ASSOCIATION OF VARIOUS MEASUREMENTS WITH LAMB CARCASS COMPOSITION AND PRELIMINARY ESTIMATES OF SOME GENETIC PARAMETERS

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INTRODUCTION

Animal nutrition and meat production experiments generally require a knowledge of the carcass composition of the experimental animals. There is therefore a need for an efficient, practical and accurate method of measuring carcass composition. In years passed, assessment of the carcass has often been performed qualitatively by eye judgement and it is clear that such a procedure does not insure a true appraisal of carcass composition. The most accurate method is to determine the composition of the carcass by physical separation or chemical analysis. These methods are both costly and time consuming. It would also be desirable to determine the composition of the carcass without completely destroying its form and shape.

Many of the studies concerning carcass composition have not been designed to estimate the genetic parameters associated with measures of composition. Improvement of lamb carcass merit can be achieved through improved environment, heredity or both. The amount of progress that can be accomplished depends in part on the heritabilities of the traits under selection and the genetic relationships of each trait with the others. When the genetic correlation between two traits is positive, selection for one trait will result in improvement of that trait and also some improvement in the correlated trait. The size and direction of the relationship between carcass traits is of great importance in selection programs.

The objectives of this study were: 1) to develop multiple regression equations for the prediction of lamb carcass composition, 2) to obtain preliminary estimates of the heritabilities of carcass characteristics and 3) to investigate the genetic correlations among these traits.

REVIEW OF LITERATURE

The composition of domestic animal carcasses has been of prime interest and importance to Animal Science researchers for many years. Lush (1926) found the correlation between carcass fat and percent offal fat in cattle to be 0.84. He indicated that offal fat was a reliable single predictor of total carcass fatness. The coefficient of multiple correlation of percent of fat in the entire carcass with dressing percent and percent of offal fat was reported as 0.93.

Pálsson (1939) studied the possibility of estimating composition of mutton and lamb carcasses by use of sample joints and the extent to which carcass measurements can be used as indices of composition. Eleven wether lambs and five wether hoggets of different breeds were studied. The lambs were approximately four and one-half months old and produced on the average 40 pound carcasses. The hoggets yielded 60 pound carcasses and were about 13 months old. In this study the carcasses were not cut into standard wholesale cuts but rather into anatomical regions. He points out that cutting a carcass into wholesale cuts requires cutting across bones which could lead to errors in the study of proportional development of the different parts of the carcass. In dividing the carcass anatomically the bones provided the major fixed cutting points. Pálsson found that the leg was the best region of the carcass for predicting fat due to its relatively early development and small amount of fat, but suggested that its use may cause slight under-estimation of total carcass fat in early maturing, over-fat animals. He reported a correlation between leg fat and carcass fat of 0.95. The loin was found to be a late-developing area in which fat is accumulated later in life. If the components of both the leg and loin were used together the results were even more satisfactory. The correlations between fat, muscle and bone of the combined leg and loin with the fat, muscle and bone of the carcass were reported as 0.97, 0.92 and 0.97, respectively. He stressed that external carcass measurements were more indicative of skeletal size than of muscle or fat development. The combined weight of the four cannons (metacarpals and metatarsals) was found to be highly correlated (0.96) with total bone weight. The weight of the left fore cannon alone was almost as highly correlated (0.94) with total bone as the weight of all four cannons. Measures of the longissimus dorsi (i.e. length, depth and length plus depth) were found to be highly associated with muscle content of the whole carcass. Pálsson reported correlations between carcass muscle and length, depth and length plus depth of the longissimus dorsi as 0.67, 0.47 and 0.77, respectively. These measurements were taken on the longissimus dorsi cross-section between the 12th and 13th ribs. Various fat measurements obtained on the cross-section of the cut between the 12th and 13th ribs were found to be related to total carcass fat. The measure of the thickest lower rib fat and carcass fat were found to be highly correlated 0.82.

Hankins (1947) reported physical separation data on 64 widely varying sheep carcasses. Ram, wether and ewe carcasses ranging in weight from 12.6 to 72.5 pounds were used in this study. The rib cut was found to be the best indicator of carcass composition. He found the correlations of physically separated rib fat, muscle and bone with carcass fat, muscle and bone to be 0.98, 0.92 and 0.97, respectively. Rib cut ether extract was shown to be highly correlated (0.98) with carcass ether extract.

Kirton and Barton (1962) investigated 20 Southdown-Romney wether lamb carcasses. They found that carcass composition could be estimated with reasonable precision from carcass weight. Their correlations between carcass weight and carcass fat and protein were 0.63 and 0.78, respectively. The relationship between dressing percent and carcass composition was found to be small. They also found that specific gravity was more highly associated with carcass protein percent than with carcass fat percent, despite the rather consistent relationship between lean and bone of the "fat free" carcass. Their regression equation for predicting fat from carcass specific gravity was:

$$\text{Carcass fat percent} = 295.3 - 255.8\ (\text{carcass specific gravity})$$

This equation had a standard error of estimate of 3.31 percent. Their correlation between carcass fat and carcass specific gravity was -.56. The percent fat in the leg, loin, rib cut and fore were all found to be highly correlated to carcass fat, 0.93, 0.97, 0.96 and 0.94, respectively. They reported small standard errors of estimate when the fat content of each wholesale cut was used in regression equations to predict carcass fat, 1.55 percent, 1.07 percent, 1.16 percent and 1.38 percent, respectively. Carcass protein was found to be related to carcass specific gravity as measured by a correlation of 0.69.

Hiner and Thornton (1962) working with data from 1138 lambs adjusted for breed of sire, breed of dam, sire, birth-year and sex, reported body width was the most reliable carcass measurement studied for estimating the yield of primal cuts ($r = 0.76$). Body width was an average measure of width through the shoulder, loin and legs. When two variables were considered, carcass weight and body width were the most reliable.

The carcasses of 165 crossbred lambs sired by Southdown rams and out of western blackfaced ewes were studied by Field et al. (1963a). The lambs ranged in age from 119 to 288 days at slaughter and averaged about 85 pounds. They determined carcass composition from the physical separation of the cuts from the right side of the carcass. The percent fat and percent lean in the carcass were predicted using simple linear regression and multiple regression. The following two equations were found to be fairly good predictors of carcass fat and lean.

$$\text{Percent carcass fat} = -201.54 + 228.43 \text{ (carcass sp. gr.)}$$

$$\text{Percent carcass lean} = -128.60 + 174.13 \text{ (carcass sp. gr.)}$$

These equations have standard errors of estimate of 3.48 and 2.83 percent, respectively. Specific gravity of the rack was correlated with percent lean and percent fat in the carcass, 0.62 and -.64, respectively. When loin eye area per 45 pounds of carcass, percent kidney and kidney fat and fat cover over the loin eye were included in a multiple regression equation to predict carcass fat, the standard error of estimate was reduced from 3.48 to 2.43 percent and the multiple correlation coefficient was 0.79. They also reported that physical separation of the rib into fat, lean and bone was an accurate method of predicting fat, lean and bone in the carcass. The correlations between carcass fat, lean and bone and the corresponding components of the rib were reported as 0.89, 0.82 and 0.84, respectively.

Barton and Kirton (1956) investigated the carcass composition of 15 Romney pasture fed ewes. These carcasses ranged in weight from 55.2 to 78.2 pounds and contained between 26.1 and 45.4 percent fat. They reported a correlation of -.88 between the fat of the half carcass and carcass specific gravity. They predicted percent carcass fat with the following equation:

$$\text{Percent carcass fat} = 100 \left(\frac{5.680}{\text{carcass specific gravity}} - 5.138\right)$$

This regression equation of carcass specific gravity on carcass fat yielded a standard error of estimate of 3.20 percent.

Timon and Bichard (1965a) studied the carcasses of 83 wether lambs slaughtered as they reached 80 pounds live weight at an average age of 175 days. These carcasses averaged 27.9 percent fat, 55.2 percent muscle and 16.3 percent bone with standard deviations of 3.9, 3.1 and 1.6, respectively. Both simple and multiple linear regressions were used in this study. The components of the individual wholesale cuts were found to be highly associated with the components of the carcass. When the components of two cuts were considered together, for example, the leg and loin, the correlation coefficients for carcass fat, lean and bone with leg and loin fat, lean and bone were 0.98, 0.98 and 0.93, respectively. Their regression equations for predicting carcass fat, lean and bone from the corresponding components of the leg and loin were:

$$\text{Percent carcass fat} = 2.5 + 0.436 \text{ leg fat} + 0.483 \text{ loin fat}$$

$$\text{Percent carcass muscle} = 0.2 + 0.511 \text{ leg muscle} + 0.435 \text{ loin muscle}$$

$$\text{Percent carcass bone} = -1.7 + 0.721 \text{ leg bone} + 0.467 \text{ loin bone}$$

The standard errors of estimate for the above equations were 0.8, 0.9 and 0.6, respectively.

In another study Timon and Bichard (1965b) used specific gravity of the carcass and the wholesale cuts to predict lamb carcass composition. Carcass specific gravity was calculated by adding together the individual wholesale cut weights (in air and in water). They found that the following regression equations utilizing carcass specific gravity explained 86.1 percent and 78.1 percent of the respective variation in carcass fat and muscle.

Percent carcass fat = 603.7 - 550.1 carcass specific gravity

Percent carcass lean = -367.6 + 403.8 carcass specific gravity

The specific gravities of the individual joints were also found to be highly associated with carcass fat and muscle percentages but not as high as carcass specific gravity. They reported correlations between loin specific gravity and percent carcass fat and lean of -.89 and 0.82, respectively. Confidence intervals ($p = .05$) were placed on individual predictions and these varied from $\pm$ 2.98 to $\pm$ 3.48 percent for fat and muscle, respectively. They suggested that these intervals were too large to place much confidence in specific gravity determination as a predictor of carcass composition on an individual basis. On the other hand they indicated that prediction of group means would be within the normally accepted range of error.

Judge and Martin (1963) worked with the carcasses of 51 ewe and wether lambs of Cheviot, Hampshire, Rambouillet, Shropshire and Southdown breeding. When fat thickness over the eye muscle, lower 12th rib fat thickness, area of the <u>longissimus dorsi</u>, kidney fat weight, leg and loin weight and chilled carcass weight were included in a multiple regression equation to predict the edible portion, the equation had a standard error of estimate of 2.89 percent and a multiple correlation of 0.78. The equation was:

Percent edible portion = 87.76 - 16.586 (12th rib fat thickness, in.) - 2.048 (kidney fat, lb.) - .270 (chilled carcass weight, lb.)

Barton and Kirton (1958a) investigated the relationships between carcass weight and chemical analysis of the total half carcass of 33 Romney-Southdown wether lambs. The correlations between carcass weight and dissectible carcass fat, lean and bone were 0.94, 0.95 and 0.79, respectively. These results are in agreement with those of Callow (1947) with cattle, McMeekan (1940) with pigs and Rathbun and Pace (1945) with guinea pigs. Shorland et al. (1947) also reported that carcass weight may be used as a simplified means of determining lamb carcass composition.

Stanley (1962) studied 83 ram lambs of Rambouillet, Columbia and Targhee breeds for live and carcass predictors of meatiness and found that live and carcass weight to be the best single criterion for lambs with small amounts of finish. Leg weight was the most highly correlated (0.89) of the wholesale cut weights with meatiness while leg width was the most highly correlated linear measurement with meatiness.

Rowe et al. (1965) calculated several multiple regression equations to predict the retail value of weanling wether and ram lambs. They reported a multiple correlation for weight of kidney fat and area of the ribeye with retail yield per pound of cold carcass weight of 0.81. Their multiple regression equation to predict retail value per pound of cold carcass weight was:

Retail value per pound of carcass weight = 56.65 - 0.00719 (weight of kidney and kidney fat, grams) + 0.232 (area of the rib eye, to nearest 0.1 $cm.^2$)

They indicated that inclusion of more than two independent variables did not materially improve the prediction equations.

Carpenter et al. (1964) reported that the percentage of retail leg was highly associated with the retail value of the carcass (r = 0.63). They also reported that fat thickness over the loin eye and loin eye area were useful objective measures for estimating the cutout value of lamb carcasses. Fat thickness and loin eye area were reported as accounting for 65 percent of the variation in carcass value per hundred pounds of carcass.

Barton and Kirton (1958b) utilized the method of Pálsson (1939) in jointing and dissecting 120 lamb and mutton carcasses. These carcasses represented a wide range of weights and grades. They found correlations of 0.98, 0.97 and 0.96 between carcass fat, muscle and bone and the corresponding components of the leg plus loin. Smaller correlations were reported between either leg or loin fat, muscle and bone and carcass fat, muscle and bone although all correlations were highly significant ($P < .01$).

Botkin et al. (1959) physically separated 30 lamb carcasses into lean, fat and bone and found that the area of the loin eye and the area of the face of the leg combined was reliable as a measure of lean content of the whole carcass.

