THE EFFECT OF STRAIN, SEX AND RATION ON RATE OF GAIN, DRESSING PERCENTAGES AND MEAT YIELD OF CHICKEN BROILERS

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ABSTRACT

A study was made of the effects of strain, sex and Calorie:protein ratio of the diet on weight gains, feed efficiency, dressing percentages and meat yields of chicken broilers. In conjunction with this study an attempt was made to determine a simple and accurate method of estimating meat yield.

The experiment, conducted in a randomized complete block design with a factorial arrangement of treatments, involved three strains, two sexes, and four diets. Groups of twenty-five chicks were randomly assigned to pens in electrically heated battery brooders. Average weight gains and feed efficiencies were based on twenty-five birds per pen. Average dressing percentages were based on ten birds per pen, and average percentage meat yields were based on six birds per pen.

The results indicated that strain, sex and Calorie:protein ratio of the diet affected weight gain, feed efficiency and dressing percentages. Sex, and the Calorie:protein of the diet affected percentage meat yield.

The regression equations of total bone weight on femur weight and total bone weight on tibiotarsi weight, which were derived to estimate edible meat yield, were significantly affected by strain, sex and Calorie:protein ratio.

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CHAPTER I

INTRODUCTION

I PURPOSE OF THE STUDY

The production of chicken broilers is a major branch of Canada's poultry industry. During the past decade broiler production has developed from an incidental sideline of egg production to its present status representing slightly over fifty per cent of Canada's poultry meat supply. Table I indicates the growth of broiler marketings in Canada during the period 1953 to 1958 inclusive. Broiler chicken, as a percentage of total chicken marketed, increased from approximately forty-nine per cent in 1953 to eighty-six per cent in 1958. This phenomenal growth was associated with concomitant technological developments in nutrition, genetics, processing and merchandising.

Extensive research has been conducted on the effects of strain, sex, and Calorie:protein ratio on growth rate and feed efficiency. Limited research has been carried out to determine the independent effects of these factors on dressing percentages and meat yields. While the individual action of strain, sex, and Calorie:protein ratio has been investigated, the effects of the interactions between these factors has not been ascertained. The purpose of this study was to determine whether significant interactions exist between strain, sex, and Calorie:protein ratio. An attempt was also made to augment present

TABLE I TOTAL CHICKEN AND BROILER CHICKEN MARKETINGS IN CANADA FROM 1953 to 1958

(DRESSED WT BASIS)

YEAR	TOTAL CHICKEN MARKETED '000 LBS	BROILER CHICKEN MARKETED '000 LBS	BROILER CHICKEN AS % TOTAL CHICKEN
1953	60,779	30,049	49.4%
1954	80,535	49,883	61.9
1955	84,098	61,347	72.9
1956	132,976	103,677	77.9
1957	150,473	126,326	83.9
1958	205,455	176,645	86.0

knowledge of the independent effects of each of these factors on growth, feed efficiency, dressing percentage and percentage meat yield of broiler type stock.

In previous investigations several methods, many of which are time consuming and laborious, have been used to determine meat yield. A simple, accurate method of determining meat yield is required. Therefore, during this study an attempt was made to determine a method of accurately estimating the total bone weight and thus the meat yield of chicken broilers from the weight of the femurs and tibiotarsi of the skeletal system. Table II is a glossary of terms used throughout the thesis.

II GLOSSARY OF TERMS

Strain 1 - Cobbs cross or (CbCb)

Strain 2 - Cornish x Cobbs or (CoCb)

Strain 3 - Vantress x Nichol or (VaNi)

Ration 1 - low protein-high energy or (LPHE)

Ration 2 - low protein-low energy or (LPLE)

Ration 3 - high protein-high energy or (HPHE)

Ration 4 - high protein-low energy or (HPLE)

CHAPTER II

REVIEW OF LITERATURE

The differences between strains and between sexes in growth rate and feed efficiency have not been studied extensively in recent years, but the results of earlier work on these two factors will be presented. Also, a summary of experiments conducted to determine the effect of the Calorie:protein ratio on growth rate and feed efficiency will be given.

Strain and sex have been shown by some researchers to have a significant effect on losses during dressing and evisceration and on the yield of edible meat from chicken broilers. Research has also shown that energy level can affect eviscerated yield. The following presentation will be limited mainly to research pertaining to the effects of strain and sex; limited information is available on the effects of energy and protein levels.

The prediction of the weight of edible meat from live, dressed or eviscerated weights has been studied and the results of these studies will be presented.

I THE EFFECT OF STRAIN, SEX AND CALORIE:PROTEIN RATIO ON WEIGHT GAINS AND FEED EFFICIENCY

Several workers have established that differences exist between strains in growth rate and feed efficiency. Asmundson and Lerner (1933), Schnetzler (1936), Jaap and Morris (1937), and Waters and

Bywaters (1943) have shown that strains within a breed often exhibit inherent differences in rates of growth.

That males exhibit a greater and more rapid gain in body weight than females has been reported by Kempster (1921) and Carver and Hougan (1935).

The effects of dietary protein and energy levels on growth rate and feed efficiency have been investigated by several workers. One of the earliest papers on this subject by Hill and Dansky (1950) revealed that growth was reduced by a high energy-low protein ration; when the energy level was reduced, growth was normal.

Peterson et al (1954) and Hill and Dansky (1954) suggested that feed consumption is determined primarily by the energy content of the diet. They also reported that feed intake varied inversely with the energy content of the diet.

Combs and Romoser (1955), Leong et al (1955) and Matterson et al (1955) reported that as the energy content of a ration was increased, the protein requirement for optimum growth increased.

Donaldson, Combs and Romoser (1956) working with productive energy levels of approximately 972, 1087 and 1200 productive Cals./ pound, found that at each energy level, average weight gain and feed conversion improved with an increase in the protein level until an adequate level was supplied.

Mraz et al (1958) corroborated previous findings that at specified energy levels, the growth of male chicks increased as the protein level increased. In their work productive energy levels ranged from 450 to 900 Cals./pound and protein levels from 7.5 to 30 per cent. Feed efficiency also improved as the protein level increased at each energy level. Furthermore, diets with Calorie:protein ratios over 45:1 were inferior to diets with Calorie:protein ratios of 45:1 or less in promoting growth of ten week old broilers.

Sunde (1956) reported that in chicks a high protein-low energy diet caused a reduction in both growth rate and feed efficiency when compared to a low protein-low energy diet. Increasing the energy level of the diet by the addition of fat increased the weight of chicks and improved feed efficiency at both four and ten weeks of age. These results indicate that when the per cent protein is high, the energy level must also be high. Sunde also suggested that a change in the protein level causes the optimum Calorie:protein ratio to change.

Vondell and Ringrose (1958) found that when protein levels ranged from 16.5 per cent to 22.5 per cent the relative effects on growth rate of increasing the Calorie:protein ratio from 36:1 to 53:1 were not different at the various protein levels. In direct contrast to Sunde (1956), they suggested that the above Calorie:protein ratios would produce similar effects throughout a wider range of protein levels than was considered in their study, provided that other nutrients were in balance. Furthermore they concluded that the choice of a specific Calorie:protein ratio should lie between 45:1 and 53:1

and that this ratio would be effective in promoting optimum growth irrespective of the level of dietary protein.

Shutze and associates (1958) compared sexes and two methods of rearing (battery and floor) to determine the effects of varying levels of energy and protein on growth and feed efficiency. They reported differences between sexes and between methods of rearing. Their results also indicated that with battery reared birds at four weeks of age there were differences between sexes in growth and feed efficiency response to increased energy levels. In contrast at eight weeks of age both sexes responded similarly to increased energy levels. These workers also reported that males showed improved growth and feed efficiency when protein level was increased but females generally showed no significant response, regardless of the energy level in the ration. It was concluded that when reared in batteries, male and female birds may have different requirements for protein, independent of the energy level.

II THE EFFECT OF STRAIN, SEX AND CALORIE:PROTEIN RATIO ON DRESSING PERCENTAGE AND MEAT YIELD

Renard (1949) found considerable variation among breeds and crosses in percentage losses during both dressing and evisceration.

Jaap and associates (1950) working with forty-four strains and crosses of varied ancestry concluded that rapid growth (weight) was the major factor increasing both the percentage dressed and percentage eviscerated yields at twelve weeks of age. However, these workers found that strain differences were evident after the effect of weight had been removed. This prompted the authors to suggest that there were heritable factors other than weight which affected percentage dressed and percentage eviscerated yields. In addition it was concluded that the percentage dressed and eviscerated yields of females were lower than males because of their (females) lower body weight.

Hathaway et al (1953) using both broiler and non broiler strains found significant differences between strains in eviscerated yields and edible meat yields. They also reported, that, in most cases, females tended to yield a greater percentage of edible meat. No significant sex differences were noted in percentage loss from live to dressed weight.

Stotts and Darrow (1953) found that in tests designed to compare Cornish crossbreds, non Cornish crossbreds and purebreds, the Cornish crossbreds gave consistently higher meat yields (as a percentage of eviscerated weight) in both males and females. Meat yield was determined by the "cooked in stockinette" method. Cornish crossbreds also had a significantly higher meat to bone ratio than non Cornish crossbreds or purebreds. Females from all stocks studied produced higher yields of edible meat (as a percentage of eviscerated weight) than males; however the differences were small and non significant.

Morrison et al (1954) compared eight broiler crosses on the basis of eviscerated and edible meat yield. They reported no significant differences between crosses in eviscerated yield (as a percentage of dressed weight) or edible meat yield (as a percentage of eviscerated weight). To separate the meat from the bones in order to determine edible meat yield, each bird was cooked for twenty minutes at fifteen pounds pressure.

Orr (1955) compared strains, rations (one ration contained no fat while the other contained five per cent stabilized animal fat) and sexes on the basis of dressed yield, eviscerated yield and cooked edible meat yield. Strain, sex and ration had no significant effect on chilled dressed weight expressed as a percentage of live weight. However, significant strain and sex differences were observed when eviscerated weight was expressed as a percentage of live weight. Cooked edible meat yield was found to differ significantly among strains on the basis of chilled dressed weight and live weight but such differences were not significant when cooked edible meat yield was expressed as a percentage of eviscerated weight. Sex and ration had no significant effect on cooked edible meat yield.

Harms et al (1957) using rations with productive energy levels of 731, 881 and 978 Cals./pound and Calorie:protein ratios of 36:1, 40:1 and 44:1 respectively, reported that as the energy level of the diet increased (thus increasing the Calorie:protein ratio) eviscerated yield, as a percentage of live weight, increased significantly.

McNally and Spicknall (1949) using Rhode Island Red males ranging in live weight from one and a half to six pounds derived regression equations to be used for the prediction of edible meat yield from live, dressed or eviscerated weight. Standard errors of estimate ranging from 17.40 gms (regression of weight of edible meat on eviscerated weight) to 49.86 gms (regression of weight of edible meat with giblets on live weight) were presented in conjunction with the regression equations.

CHAPTER III

EXPERIMENTAL PROCEDURE

I WEIGHT GAINS AND FEED EFFICIENCY

To obtain data on the effects of strain, sex and Calorie:protein ratio on weight gain and feed efficiency an experiment involving two sexes, three strains and four diets was conducted.

Six hundred broiler chicks (300 males, 300 females), obtained from several commercial hatcheries in Winnipeg were individually weighed, wingbanded and distributed into groups of twenty-five which were randomly assigned to pens in electrically heated battery brooders. Feed and water were supplied ad libitum. The birds were vaccinated at one week of age with infectious bronchitis water soluble vaccine. Individual chick weights to the nearest gram and feed consumption per pen to the nearest tenth of a pound were recorded for a period of eight weeks. This experiment was replicated upon completion.

The four diets shown in Table II were formulated so that each contained a different combination of two energy and two protein levels, and all diets were adequately balanced for other known essential nutrients.

