Some Relationships Between Lamb Growth and Carcass Composition and Among Various Measures of Carcass Merit

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There has been an ever increasing interest among stockmen in the real merit of their end product—the carcass. This is as it should be. Whatever changes are made either to improve animals through breeding or to improve efficiency of production through changes in feeding or management should not reduce the value of the carcass and, preferably, should increase it.

One of the principal difficulties encountered by stockmen and research men alike in relation to improving carcasses has been with regard to measurements of carcass value. There are many measurements that have been used. Some measure one characteristic of the carcass, others measure other characteristics. Some are good measures, others are not. Some are of interest to one segment of the industry, others to different segments. Some are very expensive to obtain, others are cheaper. In many instances the relationships among the measurements are not known or are different for different groups of carcasses.

Much of the criticism that has been directed toward the judging of our fat stock shows has arisen because the placing of the live animals did not agree with the carcass placing. Such critics have assumed that the carcass placing has been correct. It may not have been. While it is true that there are certain characteristics that can be best evaluated by an examination of the carcass, there are other characteristics that can be best evaluated in the live animal.

To solve this problem the cattle and sheep producers and research personnel should follow the example of the swine industry. Over twenty-five years ago it was discovered that a relatively simple measure on the swine carcass was a good predictor of carcass fatness. By associating live animal evaluations with this and other carcass measurements, research men, judges and producers changed their ideas of what constituted a good animal. Currently the industry is making rapid strides in really improving pork carcasses. The beef and sheep industries have been trying to follow their lead but have both encountered the same problem—a good carcass measurement.

With these ideas and problems in mind, the Animal Science Department started a study in 1962 to:

1. Develop easily obtained measures of lamb carcass merit.
2. Determine the relationships among the measures.
3. Associate the development of muscle, fat and bone in the carcass with growth and fattening patterns of the live lambs.
4. Determine detectable live lamb characteristics that are indicative of carcass excellence.

There were many reasons for selecting lambs as experimental animals.

1. To the best of our knowledge, lamb and beef carcasses develop similarly and are comparable in structure and composition. They differ principally in size.
2. To obtain the desired accuracy of certain measurements requires reducing the carcass to ground meat resulting in a per carcass loss of $10.00 for lambs or $100.00 for steers. Hundreds of carcasses are required to learn the desired answers.
3. Lambs of known origin and with complete records of growth were available.

The results from the study can be checked with relatively few cattle carcasses to determine their applicability. This paper presents some results of this continuing study.

Materials and Methods

The 124 wether lambs used in this study were produced and raised at the Ft. Reno Livestock Research Station. The ewes that produced the lambs were of predominantly Rambouillet breeding or were crosses between these ewes and Dorset rams. The lambs selected for slaughter were one-half black faces (out of Hampshire or Suffolk rams) and one-half white faces (out of Dorset rams.) One-half of the lambs by each sire were singles and one-half were twins.

The lambs were born between October 15 and November 25. They were moved with their dams to wheat pasture when they were about 10 days old. Creep feed was available to them at all times thereafter. When the lambs were about 10 weeks old, they were weaned by the removal of their dams. From weaning until slaughter they were self-fed while grazing on wheat pasture.

As the lambs approached 100 pounds full weight, they were weighed weekly. When a lamb weighed 100 or more pounds, he was hauled to the meat laboratory at Oklahoma State University. He was slaughtered about 18 hours after his Ft. Reno full weight was taken and during which time he had no feed nor water, was hauled 100 miles and was sheared. Thus, the slaughter weight was a thoroughly shrunk weight of a fresh sheared lamb.

The carcasses were allowed to chill for about 48 hours before chilled weights were taken at which time the carcasses were processed and further measurements recorded. Although about 65 measurements were taken on each carcass, only those in Table 1 will be considered in this paper. These include many of the commonly used measurements plus some that in this study appeared to be better measurements of some characteristic of the carcasses.

Table 1. A Summary of the Measures of Growth and Carcass Merit of the Lambs Used in the Study.