Meyer (1962) used specific gravity to estimate lamb carcass composition and thereby arrived at the components of growth and the caloric value of the carcass. He pointed out that carcasses from sheep very low in fat may appear to have somewhat greater amounts of fat as calculated from their specific gravity because of a very light weight under water. Meyer suggested that this could be due to entrapment of air under the fascia when the pelt was removed. Moisture loss while the carcass was chilling was found to be a problem because of the differential loss of water between thin and fat carcasses. His solution was to use the weight of the carcass immediately after slaughter as the base weight in air for the calculation of specific gravity. He reasoned that moisture contributed to carcass weight in air but not to weight in water because the weight of water under water is zero.

Carpenter (1963) investigated the carcasses of 190 lambs and used the paternal half-sib correlation method to estimate the heritability of some carcass measurements. These estimates are shown in Table I and were from the progeny of 19 sires and out of a random sample of finewool ewes. The sires were of the Delaine, Suffolk and Dorset breeds. Hillman et al. (1962) studied 176 Hampshire x Western cross-bred lambs sired by 20 Hampshire rams over a two year period. The resulting heritability estimates are also shown in Table I.

These estimates indicate that ribeye area and average fat thickness (12th rib fat) are moderately heritable and therefore selection for these traits should lead to genetic improvement. The heritabilities shown are quite comparable even though the number of sire groups was small in both reports.

Field et al. (1963b) studied the differences among offspring from 12 Southdown rams and found that lambs sired by rapid gaining rams gained faster and had leaner carcasses than those from slower gaining rams. For

TABLE I

HERITABILITIES OF CERTAIN CARCASS CHARACTERISTICS

	Hillman *et al.* (1962)	Carpenter (1963)
Avg. daily gain	54	--
Weight/day of age	53	40
Marbling	39	38
Ribeye area	39	40
Avg. fat thickness	21	29
Cutability[a]	--	45
Tenderness	--	39

[a]Yield of closely trimmed retail cuts from the leg, loin, rack and shoulder expressed as a percent of carcass weight.

each 0.10 pound increase in average daily gain of the sire, the carcasses of its progeny yielded 1.88 percent more lean. The lambs in this study were slaughtered at approximately 85 pounds.

Information relating to genetic relationships among live animal traits and measures of meatiness in the lamb carcass is lacking.

The review of literature indicated that carcass composition can be predicted with a high degree of accuracy from the components of the major wholesale cuts. The fat, lean and bone of the leg and loin were shown to be more highly associated with carcass fat, lean and bone than the corresponding components of the rack and shoulder. Carcass specific gravity was reported by several workers to be a fairly reliable measure of carcass composition. The ease with which specific gravity can be determined is advantageous. Other measures were generally reported as being of a lesser value for predicting carcass composition. Estimates of the heritibility of carcass traits and the genetic relationships among carcass traits that are reported in the literature are small in number and based on few observations. These estimates do indicate that selection for lean meat and against fat should be successful.

MATERIALS AND METHODS

Live Animal Procedures

The lambs used in this study were from the experimental flock at the Fort Reno Livestock Research Station. All of the lambs were out of grade Rambouillet x Dorset or grade Rambouillet ewes. In both years of the study one-half of the sires were Dorset (whiteface) while the other half were Hampshire or Suffolk (blackface). An equal number of single and twin reared lambs was obtained and studied from each sire with one exception. In 1964, one of the twin lambs, sired by a Dorset ram, died before reaching slaughter weight.

The lambs were born between October 10th and November 25th each year. Ten days to two weeks after birth the lambs were placed on wheat pasture with their dams. The lambs had access to a creep containing a mixture of about 32 percent ground alfalfa hay, 63 percent ground grain sorghum and 5 percent molasses. The lambs were weaned when they weighed a minimum of 46 pounds and were at least 66 days of age.

Biweekly weights were taken on the lambs until they approached 95 pounds after which time they were weighed weekly. Upon reaching a full weight of 100 pounds they were taken off feed and transported to Stillwater (100 miles). The lambs were sheared the same evening and slaughtered the following morning after being off feed and water for approximately 18 hours. The weight of the lamb, just prior to slaughter, was recorded as shrunk live weight. Means and standard deviations for live animal characteristics by sire and breed are shown in Tables II and III for 1963 and 1964, respectively.

Carcass Procedures

All lambs were slaughtered according to accepted procedures. At the time of slaughter the thymus glands, right and left crura of the diaphragm (hanging tenderloin) and the spleen were removed. The sternum was split and pork carcass flank spreaders were inserted to hold the ventral midline cut open. This was done to reduce the chance of trapping air in the carcass during the determination of specific gravity. A 1 x 1 inch wooden plug was placed in the pelvic cavity and slightly into the abdominal cavity after the bung was dropped to prevent the pelvic fat from trapping air. The kidney fat was pinned posterior to the 13th rib as an aid to more accurate specific gravity determination and so that all kidney fat would stay with the hindsaddle.

The weight of the hot carcass was recorded. The carcass was allowed to chill for 48 hours in a 34 to 38 degrees Fahrenheit cooler before grading and cutting. Maturity, quality, conformation and carcass grades were determined to the nearest one-third of a USDA grade. The grades are expressed on the following numerical scale to facilitate statistical analysis:

high prime ----- 0	high choice ----- 3
average prime -- 1	average choice -- 4
low prime ------ 2	low choice ------ 5

The carcass was then photographed full length, dorsal view, as it hung from the rail.

TABLE II

MEANS AND STANDARD DEVIATIONS FOR SOME LIVE LAMB CHARACTERISTICS BY BREED AND SIRE FOR 1963

Sire and Breed	N		Birth Weight (lbs.)	Adj. 70 Day Wt. (lbs.)	Finished Weight (lbs.)	Days of Age at Slaughter	Wt./Day of Age (lbs.)
38	6	$\bar{x}$	10.4	54.8	104.3	150.3	.703
		s	2.9	9.0	1.4	17.9	.098
44	6	$\bar{x}$	9.0	53.0	100.7	152.3	.673
		s	1.0	6.2	1.5	23.4	.095
48	6	$\bar{x}$	9.2	47.3	101.7	173.7	.599
		s	.9	7.1	1.5	27.7	.103
Hampshires	18	$\bar{x}$	9.5	51.7	102.2	158.8	.658
		s	1.9	7.8	2.1	24.5	.103
49	6	$\bar{x}$	10.6	55.0	100.8	150.7	.651
		s	3.0	12.9	1.0	27.7	.128
50	6	$\bar{x}$	10.2	54.0	100.8	155.7	.690
		s	2.0	5.6	1.2	13.9	.049
Suffolks	12	$\bar{x}$	10.4	54.5	100.8	152.9	.670
		s	2.4	9.5	1.0	21.1	.095
32	6	$\bar{x}$	10.3	54.3	101.2	176.7	.588
		s	2.4	14.8	1.3	30.4	.110
33	6	$\bar{x}$	9.6	51.3	101.5	181.3	.577
		s	2.4	12.9	.8	34.5	.112
34	6	$\bar{x}$	9.7	50.8	101.3	166.8	.618
		s	1.9	6.8	1.0	23.7	.088
51	6	$\bar{x}$	10.4	51.8	101.0	179.2	.583
		s	2.0	8.9	1.7	33.1	.129
53	6	$\bar{x}$	8.0	47.3	99.8	200.5	.500
		s	.6	7.0	3.2	14.3	.096
Dorsets	30	$\bar{x}$	9.6	51.1	101.0	180.9	.573
		s	2.0	10.1	1.8	28.5	.102
All lambs	60	$\bar{x}$	9.6	52.0	101.3	168.7	.618
		s	1.9	9.4	2.7	19.6	.103

TABLE III

MEANS AND STANDARD DEVIATIONS FOR SOME LIVE LAMB CHARACTERISTICS BY BREED AND SIRE FOR 1964

Sire and Breed	N		Birth Weight (lbs.)	Adj. 70 Day Wt. (lbs.)	Finished Weight (lbs.)	Days of Age at Slaughter	Wt./Day of Age (lbs.)
47	8	$\bar{x}$	9.3	55.2	104.1	148.4	.713
		s	2.4	10.1	4.1	17.6	.099
48	8	$\bar{x}$	8.4	51.1	102.4	157.6	.658
		s	1.6	9.1	1.2	16.9	.091
Hampshires	16	$\bar{x}$	8.9	53.2	103.2	153.0	.685
		s	2.0	9.6	3.1	17.3	.096
7	8	$\bar{x}$	8.9	55.2	104.2	149.2	.722
		s	2.0	9.4	2.9	21.8	.115
8	8	$\bar{x}$	9.0	55.8	104.6	144.0	.745
		s	2.0	11.2	3.6	22.7	.135
Suffolks	16	$\bar{x}$	9.0	55.5	104.4	146.6	.733
		s	1.9	10.0	3.2	21.7	.121
1	9	$\bar{x}$	8.0	54.8	102.3	154.0	.677
		s	2.4	8.4	.9	21.3	.101
2	8	$\bar{x}$	9.3	57.5	104.4	145.6	.731
		s	1.9	11.5	2.0	21.5	.112
3	8	$\bar{x}$	9.3	56.8	104.4	144.4	.725
		s	.9	5.0	2.6	9.0	.045
4	6	$\bar{x}$	9.0	50.8	103.8	165.2	.641
		s	1.9	11.9	1.5	23.1	.103
Dorsets	31	$\bar{x}$	8.9	55.2	103.7	151.5	.696
		s	1.9	9.2	2.0	20.0	.096
All lambs	63	$\bar{x}$	8.9	54.8	103.8	150.7	.703
		s	1.9	9.4	2.7	19.6	.103

The depth of fat over the second sacral vertebra was estimated by probing directly over the dorsal vertebral process, approximately three inches anterior to the base of the tail. This probing was done with a steel swine backfat probe.

Hydrostatic weighing, as described by Rathbun and Pace (1945), was used to determine the specific gravity of the carcasses. The chilled carcass weight was obtained to the nearest five hundredths of a pound. The weights in air and water were taken as precisely as possible, observing the necessary precautions outlined by Rathbun and Pace (1945), Whiteman _et al._ (1953) and Bray (1963). The tank and water used to weigh the submerged carcasses were maintained at the same temperature as the carcasses, i.e. 34 to 38 degrees Fahrenheit. Weights in water were determined in grams and the air weights were converted to grams. The following formula was used to calculate the specific gravity of the carcasses:

$$\text{specific gravity} = \frac{\text{weight of carcass in air}}{\text{weight of carcass in air} - \text{weight of carcass in water}}$$

One additional precaution was taken prior to weighing the carcass in water to insure a minimum amount of trapped air inside the carcasses. The muscular periphery of the diaphragm was cut loose from its attachment except at the most dorsal and most ventral attachments.

The carcasses were allowed to dry for 20 minutes after being submerged in the water. A slight knife cut (scoring) was made on both sides from the point of the patella to the junction of the humerus and radius. This scoring facilitated the removal of the flank, breast and shank at a later time. The carcasses were divided into fore- and hind-saddles between the 12th and 13th ribs by making a cut perpendicular to the line of the back and therefore across the ventral tips of the 11th and 12th ribs. The specific gravities of the fore- and hindsaddles were determined in the same manner as described for the whole carcasses. The saddles were allowed to dry for 20 minutes after being weighed in water.

The flanks were removed from the hindsaddle by a cut which started in the crotch and proceeded out to and along the scored line previously mentioned. All kidney and pelvic fat was removed. The weight of the kidney fat included the weight of the kidneys. The leg was removed from the loin between the second and third sacral vertebrae with the cut being made perpendicular to the line of the back. The shanks were removed from the legs by sawing through the thickest part of the tibia-metatarsal joint.

The breast and shank were cut from the foresaddle along the scored lines. Separation of the shank from the breast was at the natural seam. The rack and shoulder were separated by cutting between the 5th and 6th ribs and perpendicular to the line of the back. This procedure yielded a seven rib rack. The neck was removed from the shoulder by making a cut along a line which was a continuation of the line of the back.

The posterior surfaces of the shoulder, rack and loin were photographed and traced onto transparent acetate paper. On the tracings each area was designated as either fat, lean or bone. The tracings of the 12th rib sections were used to determine the area of the longissimus dorsi muscle and fat cover over the longissimus dorsi. The fat measurement was the average of three measurements taken on each side of the vertebra according to the method described by Kemp (1961). The area of the longissimus dorsi was measured by using a compensating polar planimeter and averaging the values obtained for the left and right sides of the carcasses.

The weights in air and the weights in water of the four major untrimmed wholesale cuts (shoulder, rack, loin and leg) were taken for the determination of specific gravity. After weighing the cuts in water they were allowed to dry for 20 minutes.

The subcutaneous fat was trimmed from the shoulder, rack, loin and leg and the weight of the fat from each cut was recorded as fat trim. Following the removal of the fat, the four major wholesale cuts were boned completely with great care being exercised to insure the removal of all the lean from the bones. The percent trimmed wholesale cuts was on the basis of carcass weight. No attempt was made to separate lean from fat. The boneless portion was designated as the edible portion. The weight of the bone removed from each cut was recorded.

In 1963 the weight of only the right fore cannon bone (metacarpal) was recorded to the nearest gram. In 1964 both right and left fore cannons were weighed as were the rear cannons (metatarsals).

