AN ANALYSIS OF SELECTED FACTORS AFFECTING FEATHER REMOVAL

By

BOB GENE KNAPP

Bachelor of Science

Oklahoma State University

Stillwater, Oklahoma

1958

Submitted to the faculty of the Graduate
School of the Oklahoma State University
in partial fulfillment of the requirements
for the degree of
MASTER OF SCIENCE
January, 1960

AN ANALYSIS OF SELECTED FACTORS AFFECTING FEATHER REMOVAL

Thesis Approved:

George W. Arnold
Thesis Adviser

John W. West

Dean of the Graduate School

ACKNOWLEDGEMENTS

The writer wishes to express special appreciation to his major advisor, Dr. George W. Newell, for his advice, guidance and constructive criticism throughout this study.

Appreciation is expressed to all other staff members of the Poultry Science Department for their suggestions and guidance during the writing of this thesis.

The writer also wishes to thank Dr. Robert D. Morrison for his aid in the statistical analysis.

TABLE OF CONTENTS

	Page
INTRODUCTION.	1
REVIEW OF LITERATURE.	2
METHODS AND MATERIALS	7
RESULTS	14
DISCUSSION.	30
SUMMARY AND CONCLUSIONS	34
BIBLIOGRAPHY.	36

LIST OF TABLES

Table		Page
I.	Experimental Design Used in the Study of the Force Required to Pull Feathers from White Leghorn Hens as Affected by Fasting Time, Scald Water Temperature and Scalding Time. . .	12
II.	The Force Required to Pull Feathers from Chickens of Different Breeds and Sexes	14
III.	Analysis of Variance of the Force Required for Feather Removal from White Leghorn Hens Held Without Feed and Water for Selected Periods of Time	16
IV.	Duncan's Multiple Range Test of the Force Required for Feather Removal from White Leghorn Hens Held Without Feed and Water for Selected Periods of Time	18
V.	Analysis of Variance of the Force Required for Feather Removal from White Leghorn Hens After Being Exercised for Selected Periods of Time .	20
VI.	Duncan's Multiple Range Test of the Force Required for Feather Removal from White Leghorn Hens After Being Exercised for Selected Periods of Time	20
VII.	Analysis of Variance of the Force Required for Feather Removal from White Leghorn Hens Fed Different Levels of Tranquilizing Agents . . .	21
VIII.	Duncan's Multiple Range Test of the Force Required for Feather Removal from White Leghorn Hens Fed Different Levels of Tranquilizing Agents	22
IX.	The Average Force Required for Feather Removal in White Leghorn Hens as Affected by Fasting Time, Scald Water Temperature and Scalding Time	23

Table Page

X. Analysis of Variance of Force Required for Feather Removal from White Leghorn Hens as Affected by Fasting Time, Scald Water Temperature and Scalding Time 28

LIST OF FIGURES

Figure Page

1. Nomogram for the Conversion of Chart Units of Feather Pulling Force to Grams. 10

2. The Average Force Required for Feather Removal from White Leghorn Hens Held Without Feed and Water for Selected Periods of Time for Each Replication 17

3. The Average Force Required for Feather Removal from White Leghorn Hens After Exercising for Selected Periods of Time for Each Replication. 19

4. The Average Force Needed to Pull Feathers from Hens Scalded at Different Water Temperatures . 24

5. The Average Force Needed to Pull Feathers from Hens Scalded at Different Water Temperatures and Time Intervals. 26

6. The Average Force Needed to Pull Feathers from Fasted Hens Scalded at Different Water Temperatures. 27

LIST OF PLATES

Plate Page

I. Apparatus for Measuring Pulling Force with a Bird in Position. 8

INTRODUCTION

There are many factors which affect the processing efficiency of poultry. One such factor is the removal of feathers. If the force required for feather removal were lowered, this could have a decisive effect on the cost of processing. The force required for feather removal has been thought to be affected by various factors. Some processors have suggested that varying lengths of time that birds are held without feed and water before processing, and certain other management factors may affect the force required for feather removal.

Before these factors could be accurately evaluated, a method of measuring the force required for feather removal had to be determined. A technique of precisely measuring the force required for feather removal was developed for use in this study and selected factors thought to affect feather removal were evaluated.

REVIEW OF LITERATURE

There are many factors which may affect both the ease of feather removal and the appearance of dressed poultry. One of the factors, temperature of scald water, has been the subject of considerable research.

Williamson (1954) delineated the three fundamental types of scalding as semi-scald, slack-scald and hard-scald. Semi-scald is defined as that type of scalding in which water temperatures are held sufficiently low to insure retention of the epidermal layer of skin. The temperature used in commercial processing operations is 128 degrees F. Slack-scald is that type of scalding where the purpose is to remove the epidermis with appropriately high temperatures. This temperature is approximately 135 degrees F. Hard-scald is accomplished when the water temperature is 142 degrees F. or above.

When both scald water temperature and the length of time the birds were scalded were varied, Pearce and Lavers (1949) found that the force required to pull feathers from chickens was lowered as the scald water temperature was raised. In their study, birds scalded in water of 125 degrees F. for 30 seconds required 15 ounces of pulling force to remove feathers, while birds scalded in water of 136 degrees F. for 15 seconds

required only 5 ounces.

Stadelman and Ziegler (1955) scalded birds in water of 128 degrees F. and 140 degrees F. They observed that feathers as well as pin feathers were more completely removed from the birds by mechanical pickers when the birds were scalded at 140 degrees F. than when scalded at 128 degrees F. This resulted in less hand-labor for finishing and pinning after the birds were processed through a mechanical picker.

It was reported by Gwin (1952) that the amount of labor required for pinning and finishing could be reduced if higher scald water temperatures were used. He pointed out that if scald water having a temperature of near 140 degrees F. was used, the amount of labor required for pinning and finishing could be reduced as much as 80 percent over lower scald water temperatures.

A study by Pool et al. (1954) indicated that the number of workers required for manual removal of pin feathers left by mechanical pickers was more when birds were scalded at lower temperatures. Their study indicated that the number of manual workers could be reduced by about 80 percent when the scalding temperature was increased from 126 degrees F. to 140 degrees F. Pool et al. (1954) also stated that if semi-scald water temperature (126 degrees F.) were used, it would insure a normal skin appearance of the carcass. Temperatures around 140 degrees F. will remove the epidermis and the carcass will tend to have a slick appearance.

A comparison of birds scalded in semi-scald water temperature (130 degrees F.) with birds scalded in hard-scald water temperature was made by Graf and Stewart (1953). They observed that birds scalded at hard-scald water temperature had the epidermal layer of skin removed and were glossy in appearance. A panel of judges used in the study preferred the birds scalded at semi-scald water temperature to those scalded at hard-scald water temperature from the standpoint of appearance and texture of the carcass. However, the judges could detect no flavor difference between the cooked carcasses of the birds which had been scalded at semi-scald or hard-scald water temperatures.

Other factors that may affect picking ease were suggested by Lineweaver and Klose (1952). These are bird maturity, breed, sex, killing method and delay after killing until processing the bird. These factors were not fully appraised in their study and it was their thought that variations in scald water temperatures would subdue these non-scalding factors.

Fasting has been suggested by some workers as a factor that affects force required for feather removal. An experiment was conducted on different lengths of fasting in broilers and fryers by Gwin, Newell and Jull (1949) to determine a fasting period best suited for commercial operation. Fasting periods of 1, 2, 3, 4, 5, 6 and 24 hours were used. It was concluded that the 4 hour fasting period seemed to be the most practical from the standpoint of weight loss before

commercial slaughter.

Some workers have attempted to perfect a technique by which the force required for feather removal from poultry could be measured objectively.

