THE EFFECT OF DATE OF HATCH ON GROWTH OF CHICKS

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PREFACE

In June of 1951, the writer was assigned to work with Dr. George F. Godfrey as Research Assistant in the Poultry Department of the Oklahoma Agricultural and Mechanical College.

In order to initiate studies on heritability of growth rate and on physiological factors governing or associated with growth rate, knowledge of sources of variation are necessary. Inadequacies of present experimental data preclude making sound recommendations to poultry producers concerning date of hatch for optimum growth. These considerations led to the research reported in this thesis.

The writer wished to express his appreciation to the staff of the Poultry Department of the Oklahoma Agricultural and Mechanical College for their helpful advice and criticisms and expecially to Dr. George F. Godfrey, under whose supervision the experimental work was carried out. Dr. Godfrey has been a constant source of encouragement and guidance, and has offered invaluable constructive criticisms in the writing of this thesis. Appreciation is also expressed to Dr. Franklin Graybill, who outlined the method of statistical analysis.

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INTRODUCTION

Many factors, both environmental and genetic, affect the rate of growth of chicks. To make critical analyses of factors affecting growth rate, it is highly desirable to know the sources and magnitudes of the variations involved.

Physiological limitations preclude hatching an unlimited number of chicks from each sire and dam at a given time. Therefore the breeder or experimentalist must hatch several groups of chicks at different dates in order to have a fairly large sample of chicks with which to work. This is particularly true in studies of the genetics of populations because of the large sampling errors involved. Naturally then, data secured from different hatches is a possible source of variation. Therefore, in this thesis, the variation between hatches was measured in order to determine whether or not the data from individual hatches could be pooled or should be treated separately in future work. From the results obtained it was possible to make recommendations as to when chicks grow best within the time limits imposed by the data.

REVIEW OF LITERATURE

A review of the literature indicates that chicks hatched early in the season grow better than chicks hatched in the later part of the season. Asmundson and Lerner (1933), obtained data from four hatches of Single Comb White Leghorns hatched at 15-day intervals which indicated that early hatched chicks grew faster than late hatched chicks. The difference between the growth rate of the early and late hatched chicks indicated that environment influences growth rate. These data show the importance of considering the environment when studying the inheritance of a physiological character such as growth rate. Later, Lerner and Asmundson (1938), working with Barred Plymouth Rocks and two strains of Single Comb White Leghorns during 1935 and 1936, obtained two-, four-, six-, and eight-week weights which indicated that early hatched chicks tended to be heavier than late hatched chicks. Border line significance at the 5 percent level was found for differences among the 1936 hatches, but the variation among the 1935 hatches was non-significant.

Hays and Sanborn (1929), obtained growth data from 1913 through 1928 for hatches at one-week intervals, beginning February and continuing to April 11. They concluded that early hatched chicks generally were heavier than late hatched chicks. The first hatch was 12.98 percent heavier than the last hatch at two weeks of age, 28.79 percent heavier at four weeks of age, and 21.70 percent heavier at 16 weeks of age. They concluded that high temperatures, which the later hatches were subjected to, retarded growth.

In investigations with turkeys hatched April 12 and May 24, 1932, and April 18 and May 30, 1933, Asmundson and Lloyd (1936), found that the early hatched poults grew more rapidly on the average than those hatched later in the season up to at least eight weeks of age. Feed consumption figures indicated that early hatched poults consumed 28.65 percent more feed per bird to eight weeks of age than late hatched poults. Also, early hatched birds consumed less feed per unit of gain during the first eight weeks of age than did the late hatched ones. They concluded that lower room temperatures due to lower outside temperatures may in part account for the more rapid initial growth of the early hatched poults.

Working with data obtained at the Missouri Agricultural Experiment Station, Kempster and Parker (1936), and Kempster (1938), established normal growth curves for White Leghorns, Rhode Island Reds, and White Rock pullets. From these data they concluded that the early hatched chicks grew faster when young than did those chicks hatched in April or later. High maximum temperatures during the summer months were largely responsible for the retarded growth of the late hatched chicks.