The neck, fore shank, breast and flank were boned completely. The bones from the entire carcass were weighed and the weight was recorded. The edible portion and the fat trim were mixed together in preparation for grinding. The kidney and pelvic fat were not returned to the edible portion. The boneless portion of the lamb carcass was ground and sampled for chemical analysis following the procedure of Munson et al. (1965). Duplicate determinations were made on two composite samples from each lamb carcass. The composite samples consisted of four random, 50 gram "grab" samples. Chemical analysis was done as prescribed by A.O.A.C. (1955) to include percent moisture and ether extract.

The composition of the carcass was determined from the percent ether extract and percent separable bone. The lean portion was calculated by difference. The percent moisture was determined as a check on the determination of percent ether extract. The correlation between percent ether extract and percent moisture was -.82.

Statistical Analysis

The regression portion of the analysis was accomplished by using stepwise multiple linear regression as outlined by Stevens (1962). This stepwise procedure entered one variable at a time into the regression equation starting with the variable which had the largest potential variance reduction. The potential variance reduction of all remaining variables was next considered and the variable selected that reduced the variance the most in a single iteration. The statistical significance of the reduction was calculated from the following:

$$V_i = r_{iy} \cdot r_{yi}/r_{ii}$$

$$F = V_i \cdot \phi/(1-R^2-V_i)$$

where:

ϕ = degrees of freedom of the i^{th} variable,

r_{iy} = correlation between the i^{th} X and Y,

R^2 = proportionate reduction due to fitting all previous variables.

The correlation matrix of all X_i with Y and the X_i's with the X_j's was then updated to show the effect of considering one of the X_i variables. Simple (zero-order partials) correlations became 1st-order partial correlations; i.e. the indirect effect of the X entered in the equation was removed from all other partial correlations with respect to Y. The method did not guarantee that the total explained variance attained for a particular subset of the independent variables was the largest attainable for any subset of the same size.

Initially all 64 measurements taken on the carcasses were investigated by a preliminary simple correlation analysis. The purpose of this analysis was to reduce the number of traits to those that would measure carcass composition most effectively. Table IV shows the overall means and standard deviations of the 23 independent variables studied. The overall simple correlations of the four dependent variables (percent carcass fat, lean and bone and percent trimmed wholesale cuts) with the 23 independent variables are also shown in Table IV. The means of the carcass traits by breed and year are given in the appendix.

The stepwise multiple regression procedure was calculated at three stages for each dependent variable using carcass measurements available at each stage in the cutting of the carcass. The first stage utilized the measurements taken prior to cutting the carcass. Measurements used were slaughter weight, carcass weight, dressing percent, carcass specific gravity, loin probe and right fore cannon weight. The second stage had those additional measurements added that could be obtained after the carcass was cut into fore- and hindsaddles. Foresaddle specific gravity, hindsaddle specific gravity, fat cover over the 12th rib, thickest 12th rib fat and longissimus dorsi area were therefore added to the stepwise prediction procedure. Finally all 23 measurements shown in Table IV were entered into the stepwise regression procedure. The multiple regression equations were calculated both within and across years but not within breed or sire.

TABLE IV

OVERALL MEANS AND STANDARD DEVIATIONS OF INDEPENDENT VARIABLES AND THE CORRELATIONS OF THE DEPENDENT VARIABLES WITH THE INDEPENDENT VARIABLES

		Mean	Std. Dev.	Correlations with Percent Fat	Bone	Lean	TWSC
Slaughter wt.	(lb.)	90.8	3.24	.14	.07	-.20	-.20
Carcass wt.	(lb.)	51.4	2.80	.55	-.42	-.52	.29
Dressing percent	(%)	56.6	2.32	.60	-.62	-.51	.55
Carcass sp. gr.		1.0403	.0063	-.62	.54	.57	.17
Foresaddle sp. gr.		1.0443	.0081	-.37	.33	.33	.15
Hindsaddle sp. gr.		1.0368	.0066	-.73	.61	.67	.16
Rack sp. gr.		1.0343	.0078	-.70	.64	.63	.17
Loin sp. gr.		1.0241	.0074	-.70	.57	.66	.08
Leg sp. gr.		1.0606	.0046	-.32	.32	.28	.20
Untr. loin wt.	(lb.)	9.40	.88	.64	-.56	-.58	.18
Untr. leg wt.	(lb.)	12.85	.62	-.34	.33	.30	.45
Rack fat tr. wt.	(lb.)	1.49	.31	.74	-.62	-.68	-.15
Loin fat tr. wt.	(lb.)	2.56	.52	.81	-.68	-.75	-.18
Rt. fore cannon wt.	(gm.)	58.5	5.7	-.27	.54	.14	.03
Tr. leg wt.	(lb.)	11.30	.66	-.55	.51	.50	.53
Edible leg wt.	(lb.)	9.47	.54	-.47	.37	.46	.59
Leg bone wt.	(lb.)	1.86	.18	-.53	.73	.38	.15
Kidney knob wt.	(lb.)	2.08	.63	.70	-.60	-.65	-.03
12th rib fat	(in.)	.25	.08	.58	-.53	-.53	-.18
Thickest 12th rib fat	(in.)	.75	.18	.44	-.41	-.39	-.07
5th rib fat	(in.)	.67	.13	.51	-.52	-.44	-.07
L. D. area	(sq. in.)	2.32	.25	-.10	-.06	.15	.41
Loin probe	(in.)	.72	.17	.60	-.52	-.55	-.12

Paternal half-sib analyses were used to obtain estimates of the heritabilities and genetic, environmental and phenotypic correlations. The following mathematical model was used for all traits in this study:

$$W_{ijkl} = \mu + y_i + g_{ij} + s_{ijk} + e_{ijkl}$$

where:

W_{ijkl} = an observed phenotypic value for the l^{th} lamb sired by the k^{th} sire of the j^{th} breed in the i^{th} year,

μ = the effect common to all lambs,

y_i = the effect common to all lambs of the i^{th} year,

g_{ij} = the effect common to all lambs of the i^{th} year in the j^{th} breed,

s_{ijk} = the effect common to all lambs of the i^{th} year, in the j^{th} breed by the k^{th} sire,

e_{ijkl} = the effect unique to each lamb.

The method of analysis of variance with unequal subclasses, as outlined by Steel and Torrie (1960), was utilized to obtain the mean squares. Mean squares for the sum of two variables were computed following the method described by Kempthorne (1957). The components of variance and covariance were calculated by equating the expected mean squares to the estimated mean squares.

The expectation of the mean squares shown in Table V are:

$E(B_x) = \sigma^2_{w_x} + k\sigma^2_{b_x}$

$E(W_x) = \sigma^2_{w_x}$

$E(B_y) = \sigma^2_{w_y} + k\sigma^2_{b_y}$

TABLE V

ANALYSIS OF VARIANCE

Source	d.f.	Mean Squares		
		X	Y	X+Y
Sires/groups	s-g[a]	B_x	B_y	$B_{(x+y)}$
Within sires	n-s	W_x	W_y	$W_{(x+y)}$

[a]s = number of sires.
g = number of groups.
n = the total number of observations.

$$E(W_y) = \sigma^2_{w_y}$$

$$E(B_{(x+y)}) = \sigma^2_{w_x} + \sigma^2_{w_y} + 2\sigma_{w_x w_y} + k(\sigma^2_{b_x} + \sigma^2_{b_y} + 2\sigma_{b_x b_y})$$

$$E(W_{(x+y)}) = \sigma^2_{w_x} + \sigma^2_{w_y} + 2\sigma_{w_x w_y}$$

assuming:

sires are a random sample of a population of sires,

$cov\ (s^x_{ijk},\ s^y_{i'j'k'}) = \hat{\sigma}_{b_x b_y}$, $cov\ (e^x_{ijkl},\ e^y_{i'j'k'l'}) = \hat{\sigma}_{w_x w_y}$

if and only if i=i', j=j' and k=k', otherwise the covariances are equal to zero.

where:

s^x_{ijk} is the sire effect of trait x measured on the progeny of the k^{th} sire of the j^{th} breed in the i^{th} year.

e^x_{ijkl} is the individual effect associated with the l^{th} lamb by the k^{th} sire of the j^{th} breed in the i^{th} year.

$$k = \sum_{ij} n^2_{ij} \frac{[1/n_{ij} - 1/n_{i.}]}{s - g}$$

and

$n_{i.}$ = number in the i^{th} group,

n_{ij} = number in the i^{th} group by the j^{th} sire,

also,

$\hat{\sigma}^2_{b_x}$ is an estimate of 1/4 (genetic variance in X),

$\hat{\sigma}^2_{w_x}$ is an estimate of 3/4 (genetic variance in X) plus all the environmental variance in X,

$\hat{\sigma}_{b_x b_y}$ is an estimate of 1/4 (genetic covariance between X and Y),

$\hat{\sigma}_{w_x w_y}$ is an estimate of 3/4 (genetic covariance between X and Y) plus the environmental covariance between X and Y,

therefore:

$$\text{genetic variance } (\hat{\sigma}^2_{g_x}) = 4\left[\frac{B_x - W_x}{k}\right]$$

$$\text{environmental variance } (\hat{\sigma}^2_{e_x}) = W_x - 3\left(\frac{B_x - W_x}{k}\right)$$

$$\text{phenotypic variance } (\hat{\sigma}^2_{p_x}) = \hat{\sigma}^2_{g_x} + \hat{\sigma}^2_{e_x}$$

These same principles when applied to the analysis of variance for the sum of two variables yields the covariances.

$$\text{genetic covariance } (\hat{\sigma}_{g_x g_y}) = 2\left[\frac{B_{(x+y)} - W_{(x+y)}}{k} - B_x - B_y\right]$$

environmental covariance $(\hat{\sigma}_{e_x e_y})$ =

$$1/2\left[W_{(x+y)} - W_x - W_y\right] - 3/2\left[\frac{B_{(x+y)} - W_{(x+y)}}{k} - B_x - B_y\right]$$

$$\text{phenotypic covariance } (\hat{\sigma}_{p_x p_y}) = \hat{\sigma}_{g_x g_y} + \hat{\sigma}_{e_x e_y}$$

Heritability was estimated by using the following equation:

$$h^2 = \frac{\hat{\sigma}^2_g}{\hat{\sigma}^2_p}$$

This method of calculating heritability had several limitations which are outlined by Lush (1949) and A.S.A.P. (1960). Since σ_g^2 was estimated by $4\sigma_b^2$ all sampling errors and failure to remove environmental effects were multiplied by four. In addition, the accuracy of the heritability estimates calculated in this manner depends to a great extent on the number of degrees of freedom available for estimating differences between sires. The method outlined by A.S.A.P. (1960) was used to obtain estimates of the standard errors (s_{h^2}) of the heritability estimates.

The genetic, environmental and phenotypic correlations were estimated from the following equations:

$$r_{g_x g_y} = \frac{\sigma_{g_x g_y}}{\sqrt{(\sigma^2_{g_x})\ (\sigma^2_{g_y})}}$$

$$r_{e_x e_y} = \frac{\sigma_{e_x e_y}}{\sqrt{(\sigma^2_{e_x})\ (\sigma^2_{e_y})}}$$

$$r_{p_x p_y} = \frac{\sigma_{p_x p_y}}{\sqrt{(\sigma^2_{p_x})\ (\sigma^2_{p_y})}}$$

This method of estimating these correlation coefficients was first shown by Hazel et al. (1943).

RESULTS AND DISCUSSION

Prediction of Carcass Composition

If relatively simple and inexpensive carcass measurements could be used to predict carcass composition, the lamb producer could measure more lambs and thereby intensify his selection program. In this study the composition was predicted utilizing measurements available at three different stages in the cutting of the carcass. First, as the carcass hung from the rail; second, after the carcass was cut into fore- and hindsaddles; and third, after the carcass was cut into boneless wholesale cuts.

The ultimate goal in the study of carcass composition is knowledge of the amounts of fat, lean and bone in each carcass. Since complete physical separation or chemical analysis of the whole carcass into fat, lean and bone is expensive and time consuming, it is desirable to determine carcass composition using easy to obtain measurements. A review of the literature revealed that specific gravity and the components of the wholesale cuts have been good indicators of carcass composition (Field *et al.*, 1963a; Barton and Kirton, 1958b; and Pálsson, 1939). The best indicators of the carcass composition in these data were specific gravity, loin probe and weight of the fat trim from the loin.

Phenotypic Correlations Between Carcass Traits

Intra-year, type of rearing and face color simple correlations were obtained between various carcass measurements and are shown in Table VI. Carcass grade was negatively related to carcass weight (-.35), dressing percent (-.28), loin probe (-.22) and fifth rib fat (-.26). These associations indicated that higher grading carcasses were heavier, higher dressing carcasses with large amounts of loin and fifth rib fat. Specific gravity of the carcass and hindsaddle were found to be negatively associated with measures of carcass fat.

The intra-year, type of rearing and face color simple correlations between the dependent variables and carcass measurements are found in Table VII. All correlations between specific gravities and carcass composition were highly significant ($P < .01$). Carcass, hindsaddle and rack specific gravities were the most highly associated with carcass components. The correlations between hindsaddle specific gravity and carcass fat, lean and bone were -.70, 0.69 and 0.60, respectively. Weight of the fat trimmed from the loin was the best single indicator of total carcass fat ($r = 0.75$).

