Relationship of Feeder Lamb Frame Size to Feedlot Gain and Carcass Yield and Quality Grades

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ABSTRACT: Small-(S), medium-(M), and large-(L) framed feeder lambs (n = 243 S, 247 M, and 245 L) were finished on five diets differing in amount of concentrate (C) and crude protein (CP): 1) 30% C, 12.5% CP; 2) 55% C, 12.5% CP; 3) 55% C, 14.5% CP; 4) 80% C, 12.5% CP; and 5) 80% C, 14.5% CP. Lambs were sampled over a wide weight range to establish relationships of frame size to daily gain and live weight at specific carcass grade end points. Increased frame size (F) was associated with more rapid gains during finishing, although differences in daily gain among L, M, and S lambs were not expressed consistently across all dietary treatments (D), as reflected by a significant F × D interaction for ADG. The rate at which external fat thickness increased as the lambs became heavier was not affected by frame size, sex, or diet. However, increased frame size was associated with lower (P < .05) values for fat thickness (FT), body wall thickness (BWT), yield grade (YG), and quality grade (QG) when comparisons were made at a constant slaughter weight. Similarly, later-maturing wether lambs were leaner and had lower YG and QG than ewes of the same weight. Dietary treatment had no effect on FT, BWT, and YG when treatment groups were compared at a constant live weight. Subclass regressions of YG on live weight were used to project the weights at which lambs of various frame sizes would be expected to produce YG-2 carcasses. Projected final weights for wethers were less than 50 kg for S, 50 to 55 kg for M, and greater than 55 kg for L. Projected final weights for ewe lambs were approximately 2.5 kg lower. Dietary treatment did not affect relationships among frame size, live weight, and YG. A grading/classification system for feeder lambs based on frame size could be developed to predict carcass grade end point.

Key Words: Lambs, Carcasses, Growth, Diets, Size, Grading

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Introduction

Previous research involving cattle indicates that frame size (i.e., skeletal size in relation to age) reflects an immature animal's eventual mature size (Brown et al., 1983) and is indicative of the animal's live weight at a specified degree of carcass fatness (Tatum et al., 1986). Relationships among frame size, finished weight, and carcass quality grade (or fat thickness) currently are used as the basis for classification of feeder cattle according to the Official U.S. Standards for Grades of Feeder Cattle (USDA, 1979).

McCann and Craddock (1986) and Baird et al. (1989) documented similar relationships among frame size, weight, and fatness in sheep. Moreover, there is a need for a standardized market classification system for feeder lambs that would facilitate uniform description of feeder lamb value based on factors, such as frame size, that are related to subsequent performance and carcass outcome. This study was conducted 1) to establish relationships of frame size to subsequent growth rate and live weight at a specified carcass grade end point for lambs fed different finishing diets and 2) to provide a data base for possible use in development of USDA standards for grades of feeder lambs.

Materials and Methods

Animals. Two complete replicates of the experiment were conducted in the fall months of two successive years. Feeder lambs were identified and selected from shipments of lambs arriving at three commercial feedlots in northern Colorado. The lambs had been purchased in Colorado, Kansas, Montana, Nebraska, and North Dakota, either from range producers or at auction markets. Lambs from 10 points of origin were identified for use in the study.

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Shortly after arrival at the feedlots, the lambs were classified by a three-member selection panel into three frame size categories (**S** = Small, **M** = medium, and **L** = large) by visually evaluating each lamb's skeletal size (height and length) in relation to its estimated age (Baird et al., 1989). A total of 735 lambs (n = 243 S, 247 M, and 245 L) were selected for use in the study. Lambs of all three frame sizes were obtained from each shipment. Individual ages of the lambs were unknown; however, based on appearance and probable lambing dates, all lambs were estimated to be between 5 and 7 mo old. Breed, sex, body condition, and muscling were allowed to vary randomly in the experimental sample; the sample of lambs (551 wethers, 184 ewes) obtained for the study typified the feeder lamb population in the mountain-states and western-plains regions. All research procedures were approved by the Animal Care and Use Committee at Colorado State University.

Receiving and On-Test Data Collection. Lambs selected for the study were transported to the Colorado State University research feedlot in Fort Collins, and a 14-d acclimation period was initiated. During this period, lambs were weighed individually and measured (using a tape) to determine wither height and body length (distance, measured parallel to the animal's back, between the lateral tuberosity of the humerus and the tuber ishiadicum). The lambs were started on a diet consisting of 65% corn silage, 30% chopped alfalfa hay, 3% whole shelled corn, and 2% of a supplement containing protein, vitamins, and minerals.