Work at the Oklahoma Agricultural Experiment Station by Upp and Thompson (1927) with chicks hatched at two-week intervals over the period of a year, indicated that winter and spring hatched chicks grew more rapidly than chicks hatched in summer and fall. Mortality was lower in chicks hatched during the winter and spring months than for those hatched at other seasons. High summer temperatures were largely responsible for the variation between hatches. Later work at the Oklahoma Agricultural Experiment Station by Jaap and Morris (1937), indicated that hatch probably would contribute only a small amount to the total variation in growth rate. When conditions of feeding and management are identical and chicks produced within a relatively short period, January 18th to March 15th, variety, sire, dam, and sex contributed 82 percent of the variance. The remaining 18 percent of the total variance was caused by size of egg, time of hatch, and physiological differences due to environmental response.

Winchester and Kleiber (1938), and Kleiber and Dougherty (1934), raised chicks to 16 days or less of age under controlled environmental temperatures, and obtained maximum growth rate at a temperature of 69.8° F. Winchester and Kleiber (1938), observed that chicks kept at lower temperatures consumed more feed per kilogram than those kept at higher temperatures. The relationship of feed consumption and environmental temperature seemed to be almost linear. From digestion trials they concluded that the availability of food dry matter was higher at 69.8° F. than at either extreme.

Barott and Pringle (1949), raised chicks to 18 days of age at controlled environmental temperatures, and obtained maximum growth over the period from the 9th to the 18th day when temperature dropped uniformly from 87° F. on the 9th day to 80° F. on the 18th day. The efficiency of feed utilization rose from a value of 0.43 on the 9th day to 0.49 on the 18th day. Growth and efficiency of feed utilization became less as temperature was varied either way from the range noted for maximum growth.

Hoffmann and Shaffner (1950), found a wide variation in the secretion rate of thyroxin during different seasons of the year. The secretion rate of thyroxin during the winter months was 15 gamma per day as determined by the thyroxin-thiouracil technique, and 9.5 gamma per day during the summer months. The interrelationships of endocrine glands and growth rate are not completely understood and therefore, it is difficult to make definite cause and effect statements.

MATERIALS AND METHODS

To study the source and magnitude of the effect of date of hatch on growth rate, chicks from pedigree matings of the Oklahoma Agricultural Experiment Station Strain of New Hampshires hatched during 1951 and 1952 hatching seasons, were used. Chicks from 103 and 121 dam families and 8 and 10 sire families were utilized during the 1951 and 1952 hatching seasons, respectively.

During 1951, chicks were hatched at two-week intervals, beginning February 19, and ending May 7, with the exception of the May 7 hatch, which was hatched one week after the April 30 hatch. During 1952, chicks were hatched at two-week intervals beginning January 28, and ending April 7.

Chicks hatched during the 1951 hatching season were wing-banded and placed in brooder houses, except the April 16 hatch, which was placed in battery brooders due to a lack of brooder house space. This hatch was transferred to brooder houses three to four weeks later when sufficient space was available. Chicks of all hatches in 1952 were intranasally vaccinated against Newcastle Disease at one day of age, and placed in brooder houses, except for the March 24 hatch which was placed in battery brooders due to insufficient house space. This hatch was transferred to brooder houses three to four weeks later.

All chicks were fed the same starter ration (table 1) which was considered adequate for normal growth. Mortality was recorded for each hatch to nine weeks of age. Floor space per bird ranged between .7 and 1.0 square foot.

A Taylor Maximum and Minimum Registering thermometer was used to register the outside maximum temperatures. The average maximum temperatures were calculated for the nine week growing period for each hatch.

All chicks were weighed to the nearest tenth of a pound, and sexed at nine weeks of age.

A total of 3064 and 3609 chicks was raised during the 1951 and 1952 hatching seasons, respectively. In order to circumvent the statistical problems caused by unequal sub--class members, random selections of five male and five female chicks were made from each sire family in each hatch to determine the effect of date of hatch on growth. The sources of variation were subdivided into that contributed by hatches, sires, sex, sire-hatch interaction, sire-sex interaction, sex--hatch interaction, sire-sex-hatch interaction and the error term. Variation due to dams was included in the error term because of the reduction in dam numbers which would have resulted due to the necessity of having chicks from all dams in all hatches. Therefore the error term was larger than the actual value which would tene to reduce the "F" values.