The correlation between leg bone weight and carcass bone was 0.69, while the correlation between the weight of the right fore cannon bone and carcass bone was 0.58. In 1964 the weight of all four cannons was recorded and the correlation between total cannon bone and total carcass bone was 0.81. The lean content of the carcass was found to be highly correlated to hindsaddle specific gravity (0.69) and fat trim from the loin (-.69).

TABLE VI

INTRA-YEAR, TYPE OF REARING AND FACE COLOR SIMPLE CORRELATIONS BETWEEN VARIOUS CARCASS TRAITS

		X_3	X_4	X_6	X_{11}	X_{13}	X_{14}	X_{17}	X_{18}	X_{19}	X_{23}	X_{21}	X_{24}
Carcass wt.	(X_2)	.75	-.22	-.24	.50	.45	.07	.11	.38	.29	.35	.46	-.35
Dressing %	(X_3)		-.35	-.40	.24	.50	-.20	-.18	.48	.38	.35	.41	-.28
Carcass sp. gr.	(X_4)			.85	.23	-.45	.31	.39	-.55	-.42	-.31	-.23	.05
Hind sp. gr.	(X_6)				.30	-.55	.29	.47	-.58	-.48	-.35	-.23	.08
Untr. leg wt.	(X_{11})					-.22	.41	.67	-.17	-.13	-.09	.00	-.10
Loin fat trim	(X_{13})						-.32	-.42	.39	.62	.55	.54	-.12
Right cannon wt.	(X_{14})							.53	-.18	-.20	-.17	-.24	.11
Leg bone wt.	(X_{17})								-.32	-.34	-.20	-.16	.16
Kidney knob wt.	(X_{18})									.34	.33	.13	-.09
12th rib fat	(X_{19})										.34	.34	-.13
loin probe	(X_{23})											.47	-.22
5th rib fat	(X_{21})												-.26
Carcass grade	(X_{24})												

$r > .18$; significance at $P < .05$ (d.f. = 114).
$r > .24$; significance at $P < .01$ (d.f. = 114).

TABLE VII

INTRA-YEAR, TYPE OF REARING AND FACE COLOR SIMPLE CORRELATIONS BETWEEN DEPENDENT VARIABLES AND VARIOUS CARCASS TRAITS

		Percent Carcass Fat	Percent Carcass Lean	Percent Carcass Bone	Percent Trimmed Wholedale Cuts
Slaughter weight	(X_1)	0.36	-.30	-.48	0.06
Carcass weight	(X_2)	0.32	-.32	-.37	0.43
Dressing percent	(X_3)	0.40	-.38	-.57	0.63
Carcass sp. gr.	(X_4)	-.62	0.61	0.54	0.19
Fore sp. gr.	(X_5)	-.42	0.41	0.37	0.16
Hind sp. gr.	(X_6)	-.70	0.69	0.60	0.19
Rack sp. gr.	(X_7)	-.70	0.64	0.63	0.21
Loin sp. gr.	(X_8)	-.66	0.61	0.54	0.10
Leg sp. gr.	(X_9)	-.48	0.42	0.39	0.25
Untr loin weight	(X_{10})	0.48	-.42	-.51	0.26
Untr. leg weight	(X_{11})	-.36	0.31	0.29	0.48
Rack fat trim	(X_{12})	0.64	-.59	-.54	-.15
Loin fat trim	(X_{13})	0.75	-.69	-.63	-.21
Right cannon weight	(X_{14})	-.37	0.24	0.58	0.04
Trimmed leg weight	(X_{15})	-.58	0.52	0.48	0.56
Edible leg weight	(X_{16})	-.54	0.49	0.36	0.62
Leg bone weight	(X_{17})	-.48	0.37	0.69	0.18
Kidney knob weight	(X_{18})	0.48	-.56	-.55	-.01
Fat thickness over 12th rib	(X_{19})	0.59	-.55	-.46	-.16
Thickest 12th rib fat	(X_{20})	0.47	-.43	-.38	-.09
Loin eye area	(X_{21})	-.35	0.37	0.03	0.46
Loin probe	(X_{22})	0.51	-.49	-.39	-.11
Thickest 5th rib fat	(X_{23})	0.44	-.39	-.47	-.03

$r > .18$; significance at $P < .05$ (d.f. = 114).
$r > .24$; significance at $P < .01$ (d.f. = 114).

Prediction Equations of Carcass Composition

The regression equations for percent fat and lean were first calculated across years, breeds and sires and then within years but ignoring breeds and sires. Comparable results were obtained with the two procedures. Results from the across years, breeds and sires analysis are discussed in this thesis and the within year findings are given in parenthesis. For example, the correlation coefficient between carcass specific gravity and percent carcass fat was -.62 (-.67); that is, the correlation calculated across years was -.62 and the same relationship calculated on a pooled within year basis was -.67. When the within year results differ appreciably from the across year results, they are discussed in the text. Since the percent carcass bone was similar in both years prediction of bone was done only across years, breeds and sires.

Intact Carcass Prediction Equations

Prediction equations were calculated using those variables which were most highly associated with carcass composition. Initally only those carcass measurements were used which could be obtained from the carcass as it hung from the rail. The only cutting of the carcass was a small cut over the second sacral vertebra for the loin probe and a cut to remove the right fore cannon. Regression equations for the prediction of carcass fat, lean and bone as it hung from the rail are shown in Tables VIII, IX, X, XI and XII.

In the first regression equation percent carcass fat was regressed on carcass specific gravity. The equation implies that the lower the

TABLE VIII

MULTIPLE REGRESSION EQUATIONS FOR ESTIMATING PERCENT CARCASS FAT CALCULATED ACROSS YEARS FROM MEASUREMENTS OBTAINED AS THE CARCASS HUNG FROM THE RAIL

No.	Estimating Equations[a]	R^2	s_y	Standard Error of Estimate
1.	$\hat{Y} = 46.161 - .043X_4$	.38	4.35	3.42
2.	$\hat{Y} = 9.166 - .036X_4 + .667X_2$	.55	4.35	2.91
3.	$\hat{Y} = 10.436 - .030X_4 + .489X_2 + 7.742X_{23}$	.62	4.35	2.69
4.	$\hat{Y} = 12.609 - .027X_4 + .576X_2 + 6.810X_{23} - .127X_{14}$	.64	4.35	2.62

[a] $\hat{Y}$ = percent carcass fat.

X_4 = 10000 (carcass specific gravity - 1.0000).

X_2 = cold carcass weight, lb.

X_{23} = loin probe, in.

X_{14} = right fore cannon weight, gm.

TABLE IX

MULTIPLE REGRESSION EQUATIONS FOR ESTIMATING PERCENT CARCASS FAT ON A WITHIN YEAR BASIS FROM MEASUREMENTS OBTAINED AS THE CARCASS HUNG FROM THE RAIL

No.	Estimating Equations[a]	R^2	s_y	Standard Error of Estimate
1.	$\hat{Y} = 45.830 - .042X_4$	.44	4.02	3.03
2.	$\hat{Y} = 18.185 - .037X_4 + .499X_2$	.50	4.02	2.84
3.	$\hat{Y} = 19.932 - .032X_4 + .316X_2 + 7.812X_{23}$	.59	4.02	2.57
4.	$\hat{Y} = 24.006 - .028X_4 + .384X_2 + 6.760X_{23} - .144X_{14}$	.62	4.02	2.48

a $\hat{Y}$ = percent carcass fat.

X_4 = 10000 (carcass specific gravity - 1.0000).

X_2 = cold carcass weight, lb.

X_{23} = loin probe, in.

X_{14} = right fore cannon weight, gm.

TABLE X

MULTIPLE REGRESSION EQUATIONS FOR ESTIMATING PERCENT CARCASS LEAN CALCULATED ACROSS YEARS FROM MEASUREMENTS OBTAINED AS THE CARCASS HUNG FROM THE RAIL

No.	Estimating Equations[a]	R^2	s_y	Standard Error of Estimate
1.	$\hat{Y} = 42.013 + .031X_4$	.32	3.50	2.89
2.	$\hat{Y} = 70.389 + .026X_4 - .512X_2$	.48	3.50	2.54
3.	$\hat{Y} = 69.472 + .022X_4 - .383X_2 - 5.586X_{23}$	.53	3.50	2.41
4.	$\hat{Y} = 69.287 + .022X_4 - .391X_2 - 5.507X_{23} + .011X_{14}$	.54	3.50	2.42

[a] $\hat{Y}$ = percent carcass lean.

X_4 = 10000 (carcass specific gravity - 1.0000).

X_2 = cold carcass weight, lb.

X_{23} = loin probe, in.

X_{14} = right fore cannon weight, gm.

TABLE XI

MULTIPLE REGRESSION EQUATIONS FOR ESTIMATING PERCENT CARCASS LEAN ON A WITHIN YEAR BASIS FROM MEASUREMENTS OBTAINED AS THE CARCASS HUNG FROM THE RAIL

No.	Estimating Equations[a]	R^2	s_y	Standard Error of Estimate
1.	$\hat{Y} = 42.210 + .031X_4$	.37	3.20	2.54
2.	$\hat{Y} = 59.960 + .028X_4 - .322X_2$	.42	3.20	2.44
3.	$\hat{Y} = 58.825 + .024X_4 - .189X_2 - 5.654X_{23}$	.48	3.20	2.31
4.	$\hat{Y} = 58.173 + .023X_4 - .202X_2 - 5.454X_{23} + .027X_{14}$	.48	3.20	2.31

[a] $\hat{Y}$ = percent carcass lean.

X_4 = 10000 (carcass specific gravity - 1.0000).

X_2 = cold carcass weight, lb.

X_{23} = loin probe, in.

X_{14} = right fore cannon weight, gm.

TABLE XII

MULTIPLE REGRESSION EQUATIONS FOR ESTIMATING PERCENT CARCASS BONE FROM MEASUREMENTS OBTAINED AS THE CARCASS HUNG FROM THE RAIL

No.	Estimating Equations[a]	R^2	s_y	Standard Error of Estimate
1.	$\hat{Y} = 36.900 - .363X_3$	.38	1.36	1.08
2.	$\hat{Y} = 28.266 - .321X_3 + .107X_{14}$	.58	1.36	0.89
3.	$\hat{Y} = 26.588 - .258X_3 + .100X_{14} - 2.024X_{23}$	.63	1.36	0.84
4.	$\hat{Y} = 23.671 - .230X_3 + .089X_{14} - 1.700X_{23} + .004X_4$	.65	1.36	0.81

[a] $\hat{Y}$ = percent carcass bone.

X_3 = dressing percent.

X_{14} = right fore cannon weight, gm.

X_{23} = loin probe, in.

X_4 = 10000 (carcass specific gravity - 1.0000).

carcass specific gravity the higher the fat content of the carcass. Since a stepwise multiple regression technique was employed, one variable at a time was added to the equation. The second equation in Table VIII includes the variable of those remaining which accounts for the most variation in percent carcass fat after the effect of carcass specific gravity has been removed. This equation, which has for independent variables carcass specific gravity and the loin probe, accounts for 17 (14) percent more of the variation in percent carcass fat than equation 1.

The addition of cold carcass weight and weight of the right fore cannon increased only slightly the accuracy of the prediction. The multiple correlation coefficient (R) was calculated as 0.80 (0.79) when carcass specific gravity, loin probe, cold carcass weight and right fore cannon weight were correlated to percent carcass fat.

The prediction of percent lean on a carcass basis is shown in Table X. Of the measurements obtained from the carcass as it hung from the rail, carcass specific gravity was the most highly associated with carcass lean. The standard error of estimate for the regression of percent lean on carcass specific gravity was 2.89 (2.54) percent and the correlation was 0.56 (0.60). This agrees quite closely with the correlation reported by Field et al. (1963a) of 0.47 between carcass specific gravity and percent carcass lean. The next two independent variables entered into the equation were cold carcass weight and loin probe, respectively. These three independent variables accounted for 53 (48) percent of the variation in percent carcass lean. It should be noted that those variables important in the prediction of fat were also important in the prediction of lean. The amount of variability accounted for in percent carcass fat by carcass specific gravity, carcass weight and loin probe was about the same as the variability accounted for in percent lean by the same three variables. The multiple correlation coefficients of lean and fat with carcass specific gravity, carcass weight and loin probe were 0.73 (0.69) and 0.79 (0.77), respectively.

Dressing percent was the best single predictor of carcass percent bone of the easily obtainable measurements studied. Dressing percent accounted for 38 percent of the variation in carcass bone. The addition of the right fore cannon weight to the equation further increased the amount of variation accounted for to 58 percent.

When carcass specific gravity, loin probe, weight of the right fore cannon and dressing percent were included in the regression equation the standard error of estimate was 0.81 percent. The equation implies that when all independent variables were held constant except dressing percent, the higher dressing lambs had less bone. Similarly, lambs with lighter right fore cannons produced carcasses with less total bone. Identical reasoning may be applied to the other partial regression coefficients.