Pool, et al. (1954) measured the force required for the removal of feathers from turkeys and related their force to scald water temperature and length of scalding time. Their measuring apparatus consisted of a hemostat attached to a small spring scale. After the individual turkey was scalded for the prescribed length of time in the selected scald water temperature, ten representative mature body feathers were pulled individually from the back of each turkey. The force required to remove each individual feather as measured by the spring scale was recorded. The force required for feather removal was found to be inversely related to the temperature of scald water. Also, the number of residual feathers on the processed turkeys was directly related to the force required to pull individual feathers.

This study also indicated that measurement of feather pulling force may be recommended as a reliable objective measure for determining the effect of processing conditions on the efficiency of commercial feather removal. Feather pulling force increased in a consistent manner with a decrease in scalding temperature. This was directly correlated with the number of feathers remaining on the birds after they passed through a commercial line of mechanical pickers.

Rose (1939) used feather release as a measure in evaluating electrical shock for slaughtering poultry before processing. The birds were killed by electrical shock administered by means of a metal clamp attached to the head of the bird. Satisfactory feather release was attained when the operator was able to dry-pluck the bird with reasonable ease without tearing the skin.

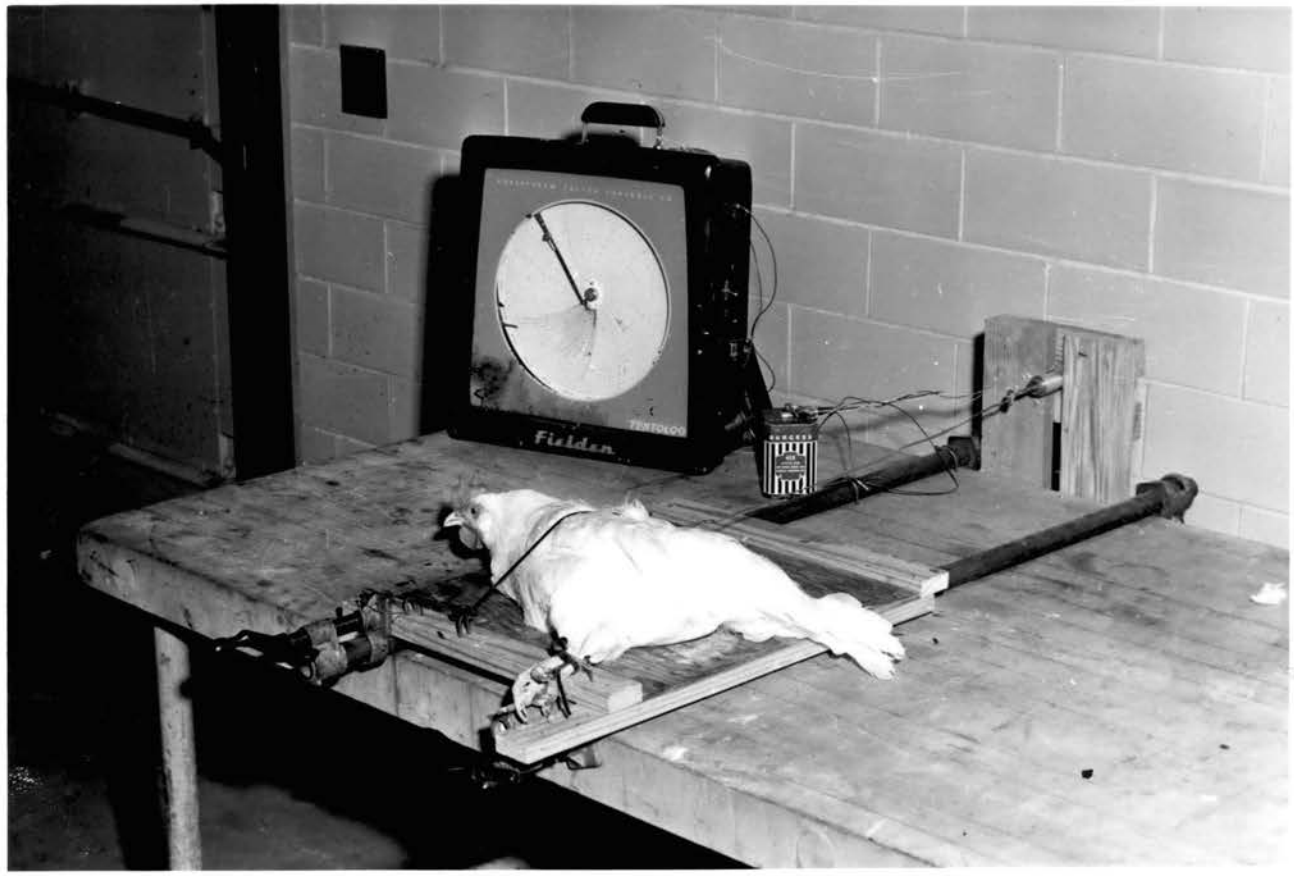
Force required to pull feathers from birds scalded at varying temperatures and time intervals was measured by Nassau (1955). After scalding the bird at the prescribed temperature and for the alloted time, the bird was taken to a scale from which a hemostat was suspended. Ten mature feathers were pulled individually from the base of the bird's back region. The pulling of an individual feather was done by attaching the hemostat to the feather and the bird was drawn away from the scale to the point where the feather pulled. The pulling force was recorded as the reading on the spring scale when the feather pulled from the body.

METHODS AND MATERIALS

In order to test factors which might affect picking ease, the method reported herein was devised to measure accurately the force required for feather removal. A displacement transducer was suggested as an instrument that might give the precise readings of force required. As pulling force was brought to bear on the displacement transducer, the transducer was found to be effective in measuring the pulling force required. The displacement transducer is a potentiometer in which force required was measured and recorded.

The displacement transducer was mounted in a horizontal position on a platform attached to the side of a table. A light inelastic cable was fastened to the arm of the transducer. At the end of the inelastic cable, an alligator clip was attached for the purpose of clamping to individual feathers on the bird, as illustrated in Plate I. When a bird was selected for feather removal, it was strapped to the platform to restrain body movement. This platform was moveable and was located in front of the displacement transducer. From this position of the platform, it was possible to make a straight and steady pull away from the displacement transducer. The alligator clip was fastened to an individual feather in the bird's posterior spinal feather tract, and pulling force was

Plate I. Apparatus for Measuring Pulling Force with a Bird in Position



brought to bear on the feather by the steady even movement of the platform away from the displacement transducer.

A Fielden recorder was wired to the displacement transducer which recorded the force required to remove an individual feather on a revolving circular chart. The force required was recorded in terms of chart units. The particular instrument was calibrated by the use of gram weights being applied to the displacement transducer. Thus, chart units can be converted to grams by the use of the nomogram (Figure 1).

The first objective of this study was to determine whether differences in force required for feather removal existed among breeds. White Leghorn, New Hampshire, White Plymouth Rock and White Wyandotte were the breeds used in the trial. Both sexes were used in this portion of the study with the exception of the breed White Wyandotte in which only females were tested. Five birds of each sex of each breed were tested and ten feathers were extracted individually from the posterior spinal feather tract of the bird.