II DRESSED, EVISCERATED AND EDIBLE MEAT YIELDS

Ten birds from each of the forty-eight pens (twenty-four pens in each replicate) were randomly selected and sacrificed at eight and one half weeks of age. All birds were dispatched by inserting a

TABLE II COMPOSITION OF RATIONS

INGREDIENT	Ration 1 (LPHE)	Ration 2 (LPLE)	Ration 3 (HPHE)	Ration 4 (HPLE)
	POUNDS			
Corn	30.00	-	150.00	-
Wheat	127.50	172.00	119.00	125.00
Oats	17.50	81.00	70.00	75.00
Oat Groats	215.00	100.00	30.00	100.00
Oat Hulls	27.50	-	9.00	-
Wheat Middlings	-	50.00	-	62.50
Wheat Bran	-	-	-	7.00
Soybean Meal	7.50	41.00	10.00	50.00
Fish Meal	17.50	6.00	72.50	17.50
Meat Meal	30.00	17.50	12.50	37.50
Yeast	10.00	10.00	10.00	10.00
Whey	10.00	10.00	10.00	10.00
Limestone	3.50	3.00	3.50	1.50
Dicalcium Phosphate	-	5.00	-	-
Salt	2.50	2.50	2.50	2.50
Aurofac "10"	0.25	0.25	0.25	0.25
Nicarbazin	0.125	0.125	0.125	0.125
Methionine	0.55	0.85	-	0.5
	GRAMS			
Dry D3	3.25	3.25	3.25	3.25
Choline	50.00	50.00	50.00	50.00
Riboflavin "77"	25.00	25.00	25.00	25.00
Manganese	25.00	25.00	25.00	25.00
Vitamin A Oil	113.00	113.00	113.00	113.00
Total	500.00 LBS	500.00 LBS	500.00 LBS	500.00 LBS
	CALCULATED ANALYSIS			
Productive Energy	966 Cals./LB	868 Cals./LB	968 Cals./LB	846 Cals./LB
Protein	18.20%	18.10%	22.20%	22.20%
Fibre	4.60%	5.00%	4.20%	4.90%
Calcium	1.03%	0.97%	1.01%	1.06%
Phosphorus	0.74%	0.83%	0.73%	0.91%

knife under the skin of the neck and severing the carotid arteries. The primary and secondary wing feathers and the main tail feathers were removed by a mechanical quill puller immediately prior to hot scald treatment (138 - 140°F). The remaining feathers were removed on a single drum rougher and by hand plucking. Live weight immediately prior to killing, weight after bleeding and warm dressed weight were recorded.

The dressed birds were hung on racks, sprayed with water and held for twenty-four hours in a walk-in cooler at a temperature of 35°F. They were then removed, dipped in water, placed in large polyethylene bags in lots of ten and held for another twenty-four hours at 35°F. Following this treatment, the birds were removed, weighed (chilled dressed weight) and eviscerated. Legs were removed at the hock joint, and the head removed by cutting between the first cervical vertebra and the occipital bone. Each bird was wiped with a dry cloth to remove excess moisture and eviscerated weight with and without giblets was recorded. The birds were then bagged and frozen at 0°F.

Six birds were selected at random from each group of ten that was killed, and used to calculate meat yield. The "cooked in stockinette" method described by Stotts and Darrow (1953) was used. The birds were removed from the freezer as required, individually wrapped in stockinette and placed in boiling water for a period of from two to two and one quarter hours. Upon removal of a bird from the water, the bones were separated from the muscle and cartilage and placed in a small polyethylene bag which was immediately sealed. Circumstances prevented the immediate weighing of the bones, but the weights of femurs, tibiotarsi and total bone to the nearest tenth of a gram were recorded for each bird as soon as possible after deboning. The weight of edible meat for each bird was obtained by calculating the difference between the total bone weight and the weight of the eviscerated carcass.

III STATISTICAL METHODS

The analysis of variance and analysis of covariance techniques were employed on four and eight week weight gains with feed consumption as the concomitant variable for the covariance analysis. Pen means were considered as experimental units with each mean based on the number of birds alive at eight weeks of age. Because of variable mortality each pen mean was not based on the same number of birds. Mortality ranged from zero to five birds per pen and the pen means were therefore calculated from twenty to twenty-five birds.

Before the analysis of variance was performed on feed conversion, feed consumption per pen was adjusted for the birds that died during the experiment. This adjustment was made by calculating the grams of feed consumed per gram of gain for the appropriate pen at the week closest to the date of death of the bird involved. From this figure and the body weight of the bird the feed consumption of the dead bird was estimated and subtracted from the pen total. No adjustment was made for birds which died before attaining the age of one week.

Dressed weight and eviscerated weight were each expressed as a percentage of live weight. Eviscerated weight was also expressed as a percentage of dressed weight. Edible meat weight was expressed as a percentage of live weight, dressed weight, and eviscerated weight. From these percentages (calculated for each of six birds per pen) pen means (in per cent) were calculated, transformed by the arcsin transformation (Snedecor, 1946) and considered as experimental units for analysis of variance.

Tukey's method, described by Snedecor (1946), was used for comparisons of means within a treatment.

The data pertaining to the total bone weight of an individual bird as related to the weight of its femurs and the weight of its tibiotarsi was analyzed by a method described by Ostle (1956). By the use of this method, regression equations and correlation coefficients for total bone weight and femur weight and total bone weight and tibiotarsi weight were calculated for each strain, sex and ration. As part of the analysis, F-tests were performed to determine if the Y-intercepts (α) and if the slopes (β) of the regression lines were significantly different within each of the above three categories (strain, sex and ration).

CHAPTER IV

RESULTS

I WEIGHT GAINS AND FEED EFFICIENCY

The results of the analyses of variance on weight gains to four and eight weeks of age are presented in Appendix I (Tables XI and XII). Significant replicate, ration and strain differences were evident at four weeks of age, and significant ration, strain and sex differences were revealed at eight weeks of age.

As indicated by Table III both four and eight week average weight gain was highest for strain two (CoCb) and lowest for strain one (CbCb). Average weight gain ranged from 309.20 grams to 345.10 grams and from 955.19 grams to 1016.37 grams at four and eight weeks respectively. An analysis of covariance (Appendix I, TableXIV) performed on eight week weight gains, with feed consumption as the concomitant variable, revealed no significant strain differences. This result indicated that the significant strain differences in the analysis of variance were attributable to differences between strains in feed consumption.

Average four week weight gains for rations ranged from 288.53 to 364.03 grams. Ration two (low protein-low energy) produced the lowest average weight gain and ration three (high protein-high energy) produced the highest weight gain. At eight weeks of age ration three again produced the highest average weight gain (1049.39gms)

TABLE III MEAN WEIGHT GAIN AND FEED CONVERSION TO 4 and 8 WEEKS OF AGE

	4 WEEK WT. GAINS	8 WEEK WT. GAINS	4 WEEK FEED CONV.	8 WEEK FEED CONV.
Ration				
1 LPHE	313.39	952.83	2.33	2.72
2 LPLE	288.53	953.92	2.40	2.76
3 HPHE	364.03	1049.39	1.93	2.51
4 HPLE	328.56	991.74	2.18	2.70
Strain				
1 (CbCb)	309.20	955.19	2.24	2.67
2 (CoCb)	345.10	1016.37	2.19	2.69
3 (VaMi)	316.58	989.35	2.21	2.65
Sex				
Males	327.36	1022.50	2.18	2.64
Females	319.91	951.44	2.25	2.70
	Rations $D_{(.05)}$ = 21.23	Rations $D_{(.05)}$ = 55.72	Rations $D_{(.05)}$ = .13	Rations $D_{(.05)}$ = .09
	Strains $D_{(.05)}$ = 16.64	Strains $D_{(.05)}$ = 43.79		

but ration one (low protein-high energy) produced the lowest average weight gain (952.83 gms).

When the energy level of the diet was increased in either the eighteen or twenty-two per cent protein diet, four week average weight gain increased significantly ($P<.05$). The increase in energy level had no significant effect on average weight gain of eight week old birds fed the eighteen per cent protein diet, but resulted in a significant ($P<.05$) increase in the average weight gain of birds fed the twenty-two per cent protein diet.

When the protein content was increased from eighteen to twenty-two per cent in the low energy diet average weight gain increased significantly ($P<.05$) at four weeks of age but not at eight weeks. When protein content was increased in the high energy diet, average weight gain increased significantly ($P<.05$) at both four and eight weeks of age.

The analysis of covariance (Appendix I, Tables XIII and XIV) performed on weight gains, with feed consumption as the concomitant variable, revealed highly significant ($P<.01$) ration differences at both four and eight weeks of age. This indicated that the significant ($P<.01$) difference between rations in weight gain was not attributable to differences in feed consumption.

The difference between sexes in average weight gain was not significant at four weeks of age but males were significantly ($P<.01$) heavier at eight weeks of age. The results of analysis of covariance

(Appendix I) revealed similar results; this indicated that greater feed consumption by males did not account for their significantly higher average weight gain to eight weeks of age.

Neither the analysis of variance nor the analysis of covariance on weight gains to four and eight weeks of age revealed significant first or second order interactions.

The average feed conversion (gms. of feed/gm. of live weight gain) of strains, sexes and diets is presented in Table III. The analysis of variance performed on feed conversion (Appendix I, Tables XV and XVI) revealed significant ration and sex differences.

Ration had a significant ($P<.01$) effect on feed conversion at both four and eight weeks of age. Grams of feed/gram of gain ranged from 1.93 (ration three) to 2.40 (ration two) at four weeks of age, and from 2.51 (ration three) to 2.76 (ration two) at eight weeks of age.

When the energy content was increased from 855 to 965 productive Cals./lb. in diets containing eighteen per cent and twenty-two per cent protein, feed efficiency improved at four and eight weeks of age. This improvement was significant ($P<.05$) only for the twenty-two per cent protein diet.

When the protein content was increased from eighteen per cent to twenty-two per cent in either the low or high energy diets the birds showed an improvement in feed conversion at both four and eight weeks of age. The improvement was significant ($P<.05$) in all cases except that of eight week old birds on the low energy diet.

Males were significantly ($P<.01$) superior to females in feed efficiency to eight weeks of age.

The analyses of variance performed on the efficiency of protein and energy utilization are presented in Appendix I, (Tables XVII to XX), and the data summarized in Table IV. The results of the analyses indicate that at four weeks and eight weeks of age, highly significant ($P<.01$) differences between diets were evident in gms. of protein/gm. of gain and in Cals. of productive energy/gm. of gain. In addition, a significant ($P<.05$) sex difference in favor of males in Cals. of productive energy/gm. of gain was revealed by the analyses of variance of four and eight week weight gains.

When the energy content was increased from low to high in diets containing eighteen per cent protein, the efficiency of protein utilization did not change significantly, but efficiency of energy utilization decreased significantly ($P<.05$) at both four and eight weeks of age.

A similar increase in energy level in diets containing twenty-two per cent protein resulted in a significant ($P<.05$) improvement in protein utilization but no significant change in efficiency of energy utilization when birds were four weeks of age. When the birds were eight weeks of age those which had received the high energy level in their twenty-two per cent protein diet, were significantly ($P<.05$) more efficient in protein utilization and significantly ($P<.05$) less efficient in energy utilization than their counterparts which received the same level of protein but the low level of energy.

TABLE IV EFFICIENCY OF PROTEIN AND ENERGY UTILIZATION TO 4 AND 8 WEEKS

	4 WEEKS		8 WEEKS	
RATION	Gms Protein /Gm Gain	Cals.Prod.Energy /Gm Gain	Gms Protein /Gm Gain	Cals.Prod.Energy /Gm Gain
1 (LPHE)	.42	4.96	.49	5.80
2 (LPLE)	.44	4.59	.50	5.27
3 (HPHE)	.43	4.12	.56	5.36
4 (HPLE)	.48	4.06	.59	5.02
STRAIN	$D_{(.05)} = .03$	$D_{(.05)} = .28$	$D_{(.05)} = .02$	$D_{(.05)} = .20$
1 (CbCb)	.45	4.49	.54	5.37
2 (CoCb)	.44	4.38	.54	5.40
3 (VaNi)	.44	4.43	.53	5.32
SEX				
Males	.44	4.36	.53	5.30
Females	.45	4.51	.54	5.42

When the protein level of the diet was increased in the low energy diet a significant ($P<.05$) depression in efficiency of protein utilization and a significant ($P<.05$) improvement in efficiency of energy utilization were noted at four weeks of age. A similar increase in protein content in the high energy diet had no significant effect on efficiency of protein utilization but resulted in a significant ($P<.05$) improvement in efficiency of energy utilization to four weeks of age.

An increase in protein content in either the low or high energy diet resulted in a significant ($P<.05$) improvement in energy utilization and a significant ($P<.05$) decrease in efficiency of protein utilization to eight weeks of age.

As indicated by the analyses of variance, no significant differences between strains in efficiency of protein or energy utilization was evident at the four and eight week stage.

II DRESSED, EVISCERATED AND EDIBLE MEAT YIELD

The data on blood loss and feather loss as percentages of live weight were transformed and subjected to analysis of variance (Appendix II, Tables XXI and XXII). The results indicate a significant ($P<.01$) replicate difference in percentage blood loss and significant ($P<.01$) replicate, strain and sex differences in percentage feather loss.

Replicate one had a significantly ($P<.01$) higher percentage blood loss and a significantly ($P<.01$) lower percentage feather loss than replicate two.