The weight of all four cannon bones was obtained for the 1964 lamb carcasses. The correlation between the weight of all four cannons and percent carcass bone was 0.81. The weight of the four cannons accounted for 66 percent of the variation in carcass bone and the regression equation was as follows:

$$\hat{Y} = 5.40 + .032 \text{ (weight of four cannons, gm.)}$$

This regression equation has a standard error of estimate of 0.72 percent. Pálsson (1939) reported that the weight of all four cannons accounted for 92 percent of the variation in total carcass bone.

Eighty percent of the variation in carcass bone was accounted for when the dressing percent and the weight of all four cannons were used in the following equation:

$$\hat{Y} = 28.95 + .025 \text{ (wt. of four cannons, gm.)} - .37 \text{ (dressing percent)}$$

This equation is based on data from the 1964 lamb carcasses and has a standard error of estimate of 0.50 percent.

Fore- and Hindsaddle Prediction Equations

The cutting of the carcasses into fore- and hindsaddles added five additional measurements for consideration in the stepwise multiple regression procedure. The added measurements were fore- and hindsaddle specific gravity, fat cover over the 12th rib, thickest 12th rib fat and area of the *longissimus dorsi*. Hindsaddle specific gravity and fat cover over the 12th rib were the only measurements that contributed appreciably to the reduction in variance of the dependent variables.

The predictions of percent fat in the carcass by various combinations of fore- and hindsaddle measurements are shown in Table XIII. Equation 1 indicates that hindsaddle specific gravity explained 53 (57) percent of the variation in carcass fat. This was 15 (13) percent more of the variation in carcass fat content than was explained by carcass specific gravity (equation 1, Table VIII). A comparison of equations 1 and 2 indicates that loin probe explained 12 (4) percent more of the variation in carcass fat. The addition of the cold carcass weight and kidney fat weight further reduced the variation of carcass fat, 4 (5) and 2 (3) percent, respectively.

TABLE XIII

MULTIPLE REGRESSION EQUATIONS FOR ESTIMATING PERCENT CARCASS FAT CALCULATED ACROSS YEARS FROM MEASUREMENTS OBTAINED ON THE FORE- AND HINDSADDLES

No.	Estimating Equations[a]	R^2	s_y	Standard Error of Estimate
1.	$\hat{Y} = 46.513 - .048X_6$	.53	4.35	2.99
2.	$\hat{Y} = 14.395 - .041X_6 + .575X_2$	.65	4.35	2.57
3.	$\hat{Y} = 14.829 - .035X_6 + .441X_2 + 6.313X_{23}$	.69	4.35	2.41
4.	$\hat{Y} = 12.404 - .031X_6 + .422X_2 + 5.086X_{23} + 10.659X_{18}$	.71	4.35	2.32

[a] $\hat{Y}$ = percent carcass fat.

X_6 = 10000 (hindsaddle specific gravity - 1.0000).

X_2 = cold carcass weight, lb.

X_{23} = loin probe, in.

X_{18} = kidney fat weight, lb.

TABLE XIV

MULTIPLE REGRESSION EQUATIONS FOR ESTIMATING PERCENT CARCASS FAT ON A WITHIN YEAR BASIS FROM MEASUREMENTS OBTAINED ON THE FORE- AND HINDSADDLES

No.	Estimating Equations[a]	R^2	s_y	Standard Error of Estimate
1.	$\hat{Y} = 45.808 - .046X_6$	.57	4.02	2.85
2.	$\hat{Y} = 23.000 - .042X_6 + .415X_2$	.61	4.02	2.72
3.	$\hat{Y} = 23.670 - .037X_6 + .275X_2 + 6.391X_{23}$	.66	4.02	2.54
4.	$\hat{Y} = 23.230 - .031X_6 + .174X_2 + 5.845X_{23} + 1.362X_{18}$	.69	4.02	2.42

[a] $\hat{Y}$ = percent carcass fat.

X_6 = 10000 (hindsaddle specific gravity - 1.0000).

X_2 = cold carcass weight, lb.

X_{23} = loin probe, in.

X_{18} = kidney fat weight, lb.

TABLE XV

MULTIPLE REGRESSION EQUATIONS FOR ESTIMATING PERCENT CARCASS LEAN CALCULATED ACROSS YEARS FROM MEASUREMENTS OBTAINED ON THE FORE- AND HINDSADDLES

No.	Estimating Equations[a]	R^2	s_y	Standard Error of Estimate
1.	$\hat{Y} = 41.611 + .036X_6$	.46	3.50	2.60
2.	$\hat{Y} = 66.287 + .030X_6 - .442X_2$	.57	3.50	2.32
3.	$\hat{Y} = 65.979 + .027X_6 - .347X_2 - 4.477X_{23}$	.61	3.50	2.23
4.	$\hat{Y} = 67.564 + .023X_6 - .334X_2 - 3.676X_{23} - 6.965X_{19}$	.61	3.50	2.20

[a] $\hat{Y}$ = percent carcass lean.

X_6 = 10000 (hindsaddle specific gravity - 1.0000).

X_2 = cold carcass weight, lb.

X_{23} = loin probe, in.

X_{19} = fat cover over 12th rib, in.

TABLE XVI

MULTIPLE REGRESSION EQUATIONS FOR ESTIMATING PERCENT CARCASS LEAN ON A WITHIN YEAR BASIS FROM MEASUREMENTS OBTAINED ON THE FORE- AND HINDSADDLES

No.	Estimating Equations[a]	R^2	s_y	Standard Error of Estimate
1.	$\hat{Y} = 42.226 + .034X_6$	.49	3.20	2.29
2.	$\hat{Y} = 56.354 + .031X_6 - .257X_2$	.52	3.20	2.22
3.	$\hat{Y} = 55.878 + .028X_6 - .157X_2 - 4.558X_{23}$	.56	3.20	2.12
4.	$\hat{Y} = 56.878 + .025X_6 - .128X_2 - 3.649X_{23} - 7.924X_{19}$	.58	3.20	2.07

[a] $\hat{Y}$ = Percent carcass lean.

X_6 = 10000 (hindsaddle specific gravity - 1.0000).

X_2 = cold carcass weight, lb.

X_{23} = loin probe, in.

X_{19} = fat cover over 12th rib, in.

TABLE XVII

MULTIPLE REGRESSION EQUATIONS FOR ESTIMATING PERCENT CARCASS BONE FROM MEASUREMENTS OBTAINED ON THE FORE- AND HINDSADDLES

No.	Estimating Equations[a]	R^2	s_y	Standard Error of Estimate
1.	$\hat{Y} = 36.900 - .363X_3$	.38	1.36	1.08
2.	$\hat{Y} = 28.266 - .321X_3 + .107X_{14}$	.58	1.36	.89
3.	$\hat{Y} = 22.583 - .244X_3 + .090X_{14} + .006X_6$	.64	1.36	.82
4.	$\hat{Y} = 22.227 - .210X_3 + .088X_{14} + .005X_6 - 1.511X_{23}$	.67	1.36	.79

[a] $\hat{Y}$ = percent carcass bone

X_3 = dressing percent.

X_{14} = right fore cannon weight, gm.

X_6 = 10000 (hindsaddle specific gravity - 1.0000).

X_{23} = loin probe, in.

The four equations in Table XV estimate percent lean in the carcass. Through the use of the three independent variables, hindsaddle specific gravity, cold carcass weight and loin probe, 61 (56) percent of the variation in carcass lean was explained. The addition of 12th rib fat to the equation (equation 4) did not contribute any further to the reduction of the variance in carcass lean. The equation (equation 4, Table XVI) calculated within years accounted for two percent more of the variation in carcass lean.

From these regression equations it appears that hindsaddle specific gravity was a better predictor of carcass fat and lean than carcass specific gravity. Hindsaddle specific gravity accounted for 53 (57) and 46 (49) percent, respectively, of the variation in carcass fat and lean while carcass specific gravity accounted for only 38 (44) and 32 (37) percent of the respective variation. This might be explained on the basis of maturity. Pálsson (1939) pointed out that the loin region was one of the latest maturing areas of the carcass and therefore one of the last places fat was deposited. If this is so then the relative differences in the amount of hindsaddle fat should be greater than relative differences in total carcass fat. The hindsaddle was a good indicator of total carcass lean possibly because of the large amounts of lean tissue in the leg. Stanley (1963) found the weight of the leg to be an excellent indicator of total carcass lean.

The regression of percent carcass bone on various carcass measurements obtained on the fore- and hindsaddles are presented in Table XVII. Dressing percent was found to be the best single predictor of carcass bone as shown in equation 1. This indicated that none of the additional measurements from the fore- and hindsaddles were any better as predictors of carcass bone than those measurements on the intact carcasses. Equation 2 shows that when two independent variables were considered no new information was obtained from the fore- and hindsaddles as compared to the whole carcass. The standard error of estimate was 0.89 percent for the equation utilizing dressing percent and right fore cannon weight. When hindsaddle specific gravity was included the standard error of estimate was reduced to 0.82 percent.

Generally the inclusion of more than two independent variables did not substantially reduce the standard error of estimates for the prediction of either fat, lean or bone. When two independent variables were used to predict percent carcass fat, lean and bone from measurements obtained on the half carcasses, the standard errors of estimate were 2.97 (2.72), 2.32 (2.22) and 0.89 percent, respectively. These regression equations accounted for 65 (61), 57 (52) and 58 percent of the variation in percent fat, lean and bone, respectively.

Prediction Equations from All Measurements

The predictions of percent carcass fat, lean and bone from measurements available on the bone-in and boneless wholesale cuts are shown in Tables XVIII, XIX, XX, XXI and XXII, respectively. Measurements that were available for consideration from the individual major wholesale cuts were specific gravity, fat trim weight, trimmed weight, boneless weight and bone weight. Many of these measurements were eliminated from use in the regression study by the preliminary correlation analysis because their association with the dependent variables were too low to be of practical importance.

TABLE XVIII

MULTIPLE REGRESSION EQUATIONS FOR ESTIMATING PERCENT CARCASS FAT CALCULATED ACROSS YEARS FROM ALL MEASUREMENTS OBTAINED

No.	Estimating Equations[a]	R^2	s_y	Standard Error of Estimate
1.	$\hat{Y} = 11.599 + 6.755X_{13}$	.66	4.35	2.55
2.	$\hat{Y} = 25.977 + 4.893X_{13} - .026X_6$	.76	4.35	2.11
3.	$\hat{Y} = 20.795 + 4.325X_{13} - .018X_6 + 1.819X_{18}$	.80	4.35	1.93
4.	$\hat{Y} = 28.811 + 4.023X_{13} - .016X_6 + 1.879X_{18} - .740X_{15}$	.81	4.35	1.89

[a] $\hat{Y}$ = percent carcass fat.

X_{13} = loin fat trim weight, lb.

X_6 = 10000 (hindsaddle specific gravity - 1.0000).

X_{18} = kidney fat weight, lb.

X_{15} = weight of trimmed leg, lb.

TABLE XIX

MULTIPLE REGRESSION EQUATIONS FOR ESTIMATING PERCENT CARCASS FAT ON A WITHIN YEAR BASIS FROM ALL MEASUREMENTS OBTAINED

No.	Estimating Equations[a]	R^2	s^y	Standard Error of Estimate
1.	$\hat{Y} = 12.291 + 6.485X_{13}$	.61	4.02	2.51
2.	$\hat{Y} = 28.180 + 4.302X_{13} - .028X_6$	.75	4.02	2.03
3.	$\hat{Y} = 22.470 + 4.089X_{13} - .020X_6 + 1.596X_{18}$	.78	4.02	1.89
4.	$\hat{Y} = 14.484 + 3.741X_{13} - .018X_6 + 1.570X_{18} + .730X_{15}$	.79	4.02	1.87

[a] $\hat{Y}$ = percent carcass fat.

X_{13} = loin fat trim weight, lb.

X_6 = 10000 (hindsaddle specific gravity - 1.0000).

X_{18} = kidney fat weight, lb.

X_{15} = weight of trimmed leg, lb.

TABLE XX

MULTIPLE REGRESSION EQUATIONS FOR ESTIMATING PERCENT CARCASS LEAN CALCULATED ACROSS YEARS FROM ALL MEASUREMENTS OBTAINED

No.	Estimating Equations[a]	R^2	s_y	Standard Error of Estimate
1.	$\hat{Y} = 67.593 - 5.031X_{13}$	.57	3.50	2.31
2.	$\hat{Y} = 56.928 - 3.650X_{13} + .019X_6$	.65	3.50	2.06
3.	$\hat{Y} = 60.806 - 3.224X_{13} + .014X_6 - 1.362X_{18}$	.70	3.50	1.96
4.	$\hat{Y} = 69.589 - 3.020X_{13} + .016X_6 - 1.213X_{18} - .115X_1$	.73	3.50	1.94

[a] $\hat{Y}$ = percent carcass lean.

X_{13} = loin fat trim weight, lb.

X_6 = 10000 (hindsaddle specific gravity - 1.0000).

X_{18} = kidney fat weight, lb.

X_1 = slaughter weight, lb.

