Comparison of U.S. Fine-Wool and Australian Merino F1 Crosses: II. Growth and Carcass Characteristics[1]

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Summary

This study investigated the effects of incorporating genes of two dissimilar Australian Merino types, fine-wool (FWM) and strong-wool (SWM), into different U.S. fine-wool flocks on growth and carcass characteristics of first cross (F1) wether lambs. The F1 wethers were offspring of U.S. fine-wool ewes in four different flocks crossed to one of three ram types: 1) FWM; 2) SWM; or 3) Rambouillet (RAMB). Six rams per sire type were used to produce the F1 lambs. Growth rate of ewe and wether lambs (n = 1391) was measured from birth to weaning. Wethers (n = 355) were slaughtered at approximately 52 kg live weight. Carcass characteristics measured included: hot carcass weight, dressing percentage, leg conformation score, USDA Quality and Yield Grades, back fat depth, longissimus muscle area and percent kidney and pelvic (KP) fat. Statistical analyses were performed for a nested split-plot design. Lambs sired by RAMB rams grew faster than FWM- and SWM-sired lambs ($P < 0.05$). Carcasses from RAMB-sired lambs were the most desirable for leg conformation score, longissimus muscle area, back fat depth and yield grade. Carcasses from lambs sired by FWM rams had higher percentage KP fat and thicker measures of back fat depth than those sired by SWM and RAMB rams ($P < 0.05$). Sire breed did not influence dressing percent or quality grade ($P > 0.10$). It is suggested that Australian fine-wool Merino-cross lambs should be slaughtered at live weights lighter than RAMB-sired lambs to be comparable in fat characteristics to the more desirable RAMB carcasses. Generally, the characteristics of the RAMB-sired lamb carcasses were superior to Merino-sired carcasses.

Key words: crossbreeding, Merino, lamb, carcass, growth.

Introduction

Sheep provide U.S. consumers with two main products: lamb meat and wool. Improving the quality or quantity of one or both of these products can potentially increase consumer demand, raise the value of the raw product, increase producer income and help U.S. sheep producers to better compete with imported products.

The significant increase in wool prices worldwide during the late 1980s was accompanied by importation of Merino rams from Australia, especially by U.S. sheep producers wanting to improve fiber characteristics and production of their sheep. The use of Australian Merino rams in a cross breeding program improved wool production of U.S. fine-wool breeds (Snowder et al., 1998).

In contrast, the effects of modern Australian Merino breeding on U.S. lamb carcass characteristics is generally

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unknown. The smaller mature size of some Australian Merinos compared to U.S. fine-wool breeds suggests that lamb carcass characteristics may be negatively influenced by a Merino infusion. An earlier study of Merino lamb carcasses suggests that Merino/Targhee wether lambs grow more slowly and mature physiologically at lighter weights compared to Targhee lambs (Sakul et al., 1993).

Increases in wool production and income are desirable only if they are not exceeded by losses in income from lamb production. Therefore, a multi-institution research project was organized to investigate the effect of Australian Merino breeding on growth and carcass characteristics of U.S. lambs.

Materials and Methods

The study was conducted at four research locations: U.S. Sheep Experiment Station (Dubois, ID); Montana State University (Bozeman, MT); Texas Agricultural Experiment Station (San Angelo, TX); and Hopland Research and Extension Center, University of California (Hopland, CA). The objectives and breeding protocol of this project were previously described by Snowder et al. (1997).

Generation of Lambs

Growth rate to weaning was measured on 1,001 first cross (F1) lambs of Australian Merino heritage and 390 Rambouillet or Rambouillet/Targhee lambs. The F1 lambs were produced by mating rams of two strains of Australian Merino, fine-wool (FWM) and strong-wool (SWM), to ewes of two U.S. western range breeds, Rambouillet or Targhee, at four different locations. The FWM strain is recognized for relatively high wool production with superior fiber diameters. The six FWM rams used in this study ranged in fiber diameter from 17.3 to 23.6 μm and grew approximately 13 kg of clean wool per year. The SWM strain produces even heavier fleeces which are generally coarser in fiber diameter; the six SWM rams in this study ranged in fiber diameter from 24.1 to 28.1 μm and averaged over 14 kg of clean wool production in a year. Six Rambouillet rams were selected from flocks in Texas to produce control populations at each location.

The 18 rams were bred by artificial insemination or natural mating to Targhee ewes at Hopland (CA) and Rambouillet ewes at Dubois (ID), Bozeman (MT) and San Angelo (TX). Ewes were randomly assigned and exposed to only one ram either artificially or naturally. Age of the ewes at breeding ranged from two to six years. Breeding in Idaho and Texas stations occurred in the fall for spring-born lambs. In California, lambs were born in December.

