Central Test Performance of Rambouillet Rams as a Predictor for Growth and Wool Traits in Feedlot and Range Environments[1]

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Summary

A study was conducted to estimate the relationship between sire's 140-d central test performance and progeny performance. The 9 centrally tested Rambouillet sires were represented by a total of 34 offspring. Regressions of progeny performance (weight gain, body weight, fleece weight, fleece yield, average staple length, and average wool fiber diameter) on sire's central test performance were used to estimate the relationship between central test performance and progeny performance, measured sequentially on the same animals, in feedlot and range environments. The nine sires represented a wide range of performance on central test. The model used for each trait included a fixed effect for type of birth of the lamb (single or multiple), a linear regression for age of the lamb in days at the start of the feeding period, a covariate for sire's performance, a covariate for dam's performance, and random effects for sire and residual error. The covariate for dam's performance was dam's body weight at breeding for gain traits, grease fleece weight of the dam for fleece weight traits and staple length, and average fiber diameter of the dam for fiber diameter traits. The regression coefficients of progeny performance on sire's performance were +.46 ($P < .01$) and -.23 ($P < .1$) for gain, +.46 ($P < .01$) and +.29 ($P < .01$) for body weight, +.34 ($P < .01$) and +.23 ($P < .1$) for clean fleece weight, +.12 ($P > .1$) and .00 ($P > .1$) for fleece yield, +.33 ($P < .05$) and +.09 ($P > .1$) for average staple length, and +.41 ($P < .01$) and +.39 ($P < .01$) for average fiber diameter, in the feedlot and range environments, respectively. There was a strong relationship between sire's performance as measured on 140-d central performance test and progeny performance in a similar environment. When progeny performance was measured on a relatively low nutrition environment, the relationship between central test performance and progeny performance was weakened for growth rate, body weight, fleece weight, fleece yield, and average staple length.

Key words: sheep, wool, central performance test, rambouillet, heritability

Introduction

Central ram performance tests are conducted to identify genetically superior sires for outstanding wool and growth characteristics, and are usually conducted in favorable nutrition environments. High protein (or energy) rations and increased intake generally result in increased growth rate, staple length, fleece weight, and fiber diameter (Schafer, 1992; Bohnert, 1994). Salisbury et al. (1997) found that increasing proportion of escape protein resulted in increases in fiber diameter and staple length in Rambouillet rams. Birrell (1992) showed that increases in forage quality and quantity resulted in an increase in fleece weights and increased average fiber diameter in grazing ewes. Lupton et al. (1992) found that rams' mean fiber diameter decreased after they were removed from favorable nutrition, such as is used for the central performance test, and placed on range. Estimates of a non-significant relationship between central test growth rate of Suffolk rams and their progeny's growth rate (Waldron et al., 1990) have raised questions about the accuracy of central test performance as a predictor of progeny performance. It is not known to what extent performance differences observed among rams on a 140-d central test, with

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Table 1. Central test performance of nine Rambouillet rams used in the subsequent progeny-test.

Sire	Body weight, kg		ADG, kg	GFW[a]	Y[b]	CFW[c]	SL[d], cm	Fiber diameter, µm	
	Initial	Final						Side	Britch
1	58.6	100.0	0.29	3.19	52.2	1.67	4.48	21.9	25.5
2	55.0	116.8	0.44	3.85	43.7	1.68	4.58	20.2	22.9
3	60.0	121.8	0.44	4.25	55.1	2.34	5.46	27.0	29.6
4	62.7	126.4	0.45	3.64	59.8	2.18	4.38	26.5	30.5
5	46.4	95.0	0.35	3.68	48.3	1.78	4.77	23.7	26.2
6	56.4	111.4	0.39	4.71	56.8	2.67	5.46	24.7	28.9
7	68.2	119.6	0.37	5.02	52.7	2.65	5.26	22.2	24.0
8	47.7	86.4	0.28	2.79	57.0	1.59	4.58	21.9	24.8
9	63.6	131.4	0.48	4.85	52.5	2.54	4.38	26.0	30.4
Mean	57.6	112.1	0.39	4.00	53.1	2.12	4.82	23.8	27.0
Maximum	68.2	131.4	0.48	5.02	59.8	2.67	5.46	27.0	30.5
Minimum	46.4	86.4	0.28	2.79	43.7	1.59	4.38	20.2	22.9

[a] GFW = grease fleece weight, kg (adjusted to 140 d).
[b] Y = lab scoured yield, %.
[c] CFW = clean fleece weight, kg (adjusted to 140 d).
[d] SL = Staple length (adjusted to 140 d).

unlimited intake of high quality feed, will be realized in the offspring reared under different conditions. Therefore, this study was designed to estimate the relationship between sire's central test performance and progeny performance. Traits analyzed included post-weaning average daily gain, fleece weight, wool fiber diameter, and wool staple length. Progeny traits were measured under conditions similar to those of the central test and on the native range.

