Group 2 were obtained indicating no apparent relation between egg weight and sex ratios.

Emergent Period and Sex Ratios

The data in table 14 show that females predominate within the early emergent periods, while males prevail in the later periods. This confirms the work of Hays (1941) working with chickens, and of Fronda and Infante (1948) using ducks. The totals of the three trials show only emergent periods three and seven with significant values. The data were divided into two groups; emergent periods one to four composing Group 1 and emergent periods five to seven Group 2. In the former group, 212 males and 286 females were obtained and in the latter group, 269 males and 220 females. Chi square values of 10.99 ($P > .01$) and 4.91 ($P > .05$) respectively were obtained. The mean emergent period for all male chicks was 4.665 ± 1.157 while for female chicks it was 4.368 ± 1.564.

These results indicate that females predominate in the first half of the hatch and males in the second half. Perhaps this is an indication of a higher metabolic rate for females than for males.

Emergent Period and Mortality

Table 15 shows the relation of emergent period and mortality to twelve weeks of age. In Trials 1 and 2, 31.1 and 18.3 percent mortality was recorded. In these trials there was a slight trend to higher mortality in the late emerging chicks. In Trial 4 which had a low mortality, 2.4 percent, this trend was reversed. When all data of the three trials were combined, there appeared to be no relation between emergent period and viability. This is not in accord with the results of Hays (1941) who found early emerging chicks to be more viable. The difference observed between these and Hays's results may be due to the extreme variation of mortality recorded in this study.

Table 16 shows the relation of emergent period to mortality in the laying house. Little relation was shown between emergent period and viability, confirming the work of Hays (1941).

Chick Weight and Sex Differences

In all trials there was a difference between day-old male and female chick weight. The mean weight at one day-old for males was 42.3163 ± 4.646 grams and that for females was 41.6481 ± 4.422 grams. When a group comparison was made, a highly significant t value of 2.78 with 1425 degrees of freedom was obtained. These data agree with those of Munro and Kosin (1940), Kosin and Munro (1941), and Romanoff (1948) showing that male chicks weigh more at hatching time than do female chicks.

The mean egg weights from which the above chicks hatched were 59.3517 $\pm$ 5.626 grams for the males and 59.1368 $\pm$ 5.603 grams for the females. A t value of 0.72 with 1425 degrees of freedom was found indicating that no significant difference exists between the mean egg weight from which the male chicks hatched and those from which the females hatched. This confirms the work of Jull and Quinn (1925).

Kosin and Munro (1941) have hypothesized that the male chicks utilize more of the shell calcium than females. This results in the male chicks having larger bones and heavier muscles and viscera than the female chicks. Romanoff (1948) found the calcium content of female chicks to be slightly greater than that of the male chicks. No data were collected in this study which would aid in answering this question.

Effect of Adult Body Size on Growth

A total of 275 pullets in two trials were weighed at 10 months of age in order to determine the effect of adult size on growth. Schnetzler (1936) has shown rate of growth to be associated with mature body weight, but it has not been shown at what age adult body size begins affecting growth. In this study it was found that adult body size began exerting its influence on growth between two and six weeks of age. The results are shown in table 17.

There was no apparent statistical relationship between adult body size and day-old chick weight. The results of Trial 1 indicate that the effect of adult body size began exerting its influence on growth at about six weeks of age, while in Trial 2 this effect is noticed at about two weeks of age. The source of variation between Trials 1 and 2 may be due to environmental factors, as the females in Trial 2 were grown during the warmer part of the year. Pullets with large mature body weights were larger at twelve weeks of age than pullets with small mature body weights.

Effect of Sexual Maturity on Growth

The age of sexual maturity of 321 pullets in two trials were determined in order to study the effect of sexual maturity on growth. Latimer (1924) and Waters (1937) obtained results indicating that rate of growth was associated with sexual maturity. Pullets which reached sexual maturity early were larger at about four to six weeks of age to 20 weeks of age than pullets which reached sexual maturity later. The results are shown in table 18.

In Trial 1 sexual maturity began exerting its influence on growth as early as four weeks of age, while in Trial 2 this influence was delayed an additional two weeks. At twelve weeks of age pullets which reached sexual maturity early weighed slightly more than pullets which reached sexual maturity later.

Relation of Emergent Period and Total Chicks Hatched

A total of 1265 chicks were hatched in three trials in which the emergent period was observed. Approximately 60.5 percent of the chicks hatched on the last half of the twenty-first day of incubation. The results are shown in table 19.

About 19.3 percent of the chicks hatched in periods one to three (20 days to 21 days), about 60.5 percent hatched in periods four and five (21 days to 21 2/3 days) and about 19.8 percent hatched in periods six and seven (21 2/3 days to 22 days).

TABLE 1

CORRELATION COEFFICIENTS BETWEEN EGG WEIGHT AND GROWTH TO 12 WEEKS OF AGE
MALES

TRIAL 1

Number of Chicks	5	61	96	40	16	218
Egg Wt. Classes g.	49-53.9	54-58.9	59-63.9	64-68.9	69-75	Total
Av. Day Old Wt. (1)	36.30	40.57	43.45	47.23	50.94	43.72
S.D. (2)	1.167	1.852	2.204	1.549	1.906	3.742
r. (3)	.778	.590**	.658**	.611**	.439	.907**
Av. 2 Week Wt.	94.60	105.15	115.26	116.40	123.06	112.73
S.D.	12.784	19.050	16.865	17.506	20.565	18.839
r.	.142	.265*	.232*	-.038	.019	.331**
Av. 4 Week Wt.	260.80	264.43	294.74	299.20	324.38	288.47
S.D.	42.170	63.890	59.760	63.140	64.000	64.213
r.	-.151	.130	.123	-.083	-.063	.263**
Av. 6 Week Wt.	1.21	1.18	1.29	1.31	1.35	1.26
S.D.	.206	.247	.225	.225	.205	.236
r.	-.200	.115	.110	-.097	-.024	.216**
Av. 8 Week Wt.	1.91	1.89	2.03	2.04	2.05	1.99
S.D.	.360	.314	.327	.304	.301	.325
r.	.005	.212	.128	-.112	-.018	.182**
Av. 10 Week Wt.	2.37	2.43	2.58	2.60	2.60	2.54
S.D.	.527	.400	.439	.384	.360	.421
r.	-.009	.182	.147	-.079	.156	.166*
Av. 12 Week Wt.	2.74	2.94	3.09	3.07	3.16	3.04
S.D.	.535	.431	.530	.460	.372	.486
r.	.205	.074	.099	-.091	.421	.153*

(1) Weight in grams from day old to 5 weeks of age, in pounds from 6 to 12 weeks of age.
(2) Standard Deviation
(3) Correlation Coefficients
* Significant (P>.05)
** Significant (P>.01)

TABLE 1a

CORRELATION COEFFICIENTS BETWEEN EGG WEIGHT AND GROWTH TO 12 WEEKS OF AGE
FEMALES

TRIAL 1

Number of Chicks	10	58	105	42	12	227
Egg Wt. Classes g.	49-53.9	54-58.9	59-63.9	64-68.9	69-75	Total
Av. Day Old Wt. (1)	36.30	39.39	43.16	46.18	49.50	42.79
S.D. (2)	1.208	1.685	1.962	2.346	2.467	3.642
r. (3)	.646*	.433**	.543**	.334**	.704*	.884**
Av. 2 Week Wt.	100.00	106.16	109.75	120.05	127.75	111.26
S.D.	22.162	18.363	15.434	18.395	15.637	25.459
r.	.695*	-.061	-.079	-.126	-.276	.012
Av. 4 Week Wt.	263.40	266.57	273.09	293.14	323.58	277.37
S.D.	48.382	56.860	50.401	53.490	44.930	54.274
r.	.350	.062	.114	.278	-.260	.262**
Av. 6 Week Wt.	1.13	1.14	1.14	1.20	1.30	1.16
S.D.	.145	.201	.186	.188	.115	.191
r.	.228	.052	.139	.208	-.121	.205**
Av. 8 Week Wt.	1.72	1.74	1.74	1.77	1.89	1.75
S.D.	.191	.268	.238	.259	.203	.249
r.	.329	.031	.126	.322	.052	.140*
Av. 10 Week Wt.	2.16	2.20	2.18	2.22	2.33	2.20
S.D.	.277	.330	.290	.278	.207	.296
r.	-.146	.080	.035	.247	.353	.105
Av. 12 Week Wt.	2.53	2.53	2.53	2.51	2.63	2.53
S.D.	.252	.335	.321	.301	.264	.320
r.	-.244	-.110	.087	.101	.479	.057

(1) Weight in grams, from day old to 5 weeks of age, in pounds from 6 to 12 weeks of age
(2) Standard Deviation
(3) Correlation Coefficients
* Significant (P>.05)
** Significant (P≥.01)