Dietary Treatments. Lambs of each frame size were stratified by weight, within source, assigned randomly to five dietary treatment groups (Table 1), and sorted into pens by dietary treatment group (one pen/treatment in each of the two replicates).

Individual weights were recorded at the onset of the finishing period, and all lambs were provided the 5% concentrate starter diet. The concentrate levels of experimental diets were increased gradually until the final concentrate level of each finishing diet was attained. Final concentrate levels for all diets were attained within 17 d after the beginning of the finishing period. Dietary treatments included three concentrate levels, 30, 55, and 80%; within the 55 and 80% concentrate levels, two protein levels, 12.5 and 14.5% crude protein, were tested. Lambs had ad libitum access to feed, which was provided once daily. Daily feed consumption of each pen was recorded.

Slaughter End Points. To establish accurate relationships between carcass traits and slaughter weight, it was necessary to sample lambs in each frame size × diet subclass over a very broad slaughter weight range. To accomplish this, each lamb randomly was assigned an approximate target slaughter weight based on its on-test weight and frame size: S target weight = 140, 145, or 150% of on-test weight; M target weight = 130, 135, or 140% of on-test weight; L target weight = 120, 125, or 130% of on-test weight. These targets were chosen simply to provide a broad array of slaughter weights within each subclass and have no other significance. Different percentages were used to calculate target weights for S, M, and L lambs so that slaughter weight ranges would be similar for all three frame size groups. All lambs were weighed individually every 14 d during the finishing period, and an off-test weight was recorded when each lamb was within 2.25 kg of its target weight. A target weight range was used, rather than a fixed target weight, to avoid shipping small numbers of lambs on a given slaughter date.

Table 1. Composition of finishing diets

	Finishing diet[a]				
Diet ingredient	30	55	55-HP	80	80-HP
Whole shelled corn	23.3	47.7	43.0	72.0	66.0
Corn silage	63.0	38.0	38.0	13.0	13.0
Alfalfa hay	7.0	7.0	7.0	7.0	7.0
Protein supplement[b]	6.7	7.0	12.0	7.5	14.0
Limestone	0	.3	0	.5	0

[a]Ingredients are expressed as percentages, calculated on an as-fed basis (30 = 30% concentrate, 12.5% crude protein; 55 = 55% concentrate, 12.5% crude protein; 55-HP = 55% concentrate, 14.5% crude protein; 80 = 80% concentrate, 12.5% crude protein; 80-HP 80% concentrate, 14.5% crude protein). Corn silage used for the study was approximately 50% corn grain.

[b]Ingredients: grain products, plant protein products, processed grain by-products, molasses, calcium carbonate, dicalcium phosphate, tri-poly phosphate, salt, D-activated vegetable sterol, vitamin A palmitate, butylated hydroxytoluene, manganese oxide, calcium iodate with calcium stearate, cobalt carbonate, iron oxide, copper oxide, magnesium, iron carbonate, and zinc oxide. Analysis: 34.0% crude protein, 1.0% crude fat, 14.0% crude fiber, 3.0% calcium, .6% phosphorus, .0006% iodine, 2 to 3% salt, and 20,000 IU/.45 kg vitamin A.

Carcass Data Collection. Lambs that had been weighed off-test were transported to a commercial lamb processing facility where they were processed using conventional commercial procedures. At 24 h postmortem, hot carcass weight was recorded, and two measures of external fat thickness were obtained. Fat thickness (**FT**) was measured over the center of the longissimus muscle at the 12th rib. Body wall thickness (**BWT**) was measured on the left side of each carcass, between the 12th and 13th ribs, approximately 11 cm lateral to the midline of the carcass. Yield grade (**YG**) and quality grade (**QG**) were determined (USDA, 1992) for each carcass.

Statistical Methods. Data for wither height and body length initially were analyzed using a least squares model that included the fixed effects of replicate, frame size, sex, and all possible interactions. Because none of the interactions was significant, the model was reduced to include only the three main effects, and the data were reanalyzed using the reduced model.

