Comparison of U.S. Fine-Wool and Australian Merino F1 Crosses: III. Lamb Production[1]

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Summary

Sheep producers in the United States have expressed interest in the inclusion of Australian Merino sheep in crossbreeding programs with U.S. fine-wool sheep to improve fleece characteristics. The impact on reproduction of the Australian Merino in a crossbreeding program is unknown. Therefore, a cooperative multi-institution research project was initiated to evaluate the reproductive performance of Australian Merino crossbred ewes. First cross (F1) ewes were produced by mating two strains (fine-wool or strong-wool) of Australian Merino rams to one of two U.S. western range breed ewes, Rambouillet or Targhee, at four different locations (ID, MT, TX, CA). Matings produced F1 lambs of one-half fine-wool Merino (FWM) or strong-wool Merino (SWM) and one-half Rambouillet or Targhee. Six Rambouillet rams were selected from flocks in Texas to produce control populations (RAMB). Reproduction was observed on F1 ewes at 2 years (n = 596) and at 3 years (n = 540) of age. Two-year-old RAMB-sired ewes had the highest overall fertility rates (average, 85%) compared with FWM (78%; P = 0.08) and SWM (79%; P = 0.12). At 3 years of age, fertility did not differ among sire breeds (P > 0.10); however, fertility of SWM (87%) was lower compared with FWM (92%; P = 0.09) and RAMB ewes (92%; P = 0.12). The RAMB ewes had higher levels of prolificacy than FWM and SWM ewes. At 2 and 3 years of age, FWM and SWM ewes weaned litters of comparable weights (P > 0.10) but lighter than RAMB ewes (P < 0.05). Litter weights for RAMB ewes were 10 to 12% heavier than the Merino-cross ewes. Large phenotypic variations among and within genotypes suggest that genetic approaches be considered to increase lamb production. When U.S. producers are considering Australian Merinos for improving wool characteristics, they must also consider sire differences for reproductive traits or any economic gains in wool production could be offset by diminished lamb production.

Key words: crossbreeding, Merino, lamb, reproduction, fertility.

Introduction

Sheep producers in the U.S. have shown interest in the inclusion of Australian Merino sheep in crossbreeding programs with domestic fine-wool sheep to improve fleece characteristics. Introduction of a foreign sheep breed into any established and adapted breed can have positive and/or negative consequences on one or all production traits. Currently, lamb production is of greater economic importance than wool production in the U.S. The impact on reproduction of modern Australian Merino sire breeds in a crossbreeding program is unknown. Therefore, a cooperative multi-institution research project was initiated to evaluate the reproductive performance of Australian Merino crossbred ewes in the western region of the U.S.

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Materials and Methods

This study involved 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. (1998).

Generation of Ewe Genotypes

First cross ewes (Fl) were produced by mating two strains of Australian Merino rams to one of two U.S. western range fine-wool breed ewes (Rambouillet or Targhee) at four different locations (ID, MT, TX, CA). The same six rams from each of the two Australian Merino strains (fine-wool or strong-wool) were bred to Rambouillet (ID, MT, TX) or Targhee (CA) ewes by artificial insemination or natural mating. Mating of Australian Merino strains produced Fl lambs of one-half fine-wool Merino (FWM) or strong-wool Merino (SWM) and one-half Rambouillet or Targhee. Six Rambouillet rams were selected from flocks in Texas to produce control populations at each location. The offspring from the Texas Rambouillet rams were either Rambouillet (ID, MT, TX) or one-half Rambouillet and one-half Targhee (CA). All lambs sired by Texas Rambouillet rams were grouped as Rambouillet-type (RAMB).

The general management of ewe lambs varied by locations. Average age at weaning ranged from 94 to 150 days, depending upon location. The weaned lambs were either managed on fenced pasture, given ad libitum access to alfalfa hay, or fed a limited amount of a pelleted balanced ration. At approximately one year of age, ewes were mixed with older ewe populations and managed on fenced pastures or under herded range conditions.

Breeding of Ewes

Different groups of five to six mature Suffolk rams from the U.S. Sheep Experiment Station were provided to each location for flock mating. The same Suffolk rams were used across years within location. All ewes were exposed to rams at approximately 18 and 31 months of age. The ewes in California were exposed to rams during June while ewes at other locations were exposed to rams in the fall.