TABLE 2

CORRELATION COEFFICIENTS BETWEEN EGG WEIGHT AND GROWTH TO 12 WEEKS OF AGE
MALES

TRIAL 2

Number of Chicks	7	31	76	41	8	163
Egg Wt. Classes g.	49-53.9	54-58.9	59-63.9	64-68.9	69-74.9	Total
Av. Day Old Wt. (1)	34.93	39.08	42.84	46.18	49.13	42.94
S.D. (2)	1.535	1.520	1.850	1.900	2.420	3.663
r. (3)	.589	.634**	.730**	.620**	.635	.926**
Av. 2 Week Wt.	90.29	100.52	109.84	110.02	120.50	107.80
S.D.	8.561	13.712	14.070	15.957	10.050	15.312
r.	.083	.419*	.157	-.243	.582	.355**
Av. 4 Week Wt.	178.29	198.74	211.28	216.54	224.38	209.44
S.D.	37.695	37.910	35.667	42.582	33.797	39.092
r.	.063	.395*	.119	-.231	.079	.235**
Av. 6 Week Wt.	.74	.82	.88	.87	.89	.86
S.D.	.201	.169	.146	.177	.234	.170
r.	-.264	.386*	.101	-.175	-.088	.158
Av. 8 Week Wt.	1.26	1.36	1.45	1.45	1.44	1.42
S.D.	.207	.272	.212	.264	.336	.250
r.	-.015	.255	.082	-.078	.121	.172*
Av. 10 Week Wt.	1.81	1.91	2.03	2.02	2.14	1.99
S.D.	.242	.363	.279	.343	.482	.330
r.	-.285	.318	-.136	-.188	-.126	.147
Av. 12 Week Wt.	2.55	2.58	2.62	2.67	2.74	2.63
S.D.	.322	.421	.366	.452	.636	.415
r.	-.550	.216	-.062	-.129	-.199	.079

(1) Weight in grams from day old to 5 weeks of age, in pounds from 6 to 12 weeks of age.
(2) Standard Deviation
(3) Correlation Coefficients
* Significant (P>.05)
** Significant (P>.01)

TABLE 2a

CORRELATION COEFFICIENTS BETWEEN EGG WEIGHT AND GROWTH TO 12 WEEKS OF AGE
FEMALES

TRIAL 2

Number of Chicks	9	29	89	45	7	170
Egg Wt. Classes g.	49-53.9	54-58.9	59-63.9	64-68.9	69-74.9	Total
Av. Day Old Wt. (1)	34.90	39.28	42.02	45.10	47.96	42.23
S.D. (2)	1.707	1.148	1.927	1.888	2.469	3.353
r. (3)	.642	.581**	.419**	.407**	.595	.870**
Av. 2 Week Wt.	95.44	99.07	104.81	109.62	113.00	104.95
S.D.	7.310	11.241	14.298	11.552	13.720	13.523
r.	-.144	.082	.293**	.011	.361	.368**
Av. 4 Week Wt.	187.33	185.59	203.84	206.82	211.14	200.94
S.D.	35.627	31.627	36.360	32.767	35.838	35.56
r.	-.122	-.068	.220*	.056	.014	.226**
Av. 6 Week Wt.	.77	.72	.80	.81	.79	.79
S.D.	.123	.142	.146	.130	.108	.142
r.	-.064	-.188	.265*	.246	-.131	.272**
Av. 8 Week Wt.	1.21	1.14	1.24	1.27	1.24	1.23
S.D.	.275	.234	.232	.183	.170	.225
r.	.261	-.074	.199	.119	-.177	.179*
Av. 10 Week Wt.	1.69	1.62	1.70	1.71	1.72	1.69
S.D.	.285	.270	.291	.239	.230	.274
r.	.415	-.026	.197	.192	.065	.131
Av. 12 Week Wt.	2.14	2.05	2.19	2.20	2.26	2.17
S.D.	.356	.339	.311	.302	.252	.320
r.	.404	-.003	.213	.238	-.054	.187*

(1) Weight in grams from day old to 5 weeks of age, in pounds from 6 to 12 weeks of age.
(2) Standard Deviation
(3) Correlation Coefficients
* Significant (P>.05)
** Significant (P>.01)

TABLE 3

CORRELATION COEFFICIENT BETWEEN EGG WEIGHT AND GROWTH TO 12 WEEKS OF AGE
MALES

TRIAL 3 - 501

Number of Chicks	17	41	39	10	109
Egg Wt. Classes g.	43-48.9	49-53.9	54-58.9	59-63.9	Total
Av. Day Old Wt. (1)	36.75	39.71	42.45	46.65	40.72
S.D. (2)	1.982	1.614	2.353	1.516	3.514
r. (3)	.520*	.643**	.421**	.555	.876**
Av. 1 Week Old Wt.	58.97	61.60	66.80	66.00	63.55
S.D.	6.359	6.363	6.302	9.433	7.492
r.	.112	.235	-.142	-.158	.324**
Av. 2 Week Old Wt.	106.91	109.31	119.80	120.25	113.29
S.D.	12.904	13.791	13.118	16.064	15.156
r.	.131	.139	.143	-.278	.397**
Av. 3 Week Old Wt.	194.12	196.19	212.04	210.25	202.17
S.D.	22.406	25.989	23.525	21.808	26.206
r.	-.039	.129	.006	-.297	.307**
Av. 4 Week Old Wt.	305.59	303.50	322.37	310.75	310.33
S.D.	32.104	40.696	34.905	24.951	37.903
r.	.137	.013	.082	-.400	.192
Av. 5 Week Old Wt.	441.18	429.31	461.71	440.25	443.06
S.D.	55.298	57.227	50.114	33.605	54.628
r.	.407	-.030	-.021	-.486	.151
Av. 6 Week Old Wt.	1.23	1.20	1.29	1.24	1.24
S.D.	.182	.178	.145	.107	.164
r.	.590**	.223	-.334*	-.546	.146

TABLE 3 (Continued)

Av. 7 Week Old Wt.	1.56	1.58	1.65	1.61	1.60
S.D.	.185	.238	.189	.201	.210
r.	.776**	.090	-.162	-.654*	.135
Av. 8 Week Old Wt.	1.89	1.88	1.98	1.95	1.92
S.D.	.203	.300	.258	.212	.267
r.	.544*	.041	-.293	-.624*	.129
Av. 9 Week Old Wt.	2.22	2.25	2.35	2.36	2.29
S.D.	.303	.344	.325	.259	.325
r.	.594**	.078	-.325*	-.571	.148
Av. 10 Week Old Wt.	2.64	2.66	2.75	2.81	2.70
S.D.	.374	.406	.355	.296	.377
r.	.576**	.044	-.025	-.603*	.173
Av. 11 Week Old Wt.	2.92	3.00	3.09	3.17	3.03
S.D.	.469	.471	.392	.250	.439
r.	.618**	.022	-.805**	-.887**	.117
Av. 12 Week Old Wt.	3.34	3.38	3.46	3.55	3.42
S.D.	.518	.467	.400	.359	.440
r.	.629**	.065	.007	-.537	.146

(1) Weight in grams from day old to 5 weeks of age, in pounds from 6 to 12 weeks of age.
(2) Standard Deviation
(3) Correlation Coefficients
* Significant (P>.05)
** Significant (P>.01)

TABLE 3a

CORRELATION COEFFICIENTS BETWEEN EGG WEIGHT AND GROWTH TO 12 WEEKS OF AGE
FEMALES

TRIAL 3 - 501

Number of Chicks	15	56	32	9	115
Egg Wt. Classes g.	43-48.9	49-53.9	54-58.9	59-63.9	Total
Av. Day Old Wt. (1)	36.76	39.51	41.63	45.60	40.03
S.D. (2)	1.682	1.732	1.973	2.738	3.102
r. (3)	.722**	.498**	.481**	.829**	.863**
Av. 1 Week Old Wt.	57.50	61.79	62.42	68.06	61.88
S.D.	3.273	7.049	5.521	3.278	6.593
r.	.501*	.110	-.245	-.128	.293**
Av. 2 Week Old Wt.	99.29	107.46	109.03	117.78	107.32
S.D.	9.276	14.180	11.356	9.384	13.303
r.	.130	.009	.118	-.467	.329**
Av. 3 Week Old Wt.	178.93	189.06	189.19	199.44	188.45
S.D.	20.034	27.295	20.635	22.879	24.555
r.	.205	.078	.137	-.839**	.162
Av. 4 Week Old Wt.	279.04	283.53	283.55	294.44	283.84
S.D.	27.610	40.079	32.118	41.214	36.416
r.	.294	.049	-.472**	-.760**	.066
Av. 5 Week Old Wt.	404.29	399.46	395.40	396.94	398.94
S.D.	35.040	51.705	45.837	52.626	47.786
r.	.346	.069	.179	-.711*	-.046
Av. 6 Week Old Wt.	1.14	1.09	1.09	1.08	1.10
S.D.	.107	.151	.124	.144	.137
r.	.518*	-.073	.080	-.662*	-.104

