HERITABILITY OF SCROTAL CIRCUMFERENCE ADJUSTED AND UNADJUSTED FOR BODY WEIGHT IN RAM LAMBS AND COVARIANCES WITH GROWTH AND REPRODUCTIVE TRAITS IN EWES

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SUMMARY

Scrotal circumferences from rams lambs were measured at weaning (SCW) and at the end of a 70 d feed test (SCUNA). The scrotal circumferences were also adjusted for body weight (BW) at the end of test (SCADJ). These three dependent variables that were analyzed using MTDFREML procedures to estimate the heritability of scrotal circumference. Body weight at the time of SC measurement was also included as a covariate Also ewe progeny records were collected for number born per ewe exposed for breeding, ewe body weight, ewe fleece weight and fleece grade. MTDFREML procedures were also used to estimate the heritabilities of the ewe traits and to estimate the covariances between SCW, SCUNA and SCADJ with the ewe traits. Heritability was .19, .30, and .21 for SCW, SCUNA and SCADJ, respectively, when BW was not included and were .33, .31 and .24 for SCW, SCUNA and SCADJ when BW was included as a covariate. Genetic correlations with ewe traits were larger when BW was included in the model and were .20, -.59, -.31 and -.15 for no. born, ewe body weight, fleece weight, and fleece grade respectively with SCUNA. These results show that scrotal circumference is moderately heritable, and when adjusted for body weight has a positive genetic correlation with number of lambs born and a negative genetic correlation with ewe body weight, fleece weight and fleece grade.

INTRODUCTION

Many studies have shown that increased ewe reproductive rate will improve the economic efficiency of sheep production enterprises by reducing the overhead cost per lamb sold (Nitter, 1987). The rate of genetic improvement can be increased by not only selecting females based on their breeding value for reproductive rate (a female sex limited trait) but also selecting males for the same trait for which breeding values can be estimated through information on the productivity of female relatives. However, if an indicator trait in males could be identified which provides an indirect measure of reproductive rate in females, selection response utilizing this information could be greatly improved (Land, 1973) provided the indirect indicator trait to be used has a moderate heritability and a high genetic correlation with reproductive rate in females in order to increase the rate of response. Matos and Thomas (1992) in a review of testis size in sheep reported the average of 40 estimates of heritability for testicular size to be .31 but also indicated that there was still some uncertainty as to the genetic correlations of testis size and female reproduction in sheep. Walkley and Smith (1980) found that when the indicator trait of testis size, having a moderate heritability and a high genetic correlation with litter size (which has a low heritability), was used in addition to litter size the selection response in litter size could be almost doubled.

The question as to whether measures of testis size should be adjusted for body weight, which has a high correlation with testis size need to be addressed. Many people feel that testis size should be adjusted for body weight therefore, selecting for testis size independently of effects on body weight. However, Land (personal communication) suggested that selecting for testis size adjusted for body weight would result in smaller sized mature ewes. The rational for this is that if testis size is a measure of attainment of puberty then adjusting for body weight will result in the selection of rams with larger testis relative to their body size or animals that have reached puberty at smaller body weights. Further if body weight at puberty is correlated with mature weight then selection based on testis size adjusted for body weight will result in smaller mature weights of the progeny. Lee et al., 1990 reported that in a divergent selection for testis size adjusted for body weight, ewe body weight decreased more in the high line than the low line while fertility was higher in the high line.

The objectives of this selection experiment were to estimate genetic parameters for scrotal circumference both adjusted for body weight and unadjusted for body weight and estimate the covariances between scrotal circumference and reproductive, growth and fleece characteristics in sheep.

MATERIALS AND METHODS

Columbia and Rambouillet rams lambs born between 1983 and 1992 were used in this study. The Columbia ram lambs were from one of two lines being selected for scrotal circumference. One ram in each line was selected each year. The selection criteria for one line was based scrotal circumference adjusted for body weight (SCADJ) while the other line was selected on the basis of scrotal circumference with no adjustment for body weight (SCUNA). Rambouillet ram lambs were from a random bred control line that was maintained with the Columbia sheep at all times. Breeding of the sheep , shearing, lambing and growth of the lambs through weaning took place at Red Bluff Research Ranch at Norris, MT. The ranch is typical of the mountain foothill area of the Northern Great Plains, where ewes and lambs are herded on unfenced pastures for the entire year except at breeding and lambing times. Lambs were weaned in mid-August at a average age of 121.6 d and weighted 29.6 kg. Ram lambs were moved to the Fort Ellis Sheep Experiment Station in Bozeman, MT where they were placed on a diet of free choice alfalfa-grass mixed hay and 454 g of barley daily. At weaning and again during the first week of November, when the lambs were an average of 195.6 d of age (end of test), scrotal circumference was measured with a steel tape by palpating the testis into the scrotum and measuring the circumference at its widest point.

After yearly data collections, all scrotal measurements at the end of test were adjusted linearly for age of the lamb. The linearly adjusted data was then analyzed using PROC REG (SAS, 1985) with both a linear and quadratic regression of scrotal circumference on body weight of the lamb at the time of measurement. Quadratic effect of body weight was never significant ($P<.25$) and therefore only the linear term was used to adjust scrotal circumference for body weight.

