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# Evaluation of Dorset, Finnsheep, Romanov, Texel, and Montadale breeds of sheep: I. Effects of ram breed on productivity of ewes of two crossbred populations

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**ABSTRACT:** Effects of Dorset, Finnsheep, Romanov, Texel, and Montadale breeds for performance as sires were estimated in the initial phase of a comprehensive evaluation of these breeds as contributors to sheep crossbreeding systems. Objectives were to evaluate the effects of ram breed, ewe breed, season of mating, and two-way interactions. Rams from the five breeds were single-sire-mated with ewes from two breed types to produce lambs over a 3-yr period. Ewes were assigned to one of three distinct 35-d mating seasons initiated each year in August, October, and December. A different sample of six rams per breed was used each year across all three seasons, and each ram was penned with ewes of both breeds. Traits evaluated and number of ewe records were conception rate and litter weaning weight per ewe exposed ( $n = 3,261$ ) and number born, litter birth weight, average birth weight, number weaned, and litter weaning weight per ewe lambing ( $n = 2,751$ ). Ram breed and ewe breed interacted ( $P < .01$ ) for conception rate and litter weaning weight per ewe exposed, implicating mating preferences, particularly of Romanov rams. In mixed groups of ewes exposed to Romanov rams, conception rate was 12.7% lower and

litter weight weaned was 8.4 kg lower in the ewe breed presumably less preferred for mating by the rams. On a per ewe exposed basis, Romanov-sired litters produced either the largest or the smallest values for litter weaning weight, depending on the breed of ewe. Effects of ram breed on number born and litter birth weight interacted ( $P < .05$ ) with season of mating. The largest litters within each ram breed were associated with the October mating season. Montadale and Romanov rams sired larger and heavier litters from August matings than from December matings, whereas the opposite was true for Dorset-sired litters. Texel- and Finnsheep-sired litters were similar in size and weight from August and December matings. Breed of ram differences affected per ewe lambing productivity measurements ( $P < .01$ ). Differences between ram breeds for ewe productivity were noted, with increased number born and improved survival of crossbred progeny to weaning for Romanov-sired litters. These results may have implications for using these ram breeds as sires in different crossbreeding systems. Structured mating systems or the creation of new composite populations involving these breeds could be used to match the resources, environment, and market of specific production situations.

Key Words: Ewe Productivity, Ram Breeds, Reproductive Traits, Sheep

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## Introduction

Genetic differences among breeds of sheep offer important opportunities for improving efficiency and quality of market lamb production through crossbreeding systems designed for specific production-marketing situations. Efficient crossbreeding systems exploit breed differences, capitalizing on the effects of individual and

maternal heterosis and complementarity. Experimental evaluations of available germplasm resources to better understand their potential roles within crossbreeding systems are essential if the U.S. sheep industry is to be viable. The Dorset is a widely used general-purpose breed that has characteristics desirable on both the maternal and paternal side of a crossbreeding scheme (Fogarty et al., 1984; Mohd-Yusuff et al., 1992). Numerous experiments have documented the superior reproduction of the Finnsheep relative to domestic breeds in the United States (Young et al., 1996). Literature suggests that the reproductive performance of Romanov-cross ewes is similar to that of Finnsheep-cross ewes; however, direct comparisons between North American samples of these two breeds or between the Romanov and other breeds have been limited (Gallivan

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**Table 1.** Number of Composite III (CIII) and northwestern whiteface (WF) ewes joined by mating type, season, and year subclasses

| Mating types     | 1990   |         |          | 1991   |         |          | 1992   |         |          | Marginal totals |
|------------------|--------|---------|----------|--------|---------|----------|--------|---------|----------|-----------------|
|                  | August | October | December | August | October | December | August | October | December |                 |
| Dorset × CIII    | 22     | 33      | 31       | 39     | 28      | 27       | 40     | 26      | 28       | 274             |
| Dorset × WF      | 42     | 39      | 40       | 60     | 36      | 39       | 53     | 30      | 32       | 371             |
| Finnsheep × CIII | 24     | 32      | 31       | 41     | 29      | 27       | 40     | 28      | 29       | 281             |
| Finnsheep × WF   | 45     | 40      | 40       | 55     | 40      | 37       | 53     | 29      | 33       | 372             |
| Romanov × CIII   | 28     | 33      | 30       | 38     | 31      | 29       | 32     | 33      | 29       | 283             |
| Romanov × WF     | 34     | 40      | 40       | 60     | 39      | 39       | 46     | 38      | 32       | 368             |
| Texel × CIII     | 28     | 36      | 29       | 30     | 30      | 28       | 37     | 28      | 31       | 288             |
| Texel × WF       | 45     | 40      | 40       | 59     | 38      | 39       | 53     | 28      | 31       | 373             |
| Montadale × CIII | 22     | 33      | 29       | 42     | 29      | 30       | 37     | 27      | 29       | 278             |
| Montadale × WF   | 43     | 40      | 39       | 61     | 38      | 38       | 55     | 28      | 31       | 373             |
| Marginal totals  | 333    | 366     | 349      | 496    | 338     | 333      | 446    | 295     | 305      | 3261            |