TABLE 3a (Continued)

Av. 7 Week Old Wt.	1.44	1.38	1.35	1.37	1.38
S.D.	.133	.179	.187	.195	.180
r.	.538*	.095	.161	-.509	-.045
Av. 8 Week Old Wt.	1.73	1.63	1.60	1.61	1.63
S.D.	.137	.198	.211	.181	.199
r.	.472	-.023	.276	.673*	-.112
Av. 9 Week Old Wt.	2.02	1.93	1.89	1.91	1.93
S.D.	.169	.227	.237	.177	.253
r.	.483	.000	.009	-.689*	-.143
Av. 10 Week Old Wt.	2.37	2.24	2.20	2.222	2.25
S.D.	.161	.261	.274	.209	.220
r.	.485	.140	.130	-.694*	-.147
Av. 11 Week Old Wt.	2.60	2.46	2.45	2.40	2.47
S.D.	.185	.270	.276	.225	.278
r.	.722**	.092	.081	-.643*	-.163
Av. 12 Week Old Wt.	2.79	2.71	2.68	2.65	2.71
S.D.	.223	.268	.277	.245	.259
r.	.473	.072	.037	-.535	-.154

(1) Weight in grams from day old to 5 weeks of age, in pounds from 6 to 12 weeks of age
(2) Standard Deviation
(3) Correlation Coefficient
* Significant (P>.05)
** Significant (P>.01)

TABLE 4

CORRELATION COEFFICIENT BETWEEN EGG WEIGHT AND GROWTH TO 12 WEEKS OF AGE
MALES

TRIAL 3 - A-13

Number of Chicks		36	41	24	103
Egg Wt. Classes g.		43-48.9	49-53.9	54.58.9	Total
Av. Day Old Wt. (1)		33.73	36.64	39.34	36.39
	S.D. (2)	1.632	1.662	1.585	2.875
	r. (3)	.632**	.581**	.610**	.881**
Av. 1 Week Old Wt.		56.04	58.06	64.48	59.04
	S.D.	5.114	5.598	4.332	6.165
	r.	-.031	.249	.132	.518**
Av. 2 Week Old Wt.		99.14	100.94	113.33	103.71
	S.D.	9.052	11.516	10.428	12.123
	r.	.019	.301	.017	.469**
Av. 3 Week Old Wt.		175.43	178.50	198.44	183.02
	S.D.	18.468	22.135	20.367	22.928
	r.	.120	.214	.022	.420**
Av. 4 Week Old Wt.		276.43	281.11	310.00	287.50
	S.D.	29.774	38.002	35.685	37.617
	r.	.173	.190	-.001	.374**
Av. 5 Week Old Wt.		404.14	411.69	446.25	418.59
	S.D.	43.325	47.338	53.464	50.788
	r.	.274	.136	-.099	.345**
Av. 6 Week Old Wt.		1.14	1.16	1.27	1.18
	S.D.	.141	.136	.164	.289
	r.	.225	.035	-.276	.160

TABLE 4 (Continued)

Av. 7 Week Old Wt.	1.48	1.51	1.65	1.53
S.D.	.219	.196	.239	.227
r.	.200	.186	-.051	.298**
Av. 8 Week Old Wt.	1.75	1.77	1.90	1.80
S.D.	.249	.217	.254	.251
r.	.196	.107	-.119	.183
Av. 9 Week Old Wt.	2.10	2.11	2.25	2.14
S.D.	.291	.259	.276	.291
r.	.255	.070	-.193	.150
Av. 10 Week Old Wt.	2.38	2.40	2.58	2.43
S.D.	.340	.294	.287	.330
r.	.244	.002	-.071	.176
Av. 11 Week Old Wt.	2.75	2.76	2.94	2.79
S.D.	.368	.352	.309	.368
r.	.211	-.034	-.082	.119
Av. 12 Week Old Wt.	3.10	3.12	3.28	3.15
S.D.	.421	.341	.335	.398
r.	.164	.087	.075	.114

(1) Weight in grams from day old to 5 weeks of age, in pounds from 6 to 12 weeks of age.
(2) Standard Deviation
(3) Correlation Coefficients
* Significant (P>.05)
** Significant (P>.01)

TABLE 4a

CORRELATION COEFFICIENTS BETWEEN EGG WEIGHT AND GROWTH TO 12 WEEKS OF AGE
FEMALES

TRIAL 3 - A-13

Number of Chicks	35	50	24	5	114
Egg Wt. Classes g.	43-48.9	49-53.9	54-58.9	59-63.9	Total
Av. Day Old Wt. (1)	33.06	36.32	39.24	42.32	36.20
S.D. (2)	1.585	1.577	2.028	1.292	3.071
r. (3)	.613**	.448**	.609**	.952**	.888**
Av. 1 Week Old Wt.	53.07	56.84	59.46	60.00	56.34
S.D.	6.872	5.479	6.583	8.515	6.791
r.	-.168	.486**	.481**	-.193	.461**
Av. 2 Week Old Wt.	93.00	98.13	104.30	97.50	97.76
S.D.	14.038	12.588	10.324	17.030	13.488
r.	.142	.528**	.310	-.188	.343**
Av. 3 Week Old Wt.	163.71	169.01	180.22	164.00	169.44
S.D.	27.546	23.680	21.559	26.344	25.396
r.	.220	.449**	.241	-.423	.265**
Av. 4 Week Old Wt.	257.36	261.92	280.65	260.50	264.21
S.D.	43.855	38.341	38.886	34.547	41.775
r.	.397*	.195	.218	-.514	.243*
Av. 5 Week Old Wt.	371.14	370.47	396.74	378.00	376.46
S.D.	62.060	56.123	50.780	44.142	57.517
r.	.214	.394**	.242	-.635	.216*
Av. 6 Week Old Wt.	1.03	1.02	1.09	1.05	1.04
S.D.	.179	.147	.153	.105	.159
r.	.313	.350*	.217	-.738	.208*

TABLE 4a (Continued)

Av. 7 Week Old Wt.	1.30	1.29	1.40	1.33	1.32
S.D.	.232	.204	.200	.206	.216
r.	.280	.411**	.184	-.790	.228*
Av. 8 Week Old Wt.	1.50	1.50	1.60	1.51	1.52
S.D.	.237	.213	.207	.136	.222
r.	.191	.356**	.243	-.777*	.209*
Av. 9 Week Old Wt.	1.76	1.77	1.87	1.78	1.79
S.D.	.262	.244	.230	.147	.248
r.	.182	.230	.219	-.859*	.184*
Av. 10 Week Old Wt.	1.98	2.00	2.12	2.13	2.02
S.D.	.276	.267	.267	.192	.272
r.	.283	.288	.172	-.851*	.248**
Av. 11 Week Old Wt.	2.25	2.24	2.36	2.34	2.27
S.D.	.281	.288	.272	.139	.283
r.	.187	.211	.023	-.898**	.188*
Av. 12 Week Old Wt.	2.50	2.49	2.58	2.63	2.52
S.D.	.280	.309	.267	.112	.287
r.	.178	.243	.246	-.814*	.175

(1) Weight in grams from day old to 5 weeks of age, in pounds from 6 to 12 weeks of age
(2) Standard Deviation
(3) Correlation Coefficients
* Significant (P>.05)
** Significant (P>.01)

TABLE 5

CORRELATION COEFFICIENTS BETWEEN EGG WEIGHT AND GROWTH TO 12 WEEKS OF AGE
MALES

TRIAL 4

Number of Chicks	30	37	23	100
Egg Wt. Classes g.	54-58.9	59-63.9	64-68.9	Total
Av. Day Old Wt. (1)	42.44	45.90	50.17	46.09
S.D. (2)	1.973	2.027	1.261	4.133
r. (3)	.630**	.562**	.461*	.935**
Av. 1 Week Old Wt.	64.08	68.11	72.72	68.28
S.D.	6.969	6.640	8.309	8.387
r.	.219	.326*	.589**	.605**
Av. 2 Week Old Wt.	124.33	127.10	129.46	127.15
S.D.	14.565	14.121	15.388	14.719
r.	.252	-.057	.479*	.288**
Av. 3 Week Old Wt.	178.58	181.01	184.67	181.93
S.D.	22.528	20.664	27.478	23.224
r.	.298	-.094	.524*	.262**
Av. 4 Week Old Wt.	291.08	296.01	304.78	298.20
S.D.	33.666	33.754	47.837	38.367
r.	.172	-.311	.482*	.270**
Av. 5 Week Old Wt.	415.58	418.11	428.04	422.75
S.D.	50.271	49.765	69.320	56.442
r.	.102	-.293	.465*	.199*
Av. 6 Week Old Wt.	1.18	1.17	1.22	1.20
S.D.	.144	.150	.175	.154
r.	.114	-.293	.587**	.194

