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YEARLING WEIGHT AND HORN TRAITS IN SOUTH AFRICAN MERINO LINES DIVERGENTLY SELECTED FOR AND AGAINST NUMBER OF LAMBS WEANED

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SUMMARY

Ovine horn phenotypes have been studied extensively but are still not fully understood. This study used data from a divergent selection experiment for (H-Line) and against (L-Line) number of lambs weaned per ewe mated (NLW) in two South African Merino lines to study the effect of selection line on yearling weight (YW) and horn traits. Mixed model analyses allowed the estimation of fixed effects and genetic parameters for YW, horn length (HL) and horn base circumference (HC) in ram yearlings. H-Line ewes were more likely to be polled (0.651 vs. 0.353; Chi^2=46.8) with a lower frequency of horns than L-Line ewes (0.032 vs. 0.323; Chi^2=128.4). HC in both sexes and HL in ewes were independent of selection line with YW as a covariate. Single- and three-trait heritability estimates were respectively 0.54 and 0.58 for YW, 0.42 and 0.45 for HL, and 0.44 and 0.53 for HC. Genetic correlations among traits ranged from 0.66 between YW and HL to 0.77 between HL and HC. Studies on horn traits in South African Merinos could provide motivation for a greater focus on the elimination of horns, as in other major sheep-producing countries.

INTRODUCTION

In wild ungulates, horns are important for defence against predators and for determining an individual's social status in a group (Simon *et al*. 2022). The utility of horns in domestic sheep is less clear as it is often associated with health and management issues, as well as injuries to other sheep and human handlers (Hatcher *et al*. 2019; Simon *et al*. 2022). Horned Soay sheep had greater reproductive success, which was traded off against a shorter lifespan (Johnston *et al*. 2013). However, evidence linking horns to reproductive success is scarce (Simon *et al*. 2022).

Against this background, we studied horn traits in a South African Merino resource flock divergently selected for and against reproduction with successful results (Cloete *et al*. 2004). Given that horns are often dimorphic between sexes in sheep (Simon *et al*. 2022), rams and ewes were considered separately.

MATERIALS AND METHODS

Experimental site and animals. The well-recorded Elsenburg Merino flock (Cloete *et al*. 2004; Nel *et al*. 2024) provided material for this study. The flock was established in 1986 and used a common base population to establish a divergent selection experiment involving two lines selected for (High or H-Line) or against (Low or L-Line) number of lambs weaned per ewe mated. The two lines were maintained in a single flock, except when being mated in single-sire groups during summer (January-February) to lamb in winter (June-July) annually. Details regarding the composition, selection regimes and management of the flock are provided in Cloete *et al*. (2004) and Nel *et al*. (2024) and will not be elaborated here.

Recordings. This study hinged on detailed horn phenotypes recorded from 2016 to 2023 on yearling ewe (N=791) and ram (N=843) progeny that were available for selection as replacements. In addition, yearling weights (YW) at an average (SD) age of 334 (29) days were also recorded.

COVID-19 restrictions prohibited the recording horns of the 2019 drop in May 2020, but YW was available (N=1847). Horn phenotypes were scored as polled, knobs, scurs and horns in both sexes (Pickering *et al*. 2009; Duijvesteijn *et al*. 2018). Horn length (HL) was measured from the base to the tip of the horn in rams and all ewes with horns or measurable scurs (Figure 1) using a standard tape measure. Horn base circumference (HC) was also measured in those individuals where it was feasible. Assuming symmetric horns, the record was consistently obtained from the right horn/scur by the same person. Progeny (N=60) and grand progeny (N=74) of a polled industry ram that was used in 2021 and 2022 to link the flock to industry resources (Nel *et al*. 2024) were excluded from all analyses. Using 2300 Merino progeny in the Sheep CRC information nucleus flock, Hatcher *et al*. (2019) showed that a polled ram mated to horned ewes will have 49% polled ram and 82% polled ewe progeny. The corresponding figures for a horned ram were respectively 6 and 18%, demonstrating the profound impact such a ram could have.