The second objective in this study was to determine if different fasting periods affect ease of feather removal. Periods of 0, 6, 8, 24, 48 and 72 hours were used during which the birds were deprived of feed and water. White Leghorn hens were used for this portion of the study. Four trials were completed which consisted of 12 birds per trial. The birds were put into individual wire cages and were fasted for the selected period of time before feather removal. Five feathers were removed from the posterior spinal feather tract of the

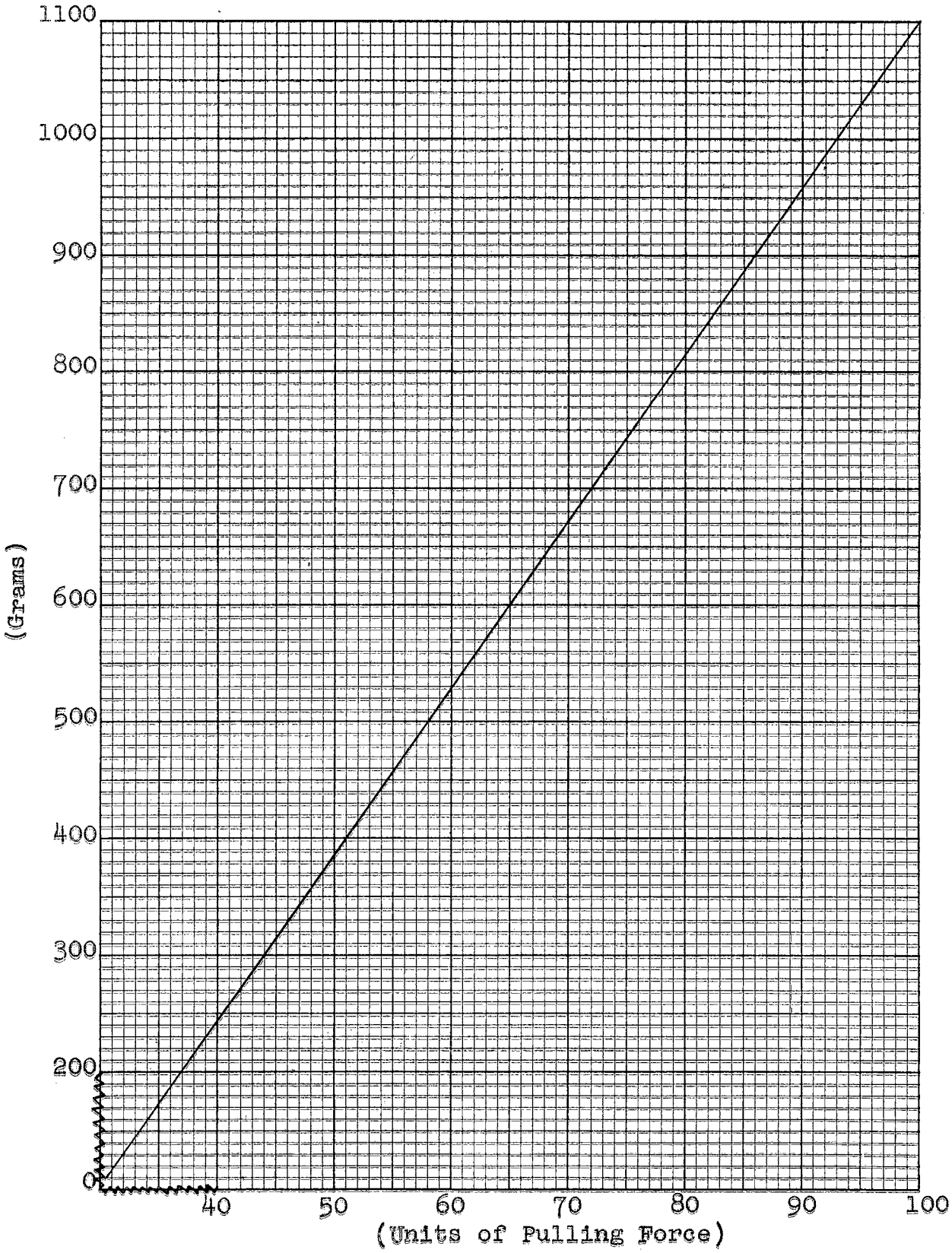


Figure 1. Nomogram for the Conversion of Chart Units of Feather Pulling Force to Grams

live bird at the end of each fasting period.

Fatigue was thought to be a factor which might affect ease of feather removal. A treadmill was built for the purpose of exercising individual birds for selected periods of time. After preliminary trials, the exercising periods of 0, 1 and 1½ minute(s) were selected. Individual birds were placed in the treadmill for exercise and the treadmill was turned at a uniform rate of sixteen revolutions per minute for all periods of exercise. White Leghorn females were used in the fatigue portion of this study. Three trials consisting of twelve birds each were conducted. After an individual bird was exercised for the prescribed period of time, she was immediately taken from the treadmill and five feathers were pulled from the posterior spinal feather tract.

Another segment of the study was to determine if tranquilizing agents being administered orally to White Leghorn hens affected the force required for feather removal. Two levels of reserpine and three levels of trifluoperazine in the feed had been administered to the birds for approximately seven months. Twelve hens from each level of tranquilizing agent were selected at random as were twelve hens from a group receiving no tranquilizing agent. Five feathers were pulled from the posterior spinal feather tract of each bird in the study.

The last objective of this experiment was to test the effect of scald water temperature, scalding time and length of fasting period on ease of feather removal in White Leghorn

hens. The experimental design for this portion of the study is shown in Table I. The scald water temperatures used were

TABLE I

EXPERIMENTAL DESIGN USED IN THE STUDY OF THE FORCE REQUIRED TO PULL FEATHERS FROM WHITE LEGHORN HENS AS AFFECTED BY FASTING TIME, SCALD WATER TEMPERATURE AND SCALDING TIME

Fasting Time (hours)	Scald Water Temperature (degrees F.)	Scalding Time (seconds)	Number of Birds
0	128	45	12
		90	12
	135	45	12
		90	12
	142	45	12
		90	12
6	128	45	12
		90	12
	135	45	12
		90	12
	142	45	12
		90	12
24	128	45	12
		90	12
	135	45	12
		90	12
	142	45	12
		90	12

128 degrees F., 135 degrees F. and 142 degrees F., with the lengths of scalding time being 45 seconds and 90 seconds. Fasting periods of 0, 6 and 24 hours were selected. Each combination of scald water temperature, scalding time and fasting period was considered as one treatment. There was a total of 18 treatments and twelve replications were made of each treatment. A total of 216 birds was used in this portion

of the study, and five feathers were removed from the back area of each individual bird after the prescribed fasting period, scald water temperature and scalding time were administered. The birds were confined in wire cages for the proper length of fasting. After the bird had been fasted for the prescribed length of time, it was immediately killed by cutting the jugular vein. The bird was allowed to bleed freely for two minutes and then was scalded manually at the selected scalding temperature and scalding time. Immediately after scalding, at the selected temperature and time, five feathers were pulled individually from the posterior spinal feather tract of the scalded bird.

RESULTS

The units of feather pulling force required for feather removal among breeds ranged from 56.99 units for White Wyandotte females to 68.65 units for New Hampshire males, as shown in Table II. The difference in feather pulling force

TABLE II

THE FORCE REQUIRED TO PULL FEATHERS FROM CHICKENS OF DIFFERENT BREEDS AND SEXES

Breed	Sex	Units of feather pulling force	Standard Deviation
White Leghorn	Males	61.62	12.56
	Females	60.69	8.31
New Hampshire	Males	68.65	17.05
	Females	58.45	12.45
White Plymouth Rock	Males	63.88	11.60
	Females	65.69	15.20
White Wyandotte	Females	56.99	12.19

between sexes within a breed was small in the White Leghorn and White Plymouth Rock breeds. White Leghorn males required 61.62 units of pulling force for feather removal as compared

to 60.90 units for the females. For the removal of feathers from White Plymouth Rock males, 63.88 units of pulling force were required, while the feathers from the females pulled with 65.69 units. White Plymouth Rock was the only breed tested in which more units of pulling force were required for feather removal from the females than from the males. A difference of 10.20 units of feather pulling force was observed between the sexes within the New Hampshire breed, with 68.65 and 58.45 units required for the males and females, respectively.

The standard deviation of the units of force required for feather removal ranged from 8.31 for White Leghorn females to 17.05 for New Hampshire males. The standard deviation was greater for the males than for the females in all breeds tested except the White Plymouth Rock. The White Plymouth Rock males had a standard deviation of 11.60 units of pulling force compared with 15.20 for the White Plymouth Rock females. The difference in the standard deviation between White Leghorn males and females was 4.25. In the New Hampshire breed the difference in standard deviation between males and females was 4.51.