A comparison of average percentage feather loss by strains indicates that strain one (CbCb) had a significantly (P<.01) higher percentage feather loss than strain two (CoCb) or strain three (VaNi) and that strain two and strain three did not differ significantly in percentage feather loss.

It is evident from Table V that females yielded a significantly (P<.01) higher percentage of feather than males.

The analysis of variance performed on average live weight of the eight and a half week old birds (ten/pen) used for the determination of dressed and eviscerated yields is presented in Appendix II (Table XXIII). The analysis revealed significant replicate, ration, strain and sex differences. The average live weight for each ration, strain and sex is presented in Table VI. The data of this table indicate that, with one exception, the effect of ration, strain and sex on average live weight at eight and a half weeks is relatively the same as their effect on average weight gain at eight weeks (Table III). The only exception was that ration two produced the lowest average live weight while ration one produced the lowest average weight gain. However, the difference between ration one and ration two was not significant (P<.05) for either average live weight or average weight gain.

The analyses of variance applied to the transformed data pertaining to chilled dressed weight as a percentage of live weight,

TABLE V AVERAGE BLOOD AND FEATHER PERCENTAGE LOSS AND TRANSFORMATION (10 BIRDS/PEN)

		FEATHER LOSS		BLOOD LOSS	
RATION		TRANS.	PERCENTAGE	TRANS.	PERCENTAGE
1	LPHE	15.76	7.4	11.46	4.0
2	LPLE	15.77	7.4	11.65	4.1
3	HPHE	15.56	7.2	11.65	4.1
4	HPLE	16.00	7.6	11.75	4.2
STRAIN		TRANS.	PERCENTAGE	TRANS.	PERCENTAGE
1	CbCb	16.32	7.9	11.48	4.0
2	CoCb	15.48	7.1	11.70	4.1
3	VaNi	15.53	7.2	11.70	4.1

$D_{(.05)} = .56$

SEX	TRANS.	PERCENTAGE	TRANS.	PERCENTAGE
Male	15.30	7.0	11.69	4.1
Female	16.25	7.8	11.57	4.0

TABLE VI AVERAGE LIVE WEIGHT TO 8½ WEEKS OF BIRDS USED FOR DETERMINATION OF DRESSING PERCENTAGES

RATIONS

1 (LPHE)	2 (LPLE)	3 (HPHE)	4 (HPLE)
1145.99	1130.31	1256.97	1189.23

$D_{(.05)} = 70.30$

STRAINS

1 (CbCb)	2 (CoCb)	3 (VaNi)
1147.29	1212.27	1182.31

$D_{(.05)} = 55.12$

SEX

MALES	FEMALES
1218.72	1142.53

revealed highly significant ($P<.01$) ration, strain and sex differences. As indicated by Table VII, ration three (high protein-high energy) which produced the highest average live body weight at eight and a half weeks (Table VI) also produced the highest average chilled dressed weight as a percentage of live weight. Ration four (high protein-low energy) which produced the second highest average live weight at eight and a half weeks had the lowest average chilled dressed weight as a percentage of live weight. The difference between ration three and ration four in average live weight at eight and a half weeks was not significant ($P<.05$) but in chilled dressed weight as a percentage of live weight, ration three was significantly ($P<.05$) superior to ration four.

The data of Table VII also indicate that strains two (CoCb) and three (VaNi) both of which had higher average live body weights than strain one (CbCb) at eight and a half weeks (Table VI) were significantly ($P<.05$) superior to strain one in dressed weight as a percentage of live weight.

Males, which were significantly ($P<.01$) heavier than females in average live weight at eight and a half weeks were also significantly ($P<.01$) superior in dressed weight as a percentage of live weight (Table VII).

The analysis of variance on the transformed data pertaining to eviscerated weight as a percentage of live weight (Appendix II, Table XXV) showed significant replicate, ration and sex differences and a significant strain x sex interaction.

TABLE VII AVERAGE DRESSING PERCENTAGES AND TRANSFORMATIONS
(BASED ON 10 BIRDS/PEN)

	CH. DR. WT. AS % LIVE WT.		EVIS. WT. % LIVE WEIGHT		EVIS. WT. % CH. DR. WT.	
	Mean Yield		Mean Yield		Mean Yield	
Ration	Trans.	Percent	Trans.	Percent	Trans.	Percent
1 (LPHE)	69.13	87.30	52.83	63.50	58.46	72.60
2 (LPLE)	68.89	87.00	52.37	62.70	58.14	72.10
3 (HPHE)	69.16	87.31	53.30	64.30	59.09	73.60
4 (HPLE)	68.62	86.70	52.76	63.40	58.78	73.10
	Mean Yield		Mean Yield		Mean Yield	
Strain	Trans.	Percent	Trans.	Percent	Trans.	Percent
1 (CbCb)	68.67	86.80	52.70	63.30	58.62	72.90
2 (CoCb)	69.09	87.30	52.78	63.40	58.49	72.70
3 (VaNi)	69.09	87.30	52.98	63.75	58.74	73.10
	Mean Yield		Mean Yield		Mean Yield	
Sex	Trans.	Percent	Trans.	Percent	Trans.	Percent
Male	69.33	87.50	52.96	63.70	58.55	72.80
Female	68.56	86.60	52.68	63.25	58.68	73.00
	Rations: $D_{(.05)} = .43$		Rations: $D_{(.05)} = .45$		Rations: $D_{(.05)} = .44$	
	Strains: $D_{(.05)} = .34$					

Ration three (high protein-high energy) which produced the highest average live weight at eight and a half weeks of age (Table VI) also produced the highest eviscerated weight as a percentage of live weight. Similarly, ration two (low protein-low energy) produced both the lowest average live weight and the lowest eviscerated weight as a percentage of live weight (Table VII).

The data in Table VII also indicate that males, which were significantly ($P < .01$) heavier than females in average live weight at eight and a half weeks, were significantly ($P < .05$) superior to females in eviscerated weight as a percentage of live weight.

The analysis of variance performed on the transformed data pertaining to eviscerated weight as a percentage of dressed weight (Appendix II, Table XXVI) revealed significant replicate and ration differences and a significant strain x sex interaction. Ration three produced the highest and ration two the lowest eviscerated weight as a percentage of dressed weight (Table VII).

As indicated by Table VII, a significant ($P < .05$) increase in eviscerated yield as a percentage of live weight resulted when the energy level was increased in either the eighteen or twenty-two per cent protein diets. The energy increase had no significant effect on eviscerated weight as a percentage of dressed weight of birds receiving either the low or high protein diet but did significantly ($P < .05$) increase dressed weight as a percentage of live weight for birds on the twenty-two per cent protein diet. Conversely, an increase in protein content from eighteen to twenty-two per cent in either the low or high energy diets resulted in a significant ($P<.05$) increase in eviscerated weight expressed as a percentage of dressed weight, but had no significant effect on dressed weight as a percentage of live weight. Eviscerated weight as a percentage of live weight responded significantly ($P<.05$) to an increase in protein content in the high energy diet but not in the low energy diet.

The analysis of variance, performed on average live weight of the eight and a half week old birds (six birds/pen) used for the determination of meat yield, is presented in Appendix II (Table XXVII). A summary of the treatment means is found in Table VIII. The results are similar to those of the analysis of variance applied to average live weight of the eight and a half week old birds (ten birds/pen) used for the determination of dressed and eviscerated yields (Table VI). Ration three produced the highest and ration two the lowest average live weight. Strain two and strain one respectively had the highest and lowest average live weight. Males were superior to females in average live weight.

The analyses of variance performed on the transformed data pertaining to meat yield as a percentage of live weight, dressed weight and eviscerated weight are presented in Appendix II (Tables XXVIII to XXX). The summary of treatment means is found in Table IX.

The analysis of variance revealed significant replicate and ration differences in meat yield expressed as a percentage of live

TABLE VIII AVERAGE LIVE WEIGHT TO 8½ WEEKS OF BIRDS USED FOR DETERMINATION OF MEAT YIELD

RATIONS

LPHE 1	LPLE 2	HPHE 3	HPLE 4
1160.77	1134.75	1257.35	1203.02
	$D_{(.05)} = 76.57$		

STRAINS

CbCb 1	CoCb 2	VaNi 3
1154.79	1220.76	1191.38
	$D_{(.05)} = 60.04$	

SEX

MALES	FEMALES
1232.49	1145.46

TABLE IX AVERAGE PERCENTAGE MEAT YIELDS AND TRANSFORMATIONS (BASED ON 6 BIRDS/PEN)

	MEAT YIELD % LIVE WT.		MEAT YIELD % DRESSED WT.		MEAT YIELD % EVIS. WT.	
RATION	TRANS.	%	TRANS.	%	TRANS.	%
1 (LPHE)	48.23	55.60	52.92	63.70	69.21	87.40
2 (LPLE)	47.84	55.00	52.67	63.20	69.51	87.70
3 (HPHE)	48.58	56.20	53.42	64.50	69.34	87.60
4 (HPLE)	47.98	55.20	52.93	63.70	69.13	87.30
STRAIN						
1 (CbCb)	48.10	55.40	52.99	63.80	69.40	87.60
2 (CoCb)	48.16	55.50	52.96	63.70	69.36	87.60
3 (VaNi)	48.21	55.60	53.01	63.80	69.13	87.30
MALES	48.19	55.5	52.97	63.70	68.98	87.10
FEMALES	48.12	55.4	53.18	64.10	69.61	87.90

Rations: $D_{(.05)} = .55$ $D_{(.05)} = .47$

or dressed weight. As indicated by Table IX, ration three (high protein-high energy), which produced the highest average live weight (Table VIII), also produced the highest average meat yield as a percentage of live weight or dressed weight. Similarly, ration two (low protein-low energy), which produced the lowest average live weight, also produced the lowest average meat yield as a percentage of live or dressed weight.

When the energy level of the eighteen per cent protein diet was increased, neither meat yield as a percentage of live weight nor meat yield as a percentage of dressed weight increased significantly ($P<.05$). However, an increase in energy in the twenty-two per cent protein diet resulted in a significant ($P<.05$) increase in meat yield as a percentage of live weight and as a percentage of dressed weight.

An increase in protein content from eighteen to twenty-two per cent in the low energy diet resulted in non significant increases in meat yield as a percentage of live weight and as a percentage of dressed weight. A similar increase in protein in the high energy diet was associated with a significant ($P<.05$) increase in meat yield as a percentage of dressed weight and a non significant increase in meat yield as a percentage of live weight.

In addition, the analysis of variance on meat yield as a percentage of dressed weight revealed a significant ($P<.01$) sex difference in favor of females.

When an analysis of variance was applied to the transformed data pertaining to meat yield as a percentage of eviscerated weight, a

TABLE X REGRESSION EQUATIONS AND CORRELATION COEFFICIENTS FOR TOTAL BONE WEIGHT ON TIBIOTARSUS WEIGHT AND TOTAL BONE WEIGHT ON FEMUR WEIGHT

REGRESSION OF TOTAL BONE WT. ON TIBIOTARSUS WT.

RATION	REGRESSION EQUATION	ST. ERROR OF ESTIMATE	CORRELATION COEFFICIENT
1 (LPHE)	Y= 24.79 + 3.91 (x)	5.3	.90
2 (LPLE)	20.17 + 4.09 (x)	4.3	.95
3 (HPHE)	25.83 + 4.04 (x)	5.4	.90
4 (HPLE)	27.16 + 3.84 (x)	5.3	.89
STRAIN			
1 (CbCb)	Y= 20.38 + 4.13 (x)	5.6	.91
2 (CoCb)	18.59 + 4.31 (x)	5.4	.91
3 (VaNi)	25.80 + 3.96 (x)	4.8	.93
SEX			
MALES	Y= 17.92 + 4.30 (x)	5.5	.90
FEMALES	20.33 + 4.24 (x)	5.1	.88

REGRESSION OF TOTAL BONE WT. ON FEMUR WT.

RATION	REGRESSION EQUATION	ST. ERROR OF ESTIMATE	CORRELATION COEFFICIENT
1(LPHE)	Y= 8.75 + 6.37 (x)	3.8	.94
2 (LPLE)	9.52 + 6.59 (x)	4.2	.96
3 (HPHE)	8.27 + 6.02 (x)	4.1	.95
4 (HPLE)	8.68 + 6.56 (x)	1.5	.99
STRAIN			
1 (CbCb)	Y= 10.56 + 6.37 (x)	4.4	.94
2 (CoCb)	10.28 + 5.90 (x)	3.9	.94
3 (VaNi)	12.42 + 6.36 (x)	3.8	.94
SEX			
MALES	Y= 12.91 + 6.20 (x)	3.1	.96
FEMALES	11.47 + 6.00 (x)	4.0	.92

significant ($P<.01$) sex difference, in favor of females, was revealed.

