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ABSTRACT: Sexual performance has been subjectively measured with a libido test during screening of rams before public sale and breeding at the U.S. Sheep Experiment Station from 1990 to 2000. The objective of this study was to determine whether sexual performance was genetically influenced. Sexual performance scores ranged from 1 to 6 with scores increasing from sexually inactive to highly sexually active in the presence of estrous ewes. The overall average score was 3.5 ± 0.02. Records from four breeds (Columbia, n = 807; Polypay, n = 1,668; Rambouillet, n = 1,208; and Targhee, n = 1,002) were combined into one analysis because breeds had similar phenotypic variances. Total number of records was 4,685, which included a second sexual performance test on 1,212 rams in the following year. Variance components were estimated using a REML algorithm. Fixed effects were breed of ram, selection line within breed, and year by breed. A permanent environmental effect for ram was included to account for repeated observations on individual animals. Age and weight of the rams at time of the libido test were linear covariates and were breed-specific. Adjusted means for sexual performance scores did not differ among breeds ($P > 0.05$). Age was a significant effect ($P < 0.01$), with sexual performance score increasing 0.05 units for each month of age. The additive genetic variance was estimated as 0.54. The estimate of variance due to ram permanent environmental effects was 1.19. The residual variance was estimated to be 0.67. The heritability estimate was moderate (0.22 ± 0.04) and repeatability was high (0.72). These results imply that one screening for sexual performance provides a reliable measure of sexual performance and that favorable response to selection for ram serving capacity may be expected.

Key Words: Sexual Behavior, Libido, Sheep

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Introduction

Libido of rams strongly influences flock fertility (Matos and Thomas, 1991). Differences in sexual behavior among rams have been recognized for many years (Terrill, 1937; Hafez, 1951). Consequently, various procedures to measure sexual behavior in rams were developed (Wiggins et al., 1983; Katz et al., 1988; Perkins and Fitzgerald, 1992). Positive associations between rams with high scores for sexual performance and ewe fertility have been reported (Mattner et al., 1971; Perkins et al., 1992). In contrast, some studies found little relationship between sexual performance scores of rams and flock fertility (Kelly et al., 1975; Kilgour and Wilkins, 1980; Mickelsen et al., 1982).

Tests for sexual performance of rams can be affected by previous exposure of rams to ewes (Price et al., 1994), separation from pen-mates (Katz et al., 1988), method of restraint of estrous ewes (Zenchak et al., 1988), shyness of rams to the test procedures (Kilgour and Wilkins, 1980), length of testing period (Kilgour and Whale, 1980), sexual attractiveness of the ewe (Tilbrook and Lindsay, 1987), and seasonal patterns in sexual behavior (Tulley and Burfening, 1983). Consequently, the repeatability of sexual performance tests of rams has been thought to be low (Kilgour, 1985; Purvis, 1985).

Hulet et al. (1962) suggested that differences among rams for sexual performance may be genetically influenced. Although some research results suggest ram sexual performance is influenced by genetic effects (Tulley and Burfening, 1983; Bench et al., 2001), there have been few estimates of heritability. Kilgour (1985) measured the mating behavior of 90 Merino rams and reported a heritability estimate of 0.33 ± 0.62. In contrast, Purvis (1985) measured serving capacity on 840 naive 20-mo-old Merino rams and reported a low heritability estimate (0.002 ± 0.10). Because the genetic component of ram sexual behavior is unclear, the objective of the current study was to determine whether sexual performance scores are heritable.

Materials and Methods

Rams were screened before public sale and breeding at the U.S. Sheep Experiment Station from 1990 to

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2000. Sexually naive yearling rams were screened in early August. Older rams (2 to 4 yr of age) previously exposed to ewes were also tested in August. The sexual performance test was conducted by exposing individual rams to three induced-estrual ewes for 30 min. Testing pens were outside, 17.5 × 13.1 m, and had solid wooden walls 4.4 m high. No feed or water was available in the pens. The ram and ewes roamed freely in the testing pen. Observers recording the data were seated outside the pen. The numbers of mounts and ejaculations were recorded and used to categorize the serving capacity of the ram (Perkins, 1991). Score for sexual performance ranged from 1 to 6, with scores increasing from sexually inactive to highly sexually active in the presence of estrous ewes. Overall average sexual performance score was 3.5 ± 0.02.