When White Leghorn hens were fasted for selected periods of time, the averages of the forces required for feather removal for the various treatments were significantly different ($P<.01$), as shown in Table III. The analysis of variance technique (Snedecor, 1955) was used throughout this study for statistical analysis. Replications of the fasting time

TABLE III

ANALYSIS OF VARIANCE OF THE FORCE REQUIRED FOR FEATHER REMOVAL FROM WHITE LEGHORN HENS HELD WITHOUT FEED AND WATER FOR SELECTED PERIODS OF TIME

Source of Variation	df	Sum of Squares	Mean Square	F Value
Total	23	1,113.34		
Replication	3	310.39	103.46	5.78**
Treatments	5	632.45	126.49	7.07**
Error	15	168.50	17.90	

** Significant at the .01 level.

intervals were also significantly different ($P < .01$). Replications 1 and 2 (Figure 2) indicated that the force required for feather removal decreased to the eighth hour of fasting. After the eight-hour fasting period, the force required for feather removal increased as the fasting periods increased to 72 hours. Replications 3 and 4 indicated that as fasting time was lengthened greater force was required to remove feathers. An average was calculated from the four replications of the force required for feather removal by the different fasting periods. Duncan's Multiple Range Test (1955) was applied to the averages of force required for the selected periods of fasting (Table IV). The averages ranged from 49.89 units of pulling force for the birds fasted 8 hours to 64.44 units for the birds fasted 72 hours. The average force required for feather removal from the birds fasted for 6 and 8 hour

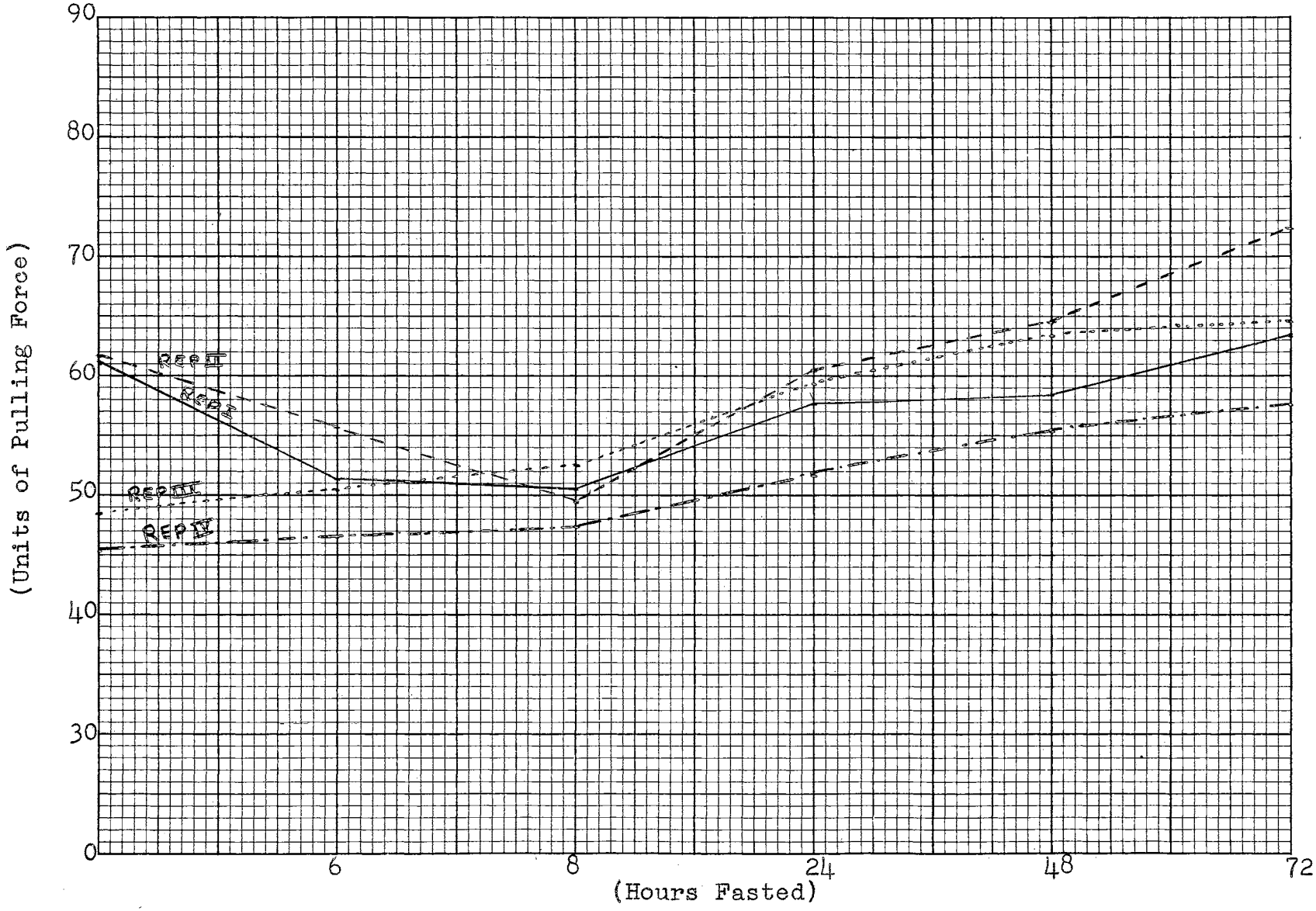


Figure 2. The Average Force Required for Feather Removal from White Leghorn Hens Held Without Feed and Water for Selected Periods of Time for Each Replication

periods was less than that for birds not fasted. Birds that were fasted for 24, 48 and 72 hours required greater force for feather removal than did the birds not fasted.

TABLE IV

DUNCAN'S MULTIPLE RANGE TEST OF THE FORCE REQUIRED FOR FEATHER REMOVAL FROM WHITE LEGHORN HENS HELD WITHOUT FEED AND WATER FOR SELECTED PERIODS OF TIME

Treatment Hours Fasted	Average Units of Feather Pulling Force	Multiple Range
72	64.44	
48	60.34	
24	57.26	
0	53.98	
6	50.99	
8	49.89	

Any two means underscored by the same line are not significantly different at the .05 level.

The force required for feather removal from White Leghorn hens after exercising in a treadmill for the selected periods of 0, 60 and 90 seconds was found to be statistically different ($P<.05$). The number of seconds the bird was exercised in the treadmill was considered as a treatment and the statistical analysis of the results are presented in Table V. Replications of this trial were not found to be significantly different ($P<.05$). The average force required for feather removal as affected by the different exercising periods is shown in Figure 3. The averages of force required to pull feathers from the birds exercised