TABLE 5 (Continued)

Av. 7 Week Old Wt.	1.48	1.46	1.49	1.48
S.D.	.177	.176	.218	.190
r.	.115	-.448**	.241	.150
Av. 8 Week Old Wt.	1.77	1.79	1.81	1.79
S.D.	.250	.198	.264	.242
r.	.058	-.034	.214	.016
Av. 9 Week Old Wt.	2.06	2.07	2.12	2.09
S.D.	.292	.246	.304	.286
r.	.100	-.334*	.261	.188
Av. 10 Week Old Wt.	2.36	2.37	2.47	2.41
S.D.	.338	.275	.344	.330
r.	.270	-.318	.165	.265**
Av. 11 Week Old Wt.	2.71	2.72	2.83	2.77
S.D.	.352	.314	.395	.371
r.	.021	-.190	.169	.274**
Av. 12 Week Old Wt.	3.17	3.18	3.14	3.18
S.D.	.380	.363	.446	.399
r.	.004	-.255	.056	.109

(1) Weight in grams from day old to 5 weeks of age, in pounds from 6 to 12 weeks of age
(2) Standard Deviation
(3) Correlation Coefficients
* Significant (P>.05)
** Significant (P>.01)

TABLE 5a

CORRELATION COEFFICIENTS BETWEEN EGG WEIGHT AND GROWTH TO 12 WEEKS OF AGE
FEMALES

TRIAL 4

Number of Chicks	27	53	20	109
Egg Wt. Classes g.	54-58.9	59-63.9	64-68.9	Total
Av. Day Old Wt. (1)	42.55	46.22	49.13	45.80
S.D. (2)	1.413	1.592	1.736	3.532
r. (3)	.509**	.624**	.722*	.895**
Av. 1 Week Old Wt.	63.24	67.21	72.13	66.96
S.D.	6.963	7.899	7.343	8.404
r.	-.081	.076	-.290	.459**
Av. 2 Week Old Wt.	120.37	122.94	130.63	123.62
S.D.	17.372	17.376	13.296	16.884
r.	-.290	-.183	-.271	.204*
Av. 3 Week Old Wt.	171.02	173.22	179.88	173.67
S.D.	25.900	25.376	20.501	24.911
r.	-.191	-.290*	-.064	.245*
Av. 4 Week Old Wt.	267.87	276.70	286.75	276.20
S.D.	39.948	44.812	29.231	41.643
r.	-.174	.293*	-.071	.283**
Av. 5 Week Old Wt.	386.57	382.55	400.13	387.55
S.D.	64.773	62.541	48.195	60.717
r.	-.249	.241	-.168	.185
Av. 6 Week Old Wt.	1.06	1.08	1.14	1.09
S.D.	.174	.131	.125	.149
r.	-.230	.169	-.362	.259**

TABLE 5a (Continued)

Av. 7 Week Old Wt.	1.30	1.32	1.39	1.33
S.D.	.209	.171	.143	.184
r.	-.274	.411**	-.309	.184
Av. 8 Week Old Wt.	1.55	1.57	1.64	1.58
S.D.	.252	.203	.203	.220
r.	-.263	.321*	-.333	.226*
Av. 9 Week Old Wt.	1.81	1.79	1.88	1.81
S.D.	.296	.239	.231	.270
r.	-.266	.487**	-.238	.241*
Av. 10 Week Old Wt.	2.04	2.03	2.12	2.06
S.D.	.361	.285	.261	.299
r.	-.243	.276*	-.292	.138
Av. 11 Week Old Wt.	2.27	2.27	2.39	2.30
S.D.	.342	.315	.263	.310
r.	-.286	.386**	-.138	.098
Av. 12 Week Old Wt.	2.58	2.59	2.69	2.61
S.D.	.361	.329	.289	.324
r.	-.279	.241	-.114	.147

(1) Weight in grams from day old to 5 weeks of age, in pounds from 6 to 12 weeks of age.
(2) Standard Deviation
(3) Correlation Coefficients
* Significant (P>.05)
** Significant (P>.01)

TABLE 6

CORRELATION COEFFICIENTS BETWEEN EMERGENT PERIOD AND GROWTH FROM DAY OLD TO 12 WEEKS OF AGE

MALES

TRIAL 1

Number of Chicks	5	61	96	40	16	218
Egg Wt. Classes g.	49-53.9	54-58.9	59-63.9	64-68.9	69-75	Total
Av. Emergent Period	3.80	4.71	4.73	5.15	5.25	4.82
S.D. (2)	.400	1.232	1.271	1.108	1.031	1.228
r. (3)	.771*	-.018	.097	.138	-.081	.192**
Av. Day Old Wt. (1)	36.30	40.57	43.45	47.23	50.94	43.72
S.D.	1.167	1.852	2.204	1.549	1.906	3.742
r.	.771*	.272*	.395**	.039	.547*	.348**
Av. 2 Week Wt.	94.60	105.15	115.26	116.40	123.06	112.73
S.D.	12.784	19.050	16.865	17.506	20.565	18.839
r.	.141	-.429**	.037	.059	.026	.045
Av. 4 Week Wt.	260.80	264.43	294.74	299.20	324.38	288.47
S.D.	42.170	63.90	59.760	63.140	64.000	64.213
r.	.140	-.461**	-.007	.053	.061	-.089
Av. 6 Week Wt.	1.21	1.18	1.29	1.31	1.35	1.26
S.D.	.206	.247	.225	.225	.205	.236
r.	.024	-.410**	-.026	.012	-.148	-.109
Av. 8 Week Wt.	1.91	1.89	2.03	2.04	2.05	1.99
S.D.	.360	.314	.327	.304	.301	.325
r.	.083	-.286*	.027	.031	-.081	-.044
Av. 10 Week Wt.	2.37	2.43	2.58	2.60	2.60	2.54
S.D.	.527	.400	.439	.384	.360	.421
r.	.209	-.328**	-.058	-.121	-.247	-.143*
Av. 12 Week Wt.	2.74	2.94	3.09	3.07	3.16	3.04
S.D.	.535	.431	.530	.460	.372	.486
r.	.177	-.152	.080	-.058	-.327	.002

(1) Weight in grams from day old to 5 weeks of age, in pounds from 6 to 12 weeks of age
(2) Standard Deviation
(3) Correlation Coefficients
* Significant (P .05)
** Significant (P .01)

TABLE 6a

CORRELATION COEFFICIENTS BETWEEN EMERGENT PERIOD AND GROWTH FROM DAY OLD TO 12 WEEKS OF AGE

FEMALES

TRIAL 1

Number of Chicks	10	58	105	42	12	227
Egg Wt. Classes g.	49-53.9	54-58.9	59-63.9	64-68.9	69-75	Total
Av. Emergent Period	4.60	4.17	4.49	4.74	5.17	4.49
S.D. (2)	1.020	1.118	1.138	1.172	.984	1.155
r. (3)	.335	.101	.253**	-.220	.051	.196**
Av. Day Old Wt. (1)	36.30	39.39	43.16	46.18	49.50	42.79
S.D.	1.208	1.685	1.962	2.346	2.467	3.642
r.	.706*	.216	.418**	.364*	.028	.333**
Av. 2 Week Wt.	100.00	106.16	109.75	120.05	127.75	111.26
S.D.	22.162	18.363	15.434	18.395	15.637	25.459
r.	.612*	.074	.146	.202	-.328	.169*
Av. 4 Week Wt.	263.40	266.57	273.09	293.14	323.58	277.37
S.D.	48.382	56.855	50.401	53.488	44.929	54.274
r.	.834**	-.004	-.082	-.116	-.202	.041
Av. 6 Week Wt.	1.13	1.14	1.14	1.20	1.30	1.16
S.D.	.145	.201	.186	.188	.115	.191
r.	.611*	-.024	-.055	-.192	-.143	-.008
Av. 8 Week Wt.	1.72	1.74	1.74	1.77	1.89	1.75
S.D.	.191	.268	.238	.259	.203	.249
r.	.707*	.062	-.091	-.236	-.058	-.029
Av. 10 Week Wt.	2.16	2.20	2.18	2.22	2.33	2.20
S.D.	.277	.330	.290	.278	.207	.296
r.	.343	.039	-.138	-.324*	-.223	-.073
Av. 12 Week Wt.	2.53	2.53	2.53	2.51	2.63	2.53
S.D.	.252	.335	.321	.301	.264	.320
r.	.473	.066	-.018	-.083	.350	.033

(1) Weight in grams from day old to 5 weeks of age, in pounds from 6 to 12 weeks of age

(2) Standard Deviation

(3) Correlation Coefficients

* Significant (P>.05)