RESULTS AND DISCUSSION

Average body weights, percent mortality, and average maximum environmental temperatures for each hatch are shown in figures 1 and 2. These data indicate that two peaks of growth were found for chicks hatched during each year. The first peak in 1951 was obtained with birds hatched March 5, and the second peak was obtained with chicks hatched April 16. The first peak in 1952 was obtained with chicks hatched February 25 and the second peak was reached with chicks hatched March 24. It seems that the trend of growth rates is nearly the same for both years.

The decline in growth rate in hatches after the first peak might be explained by infections of coccidiosis. Previous experience indicates that the first two or three hatches are usually unaffected by coccidiosis, but that later hatches are affected. Inexperienced brooder personnel are unfamiliar with the early symptoms of coccidiosis, and therefore do not recognize the presence of the disease in sufficient time to initiate treatment. If a brood of chicks is more severely affected than another, retardation of growth is generally more severe in the former than in the latter case.

The second peak might be explained by better control of the disease. Chicks in the March 24, 1952, and those in the April 16, 1951 hatch were started in battery brooders. These data indicated that chicks started in battery brooders were heavier at nine weeks of age than those started on the floor. This agrees with the work of Le Masurier and Branion (1938).

Generally, then, growth rate of chicks hatched from January 28 to March 1 increased, and then decreased for hatches after March 1 with the exception of the April 16, 1951 and the March 24, 1952 hatches, which were started in battery brooders.

The extent of mortality in all hatches for 1951 and 1952 was low. Mortality ranges from 1.57 percent for the January 28, 1952 hatched chicks to 5.87 percent for the April 30, 1951 hatched chicks. The February 19 and March 5, 1951 hatches made up the first peak in figure 1 with 2.47 percent and 2.93 percent mortality respectively. When mortality increased, there was a tendency for growth rate to decrease as shown with the March 19 and April 30 hatches. Increased mortality was probably a result of coccidiosis infections. The reverse sometimes happens as shown in the April 2, and April 16 hatches when an increased growth rate and mortality occurred. A possible explanation of increased growth and increased mortality is that one pen may have experienced a heavy infection of coccidiosis with heavy mortality, while other pens were free from coccidiosis with little mortality and less retardation of growth.

Mortality percentages of 1.57, 2.04, and 1.77 were recorded for hatches making up the first peak of growth rate for 1952. A decrease in growth rate for the March 19 hatch was accompanied by an increase in mortality to 2.47 percent. This hatch might have been affected by coccidiosis which accounted for increased mortality and retardation of growth. Sulfa drugs were placed in the feed in sufficient time to reduce the mortality, but not in time to reduce retardation of growth rate. Mortality increased to 2.78 and 3.84 percent for the March 24 and April 7 hatches.

Mortality was lower for chicks hatched in 1952 than for those hatched in 1951. The trends were similar with low mortality being recorded for hatches up to March 1 and higher mortality being recorded for hatches after March 1. Lower mortality for early hatched chicks than for late hatched chicks may in part be explained by lower environmental temperatures and reduced disease incidence.

Average maximum outside temperatures for the 1951 hatches are given in figure 1. Temperature ranged from 61.48° F. to 81.95° F. for the February 2 and May 7 hatches respectively. Average maximum temperature increased approximately 3.5° F. for each two-week interval between hatches.

Figure 1 indicates that the trend for average maximum outside temperatures for the 1951 hatches were similar to those of the 1952 hatches as shown in figure 2. Average maximum outside temperatures ranged from 55.98° F. for the January 28 and April 7 hatches. The range of 1952 temperatures averaged approximately 6° F. less than the range for 1951 hatches. Different hatch dates probably account for the differences in temperature. Maximum growth rates were obtained with hatches grown at an average maximum outside temperature of 63.2° F. and 60.3° F. for 1951 and 1952 respectively. Kleiber and Dougherty (1934), Winchester and Kleiber (1938), obtained maximum growth rates with chicks maintained at a brooder temperature of 69.8° F. Chicks in their experiments were 16 days and less of age. The average brooder temperatures were not available, but wide fluctuations in Oklahoma weather conditions make it almost impossible to maintain a constant temperature in brooder houses. It is possible that the average maximum and minimum interior temperatures might have explained certain variations among hatches. Low maximum outside temperatures which early hatched chicks were subjected to may in part account for heavier chicks with less mortality at nine weeks of age.