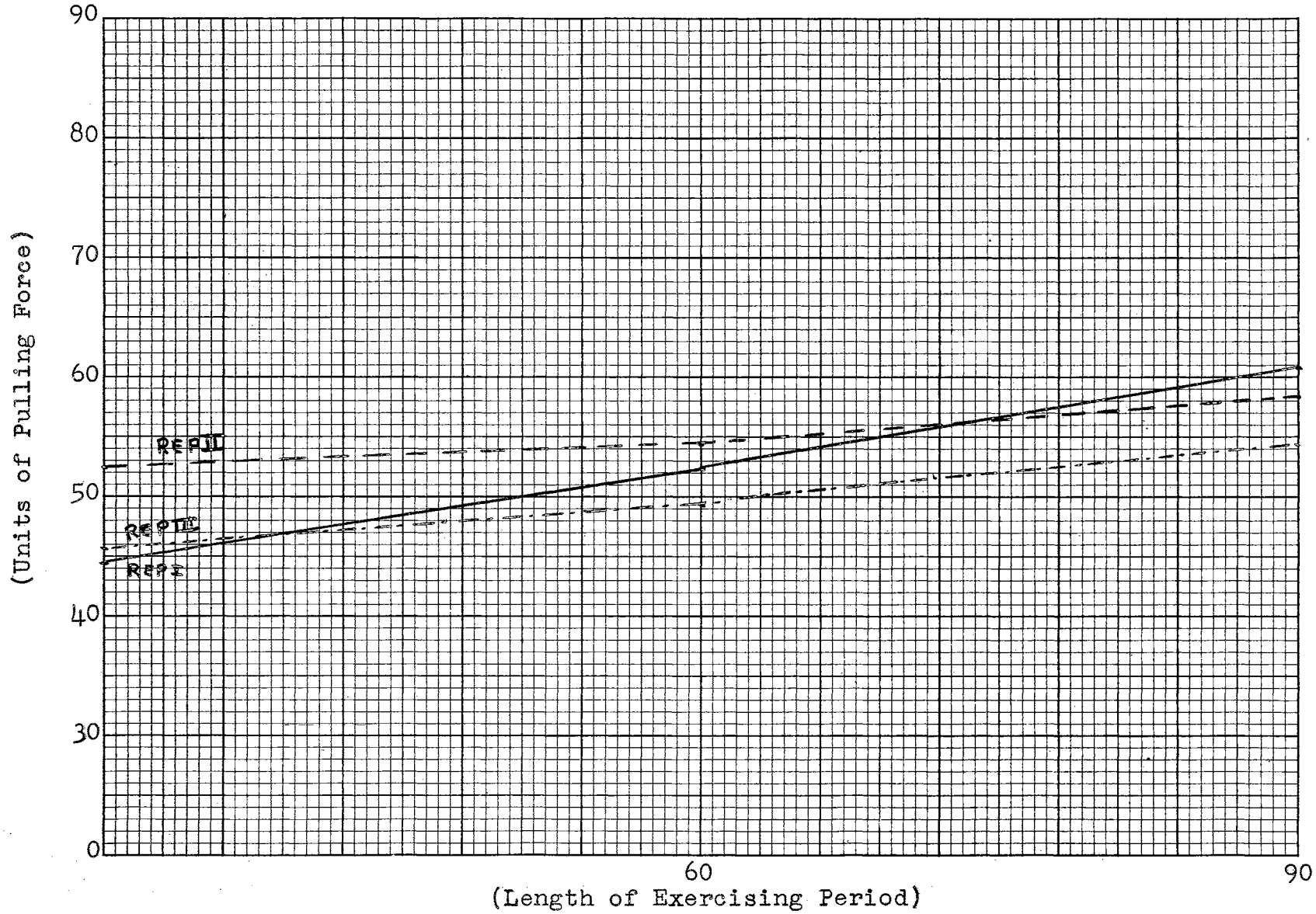


Figure 3. The Average Force Required for Feather Removal from White Leghorn Hens After Exercising for Selected Periods of Time for Each

for 0, 60 and 90 seconds in the treadmill were 47.47, 51.80 and 57.74 units, respectively. When Duncan's Multiple Range Test (1955) was applied to the averages, (Table VI), the forces required for feather removal from birds exercised 0 and 90 seconds were significantly different ($P < .05$).

TABLE V

ANALYSIS OF VARIANCE OF THE FORCE REQUIRED FOR FEATHER REMOVAL FROM WHITE LEGHORN HENS AFTER BEING EXERCISED FOR SELECTED PERIODS OF TIME

Source of Variation	df	Sum of Squares	Mean Square	F Value
Total	8	231.55		
Replications	2	38.62	19.31	2.32
Treatments	2	159.59	79.80	9.57*
Error	4	33.34	8.34	

* Significant at the .05 level.

TABLE VI

DUNCAN'S MULTIPLE RANGE TEST OF THE FORCE REQUIRED FOR FEATHER REMOVAL FROM WHITE LEGHORN HENS AFTER BEING EXERCISED FOR SELECTED PERIODS OF TIME

Treatment Seconds Exercised in Treadmill	Average Units of Feather Pulling Force	Multiple Range
0	47.47	
60	51.80	
90	57.74	

Any two means underscored by the same line are not significantly different at the .05 level.

Tranquilizing agents which were being fed to White Leghorn hens were found to affect the force required for feather removal. Each level of tranquilizing agent fed to the birds was considered a treatment. Statistical analysis (Table VII) showed the treatments to be significantly different

TABLE VII

ANALYSIS OF VARIANCE OF THE FORCE REQUIRED FOR FEATHER REMOVAL FROM WHITE LEGHORN HENS FED DIFFERENT LEVELS OF TRANQUILIZING AGENTS

Source of Variation	df	Sum of Squares	Mean Square	F Value
Total	71	3,505.23		
Treatment	5	1,661.53	332.31	11.89**
Error	66	1,843.70	27.94	

** Significant at the .01 level.

($P < .01$). The birds fed no tranquilizing agent had an average feather pulling force of 50.16 units. In all cases hens fed tranquilizing agents required a lower force for feather removal than the birds fed no tranquilizing agent. The greatest force required for feather removal from birds fed tranquilizing agents was 43.37 units. This was the average force required for feather removal from birds fed reserpine at the rate of 1.5 mg. per kg. of ration. The lowest force required for feather removal was 35.15 units, which was the average force required by birds fed trifluoperazine at the level of 306.75 mg. per kg. of ration. The

average force required for feather removal from birds fed all levels of reserpine and trifluoperazine are shown in Table VIII. When the Duncan's Multiple Range Test (1955) was

TABLE VIII

DUNCAN'S MULTIPLE RANGE TEST OF THE FORCE REQUIRED FOR FEATHER REMOVAL FROM WHITE LEGHORN HENS FED DIFFERENT LEVELS OF TRANQUILIZING AGENTS

Agent	Mg. per Kg. of Diet	Average Units of Feather Pulling Force	Multiple Range
Control	0	50.16	I
Reserpine	1.5	43.37	I
Reserpine	2.5	40.10	I
Trifluoperazine	153.37	40.01	I
Reserpine	2.0	37.42	I
Trifluoperazine	306.74	35.15	I

Any two means underscored by the same line are not significantly different at the .01 level.

applied to these data, the force required to pull feathers from the birds fed no tranquilizing agent was significantly different ($P < .01$) from all other treatments.

The average force required for feather removal from White Leghorn hens as affected by fasting time, scald water temperature and scalding time is shown in Table IX. The average values as determined for this phase of the study ranged from 19.05 units of pulling force for the birds fasted for a six-hour period and scalded at a water temperature of 128 degrees F. for a period of 45 seconds, to 6.71 units for the birds fasted 24 hours and scalded for 90 seconds at a water temperature of 142 degrees F. The average

force required to remove feathers from the birds scalded at a water temperature of 128, 135 and 142 degrees F. is illustrated graphically in Figure 4. The birds scalded at 128 degrees F. had an average feather pulling force of 15.56 units. Birds scalded at a water temperature of 135 degrees F. required an average of 12.37 units of pulling force for feather removal, with 8.90 units being required to pull the feathers from the birds scalded at 142 degrees F.