Matings of Australian Merino rams produced F1 lambs of one-half FWM or SWM and one-half Targhee or Rambouillet. The offspring from the Texas Rambouillet rams were either pure Rambouillet or one-half Rambouillet and one-half Targhee. Lambs with Texas Rambouillet sires were grouped as Rambouillet-type (RAMB).

Lamb Management

Approximately 30 days prior to lambing, ewes at Idaho were divided into small flocks of approximately 300 head and placed in a feedlot pen. The feed ration consisted of chopped alfalfa hay (approximately 2 kg/(head•day) and whole corn grain [0.6 kg/(head•day)]. As the ewes lambed, ewes and lambs were gathered and moved into small single-ewe pens (2.4 m^2) in a lambing barn. All lambs were docked and ram lambs were castrated shortly after birth. At 2 days of age, ewes and lambs were moved outside to larger mixing pens with up to 12 ewe and lamb(s) pairs. At approximately 30 days of age, ewes and lambs were given access to fenced sagebrush grassland pasture. Ewes and lambs were trailed at roughly 60 days of age to high elevation mountain meadow and tall forb grazing communities where they remained under herded conditions until weaning (average age of 115 days). After weaning, wether lambs were adjusted over a 21-day period to a 65% whole corn and 35% pelleted alfalfa ration. Lambs were targeted for slaughter when they reached approximately 57 kg live weight.

At 30 days prior to lambing, ewes at California grazed mature annual pastures and were supplemented approximately 1.0 kg/(head•day) of alfalfa hay. At 10 days prior to lambing, ewes were moved into the lambing shed and fed 1.8 kg/(head•day) of alfalfa hay. Ewes and lambs were shed confined after lambing for 3 to 5 days. While in the lambing shed, ewes were fed approximately 2.7 kg/(head•day) of alfalfa hay for 3 to 5 days. Lambs were docked and males castrated shortly after birth. Post lambing, ewes and lambs were maintained on subclover pastures until weaning at approximately 100 days of age. After weaning, wether lambs were adjusted over a 6-week period to a 60:40 whole corn and pelleted alfalfa diet to which they were provided ad libitum access until slaughter.

Management of ewes and lambs in Montana was similar to that of Idaho. Pregnant ewes were brought into feedlots 30 days prior to lambing with ad libitum access to alfalfa hay and supplemented with 0.6 kg/(head•day) of whole barley grain. Lambing occurred in December and January. At lambing, ewe and lamb(s) were moved into small pens in a lambing barn for 1 to 3 days. Afterwards, ewes and lambs were moved outside to larger mixing pens with other ewes and lambs for approximately 40 days. All lambs were docked and ram lambs were castrated shortly after birth. Ewes and lambs were transported to the Red Bluff Research Ranch (Red Bluff, MT) where they grazed upland range grasses (bluebunch bunchgrass, Idaho fescue) and forbs (rubber rabbitbrush, lupine, western yarrow) until weaning in early September at a mean age of 123 days.

In Texas, pregnant ewes were managed on fenced pasture with access to a salt-limited protein and energy supplement until lambing. At lambing, ewes and lambs were placed in small pens for 1 to 2 days and then returned to smaller pastures. All lambs were docked and males were castrated shortly after birth. During the summer, all ewes and lambs were managed as one flock and rotated through available grazing pastures. At approximately 100 days of age, the wether lambs were weaned. Wether lambs were adjusted to an ad libitum diet of 13.7% crude protein (CP) and 3.21 Mcal DE/kg based on sorghum grain and peanut hulls. Lambs were fed by sire groups in large open pens until they reached slaughter weight.

Growth rate from birth to weaning was measured on all ewe and wether lambs (n = 1391; Table 1). Carcass measures were taken on a smaller sample of wether lambs (n = 355).

Carcass Measurements

Carcass data were obtained on all available wether lambs at Idaho and Texas and on a random sample of four wether lambs per sire (24 per sire breed group) at California. Target slaughter weight was 57 kg at Idaho and Texas, while equal numbers of lambs were slaughtered at 43, 48, 52 and 57 kg at California. Actual range in slaughter weights was 48 to 62 kg at Idaho, 43 to 60 kg at Texas and 39 to 60 kg at California. The California experiment involved measurement of feed intake and of carcass fatness as determined by specific gravity; those results have been reported elsewhere (Sakul et al., 1993).

Lambs were weighed shortly before slaughter at commercial packing plants. Other data collected included hot carcass weight, dressing percentage, KP fat expressed as a percentage of hot carcass weight, leg conformation score, back fat depth between the 12th and 13th ribs over the longissimus dorsi and USDA Yield and Quality Grades. Longissimus area at the 12th and 13th ribs was observed on 124 lambs at only one location (ID).