Estimates of additive direct variances and covariances were obtained using MTDFREML (Boldman et al., 1993). Estimates of the variance components σ^2_a, σ^2_e, σ^2_p for scrotal circumference at weaning (SCW), SCUNA and SCADJ were obtained using two models. The basic linear model was: $Y = X\beta + Zu + e$, where X = incidence matrix for fixed effects, β = vector of fixed effects of breed of lamb, age of dam, year of birth and the covariate age of lamb at measurement in model I (w/o BW) and was the same for model II (BW) except body weight at the time of measurement was added as a covariate; Z = incidence matrix for random effects; u = vector of random effects (animal genetic); and e = vector of environmental effects normally and independently distributed ($0, \sigma^2_e$). To estimate the additive covariance between the various measures of scrotal circumference and the ewe traits of number of lambs born (lambs born per ewe exposed for breeding), body weight of ewe at weaning time, fleece weight and fleece grade a multiple trait analysis was used. The models for the first traits (measures of scrotal circumference) were the same as state above and for the second trait (the ewe traits) the β vector of fixed effects was breed of ewe, age of ewe in years and year of the weight record.

RESULTS

Results of including BW at weaning and at the end of test were different. Including BW for SCW and SCUNA resulted in a reduction in σ^2_p of 58% and 62%, respectively while there was little change in σ^2_p for SCADJ. However, for σ^2_a in SCW there was little change as a result of including BW, resulting in h^2_a of .19 in the model w/o BW compared to .33 when BW was included but in SCUNA, σ^2_a was reduced proportionally to σ^2_a resulting in h^2_a that were the same for SCUNA with and without BW in the model. Estimates of σ^2_a and h^2_a when SC was adjusted for BW both with and without BW in the model were smaller than those for SCUNA (Table 1).

Heritability estimates for number born, ewe body weight, fleece wt and fleece grade are shown in table 2 and agree closely with other literature estimates. Genetic correlations of SCW from models w/o BW and BW were negative and fairly large. However, at the end of the test period the same correlations with SCUNA and SCADJ were positive. When SC was not adjusted for BW or BW was not included in the model the correlation with number born was .06 but when SC was

TABLE 1. ESTIMATED VARIANCE COMPONENTS AND HERITABILITY FOR SC AT WEANING (SCW), AND END OF TEST UNADJUSTED FOR BW (SCUNA) AND ADJUSTED FOR BW (SCADJ).

Trait	SCW(cm)		SCUNA(cm)		SCADJ(cm)	
Parameter	w/o BW	BW	w/o BW	BW	w/o BW	BW
σ_a^2	2.578	2.053	5.039	1.904	1.364	1.359
σ_e^2	12.011	4.137	11.525	4.293	4.261	4.372
σ_p^2	14.769	6.190	16.620	6.198	5.725	5.731
h_a^2	.19	.33	.30	.31	.21	.24

TABLE 2. ESTIMATED COVARIANCE COMPONENTS AND GENETIC CORRELATIONS BETWEEN MEASURES OF SC UNADJUSTED FOR RAM BW (SCUNA) AND ADJUSTED FOR RAM BW (SCADJ) WITH AND WITHOUT RAM BW INCLUDED AS A COVARIATE WITH MEASURES OF EWE LAMBING RATE, BODY WEIGHT AND FLEECE TRAITS.

		Ewe traits			
Trait	Component	No. Born	Body wt. (kg)	Fleece wt. (kg)	Fleece grade (score)
Ewe Traits					
	σ_a^2	.0228	36.9279	.2647	.1466
	σ_e^2	.2143	10.8001	.3129	.2143
	h_a^2	.10	.77	.45	.39
SCW					
w/o BW	σ_a	-.1511	-2.189	-.0604	-.1525
	r_a	-.41	-.21	-.07	-.22
BW	σ_a	-.1513	-4.428	-.1786	-.0399
	r_a	-.43	-.46	-.20	-.06
SCUNA					
w/o BW	σ_a	.0263	-1.9134	.0902	-.0288
	r_a	.06	-.13	.07	-.03
BW	σ_a	.0561	-5.2101	-.2174	-.0829
	r_a	.20	-.59	-.31	-.15
SCADJ					
w/o BW	σ_a	.0689	-4.9111	-.2441	-.0956
	r_a	.30	-.68	-.43	-.21
BW	σ_a	.0693	-5.053	-.2131	-.0828
	r_a	.30	-.70	-.41	-.19

adjusted for BW either by using SCUNA with BW as a covariate or adjusting the records prior to analysis SCADJ the correlations with number of lambs born were larger (Table 2). Covariances and genetic correlations between measures of SC with ewe body weight, fleece weight and fleece grade were all negative. In general adjusting SC for BW resulted in covariances and genetic correlations that had larger negative values (Table 2).

DISCUSSION

Estimated heritabilities from this study agree closely with those reported in the review by Matos and Thomas (1992) and the positive genetic correlations with SCUNA and SCADJ also agree with most of their genetic correlations with measures of female reproduction. The moderate and negative genetic correlations of SCW with number born are difficult to explain but may relate to the season of measurement (mid-August) or the small proportion that would have attained puberty at this time (note the $\bar{x}$ of SCW was 17.4). These results show that adjusting testis size for body weight will result in increased number of lambs born and decreased body weight and fleece weight and grade. Whereas, selecting for testis size unadjusted for body weight had little impact on number born and a small impact negative impact on ewe body weight. This seems to agree with results from Haley et al., 1990 who reported that selection for testis size adjusted for body weight resulted in a decrease in body weight and an increase in female reproduction, primarily fertility. The negative correlation between testis size adjusted for body weight and fleece weight may be the result of a positive phenotypic relationship between body weight and fleece weight where larger ewes produce more fleece.

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