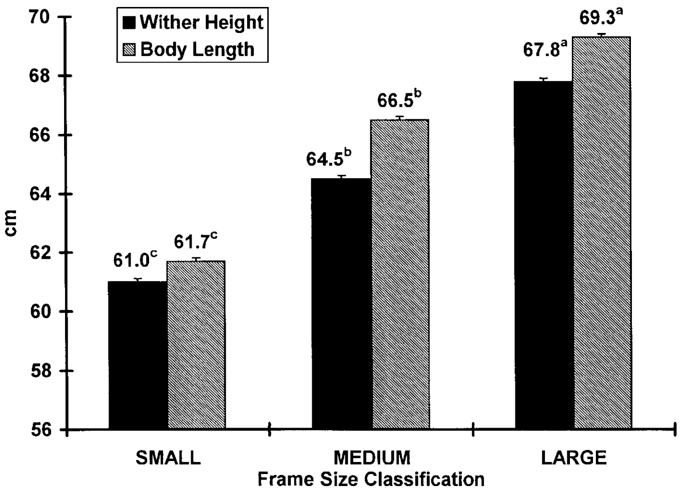

Figure 1. Wither height and body length measurements for small-, medium-, and large-framed feeder lambs. For each trait, means with different superscripts are different ($P < .05$).

Data for initial weight, final weight, days on feed, and average daily gain were analyzed using a least squares model that included fixed effects of replicate (**R**), frame size (**F**), sex, diet (**D**), and the F × D interaction.

Carcass data were analyzed using a full model that included R, F, sex, and D as fixed effects; all possible interactions among F, sex, and D; and the linear regression (b_l) of each independent variate on slaughter weight. Preliminary analyses had shown that linear regression equations provided the most appropriate mathematical representation of all carcass trait-live weight relationships. Interactions between b_l and other terms in the model also were included to test for homogeneity of subclass regression coefficients. Interactions that were not significant were included in the error term, and the data were reanalyzed using the appropriate reduced models.

All analyses were performed using the General Linear Models procedure of SAS (1985). All tests of significance were calculated using the within plus residual error mean square. Least squares means were compared statistically using *t*-tests.

Results and Discussion

Linear Measurements. Wither height (**WH**) and body length (**BL**) measurements for L, M, and S lambs, shown in Figure 1, quantify the visually discernible differences (L > M > S) in skeletal dimensions that were used to classify lambs into the three frame size categories. Large-framed lambs were 3.3 and 6.8 cm taller and 2.8 and 7.6 cm longer than M and S lambs, respectively. Ewes and wethers did not differ in BL (BL = 65.8 cm for both), but wethers (WH = 64.8 cm) were slightly taller ($P < .05$) than ewes (WH = 64.0 cm).

On-Test and Off-Test Weights. As would be expected among lambs that are similar in age, frame size classification was associated with marked differences ($P < .01$) in mean on-test weight (S: 23.3 to 55.6 kg, mean = 34.8 kg; M: 28.0 to 59.0 kg; mean = 42.4 kg; L: 27.2 to 57.2 kg, mean = 48.0 kg). Consistent with the design of the experiment, L, M, and S lambs also differed ($P < .01$) in off-test weight (S = 47.7 kg, M = 56.3 kg, L = 62.2 kg). Targets for final weight were chosen specifically to provide a broad array of slaughter weights within each frame size classification. As a result, slaughter weights ranged from 34 to 72 kg for S lambs, 36 to 81 kg for M lambs, and 43 to 88 kg for L lambs. On-test and off-test weights did not differ between wethers and ewes or for dietary treatment groups (data not presented).

Feedlot Gain. Frame size and diet interacted ($P < .05$) to affect average daily gain (Figure 2) and days on feed (Figure 3). Daily gains for L lambs were higher ($P < .05$) than gains for S lambs in all dietary treatment groups except diet 80-HP. Additionally, on diets 30-, 55-, and 55-HP, L lambs gained weight more rapidly ($P < .05$) than M lambs. However, among lambs fed diets 80 and 80-HP, rates of gain were similar for L and M lambs. Average daily gains for M lambs exceeded ($P < .05$) gains for S lambs on diets 80 and 80-HP. On all other diets, M and S lambs grew at similar rates.

Due to its influence on rate of gain, diet affected ($P < .05$) the duration of the finishing period, particularly among S and M lambs (Figure 3). Ewes and wethers had identical ADG (.22 kg/d) and required a similar number of days on feed to attain their designated slaughter weights (ewes = 67 d, wethers = 66 d).

Relationship of Carcass Fatness to Live Weight. Results of analyses conducted to establish relationships of FT and BWT with finished live weight are presented in Table 2. Both traits exhibited positive,

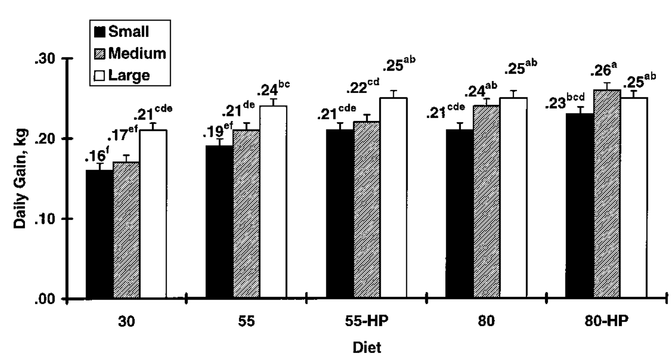

Figure 2. Frame size × diet interaction effects on average daily gain. Means that do not have a common superscript differ ($P < .05$).