Approximately 25% of the sexually naive yearling rams were identified as sexually inactive after the performance test. Young rams can be sexually inhibited at their first exposure to ewes (Price et al., 1994) and(or) uncomfortable with the testing conditions (Kilgour and Wilkins, 1980). Based on our experience, approximately 40% of yearling rams that are initially identified as sexually inactive exhibit some form of libido during follow-up tests. Therefore, rams initially identified as sexually inactive were again exposed to induced-estrual ewes up to a maximum of three performance tests within a 7- to 10-d period. Only the final performance test score was used in the analyses.

Records were available from four breeds (Columbia, n = 807; Polypay, n = 1,668; Rambouillet, n = 1,208; and Targhee, n = 1,002). All rams were born and reared at the U. S. Sheep Experiment Station. Various selection and control lines existed for each breed but none were directly selected for sexual performance of rams. However, rams were used in single-pen matings and any ram that exhibited no breeding activity as evidenced by the marking harness was replaced with another ram. Average age of spring-born rams at first screening was approximately 14 mo. A few rams were fall-born with an average age at screening of approximately 20 mo. Because season of birth was partially confounded with age, only age was considered in the analyses. After weaning, rams were managed with rams of similar age. Before the first sexual performance test, most rams were naive to estrous ewes.

For the analyses each ram was limited to two performance tests (as yearling of average age of 14 mo and as 2-yr-olds of average age of 26 mo) because few rams had more than two performance tests. Records of rams without a body weight near the time of the performance test were also removed. Total number of acceptable records was 4,685, which included a second measure for 1,212 rams in the following year. The total number of rams was 3,473.

The effect of inbreeding on sexual performance scores could not be determined because few rams (n = 23) were inbred. The average inbreeding coefficient of all rams was estimated at 0.02.

Table 1. Number and least squares means (± SE) for sexual performance score by breed

Breed	n	Mean
Columbia	807	3.3 ± 0.09
Polypay	1,668	3.6 ± 0.05
Rambouillet	1,208	3.6 ± 0.09
Targhee	1,002	3.4 ± 0.06

Differences among breeds for libido scores were determined using the MIXED procedures of SAS (SAS Inst. Inc., Cary, NC). The model included the fixed effects of breed, selection line within breed, and year. Repeated measurements were accounted for by including a random effect for ram within breed. Age and weight were fit as linear covariates nested within breed effect. Adjusted means were tested for breed differences using the TUKEY option, which properly accounts for unbalanced data among breeds. Covariates were contrasted to test for breed differences.

Estimates of variance components were accomplished using a derivative-free algorithm for REML (Boldman et al., 1995). Because phenotypic variances for sexual performance scores were similar among breeds and because of the relatively small numbers per breed, records from all breeds were combined into a single analysis. Fixed effects for the model were breed of ram, genetic selection line within breed, and year by breed. A permanent environmental effect for ram was included to account for the repeated measures. Age and weight at time of the libido test were linear covariates within breed. Convergence was considered to have been reached when the variance of the –2 log likelihood in the simplex was less than 1×10^{-6}. After initial convergence, four restarts were performed to ensure global convergence as determined when –2 log likelihood did not change to the second decimal. The standard errors of the heritability estimate was based on the average information matrix and the "delta" method (Dodenhoff et al., 1998). Repeatability of performance score was estimated as the sum of the estimates of genetic and permanent environmental variances expressed as a fraction of the estimated phenotypic variance.

Results and Discussion

Sexual performance scores were influenced by the covariate of age within breed ($P < 0.01$). However, breed-specific regression coefficients for age did not differ ($P > 0.90$). On the average, sexual performance score increased 0.05 units per month increase in age. The covariate of weight within breed was not significant ($P = 0.11$) and breed-specific regression coefficients did not differ ($P > 0.50$).

Although the breed effect was significant in the model, comparison of adjusted means for sexual performance by the Tukey-Kramer method for unbalanced data did not detect differences among breeds ($P > 0.05$; Table 1). Polypay and Rambouillet rams had the largest

Table 2. Estimates of variance components and genetic parameters[a] for sexual performance scores of rams

σ^2_P	σ^2_A	σ^2_{PE}	σ^2_E	h^2	pe^2	e^2
2.40	0.54	1.19	0.67	0.22 ± 0.04	0.50 ± 0.04	0.28 ± 0.01

[a]σ^2_P = phenotypic variance; σ^2_A = genetic variance; σ^2_{PE} = variance due to permanent environmental effects of rams; σ^2_E = residual variance; h^2 = heritability; pe^2 = fraction of variance due to permanent environmental effects; e^2 = fraction of variance due to temporary environmental effects.

mean score (3.6). The lowest adjusted score for sexual performance was observed in the Columbia breed (3.3), and Targhee rams were intermediate (3.4). Future research is needed to determine how many units difference in sexual performance scores are sufficient to be economically important and whether there is a threshold for sexual performance score to accept or reject a ram for breeding.

