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Breech strike indicator traits for Merino sheep in non-seasonal rainfall environments

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ABSTRACT: Visual trait data collected from 2 sites of the Sheep CRC Information Nucleus Flock were evaluated for their suitability as indicator traits for breeding breech strike resistance in Merinos in a non-seasonal rainfall environment. Heritability estimates and genetic and phenotypic correlations were derived for breech, body and neck wrinkle, breech and crutch cover and dag. Yearling breech strike had a moderate heritability of 0.17 ± 0.09. Potential indicator trait heritability estimates ranged from 0.05 ± 0.06 to 0.58 ± 0.09. Genetic correlations between the visual traits and breech strike were moderate to high (0.39 ± 0.30 to 0.81 ± 0.54) with large standard errors. Yearling breech wrinkle, crutch cover and neck wrinkle were identified as the most important indicator traits for breeding breech strike resistant Merinos in a non-seasonal rainfall environment.

Keywords: fly strike; wrinkle; crutch cover; Genetic parameters

Introduction

Controlling breech strike is one of the largest costs to the Australian Merino sheep industry. Mulesing has been used as a primary tool to control breech strike in conjunction with crutching and preventative chemical application (James 2006). Increasing pressure to cease the practice of mulesing has stimulated ongoing research into alternative methods to control breech strike. One permanent alternative is to breed sheep resistant to breech strike. Breech strike resistance has been found to be moderately heritable in various environments, indicating potential for its genetic improvement (Greeff et al. 2014; Smith et al. 2009; Bird-Gardiner et al. 2014).

Breech strike expression is highly environment-dependent, thus making it difficult to identify susceptible animals under various management regimes and to include in routine selection practices to improve resistance. For difficult to measure traits, such as resistance to breech strike, indirect selection on correlated indicator traits can be used to improve the trait of interest. Key properties which make a trait suitable for indirect selection are: the trait should be cost effective and easy to measure irrespective of environmental conditions; have a range of phenotypic expression with a normal distribution; and have a high heritability and a strong genetic correlation with the trait of interest across various seasonal conditions (Raadsma and Wilkinson 1990).

Recently, faecal contamination (dags), urine stain, wrinkle and breech cover have been identified as potential indicator traits for improvement of breech strike resistance appropriate for a winter dominant rainfall environment (Greeff et al. 2014). Potential indicator traits for a summer dominant rainfall environment differed slightly in importance with breech wrinkle being most important (Smith et al. 2009). Although a large proportion of the sheep population is found in the winter and summer dominant rainfall areas of Australia, a substantial number of sheep also reside in variable non-seasonal rainfall regions. The aim of this study was to identify potential indicator traits for breech strike which could be used for indirect selection in breeding breech strike resistant sheep in a non-seasonal rainfall environment.

Materials and Methods

The data for this study came from the Cowra and Trangie sites from the Sheep CRC Information Nucleus Flock (IN) (van der Werf et al. 2010) which were located within the NSW non-seasonal rainfall region. The IN progeny bred at these sites were evaluated for a suite of visual and production traits which included breech strike incidence. The long term median rainfall for the Cowra and Trangie sites are 611 mm and 467 mm respectively.

Data. The data was derived from 1089 non-mulesed Merino IN progeny born between 2008 and 2011. Flystrike control was specific to each site and contemporary group (varied between years and sites), and included crutching at weaning and post-weaning age and suitable preventative chemical application on the breech and body. The incidence of breech strike (9.4% mean across years and sites) was recorded on ewes and wethers from marking to shearing (approximately 10 months of age). Merino sire and dam genotypes contributing to the progeny comprised: fine, medium and strong wool strains and generic or strain crosses. Sires were only used in one year, but there was at least 14% of total sires linked between sites within year and dams were used across years.

Visual Traits. Animals observed to be fly struck on the breech were treated and recorded as struck. Yearling breech strike (YBSTRK) was derived as the sum of breech strikes between marking and shearing for each animal. Animals were scored for a suite of visual traits from marking to post shearing using the research version visual scoring guide (Australian Wool Innovation 2007). Only 8 traits are reported in this paper: breech wrinkle (MBRWR) and breech cover (MBCOV) scored at marking age (average age 32 days) and dags (PDAG) scored at post weaning age (average age 9 months), yearling breech (YBCOV) and crutch cover (YCCOV) were scored pre-shearing, and yearling breech (YBRWR), body (YBDWR) and neck wrinkle (YNKWR) were scored post shearing. The visual traits were scored from 1 to 5, with 1 representing least expression of a trait through to 5 as greatest expression.