Materials and Methods

Animal Management

Thirty-six Rambouillet ram lambs (progeny of 9 centrally tested sires) were used to evaluate the effect of sire's central test performance on fleece weight, fiber diameter, staple length, and weight gain under two management systems and during two distinct periods in the lives of the progeny. All sires were centrally performance tested at the Texas Agricultural Experiment Station central ram performance test in Sonora, TX during the 1993-1994 test (Waldron and Lupton, 1994). Sires were shorn and began the performance test in September and remained on test until February. During the test, side and britch fiber diameters were measured in January. Fleece weight and staple length were measured in February, representing 140 d of fleece growth. Body weight gain was measured as 140-d ADG (September to February). The nine sires were unrelated and represented a wide range of performance and wool characteristics as measured on the central performance test (Table 1).

The sires were mated to a flock of 4-yr-old commercial Rambouillet ewes in September and October of 1994 on the Winters Ranch near Brady, TX. Individual ewe body weights were recorded at the start of the breeding season. The flock of 270 ewes was divided into six categories based on body weight. Ewes were then divided randomly, within body weight category, into nine breeding groups so that the mean body weight (BW) of each group of ewes was similar. Matings occurred in single-sire pastures. Mid-side wool samples were obtained from each ewe in January 1995 prior to lambing. Fleece weights of the ewes were recorded in April, 1995. Lambs were born between January 27, 1995 and March 9, 1995. All lambs were identified with their dams, ear tagged, and weighed within 18 h of birth. The number of ram lambs per sire group varied from 9 to 16 when lambs were approximately 60 d of age. Each sire group was divided into top and bottom halves based on visual appraisal to exemplify the process breeders may use in selecting rams to submit to a central performance test. Because of limits on labor and facilities, four ram lambs per sire group were chosen at random from the top half of each sire group for this study. Lambs were weaned at a mean age of 120 d and placed on a growing ration for 30 d, then placed on native range until the initiation of the experiment.

When ram lambs averaged 195 d of age (October 1995), they were randomly allotted to pens within sire group (two rams per pen and two pens per sire) with shade and fresh water available. Rams were given ad libitum access to the test diet (Table 2) for a 14-d adjustment period. During the adjustment period, mid-side and britch wool samples were taken from each test animal and they were dosed with Ivomec (Ivermectin, Merck and Co., Rahway, NJ). All rams were shorn on

Table 2. Ingredient composition of diet[a] used in the feedlot portion of the study.

Ingredients	Percent (as fed)
Alfalfa, dehy (17%)	28.24
Cottonseed hulls	23.37
Cottonseed meal	7.30
Molasses, cane	4.87
Sorghum, grain	24.34
Soybean meal (44%)	7.30
Ammonium chloride	.49
Calcium carbonate	.49
TM[b] Salt	.97
Aurofac 10	.15
Vitamin A	.05
Binder	2.43
Total	100.00

[a] Diet is identical to the ration used at the Sonora Ram Test.
[b] TM = trace mineral premix. The percent ingredients of the premix are as follows: sodium chloride, 64.7; potassium chloride, 19; sulfur, 10; zinc oxide, .387; vitamin A (30,000 IU/g), .73; vitamin D (30,000 IU/g), .093; vitamin E (125,000 IU/g), .72; chlortetracycline (50,000 IU/g), 3.0; and molasses, 1.5.

one day, three days prior to the initiation of the test. At the initiation of the test, BW was recorded on two consecutive days and the average served as the initial weight. All test rams were allowed ad libitum access to the same diet (Table 2) for the duration of the 140-d feedlot experiment. This diet is the same as that used at the Texas Agricultural Experiment Station's Ram Performance Test in Sonora, Texas, and meets or exceeds the NRC requirements for replacement ram lambs (NRC, 1985). Physical condition of each animal was observed daily and sick animals were treated and noted for further observations.