et al., 1993; Fahmy, 1996). Leymaster and Jenkins (1993) compared growth and carcass traits of Texel- and Suffolk-sired lambs, but comparisons with other U.S. breeds are lacking. The Montadale breed was developed in the United States between 1932 and 1954 by crossing Cheviot rams and Columbia ewes. To our knowledge, comparative data evaluating the Montadale breed have not been reported.

The objective of this study was to evaluate the effects of ram breed (Dorset, Finnsheep, Romanov, Texel, and Montadale), ewe breed (Composite III and northwestern whiteface), season of mating (August, October, and December), and their interactions on reproduction and productivity. This article is the initial description of a large comprehensive study to evaluate performance of these five ram breeds in both maternal and paternal crossbreeding roles.

## Experimental Procedures

### General Experimental Design

The general design was to mate Dorset, Finnsheep, Romanov, Texel, and Montadale rams to Composite III (CIII) and northwestern whiteface (WF) ewes in an annual lambing system for 3 yr during three separate fall mating seasons of 35 d beginning approximately August 5, October 15, and December 15 each year (Table 1). Ewes were maintained in an assigned season for the duration of the experiment. Two ewe breed types were used to broaden the inference base about the performance of these five ram breeds. The CIII flock represented a population with high growth potential and large mature size (~90 kg mature ewe breeding weight). This flock was developed at the U.S. Meat Animal Research Center (MARC) and is ½ Columbia, ¼ Hampshire, and ¼ Suffolk breeding (Leymaster, 1991). Only mature CIII ewes were used throughout this experiment; replacements were brought in annually as needed. In 1990, WF ewes (n = 650) of Rambouillet background were purchased from a single producer in Montana and represented a germplasm commonly used

under extensive management systems (~78 kg mature ewe breeding weight). An additional 120 WF ewes were purchased the following year from a different Montana producer. All WF ewes were mated for the first time in this experiment to lamb at approximately 2 yr of age.

The goal was to produce 20 crossbred ewe lambs from each ram breed × ewe breed combination in each season each year for subsequent evaluation of reproductive performance. Due to the expected difference in reproductive rate between ewe breeds, the number of WF ewes exposed was greater than the number of CIII ewes. Number of ewes exposed during the August mating season for both breeds was also greater than the number exposed in October and December because of the expected lower conception rate in August. At MARC, average daylight approached 14 h at the beginning of the August breeding season and at the start of the October and December breeding seasons averaged near 10.5 and 9.5 h, respectively. Ewes joined in August were exposed to vasectomized rams beginning approximately 17 d before exposure to fertile rams. Breeding records and subsequent progeny records of 113 ewes were deleted from the analyses because of the inadvertent use of two fertile teaser rams in the August breeding season of 1990; thus, fewer observations than we intended were generated from this breeding season (Table 1).

### Sampling of Ram Breeds

Dorset and Finnsheep breeds were used as standards of comparison for general-purpose and prolific breeds, respectively. The Dorset breed is used extensively in commercial sheep production in the United States, contributing as a sire breed for market lambs as well as a ewe breed with an extended estrous season. Finnsheep have also been widely used in the United States to produce crossbred ewes for intensive lamb production. Research conducted at MARC has indicated that for each 1% increase in Finnsheep germplasm in ewes, there is a 1% increase in lambs born per ewe lambing (Dickerson, 1977). The quantitative nature of the genetic regulation of litter size in Finnsheep assists the

creation of composite ewe populations with predictable levels of reproduction (e.g., the Polypay breed).

Evaluation of performance levels of Romanov, Texel, and Montadale breeds as either paternal or maternal contributors in crossbreeding systems has been limited in the United States. The Romanov breed originated in northwestern Russia and has many characteristics in common with Finnsheep. The Romanov breed excels in adaptability, length of breeding season, age at puberty, prenatal and postnatal survival, maternal behavior, and ewe productivity (Fahmy, 1996). The Texel has made major contributions as a terminal sire breed in Europe. Evaluation of the Texel relative to the North American Suffolk as a terminal sire indicated Texel-sired progeny displayed greater survival, less rapid postweaning growth rate, more compact carcass shape, altered distribution of carcass fat, but similar composition when compared at the same carcass weight (Leymaster and Jenkins, 1993). However, comparative data for reproductive ability of the Texel in the United States are lacking. Research data on the Montadale breed also do not exist, despite significant contributions of the breed to the U.S. industry. The Montadale breed ranked 10th in number of registrations at the time this experiment was initiated (Anonymous, 1990). The breed was developed as a composite of the Cheviot and Columbia breeds by E. H. Mattingly in 1932.