The statistical analysis of the relationship between femur weight and total bone weight and between Tibiotarsi weight and total bone weight is presented in Appendix II (Tables XXXI to XXXVI). Regression equations, standard errors and correlation coefficients for each strain, sex and ration are presented in Table X. The regression lines were plotted and appear in Figures I to IX. (Appendix II).

As indicated by Table X the correlation between the weight of the femurs and total bone weight was generally stronger than the correlation between tibiotarsi weight and total bone weight. Correlation coefficients between femur weight and total bone weight ranged from .92 to .99 while between tibiotarsi weight and total bone weight they ranged from .88 to .95.

The F-tests, performed to determine if the parameters were the same for each regression line within a group (Appendix II), indicated that the slopes (β's) of the lines within each group were not significantly different when the relationship of either femur weight or tibiotarsi weight and total bone weight was considered. The Y-intercepts (α's), however, were significantly different in all but one instance.

CHAPTER V

DISCUSSION

I WEIGHT GAINS AND FEED EFFICIENCY

The results of this study indicate that at four weeks of age, average weight gain was significantly affected by the Calorie:protein ratio of the diet and the strain of birds. At eight weeks of age the sex of the birds had an effect on average live weight in addition to the effect of the Calorie:protein ratio of the diet and the strain of birds. The results also indicate that to four and eight weeks of age the Calorie:protein ratio of the diet had a significant effect on feed conversion and that to eight weeks of age, the sex of the birds also had a significant effect on feed conversion.

As the energy level of the low protein diet increased, average weight gain at four weeks of age improved significantly. No significant improvement was noted in average weight gain at eight weeks of age or in feed conversion at four or eight weeks of age. However when the protein content of the ration was increased in conjunction with the increase in energy level both weight gain and feed conversion improved significantly ($P < .05$) at both four and eight weeks of age. These results are in general agreement with the findings of Combs and Romoser (1955), Donaldson et al (1955), Leong et al (1955), and Matterson et al (1955) who all generally agreed that as the energy level of the diet increased, the percentage protein required for optimum growth also increased.

Weight gain and feed conversion have been shown to be related to the Calorie:protein ratio. Vondell and Ringrose (1958) reported that when the energy level of the diet was increased, eight week growth and feed conversion improved until the Calorie:protein ratio exceeded forty-five to one. Beyond this ratio no significant improvements in weight gain or feed efficiency were noted. The results of the present investigation, although not as extensive as those of Vondell and Ringrose (1958), indicate similar trends. Neither eight week average weight gain nor feed conversion changed significantly when the Calorie:protein ratio was increased from 47.7:1 to 53.1:1 in the eighteen per cent protein diet; in fact average weight gain decreased slightly. For birds on the twenty-two per cent protein diet, weight gain and feed conversion improved significantly ($P<.05$) when the Calorie:protein ratio was increased from 38.4:1 to 43.7:1. These results indicate that the optimum Calorie:protein ratio to eight weeks of age is less than 53:1 for the eighteen per cent protein diet and greater than 38:1 for the twenty-two per cent protein diet.

Considering the effect on weight gain and feed efficiency of increasing the protein level at a given energy level, it is evident from the results that in either the low (855 Cals./lb.) or high (965 Cals./lb.) energy diet an increase in protein content from eighteen to twenty-two per cent, resulted in an improvement, although in one instance not a significant improvement, in weight gain and feed efficiency to four and eight weeks of age. These results suggest that in either the 855 Cals./lb. or 965 Cals./lb. diet, a protein level of greater than eighteen per cent is required for optimum growth and feed conversion to four and eight weeks of age.

This suggestion may appear to contradict the findings of previous research which has indicated that a balance between energy level and protein level is necessary for optimum growth. However, while the two energy levels employed in this investigation have been designated and referred to as high and low, they are both relatively high (855 and 965 Cals./lb.). The results of this investigation are not inconsistent with previous reports in that at either energy level the higher protein diet resulted in superior weight gain and feed efficiency.

The ration x sex interaction was not significant in the analysis of variance of four week and eight week weight gains. This result indicates that to four and eight weeks of age both males and females tend to react similarly to an increase in the protein or energy content of the diet. This finding disagrees with Shutze et al (1958) who reported a significant difference between sexes in response to increased energy or protein levels when birds were battery reared.

The results indicate that efficiency of protein utilization improved and efficiency of energy utilization decreased when the energy level of the diet was increased. Conversely, when the protein level of the diet was increased, efficiency of energy utilization improved and efficiency of protein utilization decreased.

These results are in agreement with Donaldson, Combs and Romoser (1956), and Mraz <u>et al</u> (1958) who suggested that both protein and energy cannot be spared in the same diet.

It is interesting to note that to eight weeks males were significantly ($P < .05$) superior to females in efficiency of energy utilization but not in efficiency of protein utilization.

A significant ($P < .01$) difference between strains in average weight gain was evident at both four and eight weeks of age, but an analysis of covariance applied to the data indicated that at eight weeks of age the significant difference was attributable to a difference between strains in feed consumption. As all strains were reared under similar environmental conditions this result suggests a difference between genetic groups (strains) in appetite caused either by a direct genetic effect on appetite or by a difference between genetic groups (gene - environment interaction) in response to environment.

At four weeks of age the difference between strains in average weight gain was still significant after an adjustment for feed consumption had been made. The results therefore indicate that the differences between strains in average weight gain (adjusted for feed consumption) decreased between the age of four weeks and eight weeks. Knox and Gordon (1958) reported similar findings for differences in growth rate of individual cockerals.

Therefore, it is suggested that after having been adjusted for feed consumption, four week weight gain is not a reliable criterion for determining the relative merit of strains for eight week weight gain.

Kempster (1921) and Carver and Hougan (1935) reported that cockerels exhibit a greater and more rapid gain in body weight than pullets. This difference is partially attributable to a more efficient utilization of feed by males according to Ma (1954). The results of the present study agree with these findings. At eight weeks of age a significant ($P<.05$) sex difference in favor of males was evident in feed conversion and in average weight gain after an adjustment for differences in feed consumption between sexes had been made by analysis of covariance.

II DRESSED, EVISCERATED AND EDIBLE MEAT YIELDS

The results of the analyses of variance on percentage blood and percentage feather loss indicated highly significant replicate differences. Replicate one had a higher percentage blood loss while replicate two had a higher percentage feather loss. Although an effort was made to keep the sacrificing of the birds as uniform as possible, it was necessary to have a different operator dispatch the birds from each replicate. It is suggested that the birds from replicate two were not bled as completely as those of replicate one, but that additional blood drained from these birds during the scalding and picking operations. This is a possible explanation for the higher apparent percentage feather loss of replicate two and the higher percentage blood loss of replicate one.

The results of the analyses on blood and feather loss also indicated a significant sex difference in percentage feather loss but not in percentage blood loss. This will be discussed later in relation to percentage dressed yield.

The results indicate that an increase in energy level (from approximately 855 Cals./lb. to 965 Cals./lb.) in either the eighteen or twenty-two per cent protein diet resulted in an increase in eight and a half week average live weight (10 birds/pen), dressed weight and eviscerated weight, as percentages of live weight; and in eviscerated weight as a percentage of dressed weight. Similarly, an increase in protein content from eighteen to twenty-two per cent in either the low or high energy diet resulted in similar increases in average live weight and in dressing percentages with the exception of dressed weight as a percentage of live weight for birds on the low energy diet. These findings are in agreement with Jaap et al (1950), who, working with a wider range of genetic variability than was used in this investigation, reported:

"In fact anything which will increase the live weight at 12 weeks of age will automatically increase the percentage yields."

The results also support the findings of Harms et al (1957) who reported that when the energy level of the diet increased, a significant increase in eviscerated yield as a percentage of live weight was obtained.

The data indicate that no strain differences were evident in eviscerated weight as a percentage of live or dressed weight. In fact, it is apparent that eviscerated yield as a percentage of live weight or dressed weight did not reflect the differences between strains in average live weight at eight and a half weeks of age. This result is in disagreement with Jaap and associates (1950) who stated:

"It is evident that heritable differences in growth rate are directly reflected in dressed and eviscerated yields when chickens are killed at a constant age."

Strain differences in dressed weight as a percentage of live weight, however, did reflect the differences in live weight at eight and a half weeks of age. This latter result is in keeping with the findings of Renard (1949) who reported considerable differences between meat type strains and crosses in percentage dressing loss. Orr (1955), however, reported no significant differences between some strains in percentage dressed yield. Selection for this factor is inherent in selection for growth as an increase in weight gain was shown to be related to an increase in percentage dressed yield.

A significant sex difference in favor of males was revealed by the analysis of variance of both dressed weight and eviscerated weight each expressed as a percentage of live weight. It will be noted that males were significantly heavier than females in live body weight at eight and a half weeks of age and therefore these results are in general agreement with Jaap and co-workers (1950) who stated:

"Females because they are smaller in size will produce a lower percentage yield than their brothers at the same age."

Hathaway et al (1953) presented similar results when eviscerated yield (excluding giblets and neck) as a percentage of live weight was considered, but when dressed weight as a percentage of live weight was considered, no significant sex difference was evident. Orr (1955) also found a significant sex difference in favor of males in eviscerated weight (including neck and giblets) expressed as a percentage of live weight, but not in dressed weight as a percentage of live weight.

In the present investigation the difference in percentage dressing loss between sexes was largely attributable to the difference in percentage feather loss. The results indicate that the sex difference in percentage feather loss was significant ($P < .05$) but that the difference in percentage blood loss was not significantly different between sexes.

The strain x sex interaction was significant ($P < .05$) in the analysis of variance of eviscerated weight as a percentage of live weight and as a percentage of dressed weight. Both analyses indicated that males were not consistently superior to females even though average live body weight of males at slaughter (eight and a half weeks) was consistently higher than that of females within each strain. Similarly, within each sex, the strain which produced the highest average live body weight did not consistently produce the highest percentage eviscerated yield. It is concluded, therefore, when these three strains are considered at eight and a half weeks of age that within each sex a difference between strains in live body weight does not result in a similar difference in eviscerated yield expressed as a percentage of live weight or dressed weight. Also, within each strain (except strain one which is consistent in this respect) males are not necessarily superior to females in eviscerated yield as a percentage of live or dressed weight, even though average live weight of males at eight and a half weeks of age is significantly higher than that of females.

The significant replicate differences in eviscerated yield as a percentage of live weight and as a percentage of dressed weight appeared to be associated with similar differences in average live body weight at eight and a half weeks of age. In all instances replicate one was superior to replicate two.

The analyses of variance performed on the transformed data pertaining to meat yield as a percentage of live weight and as a percentage of dressed weight revealed highly significant ($P < .01$) differences between rations. However, when meat yield was expressed as a percentage of eviscerated weight, ration differences were not significant. This suggests that the significant ration differences in meat yield as a percentage of live weight and dressed weight were associated with differences in percentage dressing loss and evisceration loss but that the meat to bone ratio was not significantly different between rations.

Under the conditions and limitations of this experiment it is concluded that an increase in energy level or an increase in protein level of the diet is associated with an increase in meat yield as a percentage of live weight and as a percentage of dressed weight. The meat to bone ratio of the eviscerated carcass is not significantly affected by increases in dietary energy or protein.

A highly significant sex difference in favor of females appeared in meat yield as a percentage of dressed weight and as a percentage of eviscerated weight when analysis of variance was performed on the transformed data. No significant sex difference was found when meat yield was expressed as a percentage of live weight. These findings do not agree with the results of Stotts and Darrow (1953), who reported no significant sex effect on meat yield as a percentage of eviscerated weight (giblets included). Orr (1955) found no significant sex difference in meat yield as a percentage of dressed weight or eviscerated weight (giblets and neck not included) at ten weeks of age. He also found no significant sex difference in meat yield as a percentage of live weight and on this point he is in agreement with the findings of the present investigation. The results of Hathaway et al (1953) are also in partial agreement with the present findings. They reported a significant sex difference in favor of females in meat yield as a percentage of eviscerated weight but also found a similar sex difference in meat yield as a percentage of live weight.

While the results of the various researchers appear contradictory in some respects, the results are not strictly comparable for differences exist between the various workers in the method of determining meat yield.

In the present investigation it is evident that while the sex difference in meat yield as a percentage of dressed weight may be partly associated with a difference in percentage evisceration loss, the meat to bone ratio (meat yield as a percentage of eviscerated weight) between sexes is also significantly ($P < .01$) different.