Rams were weighed and dye-bands (Wheeler et al., 1977) were applied to a 7-cm strip at the mid-side of each ram at 28-d intervals. Upon completion of the feedlot portion of the trial (2/28/96), dye-banded samples were removed at skin level and britch wool samples were also taken. Rams were weighed on d 139 and 140 and then shorn on d 140. The consecutive body weights were averaged to adjust for rumen fill. Grease fleece weights were subtracted from the final BW to obtain the true final BW. Two rams from different sires died of unknown causes during the feedlot trial. Data from these two rams were not included in the analysis.

On February 28, 1996 all rams were placed in one pasture and were periodically rotated through four pastures to ensure adequate forage intake throughout the 140-d range trial. Due to the time of year, forage quantity was abundant, but protein levels were low. Therefore, the rams were supplemented with .46 kg ram^{-1} d^{-1} of a 20% crude protein range cube. The rams were supplemented only during the first two weigh periods (0 to 56 d) of the range trial because near the conclusion of the second weigh period it rained (11.7 cm), range conditions improved quickly, and supplementation was no longer needed. Clean, fresh water, and mineral supplements were available to all animals ad libitum. Rams were observed daily, and sick animals were treated and noted for further observation. The purpose of the range trial was primarily to evaluate the relationship between sire's central test performance and progeny performance for wool traits, although ADG and BW were also analyzed.

Rams were weighed and dye-bands were applied every 28 d as in the feedlot trial. Final BW for the range trial was calculated as for the final BW of the feedlot trial. One ram, from a third sire, died on d 3 of the range trial from injuries sustained in a fight. His data were included in the analysis for the feedlot trial but not the range trial.

Wool Analysis

Wool grown during the third period, in both the feedlot and range trials (third dye-band) was used as the measure of fiber diameter. The third period of the pen trial corresponded to the time at which fiber diameter was measured on the sires during the central performance test. The third period of the pasture trial was used because the time from the start of this portion of the trial to wool sampling was the same as for the pen trial. The OFDA (IWTO, 1995), was used for determining average fiber diameter (AFD) of the side and britch wool samples. Core samples were removed from the entire shorn fleece (Johnson and Larsen, 1978) to determine percentage yield of the fleece. The percentage yield was determined by washing subsamples of the core samples using a standard method (ASTM, 1995a). Grease fleece weight and yield percentage were used to calculate clean fleece weight (CFW). Average staple length (SL) for the entire shorn fleece was measured

Table 3. Performance of ram progeny in feedlot and range environments.

	Mean	SD	Minimum	Maximum
Feedlot environment: n = 34				
ADG[a], kg/d	35	.05	.21	.48
Final BW, kg	104.8	10.43	78.6	125.9
CFW[b], kg	4.5	0.06	2.8	6.1
Yield, %	48.9	3.12	39.4	57.8
SL[c], cm	4.5	.37	3.7	5.1
AFD[d], microns	23.6	1.73	19.8	27.7
Range environment: n = 33				
ADG[a], kg/d	-.08	.05	-.22	.03
Final BW, kg	93.6	7.22	78.6	110.0
CFW[b], kg	3.1	0.05	2.1	4.6
Yield, %	43.5	4.45	35.4	53.2
SL[c], cm	3.6	.42	2.6	4.3
AFD[d], microns	21.5	1.64	18.3	25.9

[a] ADG = 140-d Average daily gain.
[b] CFW = 140-d Clean fleece weight.
[c] SL = 140-d Staple length.
[d] AFD = Average fiber diameter.

by randomly removing 20 staples from the entire fleece, measuring them in a standard manner (ASTM, 1995b) and calculating average length of the staples. All wool analyses were conducted at Texas Agricultural Experiment Station, Wool and Mohair Research Laboratory, San Angelo, TX.

Statistical Analysis

Differences between feedlot and range performance means were tested using PROC TTEST (SAS, 1989). An F statistic was calculated to test the equality of variances between environments. For the estimation of the relationship between sire's central test performance and progeny performance, data were analyzed within environment with PROC MIXED (SAS, 1992). The model used for each trait included a fixed effect for type of birth of lamb (single or multiple), a linear regression for age of lamb in days at the start of the feeding period, a covariate for sire's performance, a covariate for dam's performance, and random effects for sire and residual error. Starting weights of the lambs were not used as covariates because it was assumed that starting weight differences were a function of genetic and environmental differences and removing some of the genetic variation, due to sire, of correlated traits by using starting weight as a covariate could bias results. Covariates for dam's performance were used to account for variation among the mates of the sires. The covariate for dam's performance was dam's body weight at breeding for gain and final BW, dam's grease fleece weight for fleece weight and staple length, and dam's fiber diameter for fiber diameter.