TABLE XXI

MULTIPLE REGRESSION EQUATIONS FOR ESTIMATING PERCENT CARCASS LEAN ON A WITHIN YEAR BASIS FROM ALL MEASUREMENTS OBTAINED

No.	Estimating Equations[a]	R^2	s_y	Standard Error of Estimate
1.	$\hat{Y} = 66.676 - 4.673X_{13}$	.50	3.20	2.26
2.	$\hat{Y} = 54.570 - 3.005X_{13} + .021X_6$	.63	3.20	1.95
3.	$\hat{Y} = 58.157 - 2.852X_{13} + .016X_6 - 1.039X_{18}$	.65	3.20	1.89
4.	$\hat{Y} = 62.620 - 2.803X_{13} + .017X_6 - 1.034X_{18} - .053X_1$	.65	3.20	1.89

[a] $\hat{Y}$ = percent carcass lean.

X_{13} = loin fat trim weight, lb.

X_6 = 10000 (hindsaddle specific gravity - 1.0000).

X_{18} = kidney fat weight, lb.

X_1 = slaughter weight, lb.

TABLE XXII

MULTIPLE REGRESSION EQUATIONS FOR ESTIMATING PERCENT CARCASS BONE FROM ALL MEASUREMENTS OBTAINED

No.	Estimating Equations[a]	R^2	s_y	Standard Error of Estimate
1.	$\hat{Y} = 5.968 + 5.602X_{17}$	.54	1.36	.94
2.	$\hat{Y} = 22.785 + 4.664X_{17} - .266X_3$	.73	1.36	.72
3.	$\hat{Y} = 21.371 + 4.496X_{17} - .207X_3 - 2.455X_{21}$	.78	1.36	.66
4.	$\hat{Y} = 19.289 + 4.148X_{17} - .141X_3 - 2.514X_{21} - .461X_{18}$	.81	1.36	.62

[a] $\hat{Y}$ = percent carcass bone.

X_{17} = leg bone weight, lb.

X_3 = dressing percent.

X_{21} = thickest fat at 5th rib, in.

X_{18} = kidney fat weight, lb.

Equation 1 of Table XVIII predicted percent carcass fat with a standard error of estimate of 2.55 (2.51) percent. Loin fat trim weight was the independent variable in the equation and was highly correlated (r = 0.81) with carcass fat. This equation accounted for 66 (61) percent of the variation in carcass fat. The addition of hindsaddle specific gravity to the equation (equation 2) reduced the standard error of estimate to 2.11 (2.03) percent and increased the multiple correlation to 0.87 (0.87). Equations 3 and 4 contributed little to the reduction of the standard error of estimate. These equations added kidney fat weight and weight of trimmed leg, respectively, as independent variables.

The regression equations for the prediction of percent carcass lean from all carcass measurements studied are shown in Table XX. Loin fat trim weight was the most highly correlated (r = -.75) independent variable with carcass lean and was therefore entered into the stepwise regression first. The regression of carcass lean on loin fat trim weight had a standard error of estimate of 2.31 (2.26) percent. The addition of hindsaddle specific gravity to the regression equation increased the amount of variance accounted for in carcass lean from 57 to 65 (50 to 63) percent. The standard error of estimate was reduced from 2.31 to 2.06 (2.26 to 1.95) percent. When kidney knob weight and slaughter weight were placed in regression equations (equations 3 and 4) only a slight increase in the multiple correlation coefficient occurred. It was understandable that slaughter weight did not contribute substantially to the correlation because slaughter weight was held relatively constant.

The equations for predicting percent carcass bone from all carcass measurements are shown in Table XXII. The weight of the leg bones accounted for 54 percent of the variation in carcass bone. The leg bones consisted of the two femurs, two tibias and the pelvic girdle. These bones were a large part of the total bone but did not account for as much of the variation in total carcass bone as the weight of the four cannons. These findings are contrary to those of Pálsson (1939) who reported the correlation between leg bone and total bone as 0.97. This rather large difference may be due to the number of bones included and the method of obtaining the bones. Pálsson included only the femur and tibia which were removed from the carcass intact while this work also included a portion of the pelvic girdle. No cuts were made across bone in Pálsson's work while in this study the pelvic girdle was cut into two pieces in order that the weight of the wholesale leg could be measured. The addition of dressing percent to the equation (equation 2) increased the multiple correlation coefficient to 0.85. This equation accounted for 19 percent more of the variation in total carcass bone than equation 1. The addition of thickest 5th rib fat and kidney knob weight also increased the magnitude of the multiple correlations to 0.88 and 0.90, respectively.

Summary of Carcass Composition Prediction Equations

There was an increase in the accuracy of the prediction of percent carcass fat, lean and bone as more independent variables were included in the equations and as the amount of time and effort necessary to obtain the measurements increased. Those measurements available on the intact carcasses did not predict carcass composition as accurately as the measurements available after the carcasses were cut into fore- and hindsaddles. The most accurate prediction of carcass composition was from the measurements taken after the carcasses were cut into wholesale cuts.

From a practical standpoint certain measurements are of more value than others. Slaughter weight and dressing percent are dependent on the amount of shrink the animal was subjected to prior to slaughter. The shrink of experimental animals can usually be controlled within rather narrow limits if they are slaughtered in a University abattoir but not when they are slaughtered commercially. Dressing percent in lambs is also greatly influenced by the length of fleece and control over fleece length is not always practical at commercial slaughter facilities. Measurements that are not influenced by the preslaughter environment are more reliable because they can be standardized from one animal to another. Measurements such as specific gravity of the carcass, loin probe and cannon bone weight are not greatly affected by preslaughter environmental differences and should therefore give a more widely usable measure of the differences among carcasses. Carcass specific gravity is influenced by differences in the amounts of fat, lean and bone, differences in the density of fat, lean and bone from carcass to carcass and errors of measurement.

Prediction of carcass composition from measurements obtained as the carcass hung from the rail accounted for from 32 to 65 percent of the variation in percent carcass fat, lean and bone. Carcass specific gravity was the best of these measurements for estimating percent lean or fat. The weights necessary for calculating carcass specific gravity may be obtained in many packing houses and this measurement is therefore of some practical importance. Because of the small amount of variation accounted for by specific gravity and the other measurements available as the carcass hung from the rail, differences between animals would be hard to detect accurately. These rather simple measurements should be of some value for estimating the differences between groups of lamb carcasses.

Although data were available for only one year, the weight of all four cannon bones was found to be the most accurate predictor of total carcass bone. Obtaining this measurement would not drastically change the basic shape of the carcass and perhaps therefore be permitted by meat packers.

When the weight of the four cannon bones and carcass specific gravity were used to predict percent carcass bone, fat and lean the following equations resulted:

Percent bone = -72.716 + 77 (carcass sp. gr.) + .026 (cannon wt., gm.)
Percent fat = 448.171 - 390 (carcass sp. gr.) - .036 (cannon wt., gm.)
Percent lean = -273.069 + 310 (carcass sp. gr.) + .012 (cannon wt., gm.)

These three equations accounted for 76, 60 and 43 percent of the variation in percent bone, fat and lean, respectively. From the results of these equations and the other equations discussed in this paper it appears that one set of two or three independent variables will not predict fat, lean and bone with equal accuracy.

The additional measurements available from the fore- and hindsaddle did not add a great deal to the accuracy of the prediction of carcass composition. Hindsaddle specific gravity was found to be more highly associated with percent carcass fat and lean than carcass specific gravity. Since the loin region is considered as one of the latest maturing areas of the lamb, differences in composition should be reflected in the hindsaddle specific gravity. In some localities lamb carcasses are handled by the packers as fore- and hindsaddles and therefore hindsaddle specific gravity may be of practical importance.

Fat trimmed from the late maturing loin was the best single predictor of both carcass percent fat and lean. The differential rate at which fat was deposited in the loin region appeared to be highly indicative of total carcass fat. The relationship between total fat and total lean was high and this partly explains why loin fat trim was also a good predictor of carcass lean. The loin fat trim weight involves considerable time and effort to obtain and requires cutting the loins into closely trimmed wholesale cuts. It is highly improbable that a meat packer would allow such a measurement to be taken. Some packers do sell the wholesale cuts and the purchase of the loin from the packer would allow the estimation of carcass composition from this measurement. Loin fat trim weights should be available from the majority of the lambs slaughtered at university meat laboratories. Although the weight of the fat trimmed from the loin accounted for much of the variation in percent carcass fat and lean more detailed measurements appear necessary if the composition of individual lamb carcasses are to be estimated with a high degree of certainty.

Prediction of Percent Trimmed Wholesale Cuts

The prediction of percent trimmed wholesale cuts (TWSC) was done in the same manner as carcass composition, that is, from measurements obtained as the carcass hung from the rail and again from those additional measurements available after the carcass was cut into fore- and hindsaddles. Every attempt was made in this study to remove all subcutaneous fat from the wholesale cuts.

Table XXIII shows the prediction equations of TWSC from those measurements available on the intact carcass. No one independent variable could account for more than 31 percent of the variation in percent TWSC. Dressing percent was the best single predictor of percent TWSC. The value of dressing percent to estimate percent TWSC is doubtful unless all lambs are subjected to the same preslaughter shrink. The addition of the loin probe increased the amount of variation accounted for in percent TWSC by 16 percent. Carcass specific gravity accounted for another 11 percent of the variation in percent TWSC which brought the total accounted for to 58 percent. Hiner and Thornton (1962) reported carcass weight to be highly associated with primal cuts. Both carcass weight and slaughter weight were found in this study to have low correlations with percent TWSC and this was expected because the lambs were slaughtered at a relatively constant weight.

The prediction of percent TWSC on a carcass basis is shown in Table XXIV. None of the added measurements from the fore- and hindsaddles could predict percent TWSC more accurately than dressing percent. Dressing percent accounted for 31 percent of the variation in percent TWSC. When hindsaddle specific gravity was included in the multiple regression equation the equation accounted for 52 percent of the variation in percent TWSC. The addition of the loin probe and 12th rib fat (equation 4) to the prediction equation increased the amount of variance accounted for in percent TWSC to 66 percent.

The additional measurements obtained when the carcasses were cut into the fore- and hindsaddles did not substantially increase the accuracy of the prediction of percent TWSC. When four independent variables were used from the intact carcass the standard error of estimate

TABLE XXIII

MULTIPLE REGRESSION EQUATIONS FOR ESTIMATING PERCENT TRIMMED WHOLESALE CUTS FROM MEASUREMENTS OBTAINED AS THE CARCASS HUNG FROM THE RAIL

No.	Estimating Equations[a]	R^2	s_y	Standard Error of Estimate
1.	$\hat{Y} = 16.783 + .369X_3$	.31	1.54	1.29
2.	$\hat{Y} = 12.230 + .502X_3 - 4.132X_{23}$	.47	1.54	1.13
3.	$\hat{Y} = 4.479 + .567X_3 - 3.356X_{23} + .009X_4$	.58	1.54	1.02
4.	$\hat{Y} = 11.942 + .562X_3 - 2.962X_{23} + .009X_4 - .086X_1$	.61	1.54	.98

[a] $\hat{Y}$ = percent trimmed wholesale cuts.

X_3 = dressing percent.

X_{23} = loin probe, in.

X_4 = 10000 (carcass specific gravity - 1.0000).

X_1 = slaughter weight, lb.

TABLE XXIV

MULTIPLE REGRESSION EQUATIONS FOR ESTIMATING PERCENT TRIMMED WHOLESALE CUTS FROM MEASUREMENTS OBTAINED ON THE FORE- AND HINDSADDLES

No.	Estimating Equations[a]	R^2	s_y	Standard Error of Estimate
1.	$\hat{Y} = 16.783 + .369X_3$	.31	1.54	1.29
2.	$\hat{Y} = 3.385 + .526X_3 + .012X_6$	.52	1.54	1.07
3.	$\hat{Y} = 2.393 + .597X_3 + .010X_6 - 3.073X_{23}$	.61	1.54	.98
4.	$\hat{Y} = 2.596 + .623X_3 + .008X_6 - 2.501X_{23} - 5.343X_{19}$	.66	1.54	.92

[a] $\hat{Y}$ = percent trimmed wholesale cuts.

X_3 = dressing percent.

X_6 = 10000 (hindsaddle specific gravity - 1.0000).

X_{23} = loin probe, in.

X_{19} = fat cover over the 12th rib, in.

was 0.98 percent as compared to 0.92 percent when four variables from the fore- and hindsaddles were employed.

Heritabilities

The heritability estimates discussed herein are preliminary estimates based on only 18 sire groups. The analyses of variance for the traits studied are shown in Table XXV. A number of the traits showed significant ($P > .05$) and highly significant ($P > .01$) differences between breeds. Thus the intra-breed analyses were effective in removing extraneous variations that would have otherwise been confounded with sire effects. The variance components, heritability estimates, and standard error of the heritability estimates are shown in Table XXVI.

The heritability estimates of percent carcass lean and percent carcass fat were both .17. These low heritabilities indicate that selection for lean and fat would result in very slow genetic progress. The high heritability estimate for bone ($h^2 = .64$) indicates that selection for more or less bone could be effective.

Estimates of the heritability of the various specific gravities were moderate to high. The heritability of carcass specific gravity was .72 compared to hindsaddle specific gravity which had a heritability estimate of .23. Loin fat trim weight, which was found to be a good predictor of carcass fat and lean, was estimated to have a heritability of .70. The good predictors of carcass bone, dressing percent and weight of the right fore cannon, were found to have heritability estimates of .13 and .35, respectively.