Measure	Mean[1]
Birth weight (lb.)	9.3
Av. daily gain to 10 wks. (lb.)	0.63
Av. daily gain after 10 wks. (lb.)	0.57
Wt./da./age at slaughter (lb.)	0.66
Shrunk live weight (lb.)	90.6
Dressing percentage (Percent)	56.6
Ether extract (Percent)	28.9
Total carcass fat (lb.)	14.9
Loin fat trim (lb.)	2.6
Wholesale cut fat trim (lb.)	6.9
Fat at 12th rib (in.)	0.25
Quality score	11.4
Carcass Lean (Percent)	54.7
Total carcass lean (lb.)	28.0
Edible wholesale cut (lb.)	28.1
Ratio, lean to bone (lb.)	3.31
Conformation score	11.9
Specific gravity, hind	1.037
Loin eye area (sq. in.)	2.31
Trimmed wholesale cuts (Percent)	37.6
Carcass bone (percent)	16.4
Total bone (lb.)	8.4

[1] Mean = Average

The following measurements may need some explanation:

1. Ether extract—this is a measure of the percent fat in the carcass obtained by grinding the bone free portion, sampling the mixture and chemically determining the fat content.
2. Loin fat trim—this is the weight of fat trimmed from the loin. In this study it was the best measure of fat in the carcass other than ether extract which requires grinding the whole carcass.
3. Quality and conformation scores were given values prime + = 15; prime = 14; prime — = 13; choice + = 12; etc. These carcasses were scored by a highly qualified grader.
4. Carcass lean (Percent)—this measure was obtained by difference, that is, 100 percent minus percent ether extract minus percent bone = percent lean.
5. Edible wholesale cut—this was the pounds of shoulder, rack, loin and leg after all external fat was trimmed off and the bone was removed.
6. Ratio of lean to bone—pounds of lean per pound of bone. The idea here is that the amount of fat in a carcass is controllable by feeding methods or when the animal is removed from feed and marketed. The ratio of lean to bone is more likely to be bred into the animal.
7. Specific gravity, hind—this is a measure of the density of the hind saddle (the hind saddle of a lamb is essentially the same as the two hind quarters of a beef carcass.) Since fat is lighter than water, the fatter carcasses have lower specific gravities. This was

one of the best measures of either percent fat or percent lean in the carcasses.

Results

In reviewing these results, a very important consideration should be kept in mind. The lambs were killed at very similar live weights. Thus, carcass weights were very uniform. Herein these results are or may be different than those usually obtained with beef carcasses and frequently obtained with lamb carcasses. If animals are slaughtered such that live and carcass weights vary widely, there are automatic associations in the results that cause confusion. Larger carcasses will frequently have larger rib-eye areas, more fat, and more lean because they are larger. Thus, any measurement involving area, distance, or weight of some part is usually associated with carcass weight. Carcasses are sold by the pound and, consequently, percentages of the tissues (fat, lean and bone) may be more indicative of value per pound. Figure 1 illustrates schematically how the carcass develops from birth until about 30 percent fat is deposited.

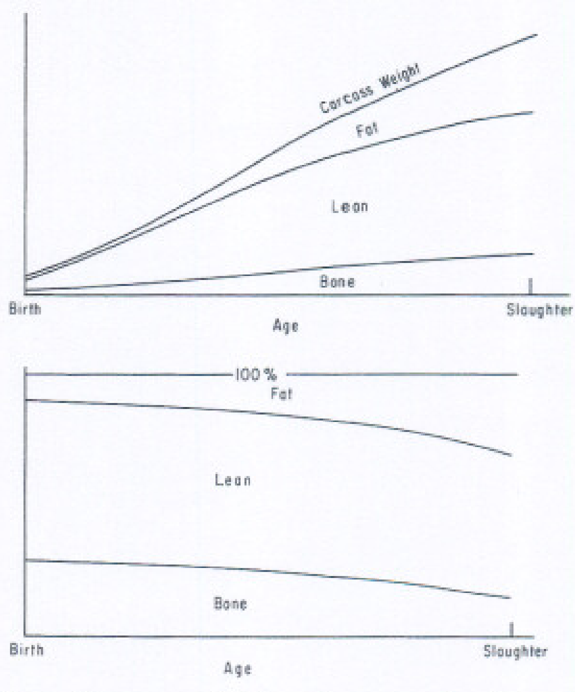

Figure 1. Schematic representation of carcass development in pounds (top) and in percentage (bottom).

In each case the carcass develops until it is about 16 percent bone, 54 percent lean and 30 percent fat. In the upper figure, normal carcass development is depicted where the upper curved line represents carcass weight and the space between the lines represents the principal tissue at different ages. Bone growth is relatively constant throughout. Lean development is rapid early but slows down toward the end. Fat deposition starts slowly but is increasing rapidly toward the end. All tissues are still increasing at the end so that if the animal is allowed to get bigger, the amounts of fat, lean, and bone will all increase.

In the lower figure where the top line represents 100 percent of the carcass, it can be seen that as the animal gets older and fat deposition increases, the percentages of both lean and bone must decrease.