Statistical analyses, table 2 and 3, of these data gave "F" values which were highly significant for variation among hatches, sires, sex, and sire-hatch interaction. Hatch contributed 3.65 percent and 1.46 percent of the total variation in growth rate during 1951 and 1952 respectively. The average weight of chicks from all hatches during 1951 was 13 percent less than those during 1952. The data of table 4 indicate that the coefficient of variability is less for chicks from hatches with higher growth rate than those with lower growth rate. Chicks from hatches with a low coefficient of variability would be more uniform, thus they would contribute less to the total variation than chicks from hatches with high coefficients of variability. Therefore, it is reasonable to assume that chicks from hatches during 1952 were more uniform, and contributed less to the total variation than those during 1951.

Differences among sires contributed 1.27 and 0.51 percent of the total variation in growth rate during 1951 and 1952 respectively. The sires were more variable in their contributions of genes for growth rate of chicks in 1951 than in 1952, contributing more to total variation in growth rate.

Variation due to sex accounted for a major portion of the total variation. Sex accounted for 78.70 and 88.36 percent of the total variation during 1951 and 1952 respectively. When growth rate was retarded, males seemed to be more affected than females. Females averaged 87 percent of the weight of the males during 1951, and only 84 percent during 1952. The greater range between sexes is a possible explanation for the larger percent of total variation accounted for by sex during 1952 than for 1951.

Sire-hatch interaction contributed only a very small portion of the total variation. Percentages of 0.73 and 0.87 were contributed by sire-hatch interaction during 1951 and 1952 respectively. Non-randomization of the chicks when placed in brooder houses is a possible explanation of the sire-hatch interaction. Chicks from two or three sires may have been placed in each brooder house. Disease may have affected the chicks in one brooder house more severely than those in another house, thus leading to a sire-hatch interaction. An environment which is more similar for related individuals than for non-related ones, is apt to cause individuals with different genotypes to have the same phenotype (Lerner, 1950). Also there is a possibility that a gene-environmental interaction is involved here.

Previous experience has indicated that a good producing strain of chicks bred in one section of the country may do very poorly in another section of the country. Genes for growth rate might have an optimum environment for maximum efficiency; therefore, it is possible that chicks from a sire may react differently to different temperatures or other conditions due to gene--environmental interactions.

In conducting future experiments, it would be desirable to randomize chicks in the various brooder houses. Non-randomization may cause an environment to be more similar for related individuals than for non-related ones. It would also be desirable to start all chicks in the brooder houses since those started in battery brooders contributed more variation than those grown in brooder houses. More experienced personnel or better training of present personnel would reduce the variation caused by disease to a minimum. Information concerning the amount of feed and efficiency of feed consumed by chicks of different hatches to nine weeks of age may be desirable.

TABLE 1

CHICK STARTER RATION

Ingredients	Percent/100 lbs./feed
Ground yellow corn	25.5
Ground kafir	20.0
Wheat shorts	20.0
Alfalfa meal	5.0
Fish meal	6.0
Soybean meal	15.0
Meat and bone scraps	5.0
Steam bone meal	2.0
Salt	.5
Vitamin Concentrate	1.0

TABLE 2

ANALYSIS OF VARIANCE OF NINE WEEK WEIGHT OF CHICKS

1951 HATCHES

Source	D.F.	S.S.	M.S.	F Value
Total	559	66.66	----	----
Hatch	6	10.04	1.67	23.80**
Sires	7	3.04	0.43	6.00**
Sex	1	11.34	11.34	162.00**
Hatch-Sex	6	0.40	0.07	1.00
Sire-Hatch	42	5.43	0.13	1.84**
Sire-Sex	7	0.98	0.14	2.00
Sire-Sex-Hatch	42	3.80	0.09	1.28
Error	448	31.63	0.07	

