Preweaning performance of lambs sired by Suffolk, Siremax composite, and USSES paternal composite rams in an extensive rangeland production system[1,2]

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INTRODUCTION

Optimal use of additive breed effects, heterosis, and nonadditive effects of breed complementarity in livestock production can be achieved using structured crossbreeding systems (Moav, 1966; Fitzhugh et al., 1975). In sheep production, these systems often use locally adapted dam breeds and large, relatively lean terminal-sire breeds to optimize dam fitness and offspring growth and carcass value. Positive effects of heterosis and breed complementarity in crossbred or composite ewes and lambs have been documented (Nitter, 1978; Leymaster, 2004), but the contribution of crossbred or composite sires on flock productivity is less understood (Leymaster, 1987; Notter, 1987).

Suffolk sires produced heavier lambs than other candidate terminal-sire breeds of sheep (Leeds et al., 2012; Notter et al., 2012), but concerns regarding the fitness and longevity of Suffolk rams (McInturff, 2001) and, perhaps, survival rates for their crossbred lambs (Leymaster and Jenkins, 1993) created interest in the development of new composite terminal-sire breeds. Development of Siremax began in 1993 and involved contributions from the Columbia, Texel, Suffolk, and Hampshire breeds (www.siremax.com). Siremax has been closed to outside introductions of breeding animals since 2001. Development of the U.S. Sheep Experiment Station (USSES) paternal composite (PC) began in 2005 by mating Columbia and Suffolk ewes from USSES to Columbia, Suffolk, and Texel rams used in the terminal-sire evaluation project described by Leeds et al., (2012). Additional sampling of industry Suffolk and Texel rams and inter se mating of crossbred individuals resulted in formation of a composite line with 3/8 Suffolk, 3/8 Columbia, and 1/4 Texel breeding in 2009. Occasional new introductions of purebred sires of foundation breeds and generation of new 3/8 Suffolk, 3/8 Columbia, and 1/4 Texel founder animals has continued since 2009.

The objective of this project was to compare performance of Suffolk, Siremax, and PC rams mated to Polypay, Targhee, and Rambouillet ewes in an extensive rangeland production system. The current study considers breed effects on performance to weaning.

MATERIALS AND METHODS

The USSES Institutional Animal Care and Use Committee approved all husbandry practices and experimental procedures used in this study.

[1]Mention of trade names or commercial products in this publication is solely for the purpose of providing specific information and does not imply recommendation or endorsement by the U.S. Department of Agriculture. The USDA is an equal opportunity provider and employer.

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In autumn of 2015, 2016, and 2017, approximately equal numbers of Polypay, Targhee, and Rambouillet ewes were mated to Suffolk, Siremax, or PC rams in single-sire mating pens. Eight or nine rams of each breed were used in each year. Two rams per breed were used in adjacent years to create genetic linkages. Most Suffolk rams were purchased from industry flocks, and a majority came from flocks that participated in the U.S. National Sheep Improvement Program (NSIP). Siremax rams came from flocks in Minnesota and Oregon and PC rams were produced at USSES. Across the 3 yr, 478 individual ewes produced 658 litters and 1,288 lambs sired by 58 different rams (20 Suffolk, 20 Siremax, and 18 PC).

Ewes were mated to individual rams in feedlot pens for 21 d in October and early November. Ewes were then moved to winter grazing, exposed to groups of Suffolk clean-up rams for 21 d, and brought back to the feedlot in mid to late January. Ewes were closely monitored (i.e., observed every 30 min) during lambing. Within 15 min after birth, ewes and lambs were moved to individual indoor claiming pens for approximately 48 h. Lamb birth weights were recorded, lambs were docked, and male lambs were castrated. Because of industry claims of higher dystocia levels with Texel and Texel-composite breeds, each lamb was assigned a lambing difficulty score of 1–8 (1 = normal, no assistance; 2 = normal, but lamb was palpated in birth canal to check status; 3 = assistance due to malpresentation of leg(s); 4 = assistance due to malpresentation of head; 5 = assistance, breech; 6 = assistance due to lack of cervical dilation; 7 = assistance due to other reasons, with explanation; and 8 = assistance due to large lamb). Triplet and larger litters were reduced to two lambs or, occasionally, one lamb soon after birth. Surplus lambs were grafted to recipient ewes or reared artificially. Ewes and lambs were then comingled with the flock in outdoor feedlot pens through late April and subsequently grazed sagebrush steppe until weaning in mid-July.