** Significant (P>.01)

TABLE 7
CORRELATION COEFFICIENTS BETWEEN EMERGENT PERIOD AND GROWTH FROM DAY OLD TO 12 WEEKS OF AGE
MALES
TRIAL 2

Number of Chicks	7	31	76	41	8	163
Egg Wt. Classes g.	49-53.9	54-58.9	59-63.9	64-68.9	69-75	Total
Av. Emergent Period	3.29	4.19	4.40	4.63	4.00	4.35
S.D. (2)	1.030	1.088	.960	1.205	1.118	1.099
r. (3)	.536	.178	.095	-.017	.192	.182*
Av. Day Old Wt. (1)	34.93	39.08	42.84	46.18	49.13	42.94
S.D.	1.535	1.520	1.850	1.900	2.420	3.663
r.	.539	.658**	.348**	.425**	.785*	.370**
Av. 2 Week Wt.	90.29	100.52	109.84	110.02	120.50	107.80
S.D.	8.561	13.712	14.070	15.957	10.050	15.312
r.	-.579	.371	-.103	.113	.636	.124
Av. 4 Week Wt.	178.29	198.74	211.28	216.54	224.38	209.44
S.D.	37.695	37.910	35.667	42.582	33.797	39.092
r.	-.346	.231	.010	.053	.490	.118
Av. 6 Week Wt.	.74	.82	.88	.87	.89	.86
S.D.	.201	.169	.146	.177	.234	.170
r.	-.566	.264	-.027	.184	.526	.141
Av. 8 Week Wt.	1.26	1.36	1.45	1.45	1.44	1.42
S.D.	.207	.272	.212	.264	.336	.250
r.	-.386	.198	-.182	.190	.299	.085
Av. 10 Week Wt.	1.81	1.91	2.03	2.02	2.14	2.00
S.D.	.242	.363	.279	.343	.482	.330
r.	-.449	.302	-.275	.147	.589	.067
Av. 12 Week Wt.	2.55	2.58	2.62	2.67	2.74	2.63
S.D.	.322	.421	.366	.452	.636	.415
r.	-.541	.377*	-.154	.109	.507	.082

(1) Weight in grams from day old to 5 weeks of age, in pounds from 6 to 12 weeks of age
(2) Standard Deviation
(3) Correlation Coefficient
* Significant (P>.05)
** Significant (P>.01)

TABLE 7a

CORRELATION COEFFICIENTS BETWEEN EMERGENT PERIOD AND GROWTH FROM DAY OLD TO 12 WEEKS OF AGE

FEMALES

TRIAL 2

Number of Chicks	9	29	80	45	7	170
Egg Wt. Classes g.	49-53.9	54-58.9	59-63.9	64-68.9	69-75	Total
Av. Emergent Period	3.56	4.24	4.03	4.02	3.86	4.03
S. D. (2)	.942	1.041	1.265	1.221	1.457	1.220
r. (3)	.448	-.092	.009	.110	-.304	.006
Av. Day Old Wt. (1)	34.90	39.28	42.02	45.10	47.96	42.23
S.D.	1.707	1.148	1.927	1.888	2.469	3.353
r.	.761*	.129	.472**	.575**	.509	.265**
Av. 2 Week Wt.	95.44	99.07	104.81	109.62	113.00	104.95
S.D.	7.310	11.241	14.278	11.552	13.720	13.523
r.	.134	-.308	.098	-.344	-.421	-.131
Av. 4 Week Wt.	187.33	185.59	203.84	206.82	211.14	200.94
S.D.	35.627	31.627	36.360	32.767	35.838	35.561
r.	-.436	-.205	.042	-.315*	-.612	-.139
Av. 6 Week Wt.	.77	.72	.80	.81	.79	.79
S.D.	.123	.142	.146	.130	.108	.142
r.	-.344	-.373*	.042	-.253	-.778	-.150
Av. 8 Week Wt.	1.21	1.14	1.24	1.27	1.24	1.23
S.D.	.275	.234	.232	.183	.170	.225
r.	-.059	-.354	.016	-.296*	-.380	-.137
Av. 10 Week Wt.	1.69	1.62	1.70	1.71	1.72	1.69
S.D.	.285	.270	.291	.239	.230	.274
r.	-.043	-.392*	-.045	-.365*	-.587	-.189*
Av. 12 Week Wt.	2.14	2.05	2.19	2.20	2.26	2.17
S.D.	.356	.339	.311	.302	.252	.320
r.	.171	-.304	-.067	-.298*	-.658	-.186*

(1) Weight in grams from day old to 5 weeks of age, in pounds from 6 to 12 weeks of age
(2) Standard Deviation
(3) Correlation Coefficient
* Significant (P>.05)
** Significant (P>.01)

TABLE 8

CORRELATION COEFFICIENTS BETWEEN EMERGENT PERIOD AND GROWTH FROM DAY OLD TO 12 WEEKS OF AGE
MALES

TRIAL 4

Number of Chicks	30	37	23	100
Egg Wt. Classes g.	54-58.9	59-63.9	64-68.9	Total
Av. Emergent Period	4.70	4.81	5.04	4.85
S.D. (2)	1.005	.953	.854	.963
r. (3)	.091	-.211	-.399	.086
Av. Day Old Wt. (1)	42.44	45.90	50.17	46.09
S.D.	1.973	2.027	1.261	4.133
r.	-.330	-.303	-.084	-.019
Av. 1 Week Old Wt.	64.08	68.11	72.72	68.28
S.D.	6.969	6.640	8.309	8.387
r.	-.224	-.219	-.578**	-.243*
Av. 2 Week Old Wt.	124.33	127.10	129.46	127.15
S.D.	14.565	14.121	15.388	14.719
r.	-.258	.012	-.490*	-.162
Av. 3 Week Old Wt.	178.58	181.01	184.67	181.93
S.D.	22.528	20.664	27.478	23.224
r.	-.184	.210	-.241	-.022
Av. 4 Week Old Wt.	291.08	296.01	304.78	298.20
S.D.	33.666	33.754	47.837	38.367
r.	-.067	.315	-.113	.086
Av. 5 Week Old Wt.	415.58	418.11	428.04	422.75
S.D.	50.271	49.765	69.320	56.442
r.	-.363*	.105	-.366	-.174

TABLE 8 (Continued)

Av. 6 Week Old Wt.	1.18	1.17	1.22	1.20
S.D.	.144	.150	.175	.154
r.	-.393*	.217	-.279	-.126
Av. 7 Week Old Wt.	1.48	1.46	1.49	1.48
S.D.	.177	.176	.218	.190
r.	-.364*	.383*	-.279	-.039
Av. 8 Week Old Wt.	1.77	1.79	1.81	1.79
S.D.	.250	.198	.264	.242
r.	-.361	.135	-.285	-.134
Av. 9 Week Old Wt.	2.06	2.07	2.12	2.09
S.D.	.292	.246	.304	.286
r.	-.332	.143	-.257	-.121
Av. 10 Week Old Wt.	2.36	2.37	2.47	2.41
S.D.	.338	.275	.344	.330
r.	-.389*	.044	-.251	-.172
Av. 11 Week Old Wt.	2.71	2.72	2.83	2.77
S.D.	.352	.314	.395	.371
r.	-.469*	.372*	-.244	-.071
Av. 12 Week Old Wt.	3.17	3.18	3.14	3.18
S.D.	.380	.363	.446	.399
r.	-.413*	.228	-.127	-.098

(1) Weight in grams from day old to 5 weeks of age, in pounds from 6 to 12 weeks of age
(2) Standard Deviation
(3) Correlation Coefficients
* Significant (P>.05)
** Significant (P>.01)

TABLE 8a

CORRELATION COEFFICIENTS BETWEEN EMERGENT PERIOD AND GROWTH FROM DAY OLD TO 12 WEEKS OF AGE
FEMALES

TRIAL 4

Number of Chicks	27	53	20	109
Egg Wt. Classes g.	54-58.9	59-63.9	64-68.9	Total
Av. Emergent Period	4.26	4.83	4.50	4.63
S.D. (2)	.844	1.005	.975	1.029
r. (3)	.350	.106	.205	.094
Av. Day Old Wt. (1)	42.55	46.22	49.13	45.80
S.D.	1.413	1.592	1.736	3.532
r.	-.242	-.187	-.007	-.016
Av. 1 Week Old Wt.	63.24	67.21	72.13	66.96
S.D.	6.963	7.899	7.343	8.404
r.	-.235	-.415**	-.498*	-.333**
Av. 2 Week Old Wt.	120.37	122.94	130.63	123.62
S.D.	17.372	17.376	13.296	16.884
r.	-.371	-.283*	-.632**	-.356**
Av. 3 Week Old Wt.	171.02	173.22	179.88	173.67
S.D.	25.900	25.376	20.501	24.911
r.	-.175	-.260	-.378	-.271**
Av. 4 Week Old Wt.	267.87	276.70	286.75	276.20
S.D.	39.948	44.812	29.231	41.643
r.	-.119	-.260	-.193	-.227*
Av. 5 Week Old Wt.	386.57	382.55	400.13	387.55
S.D.	64.773	62.541	48.195	60.717
r.	-.290	-.482**	-.424	-.418**