Samples of Finnsheep, Montadale, and Dorset rams were purchased from industry flocks each year. With the assistance of the appropriate breed association, three breeders from each breed were chosen each year to provide two rams from different sires. During the 1st year, two additional rams were purchased from a fourth breeder in each breed to serve as replacements for injured or sick rams. All Texel and Romanov rams were sampled from the purebred flocks maintained at MARC. During the experiment, the only Texel rams available in the United States were those from the MARC flock established by importation in 1985 (Leymaster and Jenkins, 1993). The Romanov flock at MARC was established in 1986 with four rams and 16 pregnant ewes provided by Agriculture Canada, Lennoxville Research Station. Agriculture Canada provided MARC with as broad a genetic sample of the breed as was possible. The same six rams from each breed were used in all three mating seasons within a year unless rams were injured or sick, in which case the rams were replaced. This practice was done to avoid any confounding between mating season and genetic sampling of rams. Each ram was evaluated for libido and semen quality before each mating season. During this study 20, 21, 19, 23, and 19 individual rams were sampled from the Dorset, Finnsheep, Romanov, Texel, and Montadale breeds, respectively.

#### *Description of Traits and Flock Management*

Traits evaluated were conception rate, number born, litter birth weight, average birth weight, number

weaned, and litter weaning weight. Each component trait was analyzed to help understand its contribution to differences in ewe productivity at weaning. Each record was considered a trait of the ewe. Ewes were managed together as a single group within each season, except during the 35-d breeding season in which single-sire mating pens were used. Each ram was penned with ewes of both breeds. Ewes were on pasture during gestation and given supplemental feed only as needed to meet their nutritional requirements. Conception rate (0,1) was determined on ewes present at the start of each lambing season. A total of 3,261 ewe records were analyzed for conception rate and litter weaning weight per ewe exposed, a composite trait reflecting a natural index of ewe productivity. Ewes lambed in a building with an elevated, woven-wire floor. Number born and number weaned, litter birth weight, average birth weight, and litter weaning weight were analyzed for 2,751 ewes with lambing records. First-cross lambs were placed in nursery facilities for artificial rearing only when a lamb's nutritional status was observed to be failing. Typically, lambs that were least successful within the litter in obtaining milk from the ewe were removed. For purposes of this article, only records of dam-reared lambs were analyzed for traits measured at weaning. A total of 232 (5.4% of total) lambs placed in nursery facilities were not credited to the birth ewe for the analysis of ewe performance traits at weaning. Number of lambs placed in the nursery was approximately proportional to the total number born to each ram-ewe breed combination. All lambs were weighed at birth and weaning (average age of 56 d). Access to a total-mixed creep feed containing 14.5% CP and 2.95 Mcal/kg of dietary DM was provided to naturally reared lambs by 14 d of age. Before analysis, weaning weights were adjusted for variation in weaning age to a constant 56-d age assuming linear growth by using average daily gain from birth to weaning for each animal. All males were castrated by banding at approximately 14 d of age.

#### *Statistical Analysis*

Data were analyzed with the MIXED procedure of SAS (1996). The model included the fixed effects of year of mating (1990, 1991, or 1992), ram breed (Dorset, Finnsheep, Romanov, Texel, or Montadale), ewe breed (CIII or WF), mating season (August, October, or December), all possible two-way interactions among these fixed effects, and the three-way interaction of ram breed  $\times$  ewe breed  $\times$  season. The random effect of individual rams within year and ram breed was included. Levels of significance associated with the effects of year, ram breed, and year  $\times$  ram breed were tested with the ram within year and breed mean square and were considered approximations due to unbalanced data. Remaining fixed effects and their interactions were tested against the residual mean square. Linear contrasts were made among the main effect means when the *F*-

**Table 2.** Levels of significance, least squares means, and average standard errors for the interaction of ram breed × ewe breed (Composite III, CIII; northwestern whiteface, WF)