The covariate of sire's performance on central test (gain, final BW, clean fleece weight, yield, staple length, or fiber diameter) was used to relate sire's central test performance to progeny performance. The random effect of sire was included in the model in order to account for covariance among paternal half-sibs (Henderson, 1984; Waldron et al., 1990). Correlation coefficients were calculated between feedlot and range performance.

Results and Discussion

Animal Performance and Wool Characteristics

The mean performances of rams in the two environments are shown in Table 3. Average daily gains for the feedlot and range trials were .35 (min = .21, max. = 0.48) and -.08 kg/d (min. = (-.22), max = .03), respectively. Traits measured on the rams in the feedlot environment had means similar to those of the sires on the central test (Table 1). As expected, the performance for all traits was lower ($P < .001$) when measured under range conditions. However, the sample variances were similar across environments ($F > .3$) for ADG, clean fleece weight, SL, and AFD, which suggests that the phenotypic variation among rams was not a function of environment for these traits. Sample variance was larger ($F < .05$) in the feedlot environment for final BW, and larger ($F < .05$) in the range environment for yield.

Regression Analysis for Offspring Versus Sire Traits.

The estimated regression coefficients relating sire's central performance to progeny performance are shown in Table 4. The estimate for ADG measured on range was the only relationship that was negative and different from zero ($P = .058$). With the exception of fleece yield in the

Table 4. Regression coefficients of offspring performance on sire's central test performance and correlations of offspring performance between environments.

Item	Feedlot trial				Range trial		
	Regression coefficient	SE	P	Correlation between environments	Regression coefficient	SE	P
ADG[a]	+.46	.12	.001	-.75	-.23	.11	.058
Final BW	+.46	.11	.001	.89	+.29	.09	.003
CFW[b]	+.34	.09	.001	.29	+.23	.11	.053
Yield	+.12	.11	.291	.57	-.00	.16	.981
SL[c]	+.33	.13	.019	.27	+.09	.17	.603
AFD[d]	+.41	.09	.001	.85	+.39	.09	.001

[a] ADG = 140-d Average daily gain.
[b] CFW = 140-d Clean fleece weight.
[c] SL = 140-d Staple length.
[d] AFD = Average fiber diameter.

range environment, all other estimates were positive. Estimates for all traits measured in the feedlot environment, except for fleece yield, were different from zero (P < .05). These results indicate that sire's central test performance was a valid predictor of progeny performance when measured in a similar feedlot environment. Waldron et al. (1990) did not find a significant relationship between sire's central test performance (ADG) and progeny performance using 18 Suffolk rams from three separate 63-d central tests. Waldron et al. (1990) suggested that a 63-d test was not long enough to be free from pre-test environmental effects and therefore the accuracy of central test data for predicting genetic value for postweaning ADG was limited. Bradford and Spurlock (1972) using 17 sires from one flock rather than from a central performance test, reported correlations of sire weights and gains at different ages with progeny growth rate, and reported that sire's postweaning BW (120-d wt, 6-mo wt, or yearling wt) was a better predictor of progeny growth rate than sire's 46-d post weaning gain. Schwulst et al. (1996) classified 12 Suffolk rams that had been on a performance test as either high- or low-ranking based on an index that gave equal emphasis to postweaning ADG and weight per day of age. They found that lambs sired by high-ranking rams had greater postweaning ADG than lambs sired by low-ranking rams. The magnitude of the difference in sire's ADG or weight per day of age was not reported (Schwulst et al., 1996). The central test from which the sires of the present study were selected was approximately twice as long (140 d vs 63 d) as those typically conducted in the Midwest (Waldron et al., 1989). Additionally, central ram performance tests in the Midwest began when rams were approximately 3 mo old, whereas the Texas Rambouillet test began when rams were from 6 to 10 mo old. The different length of test and/or the age at the start of the test may have contributed to the difference in results.

Our results agree with those of Shelton (1959). He also reported a positive relationship between sire's central test wool performance and offspring performance, but his sire-offspring regression coefficients were markedly lower than ours obtained from the feedlot environment. One difference between our data and Shelton's (1959) is that we tested intact rams under a similar environment as their sires, whereas his data were obtained from ewes and wethers raised under range conditions. The central testing period was even longer (>300 d) in the 1950s when Shelton sampled rams from the central test for the 1959 report.