The results of the analysis of the data pertaining to the relationship of total bone weight to femur weight (both femurs included) or tibiotarsus weight (both tibiotarsi included) indicated that the regression lines for each of the two relationship differed significantly in Y-intercept values (a) between strains and between diets. Between sexes there was a significant ($P < .05$) difference in Y-intercept values for the regression of total bone weight on femur weight, but not for the regression of total bone weight on tibiotarsus weight.

The regression equations presented for each strain, sex and ration appear to be relatively accurate. It is evident from the results (Table X) that the highest standard error for estimating total bone weight was 5.6 gms. Therefore as edible meat yield was obtained by the subtraction of total bone weight from the weight of the eviscerated carcass, the error in estimating edible meat yield was also no higher than 5.6 gms. The lowest weight of edible meat obtained in this investigation was approximately 455 gms. Therefore the error in estimating meat yield was no greater than 1.2% ($5.6/455 \times 100$) or

12.0 gms. per 1000 gms. edible meat.

Further investigation is necessary to determine the range of applicability of the equations presented but they could be expected to be applicable only for the particular conditions under which they were derived. Once derived for a particular genetic group under a given set of environmental conditions the regression equation could be a valuable tool for future estimations of meat yield. An accurate evaluation of this technique awaits investigation into the effect of other environmental factors on the regression of total bone weight on femur weight and on tibiotarsi weight.

CHAPTER VI

SUMMARY AND CONCLUSIONS

A study was made of the effect of Calorie:protein ratio, strain and sex on weight gain, feed efficiency, dressing percentages and meat yield of chicken broilers. In conjunction with this investigation an attempt was made to determine the relationship between tibiotarsus weight and total bone weight and between femur weight and total bone weight. The effects of Calorie:protein ratio, strain and sex on these relationships were also studied.

Under the conditions and limitations of these investigations the following conclusions were drawn:

1. An increase in the energy or protein content of the diet is associated with an increase in four and eight week average weight gain and feed efficiency.

2. Strain has a significant effect on four and eight week weight gain and eight week feed conversion. The significant difference in eight week weight gain was caused by a difference in feed consumption between strains.

3. Males are significantly superior to females in eight week weight gain and feed efficiency.

4. The efficiency of protein utilization and of energy utilization varies inversely with the protein and energy content of the diet respectively.

5. An increase in the energy or protein content of the diet is associated with an increase in chilled dressed weight as a percentage of live weight (with one exception), eviscerated weight as a percentage of live weight and eviscerated weight as a percentage of chilled dressed weight.

6. Significant strain differences in average live weight at slaughter are not associated with similar differences in eviscerated weight as a percentage of live weight or dressed weight.

7. Strain differences in dressed weight as a percentage of live weight are significant and reflect significant differences in average live weight at slaughter.

8. Males are significantly superior to females in chilled dressed weight as a percentage of live weight and eviscerated yield as a percentage of live weight.

9. The superiority of males over females in eviscerated weight as a percentage of live weight or chilled dressed weight is dependent upon the strain of birds employed. Similarly, the superiority of one strain of birds over another in the percentage eviscerated yields is dependent upon the sex of the birds considered.

10. An increase in the energy or protein content of the diet is associated with an increase in meat yield as a percentage of live weight and as a percentage of dressed weight.

11. Meat yield as a percentage of eviscerated weight is not significantly affected by an increase in dietary energy or protein.

12. Females are significantly superior to males in meat yield as a percentage of dressed or eviscerated weight. These differences are associated with significant differences in percentage bone.

13. Strain and ration have significant effects on the regression of total bone weight on tibiotarsi weight and the regression of total bone weight on femur weight.

14. Sex has a significant effect on the regression of total bone weight on femur weight but not on the regression of total bone weight on tibiotarsi weight.

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APPENDIX I

TABLE XI ANALYSIS OF VARIANCE OF WEIGHT GAIN TO 4 WEEKS OF AGE

SOURCE	d.f.	Mean Sq.	F
Replicates	1	7681.33	21.69**
Rations	3	1974.17	5.57**
Strains	2	5748.73	16.23**
Sex	1	662.08	1.87
Rat. x Str.	6	435.38	1.23
Rat. x Sex	3	615.07	1.74
Strain x Sex	2	839.86	2.37
Rat. x Str. x Sex	6	286.95	<1
Error	23	354.14	

** Significant at the 1% level

TABLE XII ANALYSIS OF VARIANCE OF WEIGHT GAIN TO 8 WEEKS OF AGE

SOURCE	d.f.	Mean Sq.	F
Replicates	1	215.40	<1
Rations	3	24708.39	10.09**
Strains	2	15034.56	6.14**
Sex	1	60590.70	24.76**
Rat. x Strain	6	2314.05	<1
Rat. x Sex	3	912.54	<1
Strain x Sex	2	979.79	<1
Rat. x Str. x Sex	6	520.07	<1
Error	23	2447.55	

** Significant at the 1% level

TABLE XIII ANALYSIS OF COVARIANCE OF 4 WEEK WEIGHT GAINS (FEED CONSUMPTION AS X VARIABLE)

SOURCE	d.f.	x^2	xy	y^2	y_d^2	d.f.	M.Sq.	F
Reps	1	24715.35	13778.47	7681.33				
(A) Rations	3	9356.51	2011.09	35922.52				
(B) Strains	2	35730.92	20168.32	11497.46				
(C) Sex	1	166.44	- 331.93	662.08				
(AB) Ration x Strains	6	7411.35	1318.39	2612.28				
(AC) Ration x Sex	3	3765.55	1173.31	1845.20				
(BC) Strains x Sex	2	575.54	651.56	1679.71				
(ABC) Rat X Str x Sex	6	5683.93	1081.62	1721.70				
Error	23	50122.68	13177.21	8145.55	4681.39	22	212.79	16.28**
TOTAL	47	137,528.77	53,028.04	71,767.83				
Reps + Error	24	74838.03	26955.68	15826.88	6117.98	23		
					1436.59	1	1436.59	6.75*
Rations + Error	26	59479.19	15188.30	44068.07	40189.74	25		
					35508.35	3	11836.12	55.62**
Strains + Error	25	85853.60	33345.53	19643.01	6691.94	24		
					2010.55	2	1005.28	4.72*
Sex + Error	24	50289.12	12845.28	8807.63	5526.69	23		
					845.3	1	845.30	3.97
AB + Error	29	57534.03	14495.60	10757.83	7105.81	28		
					2424.42	6	404.07	1.90
AC + Error	26	53888.23	14350.52	9990.75	6169.21	25		
					1487.82	3	495.94	2.33
BC + Error	25	50698.22	13828.77	9825.26	6053.32	24		
					1372.13	2	686.06	3.22
ABC + Error	29	55806.61	14258.83	9867.25	6224.12	28		
					1542.73	6	257.12	1.21

* Significant at the 5% level
** Significant at the 1% level

TABLE XIV ANALYSIS OF COVARIANCE OF 8 WEEK WEIGHT GAINS (FEED CONSUMPTION AS X VARIABLE)

SOURCE	d.f.	x^2	xy	y^2	y^2_d	d.f.	M.Sq.	F
Reps	1	32.87	84.20	215.40				
A Rations	3	56676.37	17937.80	74125.18				
B Strains	2	317730.27	96122.10	30069.12				
C Sex	1	209301.87	112613.30	60590.70				
AB Ration x Strain	6	82199.10	31247.80	13884.30				
AC Ration x Sex	3	54991.50	6285.70	2737.62				
BC Strain x Sex	2	32180.60	7849.30	1959.58				
ABC Rat x Str x Sex	6	89013.50	11188.30	3120.44				
Error	23	513423.66	140653.04	56293.80	17768.53	22	807.66	47.70**
TOTAL	47	1355549.7406	423981.5475	242996.1419				
Reps + Error	24	513456.53	140737.24	56509.20	17933.12	23		
					164.59	1	164.59	1
Rations + Error	26	570100.03	158590.84	130419.60	86299.63	25		
					68531.10	3	22843.70	28.28**
Strains + Error	25	831153.93	236775.14	86362.92	18905.68	24		
					1137.15	2	568.57	1+
Sex + Error	24	722725.53	253266.34	116884.50	28139.98	23		
					10371.45	1	10371.45	12.84**
AB + Error9	29	595622.76	171900.84	70178.10	20567.52	28		
					2798.99	6	466.50	1
AC + Error	26	568415.16	146938.74	59031.42	21047.76	25		
					3279.23	3	1093.08	1.35
BC + Error	25	545604.26	148502.34	58253.38	17831.04	24		
					62.51	2	31.25	1
ABC + Error	29	602437.16	151841.34	59414.24	21150.22	28		
					3381.69	6	563.62	1

** Significant at the 1% level

TABLE XV ANALYSIS OF VARIANCE OF FEED CONVERSION TO 4 WEEKS OF AGE

SOURCE	d.f.	Mean Sq.	F
Replicates	1	.0166	1.12
Rations	3	.5133	34.54**
Strains	2	.0150	1.02
Sex	1	.0600	4.04
Rat. x Strain	6	.0166	1.12
Rat. x Sex	3	.0266	1.79
Str. x Sex	2	.0250	1.68
Rat. x Str. x Sex	6	.0136	<1
Error	23	.0149	

** Significant at the 1% level

TABLE XVI ANALYSIS OF VARIANCE OF FEED CONVERSION TO 8 WEEKS OF AGE

SOURCE	d.f.	Mean Sq.	F
Replicates	1	.0050	<1
Rations	3	.1528	23.15**
Strains	2	.0093	1.41
Sex	1	.0536	7.78*
Rat. x Strain	6	.0005	<1
Rat. x Sex	3	.0060	<1
Str. x Sex	2	.00005	<1
Rat. x Str. x Sex	6	.0064	<1
Error	23	.0066	

* Significant at the 5% level
** Significant at the 1% level

TABLE XVII ANALYSIS OF VARIANCE OF PROTEIN UTILIZATION TO 4 WEEKS OF AGE

SOURCE	d.f.	Mean Sq.	F
Replicates	1	.001	1.78
Rations	3	.008	14.28**
Strains	2	.001	1.78
Sex	1	.002	3.56
Rat. x Str.	6	.0006	1.07
Rat. x Sex	3	.0006	1.07
Str. x Sex	2	.001	1.78
Rat. x Str. x Sex	6	.0006	1.07
Error	23	.00056	

** Significant at the 1% level

TABLE XVIII ANALYSIS OF VARIANCE OF ENERGY UTILIZATION TO 4 WEEKS OF AGE

SOURCE	d.f.	Mean Sq.	F
Replicates	1	.05	<1
Rations	3	2.16	36.00**
Strains	2	.04	<1
Sex	1	.26	4.33*
Rat. x Str.	6	.07	1.01
Rat. x Sex	3	.12	2.00
Str. x Sex	2	.11	1.83
Rat. x Str. x Sex	6	.05	<1
Error	23	.06	

* Significant at the 5% level
** Significant at the 1% level

TABLE XIX ANALYSIS OF VARIANCE OF PROTEIN UTILIZATION TO 8 WEEKS OF AGE

SOURCE	d.f.	Mean Sq.	F
Replicates	1	0.00	<1
Rations	3	.027	67.5**
Strain	2	0.00	<1
Sex	1	0.00	<1
Rat. x Str.	6	0.00	<1
Rat. x Sex	3	0.00	<1
Str. x Sex	2	0.00	<1
Rat. x Str. x Sex	6	0.00	<1
Error	23	.0004	

** Significant at the 1% level

TABLE XX ANALYSIS OF VARIANCE OF ENERGY UTILIZATION TO 8 WEEKS OF AGE

SOURCE	d.f.	Mean Sq.	F
Replicates	1	.01	<1
Rations	3	1.26	37.88**
Strains	2	.03	<1
Sex	1	.18	5.45*
Rat. x Str.	6	.006	<1
Rat. x Sex	3	.016	<1
Str. x Sex	2	0	<1
Rat. x Str. x Sex	6	.043	1.30
Error	23	.033	

* Significant at the 5% level
** Significant at the 1% level

APPENDIX II

TABLE XXI ANALYSIS OF VARIANCE OF THE TRANSFORMED DATA PERTAINING TO WEIGHT OF BLOOD AS A PERCENTAGE OF LIVE WEIGHT

SOURCE	d.f.	Mean Sq.	F
Replicates	1	7.58	75.80**
Rations	3	.166	1.66
Strains	2	.26	2.60
Sex	1	.18	1.80
Rat. x Strain	6	.05	<1
Rat. x Sex	3	.053	<1
Strain x Sex	2	.015	<1
Rat. x Str. x Sex	6	.106	1.06
Error	23	.10	