Lamb Management

Thirty days before lambing, ewes at Idaho were placed in a feedlot pen and fed 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. At 2 days of age, ewes and lambs were moved outside to larger mixing pens with up to 12 ewe and lamb pairs. At approximately 30 days of age, ewes and lambs were given access to fenced sagebrush grassland pasture. Ewes and lambs were trailed 30 days later to high elevation mountain meadow and tall forb grazing communities where they remained under herded conditions until weaning. The average lamb weaning age was 129 days at first parity and 124 days at second parity.

At 30 days before lambing, ewes at California grazed mature annual pastures and were supplemented with 1.0 kg/(head•day) of alfalfa hay. At 10 days before 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 and fed approximately 2.7 kg/(head•day) of alfalfa pellets. Post lambing, ewes and lambs were maintained on subterranean clover/annual grass pastures until weaning. The average age of lambs at weaning was 109 days at first and second parities.

Management of ewes and lambs in Montana was similar to that in Idaho. Ewes were brought into feedlots with ad libitum access to alfalfa hay and supplemented with 0.6 kg/day of whole barley grain. At lambing, ewe and lamb(s) were moved into single animal pens of a lambing barn for 1 to 3 days. Afterwards ewes and lambs were moved outside to larger mixing pens with other ewe and lamb(s) pairs for approximately 40 days. Ewes and lambs were transported to the Red Bluff Research Ranch (Red Bluff, MT) to graze upland range grasses (bluebunch wheatgrass, Idaho fescue) and forbs (rubber rabbitbrush, lupine, western yarrow) until weaning. The average age of lamb at weaning was 130 days at first parity and 121 days at second parity.

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 pasture. Lambs were weaned at an average age of 119 days at first parity and 109 days at second parity.

Data collected at lambing included birth date, birth type, and sex of lamb. All ram lambs were castrated shortly after birth at each location. Fertility (number of ewes lambing per ewe exposed and alive at lambing) and prolificacy (number of lambs born per ewe lambing) were recorded for sire breed classification. At weaning, date and lamb weight were recorded. Litter weight weaned was calculated for ewes with a live lamb(s).

Some locations experienced lamb losses due to predation (CA, TX). Because all ewes and their lambs were managed as one flock at each location, the effect of predation was assumed to be random. Therefore, analyses of litter weight weaned was limited to data from ewes that reared at least one lamb.

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 design. Data were analyzed for nested effects interacting with cross-classified fixed effects. The statistical models for fertility and prolificacy included fixed effects for ewes' sire breed (FWM, SWM, RAMB) and location (ID, CA, TX, MT). Sire of dam (n = 18) was considered a random effect. Sire of dam effect was nested within sire breed and used as the error term for sire breed effect. The interaction of location by sire-of-dam nested within sire breed was used as the error term for location and the location-by-sire breed interaction. Preliminary analyses had shown that all other first level interactions were not important ($P > 0.10$).

Litter weight weaned was analyzed by a statistical model similar to that used for fertility and prolificacy. Litter weight weaned for a dam is the sum of the lamb' weaning weights corrected for sex. Type of rearing (single, twin) was included in the correction model so that estimates of correction for sex effect would be unbiased by type of rearing. Therefore, litter weight weaned for the dam is the sum of the lamb weaning weights corrected for sex. Least-square means (LSM) for litter weight were obtained from a statistical model with fixed effects and interactions for sire breed, sire of dam nested with sire breed, location, location-by-sire breed and location-by-sire of dam nested within sire breed. Age at weaning was considered a covariate in the model. The lamb's sire effect was not considered because it is confounded with location.

An inherent confounding of year and age of the ewe (all ewes were born in the same year) did not allow for separation of these effects. Therefore, statistical analyses did not include year or age of ewe effects but were conducted within age of ewe. Differences among sire breeds at a given age for reproductive traits were of greater importance than testing differences due to ewe ages which could not be accurately described due to confounding with year effects.

Statistical comparisons of sire breeds were accomplished by contrasting LSM of independent variables using pairwise t-tests. When the interaction of sire breed by location was not significant ($P \leq 0.05$), only the overall means were contrasted.

Because the sires of the dams within sire breeds were highly selected for their wool traits, it was of interest to determine if sufficient genetic variation for lamb production traits existed among sires so that selection may be used to improve reproductive traits. A statistical model to estimate sire-of-dam LSM for reproductive traits was performed within each sire breed. Sire of dam and location were fixed effects when evaluating fertility and prolificacy. The covariate of lamb age at weaning was added for analyzing litter weight weaned. Preliminary analysis showed the sire-of-dam-by-location interaction was not significant ($P > 0.10$) for the lamb production traits analyzed. LSM were contrasted using pairwise t-tests when the sire-of-dam effect was significant ($P < 0.05$).