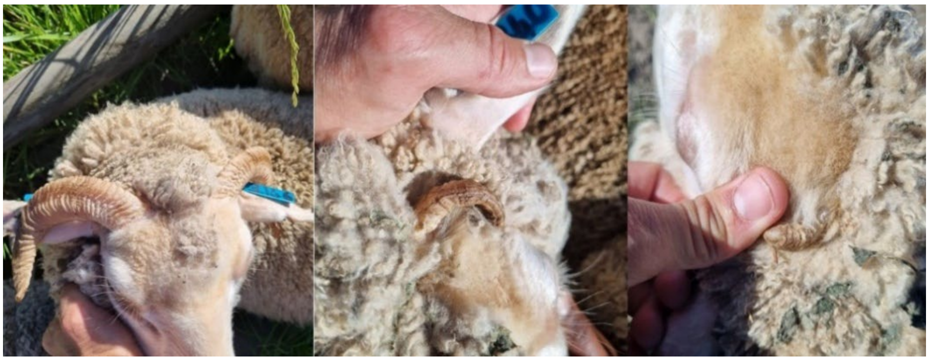

Figure 1. Yearling ewes with horns (a), measurable scurs (b) and scurs not measured (c)

Statistical analysis. Frequencies derived from the presence/absence of horn phenotypes of ewe yearlings were compared between lines using the online Chi²-calculator of Preacher (2001). YW, HL and HC of rams were analysed using a linear mixed model analyses in ASReml V4.2 (Gilmour *et al.* 2021). The analysis included the fixed effects of selection line (H- or L-Line), dam age (2-6+ years), birth type (single or multiple) and birth year as defined. Yearling age and YW (only for horn traits) were included as linear covariates. The additive random effect of animal was added to the model to enable the estimation of genetic and phenotypic (co)variance components and ratios. Birth year was excluded from the parallel analysis on HL and HD of 74 horned ewe yearlings as the horn phenotype was absent in the H-Line (N=20) in two out of seven years.

RESULTS AND DISCUSSION

Horn phenotypes within ewe selection lines. H-Line ewe yearlings were almost twice as likely to be polled than their L-Line contemporaries (P<0.01; Table 1). The presence of knobs and scurs was independent of the selection line (P>0.20) and added up to around 32% of the phenotypes when combined. L-Line yearlings were about 10 times more likely to be horned than their H-line contemporaries. Polled ewes contributed 0.459 to the 2448 Merinos sampled by Duijvesteijn *et al*. (2018), a proportion that was intermediate compared to the Elsenburg selection lines. At around 50% of the ewes sampled, knobs and scurs combined were more common than in Table 1. At 0.036, the proportion of horned ewes was in the same range as in the H-Line, but much lower than in the L-Line. The relative proportions of horn phenotypes in 35 Icelandic ewes were 0.743 polled, 0.171 scurs, and 0.086 horns (Simon *et al*. 2024). Although these figures deviated quite considerably from those in Table 1, it would not be too deviant from H-Line proportions if ewes with knobs were regarded as polled. Simon *et al*. (2024) did not detail how knobs were dealt with. It is not yet known if the results in Table 1 are related to selection taking place in the resource flock, as Simon *et al*. (2019) did not find an association of horns with reproduction in livestock species they reviewed. It is unclear if the observed line effects are conclusively the result of the divergent selection practiced in the flock since 1986, or an effect of random genetic drift. Out of 72 ewes with scurs in the H-Line, 17 were measurable. All 13 scurs in L-Line were unmeasurable, not allowing comparisons in this line. A two-sample t-test assuming unequal variances was used to test the hypothesis that horn traits in the H-Line were not different (P>0.05). The alternative hypothesis that horns had larger dimensions than scurs was accepted (HL: t =5.15; HC: t =5.70; P<0.01; Table 1).

