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GENETIC PARAMETERS FOR DAG- AND COVER SCORES OF MERINO EWES DIVERGENTLY SELECTED FOR NUMBER OF LAMBS WEANED

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SUMMARY

Divergent selection for number of lambs weaned per ewe joined from the same base population since 1986 resulted in Merino lines that differ markedly in reproduction rate. Subjective scores for dags (DS), breech cover (BCS), crutch cover (CCS) and belly wool quality (BQS) (1 = lowest; 5 = highest) were recorded for mature ewes of these lines. Expressed relative to High (H) line performance, BCS was 19% higher in the Low (L) line ewes. Corresponding selection line differences in favour of the H line amounted to 9% for DS and 32% for CCS. In contrast, BQS were reduced by 24% in the H Line. Ewes that reared more lambs had a higher mean for DS and lower scores for the other traits than ewes not rearing any lambs ($P<0.01$). All traits were heritable, with estimates ranging from 0.36 for DS to 0.68 for BCS. Genetic correlations suggested that DS was not highly related to BSC, CCS or BQS. Genetic correlations among the latter three traits all exceeded 0.80, suggesting that these traits were genetically very similar. Selection for improved reproduction in Merinos resulted in favourable breech and crutch characteristics, but not in BQS. The favourable breech and crutch conformation supported the reduced susceptibility to breech strike in this line.

INTRODUCTION

Two Merino lines were divergently selected over about 30 years to differ substantially in their reproductive ability (Cloete *et al*. 2004). A difference in the susceptibility of breeding ewes to breech strike was also reported between these lines, with the line selected for increased reproduction (High or H line) being less susceptible than the line selected against reproduction (Low or L line) (Scholtz *et al*. 2010). Cloete *et al*. (2005) also reported line differences, with unmulesed hoggets from the L line being scored as more wrinkly than their H line contemporaries. Breech characteristics have been associated with the susceptibility of Merino sheep to breech blowfly strike and it has been argued that strikes could be reduced if sheep were selected to eliminate susceptible crutches (De Vries and De Klerk 1944). It has been recommended that the bare patch in the locality of the anus and vulva should be as "*large as possible*" (De Vries and De Klerk 1944). Despite these arguments or recommendations, genetic solutions to breech strike were not pursued in earlier years, most probably due to the exceptional effectiveness of surgical mulesing. Mulesing, however, has been discarded as an appropriate management strategy because of its obvious impact on animal welfare.

Selective breeding for resistance to breech strike is considered an alternative long term solution. Apart from wrinkle scores, breech cover score has been identified as an indicator trait associated with breech strike (Brown *et al*. 2010). Dag score was also found to be genetically related to breech strike (Greeff *et al*. 2014). These traits were thus studied in mature ewes recorded in the recent years of the H and L lines in an attempt to relate the proven line difference in breech strike prevalence (Scholtz *et al*. 2010) of breeding ewes to these subjective scores.

MATERIALS AND METHODS

Animals and selection procedures. Two lines of Merino sheep were divergently selected from the same base population from 1986 to the present, using maternal ranking values for number of

lambs weaned per ewe joined. Details of the origin of the lines and the procedures for the selection of replacements have been reported elsewhere (Cloete and Scholtz 1998; Cloete *et al*. 2004). Briefly male and female progeny of ewes that reared more than 1 lamb per joining (i.e. reared twins at least once) were preferred as replacements in the H line. Replacements in the Low (L) line were preferably descended from ewes that reared fewer than one lamb per joining (i.e. were barren or lost all lambs at least once).