** Significant at the 1% level

TABLE XXII ANALYSIS OF VARIANCE OF THE TRANSFORMED DATA PERTAINING TO WEIGHT OF FEATHERS AS A PERCENTAGE OF LIVE WEIGHT

SOURCE	d.f.	Mean Sq.	F
Replicates	1	9.48	28.90**
Rations	3	.396	1.21
Strains	2	3.55	10.82**
Sex	1	11.02	33.60**
Rat. x Strain	6	.313	<1
Rat. x Sex	3	.080	<1
Strain x Sex	2	.005	<1
Rat. x Str. x Sex	6	.22	<1
Error	23	.328	

** Significant at the 1% level

TABLE XXIII ANALYSIS OF VARIANCE OF LIVE WEIGHT AT 8½ WEEKS OF AGE (10 BIRDS / PEN)

SOURCE	d.f.	Mean Sq.	F
Replicates	1	46440.40	11.97**
Rations	3	38535.47	9.94**
Strains	2	16924.95	4.36*
Sex	1	69671.90	17.96**
Rat. x Strain	6	1955.16	<1
Rat. x Sex	3	1041.16	<1
Strain x Sex	2	1614.35	<1
Rat. x Str. x Sex	6	2017.05	<1
Error	23	3878.36	

* Significant at the 5% level
** Significant at the 1% level

TABLE XXIV ANALYSIS OF VARIANCE OF THE TRANSFORMED DATA PERTAINING TO CHILLED DRESSED WEIGHT AS A PERCENTAGE OF LIVE WEIGHT (10 BIRDS / PEN)

SOURCE	d.f.	Mean Sq.	F
Replicates	1	.01	<1
Rations	3	.76	5.24**
Strains	2	.95	6.55**
Sex	1	7.15	49.31**
Rat. x Strain	6	.175	1.21
Rat. x Sex	3	.116	<1
Strain x Sex	2	.07	<1
Rat. x Str. x Sex	6	.08	<1
Error	23	.145	

** Significant at the 1% level

TABLE XXV ANALYSIS OF VARIANCE OF THE TRANSFORMED DATA PERTAINING TO EVISCERATED WEIGHT AS PERCENTAGE OF LIVE WEIGHT (10 BIRDS/PEN)

SOURCE	d.f.	Mean Sq.	F
Replicates	1	1.11	6.89*
Rations	3	1.75	10.87**
Strains	2	.33	2.05
Sex	1	.96	5.96*
Rat. x Strain	6	.09	<1
Rat. x Sex	3	.08	<1
Strain x Sex	2	.60	3.72*
Rat. x Str. x Sex	6	.09	<1
Error	23	.161	

* Significant at the 5% level
** Significant at the 1% level

TABLE XXVI ANALYSIS OF VARIANCE OF THE TRANSFORMED DATA PERTAINING TO EVISCERATED WEIGHT AS A PERCENTAGE OF CHILLED DRESSED WEIGHT (10 BIRDS / PEN)

SOURCE	d.f.	Mean Sq.	F
Replicates	1	1.78	11.26**
Rations	3	2.01	12.72**
Strains	2	.245	1.55
Sex	1	.19	1.31
Rat. x Strain	6	.056	< 1
Rat. x Sex	3	.21	1.33
Strain x Sex	2	.63	3.99*
Rat. x Str. x Sex	6	.04	< 1
Error	23	.158	

* Significant at the 5% level
** Significant at the 1% level

TABLE XXVII ANALYSIS OF VARIANCE ON LIVE WEIGHT AT 8½ WEEKS OF AGE (6 BIRDS / PEN)

SOURCE	d.f.	Mean Sq.	F
Replicates	1	53522.20	11.63**
Rations	3	34431.01	7.48**
Strains	2	17476.60	3.80*
Sex	1	90893.30	19.75**
Rat. x Strain	6	3006.45	<1
Rat. x Sex	3	2277.46	<1
Strain x Sex	2	9844.25	2.14
Rat. x Str. x Sex	6	1786.83	<1
Error	23	4602.62	

* Significant at the 5% level
** Significant at the 1% level

TABLE XXVIII ANALYSIS OF VARIANCE OF THE TRANSFORMED DATA PERTAINING TO MEAT YIELD AS A PERCENTAGE OF LIVE WEIGHT (6 BIRDS / PEN)

SOURCE	d.f.	Mean Sq.	F
Replicates	1	1.70	7.49*
Rations	3	1.24	5.46*
Strains	2	.045	<1
Sex	1	.06	<1
Rat. x Strain	6	.126	<1
Rat. x Sex	3	.18	<1
Strain x Sex	2	.135	<1
Rat. x Str. x Sex	6	.096	<1
Error	23	.227	

* Significant at the 5% level

TABLE XXIX ANALYSIS OF VARIANCE OF THE TRANSFORMED DATA PERTAINING TO MEAT YIELD AS A PERCENTAGE OF CHILLED DRESSED WEIGHT (6 BIRDS / PEN)

SOURCE	d.f.	Mean Sq.	F
Replicates	1	1.95	11.34**
Rations	3	1.16	6.74**
Strains	2	.01	< 1
Sex	1	1.81	10.65**
Rat. x Strain	6	.095	< 1
Rat. x Sex	3	.106	< 1
Strain x Sex	2	.205	1.20
Rat. x Str. x Sex	6	.16	< 1
Error	23	.17	

** Significant at the 1% level

TABLE XXX ANALYSIS OF VARIANCE OF THE TRANSFORMED DATA PERTAINING TO MEAT YIELD AS A PERCENTAGE OF EVISCERATED WEIGHT (6 BIRDS/PEN)

SOURCE	d.f.	Mean Sq.	F
Replicates	1	.14	<1
Rations	3	.34	1.82
Strains	2	.33	1.82
Sex	1	4.69	25.08**
Rat. x Strain	6	.08	<1
Rat. x Sex	3	.14	<1
Strain x Sex	2	.15	<1
Rat. x Str. x Sex	6	.145	<1
Error	23	.187	

** Significant at the 1% level

TABLE XXXI DATA AND TESTS OF HYPOTHESES REGARDING STRAIN DIFFERENCES IN THE REGRESSION OF TOTAL BONE WEIGHT ON FEMUR WEIGHT

GROUPS	d.f.	x^2	xy	y^2	b	y_d^2	d.f.	Mean Sq.
Strain 1	95	386.83	2465.76	17504.01	6.37	1797.12	94	
2	95	428.40	2527.64	16318.22	5.90	1405.14	94	
3	95	381.72	2429.70	16845.85	6.36	1392.96	94	
						4595.22	282	16.30
Within Groups	285	1196.95	7423.10	50668.08	6.20	4644.86	284	
Among Groups	2	39.00	239.75	1725.96	6.15	251.50	1	
TOTAL	287	1235.95	7662.85	52394.04	6.20	4884.37	286	

H_1 : $\alpha_1 = \alpha_2 = \alpha_3$, $\beta_1 = \beta_2 = \beta_3$

$F = 4.43$*

H_2 : $\beta_1 = \beta_2 = \beta_3$

$F = 1.52$

* Significant at the 5% level

TABLE XXXII DATA AND TESTS OF HYPOTHESES REGARDING RATION DIFFERENCES IN THE REGRESSION OF TOTAL BONE WEIGHT ON FEMUR WEIGHT

GROUPS	d.f.	x^2	xy	y^2	b	y_d^2	d.f.	Mean Sq.
Ration 1	71	227.28	1447.40	10223.80	6.37	1003.86	70	
2	71	261.83	1724.64	12598.91	6.59	1233.53	70	
3	71	289.49	1743.77	11706.76	6.02	1209.26	70	
4	71	225.66	1479.38	9866.42	6.56	161.69	70	
						3608.34	280	12.89
Within Groups	284	1004.26	6395.19	44395.89	6.37	3658.53	283	
Among Groups	3	231.69	1267.66	7998.15	5.47	1064.05	2	
TOTAL	287	1235.95	7662.85	52394.04	6.20	4884.37	286	

$H_1: \sigma_1 = \sigma_2 = \sigma_3 = \sigma_4$, $\beta_1 = \beta_2 = \beta_3 = \beta_4$

F = 16.50**

$H_2: \beta_1 = \beta_2 = \beta_3 = \beta_4$

F = 1.30

** Significant at the 1% level

TABLE XXXIII DATA AND TESTS OF HYPOTHESES REGARDING SEX DIFFERENCES IN THE REGRESSION OF TOTAL BONE WEIGHT ON FEMUR WEIGHT

GROUPS	d.f.	x^2	xy	y^2	b	y_d^2	d.f.	Mean Sq.
Males	143	586.70	3635.84	23889.64	6.20	1347.56	142	
Females	143	400.50	2403.92	16660.00	6.00	2236.48	142	
						3584.04	284	12.62
Within Groups	286	987.20	6039.76	40549.64	6.12	3586.31	285	
Among Groups	1	248.75	1623.09	11844.40	6.52	1261.85	0	
TOTAL	287	1235.95	7662.85	52394.04	6.20	4884.37	286	

H_1 : $\alpha_1 = \alpha_2$, $\beta_1 = \beta_2$ H_2 : $\beta_1 = \beta_2$

F = 53.00** F = 1

** Significant at the 1% level

TABLE XXXIV DATA AND TESTS OF HYPOTHESES REGARDING STRAIN DIFFERENCES IN THE REGRESSION OF TOTAL BONE WEIGHT ON TIBIOTARSI WEIGHT

GROUPS	d.f.	x^2	xy	y^2	b	y_d^2	d.f.	Mean Sq.
Strain 1	95	855.92	3534.87	17504.01	4.13	2905.00	94	
2	95	728.83	3140.09	16318.22	4.31	2784.43	94	
3	95	934.78	3704.83	16845.85	3.96	2174.72	94	
						7864.15	282	27.89
Within Groups	285	2519.53	10379.79	50668.08	4.12	7903.35	284	
Among Groups	2	43.55	265.23	1725.96	6.09	110.71	1	
TOTAL	287	2563.08	10645.02	52394.04	4.15	8217.21	286	

H_1 : $\alpha_1 = \alpha_2 = \alpha_3$, $\beta_1 = \beta_2 = \beta_3$

F = 3.23*

H_2 : $\beta_1 = \beta_2 = \beta_3$

F = 1

* Significant at the 5% level

TABLE XXXV DATA AND TESTS OF HYPOTHESES REGARDING RATION DIFFERENCES IN THE REGRESSION OF TOTAL BONE WEIGHT ON TIBIOTARSI WEIGHT

GROUPS	d.f.	x^2	xy	y^2	b	y_d^2	d.f.	Mean Sq.
Ration 1	71	540.98	2114.70	10223.80	3.91	1955.32	70	
2	71	676.14	2763.28	12598.91	4.09	1297.09	70	
3	71	591.22	2390.72	11706.76	4.04	2048.25	70	
4	71	532.95	2048.46	9866.42	3.84	2000.33	70	
						7300.99	280	26.07
Within Groups	284	2341.29	9317.16	44395.89	3.98	7313.59	283	
Among Groups	3	221.79	1327.86	7998.15	5.99	44.27	2	
TOTAL	287	2563.08	10645.02	52394.04	4.15	8217.21	286	

H_1 : $\alpha_1 = \alpha_2 = \alpha_3 = \alpha_4$, $\beta_1 = \beta_2 = \beta_3 = \beta_4$ $\qquad$ H_2 : $\beta_1 = \beta_2 = \beta_3 = \beta_4$

F = 5.86** $\qquad$ F = 1

** Significant at the 1% level

TABLE XXXVI DATA AND TESTS OF HYPOTHESES REGARDING SEX DIFFERENCES IN THE REGRESSION OF TOTAL BONE WEIGHT ON TIBIOTARSI WEIGHT

GROUPS	d.f.	x^2	xy	y^2	b	y_d^2	d.f.	Mean Sq.
Males	143	1055.63	4540.90	23889.64	4.30	4363.60	142	
Females	143	718.74	3047.65	16660.00	4.24	3737.96	142	
						8101.56	284	28.53
Within Groups	286	1774.37	7588.59	40549.64	4.28	8070.48		
Among Groups	1	788.71	3056.43	11844.40	3.88	.74	0	
TOTAL	287	2563.08	10645.02	52394.04	4.15	8217.21	286	

$$H_1 : \alpha_1 = \alpha_2,\ \beta_1 = \beta_2$$

$$F = 2.03$$

FIG. 1. [illegible] OF TOTAL BODY [illegible] ON (1) [illegible] AND (2) [illegible] WEIGHT FOR RATION 2 ([illegible]).