The heritability estimate of .51 for area of the longissimus dorsi was slightly larger than those reported in Table I. The heritability

TABLE XXV

ANALYSES OF VARIANCE FOR CERTAIN CARCASS CHARACTERISTICS OF LAMBS

Item	Mean Squares		
	Breeds	Sires/ Breeds	Half Sibs/ Sires
Degrees of freedom	4	12	105
Percent carcass lean	52.9660*	11.1652	8.5847
Percent carcass fat	116.7333**	16.1329	12.4982
Percent carcass bone	14.7114*	2.7456	1.1958
Percent trimmed wholesale cuts	2.5686	2.8003	2.3346
Dressing percent	22.3162*	5.1356	4.1628
Carcass specific gravity	16,054.22	7,793.45	3,140.87
Foresaddle specific gravity	14,389.53	13,948.33	5,426.31
Hindsaddle specific gravity	19,517.82*	5,227.33	3,721.92
Rack specific gravity	23,502.60	10,566.92	4,936.44
Loin specific gravity	18,853.33	9,692.00	4,294.59
Untrimmed loin weight	1.5819	.7957	.4548
Weight of kidney knob	1.1291	.8336	.2539
Fat cover over 12th rib	.0199	.0071	.0051
Thickest 12th rib fat	.1626*	.0342	.0231
Thickest 5th rib fat	.1198*	.0232	.0130
Area of *longissimus dorsi*	.0677	.1036	.0520
Untrimmed leg weight	.2724	.4354	.3909
Rack fat trim	.5643**	.1013	.0624
Loin fat trim	1.2031	.4299	.1768
Right fore cannon weight	101.85	43.95	26.80
Leg bone weight	.1290	.0505	.0258

*$P < .05$
**$P < .01$

TABLE XXVI

COMPONENTS OF VARIANCE AND HERITABILITY ESTIMATES OF CERTAIN CARCASS CHARACTERISTICS OF LAMBS

Characteristic	$\hat{\sigma}^2_s$	$\hat{\sigma}^2_w$	$\hat{\sigma}^2_p$	h^2	s_{h^2}
Percent carcass lean	.3818	8.5847	8.9665	.170	.301
Percent carcass fat	.5378	12.4982	13.0362	.165	.298
Percent carcass bone	.2293	1.1958	1.4251	.644	.466
Percent trimmed wholesale cuts	.0689	2.3346	2.4035	.114	.282
Dressing percent	.1439	4.1628	4.3067	.134	.288
Carcass sp. gr.	688.49	3,140.87	3,829.36	.719	.492
Foresaddle sp. gr.	1,261.01	5,426.31	6,687.32	.754	.504
Hindsaddle sp. gr.	222.76	3,721.92	3,944.68	.226	.330
Rack sp. gr.	833.15	4,936.44	5,769.59	.578	.443
Loin sp. gr.	798.66	4,294.59	5,093.25	.627	.460
Untrimmed loin wt.	.0504	.4548	.5052	.399	.381
Wt. of kidney knob	.0858	.2539	.3397	1.010	.593
Fat cover over 12th rib	.0003	.0051	.0054	.222	.318
Thickest 12th rib fat	.0016	.0231	.0247	.259	.335
Thickest 5th rib fat	.0015	.0130	.0145	.414	.387
Area of *L. dorsi*	.0076	.0520	.0596	.510	.420
Untrimmed leg wt.	.0066	.3909	.3975	.066	.265
Rack fat trim	.0058	.0624	.0682	.340	.359
Loin fat trim	.0375	.1768	.2143	.700	.485
Right fore cannon wt.	2.5377	26.80	29.3377	.346	.362
Leg bone wt.	.0037	.0258	.0295	.502	.414

$k = 6.758$

estimate of 12th rib fat thickness was .22. This estimate lies between those of Hillman et al. (1962) and Carpenter (1963) shown in Table I. Carpenter (1963) reported the heritability of cutability (percent closely trimmed retail cuts) as .45. The heritability estimate of cutability (percent trimmed wholesale cuts) from this study was .11 which was considerably lower than Carpenter's (1963) estimate. This difference may have been due in part to the difference in the unit measured.

These relatively high heritability estimates should be observed with caution because of the limited number of sire groups in the study. The standard errors of the heritability estimates given in Table XXVI are all large. If on the other hand these estimates are correct or nearly so, then progress could be expected from selection for the various carcass traits studied. Selection would have to be based on sib or progeny test because information on carcass traits requires that individuals be slaughtered.

Correlations

Genetic and environmental correlations are measures of the genetic and environmental associations affecting the phenotypic correlations between two traits. A genetic correlation among traits is the result of genes favorable for the expression of one trait tending to be either favorable (positive) or unfavorable (negative) for the expression of another trait. Table XXVII shows the genetic, environmental and phenotypic variances and covariances used to compute the genetic, environmental and phenotypic correlations given in Table XXVIII.

These estimates of the genetic, environmental and phenotypic correlations are preliminary and therefore should be considered with caution.

TABLE XXVII

GENETIC, ENVIRONMENTAL AND PHENOTYPIC VARIANCES AND COVARIANCES FOR CERTAIN CARCASS CHARACTERISTICS

		Dressing Percent	Carcass Specific Gravity	Loin Fat Trim Weight	Right Fore Cannon Weight	Percent Carcass Lean	Percent Carcass Bone	Percent Carcass Fat
Dressing percent	G[a]	.5758	-28.8438	.2333	.5244	-.6155	.3737	1.1789
	E	3.7310	-11.7029	.2317	-2.5576	-1.4958	-1.4507	2.2825
	P	4.3068	-40.5466	.4650	-2.0331	-2.1113	-1.0770	3.4614
Carcass specific gravity	G		2753.80	-4.5036	7.6723	61.6805	22.7101	-81.6765
	E		1075.52	-6.4754	83.8672	41.8891	10.9580	-54.8674
	P		3829.32	-10.9790	91.5395	103.5696	33.6681	-136.5439
Loin fat trim weight	G			.1498	.2357	-.4198	-.0220	.4227
	E			.0644	-.9761	-.4797	-.2939	.7869
	P			.2142	-.7404	-.8994	-.3159	1.2096
Right fore cannon weight	G				10.1529	-2.8430	3.0429	-.3729
	E				19.1866	5.8333	.8099	-6.3707
	P				29.3396	2.9903	3.8528	-6.7436
Percent carcass lean	G					1.5273	-.0260	-1.3904
	E					7.4392	1.4290	-8.8905
	P					8.9666	1.4031	-10.2808
Percent carcass bone	G						.9173	-.8853
	E						.5078	-1.9283
	P						1.4251	-2.8136
Percent carcass fat	G							2.1513
	E							10.8847
	P							13.0360

[a]Genetic (G), environmental (E) and phenotypic (P).

TABLE XXVIII

GENETIC, ENVIRONMENTAL AND PHENOTYPIC CORRELATIONS AMONG CERTAIN CARCASS CHARACTERISTICS

		Carcass Specific Gravity	Loin Fat Trim Weight	Right Fore Cannon Weight	Percent Carcass Lean	Percent Carcass Bone	Percent Carcass Fat
Dressing percent	G[a]	-.72	.79	.22	-.66	.51	1.04
	E	-.18	.47	-.30	-.28	-1.05	.36
	P	-.32	.48	-.18	-.34	-.44	.47
Carcass specific gravity	G		-.22	.05	.95	.45	-1.06
	E		-.78	.58	.47	.47	-.51
	P		-.38	.27	.56	.46	-.61
Loin fat trim weight	G			.19	-.88	-.06	.74
	E			-.88	-.69	-1.62	.94
	P			-.30	-.65	-.57	.72
Right fore cannon weight	G				-.72	.99	-.08
	E				.49	.26	-.44
	P				.18	.60	-.34
Percent carcass lean	G					-.02	-.77
	E					.74	-.99
	P					.39	-.95
Percent carcass bone	G						-.63
	E						-.82
	P						-.65

[a]Genetic (G), environmental (E) and phenotypic (P).

Because of the small number of sires there are only 12 degrees of freedom available for estimating between sire differences. The correlations between percent carcass fat and the other variables were in some cases larger than one. These large genetic correlations may have been due in part to the small fraction of the total variance in carcass fat that was genetic and to sampling errors. The small genetic variance strongly influenced the denominator of the correlation and therefore the magnitude of the genetic correlation.

The genetic correlation between percent lean and percent fat was -.77 and the sign of the coefficient indicated that selection against carcass fat was not antagonistic to selection for more lean meat. The environmental correlation was also highly negative (r_e = -.99) which gives evidence that the environment that favored lean production also favored production of less fat.

In general, those measurements of fat which were good predictors of fat were also highly related genetically to carcass fat. There was a direct genetic relationship between dressing percent and percent carcass fat as measured by a correlation which exceeded one (r_g = 1.043). Loin fat was also positively correlated (r_g = .74) to percent carcass fat. Carcass specific gravity was highly negatively correlated (r_g = -1.061) to carcass fat.

The genetic correlation between percent carcass lean and carcass specific gravity was 0.95. This large genetic correlation indicated that positive genetic improvement in percent carcass lean can be made through selection for carcass specific gravity. Selection, of course, would have to be made from data collected on progeny or sibs since slaughter of the lamb is necessary for measuring carcass specific gravity.

The genetic correlations of carcass lean with dressing percent and loin fat were -.66 and -.89, respectively. This implies that selection for lower dressing percent and less loin fat trim should result in a larger percent carcass lean.

The weight of the right fore cannon was highly related genetically to total carcass bone (r_g = .99). It should be noted that this is a part-whole relationship although the right fore cannon makes up about only one sixty-fourth of total bone weight. The genetic correlation between carcass specific gravity and carcass bone was 0.45. This correlation indicates that selection for or against carcass bone based on carcass specific gravity would result in genetic change.

Although these estimates of genetic parameters were based on a small number of sire groups and therefore subject to large errors, they do indicate that genetic improvement can be anticipated from a good selection program. In addition, it appears that there are no basic antagonisms between carcass traits studied.

SUMMARY

The data used in this study were collected over a period of two years using 123 lambs sired by Dorset, Hampshire and Suffolk rams. The lambs were out of Western and Dorset x Western crossbred ewes. All lambs were from the experimental flock at the Fort Reno Livestock Research Station. Ten days to two weeks after birth the lambs were placed on wheat pasture with their dams. The lambs had access to a high concentrate ration while on the wheat pasture and they were weaned when they weighed a minimum of 46 pounds and were at least 66 days old. On the first Monday that the lambs reached a minimum full weight of 100 pounds they were taken off feed and transported to Stillwater. The lambs were slaughtered after being sheared and held off feed for 18 hours. Carcass measurements, specific gravities and various measures of the fat trim, bone and edible portion of the wholesale cuts were obtained. Carcass composition was determined from the weight of separable bone and the percent ether extract in the boneless portion. The lean tissue weight was determined by difference.

The composition of the carcass was predicted at three stages in the cutting of the carcass utilizing the measurements available at each stage. The stages were: 1) as the carcass hung from the rail, 2) after the carcass was cut into fore- and hindsaddles and 3) after the saddles were cut into bone-in and boneless wholesale cuts. A stepwise multiple linear regression technique was used which entered one variable at a time into the prediction equations.

Carcass specific gravity was the best predictor of carcass fat and lean of the measurements available on the carcass as it hung from the rail. Carcass specific gravity accounted for 34 and 32 percent of the variation in the carcass fat and lean, respectively. When carcass specific gravity and loin probe were included in a prediction equation the equation accounted for 50 percent of the variation in carcass fat. The weight of all four cannons was available for only one year's lambs but accounted for 66 percent of the variation in percent carcass bone. Dressing percent and weight of all four cannons when used together in a prediction equation increased the variance accounted for to 80 percent. It appeared that the inclusion of more than two independent variables did not substantially increase the accuracy of the prediction.

The additional measurements available from the fore- and hindsaddles increased the accuracy of prediction only slightly. Hindsaddle specific gravity yielded regression equations which accounted for 47 and 46 percent of the variation in carcass fat and lean, respectively. The new measurements did not greatly improve the estimating equations for the percent carcass bone.

When the carcass was cut into bone-in and boneless wholesale cuts it was found that the weight of the fat trimmed from the loin was the best predictor of percent fat and lean. Loin fat trim weight accounted for 64 and 57 percent of the variation in percent carcass fat and lean, respectively. The addition of hindsaddle specific gravity to the regression equations for estimating fat and lean increased the variance accounted for to 73 and 65 percent, respectively. Detailed measurements appear necessary if the composition of individual lamb carcasses are to be estimated with a high degree of certainty.

Dressing percent was found to be the best predictor of percent trimmed wholesale cuts and accounted for 31 percent of the variation in trimmed wholesale cuts. When carcass specific gravity was included in the regression equation with dressing percent 58 percent of the variation in trimmed wholesale cuts was accounted for.