Statistical Analyses

The statistical analyses were performed using the Mixed Model Least-Squares and Maximum Likelihood computer program by Harvey (1990). The experimental design of this project was a nested split-plot. Therefore, Harvey's statistical model 7 was used because it allows analyses of experimental designs with nested effects that interact with a set of cross-classified fixed effects. Weaning weight and growth rate were analyzed with fixed effects for sire breed (FWM, SWM, RAMB), location (ID, CA, TX, MT), sex of lamb (ewe, wether), type of rearing (single, twin) and age of dam (2, 3, 4, 5, ≥ 6 years). Sire of lamb (n = 18) was considered a random effect. Sire effect was nested within sire breed and used as the error term for sire breed effect. Age at weaning was treated as a continuous variable. The effect of location by sire within sire breed was used as the error term for location and the location by sire breed interaction. Preliminary analyses showed all other first level interactions were not important ($P > 0.10$).

Carcass characteristics were analyzed using a model similar to that previously described but age at weaning and three fixed effects were not included. Because only wether lambs were slaughtered, the effect of lamb's sex was not included. Type of rearing (single vs. twin) and age of dam were shown not to be significant effects in preliminary analyses. Hot carcass weight was included as a continuous variable when analyzing the independent carcass variables of percentage KP fat, back fat depth, leg conformation score, USDA Yield and Quality Grade. Hot carcass weight and dressing percentage were analyzed without the covariate of hot carcass weight. Only three locations (ID, TX, CA) reported carcass characteristics. Because longissimus area was measured at only one location (ID), a reduced statistical model was used with only fixed effects for sire and sire breed with sires nested within sire breed and hot carcass weight as a covariate.

Statistical comparisons of sire breeds were accomplished by contrasting least-squares means (LSM) of independent variables using pairwise t-tests. When the interaction of sire breed by location was not significant, only the overall means were contrasted.

Because the sires within sire breeds were highly selected, it was also of interest to determine differences among sires within a sire breed for economically important traits. Differences among sires may indicate that further selection among all possible rams can improve economically important traits such as carcass characteristics. This was accomplished by separate statistical analyses for each sire breed. The statistical model for carcass characteristics included sire and location as fixed effects and hot carcass weight as a continuous variable when appropriate. Preliminary analysis demonstrated that the sire-by-location interaction was not significant for carcass characteristics. Sire LSM were contrasted using pairwise t-tests when sire effect was significant.

Table 1. Number of Australian Merino- and Rambouillet-sired F1 lambs by location.

Sire breed[a]	ID	TX	MT	CA	Total
FWM	120	121	112	146	499
SWM	107	145	96	154	502
RAMB	81	121	57	131	390
Total	308	387	265	431	1,391

[a] FWM = one-half Australian Merino fine-wool strain; SWM = one-half Australian Merino strong-wool strain; RAMB = purebred Rambouillet (ID, MT, TX) or one-half Rambouillet and one-half Targhee (CA).

Results and Discussion

The effect of location was significant for all variables measured; however, the objective of this study was not to compare environments because the base populations also differed in genetic background. The experimental design across locations creates confounding of breeds and data collection procedures within locations. For example, lamb carcasses were evaluated by different graders across locations. Also, the Rambouillet-type breed designation is used for purebred

Rambouillet and Rambouillet/Targhee lambs at different locations. Because breeds and data collection procedures are confounded by location, the effect of sire breed-by-location interaction was important to consider. This interaction was not significant for any independent variables in the preliminary analyses indicating that sire breeds ranked consistently in all locations. Data representing locations are reported within sire breed classifications but are not discussed.

The number of F1 Australian Merino and Rambouillet-sired lambs evaluated in this study are listed by location in Table 1. LSM for weaning weights and growth rates from birth to weaning by location and sire breeds are presented in Table 2. All fixed effects were significant except for the interaction of sire breed by location ($P = 0.36$ for weaning weight, $P = 0.24$ for growth rate). Although there were significant differences in the growth of the lambs due to location, sex of the lamb and age of dam, only the LSM for sire breed-by-location and overall sire breed classifications are reported and discussed.

Obvious differences in growth rates due to location effects were present. Montana lambs grew more slowly and weighed less at weaning than lambs raised at other locations. Differences among locations cannot be fully explained as the cause(s) is(are) most likely confounded with genetic differences among maternal populations, management and nutrition.