Location and recordings. The resource flock was maintained at the Elsenburg Research Farm near Stellenbosch. The climate, pastures grown and management of the animals were described by Cloete *et al*. (2004), while lambing and reproduction practices in the breeding flock were described by Cloete and Scholtz (1998). Winter lambing (June-July) was practiced routinely. Although these references are quite old, the same basic conditions still prevail at the site. All lambs had their tails docked at the third palpable joint and none of the ewes participating in the study were mulesed as lambs. Mature ewes were shorn in April/May just prior to lambing and crutched in springtime (5-6 month's wool growth) to reduce the probability of strikes over the early summer period (Scholtz *et al*. 2010). A number of commercial rams have been introduced to the flock since 2008 to link the lines to the commercial industry. These rams were selected on the same principles used for within-line selection and it was thus not attempted to account for their impact. Since the traits under consideration were not directly selected for it was assumed that the impact of these introductions would be minimal for the traits considered. From 2009 to 2016, mature reproducing ewes (2 – 7+ years) were subjectively scored for the accumulation of dags (DS), breech cover (BCS) and crutch cover (CCS) by the same experienced scorer using the Visual Breech Scoring System (Australian Wool Innovation Limited 2007). All scores were recorded in November, a month after the ewes weaned their lambs. Scores of 1 to 5 were allocated to each trait with 1 = least expression of the trait and 5 = most expression of the specific trait. Quality of belly wool (BQS) was evaluated on a linear scale from 1 to 5; where 1 = poor and 5 = excellent quality. Belly wool quality was defined as the regularity, evenness and definition of crimp, softness of handle and the absence of coarse fibres.

Statistical analyses. Systematic effects present for DS, BCS, CCS and BQS were determined in a general linear model analysis to obtain an operational model before random effects were added. The fixed effects model used included the effects of selection line (H vs. L), reproduction status (3 levels: 0, 1, 2+ lambs weaned), ewe age group (6 levels: 2 – 7+ years) and interactions among effects. Ewes dry after lambing were managed in a separate group with yearling replacements. Initial fixed effect models and the subsequent single- and four-trait genetic analyses were conducted in ASReml (Gilmour *et al*. 2015). Ewe additive genetic and ewe permanent environmental (PE) terms were included as random effects and assessed for significance by log likelihood test. Heritability estimates and genetic correlations among traits were derived from the 4-trait analyses.

RESULTS AND DISCUSSION

The scorer used the full range of scores for all subjective traits considered (Table 1). All traits were variable, with coefficients of variation ranging from 41% for DS to 52% for CCS.

Table 1. Descriptive statistics for dag score (DS), breech cover score (BCS), crutch cover score (CCS) and belly wool quality score (BQS) recorded on ewes post-weaning

Trait	Number of records	Mean	Standard deviation	Minimum	Maximum
DS	671	1.39	0.57	1	5
BCS	1107	2.27	1.03	1	5
CCS	1107	1.69	0.88	1	5
BQS	1101	2.30	0.96	1	5

When expressed relative to the relevant least squares mean for the L Line, the cover score traits were between 8% (DS) and 32% for CCS lower (P<0.05) (i.e. influenced in the desired direction) in the H Line (Table 2). These results are consistent with previous results reporting favourable correlated responses in dag score and perineal bare area dimensions in the H Line (Scholtz *et al*. 2011). It also supports the report that H Line ewes were less susceptible to breech strike than L Line contemporaries (Scholtz *et al*. 2011). In contrast, BQS was poorer in the H Line than in the L line. Ewes that reared lambs had a higher mean for DS and lower scores for the other traits than those ewes not rearing any lambs (P<0.01). The differences between ewes rearing singles and those rearing multiples were, however, small and not significant. Ewes at 4 and 6 years of age had lower means for DS than 2-, 3- and 7+-year-old ewes (P<0.05). BCS was unaffected by ewe age, while CCS declined with ewe age. BQS generally also declined with ewe age, but tended to stabilise from 5-year-old ewes. All traits barring BCS were affected by lambing year (results not shown). Year effects depend on climatic and managerial factors inherent to that specific year. Such effects were thus not presented, except when year interacted with selection line.

Table 2. Least-squares means (±s.e.) depicting the effects of selection line, number of lambs weaned, ewe age and lambing year on DS, BCS, CCS and BQS recorded on Merino ewes in the initial fixed model analyses (see Table 1 for abbreviations)