The overall phenotypic standard deviation of 2.40 for sexual performance scores (Table 2) was large, showing significant variation among rams. The estimate of heritability for sexual performance was moderate, 0.22 ± 0.04. This estimate is less than that of Kilgour (1985), who reported an estimate of 0.33 ± 0.62 for 90 Merino rams measured from 1 to 3 yr of age. Purvis (1985) reported a much lower estimate (0.002 ± 0.10) for 840 naive 20-mo-old Merino ram. Differences in these estimates may be due to differences in populations, performance testing technique, and statistical procedures.

Genetic influences on sexual behavior of domestic livestock have been previously reported. For example, in cattle, significant differences in libido among sire-son groups were observed by Hültnas (1959). A high estimate of heritability for serving capacity of bulls (0.59 ± 0.16) was reported by Blockey et al. (1978).

The moderate estimate of heritability of 0.22 for serving capacity is encouraging because response to selection for serving capacity should be favorable. Therefore, if selection resulted in rams capable of mating with more ewes, the reproductive efficiency of the flock would be improved and fewer rams needed. Rams with high sexual performance scores have been observed to not only ejaculate at a faster rate but also to switch females more often than rams with low sexual performance scores (Price et al., 1996). If a ram's sexual performance is genetically correlated with ewe reproduction, then ewe reproduction could be improved by selection on male sexual performance. These conclusions are supported by Bench et al. (2001), who reported that after a single generation of artificial selection for increased sexual performance, the sexual performance of male progeny was greater and first behavioral estrus was earlier in female progeny compared to offspring from rams with low sexual performance. However, ovulation rate did not differ between the two groups.

The estimate of repeatability of sexual performance score was 0.72, large for a measure of behavior. This large estimate implies that the test is a reliable measure of sexual performance across time and that ram sexual performance measured at 14 mo is similar to what is measured at 26 mo. In contrast, Purvis (1985) reported that repeatability of serving capacity scores of 20-mo-old Merino rams was low (0.27). Kilgour (1985) also reported a moderate repeatability of 0.42 for Merino rams measured at 13 to 37 mo of age. Why repeatability estimates differed among these studies is not clear, but differences in breeds and performance testing methods may be possible causes.

Caution needs to be expressed because there is little information about whether selection for increased sexual performance or serving capacity will be accompanied by improvement in semen quality or quantity or whether a ram with high serving capacity as measured by the performance test will successfully inseminate more ewes. Wiggins et al. (1983) reported a small positive correlation between the number of ejaculates (serving capacity) in a 30-min period and the fraction of ewes lambing and concluded that rams with a high degree of libido are more fertile than rams with less libido. Perkins et al. (1992) reported that flock fertility increased significantly when matings were to rams with a high serving capacity compared to rams with a low serving capacity. However, Bench et al. (2001) reported that mating efficiency (ratio of ejaculations to total mounts) did not differ between rams from high and low sexual performance lines, although the rams in the high sexual performance line had significantly more ejaculations and mounts without ejaculations. Bench et al. (2001) suggested that sexual performance of rams is based on differences in libido rather than differences in ability to perform efficiently the motor patterns associated with mounting and copulation.

Much is yet to be learned about the effects of selection for increased sexual performance. Research questions to be answered include the optimal ratio of high sexual performance rams to ewes in pasture mating, the genetic and phenotypic relationships between the behavior of rams measured for sexual performance and semen quality and quantity, and the genetic relationship between male sexual behavior and female reproductive performance. It may also be of interest to investigate the association of ram sexual performance with ram growth rate or ewe behavior for mothering ability. Before recommendations can be made about selection for sexual performance such questions need to be answered.

Implications

The test of sexual performance of rams at the U.S. Sheep Experiment Station seems to be a reliable test based on the large estimate of repeatability. The test can identify rams with high sexual performance at an early age (14 mo). The heritability estimate for sexual performance score is moderate, which suggests sexual performance will respond well to selection. Selection indices for overall merit will need to consider sexual performance scores if future research identifies positive relationships between sexual performance and ewe fertility. Rams with highly desirable production traits and high serving capacity will leave more offspring for future generations compared to rams with similar desirable production traits but a low serving capacity, which would increase the rate of genetic improvement for both serving capacity and production traits.

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