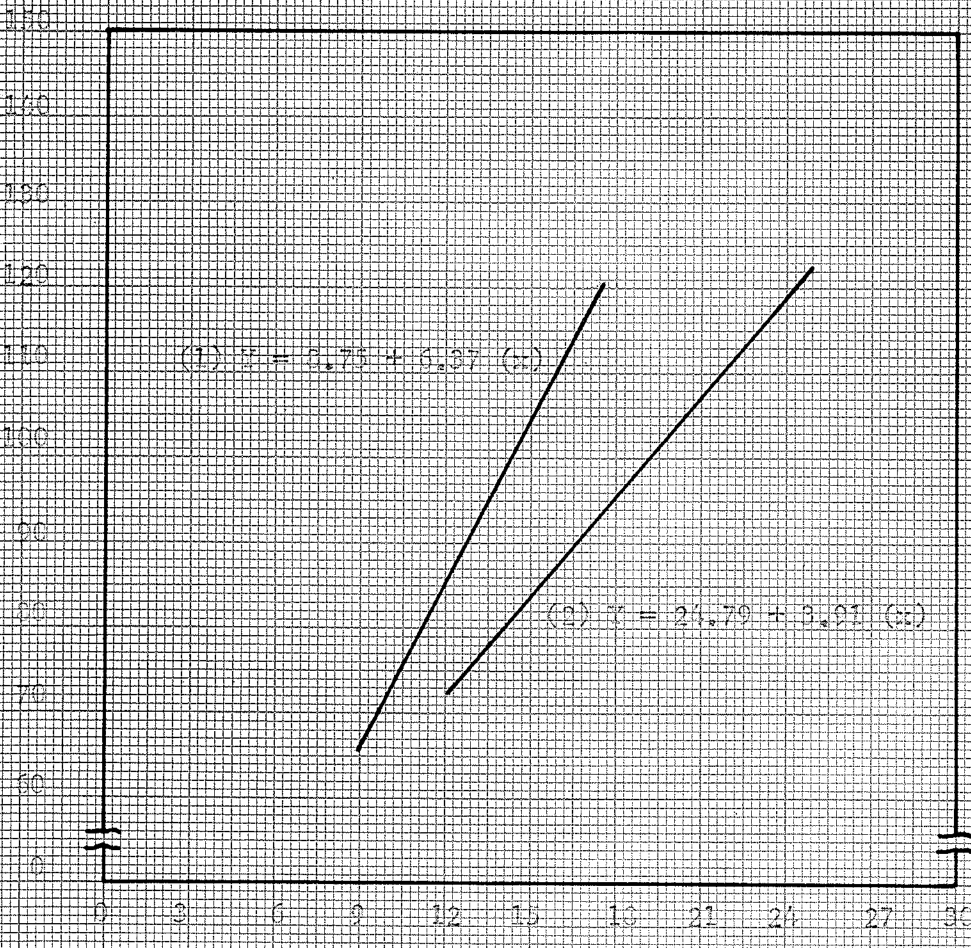

FIG. II. REGRESSION OF TOTAL BONE WEIGHT ON (1) FEMUR WEIGHT
AND (2) TIBIOTARSI WEIGHT FOR RATION 2 (LPLE).

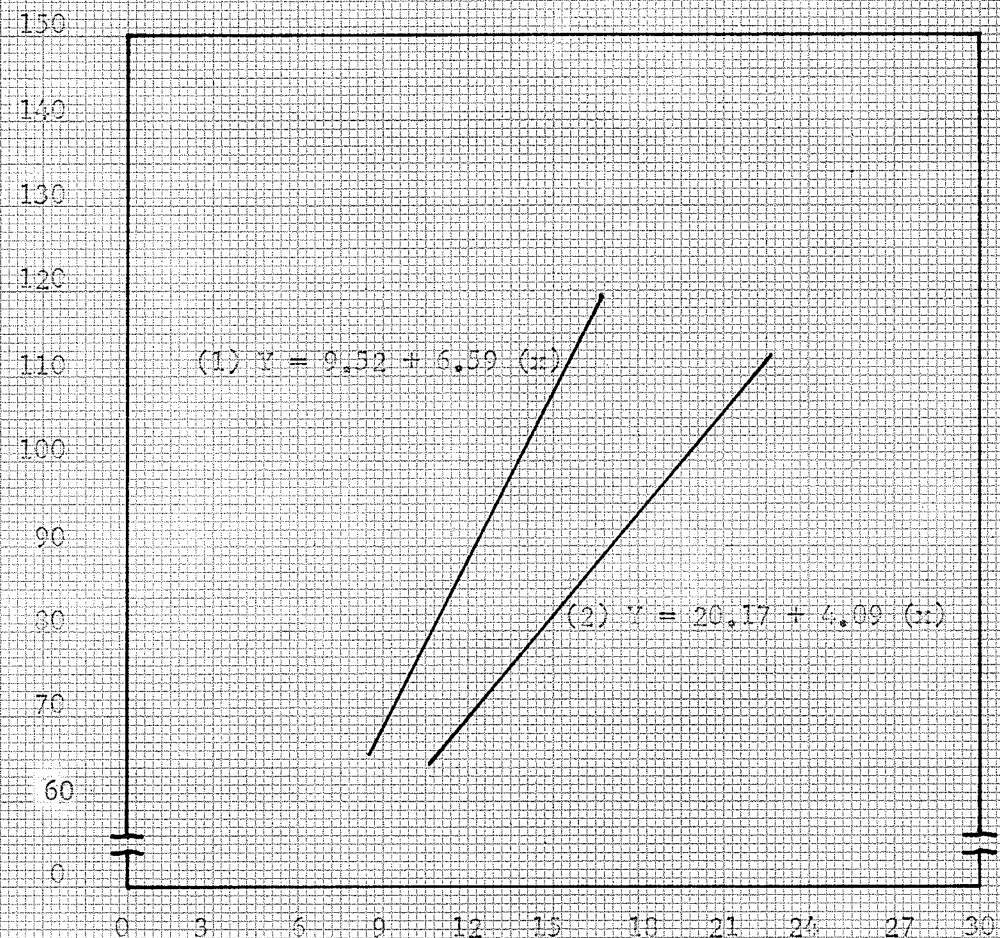

FIG. III. [illegible] OF TOTAL BODY WEIGHT ON (1) [illegible] WEIGHT AND (2) [illegible] WEIGHT FOR RATION 3 ([illegible]).

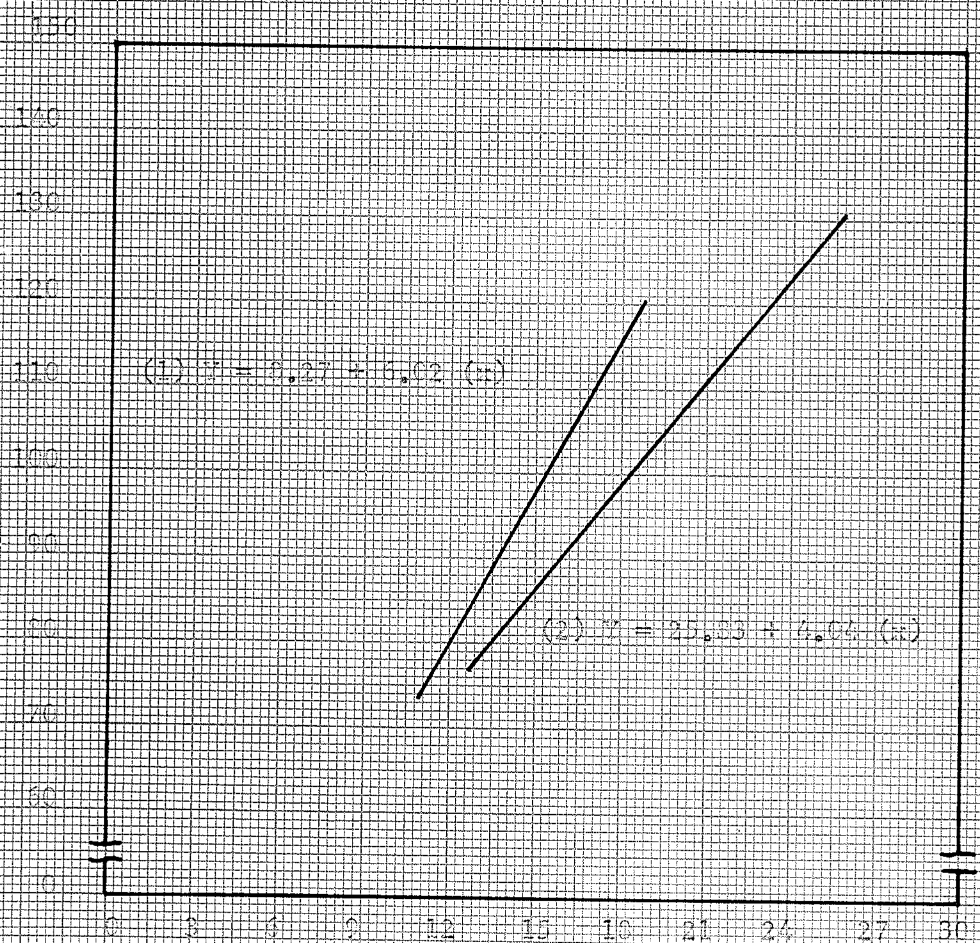

FIG. IV. REGRESSION OF TOTAL BONE WEIGHT ON (1) [illegible] WEIGHT AND (2) TIBIOTARSI WEIGHT FOR RATION 4 ([illegible]).

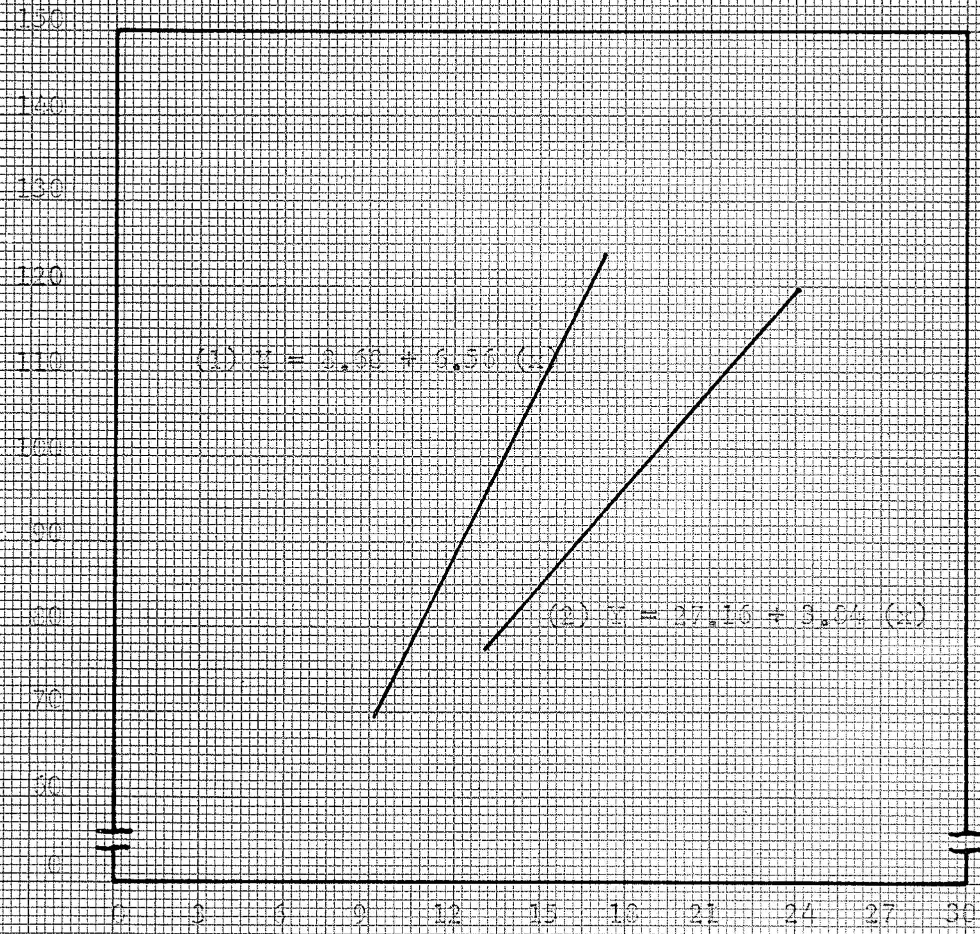

FIG. 7. REGRESSION OF TOTAL BONE WEIGHT ON (1) FEMUR WEIGHT AND (2) TIBIOTARSUS WEIGHT FOR STRAIN 1 (3b65).