| Item               | Conception rate, % | Birth trait |               |            | Weaning trait        |                      |      |
|--------------------|--------------------|-------------|---------------|------------|----------------------|----------------------|------|
|                    |                    | Number      | Litter wt, kg | Avg wt, kg | Number <sup>a</sup>  | Litter wt, kg        |      |
|                    |                    |             |               |            | Lambing <sup>a</sup> | Exposed <sup>b</sup> |      |
| Significance       | <.01               | .39         | .99           | .17        | .47                  | .79                  | .02  |
| Least squares mean |                    |             |               |            |                      |                      |      |
| Dorset × CIII      | 84.5               | 1.722       | 9.24          | 5.57       | 1.453                | 30.6                 | 25.9 |
| Dorset × WF        | 85.0               | 1.445       | 7.70          | 5.49       | 1.214                | 24.9                 | 21.2 |
| Finnsheep × CIII   | 90.6               | 1.748       | 8.58          | 5.07       | 1.473                | 30.6                 | 27.7 |
| Finnsheep × WF     | 84.2               | 1.419       | 7.03          | 5.11       | 1.226                | 24.9                 | 21.2 |
| Romanov × CIII     | 85.9               | 1.786       | 8.82          | 5.10       | 1.592                | 32.8                 | 28.1 |
| Romanov × WF       | 73.2               | 1.493       | 7.36          | 5.09       | 1.327                | 26.8                 | 19.7 |
| Texel × CIII       | 85.8               | 1.706       | 9.39          | 5.72       | 1.476                | 30.9                 | 26.6 |
| Texel × WF         | 88.0               | 1.473       | 7.93          | 5.59       | 1.264                | 26.1                 | 23.1 |
| Montadale × CIII   | 89.2               | 1.641       | 9.19          | 5.82       | 1.359                | 28.7                 | 25.4 |
| Montadale × WF     | 85.1               | 1.423       | 7.69          | 5.59       | 1.216                | 24.2                 | 20.5 |
| Avg SEM            | 3.0                | .032        | .15           | .07        | .036                 | .7                   | 1.0  |

<sup>a</sup>Dam-reared lambs per ewe lambing.  
<sup>b</sup>Dam-reared lambs per ewe exposed.

tests for the two-way interactions were not significant and the main effect was significant at the  $P < .05$  level.

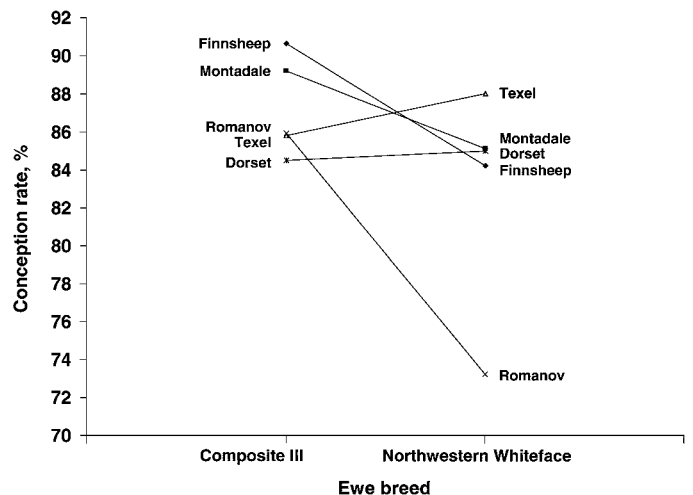
**Results and Discussion**

Levels of significance and least squares means are reported for effects of ram breed, ewe breed, season of mating, and two-way interactions. Estimated differences between ram breeds are the result of direct additive genetic effects as well as any differences due to specific individual heterosis effects of the crossbred progeny produced. Effects of year and its interaction with ram breed, ewe breed, and season of mating are not discussed because conditions contributing to these effects could not be identified, the effects cannot be predicted to recur in the future, and it is likely that breeders will choose a breeding program that is most profitable for average year effects. Effects of season of mating can affect decisions about use of breeds in specific seasonal production. Results are presented by sources of variation in Tables 2 to 5. The three-way interaction of ram breed × ewe breed × season was tested but was not significant for any trait and therefore was not tabulated.

*Conception Rate*

The interaction of ram breed × ewe breed was important ( $P < .01$ ) for conception rate (Table 2). The cause of this interaction was the lower conception rate of WF ewes than of CIII ewes when exposed to Romanov rams and, to a lesser extent, Finnsheep and Montadale rams (Figure 1). Similar conception rates of the two ewe breeds were observed when they were exposed to Texel and Dorset rams. Conception rates of CIII ewes exposed to Romanov rams ranked intermediate relative to con-

ception rates of CIII ewes exposed to the other four ram breeds. This result, along with the libido and semen evaluation before each mating season, indicated that the sample of rams used did not have extensive fertility problems. Decreased conception rate of WF ewes exposed to Romanov rams was a consistent general phenomenon from this sample of 19 rams during the 3 yr and across the three seasons. Substantial variation in percentage of ewes pregnant (range 40 to 100%) was observed among rams of the Romanov breed. Upon examination of data from each Romanov ram, conception rates were consistently lower for WF than for CIII ewes for 17 of the 19 rams. A random sample, within a mating season, of the available ewes from both breeds was allocated to individual sires each year. This approach



**Figure 1.** Interaction of ram breed and ewe breed for conception rate.

made it unlikely that the WF ewes assigned to Romanov rams each year had potential fertility different from that of WF ewes assigned to the other four ram breeds.