Results and Discussion

There were 596 F1 and purebred ewes at 2 years of age and 540 at 3 years of age (Table 1). Sire breed of ewe responses for fertility and prolificacy did not differ among locations at 2 or 3 years of age ($P = 0.74$ and 0.45, respectively). Locations did vary in 2-year-old ewe fertility and prolificacy ($P < 0.01$; overall location LSM are not shown). The lower values for fertility and prolificacy in California of 2-year-old ewes is related to the breeding season used in California which was June while other locations (ID, MT, TX) exposed ewes to rams during the fall. Fertility of 2-year-old ewes was higher in Idaho and Montana flocks compared with Texas and California flocks (Table 2). Two-year-old RAMB ewes had the highest overall fertility rates (85%) compared to FWM (78%; $P = 0.08$) and SWM (79%; $P = 0.12$). At 3 years of age, there were no significant differences among sire breeds for fertility; however, fertility of SWM (87%) was lower than FWM (92%; $P = 0.09$) and RAMB ewes (92%; $P = 0.12$).

Prolificacy rates were influenced by location ($P < 0.01$; overall location LSM are not shown) and ewes' sire breed ($P < 0.05$). Prolificacy rates of 2-year-old ewes were generally higher in Idaho and Montana compared with Texas and California. At 3 years of age, Texas ewes generally had lower prolificacy rates than other locations. The ranking of sire breeds for prolificacy were consistent across ewe age or year; RAMB ewes had higher ($P < 0.05$) levels of prolificacy than FWM and SWM ewes. FWM ewes had lower prolificacy rates than SWM and RAMB ewes. Prolificacy increased with parity as expected (Bradford, 1985).

The ability to raise a lamb(s) successfully may be quantified by the total litter weight weaned. Total litter weight weaned is positively correlated with fertility, prolificacy, milking performance, lamb survival, lamb growth rate and maternal ability (Snowder et al., 1996). Litter weight weaned was influenced by location ($P < 0.01$; overall location LSM are not presented) and sire breed ($P < 0.05$) effects. The ranking of sire breeds did not differ ($P > 0.10$) among locations (Table 3). Highest litter weights weaned among sire breeds and ages were observed in Idaho. At 2 and 3 years of age, FWM and SWM ewes weaned litters of comparable weights ($P > 0.10$) but lighter than RAMB ewes ($P < 0.05$). Litter weights for RAMB ewes were 10 to 12% heavier, a very significant economic factor to consider.

Sires of dams were highly selected within their sire breeds for wool characteristics. Therefore, it was important to evaluate phenotypic differences in

Table 1. Numbers of F1 Australian Merino- and Rambouillet-sired ewes by location at two (and three) years of age.

Sire breed[a]	ID	TX	MT	CA	Total
FWM	52 (47)	49 (47)	40 (40)	61 (53)	202 (187)
SWM	61 (57)	67 (64)	39 (35)	66 (58)	233 (214)
RAMB	38 (32)	46 (41)	23 (23)	54 (43)	161 (139)
Total	151 (136)	162 (152)	102 (98)	181 (154)	596 (540)

[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).

reproductive traits among sires within a sire breed to decide if selection within a sire breed might be a possibility for improving reproductive traits. Therefore, the effects of sire-of-dam were investigated within sire breed classification. Location was an important effect ($P < 0.01$) on all reproductive traits but these are not discussed in detail because the intent of the project was to compare sire breeds under varying production systems and locations. The fact that the interaction between sire breed and location was not significant confirms that the rank of performance among sire breeds did not differ across locations. Ewe fertility and prolificacy among FWM and RAMB sires did not differ ($P > 0.22$). However, sires of SWM ewes varied in daughters' reproductive traits (Table 4). The daughters from Sires 1 and 3 had higher fertility and prolificacy rates than ewes from other sires.

The RAMB sires did not differ in their daughters' litter weight weaned ($P > 0.60$). Differences among SWM sires for their daughters' litter weight weaned approached levels of significance ($P = 0.08$ and 0.11 at 2 and 3 years of age, respectively) but were not reported. The FWM sires did not differ in their daughters' performance for litter weight weaned at 2 years of age ($P = 0.56$) but sire differences were significant at 3 years of age (Table 5). Litter weights from ewes of Sire 5 were 19% heavier ($P < 0.05$) than the average of the other sires.