The regression estimates for growth rate and wool quantity measurements (FW and SL) obtained in the range trial were smaller than those of the feedlot trial. However, sire's fiber diameter, as measured on central test, was a significant predictor of progeny fiber diameter in both the feedlot and range environments. The negative mean ADG on range (Table 3) is not representative of a normal growth pattern, but was not unexpected for the present design where rams were fed ad libitum for 140 d, and then subject to the range environment for 140 d. The negative relationship between sire's central test ADG and progeny ADG on range (Table 4) may be a result of the sequence of feeding environments of the rams. Because of the animal's ability to mobilize body reserves, the results from the analyses of ADG and BW data of the range trial must be interpreted with caution. The estimated correlation coefficients between feedlot and range performance for final BW and all wool traits were positive (Table 4). However, the estimated correlation between ADG on the feedlot trial and ADG on the range trial was -.75. This indicates that change in body weight during the 140-d range trial appears to be a function of ADG during the feedlot trial. The rams with high gains in the feedlot tended to lose more weight during the range portion of the trial. The strong negative correlation between feedlot and range ADG suggests that the high ADG rams were accumulating energy reserves during the feedlot trial and expending those reserves during the range trial. Because the low-nutrition range trial followed the ad libitum-feeding feedlot trial, the negative regression of range ADG on sire's central test performance ADG does not, therefore, suggest that rams with higher central test ADG will produce progeny with lower ADG under range conditions, except if the range ADG is measured immediately after a long feeding period of high body weight gains. The strong positive correlation between final BW in the feedlot and range environments was expected because of the part-whole relationship of the two weights. Sire's final BW on central performance test was positively related to progeny final BW in both trials (P < .01). Because the rams' growth rate on range was measured after the feedlot trial, the rams were closer to maturity during the range trial. If the growth curve was changing shape at this age, differences may have been observed as a function of maturity. The stage of maturity was confounded with the switch from feedlot to range environments in this study because the rams were being compared at two different physiological stages in their lives. Shelton's (1959) result (estimated regression of .11 between central test ADG and weaning weight under range conditions) is not comparable to the regression of progeny ADG on central test ADG of the present study because weaning weights were obtained from lambs grown entirely in a range environment rather than grown in a high-nutrition environment followed by a low-nutrition environment and the progeny traits were measured at different stages of life (preweaning versus postweaning). The positive regression coefficient relating progeny final BW to sire's central test final BW, indicates that even after being in the range environment for 140 d, and losing weight, sons of sires with high central test final BW were heavier.

Because wool is not an energy store that can be mobilized, as body reserves are, wool traits as measured on the range trial, were not affected in the same way as ADG. The relationship between sire's central test AFD and progeny AFD was strong in both environments. This is in contrast to the result for fleece yield, where a significant relationship was not found in either environment. However, progeny CFW, which is a function of yield, was positively related to sire's central test CFW. Although the means of CFW and AFD were lower on the range, the positive estimates of the relationship between sire's performance and progeny performance indicate that central test performance was indicative of progeny performance, even in the range environment for these traits. These results for CFW and AFD suggest that it is effective to use a favorable environment for a central performance test even though progeny may be raised in a range environment.

The regression coefficients of Table 4 can be multiplied by two to obtain heritability estimates. The heritability estimates are generally on the high side of the range of previous estimates (Young et al., 1960; Fogarty, 1995). However, the heritability estimates for fleece yield were lower, especially for the range environment, than previously published estimates (Young et al., 1960). Given the small number of sires used in the present study, the lack of precision (i.e. large standard errors) was not unexpected. The feedlot environment was chosen to be similar to the environment in which the sire's central test performance was measured. The similarity of environments and small amount of environmental variation in the feedlot environment may have contributed to the magnitude of the sire-offspring regression coefficients (Table 4). Lasslo et al. (1985) reported a greater response to selection for increased lamb weaning weight in a more favorable environment than in a range environment.

The results from the range trial of the present study may have been influenced by its design where the range trial immediately followed the feedlot trial and the same animals were used in both trials. The resulting confounding of environment and age period precludes estimation of effects of environment and age period. Contemporary evaluation of samples of progeny in the two environments would be necessary to obtain estimates free of this confounding.

Conclusions

A ram's 140-d central test performance was a valid indicator of offspring performance under similar conditions. However, sire's test performance was not as strong an indicator of offspring performance under range conditions when evaluated immediately after a 140-d performance test under good nutrition. The value of using sire's AFD on central test to predict progeny AFD was similar in both environments. Central performance test evaluations can effectively rank rams for their offspring's postweaning growth rate and wool traits.

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