Ewe reproductive performance (percentage of ewes that lambed, incidence of lambing difficulty, and litter size at birth, 3 d after lambing, and weaning) and productivity (kilograms of lamb weaned per ewe lambing or per ewe exposed) were analyzed with a linear model. The model included fixed effects of lambing year, sire breed, dam breed, dam age at lambing (2, 3, 4, 5, or ≥ 6 yr), and two-way interactions among fixed effects and a random effect of sire (nested within sire breed and lambing year). Lambing difficulty scores were recoded for these analyses. A final score of 0 (no assistance) corresponded to an original score of 1 or 2 and a final score of 1 (assisted birth) corresponded to original scores of 3 through 8. Lambing difficulty was analyzed as a trait of the ewe. Each ewe was assigned a final score equal to the highest score assigned to the individual lambs in her litter. Interactions that were not significant ($P > 0.05$) for any of the ewe performance traits were removed from the final model.

Individual lamb birth weights were analyzed with a linear model that included fixed effects of lambing year, sire breed, dam breed, lamb sex, dam age at lambing, and two-way interactions among fixed effects and a random sire effect (nested within sire breed and lambing year). Thirteen stillborn lambs had been coded as premature and were excluded from the birth weight analysis. The same model was used to analyze lamb death losses, coded as 0 for lambs that died and 1 for live lambs. The model for weaning weight also included a continuous effect of weaning age. Effects of litter size and number of lambs reared were not included in the models. Difference in prolificacy were therefore included in the dam breed effect. Interactions that were not significant ($P > 0.05$) for any of the lamb performance traits were removed from the final model.

The GLIMMIX Procedure of SAS (SAS Institute, Cary, NC) was used for all analyses. Lambs sired by clean-up rams were not included in the data, and lambs born in litters of four or five lambs (five Polypay and two Rambouillet litters) were not included in the analyses of individual lamb performance. Surplus lambs that were fostered to recipient ewes or artificially reared were not included in analyses of lamb weaning weights. The final data set included 1,179 birth weights and 850 weaning weights. Birth and weaning weights were assumed to have a normal distribution. Ewe fertility and lamb survival were analyzed as binomial variables. Orthogonal contrasts were used to compare Suffolk rams to the average of the two composite lines to compare Siremax and PC rams, to compare Polypay ewes to the average of Rambouillet and Targhee ewes, and to compare Rambouillet and Targhee ewes. The Tukey–Cramer procedure (Dunnett, 1980) was used for mean separation.

RESULTS AND DISCUSSION

Sire breed did not affect the incidence of lambing difficulty or litter size at birth, at 3 d after lambing, or at weaning ($P \geq 0.36$; Table 1). However, the percentage of ewes that lambed was higher ($P \leq 0.02$) for PC rams (95%) than for Suffolk (85%) or Siremax

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Table 1. Performance to weaning of Polypay (PP), Rambouillet (RA), and Targhee (TA) dams mated to Suffolk (SU), Siremax composite (SX), and USSES PC sires[a]

	Sire breed[b]				Dam breed					
Measurement	SU	SX	PC	Average SE	PP	RA	TA	Average SE	PP vs. range breeds	RA vs. TA
% lambing	85[e]	84[e]	95[f]	3	90	91	88	2	ns	ns
Litter size at birth	1.97	1.94	2.00	0.04	2.27[g]	1.92[h]	1.72[i]	0.04	***	**
Dystocia, %	10	12	16	2	14	12	11	2	ns	ns
Litter size at 3 d[c]	1.54	1.43	1.51	0.05	1.55[g]	1.55[g]	1.37[h]	0.05	†	**
Litter size at weaning[c]	1.41	1.30	1.38	0.05	1.44[g]	1.41[g]	1.23[h]	0.05	*	**
Litter weight at weaning, kg[d]	53.8[e] (44.1)[e,f]	47.0[f] (39.4)[e]	49.9[e,f] (47.1)[f]	1.7 (2.3)	53.5[g] (46.3)[g]	51.3[g] (46.0)[g]	45.9[h] (38.3)[i]	1.7 (1.9)	* (*)	* (**)

[a]Siremax was derived from crosses among the Columbia, Hampshire, Suffolk, and Texel breeds (www.siremax.com). The USSES PC was developed by USDA, ARS, Dubois, ID, by crossing the Columbia, Suffolk, and Texel breeds.