Preliminary estimates of the heritability of certain carcass traits and the genetic correlations between carcass traits were also studied using the intra-group paternal half-sib analysis of variance and covariance. The heritability estimates of certain carcass traits were: percent carcass lean, .17; percent carcass fat, .17; percent carcass bone, .64; percent trimmed wholesale cuts, .11; carcass specific gravity, .72; hindsaddle specific gravity, .23; loin fat trim, .70; and right fore cannon weight, .35. These estimates indicate that selection for any one of these traits should be effective. The genetic correlations presented indicate that selection for lean meat and against fat are not antagonistic.

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APPENDIX

TABLE XXIX

MEAN VALUES FOR VARIOUS CARCASS AND FAT THICKNESS MEASUREMENTS BY SIRE AND BREED FOR THE 1963 LAMBS

Sire and Breed	N	Slaughter Weight (lbs.)	Chilled Carcass Wt. (lbs.)	Dressing Percent	Kidney Knob (lbs.)	Fat Cover Over 12th Rib (in.)	Thickest 12th Rib Fat (in.)	Thickest 5th Rib Fat (in.)	Loin Probe
38	6	91.2	49.71	54.50	1.68	.21	.69	.63	.64
44	6	88.2	50.02	56.73	1.82	.30	.84	.77	.71
48	6	87.8	49.02	55.88	2.06	.24	.79	.64	.65
All Hampshires	18	89.1	49.58	55.71	1.85	.25	.78	.68	.67
49	6	89.4	47.88	53.65	1.38	.24	.59	.57	.56
50	6	89.4	48.23	54.12	1.45	.19	.60	.57	.57
All Suffolks	12	89.4	48.06	53.88	1.42	.22	.59	.57	.57
32	6	89.2	50.60	56.75	1.84	.25	.84	.74	.78
33	6	88.3	49.24	55.80	1.87	.24	.79	.66	.64
34	6	88.5	49.78	56.22	2.21	.30	.86	.64	.74
51	6	88.6	50.28	56.75	1.62	.21	.79	.60	.75
53	6	87.1	50.72	58.23	2.42	.28	.90	.68	.77
All Dorsets	30	88.3	50.12	56.75	1.99	.25	.84	.66	.73
All Lambs	60	88.8	49.55	55.86	1.83	.24	.77	.65	.68

TABLE XXX

MEAN VALUES FOR VARIOUS CARCASS AND FAT MEASUREMENTS BY SIRE AND BREED FOR THE 1964 LAMBS

Sire and Breed	N	Slaughter Weight (lbs.)	Chilled Carcass Wt. (lbs.)	Dressing Percent	Kidney Knob (lbs.)	Fat Cover Over 12th Rib (in.)	Thickest 12th Rib Fat (in.)	Thickest 5th Rib Fat (in.)	Loin Probe
47	8	91.4	52.88	57.85	1.79	.23	.75	.83	.76
48	8	91.2	53.01	58.09	2.73	.25	.57	.64	.74
All Hampshires	16	91.3	52.94	57.97	2.26	.24	.66	.74	.75
7	8	94.1	52.48	55.76	2.04	.19	.62	.54	.60
8	8	93.4	53.45	57.22	2.09	.23	.78	.59	.61
All Suffolks	16	93.8	52.97	56.49	2.07	.21	.70	.57	.61
1	9	91.7	52.61	57.37	2.69	.32	.79	.75	.84
2	8	92.8	54.09	58.34	2.83	.29	.75	.75	.90
3	8	93.6	52.78	56.35	2.11	.25	.71	.76	.77
4	6	93.2	53.78	57.79	2.08	.30	.84	.74	.90
All Dorsets	31	92.8	53.26	57.43	2.46	.29	.77	.75	.85
All Lambs	63	92.7	53.11	57.33	2.31	.26	.72	.70	.76

TABLE XXXI

MEAN VALUES FOR CARCASS COMPOSITION AND GRADES BY BREED AND SIRE FOR THE 1963 LAMBS

Sire and Breed	N	Percent Lean in the Carcass	Percent Fat in the Carcass	Percent Bone in the Carcass	Percent Trimmed Wholesale Cuts	Conformation Grade	Quality Grade	Carcass Grade	Area L. Dorsi (sq. in.)
38	6	56.88	25.92	17.19	37.13	3.5	3.8	3.3	2.14
44	6	56.55	27.12	16.33	37.60	3.2	3.7	3.5	2.34
48	6	54.47	29.36	16.20	37.42	3.5	4.0	3.7	2.10
All Hampshires	18	55.97	27.47	16.58	37.38	3.4	3.8	3.5	2.19
49	6	59.68	22.20	18.20	37.62	3.5	4.5	4.0	2.18
50	6	59.22	22.96	17.82	37.77	4.0	4.5	4.3	2.30
All Suffolks	12	59.45	22.58	18.01	37.69	3.8	4.5	4.2	2.24
32	6	53.69	29.84	16.47	37.28	4.2	4.0	4.2	2.16
33	6	55.97	27.56	16.40	37.37	3.3	4.0	3.7	2.22
34	6	53.90	29.52	16.59	37.10	3.7	3.3	3.5	2.09
51	6	56.99	26.26	16.76	39.52	1.5	3.0	2.3	2.48
53	6	54.20	31.34	14.45	38.75	2.3	2.5	2.3	2.34
All Dorsets	30	54.95	28.90	16.13	38.00	3.0	3.4	3.2	2.26
All Lambs	60	56.15	27.21	16.64	37.76	3.3	3.7	3.5	2.23

TABLE XXXII

MEAN VALUES FOR CARCASS COMPOSITION AND GRADES BY BREED AND SIRE FOR THE 1964 LAMBS

Sire and Breed	N	Percent Lean in the Carcass	Percent Fat in the Carcass	Percent Bone in the Carcass	Percent Trimmed Wholesale Cuts	Conformation Grade	Quality Grade	Carcass Grade	Area L. Dorsi (sq. in.)
47	8	52.48	31.07	16.45	37.69	2.5	3.4	3.1	2.50
48	8	52.72	31.83	15.46	38.21	2.0	3.2	2.5	2.49
All Hampshires	16	52.60	31.45	15.96	37.95	2.2	3.3	2.8	2.50
7	8	54.54	27.88	17.56	37.51	3.6	3.8	3.6	2.36
8	8	54.67	28.42	16.90	37.97	3.8	3.2	3.5	2.30
All Suffolks	16	54.61	28.15	17.23	37.74	3.7	3.5	3.6	2.33
1	9	51.55	32.89	15.33	36.84	3.0	3.7	3.4	2.46
2	8	52.41	31.66	15.93	37.63	3.1	3.4	3.1	2.40
3	8	55.23	29.31	15.48	37.10	1.8	3.4	2.5	2.48
4	6	53.08	31.07	15.70	37.56	2.5	3.2	3.0	2.16
All Dorsets	31	53.02	31.29	15.60	37.25	2.6	3.4	3.0	2.39
All Lambs	63	53.31	30.53	16.10	37.55	2.8	3.4	3.1	2.40

TABLE XXXIII

MEAN VALUES FOR SPECIFIC GRAVITY OF THE CARCASS, FORE- AND HINDSADDLES AND WHOLESALE CUTS OF THE 1963 LAMBS

Sire and Breed	N	Specific Gravity of Carcass	Specific Gravity of Foresaddle	Specific Gravity of Hindsaddle	Specific Gravity of Rack	Specific Gravity of Loin	Specific Gravity of Leg
38	6	1.0459	1.0516	1.0408	1.0445	1.0332	1.0622
44	6	1.0379	1.0379	1.0373	1.0325	1.0254	1.0576
48	6	1.0329	1.0334	1.0328	1.0280	1.0196	1.0582
All Hampshires	18	1.0389	1.0410	1.0369	1.0350	1.0261	1.0593
49	6	1.0466	1.0491	1.0435	1.0424	1.0330	1.0608
50	6	1.0454	1.0471	1.0438	1.0398	1.0308	1.0624
All Suffolks	12	1.0460	1.0481	1.0437	1.0411	1.0319	1.0616
32	6	1.0400	1.0459	1.0341	1.0307	1.0182	1.0605
33	6	1.0364	1.0372	1.0351	1.0306	1.0247	1.0561
34	6	1.0376	1.0418	1.0332	1.0326	1.0206	1.0599
51	6	1.0439	1.0490	1.0393	1.0358	1.0268	1.0598
53	6	1.0382	1.0425	1.0340	1.0304	1.0246	1.0593
All Dorsets	30	1.0392	1.0433	1.0351	1.0320	1.0230	1.0591
All Lambs	60	1.0405	1.0436	1.0374	1.0347	1.0257	1.0597

TABLE XXXIV

MEAN VALUES FOR SPECIFIC GRAVITY OF THE CARCASS, FORE- AND HINDSADDLES AND WHOLESALE CUTS OF THE 1964 LAMBS

Sire and Breed	N	Specific Gravity of Carcass	Specific Gravity of Foresaddle	Specific Gravity of Hindsaddle	Specific Gravity of Rack	Specific Gravity of Loin	Specific Gravity of Leg
47	8	1.0412	1.0455	1.0376	1.0334	1.0237	1.0608
48	8	1.0376	1.0424	1.0333	1.0302	1.0210	1.0611
All Hampshires	16	1.0394	1.0440	1.0354	1.0318	1.0223	1.0610
7	8	1.0436	1.0488	1.0400	1.0374	1.0260	1.0630
8	8	1.0424	1.0472	1.0377	1.0366	1.0225	1.0631
All Suffolks	16	1.0430	1.0480	1.0388	1.0370	1.0243	1.0630
1	9	1.0366	1.0423	1.0321	1.0307	1.0180	1.0594
2	8	1.0378	1.0428	1.0348	1.0319	1.0236	1.0610
3	8	1.0424	1.0458	1.0389	1.0371	1.0245	1.0636
4	6	1.0395	1.0446	1.0354	1.0344	1.0215	1.0596
All Dorsets	31	1.0390	1.0438	1.0352	1.0334	1.0218	1.0610
All Lambs	63	1.0401	1.0449	1.0362	1.0339	1.0226	1.0615

TABLE XXXV

MEAN VALUES OF SOME MEASUREMENTS OBTAINED FROM THE WHOLESALE CUTS OF THE 1963 LAMBS

Sire and Breed	N	Un-trimmed Loin (lb.)	Un-trimmed Leg (lb.)	Fat Trimmed From Rack (lb.)	Fat Trimmed From Loin (lb.)	Right Cannon (gm.)	Trimmed Leg (lb.)	Edible Leg (lb.)	Leg Bone (lb.)
38	6	8.86	13.03	1.25	2.27	59.5	11.62	9.62	1.99
44	6	8.81	13.04	1.52	2.52	58.7	11.24	9.36	1.89
48	6	8.61	12.78	1.41	2.37	56.2	11.22	9.39	1.85
All Hampshires	18	8.76	12.95	1.39	2.39	58.1	11.36	9.46	1.91
49	6	8.21	12.89	1.03	1.73	57.7	11.62	9.63	1.99
50	6	8.58	13.05	1.18	2.02	59.2	11.68	9.69	1.98
All Suffolks	12	8.39	12.97	1.10	1.88	58.4	11.65	9.66	1.98
32	6	9.85	12.68	1.71	3.00	55.7	11.10	9.23	1.88
33	6	8.77	12.97	1.36	2.30	55.3	11.22	9.42	1.80
34	6	8.85	12.58	1.49	2.54	59.2	11.10	9.32	1.79
51	6	8.74	13.30	1.31	2.06	58.8	11.81	9.89	1.91
53	6	9.61	12.38	1.48	2.78	50.2	10.78	9.19	1.58
All Dorsets	30	9.16	12.78	1.47	2.54	55.8	11.20	9.41	1.79
All Lambs	60	8.89	12.87	1.37	2.36	57.0	11.34	9.48	1.87

TABLE XXXVI

MEAN VALUES OF SOME MEASUREMENTS OBTAINED FROM THE WHOLESALE CUTS OF THE 1964 LAMBS

Sire and Breed	N	Un-trimmed Loin (lb.)	Un-trimmed Leg (lb.)	Fat Trimmed From Rack (lb.)	Fat Trimmed From Loin (lb.)	Right Cannon (gm.)	Trimmed Leg (lb.)	Edible Leg (lb.)	Leg Bone (lb.)
47	8	9.96	12.81	1.77	2.97	59.8	11.16	9.24	1.91
48	8	9.86	12.60	1.59	2.75	57.0	11.07	9.28	1.78
All Hampshires	16	9.91	12.70	1.68	2.86	58.4	11.11	9.26	1.85
7	8	9.51	13.06	1.32	2.41	63.0	11.68	9.72	1.96
8	8	9.89	12.90	1.43	2.67	64.4	11.44	9.68	1.89
All Suffolks	16	9.70	12.98	1.38	2.54	63.7	11.56	9.70	1.92
1	9	9.79	12.63	1.75	2.90	59.2	11.01	9.36	1.78
2	8	10.00	12.96	1.67	2.82	61.1	11.28	9.40	1.88
3	8	9.82	12.63	1.56	2.55	55.5	11.24	9.53	1.76
4	6	10.42	13.18	1.74	3.04	58.3	11.41	9.61	1.82
All Dorsets	31	9.97	12.82	1.68	2.82	58.6	11.21	9.46	1.81
All Lambs	63	9.89	12.83	1.60	2.76	59.8	11.27	9.47	1.85

VITA

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