Table 2. Least squares means for carcass traits adjusted to a constant live weight (56 kg) and regression coefficients for the linear relationship between each carcass trait and live weight

		Carcass trait[a]			
Effect	n	FT, cm	BWT, cm	YG	QG
Frame size		P = .0001	P = .0001	P = .0001	P = .0001
Small	243	.72[b]	2.90[b]	3.23[b]	11.7[b]
Medium	247	.64[c]	2.54[c]	2.92[c]	11.4[c]
Large	245	.51[d]	2.25[d]	2.39[d]	11.0[d]
Sex		P = .0001	P = .0001	P = .0001	P = .0001
Ewe	184	.66[b]	2.67[b]	2.99[b]	11.5[b]
Wether	551	.59[c]	2.45[c]	2.70[c]	11.2[c]
Diet		P = .6547	P = .1914	P = .6547	P = .0332
30	144	.61	2.60	2.80	11.2[d]
55	146	.64	2.51	2.91	11.4[bcd]
55-HP	146	.62	2.50	2.86	11.4[bc]
80	152	.62	2.62	2.86	11.5[b]
80-HP	147	.61	2.59	2.80	11.3[cd]
b_1 (live wt)		.022	.061	.086	.093
Residual SD[e]		.174	.573	.684	.826

[a]FT = fat thickness over the longissimus at the 12th rib; BWT = body wall thickness between the 12th and 13th ribs; YG = yield grade; QG = quality grade (encoded as 10 = low Choice, 11 = average Choice, 12 = high Choice).

[b,c,d]Means in the same column within an effect without a common superscript letter are different (P < .05).

[e]Standard errors of least squares means can be calculated as SEM = residual SD × (1/n), where n = number of observations in the appropriate subclass.

linear relationships with live weight, suggesting that thickness of external fat increased at a relatively constant rate across the weight intervals examined in this study. On average, every 10-kg increase in live weight was associated with a .22-cm increase in FT and a .61-cm increase in BWT.

Subclass regression coefficients for FT and BWT were homogeneous for the three frame size groups, indicating that S, M, and L lambs exhibited similar rates of subcutaneous fat deposition relative to increased live weight. In contrast, Baird et al. (1989) reported that frame size had a significant effect on the rate at which FT increased as lambs became heavier.

Despite having similar relative rates of fat deposition, S, M, and L lambs had different values for FT and BWT (S > M > L) when compared at a constant

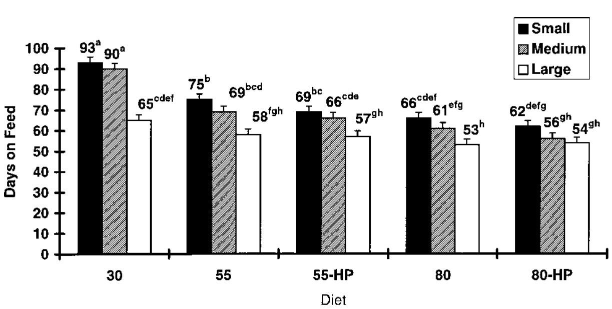

Figure 3. Frame size × diet interaction effects on days-on-feed. Means that do not have a common superscript differ (P < .05).

slaughter weight (Table 2). These differences in fatness at a constant weight simply reflected differences in developmental maturity (Butterfield, 1988) among the frame size groups. In this regard, our results are consistent with those of McCann and Craddock (1986) and Baird et al. (1989).

Regressions of FT and BWT on live weight were similar for ewes and wethers. However, the earlier-maturing ewe lambs were fatter than wethers of the same weight (Table 2).

Even though lambs fed different diets grew at markedly different rates during finishing, dietary treatment had no effect on relative rate of external fat deposition or on measurements of FT and BWT when dietary treatment groups were compared at a constant weight (Table 2). A number of previous reports suggest that lamb carcass fatness is closely associated with body weight, and that differences in energy intake or dietary protein level have little effect on carcass fatness when lambs are compared at the same live weight (Burton and Reid, 1969; Truscott, 1982; Smith, 1984). Crouse et al. (1981) found that percentage of kidney and pelvic fat differed between lambs finished on high-energy and low-energy diets, and Ahmad and Davies (1984) reported higher percentages of dissected subcutaneous fat for lambs finished on high-energy than lambs finished on low-energy diets. However, in both of these studies, measurements of subcutaneous fat thickness were similar for lambs fed high-energy and low-energy diets to a weight-constant end point.