TABLE 8a (Continued)

Av. 6 Week Old Wt.	1.06	1.08	1.14	1.09
S.D.	.174	.131	.125	.149
r.	-.309	-.105	-.398	-.230*
Av. 7 Week Old Wt.	1.30	1.32	1.39	1.33
S.D.	.209	.171	.143	.184
r.	-.298	.037	-.457*	-.141
Av. 8 Week Old Wt.	1.55	1.57	1.64	1.58
S.D.	.252	.203	.203	.222
r.	-.326	-.027	-.638**	-.255**
Av. 9 Week Old Wt.	1.18	1.79	1.88	1.81
S.D.	.296	.239	.231	.270
r.	-.398*	-.082	-.570**	-.299**
Av. 10 Week Old Wt.	2.04	2.03	2.12	2.06
S.D.	.361	.285	.261	.299
r.	-.371	-.087	-.534*	-.220*
Av. 11 Week Old Wt.	2.27	2.27	2.39	2.30
S.D.	.342	.315	.263	.310
r.	-.367	-.060	-.565**	-.198*
Av. 12 Week Old Wt.	2.58	2.59	2.69	2.61
S.D.	.361	.329	.289	.324
r.	-.401*	-.077	-.374	-.209

(1) Weight in grams from day old to 5 weeks of age, in pounds from 6 to 12 weeks of age.
(2) Standard Deviation
(3) Correlation Coefficients
* Significant (P>.05)
** Significant (P>.01)

TABLE 9

RELATION OF EMERGENT PERIOD AND BODY WEIGHT AT 5 MONTHS OF AGE
FEMALES

Emergent Period	1	2	3	4	5	6	7	Totals and Averages	Correlation Coefficients
Trial 1									
Number of Pullets Housed	___	8	36	63	59	32	8	206	
Mean Body Weight Lbs.	___	3.66	3.61	3.70	3.70	3.63	3.83	3.67	.047
Trial 2									
Number of Pullets Housed	1	14	41	51	30	17	4	158	
Mean Body Weight Lbs.	3.75	3.67	3.69	3.70	3.41	3.49	3.65	3.62	-.202*

* Significant (P>.05)

TABLE 10

THE RELATION OF EMERGENT PERIOD TO SEXUAL MATURITY

Emergent Period	2	3	4	5	6	7	Averages	r(1)
Trial 1 Average Days to Sexual Maturity	167.1	189.0	183.9	183.9	188.5	190.6	185.2	.075
Trial 2 Average Days to Sexual Maturity	180.3	184.9	188.2	203.2	196.8	200.8	190.8	-.268**

** Significant (P>.01)
(1) Correlation Coefficients

TABLE 11

THE RELATION OF EMERGENT PERIOD TO EGG PRODUCTION

Emergent Period		2	3	4	5	6	7	Averages	Correlation Coefficients
Egg Production of the Surviving Pullets	(1) Trial 1 Average	163.8	128.9	117.1	125.7	108.1	149.5	124.0	-.108
	(2) Trial 2 Average	118.1	92.2	87.5	83.9	79.9	64.8	88.0	-.140
Egg Production of All Pullets Housed	Trial 1 Average	123.4	93.9	89.3	89.5	76.0	128.3	91.8	-.069
	Trial 2 Average	114.9	92.2	79.2	78.1	70.1	64.8	82.8	-.171*

(1) 11 months duration
(2) 8 months duration
* Significant ($P>.05$)

TABLE 12

THE RELATION OF EMERGENT PERIOD TO EGG SIZE

Emergent Period	1	2	3	4	5	6	7	Totals and Averages	r(2)
Trial 1									
No. Chicks Hatched	1	17	99	180	194	115	41	647	
Av. Egg Wt. (1)	54.00	59.26	59.82	60.52	61.45	61.57	61.48	60.90	.156**
Trial 2									
No. Chicks Hatched	2	25	85	142	94	40	10	398	
Av. Egg Wt.	62.50	61.18	60.86	61.24	62.15	61.60	63.60	61.46	.100*
Trial 4									
No. Chicks Hatched	-	1	16	72	85	41	5	220	
Av. Egg Wt.	-	62.80	60.02	60.47	61.78	62.32	60.02	61.29	.082
Totals									
No. Chicks Hatched	3	43	200	394	373	196	56	1265	
Av. Egg Wt.	59.67	60.46	60.28	60.77	61.70	61.74	61.67	61.14	.116**

(1) Weight in grams
(2) Correlation Coefficients
* Significant (P>.05)
** Significant (P>.01)

TABLE 13

THE RELATION OF EGG WEIGHT TO SEX RATIOS

Egg Weight Classes g.	43-48.9	49-53.9	54-58.9	59-63.9	64-68.9	69-75	Totals
Trial 1							
No. Chicks Hatched	---	15	119	201	82	28	453
Percent Males	---	33.3	51.3	47.8	48.8	57.1	48.1
Trial 2							
No. Chicks Hatched	---	16	60	165	86	15	333
Percent Males	---	43.8	51.7	46.1	47.7	53.3	48.9
Trial 3							
No. Chicks Hatched	76	123	145	78	19	---	441
Percent Males	50.0	47.1	44.8	52.5	52.6	---	48.1
Trial 4							
No. Chicks Hatched	1	8	57	90	43	10	209
Percent Males	0.0	50.0	52.6	41.1	53.5	60.0	47.8
Totals							
No. Chicks Hatched	77	162	381	534	230	53	1428
Percent Males	49.4	45.7	49.1	46.8	49.6	56.6	48.5

TABLE 14

THE RELATION OF EMERGENT PERIOD TO SEX RATIOS

Emergent Period	1	2	3	4	5	6	7	Totals
Trial 1								
No. Chicks Hatched	--	13	67	121	131	87	26	443
Percent Males	--	46.2	40.3	43.8	49.6	56.3	69.2	48.8
Chi Square Value	--	.31	2.52	1.86	.01	1.39	3.85*	.27
Trial 2								
No. Chicks Hatched	2	21	68	117	80	37	8	333
Percent Males	50.0	28.6	36.8	52.1	58.8	52.4	50.0	49.0
Chi Square Value	.00	3.86*	4.76*	.21	2.45	.27	.00	.15
Trial 4								
No. Chicks Hatched	--	1	16	72	78	35	5	209
Percent Males	--	100.00	37.5	36.1	59.0	45.7	100.00	47.9
Chi Square Value	--	--	1.00	5.56*	2.51	.26	5.00*	.39
Totals								
No. Chicks Hatched	2	35	151	310	289	159	41	987
Percent Males	50.00	37.1	38.4	45.2	54.7	52.8	65.9	48.7
Chi Square Value	.00	2.31	81.10**	2.90	2.52	.50	4.12*	.63

* Significant (P>.05)

** Significant (P>.01)

TABLE 15

THE RELATION OF EMERGENT PERIOD TO GROWING MORTALITY TO 12 WEEKS OF AGE

Emergent Period	1	2	3	4	5	6	7	Total	Correlation Coefficient
Trial 1									
Number of Chicks Started (1)	1	16	97	178	191	113	41	637	
Number Dead	1	4	30	60	61	27	15	198	.024
Percent Dead	100.0	25.0	30.9	33.7	31.9	23.9	36.6	31.1	
Trial 2									
Number of Chicks Started	2	24	81	143	94	38	10	392	
Number Dead	0	3	15	28	22	2	2	72	.018
Percent Dead	0	12.5	18.5	19.6	23.4	5.3	20.0	18.3	
Trial 4									
Number of Chicks Started	-	1	16	72	77	37	5	208	
Number Dead	-	1	1	1	1	1	0	5	-.089
Percent Dead	-	100.0	6.3	1.4	1.3	2.7	0.0	2.4	
Totals									
Number of Chicks Started	3	41	194	393	362	188	56	1237	
Number Dead	1	8	46	89	84	30	17	275	.009
Percent Dead	33.3	19.5	23.7	22.6	23.2	16.0	30.4	22.2	

(1) Both sexes

TABLE 16

THE RELATION OF EMERGENT PERIOD TO LAYING HOUSE MORTALITY

Emergent Period	2	3	4	5	6	7	Total	Correlation Coefficient
(1) Trial 1								
Number of Pullets Housed	8	28	51	54	26	7	174	
Number Dead	2	9	12	19	11	1	54	.004
Percent Dead	25.0	32.1	23.5	35.2	42.3	14.3	31.0	
(2) Trial 2								
Number of Pullets Housed	10	35	46	29	15	4	139	
Number Dead	1	0	6	2	3	0	12	-.084
Percent Dead	10.0	0.0	13.0	6.9	20.0	0.0	8.6	
Totals								
Number of Pullets Housed	18	63	97	83	41	11	313	
Number Dead	3	9	18	21	14	1	66	.033
Percent Dead	16.7	14.3	18.6	25.3	34.1	9.1	21.1	