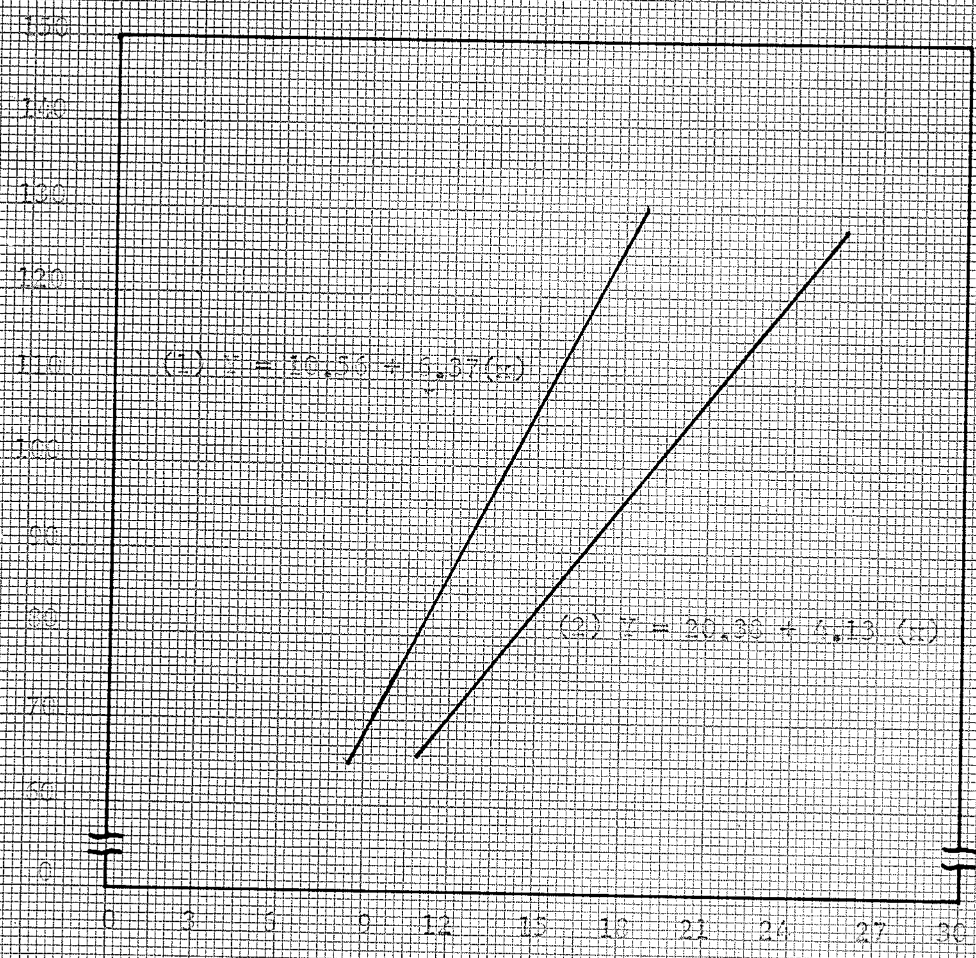

FIG. VI. REGRESSION OF TOTAL BODY WEIGHT ON (1) FEMUR WEIGHT AND (2) TIBIOTARSI WEIGHT FOR STRAIN 2 (CoC5).

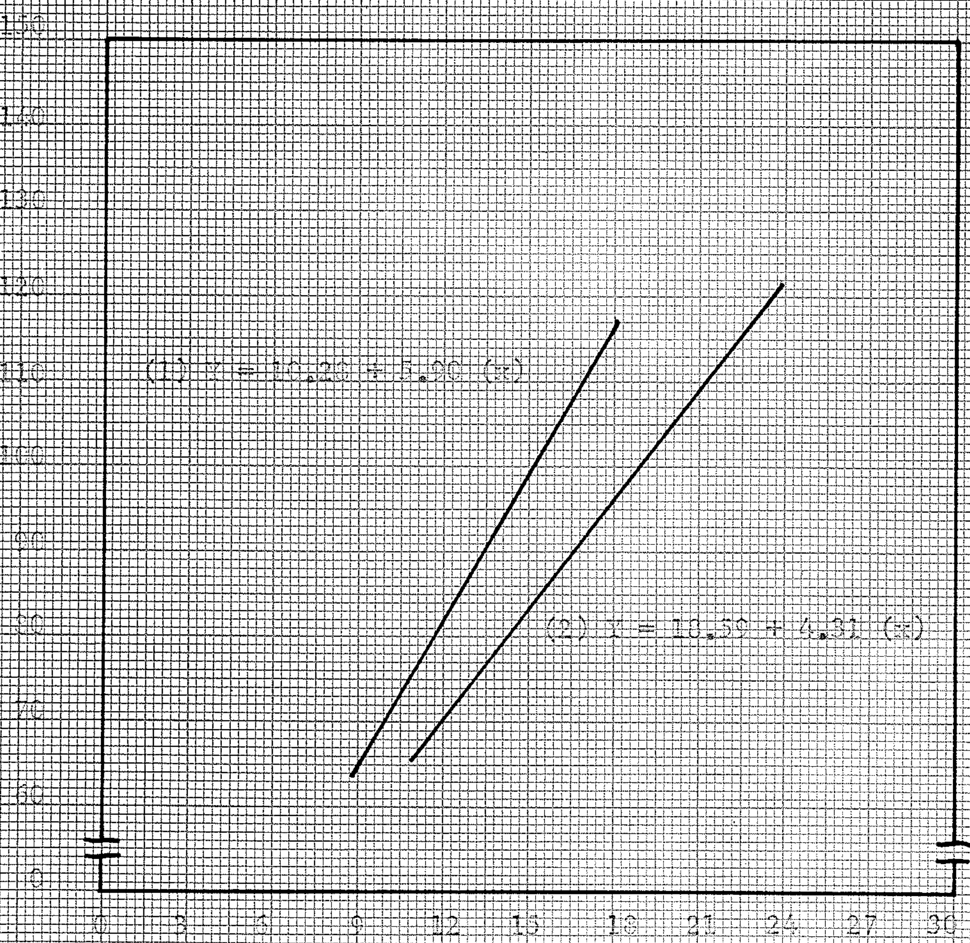

FIG. VIII. REGRESSION OF TOTAL BONE WEIGHT ON (1) FEMUR WEIGHT AND (2) TIBIOTARSI WEIGHT FOR STRAIN 3 (VanH).

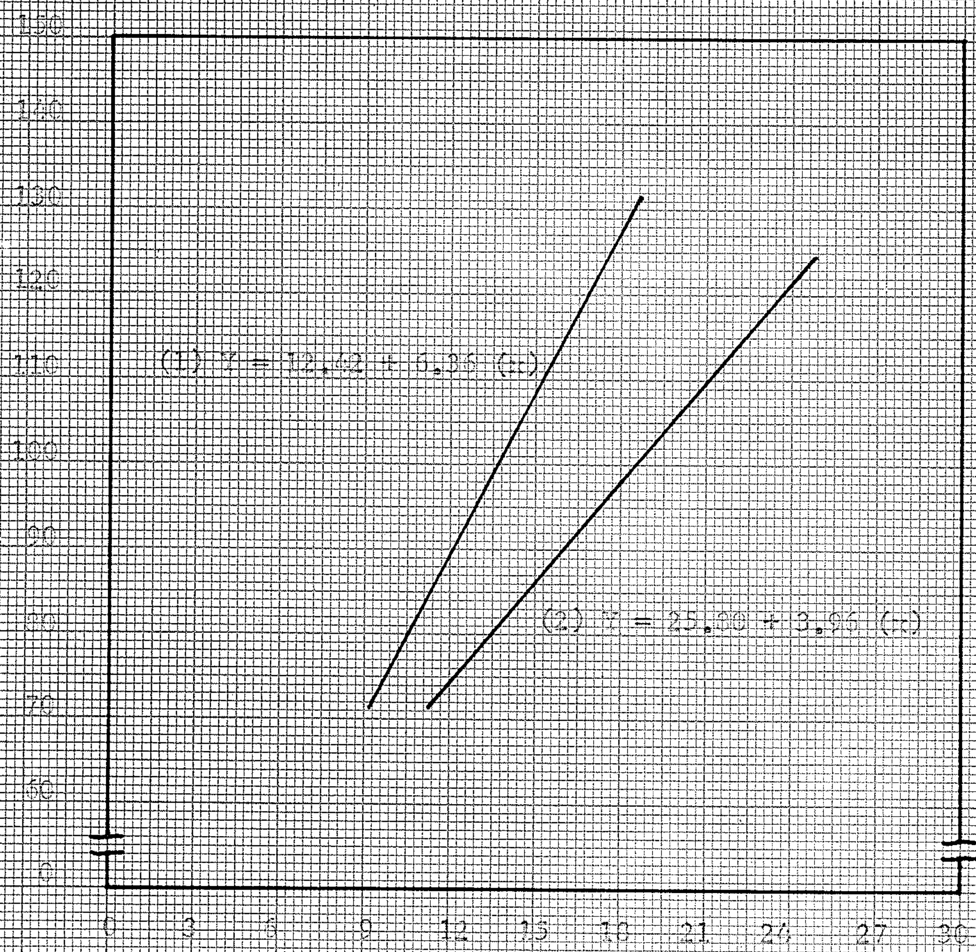

FIG. VIII. REGRESSION OF TOTAL BONE WEIGHT ON (1) FEMUR WEIGHT AND (2) TIBIOTARSI WEIGHT FOR MALES.

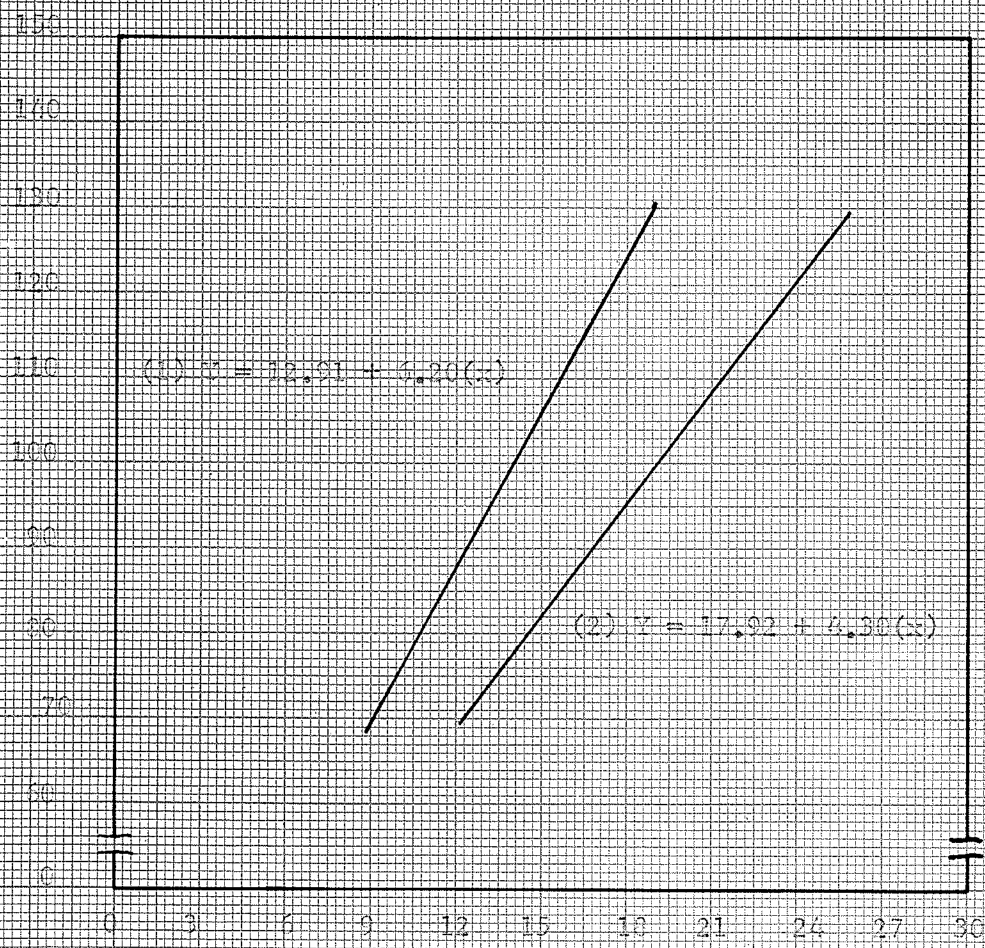

FIG. 11. REGRESSION OF TOTAL BODY WEIGHT ON (1) FEMUR WEIGHT AND (2) [illegible] WEIGHT FOR FEMALES.