Low conception rate of WF ewes exposed to Romanov rams was an unexpected result given that the Romanov as a purebred is considered highly fertile, reaching puberty at a young age and characterized by a long season of sexual activity (Fahmy, 1996). Both WF and CIII ewes were penned together with individual rams in a single pen. It seems likely that Romanov rams preferentially mated CIII ewes rather than WF ewes when ewes exhibited estrus. It is unlikely that the lower conception rates observed for WF ewes exposed to Romanov rams was due to substantial embryonic losses, because number born was numerically greater in both ewe breeds when mated to Romanov rams in this study (Table 2). Although their study did not include the Romanov breed, Hulet et al. (1962b) reported significant breed of ram differences in mating behavior characteristics of rams in single-sire pens. However, despite substantial individual differences in measures of mating activity, these behavioral characteristics were not correlated with percentage of ewes lambing (Hulet et al., 1962b). In a related study, Hulet et al. (1962a) also observed that certain ewes initiated contact with a ram and also attempted to dominate continued attention of the ram by physically crowding out other estrous ewes. Perhaps the Romanov rams in the current study were influenced to a greater degree than rams of the other four breeds by expressed mating behavior differences of these two ewe breeds. To address this issue it would be necessary to evaluate the fertility of ewes exposed to Romanov rams when WF or CIII ewes are in separate mating pens compared to a mixture of these ewe breeds. These results highlight the fact that the experimental design influences the extrapolation of breed comparison results. It is likely that conception rates of WF ewes exposed to Romanov rams would have been higher if they had not been penned together with CIII ewes. Commercial crossbreeding systems would not typically foster this interaction because a single ewe breed type would be exposed to rams.

Effects of ram breed  $\times$  season and ewe breed  $\times$  season were not significant for conception rate (Tables 3 and 4). The main effect of ewe breed was important ( $P < .01$ ) and, on average, 4.1% more CIII ewes than WF ewes conceived (Table 5). Fertility of the sample of mature CIII ewes in this experiment is virtually identical to the 87.5% conception rate previously reported for this composite population (Leymaster, 1991). Fertility of WF ewes in this experiment was at least as high as literature estimates for this ewe type (Glimp, 1971; Dickerson, 1977). As expected, conception rate in August was lower ( $P < .05$ ) than in October and December (13.9 and 12.7%, respectively; Table 5).

#### *Ewe Productivity Traits at Birth*

The interaction of ram breed  $\times$  ewe breed was not significant for number born, litter birth weight, or aver-

age birth weight (Table 2). The interaction of ram breed and season (Table 3) was important ( $P < .05$ ) only for number born and litter birth weight. For each ram breed, the greatest number born and heaviest litters resulted from the October breeding, although these two traits did not always significantly differ among seasons. Previous observations (Shelton and Morrow, 1965; Glimp, 1971) indicated the October breeding season would coincide with the peak ovulation rate of these ewe breeds. The main cause of the interaction seemed to be the change in rank of the August and December breeding seasons across ram breeds. Litters sired by Montadale and Romanov rams were larger and heavier ( $P < .05$ ) from the August breeding than from the December breeding, but the opposite was true for litters sired by Dorset rams. Litter size and weight did not differ ( $P > .05$ ) between the August and December breeding seasons with Texel and Finnsheep rams.

Increased number born from matings with Romanov rams has been previously documented. Gallivan et al. (1993) reported a significant increase of .22 lambs born from Targhee ewes mated during September-October to Romanov rams compared to those mated to Finnsheep rams. This advantage was due to a higher incidence of triplet births. In the current study, Romanov-sired litters exceeded Finnsheep-sired litters by .11 lambs born from both August and October mating seasons. Possibly, lower energy requirements of the small Romanov fetus played a role in the superior rates of prenatal survival, allowing a higher percentage of twin and triplet litters to survive to birth. Ricordeau et al. (1990) reviewed information on superior embryonal survival rates of purebred Romanov embryos relative to purebred Finnsheep.

The impact of season of mating on ewe reproductive performance has been previously studied (Dutt, 1954; Hulet et al., 1956; Glimp, 1971). In the current study, ewes mated in the August and December breeding seasons were exposed to substantially different environmental conditions, particularly during the critical time associated with conception and early embryonal survival. These seasonal conditions interacted with breed of ram for number born but not for conception rate (Table 3). The impact of high temperature conditions compared to low temperature conditions interacted with breed of the crossbred embryo, indicating that differences existed between ram breeds for fertilization rate and/or early embryonal survival. Ovulation rate information from these matings was not available to evaluate these components independently.