(1) 11 months duration
(2) 8 months duration

TABLE 17

THE RELATION OF ADULT BODY SIZE TO GROWTH FROM ONE DAY TO 20 WEEKS OF AGE

FEMALES

	Adult (2) Body Size	Day Old	2 Weeks	4 Weeks	6 Weeks	8 Weeks	10 Weeks	12 Weeks	20 Weeks
Trial 1									
Average Wt. (1)	5.53	42.77	111.83	282.32	1.18	1.78	2.23	2.56	3.70
Correlation Coefficient		.077	.144	.168	.308**	.374**	.464**	.502**	.496**
Trial 2									
Average Wt.	5.83	42.12	105.22	201.99	.79	1.23	1.71	2.19	3.62
Correlation Coefficient		.061	.237**	.389**	.432**	.521**	.575**	.599**	.703**

(1) Day Old, 2 week, 4 week weights are in grams, the remainder in pounds
(2) Weights taken at 40 weeks of age
** Significant (P>.01)

TABLE 18

THE RELATION OF SEXUAL MATURITY TO GROWTH FROM 2 TO 20 WEEKS OF AGE

FEMALES

	Sexual Maturity	2 Weeks	4 Weeks	6 Weeks	8 Weeks	10 Weeks	12 Weeks	20 Weeks
Trial 1								
Average Wt. (1)	185.17 (2)	111.90	280.31	1.17	1.77	2.23	2.57	3.71
Correlation Coefficient		-.065	-.151*	-.193*	-.175*	-.220**	-.201**	-.269**
Trial 2								
Average Wt.	190.05	105.36	202.70	.80	1.24	1.71	2.19	3.65
Correlation Coefficient		-.089	-.129	-.206*	-.247**	-.249**	-.328**	-.356**

(1) Day old, 2 week, 4 week weights are in grams, the remainder in pounds
(2) Days
* Significant (P>.05)
** Significant (P>.01)

TABLE 19

PERCENTAGE OF CHICKS EMERGING IN THE DIFFERENT PERIODS

Emergent Period	1	2	3	4	5	6	7	Totals
Trial 1								
No. Chicks Hatched	1	17	99	180	194	115	41	647
Percent Emerged	0.1	2.6	15.3	27.8	29.9	17.7	6.3	100.00
Trial 2								
No. Chicks Hatched	2	25	85	142	94	40	10	398
Percent Emerged	0.5	6.2	21.3	31.2	23.6	10.0	2.5	100.00
Trial 4								
No. Chicks Hatched	0	1	16	72	85	41	5	220
Percent Emerged	0.0	0.4	7.2	32.7	38.6	18.6	2.2	100.00
Totals								
No. Chicks Hatched	3	43	200	394	373	196	56	1265
Percent Emerged	0.2	3.3	15.8	31.1	29.4	15.4	4.4	100.00

DISCUSSION

Effect of Egg Size on Growth and Reproductive Performance

The results obtained in these various trials indicate that egg size has little effect on growth at broiler age (10 to 12 weeks of age).

Weight at hatching time is largely dependent upon egg size as shown by Benjamin (1920), Upp (1924), and others. Sometime between one day-old and twelve weeks of age much of the advantage of egg size is overcome. The results of this study indicate that chicks from eggs which have as little as two grams variation in size can overcome this range in egg size within the first week. Chicks from eggs with a greater variation than 2 grams (43 to 75 grams) require an additional length of time to overcome the advantage of egg size. Most of the advantage of egg size has disappeared by four to six weeks of age within this range of variation. Therefore, the duration of the effect of egg size on growth seems to be dependent on the range in egg size involved.

There are at least three factors which have some influence in overcoming the effect of egg size. These factors are: (1) size to be attained or adult body size, (2) sexual maturity, and (3) the time the chick emerges from the shell.

In figure I, can be seen the time at which the four factors--egg size, adult body size, rate of sexual maturity and emergent period--exerted a significant part of their influence on growth to 12 weeks of age in females of Trial 1 and 2. It appears that egg size exerted its influence up to about eight weeks of age. Adult body size began exerting its influence at about two to six weeks of age, while rate of maturity began exerting its influence at about four weeks of age. The influence of emergent period appears later, or at about six weeks of age.

It would appear that at 12 weeks of age adult body size was exerting the most influence on growth with rate of sexual maturity, egg size and emergent period next in order as shown by coefficients of determinations of 36 percent, 11 percent, 3.5 percent, and 3.4 percent respectively.

The variations that were observed in the time required for chicks to overcome egg size may be the result of several factors. The amount of selection for growth that has been practiced may be a cause of variation. In Trial 3 - 501, the chicks were from a flock which had been selected for growth. The advantage of egg size in this group was overcome by three weeks of age in both sexes. Trial 3 - A-13, chicks were grown at the same time and on the same ration. These chicks were from a flock with little selection for growth. Here it took 3 to 6 weeks longer to overcome the advantage of egg size. Therefore, it seems that the rate of growth determines to some extent how long egg size affects growth. The fast growing chicks seem to overcome the effect of egg size sooner than do slow growing chicks. The environment under which the chicks were grown causes some variation in time required to overcome egg size. Trial 2 was conducted during the late spring and early summer. Both the males and females required eight weeks or longer to overcome the effect of egg size. As growth was delayed by the high environmental temperature, this would appear to substantiate the fact that rate of growth determines to some extent how long egg size affects growth. The time at which the chicks are removed from the incubator leads to some variation. Trial 4 chicks were removed from the incubator within eight hours after emerging from the shell. In this trial large correlations were obtained the first four or five weeks for both sexes. After this time, the advantage of egg size is quickly overcome. In all the data, weight of birds which died at any age are included. In some instances this may influence the resulting correlations. Some variation of the time required to overcome egg size may be due to the result of mortality.

The two instances where significant correlations were found at twelve weeks of age might be caused by one or another of the above factors, or might be due to the sampling nature of the correlation coefficients. The males of Trial 1 were from a flock where little selection for growth rate had been practiced. As shown in Trial 3, chicks from such a flock require a slightly longer time to overcome the advantage of egg size. Other environmental factors may have had some influence. The females in Trial 2 were grown during the summer months. The weights of all weeks were smaller than those in other trials. Such a retardation of growth during hot weather was reported by Kempster (1941) and Upp and Thompson (1927).

Gutteridge and O'Neil (1942) found that environment had a much greater effect than heredity upon the course of growth during the period of rapid development. Galpin (1939) has suggested that characters vested in the egg, probably related to factors controlling the physiological activity of the dam, influence growth rate. Because of this delay and that of high environmental temperature, the time required to overcome the influence of egg size was longer than in those chicks grown during the cooler part of the year.

Broiler producers would gain little by obtaining chicks that were hatched from large eggs. The coefficients of determination for egg size and chick weight at one day of age was approximately 86 percent as compared to about 2 percent at twelve weeks of age. Egg size at one day of age accounts for approximately 86 percent of the total variation in chick weight, while at 12 weeks of age, egg size accounts for only about 2 percent of the total variation. Broiler producers obtaining chicks hatched from eggs averaging 20 to 22 ounces per dozen may expect satisfactory growth at ten to twelve weeks of age.

As shown in this study, little relation exists between the size of the egg from which the pullet hatched and sexual maturity or egg production.

If the size of the egg from which the pullet hatched is related to sexual maturity, it would be related through body size at age of sexual maturity. Callenbach (1934) has shown that birds which are larger at sixteen weeks of age reach sexual maturity earlier than do smaller birds. The results of this study indicate that larger birds of this strain generally reach sexual maturity earlier than do the smaller birds. This data would indicate that the size of the egg from which the pullet hatched has little effect on growth at twenty weeks of age; therefore, little relation could be expected to exist between size of the egg from which the pullet hatched and sexual maturity within this strain.

Hays and Bennett (1923) have shown sexual maturity to be correlated with annual egg production. Finne (1948) found that early sexual maturing birds lay more eggs during their first laying year than do late sexual maturing birds. As there was little relationship between the size of the egg from which the pullets hatched and sexual maturity, little relation could be expected between size of the egg from which the pullet hatched and egg production.

The difference of the results of the two trials of pullets housed to study the effect of size of the egg from which the pullet hatched and reproductive performance may be due to the extreme difference in mortality rate. Trial 1 had 31 percent mortality while Trial 2 had 9 percent mortality. Another possible source of variation may be the difference of time each trial was in production. Trial 1 was in production for a duration of 11 months and Trial 2, 8 months. When the production of all birds housed for both trials was considered little relation appears to exist between the size of the egg from which the pullet hatched and egg production. However, additional data using larger numbers would be desirable before coming to a definite conclusion as to the effect that size of the egg from which the pullet hatched may have on egg production.

