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GENETIC PARAMETERS FOR ARENA BEHAVIOUR OF LAMBS FROM MERINOS DIVERGENTLY SELECTED FOR LAMBS WEANED PER EWE MATED

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SUMMARY

This paper reports on the genetics of the response of lambs to humans in an arena test. Data of 2291 8-month-old Merino lambs from reproduction selection lines at Elsenburg were used. Divergent selection for number of lambs weaned per ewe mated (NLW) was used to produce widely divergent lines (named the H line for upward selection and the L line for downward selection) from 1986 to the present. Overall line differences suggested that animals selected for reproduction would approach a human operator closer, travel longer distances during the test (based on the number of crosses) and would be less likely to urinate or defecate than their L line contemporaries during the test (all $P<0.05$). The distance lambs maintained from the human operator was lowly heritable (0.08±0.03), whereas the number of lines crossed (0.22±0.04) and bleats (0.35±0.05) were moderately heritable. Urinating (0.13±0.03) and defecating (0.04±0.02) events were also lowly heritable. Genetic and phenotypic correlations suggested that animals maintaining a larger distance from the human operator covered a greater distance in the arena (respectively 0.39±0.18 and 0.22±0.02). Selection for NLW in the H line resulted in behavioural repertoires indicative of lower levels of stress during their interaction with humans. Lower levels of stress and good animal-stockperson relations during unfamiliar procedures facilitates animal welfare.

INTRODUCTION

Temperament is defined as an animal's inherent response to a stressful stimulus and is determined by genetic and permanent environmental effects such as early life experiences (Dodd *et al*. 2012). Producers prefer animals that are easier to handle in open situations as well as in more restricted environments. Moreover, temperament is be linked to production traits such as growth of lambs and rearing ability of ewes (Murphy *et al*. 1994; Kilgour and Szantar-Coddington 1995).

Syndromes such as pale, soft and exudative meat in pork and dark, firm and dry meat in beef may result from either acute short-term or chronic long-term stress. Cloete *et al.* (2005) reported that selection against number of lambs weaned per ewe mated (NLW) resulted in animals with an inferior meat quality. Murphy *et al.* (1994) suggested that animals of quiet temperament grew faster and were better producers than animals with restless, nervous or aggressive temperaments. Animal welfare considerations are increasing in importance. Selection for temperament is seen as a potential way to reduce an animal's response to stress without a need to alter management (Dodd *et al.* 2012). Against this background, we report the genetic and environmental parameters for the responses of 2291, 8-month-old Merino lambs from lines divergently selected for NLW at Elsenburg to a human operator during an arena test.

MATERIALS AND METHODS

The responses of 8-month old Merino lambs to humans were assessed for lambs born from 2001 to 2014. Male and female replacements in the respective lines were initially selected on a ranking table using principles suggested by Turner (1977). This selection resulted in widely divergent lines (namely the H line for upward selection and the L line for downward selection) from 1986 to the present (Cloete and Scholtz 1998; Cloete *et al.* 2009). The lines grazed in the same flock but no genetic material were exchanged between the pure lines in the animals included. Overall means for NLW in 1997-2002 amounted to 0.78 in the L line and 1.16 in the H line (Cloete *et al*. 2003). These animals were assessed in an arena test (Murphy *et al*. 1994; Kilgour and Szantar-Coddington 1995) that was modified as described by Cloete *et al*. (2005). Individual animals were placed in an arena of 10.6 m x 4.0 m. The floor of the arena was marked out in 18 equal sized rectangles and numbered. A pen containing six to seven contemporaries of the test animal was placed at one end of and outside the arena. A human operator sat on a chair directly in front of this pen and inside the arena. A second operator introduced the test sheep to the arena at the furthest point (a distance of 10.6 m) from the human seated inside the arena. The test sheep remained in the arena for three minutes and was observed by two recorders located in a building overlooking the arena. The presence of the animal in a specific rectangle was recorded every 15 seconds. The following traits described the behaviour of the sheep: 1) the mean distance from the seated person, 2) the total number of boundaries crossed between rectangles based on the position of the left front foot of the animal at 15 s intervals (as an indication of the total distance travelled), 3) the number of bleats (both high- and low pitched), 4) the number of times an animal urinated or defecated.

Animals were tested once, as Murphy *et al.* (1994) suggested that the repeatability of similar measurements of temperament were fairly high (>0.55). The latter authors did not partition animal effects in genetic and permanent environmental components. The data recorded was analyzed using a five-trait animal model that included the single random effect of animal (Gilmour *et al*. 2015). Fixed effects included were: selection line, year of birth, sex, age of the dam and birth type (single or multiple). All counts were square root transformed to normalize the distributions prior to analysis after 0.5 was added to ensure a smaller difference between raw counts of 0 and 1 (Dickson and Sanford 2005). Genetic correlations among traits were also estimated. Animal solutions obtained from the output of an analysis excluding selection line and its interactions with birth year were averaged to indicate genetic differences between lines. The pedigree file contained 8739 animals, the progeny of 335 sires and 1954 dams.

RESULTS AND DISCUSSION

Descriptive statistics for the data analysed are provided in Table 1. After the transformation, the count data were normally distributed. Coefficients of variation ranged from 29% for times urinated to 42% for the distance from the operator. Fixed effect solutions are provided in Table 2 for selection line. Least-squares means for transformed data were tabulated but back-transformed means are discussed, as they resembled the counts recorded. H line lambs approached the seated human closer, travelled longer distances during the test and were less likely to urinate and defecate than L line contemporaries (P<0.05). Back-transformed means for the number of crosses in the L line amounted to 88% of those in the H Line (15.4 vs. 17.5). The number of urination and defecation events of L line progeny exceeded those of their H line contemporaries by respectively 28% (back-transformed means of 0.82 vs. 0.64) and 19% (back-transformed means of 0.87 vs. 0.73).