TABLE IX

THE AVERAGE FORCE REQUIRED FOR FEATHER REMOVAL IN WHITE LEGHORN HENS AS AFFECTED BY FASTING TIME, SCALD WATER TEMPERATURE AND SCALDING TIME

Fasting Time (hours)	Scald Water Temperature (degrees F.)	Scalding Time (seconds)	Average Pulling Force (units)
0	128	45	18.47
		90	12.18
	135	45	13.15
		90	15.75
	142	45	10.50
		90	7.07
6	128	45	19.05
		90	13.05
	135	45	11.63
		90	11.73
	142	45	10.23
		90	8.17
24	128	45	17.78
		90	12.82
	135	45	11.02
		90	10.95
	142	45	10.71
		90	6.71

The average forces required for feather removal from birds scalded in the selected scald water temperatures and

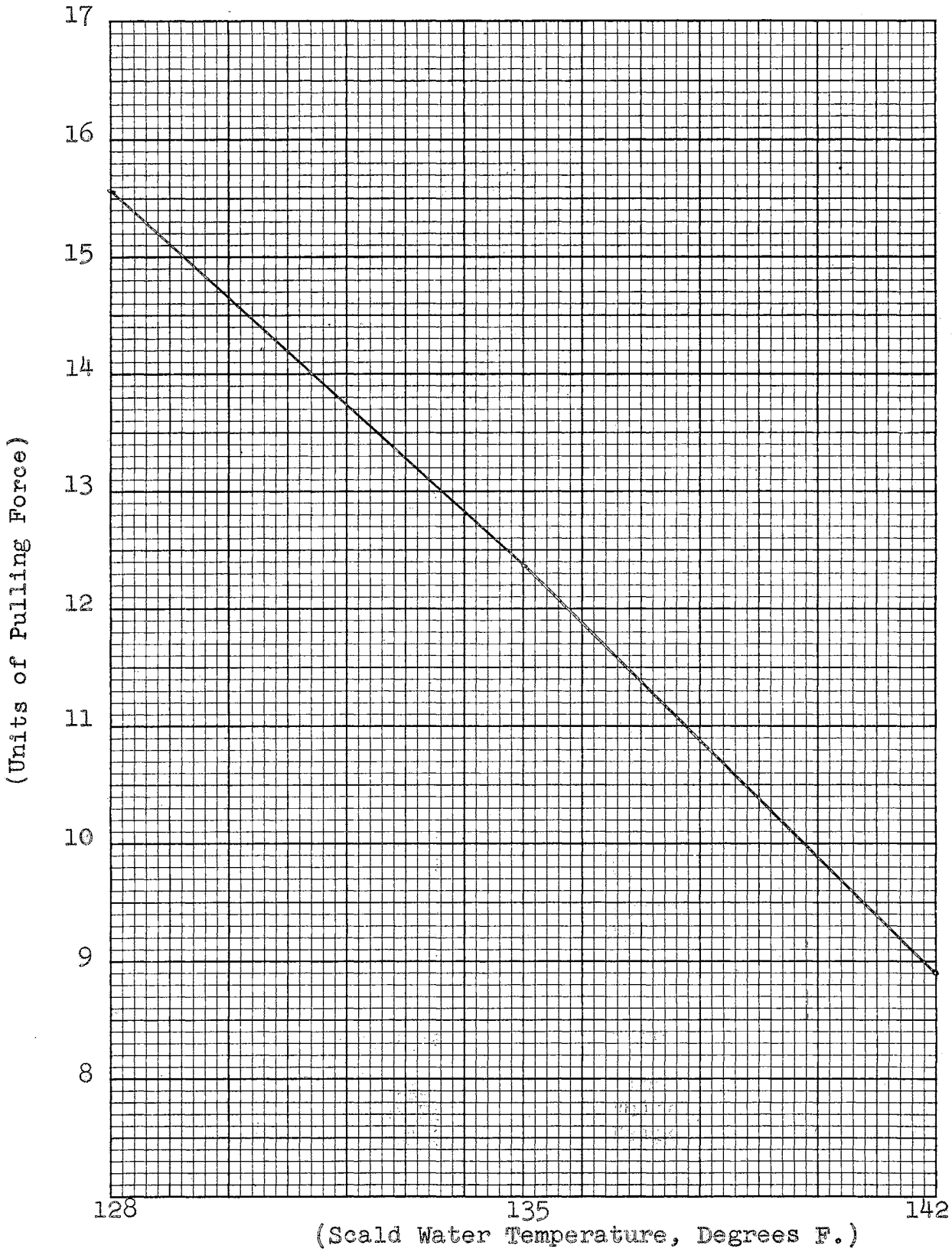


Figure 4. The Average Feather Pulling Force Required for Feather Removal from White Leghorn Hens at Selected Scald Water Temperatures

scalding times are graphically portrayed in Figure 5. The average force required for feather removal from birds scalded in water which was 128 degrees F. for 45 and 90 seconds was 18.43 units and 12.68 units, respectively. When the scalding time was increased from 45 to 90 seconds with a water temperature of 135 degrees F., the feather pulling force increased from 11.93 to 12.81 units. This was the only scalding temperature tested that required more units of pulling force for feather removal from birds scalded for 90 seconds than from the birds scalded for 45 seconds. Birds scalded in water temperature of 142 degrees F. for 45 seconds required 10.48 units of pulling force for feather removal and birds scalded for 90 seconds at the same temperature required 7.32 units of pulling force for feather removal.

The average forces required for feather removal from birds fasted 0, 6 and 24 hours and scalded at water temperatures of 128, 135 and 142 degrees F. are illustrated in Figure 6. Birds scalded at 128 degrees F. and fasted for the periods of 0 and 24 hours had feather pulling forces of 15.33 units and 15.30 units, respectively. The birds scalded at a water temperature of 128 degrees F. and fasted for 6 hours required a greater feather pulling force for feather removal than did either of the other two groups of birds scalded at the same temperature. The force required for feather removal from the birds scalded in water of 128 degrees F. and fasted for 6 hours was 16.05 units. Birds scalded in a water temperature of 135 degrees F. and fasted for 0 hours