It does not seem necessary that consideration should be given to the size of the egg from which the pullet hatched other than to maintain average egg size in the flock.

Effect of Emergent Period on Growth And Reproductive Performance

The results of this study indicate that early emerging chicks grow faster than do late emerging chicks.

The early emerging chicks, when removed from the incubator soon after hatching, have a slight advantage in growth. This slight advantage in growth is probably due to two factors. First, the chicks secure feed and water sooner. Second, those chicks which emerge early may be faster growing. By having feed and water available sooner, the chicks which emerge early and become hungry can obtain feed. Little or no loss of weight occurs because the chicks are soon eating. These chicks are able to use the energy of the feed rather than that of the yolk material. If the chicks remain in the incubator, there is a loss of weight due to the absorption of yolk material as a source of energy and due to a loss of moisture. Even with this loss of weight those chicks which emerged early grew slightly faster.

The variations found between emergent period and day-old chick weight in Trials 1 and 2 and Trial 4 are caused by the differences in the time the chicks were removed from the incubator. Chicks in Trials 1 and 2 remained in the incubator until the twenty-second day, while those in Trial 4 were removed within eight hours after emerging from the shell. Those chicks which emerged early and remained in the incubator for the duration of the hatch lost weight. Those chicks which emerged early and were removed did not lose weight. The early emerging chicks were slightly larger than the later emerging chicks. On the average, chicks which were removed from the incubator soon after hatching weighed about 75 percent of the original egg weight while chicks which remained in the incubator until the twenty-second day weighed about 70 percent of the original egg weight. There was approximately a 5 percent difference in weight of day-old chicks between Trial 1 and 2 and Trial 4. This source of variation was true for the results obtained between emergent period and growth after one day-old for these trials. The chicks which were removed from the incubator soon after hatching were able to maintain the advantage in growth gained by emerging early from the shell.

In most hatchery operations the hatcheryman removes all his chicks from the incubator at one time. Generally, this is the beginning of the twenty-second day of incubation. Following this practice little advantage in growth is gained by the early emerging chicks, and the slight gain in growth rate would probably be more than offset by the cost of labor needed to remove the early emerging chicks from the hatcher. This additional cost would no doubt be added to the sale price of the chicks. In large hatcheries where chicks are removed early in order to reduce crowding in the hatching trays, the broiler producer would be able to obtain early emerging chicks. But, about 57.4 percent of the early emerging chicks were females, hence broiler producers would have less total weight to sell at ten to twelve weeks of age. Ackerson and Mussehl (1930) and Asmundson and Lerner (1933) have shown that male chicks grow more rapidly than female chicks. Commercial broiler producers would gain little by obtaining the early emerging chicks.

As shown in this study, generally pullets which emerge early tend to reach sexual maturity sooner and lay a few more eggs than pullets which emerge later.

Early sexual maturity results in a higher annual egg production (Hays (1944), Hays and Bennet (1923) and Finne (1948). This explains the results obtained in Trial 2 pullets but does not explain the results obtained in Trial 1. In Trial 2 the early emerging pullets reached sexual maturity sooner and laid more eggs. The early emerging pullets of Trial 1 reached sexual maturity later but laid more eggs. This indicates that factors other than sexual maturity cause a difference of egg production between early and late emerging chicks.

Because of the many environmental factors which influence egg production, it is doubtful that much could be gained by selecting the early emerging pullets for egg production.

Effect of Egg Size on Emergent Period

The results of these data tend to show that chicks from large eggs emerge later than do chicks from small eggs.

Although there is an indication that large eggs take longer to hatch than do small eggs, the varations observed within these data indicate that other factors may affect the time chicks emerge from the shell. The variation in the development of the embryo due to holding temperature, position of the egg in the cycle and time the egg remains in the oviduct are possible sources of variation. The environmental conditions of incubation could affect the emergent period of the chicks. Smyth and Howes (1949) have shown by selection that there may be genes controlling the length of incubation period.

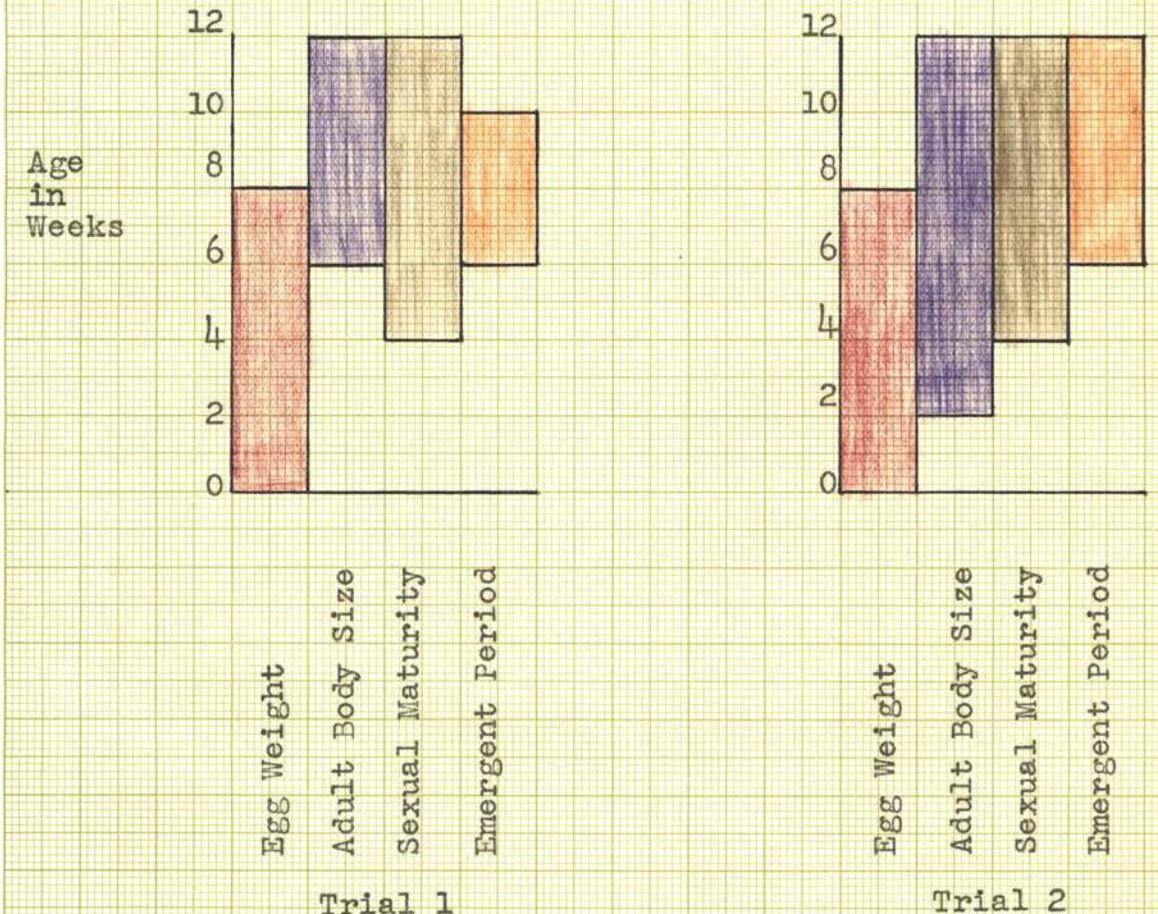

Figure 1

The Relation of Factors Affecting Growth Through 12 Weeks of Age

SUMMARY AND CONCLUSIONS

The effect of egg size on growth and reproductive performance was studied. From this study of 693 male and 735 female chicks and 323 pullets the following conclusion may be drawn:

1. Egg size has little effect on growth at ten to twelve weeks of age.
2. Egg size, as it influences chick weight, disappears between four and six weeks of age.
3. Egg size and day-old chick weight are highly correlated.
4. There is no relation between the size of the egg from which the pullet was hatched and sexual maturity.
5. There is no relation between the size of the egg from which the pullet was hatched and egg production.
6. Male chicks weigh more than female chicks at hatching time.
7. Egg size has no effect on sex ratios.
8. Adult body size begins exerting its influence on growth at about two to six weeks of age.
9. Rate of sexual maturity begins exerting its influence on growth at about four to six weeks of age.

The effect of emergent period on growth and reproductive performance was studied. From this study of 481 male and 506 female chicks and 323 pullets the following conclusion may be drawn:

1. Early emerging chicks grow slightly faster than late emerging chicks.

2. Early emerging pullets mature sexually slightly earlier than late emerging pullets.
3. Early emerging pullets lay a few more eggs than do late emerging pullets.
4. There is no relation between emergent period and mortality to twelve weeks of age.
5. There is no relation between emergent period and mortality during the period of egg production.
6. Egg weight and emergent period is highly correlated; therefore, the larger the egg, generally, the longer time required for it to hatch.
7. Female chicks predominate during the first half of the hatch, while male chicks predominate during the second half.

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