** Significant at the 1 percent level

TABLE 3

ANALYSIS OF VARIANCE OF NINE WEEK WEIGHT OF CHICKS

1952 HATCHES

Source	D.F.	S.S.	M.S.	F Value
Total	599	72.90	——	——
Hatch	5	6.64	1.33	19.00**
Sires	9	2.84	0.32	4.57**
Sex	1	21.47	21.47	306.71**
Hatch-Sex	5	0.22	0.04	0.57
Sire-Hatch	45	5.08	0.15	2.14**
Sire-Sex	9	0.73	0.08	1.14
Sire-Sex-Hatch	45	2.84	0.06	0.86
Error	480	33.08	0.07	

**Significant at the 1 percent level

TABLE 4

COEFFICIENTS OF VARIABILITY OF NINE WEEK WEIGHTS OF CHICKS

1951 AND 1952 HATCHES

Hatch Date	Av. Wt. At 9 Wks. Lbs.	Variance	Standard Deviations	Coefficient of Variability
Feb. 19, 1951	1.97	.1239	.35	17.77%
Mar. 5, 1951	1.99	.1100	.33	16.58%
Mar. 19, 1951	1.64	.0915	.30	13.29%
Apr. 2, 1951	1.86	.0897	.30	16.07%
Apr. 16, 1951	2.05	.0779	.28	13.66%
Apr. 30, 1951	1.87	.1093	.33	17.65%
May 7, 1951	1.76	.1158	.34	19.31%
Jan. 28, 1952	2.06	.1359	.37	17.96%
Feb. 14, 1952	2.16	.0991	.31	14.35%
Feb. 25, 1952	2.35	.1126	.34	14.46%
Mar. 10, 1952	2.10	.1192	.32	15.23%
Mar. 24, 1952	2.22	.1040	.32	14.41%
Apr. 7, 1952	2.05	.0984	.31	15.12%

Figure 1: Average Growth Rate, Percent Mortality, and Average Maximum Temperatures for Chicks to Nine Weeks of Age in 1951 Hatches