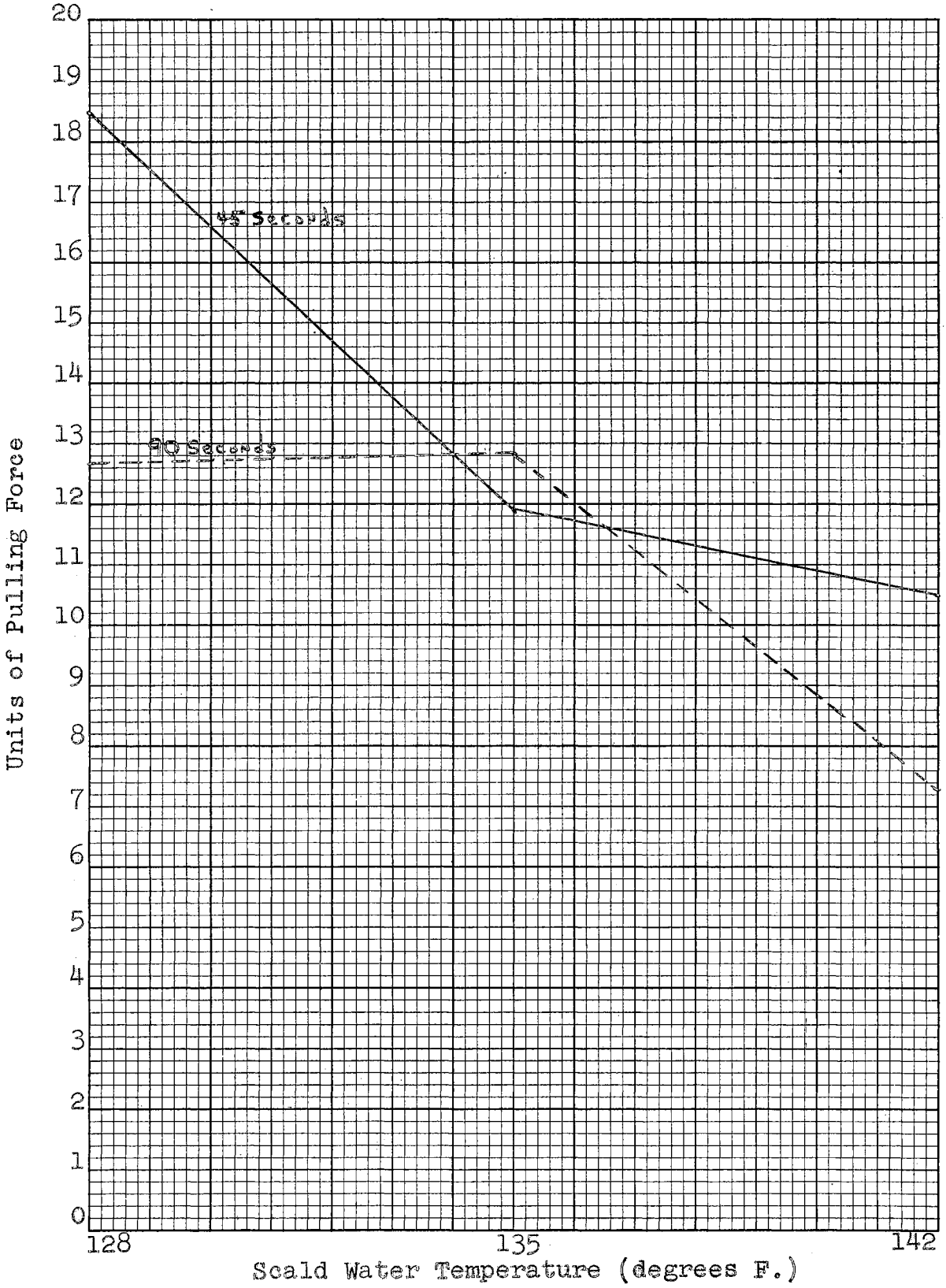


Figure 5. The Average Force Needed to Pull Feathers from Hens Scalded at Different Water Temperatures and Time Intervals

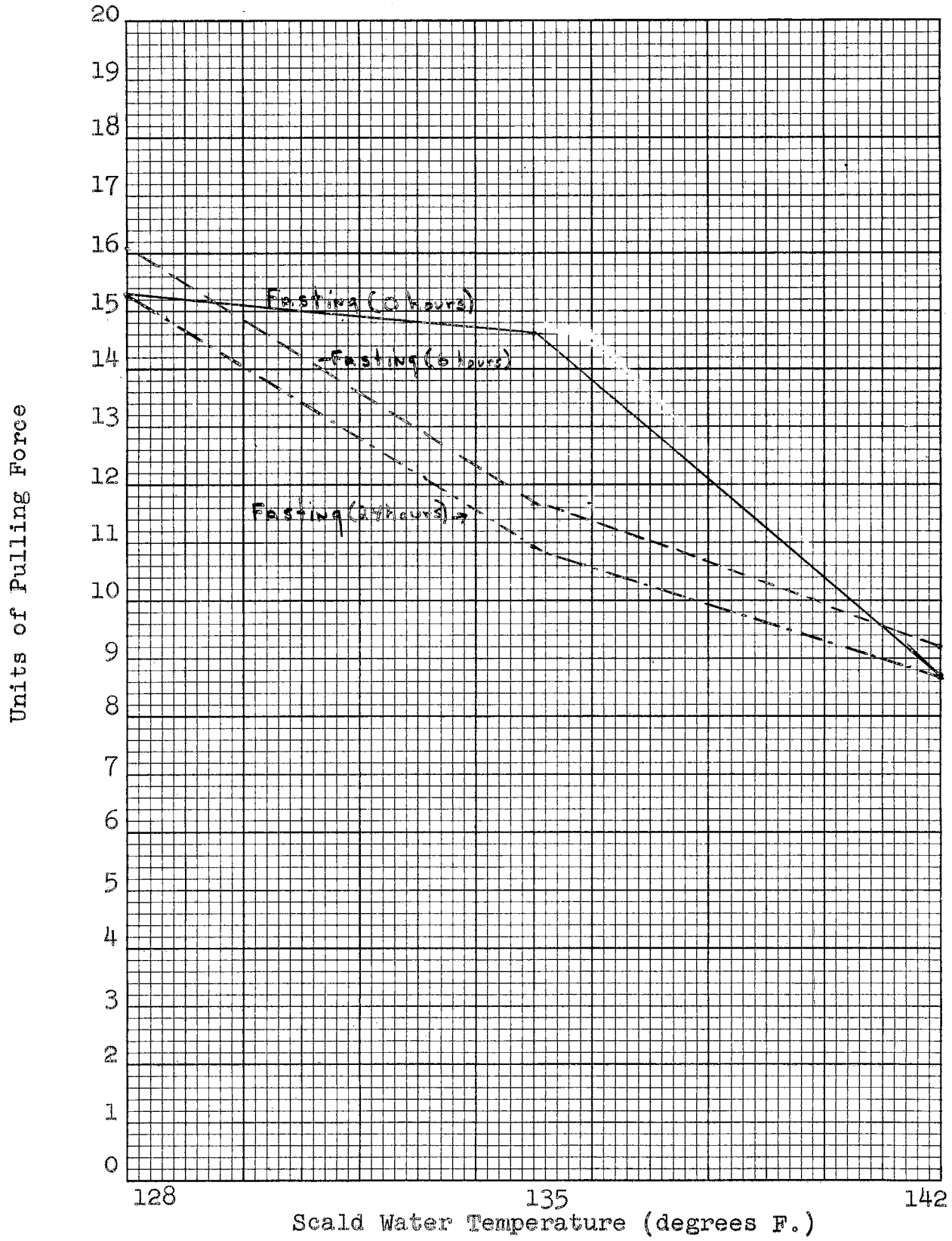


Figure 6. The Average Force Needed to Pull Feathers from Fasted Hens Scalded at Different Water Temperatures

required a greater force for feather removal than did the other groups of birds which were scalded in water at 135 degrees F. and fasted for 6 and 24-hour periods. Birds scalded in water at 135 degrees F. required 14.45 units of pulling force for feather removal when fasted 0 hours, 11.68 units when fasted 6 hours and 10.98 units when fasted for a period of 24 hours. Birds scalded in water temperature of 142 degrees F. and fasted for periods of 0, 6 and 24 hours required 8.78, 9.20, and 8.72 units of pulling force, respectively, for feather removal. Birds fasted for 6 hours and 24 hours required a greater amount of pulling force for feather removal as scald water temperature was lowered. When statistical analysis (Table X) was made of the data, using analysis of variance

TABLE X

ANALYSIS OF VARIANCE OF FORCE REQUIRED FOR FEATHER REMOVAL FROM WHITE LEGHORN HENS AS AFFECTED BY FASTING TIME, SCALD WATER TEMPERATURE AND SCALDING TIME

Source of Variation	df	Sum of Squares	Mean Square	F Value
Total	1079	103,692.22		---
Replication	11	26,369.45	2,397.22	11.86**
Fasting (F)	2	253.85	126.92	---
Scald Water Temperature (SWT)	2	7,984.90	3,992.45	19.75**
Linear	(1)	7,979.21	7,979.21	39.46**
Quad	(1)	5.69	5.69	---
Scalding Time (ST)	1	1,938.70	1,938.70	9.59**
F x SWT	4	612.65	153.16	---
F x ST	2	18.45	9.25	---
SWT x ST	2	2,008.75	1,004.38	4.97**
SWT_{Linear} ST_{Linear}	(1)	300.39	300.39	1.49
SWT_{Quad} ST_{Linear}	(1)	1,708.36	1,708.36	8.44**
F x SWT x ST	4	203.55	50.88	---
Error				---
Replication x Treatment	187	37,809.10	202.20	---
Sampling Error	864	26,792.80	30.66	---

** Significant at the .01 level.

technique, the differences due to scald water temperatures as well as scalding times were found to be significant ($P < .01$). The interaction between scald water temperature and scalding time was found to be significant ($P < .01$). Fasting was not found to be a significant factor in force required for feather removal ($P < .05$).

DISCUSSION

The force required to pull feathers from live chickens of different breeds and sexes was measured with the displacement transducer, and it was observed that differences in pulling force for feather removal did exist for different breeds and sexes. Any attempt to attribute these differences to any genetic or physiological character of the birds was beyond the scope of this study. However, some factors that might be suggested are age of the bird and time of molt.