Table 1. Horn length (HL) and horn base circumference (HC) of measurable horns and scurs (only in the H-Line) and the relative proportions of horn phenotypes (record numbers in brackets), within the divergently selected H- and L-Lines in yearling Elsenburg Merino ewes

Horn/Scur size, ewe numbers and horn phenotype	HL (cm)	**H-Line** HC (cm)		**L-Line**
Total number of ewes			624	167
Polled	NA	NA	0.651 (406)	0.353 (59) **
Knobs	NA	NA	0.202 (126)	0.246 (41) ^{NS}
Scurs	7.5 (17)	6.3	0.115 (72)	0.078 (13) ^{NS}
Horns	20.1 (20)	11.3	0.023 (20)	0.323 (54) **

** Significant (P<0.01); NS Not significant (P>0.05); NA Not applicable

Environmental and genetic effects on YW and horn traits in rams. The low incidence of horns in general and H-Line ewes in particular compromised genetic analyses on horn traits across sexes. Apart from being absent in two years, the numbers of H-Line ewe yearlings with horns ranged from 1 to 7 in the other years, while the corresponding range in the L-Line was from 6 to 10. Both H-Line ewes and rams were heavier than their L-Line contemporaries (Table 1). When analysed with YW as a covariate, HD in both sexes as well as HL in ewes were independent of selection line (P>0.05; Table 2). HL was still slightly higher in H-Line rams after the correction (P<0.05).

Table 2. Least-squares means (±SE) depicting the effect of selection line (H-Line vs L-Line) on yearling weight, horn length and horn circumference of Merino ewe and ram yearlings

Sex and level	**Yearling weight (kg)**	**Horn length (cm)**	**Horn circumference (cm)**
Ewe yearlings	**	NS	NS
H-Line	32.5±0.2	17.6±1.6	10.7±0.5
L-Line	28.1±0.3	20.0±0.9	10.1±0.3
Ram yearlings	**	*	NS
H-Line	35.4±0.4	35.6±0.2	16.5±0.1
L-Line	31.4±0.5	34.7±0.3	16.5±0.1

* Significant (P<0.05); ** Significant (P<0.01); NS Not significant (P>0.05)

Single-trait heritability estimates were 0.54±0.09 for YW, 0.42±0.09 for HL and 0.44±0.10 for HD, the latter traits analysed with YW as a covariate. The three-trait analysis yielded slightly higher heritability estimates ranging from 0.45 for HL to 0.58 for YW (Table 3). Adjusting for size could have reduced between family variation in HL and HC in single-trait analyses, although significance could not be demonstrated. The estimated heritability for YW is higher than a previous figure of 0.38 on the same flock (Cloete *et al*. 2005). However, the previous study also reported a maternal genetic variance ratio of 0.09. Genetic correlations ranged from 0.67 between YW and HL to 0.77

between HL and HC. Phenotypic correlations were also positive. It was not unexpected that YW, HL and HD was positively correlated at both the genetic and phenotypic levels, as horn traits could also be size-related. However, the direct impact of genetic variation in horn traits of domestic sheep is not apparent, as the overall objective is to breed towards polled sheep, for reasons outlined by Hatcher *et al*. (2019). In contrast, horns have an intrinsic economic value as part of the trophy-hunting industry in wild ungulates. Sim and Coltman (2019) reported somewhat lower heritability estimates than those in the present study of 0.33 for HL and 0.36 for HD in Dall's sheep (*Ovis dalli dalli*) that were harvested routinely. Heritable variation in ovine horn traits thus seems available.

Table 3. Phenotypic variances, as well as heritability (bold on the diagonal), genetic correlations (below diagonal) and phenotypic correlations (above diagonal) for yearling weight, horn length and horn base circumference of yearling Merino rams in the H- and L-Lines from a three-trait genetic analysis

Effect and level	Phenotypic variance	Yearling weight	Horn length	Horn circumference
Yearling weight (kg)	31.54	**0.58±0.10**	0.64±0.03	0.62±0.03
Horn length (cm)	26.81	0.67±0.09	**0.45±0.10**	0.64±0.03
Horn circumference (cm)	2.850	0.70±0.09	0.77±0.08	**0.53±0.10**

CONCLUSIONS

The incidences of polledness and horns differed markedly between ewes from the H- and L-Lines. After adjusting for the bigger skeletal size of H-Line ewes and rams, HD in both sexes and HL in ewes were independent of selection line. Apart from the efforts of some individual breeders, there is no concerted effort to breed for polled phenotypes in South African Merinos. It would be of value to demonstrate that selection for reproduction could aid in achieving this goal. Further studies on the inheritance of horns in South African sheep are thus warranted.

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