The lamb carcasses used in this study are probably comparable in their relationships to what would be found in beef carcasses if calves were creep fed, weaned at about 175 days of age, put on a full feed and slaughtered at about 700 pounds.

Single vs twin lambs. One of the principal sources of variation in lamb growth rate is associated with whether a lamb is born and raised as a single or as one of a set of twins. On the average single lambs are genetically similar to twins and differences in growth rate are principally due to the fact that twin lambs usually get only about 65 percent as much milk as singles. Consequently, an analysis of the carcasses from singles as compared to twins should reflect the influence of milk during early life on carcass composition.

Table 2 shows the comparison of single and twin lambs for growth measures and certain carcass characteristics. The single lambs were 1.7 pounds heavier at birth, gained .14 pounds per day more up to 10 weeks of age (approximate weaning age), and gained only slightly faster after 10 weeks than the twin lambs. The average slaughter age was 148 days for singles and 171 days for twins.

The carcass measures indicate that the single lambs had less fat and more bone than the twins. The single and twin lambs had similar average values for lean tissue, percent trimmed wholesale cuts, loin eye area, and hind saddle specific gravity. The twin lambs had more fat trim from the loin and a higher ratio of lean to bone than the singles.

There were enough lambs involved in this study to critically evaluate the difference between single and twin wether lambs when they are slaughtered at similar and realistic weights. The differences observed are interpreted to be primarily a result of the differences in milk consumption by the lambs. Since none of the carcass differences are very great, it seems logical to assume that milk consumption during early life has relatively little influence on carcass composition when the lambs are slaughtered at similar weights.

Type of sire of lambs. It has been established that animals with a larger mature size exhibit a slightly different growth pattern than those with a smaller size. For this reason one-half of the lambs used in this

Table 2. Growth Rate and Carcass Composition of Single and Twin Lambs.

Characteristic	Singles	Twins
Number	62	62
Birth Weight (lbs.)	10.1	8.4
Av. Daily gain to 10 wks.	.70	.56
Av. Daily gain (10 wks. to sl.)	.58	.56
Dressing percentage	56.4	56.8
Ether Extract (Percent)[1]	28.5	29.2
Lean tissue (Percent)[1]	54.8	54.7
Bone and tendons (Percent)[1]	16.7	16.1
Trimmed wholesale cuts (Percent)[2]	37.6	37.6
Loin fat trim (lb.)	2.46	2.66
Fat at 12th rib (in.)	.24	.26
Loin eye area (sq. in.)	2.31	2.32
Specific gravity, hind	1.036	1.036
Ratio of lean to bone	3.25	3.36

[1] Based on chilled carcass weight.
[2] Based on shrunk, sheared live weight. Cuts are shoulder, rack, loin and leg.

experiment were sired by Hampshire and Suffolk rams (relatively large) and one-half were sired by Dorset rams (relatively small.) Although a few Dorset (whiteface) rams were larger than the smallest Hampshire and Suffolk (blackface) rams, the blackfaced rams averaged considerably larger than the whitefaced rams.

The results in Table 3 illustrate the influence that the type of sire can transmit to his offspring. Relative to the growth pattern, the type of sire had little influence on either birth weight or early growth rate. The size of the newborn is largely governed by the size of the dam and her nutritive state. The rate of early growth is mostly governed by the milk supply. The blackfaced lambs gained considerably faster from 10 weeks until slaughter. Since the lambs were weaned at about 10 weeks of age, their inherited capacity for gain came into play and could be exhibited. It should be remembered that both kinds of lambs had the same kind of mothers so that the differences shown in Table 3 are the influence of their sires.

A study of the carcass characteristics in Table 3 indicates that the whitefaced lambs had a higher dressing percentage, more ether extract (fat), more loin fat trim, and more fat at the 12th rib than the blackfaced lambs. All of the above measures are either measures of fat or are influenced by fat. Apparently, as is generally believed, the whitefaced lambs increase their fat deposition (Figure 1) at a lighter weight so that at 100 pounds live weight, they have deposited more fat than the blackfaced lambs.

The blackfaced lambs had more lean and bone which was also reflected in higher specific gravity values. It should be noted that neither percent trimmed wholesale cuts nor loin eye area showed a difference between the whiteface and blackfaced lambs. Their value in predicting carcass composition has been questioned before. They have some predictive value but, as this data indicates, they are not good indicators.