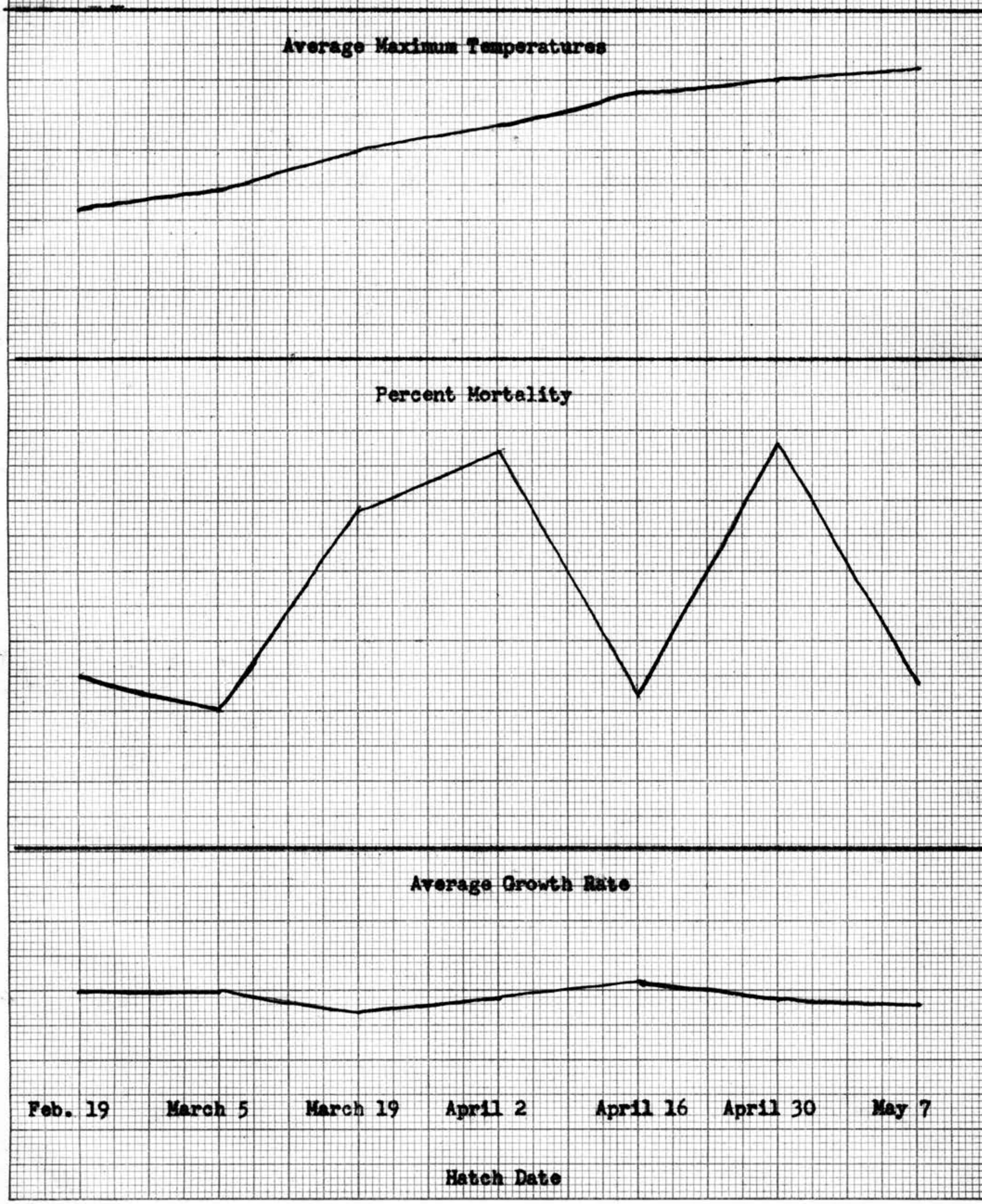
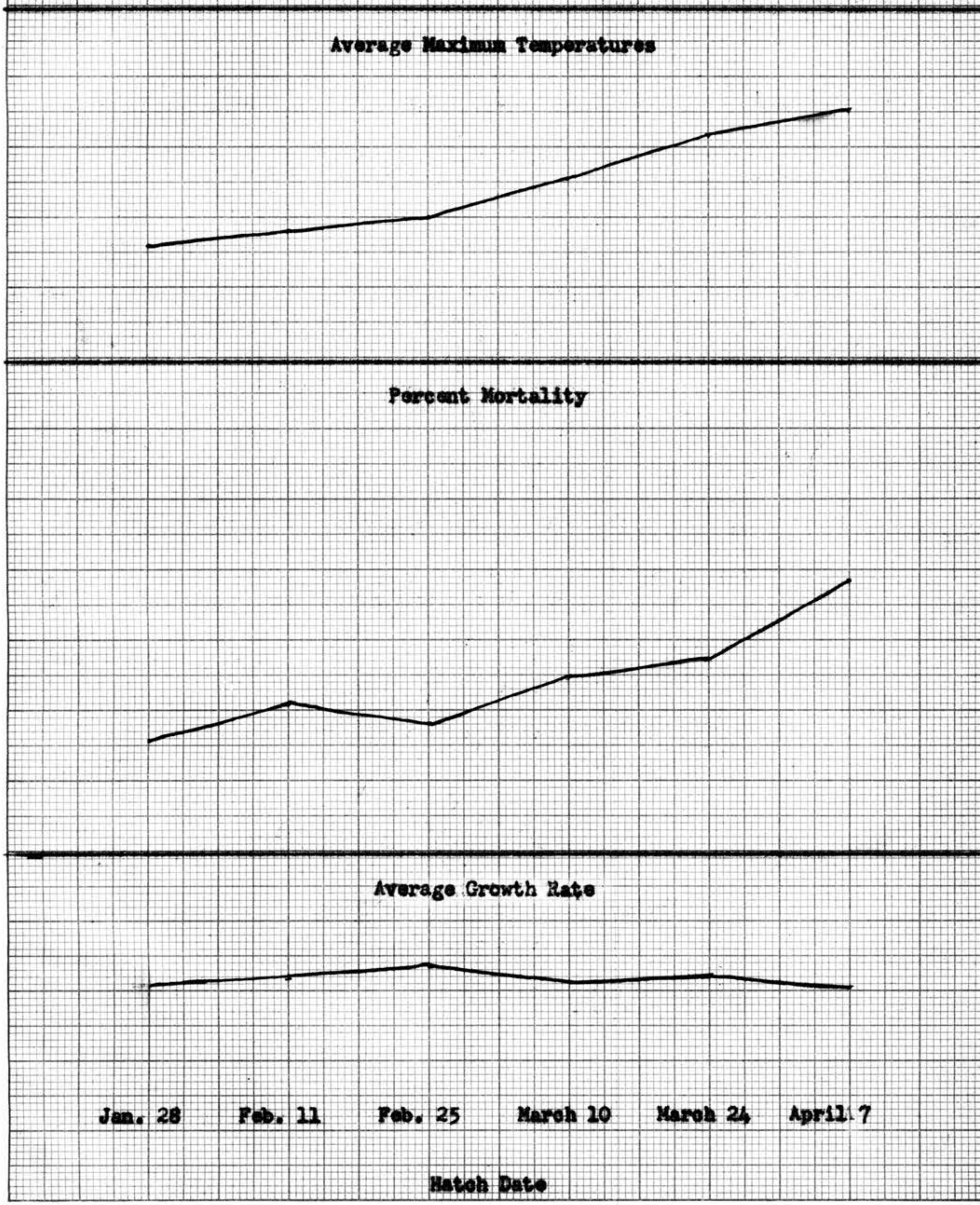