Statistical analyses. Data were analysed using ASReml (Gilmour et al. 2009) and a pedigree file sourced from research and MERINOSELECT databases, with genetic groups fitted. Linear mixed models were used to evaluate the fixed effects, with sire fitted as the random effect. Site, sex, year of birth, birth rearing type, dam age, sire and dam genotype, and their interactions were fitted to each trait and were included in the model if significant ($P < 0.05$). All traits were analysed assuming a normal distribution on the observed scale. Three random effect models were evaluated for each trait: Model 1: animal (direct additive genetic effect); Model 2: animal plus maternal permanent environment (PE) and Model 3: animal, PE and sire by site effect. Log-likelihood ratio tests were used to evaluate the models and the model with the most significant log-likelihood (Table 1) was used to derive heritability estimates. Variance components derived from bivariate analyses between breech strike and potential indicator traits were used to estimate genetic and phenotypic correlations.

Table 1. Number of records (*n*), mean, minimum, maximum and standard deviation (s.d.) and best model for each trait.

Trait	*n*	Mean	Min	Max	s.d.	Model*
YBSTRK	1088	0.11	0	3	0.36	2
MBRWR	1087	3.01	1	5	1.01	3
MBCOV	1087	4.37	2	5	0.66	3
PDAG	1058	1.55	1	4	0.67	3
YBRWR	1055	2.42	1	4	0.61	2
YBDWR	937	2.17	1	4	0.54	3
YNKWR	937	2.35	1	4	0.58	3
YBCOV	937	3.64	1	5	0.77	3
YCCOV	946	3.25	1	5	0.76	2

*Random effect model 2:animal + maternal permanent environment; model 3: animal + maternal permanent environment + sire by site.

Following the work of Raadsma and Wilkinson (1990) the relative genetic potential (RP) of each visual trait was used to rank the suitability of indicator traits for indirect selection, this was calculated as:

$$RP = r_g * (h^2_{ind} / h^2_{bs})^{0.5} \quad \text{where:}$$

RP = relative genetic potential of the indicator trait;
r_g = genetic correlation between breech strike and the indicator trait;
h^2_{ind} = heritability of the indicator trait;
h^2_{bs} = heritability of breech strike.

Results and Discussion

The number of records, summary statistics and the model fitted to each of the traits are shown in Table 1. Breech strike incidence for this data set was considerably lower (by approximately 15%) than other studies of Greeff et al. (2014) and Smith et al. (2009), which is expected due to flystrike preventative treatment. The animals had moderate wrinkle and wool coverage depicted by the wrinkle and cover scores and were carrying more wrinkle development than the research flock described by Greeff et al. (2014).

Heritability and variance components: Phenotypic variation and heritability estimates derived from univariate analyses are reported in Table 2. Sire by site variance component accounted for 5%, 8%, 3% and 1% of the phenotypic variance for MBCOV, YBDWR, MBRWR and YNKWR respectively. The maternal permanent environment variance comprised 22%, 10%, 6% and 7% of the estimated variance for YBSTRK, MBRWR, YBDWR and YNKWR respectively. No other studies have reported significant maternal effects for breech strike or NKWR, although permanent environment estimates of similar magnitude were reported by Brown et al. (2010) for early breech wrinkle and late body wrinkle.

Table 2. Phenotypic variation (σ^2_p), heritability (h^2) (±s.e.), genetic (r_g ± s.e.) and phenotypic (r_p) correlations of indicator traits with yearling breech strike.

Trait	σ^2_p	h^2	r_g	$r_p^{\&}$
YBSTRK	0.12	0.17 (0.09)		
MBRWR	0.74	0.36 (0.17)	0.47 (0.24)	0.11
MBCOV	0.37	0.20 (0.10)	0.76 (0.35)	0.09
PDAG	0.26	0.05 (0.06)	0.81 (0.54)	0.08
YBRWR	0.31	0.58 (0.09)	0.66 (0.22)	0.17
YBDWR	0.25	0.26 (0.20)	0.52 (0.38)	0.11
YNKWR	0.29	0.51 (0.17)	0.53 (0.27)	0.12
YBCOV	0.45	0.18 (0.10)	0.39 (0.30)	0.17
YCCOV	0.41	0.47 (0.09)	0.65 (0.30)	0.09

&Phenotypic correlation s.e. ≤ 0.04.