Relationships of Carcass Grades to Live Weight. Both YG and QG increased linearly as live weight increased

Table 3. Live weights[a] (kg) at which small-, medium-, and large-framed wether and ewe lambs would be projected to produce carcasses with specific external fat thickness measurements (cm) or specific yield grades

Frame size and sex	FT: YG:	.28 1.5	.38 1.9	.53 2.5	.64 2.9	.79 3.5	.89 3.9
Wethers							
Small		36.4	41.1	48.1	52.7	59.7	64.4
Medium		40.4	45.0	52.0	56.7	63.7	68.4
Large		46.0	50.7	57.7	62.3	69.3	74.0
Ewes							
Small		33.2	37.9	44.9	49.6	56.6	61.2
Medium		36.3	40.9	47.9	52.6	59.6	64.3
Large		44.4	49.0	56.0	60.7	67.7	72.4

[a]Projected using subclass regressions of yield grade on live weight.

(Table 2). It should be noted that results for YG are synonymous with results for FT because YG is computed using FT values: YG = .4 + (10·FT). The relationship between YG and live weight reflected an increase in external fat thickness as the lambs became heavier; the relationship between QG and live weight essentially reflected an increase in the degree of fat streaking in the flanks of the lamb carcasses as finished weight increased. Tests for heterogeneity of subclass regressions were not significant, indicating that the relative rates of change in YG and QG with increased live weight were not affected by frame size, sex, or diet.

Least squares means contrasting the three frame size groups at a finished weight of 56 kg (Table 2) showed that, at a constant live weight, increased frame size was associated with lower values for YG (more desirable yield grades) and QG (less desirable quality grades). Similarly, when the two sex classes were compared at a constant live weight, the later-maturing wether lambs had lower ($P < .05$) values for YG and QG than did the earlier-maturing ewes (Table 2).

Least squares means corresponding to the diet main effect (Table 2) compare carcass grades for lambs of the same frame size, sex, and live weight. Dietary treatment had no effect on YG. Diet-related differences in QG, though statistically significant, were too small in magnitude to be practically important.

Since 1979, USDA grades for feeder cattle have been determined using visual assessments of frame size (skeletal height and length in relation to age) and thickness (thickness and shape of the musculature in relation to skeletal size). The use of frame size and thickness evaluations in the feeder cattle grading system (USDA, 1979) is based on the rationale that 1) immature skeletal size (frame size) is indicative of an animal's potential mature size and associated effects on growth rate and the weight at which the animal will attain a specified level of fatness, and 2) visually discernible differences among feeder cattle in size, shape, and thickness of the musculature (thickness) reflect inherent variation in muscularity and its influence on carcass cutability and yield grade. Grade specifications for frame size in the feeder cattle grading system are based on the weight at which a feeder steer or heifer would be expected to produce a carcass with a quality grade of low Choice (approximately 1.25 cm external fat thickness). For steers, these weights are as follows: Small, less than 450 kg; Medium, 450 to 550 kg; Large, over 550 kg. Corresponding weights for heifers are 90 kg lower.

Using data from the current study, a similar grading system (based on frame size evaluations) could be developed for feeder lambs. A logical grading approach would be to use evaluations of frame size to reflect differences in the live weight at which a lamb would be expected to produce a carcass with a specific thickness of external fat or a specific USDA yield grade (Table 3). If, for example, a USDA YG of 2 was used as a standard (YG-2 lambs have .41 to .64 cm fat thickness), then the following approximate live weight specifications for wethers could be used: Small, less than 50 kg; Medium, 50 to 55 kg; Large, more than 55 kg. Weight specifications for ewes would be approximately 2.5 kg lower. Our results suggest that these weight specifications would be about the same for lambs fed corn/corn silage diets with concentrate levels ranging from 30 to 80%. It is noteworthy that, in the present study, a YG of 2.5 coincided with a QG of average Choice for all frame size × sex subclasses.

Implications

The market value of a feeder animal is determined by its ability to gain weight rapidly and efficiently during finishing and produce a carcass of the desired grade at an acceptable market weight. In this study, evaluations of feeder lamb frame size were indicative of differences in growth rate during finishing and the weights at which lambs produced carcasses of specific yield grades. Relationships established in this study could be used to develop a practical and effective grading/classification system for use in describing value differences among feeder lambs.

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