Figure 2: Average Growth Rate, Percent Mortality, and Average Maximum Temperatures for Chicks to Nine Weeks of Age in 1952 Hatches.



SUMMARY

Data obtained from progeny of pedigree matings of New Hampshires were analysed to determine the effect of hatch date on growth rate of chicks. From these analyses it was found that:

1. Differences among hatches, sires, sex and sire-hatch interaction were highly significant. Hatches contributed 3.65 and 1.46 percent of the total variation in growth rate during 1951 and 1952 respectively. Sires accounted for 1.27 and 0.54 percent of the total variation in growth rate during 1951 and 1952 respectively. Variation due to sex contributed the major portion of total variation in growth rate. Sex contributed 78.70 and 88.36 percent of the total variation for 1951 and 1952 respectively. Sire-hatch interaction contributed only 1.47 and 0.99 percent of the total variation during 1951 and 1952 respectively. Highly significant differences among hatches make it desirable to use chicks of the same hatch for studying the inheritance of physiological characters.

2. Chicks hatched before March 1 were generally heavier and had less mortality than those hatched after March 1.

3. Average maximum environmental temperatures were lower for early hatched chicks than for late hatched chicks. The higher growth rate of early hatched chicks could be due to lower environmental temperatures during the growing period.

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APPENDIX I

The Model and Method of Analysis

Model of the Analysis:

$$Y_{ijkl} = \mu + H_i + S_j + G_k + (SH)_{ij} + (HG)_{ik} + (SG)_{jk} + (SHG)_{ijk} + E_{ijkl}$$

Where Y_{ijkl} = Observation

H = Hatch

S = Sire

G = Sex

SH = Sire-hatch interaction

HG = Hatch-sex interaction

SG = Sire-sex interaction

SHG = Sire-sex-hatch interaction

E_{ijkl} = Individual variation

$i = 1, 2, .. N.$ N = Number of hatches

$j = 1, 2, .. M.$ M = Number of sires

$k = 1,2,$

$l = 1, 2, .. P.$ P = Number of individuals per sex, per sire, per hatch.