The interaction of ewe breed and season was significant for number born, litter birth weight, and average birth weight (Table 4). For CIII ewes, number born and litter birth weight were similar between August and December and both were lower than for October. Average birth weight from a CIII ewe was heavier from August breeding than from October and December breedings. In contrast, number born, litter birth weight, and average birth weight were similar across breeding seasons for WF ewes.

**Table 3.** Levels of significance, least squares means, and average standard errors for the interaction effect of ram breed × season of mating

| Item                 | Conception rate, % | Birth trait |               |            | Weaning trait        |                      |      |
|----------------------|--------------------|-------------|---------------|------------|----------------------|----------------------|------|
|                      |                    | Number      | Litter wt, kg | Avg wt, kg | Number <sup>a</sup>  | Litter wt, kg        |      |
|                      |                    |             |               |            | Lambing <sup>a</sup> | Exposed <sup>b</sup> |      |
| Significance         | .40                | .03         | .04           | .28        | .41                  | .57                  | .39  |
| Least squares mean   |                    |             |               |            |                      |                      |      |
| Dorset × August      | 75.9               | 1.506       | 8.17          | 5.63       | 1.296                | 28.5                 | 21.8 |
| Dorset × October     | 88.2               | 1.645       | 8.85          | 5.51       | 1.370                | 27.8                 | 24.5 |
| Dorset × December    | 90.1               | 1.601       | 8.39          | 5.45       | 1.334                | 27.0                 | 24.4 |
| Finnsheep × August   | 80.5               | 1.527       | 7.61          | 5.18       | 1.319                | 27.8                 | 22.7 |
| Finnsheep × October  | 91.1               | 1.645       | 7.96          | 4.99       | 1.352                | 27.3                 | 25.0 |
| Finnsheep × December | 90.6               | 1.579       | 7.85          | 5.09       | 1.378                | 28.1                 | 25.7 |
| Romanov × August     | 67.3               | 1.642       | 8.16          | 5.11       | 1.474                | 31.3                 | 21.2 |
| Romanov × October    | 86.4               | 1.758       | 8.55          | 5.04       | 1.548                | 30.5                 | 26.8 |
| Romanov × December   | 84.8               | 1.519       | 7.56          | 5.13       | 1.357                | 27.8                 | 23.7 |
| Texel × August       | 79.3               | 1.556       | 8.72          | 5.80       | 1.333                | 28.8                 | 22.8 |
| Texel × October      | 90.2               | 1.633       | 8.82          | 5.63       | 1.424                | 29.1                 | 26.5 |
| Texel × December     | 91.1               | 1.579       | 8.45          | 5.53       | 1.354                | 27.6                 | 25.2 |
| Montadale × August   | 78.3               | 1.537       | 8.51          | 5.74       | 1.264                | 27.6                 | 21.6 |
| Montadale × October  | 94.8               | 1.639       | 8.85          | 5.58       | 1.362                | 27.0                 | 25.6 |
| Montadale × December | 88.2               | 1.419       | 7.95          | 5.80       | 1.237                | 24.8                 | 21.8 |
| Avg SEM              | 3.3                | .039        | .18           | .08        | .044                 | .9                   | 1.1  |

<sup>a</sup>Dam-reared lambs per ewe lambing.

<sup>b</sup>Dam-reared lambs per ewe exposed.

Main effect of ram breed was significant for number born, litter birth weight, and average birth weight. Ewes mated to Montadale rams had fewer ( $P < .05$ ) lambs at birth than ewes mated to Romanov rams; no other differences among sire breeds were significant for number born. Litters sired by the prolific breeds (Romanov, Finnsheep) had lighter ( $P < .05$ ) litter and average birth weights than litters sired by Texel, Montadale, and Dorset rams. Lambs sired by Montadale rams also had heavier ( $P < .05$ ) average birth weights than lambs sired by Dorset rams.

Number born of the CIII ewes exceeded ( $P < .01$ ) that of WF ewes by .27 lambs born per ewe lambing. Litter birth weight was 1.5 kg heavier for CIII ewes than for

WF ewes ( $P < .01$ ). Despite being in larger litters, the average birth weight of a lamb from a CIII ewe was slightly heavier ( $P < .02$ ) than that of a lamb from a WF ewe. Overall performance of mature CIII ewes has been documented in a straightbred comparison to the Suffolk (Leymaster, 1991), and fertility and productivity traits of the mature CIII ewes in our study were consistent with those previous results.