Litter weight weaned is the most economically important trait measured for many producers because it represents the actual weight of product being marketed on a per ewe basis.

Genotypic variation among and within sire breeds suggests that genetic approaches for increasing lamb production might be successful. Selection of rams from three sire breeds (FWM, SWM, RAMB) for wool characteristics did result in noticeable differences among ewes for reproduc-

Table 2. Least-squares means (LSM)for fertility and prolificacy of F1 Australian Merino- and Rambouillet-sired ewes by age of ewe at lambing and location.

	2 years			3 years		
Trait/location	FWM[a]	SWM[a]	RAMB[a]	FWM[a]	SWM[a]	RAMB[a]
Fertility, %						
ID	96.2	96.7	100.0	94.6	89.2	100.0
TX	61.2	61.2	73.9	92.2	91.6	93.0
MT	97.5	92.3	95.7	90.9	78.8	83.1
CA	57.4	66.7	72.2	90.4	88.6	90.5
Overall ± SE	78.1 ± 2.7^b	79.2 ± 2.6^b	85.4 ± 3.2^b	92.0 ± 2.4^b	87.0 ± 2.3^b	92.1 ± 2.8^b
Prolificacy, %						
ID	126	136	139	140	162	159
TX	107	125	140	112	114	137
MT	134	121	157	124	126	142
CA	107	106	111	130	137	137
Overall ± SE	119 ± 5.9^b	122 ± 5.6^b	137 ± 5.9^c	127 ± 6.0^b	135 ± 6.1^b	144 ± 6.4^c

[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] Overall values with different superscripts within age of ewe and same row are different ($P < 0.05$).

Table 3. Least-squares means (LSM) for total litter weight weaned (kg) of F1 Australian Merino- and Rambouillet-sired ewes by age of ewe and location.[a]

	2 years			3 years		
Location	FWM	SWM	RAMB	FWM	SWM	RAMB
ID	38.9	42.6	45.4	54.3	54.5	57.3
TX	32.6	34.3	34.5	32.9	34.0	37.7
MT	36.5	35.4	39.2	40.5	42.1	49.4
CA	31.9	32.4	34.9	29.8	30.1	32.1
Overall ± SE	35.0 ± 1.21^b	36.2 ± 1.8^b	38.5 ± 1.9^c	39.4 ± 1.1^b	40.2 ± 1.1^b	44.1 ± 1.2^c

[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] Values with different superscripts in the same row and age group differ ($P < 0.05$).

tive traits. This study also identified significant differences among rams within the FWM breed. Therefore, breeders selecting rams for superior wool characteristics may also benefit from additional selection of rams with more desirable breeding values for reproduction.

Conclusions

Selection of FWM or SWM sires based only on improved wool characteristics can decrease prolificacy and total litter weight weaned per ewe in U.S. fine-wool flocks. This study clearly shows that sire differences for reproductive traits must be considered concurrently with wool traits or any economic gains in wool production could be offset by diminished lamb production.

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Table 4. Least-squares means (LSM) of ewe fertility and prolificacy rates by Australian strong-wool Merino sire of ewe and age of ewe.

		Fertility		Prolificacy	
Sire	Number[a]	2 years	3 years	2 years	3 years
1	35	94.4[b]	98.2[b]	138[b]	141[b]
2	40	71.4[c]	85.2[c]	117[c,d]	116[c,d]
3	44	87.5[d]	95.4[b]	122[c,d]	149[b]
4	30	77.0[c]	89.3[c]	111[d,e]	113[c]
5	42	70.0[c]	84.1[c]	119[c,d]	105[c]
6	38	69.0[c]	85.1[c]	105[e]	123[d]

[a] Number of 2-year-old ewes present at lambing. There were 14 less 3-years-old ewes .
[b,c,d,e] Values with different superscripts in the same column differ ($P < 0.05$).

Table 5. Sire least-squares means (LSM) of litter weight weaned of Australian fine-wool Merino ewes.

Sire	Number	3 years
1	21	38.2[a]
2	14	38.3[a]
3	22	38.2[a]
4	35	39.1[a]
5	25	45.1[b]
6	22	35.4[a]

[a,b] Means with different superscripts within a column differ ($P < 0.05$).