Lamb genotypes differed in weaning weights and growth rates. Overall, FWM lambs grew the slowest ($P < 0.01$) while RAMB lambs grew the fastest ($P < 0.01$). Weaning weight and growth rate of SWM lambs were intermediate to FWM and RAMB lambs. This is somewhat surprising because the promotional information provided with the SWM and FWM rams used in this study indicated the mature average body weight (BW) of the selected SWM rams was 13 kg greater than that of the selected FWM rams.

There was no difference ($P = 0.18$) in hot carcass weights or dressing percentages among sire breeds (Table 3). Dressing percentages differed among locations ($P < 0.05$); the lower lamb dressing percentages in Idaho were caused by depriving lambs for a shorter period of time of feed and water prior to slaughter and the carcass weight did not include the kidney and pelvic fat which was included in the carcass weight at Texas and California. Leg conformation scores and longissimus muscle areas are considered to be indicators of muscling characteristics and differed among sire breeds ($P < 0.05$). Rambouillet wether lamb carcasses had higher leg conformation scores and greater longissimus muscle area than FWM lamb carcasses. There were no significant differences between RAMB and SWM lambs for leg conformation scores and longissimus muscle areas, but means tended to consistently favor RAMB-sired lamb carcasses.

Measurements of fatness and quality grade are presented in Table 4. Percentage KP fat and back fat depth were greater for FWM than for SWM and RAMB ($P < 0.05$). Percentage KP fat was 33% greater in FWM than the other sire breeds. Carcasses of SWM and RAMB had similar percentage KP fat ($P = 0.53$), but back fat depth was lower in RAMB ($P = 0.04$).

USDA Yield Grade is determined by back fat depth which can be adjusted for asymmetric carcass fat distribution. Therefore, ranking of lamb sire breeds by yield grade and by back fat depth were identical. Most of the carcasses were evaluated "Choice" for USDA Quality Grade, thus there were no significant differences among sire breeds ($P > 0.18$).

The greater subcutaneous and intraperitoneal fat values of FWM carcasses indicate that these wethers were more physiologically mature than SWM and RAMB wethers when compared at equal carcass weight. Sakul et al. (1993) evaluated the carcass chemical composition of similar sire breeds by specific gravity and determined that on a 23% carcass fat basis, FWM lambs would have to be slaughtered at a live weight 16 kg lighter than RAMB lambs. Other authors also have suggested that FWM crossbred lambs be slaughtered at lighter weights than Rambouillet lambs (Willingham et al., 1992). A lighter slaughter weight for FWM lambs would not be desirable because of preferences by packers for heavier carcasses and U.S. consumers for larger loin chops.

The effect of sire nested within sire breed was highly significant in all

Table 2. Least-squares means (LSM) for weaning weights and growth rates from birth to weaning of Australian Merino- and Rambouillet-sired F1 lambs.[a]

Trait by location	FWM	SWM	RAMB
Weaning weight, kg			
ID	30.7	32.2	33.6
TX	30.0	29.0	30.2
MT	25.3	25.7	27.0
CA	30.4	31.0	31.9
Overall ± SE	29.1 ± 0.1[b]	29.5 ± 0.1[c]	30.6 ± 0.1[d]
Growth rate, kg/day			
ID	0.23	0.24	0.25
TX	0.23	0.22	0.23
MT	0.19	0.19	0.20
CA	0.23	0.24	0.25
Overall ± SE	0.22 ± 0.01[b]	0.23 ± 0.01[c]	0.25 ± 0.01[d]

[a] FWM = one-half Australian Merino fine-wool strain; SWM = one-half Australian Merino strong-wool strain; RAMB = purebred Rambouillet (ID, MT, TX) or one-half Rambouillet and one-half Targhee(CA).

[b,c,d] Values with different superscripts in the same row are different ($P < 0.05$).

statistical models. Therefore, the effect of sire was investigated within sire breed group. Sire effects were not important for carcass characteristics of FWM and RAMB (P > 0.21). Hot carcass weight, dressing percentage and quality grade were comparable among SWM sires (P > 0.10). Differences among SWM sires for measures related to fat were large and important; one individual ram (Sire 3) was obviously less desirable for some carcass traits (Table 5). The carcasses of offspring from Sire 3 had 41% more kidney and pelvic fat than offspring from Sires 4 and 6 (P < 0.01). Also, the back fat depths of carcasses of offspring from Sire 3 were 27% thicker compared to offspring from Sire 1 (P < 0.01).

Sheep breeders selecting Australian Merino or Rambouillet rams primarily for improved wool quality and production should realize that lamb carcass characteristics can be improved at the same time by careful genetic selection (Glimp and Snowder, 1989; Wolf et al., 1981).