Table 3. Growth Rate and Carcass Composition of Whitefaced (Dorset Sired) and Blackfaced (Hampshire or Suffolk Sired) Lambs.

Characteristic	Whitefaced	Blackfaced
Number	62	62
Birth weight (lb.)	9.2	9.3
Average daily gain to 10 wks.	.63	.63
Average daily gain (10 wks. to sl.)	.54	.61
Dressing percentage	57.1	56.1
Ether extract (Percent)[1]	30.1	27.7
Lean tissue (Percent)[1]	54.0	55.5
Bone and Tendons (Percent)[1]	15.9	16.9
Trimmed wholesale cuts (Percent)[2]	37.6	37.6
Loin fat trim (lb.)	2.68	2.44
Fat at 12th rib (in.)	.27	.23
Loin eye area (sq. in.)	2.32	2.31
Specific gravity, hind	1.035	1.038
Ratio of lean to bone	3.37	3.25

[1] Based on chilled carcass weight.
[2] Based on shrunk, sheared live weight. Cuts are shoulder, rack, loin and leg.

This portion of the study indicates that sires may rather strongly influence the percentages of fat, lean, and bone of their progeny where such progeny are killed at about the same weight. This probably comes about through transmitted tendencies to start rapid fattening at different sizes as the lambs grow and also through transmitted ability to grow lean tissue at different rates. A lamb with great inherited ability to grow lean and bone tissue will probably reach 100 pounds before he has time to deposit much fat. On the other hand a lamb with poor lean and bone growth potential will have time to deposit more fat before reaching 100 pounds. Inherited ability to fatten and inherited ability to grow both influence growth rate and carcass composition. Consequently, the association between growth rate and carcass composition is not high as shown in Table 4.

The size of the correlation (whether + or —) between two measures is an indication of how precisely one may be predicted from the other. None of the correlations in Table 4 are high enough to have good predictive value.

Evaluation of measurements. As suggested in the introduction, there is a great need for measurements which will accurately tell something about a carcass. No single measurement will give good information about the several carcass characteristics that are of interest to different people. This study attempted to find good indicators of the percentages of fat, lean, and bone in the carcass. If a measure will give a good prediction of percent fat, the percent value multiplied times the carcass weight will give the amount of fat.

These data were analyzed to determine the association (correlation) between several measures and the composition of fat, lean and bone. The study was conducted in such a way that the values given in Table 5 represent the associations that one would expect to find among lamb car-

Table 4. Correlation[1] Between Measures of Rate of Gain and Measures of Carcass Composition.

Measures of composition	Birth Wt.	Measures of Rate of Gain A.D.G. to 10 weeks	A.D.G. after 10 weeks
Ether extract (Percent)	—.48	—.25	—.22
Lean tissue (Percent)	.44	.04	.18
Bone and tendons (Percent)	.49	.29	.33
Loin eye area (sq. in.)	.15	.18	.07
Loin fat trim (lb.)	—.40		—.38
Trimmed wholesale cuts (Percent)	.14		—.10
Fat at 12th rib	—.25		—.13

[1] These associations are what would be found among lambs of the same face color and rearing category.

casses from wether lambs of the same face color and the same birth and rearing category. If a measure is to be a good one, it must detect differences among carcasses that are reasonably uniform as would be found in these data handled as described.

An examination of the correlations in Table 5 indicates that the same measure does not show the same relation to the percentages of the three tissues. The percent ether extract was best estimated by the wholesale cut fat trim, loin fat trim, or specific gravity of the hind saddle. It should be noted that thickness of fat at the 12th rib (a standard measure) had only moderate predictive value. None of the other measures were of much value in predicting percent ether extract.

Percent lean was best estimated by the same measures as percent ether extract, that is, wholesale cut fat trim, loin fat trim, and the specific gravity of the hind saddle. (The fact that some of the correlations are negative does not influence the predictability of the measure). It should be noted that the size of the rib eye (another standard measure) has low predictive value. None of the other measures were good predictors.

Percent bone was best predicted by the weights of the four cannon bones. This has been reported by other workers and was not surprising. None of the other measures were nearly as good as the bone weight. Since these bones can be cut from a carcass for weighing without materially influencing the value of the carcass, it can be a valuable measure of bone where such is needed.

A few other relationships are worthy of note. Quality score, which is our best evaluation of marbling, was not highly associated with any of the carcass component percentages. It should be kept in mind, however, that these carcasses were from full-fed lambs and were all adequate in quality.