#### Ewe Productivity Traits at Weaning

Ewe productivity traits at weaning are biologically and economically important measures of performance. Litter weaning weight provides a natural index of the

**Table 4.** Levels of significance, least squares means, and average standard errors for the interaction effect of ewe breed (Composite III, CIII; northwestern whiteface, WF) × season of mating

| Item               | Conception rate, % | Birth trait |               |            | Weaning trait        |                      |      |
|--------------------|--------------------|-------------|---------------|------------|----------------------|----------------------|------|
|                    |                    | Number      | Litter wt, kg | Avg wt, kg | Number <sup>a</sup>  | Litter wt, kg        |      |
|                    |                    |             |               |            | Lambing <sup>a</sup> | Exposed <sup>b</sup> |      |
| Significance       | .61                | .01         | .02           | <.01       | .17                  | .55                  | .09  |
| Least squares mean |                    |             |               |            |                      |                      |      |
| CIII × August      | 77.6               | 1.659       | 8.98          | 5.63       | 1.422                | 31.3                 | 24.2 |
| CIII × October     | 92.9               | 1.839       | 9.51          | 5.36       | 1.547                | 31.3                 | 29.2 |
| CIII × December    | 91.1               | 1.663       | 8.65          | 5.38       | 1.444                | 29.5                 | 26.9 |
| WF × August        | 74.9               | 1.448       | 7.49          | 5.36       | 1.253                | 26.3                 | 19.8 |
| WF × October       | 87.4               | 1.489       | 7.70          | 5.34       | 1.275                | 25.3                 | 22.2 |
| WF × December      | 86.9               | 1.416       | 7.43          | 5.42       | 1.220                | 24.6                 | 21.4 |
| Avg SEM            | 1.8                | .025        | .11           | .05        | .028                 | .6                   | .7   |

<sup>a</sup>Dam-reared lambs per ewe lambing.

<sup>b</sup>Dam-reared lambs per ewe exposed.

**Table 5.** Levels of significance, least squares means, and average standard errors for the main effects of ram breed, ewe breed (Composite III, CIII; northwestern whiteface, WF), and season of mating

| Item               | Conception rate, % | Birth trait |               |            | Weaning trait        |                      |      |
|--------------------|--------------------|-------------|---------------|------------|----------------------|----------------------|------|
|                    |                    | Number      | Litter wt, kg | Avg wt, kg | Number <sup>a</sup>  | Litter wt, kg        |      |
|                    |                    |             |               |            | Lambing <sup>a</sup> | Exposed <sup>b</sup> |      |
| <b>Ram breed</b>   |                    |             |               |            |                      |                      |      |
| Significance       | .22                | .04         | <.01          | <.01       | <.01                 | <.01                 | .52  |
| Least squares mean |                    |             |               |            |                      |                      |      |
| Dorset             | 84.8               | 1.584       | 8.47          | 5.53       | 1.333                | 27.8                 | 23.6 |
| Finnsheep          | 87.4               | 1.584       | 7.81          | 5.09       | 1.350                | 27.7                 | 24.5 |
| Romanov            | 79.5               | 1.640       | 8.09          | 5.09       | 1.460                | 29.8                 | 23.9 |
| Texel              | 86.9               | 1.589       | 8.66          | 5.65       | 1.370                | 28.5                 | 24.8 |
| Montadale          | 87.1               | 1.532       | 8.44          | 5.71       | 1.288                | 26.4                 | 23.0 |
| Avg SEM            | 2.7                | .023        | .12           | .05        | .025                 | .5                   | .8   |
| <b>Ewe breed</b>   |                    |             |               |            |                      |                      |      |
| Significance       | <.01               | <.01        | <.01          | .02        | <.01                 | <.01                 | <.01 |
| Least squares mean |                    |             |               |            |                      |                      |      |
| CIII               | 87.2               | 1.721       | 9.04          | 5.46       | 1.471                | 30.7                 | 26.8 |
| WF                 | 83.1               | 1.451       | 7.54          | 5.37       | 1.249                | 25.4                 | 21.1 |
| Avg SEM            | 1.4                | .015        | .07           | .03        | .016                 | .3                   | .4   |
| <b>Season</b>      |                    |             |               |            |                      |                      |      |
| Significance       | <.01               | <.01        | <.01          | <.01       | <.01                 | <.01                 | <.01 |
| Least squares mean |                    |             |               |            |                      |                      |      |
| August             | 76.3               | 1.554       | 8.23          | 5.49       | 1.337                | 28.8                 | 22.0 |
| October            | 90.2               | 1.664       | 8.61          | 5.35       | 1.411                | 28.3                 | 25.7 |
| December           | 89.0               | 1.539       | 8.04          | 5.40       | 1.332                | 27.1                 | 24.1 |
| Avg SEM            | 1.5                | .018        | .08           | .03        | .020                 | .4                   | .5   |

<sup>a</sup>Dam-reared lambs per ewe lambing.<sup>b</sup>Dam-reared lambs per ewe exposed.