[b]Suffolk rams differed from the average of composite rams for litter weight weaned per ewe lambing (P = 0.008), and PC rams differed from Siremax rams for percentage of ewes lambing (P = 0.005) and litter weight weaned per ewe exposed (P = 0.02). No other contrasts among sire breed means were significant (P > 0.36).

[c]Reductions in litter size at 3 d of age and weaning included lambs that died and surplus lambs that were removed for artificial rearing. Litters were normally reduced to no more than two lambs within 48 h of birth.

[d]Per ewe lambing and, in parentheses, per ewe exposed.

[e,f]Sire breed means with different superscripts differ (P < 0.05) based on the Tukey–Kramer mean separation procedure.

[g,h,i]Dam breed means with different superscripts differ (P < 0.05) based on the Tukey–Kramer mean separation procedure.

ns = $P \geq 0.10$; † = $P < 0.10$; * = $P < 0.05$; ** = $P < 0.01$; *** = $P < 0.001$.

(84%) rams. These results were consistent with results of Leeds et al. (2012) indicating that Suffolk rams were equal or superior to Texel, Columbia, and U.S. Meat Animal Research Center PC rams in litter size at birth and weaning and lamb survival. The average litter weight weaned per ewe lambing was greater (P = 0.008) for Suffolk-sired litters (53.8 kg) than for litters sired by PC (49.9 kg) and Siremax rams (47.0), reflecting the significantly greater individual weaning weights and nonsignificantly greater survival to weaning of Suffolk-sired lambs (Table 2). However, the average litter weight per ewe exposed was greater for ewes exposed to PC rams than for ewes exposed to Siremax rams (47.1 vs. 39.4 kg; P = 0.02). The average litter weight for ewes exposed to Suffolk rams (44.1 kg) did not differ from that for ewes exposed to composite-breed rams (P = 0.75). The greater percentage of ewes that lambed and correspondingly heavier litter weights per ewe exposed for ewes mated to PC rams may have reflected benefits of local production and, perhaps, adaptation for PC rams and greater anticipated levels of hybrid vigor in a more recently developed composite breed. However, the relatively small numbers of rams used in this study, diverse origins of the Suffolk rams, and local production of PC rams limit conclusions that can be drawn about genetic differences in breeding efficiency and preclude meaningful consideration of sire-breed effects on ram fitness and longevity.

The percentage lambing did not differ (P = 0.54) among ewe breeds. Polypay ewes had larger litters (P < 0.001) at birth (2.27 lambs per ewe lambing) than Targhee and Rambouillet ewes (Table 1), and Rambouillet ewes had larger litters at birth (P = 0.001) than Targhee ewes (1.92 and 1.72 lambs, respectively). After accounting for perinatal death losses and removal of surplus lambs from litters of three or more lambs, Polypay and Rambouillet ewes both averaged 1.55 lambs per litter at 3 d after lambing. Targhee ewes had smaller litters at 3 d (1.37 lambs) than Polypay or Rambouillet ewes (P = 0.01). Polypay and Rambouillet ewes weaned similar numbers and total weight of lambs ($P \geq 0.61$), and both weaned more lambs and weight of lambs than Targhee ewes (P < 0.05).

Survival of individual lambs to 3 d after birth and to weaning (Table 2) did not differ among sire breeds ($P \geq 0.41$). Suffolk-sired lambs were 5% heavier at weaning than lambs sired by composite rams (P = 0.005). Lambs sired by Siremax and PC rams had similar weaning weights (P = 0.81). Sire-breed differences in birth weight were only partially consistent with sire-breed effects on weaning weight. Lambs sired by Suffolk and PC rams had similar birth weights (P = 0.98) and were 6% heavier at birth than Siremax-sired lambs ($P \leq 0.006$). Heavier birth weights of lambs sired by PC rams were consistent with their numerically higher incidence of lambing difficulty (Table 1).