Table 1. Descriptive statistics for the average distance from the operator (DIST) and square root transformed counts for the number of crosses (CROSS), bleats (BLEAT), urinating events (URINE) and defecating events (DEFEC) after 0.5 was added (n=2291)

Effect and	Trait				
level	DIST	CROSS	BLEAT	URINE	DEFEC
Mean±s.d.	3.82±1.24	4.18±1.24	3.89±1.44	1.07±0.31	1.11±0.41
Range	1.07–9.20	0.71–9.19	0.71–8.34	0.71–2.55	0.71–2.35
Skewness	0.71	0.44	-0.46	-0.49	-0.83
Kurtosis	0.21	0.53	-0.14	0.23	0.50

Table 2. Least-squares means (±s.e.) of Merino weaners depicting the effect of selection line on the average distance from the operator (DIST), counts for the number of crosses (CROSS), bleats (BLEAT), urinating events (URINE) and defecating events (DEFEC)

Effect and	Trait				
level	DIST	CROSS	BLEAT	URINE	DEFEC
Line	**	**	0.30	**	*
H line	3.77±0.04	4.24±0.03	3.83±0.04	1.07±0.01	1.11±0.01
L line	3.99±0.10	3.98±0.08	3.90±0.08	1.15±0.02	1.17±0.02

* - P<0.05; ** P<0.01; Actual significance for P>0.05

Ewe lambs were significantly more likely to bleat and defecate than rams, but less likely to urinate (P<0.05; means not shown). All arena traits were independent of birth type (P>0.10), as was also reported by Wolf *et al.* (2008). Year affected all arena traits (P<0.01). Significant effects not tabulated were included in the genetic analysis for the variation they controlled.

The distance lambs maintained from the seated operator was lowly heritable (0.08±0.03; Table 3). Wolf *et al*. (2008) also suggested that traits associated with the distance from the human in the arena were lowly heritable, estimates ranging from 0.02 to 0.22. The number of crosses and bleats were moderately heritable at respectively 0.22±0.04 and 0.35±0.05. These estimates are consistent with previous results reported by Wolf *et al.* (2008), namely 0.29 for boundaries crossed and 0.39 for number of bleats. The heritability of the number of urinating events was smaller in magnitude (0.13±0.03). The number of defecating events was lowly heritable at 0.04±0.02. Significant genetic correlations suggested that animals maintaining a larger distance from the operator crossed more rectangles, were more likely to urinate and tended to have more defaecation events (Table 3). Animals with more urination events tended to also exhibit more defecation events. Phenotypic correlations were in the same direction as genetic correlations but mostly smaller in magnitude.

Table 3. Phenotypic variance (σ^2_P) and correlations between the average distance from the operator (DIST) counts for the number of crosses (CROSS), bleats (BLEAT), urinating events (URINE) and defecating events (DEFEC)

Component	Trait				
and trait	DIST	CROSS	BLEAT	URINE	DEFEC
σ^2_P	2.415	1.462	1.894	0.0918	0.1559
(Co)variance ratios*					
DIST	**0.08±0.03**	0.39±0.18	0.26±0.17	0.46±0.23	0.35±0.22
CROSS	0.20±0.02	**0.22±0.04**	0.05±0.13	0.22±0.17	-0.14±0.24
BLEAT	0.33±0.02	0.27±0.02	**0.35±0.05**	0.12±0.15	0.26±0.23
URINE	0.01±0.02	0.01±0.03	0.04±0.02	**0.13±0.03**	0.37±0.24
DEFEC	0.10±0.02	-0.02±0.02	0.02±0.02	0.23±0.02	**0.04±0.02**

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

Selection line averages for arena trait breeding values were lower in the H line for the average distance from the human operator, as well as for numbers of bleats, urinating events and defecating events compared to L line lambs (Table 4). In contrast, average breeding values for number of crosses were higher than in the L line. H line lambs thus approached the human operator closer, urinated and defecated at a lower frequency, but covered a greater distance in the arena than their L line contemporaries, both at the phenotypic (Table 2) and genetic (Table 4) level. Some of these behavioural repertoires suggested lower levels of stress. For instance, defecation and/or urination are widely accepted as responses to stressful conditions in small laboratory animals (Archer 1973). These responses are additional desirable correlated responses of selection for NLW on animal welfare along with an improved lamb survival (Cloete *et al*. 2009), a reduced susceptibility to flystrike (Scholtz *et al*. 2010) and a reduced crutching time (Scholtz *et al*. 2012) in the H line.

Table 4. Overall means (±s.e.) for estimated breeding values for the arena behaviour traits derived from the multiple trait analysis not incorporating selection line as a fixed effect

Trait	Selection line	
	H Line	**L Line**
Average distance from human (m)	0.034 ± 0.004	0.259 ± 0.009
Transformed counts		
Crosses (#)	0.271 ± 0.006	0.012 ± 0.015
Bleats (#)	-0.118 ± 0.009	-0.004 ± 0.020
Urination events (#)	-0.024 ± 0.001	0.052 ± 0.003
Defecation events (#)	-0.027 ± 0.001	0.019 ± 0.002

Selection line differences were significant (P<0.01) for all arena traits

CONCLUSIONS

This research has shown that some behaviour differences between sheep are heritable. The genetic adaptation of farm animals to lower levels of fear during routine operations is highly desirable from an ethical viewpoint. The favourable correlated response to selection for NLW in the reaction of H line animals towards humans needs to be verified by the estimation of genetic correlations with NLW before possible inclusion in selection programmes.

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