reproductive success and maternal ability of the dam and survival and growth ability of the progeny. The interaction of ram breed with ewe breed was not significant for number weaned or litter weaning weight per ewe lambing (Table 2). The influence of ram breed and ewe breed interactions for conception rate remained important when evaluating litter weaning weight per ewe exposed. Across all mating types, CIII ewes exposed to Romanov rams produced the largest value for litter weaning weight per ewe exposed (28.1 kg), whereas WF ewes exposed to Romanov rams produced the smallest value (19.7 kg). As stated previously, these results might have been different if the experimental design had not imposed the mixture of ewe breeds in single-sire mating pens. If a mating system is employed in which rams are exposed to only one type of ewe, prenatal and postnatal survival advantages of Romanov-sired litters may become more pronounced.

In contrast to traits evaluated at birth, breed of ram did not interact with season of mating ( $P > .40$ ) for ewe productivity measured at weaning (Table 3). The differences in performance levels measured at weaning attributed to these ram breeds were noted over the entire range of seasons and mating combinations evaluated. The interaction of ewe breed and season was not a significant source of variation for number weaned or litter weaning weight, expressed per ewe lambing or per ewe exposed (Table 4).

Ewes mated to Romanov rams weaned more lambs ( $P < .05$ ) than ewes mated to any of the other sire breeds (Table 5). In addition, ewes mated to Montadale rams had fewer lambs at weaning than those mated to Texel, Dorset, and Finnsheep rams, but only the difference relative to Texel was significant. Number weaned did not differ ( $P > .05$ ) for ewes mated to Texel, Dorset, and Finnsheep rams. Litter weaning weight was lower ( $P < .05$ ) for ewes mated to Montadale rams than for ewes mated to Texel and Romanov rams; this difference approached significance ( $P < .07$ ) for ewes mated to Dorset rams. Ewes mated to Finnsheep rams also had lower ( $P < .05$ ) litter weaning weights than ewes mated to Romanov rams. On a per ewe lambing basis, the advantage of Romanov sires in number born that was established at birth was even greater at the time of weaning. Survival rates to weaning of the crossbred Romanov progeny were superior to the survival rates observed for other breed crosses, even though litters were larger. Breed of sire effects analyzed on an individual lamb basis for postnatal survival will be reported and discussed in a subsequent article. Despite the advantages of Romanov-sired litters in number born and apparent postnatal survival, the significantly lower conception rates of WF ewes when mated to Romanov rams removed any sire breed differences in litter weaning weight per ewe exposed. On a per ewe exposed basis, the effects of breed of the ewe and season of mating were more important sources of

variation for litter weaning weight than was breed of ram. If a systematic crossbreeding scheme is to capitalize on the fitness advantages of the Romanov breed in a sire role, apparent behavioral interactions with specific ewe breeds during mating must be recognized.

On average, CIII ewes had more lambs and heavier litter weights at weaning than WF ewes ( $P < .01$ ). Litter weaning weight was 5.3 kg greater in litters born to CIII ewes. Number weaned was greater ( $P < .01$ ) for ewes bred in October than for ewes bred in August or December, reflecting the differences detected at birth. Litter weaning weight per ewe lambing did not differ ( $P \sim .41$ ) between the August and October breeding seasons but was lower ( $P < .05$ ) during the December breeding season. In contrast, litter weaning weight per ewe exposed was greater ( $P < .01$ ) for the December than for the August breeding season due to higher conception rates. Litter weight weaned per ewe exposed was higher ( $P < .05$ ) for ewes bred in October than for those bred in December or August.

Genetic variation among sheep breeds is large for many important production traits. The current experiment was designed to estimate the relative value of these breeds in different roles of a commercial crossbreeding system. This information will provide producers the opportunity to make informed decisions about breeding programs that fit specific marketing situations. Studies to evaluate the performance of the first-cross progeny from these breeds for traits associated with fitness, growth, carcass, reproduction, and wool characteristics have been completed and will be reported subsequently.

### Implications

Differences among breeds of sheep in performance for economically important traits are genetically based and can be exploited through strategic use in crossbreeding systems. This study comparing Dorset, Finnsheep, Romanov, Texel, and Montadale breeds provides information to help producers identify breeds that meet targeted levels of performance for specific production-marketing situations. Differences among these breeds of rams for traits recorded to weaning were consistent regardless of breed of ewe, except for conception rate. When penned with ewes of two breeds, Romanov rams preferentially mated with ewes of the Composite III breed compared to northwestern whiteface ewes. Effects of breeds of rams and ewes on number born and

litter birth weight depend on the season of mating. Therefore, it is important to use genetic resources in appropriate mating seasons if performance is to be optimized. Ewes giving birth to Romanov-sired litters produced more lambs at birth with greater survival to weaning.

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