Lambs from Polypay ewes weighed less at birth (P < 0.001) than lambs from Rambouillet and Targhee ewes, and lambs from Rambouillet ewes

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Table 2. Means, average SE, and significance of orthogonal contrasts for body weights and lamb survival (LS) of lambs from Polypay (PP), Rambouillet (RA), and Targhee (TA) ewes and Suffolk (SU), Siremax composite (SX), and USSES PC rams[a]

	Sire breed						Dam breed					
Measurement	SU	SX	PC	Average SE	SU vs. composites	SX vs. PC	PP	RA[c]	TA	Average SE	PP vs. range breeds	RA vs. TA
Birth weight, kg	5.56[b]	5.26[c]	5.58[b]	0.07	†	***	4.85[d]	5.66[e]	5.89[f]	0.07	***	**
Weaning weight, kg	38.9[b]	37.0[c]	37.2[c]	0.5	**	ns	37.4	37.5	38.1	0.4	ns	ns
LS to 3 d, %	80	76	79	2	ns	ns	71[d]	83[e]	81[e]	2	***	ns
LS to weaning, %	73	69	72	2	ns	ns	66[d]	75[e]	73[d,e]	2	**	ns

[a]Siremax was derived from crosses among the Columbia, Hampshire, Suffolk,and Texel breeds (www.siremax.com). The USSES PC was developed by USDA, ARS, Dubois, ID, by crossing the Columbia, Suffolk, and Texel breeds.

[b,c]Sire breed means with different superscripts differ ($P < 0.05$) based on the Tukey–Kramer mean separation procedure.

[d,e,f]Dam breed means with different superscripts differ ($P < 0.05$) based on the Tukey–Kramer mean separation procedure.

ns = $P \geq 0.10$; † = $P < 0.10$; ** = $P < 0.01$; *** = $P < 0.001$.

weighed less at birth than lambs from Targhee ewes ($P = 0.01$). This result in part reflected the greater litter sizes of Polypay and, to a lesser extent, Rambouillet ewes compared with Targhee ewes. If birth weights were adjusted for effects of litter size, lambs from Rambouillet (5.65 kg) and Targhee ewes (5.66 kg) did not differ ($P > 0.99$). The birth weight difference between lambs from Polypay ewes and lambs from Rambouillet and Targhee ewes was reduced from 0.92 to 0.61 kg, but lambs from Polypay ewes still weighed less (5.05 kg) than lambs from Rambouillet and Targhee ewes ($P < 0.001$). Lamb weaning weights did not differ among ewe breeds ($P = 0.45$).

IMPLICATIONS

The composite sire breeds evaluated in the study did not differ from Suffolk rams in litter size or lamb survival to weaning. However, Suffolk sires produced heavier individual lambs and heavier litters per ewe lambing at weaning than composite sires. The percentage of ewes that lambed and corresponding litter weights per ewe exposed were higher for PC rams than for Suffolk or Siremax rams. Individual lamb performance through weaning was similar for lambs sired by Siremax and PC rams. Siremax was established in 2001 and subsequently used objective recording of animal performance for genetic improvement (www.sheep-genetics.org.au, www.siremax.com). By contrast, PC was not established until 2009. Many Suffolk rams and a few Columbia rams used as founders for PC came from flocks that participated in NSIP. The two strategies of composite breed formation (composite formation followed by performance-based selection in Siremax vs. composite formation using performance-tested purebred rams in PC) appeared to lead to similar results, at least to weaning. This result and the greater breeding efficiency of the more recently formed PC suggested opportunity to use continuous strategic introductions of purebred animals into composite lines to maintain genetic diversity and hybrid vigor and potentially accelerate genetic improvement.

If triplet and larger litters were reduced to at most two lambs at birth, relatively prolific Polypay ewes (mean litter size of 2.27 lambs) were not more productive to weaning than Rambouillet ewes (mean litter size of 1.92 lambs). Targhee ewes had a mean litter size of 1.72 lambs, were less productive than Polypay or Rambouillet ewes, and would benefit from genetic improvement in litter size. In agreement with Notter et al., (2018), the optimum litter size for ewes in extensive rangelands conditions was not substantially greater than two lambs per litter. Greater prolificacy levels were justified only if coupled with cost-effective strategies for managing surplus lambs from triplet and larger litters.

Conflict of interest statement. None declared.

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