The YBSTRK heritability estimate of 0.17 ± 0.09 was lower than those reported by Smith et al. (2009) (0.32 ± 0.11) or Bird-Gardiner et al. (2013) (0.43 ± 0.13). This may be due to the lower breech strike incidence in this study and the use of different analytical models. When maternal permanent environment was not fitted as a random effect the heritability estimate obtained was 0.48 ± 0.09. Heritability estimates for the visual traits were moderate to high and comparable with other published values, except PDAG (0.05 ± 0.06) which was lower and YNKWR (0.51 ± 0.17) which was higher than other reported estimates (Brown et al. 2010; Greeff et al. 2014; Smith et al. 2009; Scholtz et al. 2011).

Genetic and Phenotypic Correlations: Genetic correlations obtained between visual traits and breech strike outlined in Table 2 were all moderate to high, with large standard errors. PDAG has the highest positive genetic correlation with breech strike. The strong genetic correlation suggests that animals genetically susceptible to scouring and dags are also more susceptible to breech strike. However as with breech strike, the expression of dags in non-seasonal rainfall regions can be highly variable between years, increasing the difficulty of measurement. Furthermore, the low heritability and relative genetic potential (Table 3) of PDAG suggests it would be of limited value as an indicator trait for the non-seasonal rainfall environment.

Table 3. Relative genetic potential (RP) of indicator traits

Trait	RP	Trait	RP
YBRWR	1.22	MBRWR	0.69
YCCOV	1.09	YBDWR	0.65
YNKWR	0.94	PDAG	0.45
MBCOV	0.84	YBCOV	0.41

Genetic correlations obtained for wrinkle traits and breech strike were higher than those published by Greeff et al. (2014) and this could be due to the fact that the sheep in the present study had higher average wrinkle scores. All of the wrinkle score traits were strongly correlated with breech strike, indicating that sheep with higher wrinkle scores were more susceptible to breech strike. For the wrinkle traits, YBRWR had the highest relative genetic potential followed by YNKWR, indicating that these traits were more important than YBDWR or MBRWR as indicator traits for the non-seasonal rainfall environment. For this data set there was a strong genetic correlation between YNKWR and YBRWR at 0.89 ± 0.10 and a phenotypic correlation of 0.45 ± 0.03. The large positive genetic correlation, high heritability and RP obtained for YNKWR indicated that this trait could be used as a key indicator trait in mulesed sheep where the breech wrinkle has been altered.

Yearling crutch cover had a high positive genetic correlation with YBSTRK and was ranked as the second most important breech strike indicator trait. Greeff et al. (2014) found that crutch cover generally had a higher heritability than breech cover and a similar trend was evident in this data. Of the 8 traits reported here this trait can be more difficult to accurately evaluate than the others.
Marking breech cover had a large positive genetic correlation with YBSTRK and was ranked 4th as a potential indicator trait for indirect selection on resistance to yearling breech strike. Breech cover at yearling age had a lower heritability and genetic correlation with breech strike than at marking age. This trait was identified as having the lowest relative genetic potential of all the indicator traits. Sheep genetically resistant to breech strike are expected to be associated with lower breech and crutch cover scores (more bare skin). The majority of these visual traits can be readily scored during routine management practices on non-mulesed sheep. But neck wrinkle can also be scored on mulesed sheep.

All phenotypic correlations estimates were low and could have been underestimated due to the low incidence of YBSTRK (nearly reflecting a binomial trait). Phenotypic correlations can be underestimated between continuous and binomial traits as they are incident dependent (Evans and McGuirk; 1983). This incident dependence is not expected to apply to genetic correlations (Raadsma and Wilkinson 1990).

The standard errors associated with the genetic correlations obtained in this study are large, which is typical of small data sets, especially when reviewing the relative genetic potential for indicator traits, as these values and ranking could change substantially if the data set were larger. Furthermore single trait selection would not be recommended and more genetic progress in breech strike resistance may be possible though multiple trait selection. The practice of indirect selection to improve difficult to measure traits can be effective, but consideration must also be given to correlated responses in production and wool quality traits. Further analysis will examine these relationships and predicted response to selection.

Conclusion

Visual traits assessed ranged in heritability from low to moderate. Estimated genetic correlations between visual traits and yearling breech strike were moderate to high for all traits. Yearling breech wrinkle, crutch cover and neck wrinkle were identified as key indicators traits which could be used in indirect selection to breed breech strike resistant sheep in a non-seasonal rainfall environment.

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