An attempt was made to study the effect of the age of the bird by the use of some White Leghorn cockerels in which the force required for feather removal was recorded weekly. There was an indication that as the cockerels reached sexual maturity the force required to pull the feathers became greater. However, the appearance of immature feathers during the change from chick to juvenile to adult plumage hampered the pulling of the feathers, and the data were not included in this writing.

During the preliminary testing of the precision of the displacement transducer, different ages of mature New Hampshire females were used. It appeared that one factor which might affect the force required for feather removal was time of molt of these birds. The New Hampshire females which had

molted seemed to require less pulling force for feather removal than did the New Hampshire females that had not molted.

Management is also a factor which may affect the force required for feather removal. The nutrition of the bird, and the way the birds are handled could be additional factors. However, none of these factors was directly studied and are only suggested as factors which might affect the force required for feather removal.

When White Leghorn hens were held without feed and water for different lengths of time, the force required to remove feathers from these birds was affected. The fasting periods of 0, 6, 8, 24, 48 and 72 hours were selected because the time birds are held without feed and water varies from the time they leave the producer until they are processed. It would be an unusual situation when birds were held longer than 24 hours. The fasting periods of 48 and 72 hours were included only to see what effect these extreme lengths of fasting would have on feather pulling force. The results of this study showed that when birds were held without feed and water up to 8 hours the effect on the force required for feather removal was slight. This indicates that processors could hold birds without feed and water up to a period of 8 hours. However, if it becomes necessary for a processor to hold birds for longer periods of time than 8 hours without feed and water, it would require a greater pulling force to remove the feathers. It would, then, be advantageous for the

processor to feed and water the birds before processing if the birds were fasted for more than 8 hours, from the standpoint of feather pulling force as well as the weight loss of the bird.

Fatigue was a factor which affected the force required for feather removal in White Leghorn hens. Preliminary trials were held in deciding on the exercising times of 0, 60 and 90 seconds. At the end of the 90 second period gross observation indicated considerable effect on the bird. The heart rate had increased and polypnea was evident. It was thought that this would be comparable to catching and loading birds on trucks for transporting to the processor, or to scaring the birds in the processing plant before slaughter. The results of this study showed that as the birds became more fatigued and scared, the force required for feather removal became greater. This indicated that, from the standpoint of feather pulling force, care should be taken to scare or exercise the birds as little as possible before slaughter.

White Leghorn hens being fed different levels of tranquilizing agents were available for use in this study. The effect of the tranquilizing agents on egg production was the main objective of the study, and the birds had been fed the tranquilizing agents for a period of approximately 7 months prior to their use in the study reported herein. The tranquilizing agents fed to these hens lowered significantly the force required for feather removal. The birds fed the tranquilizing agents required considerable less force for feather

removal than did the birds fed no tranquilizing agent. If tranquilizing agents are found to be an aid in egg production and are components of future rations, then birds fed these agents could be considerably easier to process than birds fed no tranquilizing agent. This could be a big factor in the processing of hens in the future from the standpoint of picking ease.

White Leghorn hens were used in a trial to measure differences in pulling force required for feather removal as affected by fasting time, scald water temperature and scalding time. It was observed (Figure 4) that as the scald water temperature increased, the force required for feather removal decreased. However, when the birds were scalded for selected periods of time at the different scald water temperatures (Figure 5), one departure from a straight linear relationship was observed. The force required for the removal of feathers from birds scalded in water at 135 degrees F. was slightly greater when the birds were scalded for a time period of 90 seconds than when scalded for a period of 45 seconds. This could have been caused by coagulation of protein in the feather follicle at this particular scalding temperature and time, which caused the feathers to require more pulling force for removal. When scalding birds at a water temperature of 135 degrees F., picking ease is apparently not enhanced by increasing the scalding time up to 90 seconds.

The length of fasting (Figure 6) seemed to have little effect on the force required for feather removal except when birds were scalded in water at 135 degrees F. At this scalding temperature, the longer fasting period seemed to result in less force required for feather removal.

SUMMARY AND CONCLUSIONS

An objective measure of the force required for feather removal was developed by the use of a displacement transducer. The displacement transducer was found to be precise in measuring the force required for the removal of feathers from chickens. The force required for feather removal from the different breeds and sexes available for this study was measured. Measurements were made of the force required for feather removal from White Leghorn hens as affected by the factors of fasting, fatigue, the feeding of tranquilizing agents, scald water temperature and scalding time. From this study, the following conclusions were drawn:

(1) In all breeds tested, with the exception of White Plymouth Rock, more force was required to pull feathers from the males than from the females.

(2) White Leghorn hens fasted for more than 8 hours required a greater force for feather removal than did White Leghorn hens not fasted or fasted for periods of less than 8 hours.

(3) Exercising in a treadmill for different lengths of time up to 90 seconds caused a greater force to be required for feather removal from White Leghorn hens.

(4) The feeding of tranquilizing agents decreased the

force required for feather removal from White Leghorn hens.

(5) The force required for feather removal from White Leghorn hens decreased as the temperature of scald water was increased.

(6) The force required for feather removal from White Leghorn hens decreased as scalding time increased, except for birds scalded in water at 135 degrees F.

(7) The factor of fasting lowered the force required for feather removal from White Leghorn hens which were scalded in water at 135 degrees F.

(8) The displacement transducer was found to be precise in the measuring of force required for feather removal from chickens.

LITERATURE CITED

Duncan, D. B., 1955. Multiple range and multiple F test. Biometrics 11:1.

Graf, R. L., and G. F. Stewart, 1953. Slack versus sub scald for broilers. Poultry Processing and Marketing 59:12-13, 20-24.

Gwin, J. M., 1952. Subscalding saves pinning labor. U. S. Egg and Poultry Magazine 58(1):15.

Gwin, James M., George W. Newell, and Morley A. Jull, 1949. Some observations concerning the period of fasting poultry before slaughter. Poultry Science 28:229-231.

Lineweaver, H., and A. A. Klose, 1952. Subscalding versus semi-scalding. Turkey World 28(11):18, 66.

Nassau, Benard, 1955. The relationship of time and temperature in the removal of feathers. Unpublished thesis Oklahoma A. & M. College.

Pearce, J. A., and C. G. Lavers, 1949. Frozen storage of poultry and effects of some processing factors on quality. Canadian Reserve Journal 27:253-265.

Pool, M. F., E. P. Mecchi, H. Lineweaver, and A. A. Klose, 1954. The effect of scalding temperature on the processing and initial appearance of turkeys. Poultry Science 33:274-279.

Rose, D. C., 1939. Electrical methods of killing poultry. The U. S. Egg and Poultry Magazine 45:270-275.

Snedecor, G. W., 1955. Statistical Methods. Iowa State College Press; Ames, Iowa.

Stadelman, William J., and Frank Ziegler, 1955. The effect of different scald water temperatures on the shelf life of fresh non-frozen fryers. Poultry Science 34:237-238.

Williamson, H. F., 1954. Scald right for easy picking. Poultry Processing and Marketing 60:16, 36.

VITA

Bob Gene Knapp

Candidate for the Degree of

Master of Science

Thesis: AN ANALYSIS OF SELECTED FACTORS AFFECTING FEATHER REMOVAL

Major Field: Poultry Marketing

Biographical:

Personal Data: Born March 25, 1936 at Seminole, Oklahoma, the son of Robert and Ruth Knapp.

Education: Attended elementary school and graduated from Seminole High School, Seminole, Oklahoma in 1954. Undergraduate work at Oklahoma State University, 1954-1958. Graduate study at Oklahoma State University, 1958-1960.

Experience: Graduate teaching assistant, September 1958 to May 1959. Research assistant in Poultry Marketing, May 1959 to January 1960.

Organizations: Poultry Science Club, Aggie Society, Poultry Science Association.

Date of Final Examination: January, 1960.