EXAMPLE OF CALCULATIONS

USING DATA OF THE JANUARY 28, 1952 HATCH

Sex		Male	Female		Male	Female
Chicks	1.	2.4	2.2	....	2.3	2.0
	2.	2.2	2.1	....	1.8	2.0
	3.	1.8	1.4	....	2.0	2.0
	4.	2.6	2.0	....	2.5	1.6
	5.	2.3	1.8	....	2.0	1.9
Sex total		11.3	9.5	....	10.6	9.1
Sire total with hatch		20.8		....	19.7	

Total male SX's when X = individual weights in lbs. = 113.7

Total female SX's when X = individual weights in lbs. = 92.5

Hatch total - = 206.2

Average - = 2..6

Calculations for other hatches are the same as shown for the January 28 hatch.

Totals for all Hatches:

Sires	1			10		Hatch Total
	Male	Female		Male	Female	
January 28 hatch	11.3	9.5	....	10.6	9.1	206.2
Sire total within hatch	20.8		....	19.7		206.2
Hatch 2						
Hatch 3						
Hatch 4						
Hatch 5						
Hatch $_n$						
Sex within sire	64.5	58.2	....	70.0	57.1	= 1296.1
Sire total	122.7			127.1		= 1296.1
Total SX's for males	64.5		....	70.0		= 704.8
Total SX's for females		58.2	....		57.1	= 591.3

CALCULATION OF SUM OF SQUARES

N = 600

C.F. = $(1296.1)^2/600 = 2799.79$

Total SX^2 =

$(2.4)^2 + \ldots\ldots\ldots + (1.9)^2 - C.F.$ = 72.9

Hatch SX^2 =

$(206.2)^2/100 + \ldots\ldots\ldots + (SX\text{'s } H_n)^2/100 - C.F.$ = 6.64

Sire SX^2 =

$(122.7)^2/60 + \ldots\ldots\ldots + (127.1)^2/60 - C.F.$ = 2.84

Sex SX^2 =

$$(704.8)^2/300 + (591.3)^2/300 - C.F. = 21.47$$

Hatch-sex SX^2 =

$$(113.7)^2/50 + \cdots\cdots + (92.5)^2/50 - (C.F. + H + G) = 0.22$$

Sire-hatch SX^2 =

$$(20.8)^2/10 + \cdots\cdots + (19.7)^2/10 - (C.F. + sire + H) = 5.08$$

Sire-sex SX^2 =

$$(64.5)^2/30 + \cdots\cdots + (57.1)^2/30 - (C.F. + sire + G) = 0.73$$

Sire-sex-hatch SX^2=

$$(11.3)^2/5 + \cdots\cdots + (9.1)^2/5 - (C.F. + sire + G + H) = 2.84$$

APPENDIX II

COMPONENT ANALYSIS OF VARIANCE

FOR CHICKS TO NINE WEEKS OF AGE FOR HATCHES IN 1952

Source of Variation	Mean Square	Mean Square is an Estimate of
Hatch	1.33	$\sigma^2 + 10\,\sigma^2_{sh} + 100\sigma^2_{h}$
Sires	0.32	$\sigma^2 + 60\sigma^2_{s}$
Sex (g)	21.47	$\sigma^2 + 30\sigma^2_{sh} + 300\sigma^2_{g}$
Sex-hatch	0.04	$\sigma^2 + 5\sigma^2_{shg} + 50\sigma^2_{g}$
Sire-hatch	0.15	$\sigma^2 + 10\sigma^2_{sh}$
Sire-sex	0.08	$\sigma^2 + 30\sigma^2_{sg}$
Sire-sex-hatch	0.06	$\sigma^2 + 5\sigma^2_{hsg}$
Individuals	0.07	σ^2

h = Hatch
s = Sires
g = Sex
gh = Sex-hatch
sh = Sire-hatch
sg = Sire-sex
sgh = Sire-sex-hatch

To estimate relative influence of hatch, substitute in appropriate formula : 1.33 - (0.08 + 0.07) /100 = 0.0118 ÷ 0.8122 = 1.46 percent of the total variation contributed by hatch.

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Thesis: THE EFFECT OF DATE OF HATCH ON GROWTH OF CHICKS

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The content and form have been checked and approved by the author and thesis adviser. Changes or corrections in the thesis are not made by the Graduate School office or by any committee. The copies are sent to the bindery just as they are approved by the author and faculty adviser.

TYPIST: Mrs. Anna Cress