Conformation score, which is an evaluation of the shape of the carcass, was almost if not completely unrelated to the percentages of ether extract and lean. Trimmed wholesale cuts, as a percentage of live weight, was a poor indicator of carcass composition as was edible wholesale cut weight.

Table 5. Correlations of Several Measures with Carcass Composition, i.e., the Percentages of Fat, Lean, and Bone.

Measures	Carcass Composition Percent E.E.	Percent Lean	Percent Bone
Dressing percentage	.40	—.38	—.57
Wholesale cut fat trim (lbs.)	.75	—.69	—.62
Loin fat trim (lbs.)	.75	—.69	—.63
Fat 12th rib (in.)	.59	—.55	—.46
Quality score	.32	—.26	—.38
Edible wholesale cuts (lbs.)	—.14	.16	—.11
Ratio, lean to bone (lbs.)	—.04	.23	—.47
Specific gravity, hind	—.70	.69	.60
Loin eye area (sq. in.)	—.35	.37	.03
Conformation score	.07	.01	—.22
Trimmed wholesale cuts (Percent)[1]	—.26	.27	—.05
Wt. of cannon bones (gm.)			.81[2]
Total carcass lean (lbs.)[3]	—.70	.74	.21
Total carcass fat (lbs.)[3]	.92	—.91	—.70
Total carcass bone (lbs.)[3]	—.47	.32	.84

[1] Based on shrunk, sheared live weight.
[2] This correlation is based on only one year's data involving 64 carcasses.
[3] These should not be considered as predictors because they are as difficult and expensive to obtain as the percentages of ether extract, lean, and bone.

The ratio of lean to bone was essentially independent of percent ether extract. This means that muscular lambs can be lean or fat as can nonmuscular lambs and apparently the various combinations occur about equally often. The ratio of lean to bone was associated with the percentages of lean and bone, but it had to be, because it was calculated from the pounds of these tissues. The values were not high, however. The ratio of lean to bone was not intended to be a measure that one would use to estimate carcass composition. Rather, it was intended to be an index of carcass composition.

More lambs are being slaughtered each year in this continuing study. It is hoped that better measures than those reported herein will be found or that two or more of these measures can be combined to give even better estimates. The increased data will also permit a further evaluation to determine whether the measurements that appeared best in this study are still best when evaluated on separate independent carcasses.

Summary

The carcasses from 124 wether lambs were studied. One-half of the lambs were sired by growthy, blackfaced (Hampshire or Suffolk) rams and one-half by earlier maturing whitefaced (Dorset) rams. Further one-half of the lambs by each sire were single born and reared lambs and the other one-half were twins. The lambs were creep fed while nursing their mothers; weaned at about 10 weeks of age; and full-fed to slaughter weights of 100 pounds.

A comparison of the carcasses from the single and twin lambs indicated that the slower early growth of the twin lambs due to a smaller milk

supply was not associated with appreciable differences in carcass composition. The twins were slightly fatter and had less bone.

The growthier blackfaced rams sired lambs that grew faster after weaning and produced carcasses with more lean and bone than the lambs from the whitefaced rams. Since the carcass composition values used were percentages, the blackfaced lambs with more bone and lean automatically had less fat than the whiteface lambs.

A study of the association of measures of growth with carcass components (fat, lean, and bone) indicated low associations generally. Lambs that were heavier at birth had less fat and more lean and bone in the carcass when slaughtered than lambs with lighter birth weight.

The lambs that gained faster from birth to 10 weeks (those that got more milk and for other reasons) had less fat and more bone than slower gaining lambs. The lambs that gained faster from 10 weeks of age to slaughter weight tended to have less fat, more lean and more bone than the slower gaining lambs but the associations were all low.

Percent fat in the carcass was best estimated by wholesale cut fat trim, loin fat trim or specific gravity of the hind saddle. The same measures were the best predictors of percent lean. Percent bone was best predicted by the weight of the cannon bones. None of the measures were good enough as predictors to be classed as excellent but they were all substantially better than some that are traditionally used such as loin eye area, fat thickness at the 12th rib or wholesale cuts as a percent of the live weight.

The study is continuing and it is hoped that better measures or better combinations of measures will be found. Preliminary work with combinations of some of these measures show real promise of improved predictability.

The Cumulative Influence of Level of Wintering on the Lifetime Performance of Beef Females Through Six Calf Crops

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The type of forage available to range beef cows during the winter months dictates in many cases that supplemental protein and often supplemental energy be provided to insure acceptable cow performance.

The amount of supplemental feed required is of economic importance in terms of feed cost as well as the ultimate influence on reproductive performance and milk production of the dam.