Conclusions

Although some differences in carcass measures for the three sire breeds evaluated are statistically significant, these differences may not be of great commercial importance at the present time. However, if in the future, a premium is paid for lean carcasses then the U.S. Rambouillet will have a clear advantage when compared to the Australian Merino. Carcass characteristics of Australian Merino sired lambs may be improved by selection for rams superior in wool and carcass traits as observed in lambs sired by SWM rams.

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Table 3. Least-squares means (LSM) of hot carcass weight, dressing percentage, leg conformation score and longissimus muscle area of Australian Merino- and Rambouillet-sired F1 lambs.[a]

Trait by location	Number	FWM	SWM	RAMB
Hot carcass weight, kg				
ID	124	25.0	25.3	25.4
TX	160	27.1	26.6	27.8
CA	71	25.0	24.9	25.2
Overall ± SE	355	25.7 ± 0.25	25.6 ± 0.26	26.1 ± 0.27
Dressing percentage, %				
ID	124	46.8	46.6	46.7
TX	160	52.9	52.4	53.3
CA	71	51.4	50.0	50.4
Overall ± SE	355	50.4 ± 0.40	49.7 ± 0.40	50.1 ± 0.41
Leg conformation[b]				
ID	124	11.0	10.9	11.3
TX	160	11.6	11.7	11.9
CA	71	11.2	11.8	11.7
Overall ± SE	355	11.3 ± 0.09[c]	11.5 ± 0.09[cd]	11.6 ± 0.09[d]
Longissimus area, cm^2				
ID ± SE	124	11.5 ± 0.14[c]	11.9 ± 0.12[cd]	12.9 ± 0.14[d]

[a] FWM = one-half Australian Merino fine-wool strain; SWM = one-half Australian Merino strong-wool strain; RAMB = purebred Rambouillet (ID, TX) or one-half Rambouillet and one-half Targhee (CA).
[b] Leg conformation: 10 = low choice; 11 = average choice; 12 = high choice.
[c,d] Values with different superscripts in the same row are different (P < 0.05).

Table 4. Least-squares means (LSM) for percentage kidney and pelvic (KP) fat, back fat depth, USDA Yield and Quality Grades of Australian Merino- and Rambouillet-sired lambs.[a]

Trait by location	Number	FWM	SWM	RAMB
KP fat, %				
ID	124	3.4	2.4	2.5
TX	160	2.9	2.2	2.2
CA	71	5.6	4.4	4.0
Overall ± SE	355	4.0 ± 18[b]	3.0 ± 0.18[c]	2.9 ± 0.19[c]
Back fat depth, mm				
ID	124	6.8	6.5	6.2
TX	160	5.5	5.0	4.5
CA	71	5.4	5.4	4.6
Overall ± SE	355	5.9 ± 0.20[b]	5.6 ± 0.17[c]	5.1 ± 0.21[d]
Yield grade[e]				
ID	124	3.2	3.1	2.9
TX	160	2.6	2.2	2.1
CA	71	3.2	2.8	2.4
Overall ± SE	355	2.9 ± 0.08[b]	2.6 ± 0.08[c]	2.4 ± 0.09[d]
Quality grade[f]				
ID	124	11.3	11.1	11.7
TX	160	10.3	10.1	11.1
CA	71	11.1	11.3	10.2
Overall ± SE	355	10.9 ± 0.06	10.9 ± 0.10	10.8 ± 0.10

[a] FWM = one-half Australian Merino fine-wool strain; SWM = one-half Australian Merino strong-wool strain; RAMB = purebred Rambouillet (ID, TX) or one-half Rambouillet and one-half Targhee (CA).

[b,c,d] Values with different superscripts in the same row are different ($P < 0.05$).

[e] USDA Yield Grade scores from 1 to 5 with lower values representing higher yield of trimmed retail cuts.

[f] USDA Quality Grade: 10 = low choice; 11 = average choice; 12 = high choice.

Table 5. Least-squares means (LSM) for carcass traits of Australian strong-wool Merino sires.

		Carcass trait		
Sire	Number	KP fat, %	Back fat, mm	Yield grade[a]
1	23	3.6[b]	5.5[c]	2.6[c]
2	19	4.5[b]	5.7[c]	2.6[c]
3	30	4.8[b]	7.0[d]	3.4[d]
4	21	3.4[b]	6.4[d]	3.1[d]
5	23	3.6[b]	6.0[bc]	2.8[bd]
6	18	3.4[b]	6.5[bd]	3.2[bd]

[a] USDA Yield Grade scores from 1 to 5 with lower values representing higher yield of trimmed retail cuts.

[b,c,d] Values with different superscripts in the same row differ ($P < 0.05$).