Effect and level	Number of observations[#]	Trait			
		DS	BCS	CCS	BQS
Selection line		*	**	**	**
H Line	872	1.25 ± 0.03	2.17 ± 0.05	1.51 ± 0.04	2.12 ± 0.04
L Line	235	1.36 ± 0.05	2.69 ± 0.10	2.22 ± 0.07	2.77 ± 0.08
Lambs weaned		**	**	**	**
0	285	1.20 ± 0.05	2.99 ± 0.07	2.49 ± 0.05	3.04 ± 0.06
1	604	1.37 ± 0.04	2.16 ± 0.06	1.55 ± 0.04	2.23 ± 0.05
2+	218	1.36 ± 0.08	2.14 ± 0.11	1.56 ± 0.09	2.08 ± 0.09
Ewe age		*	0.17	**	**
2 Years	290	1.35 ± 0.03	2.61 ± 0.08	2.11 ± 0.06	2.76 ± 0.07
3 Years	301	1.40 ± 0.03	2.49 ± 0.08	2.03 ± 0.06	2.64 ± 0.07
4 Years	234	1.24 ± 0.03	2.34 ± 0.08	1.86 ± 0.06	2.41 ± 0.07
5 Years	180	1.33 ± 0.04	2.47 ± 0.09	1.86 ± 0.07	2.27 ± 0.08
6 Years	77	1.17 ± 0.04	2.38 ± 0.13	1.81 ± 0.10	2.26 ± 0.11
7+ Years	25	1.35 ± 0.07	2.30 ± 0.20	1.53 ± 0.15	2.37 ± 0.17

[#] - For BCS and CCS; * - P<0.05; ** P<0.01; Absolute significance shown for P>0.05

CCS and BQS were affected by a significant interaction between lambing year and selection line in the fixed model analyses. Expressed relative to H Line means, the mean for CCS of L Line ewes exceeded that of H Line ewes by 18% in 2016, as compared to between 40 and 64% in other years. The corresponding difference for BQS amounted to 13% in 2016, compared to 31-40% in other years. Selection line also interacted with number of lambs weaned for CCS. Although CCS was clearly lower in H Line ewes compared to their L Line contemporaries across reproduction categories, the magnitude of the difference amounted to 48% for ewes not rearing a lamb, 34% for ewes that reared singles and 60% for ewes that reared multiples (all P<0.05). Significant fixed effects and interactions were included in the subsequent random model analyses.

Heritability estimates in the four-trait analysis were mostly within 0.02 relative to single-trait estimates. The only slightly larger difference were for BQS where the single-trait estimate amounted to 0.39 ± 0.08 and the four-trait estimate to 0.46 ± 0.05. Some variation in this trait was repartitioned from ewe PE to the additive component in the four-trait analysis. Only four-trait results are thus

presented in Table 3. All traits were heritable, estimates ranging from 0.36 for DS to 0.68 for BCS. In addition, the PE of ewes also affected DS (0.30 ± 0.09) and BQS (0.10 ± 0.03), resulting in repeatability estimates for both traits exceeding 0.50. We did not find previous results in the literature on the magnitude of heritability estimates for the indicator traits for breech strike studied in mature ewes. However, but it is well known that these traits are heritable in young animals (Brown *et al*. 2010; Scholtz *et al*. 2011; Greeff *et al*. 2014), supporting the present results on the genetic basis of indicator traits. Genetic correlations suggested that DS was not highly related to BCS, CCS or BQS (Table 3). In contrast, the genetic correlations among the latter three traits all exceeded 0.80, suggesting that they were genetically very similar. Phenotypic correlations were mostly in the same direction as genetic correlations, but smaller in magnitude.

Table 3. Four-trait phenotypic (σ^2_P), additive (σ^2_A) and ewe permanent environmental (σ^2_C) variance components and (co)variance ratios for DS, BCS, CCS and BQS of the Merino ewes studied (see Table 1 for abbreviations)

Component and trait	Trait			
	DS	**BCS**	**CCS**	**BQS**
σ^2_P	0.360	0.965	0.568	0.658
σ^2_A	0.128	0.661	0.358	0.300
σ^2_C	0.108	-	-	0.063
(Co)variance ratios*				
DS	**0.36 ± 0.10**	0.00 ± 0.10	0.08 ± 0.11	0.06 ± 0.15
BCS	-0.02 ± 0.05	**0.68 ± 0.03**	0.83 ± 0.03	0.82 ± 0.05
CCS	0.03 ± 0.05	0.63 ± 0.02	**0.63 ± 0.03**	0.85 ± 0.05
BQS	0.01 ± 0.05	0.60 ± 0.03	0.57 ± 0.03	**0.46 ± 0.05**

* Heritability in bold on the diagonal, genetic correlations above the diagonal and phenotypic correlations below the diagonal

CONCLUSIONS

All traits were heritable and should respond to selection if needed. Selection for improved reproduction in Merinos resulted in favourable dag, breech and crutch characteristics previously related to reductions in breech strike. In contrast, scores for BQS were compromised by selection for an improved reproduction.

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