Contributed paper

VISUAL CLASSING GRADES ARE HERITABLE AND VISUALLY CLASSED MERINO SHEEP BORN AND REARED AS TWINS ARE GRADED LOWER THAN SINGLES

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SUMMARY

Selection of Merino sheep for use in breeding programs includes the combination of visual assessment and measurement of production traits. Genetic evaluation of these assessments and traits takes into account non-genetic effects to improve the accuracy of breeding value predictions. The hypothesis tested in this paper was that visual classing assessment of sheep on a traditional three-point and a novel five-point visual scoring system are heritable and both are also affected by non-genetic effects such as birth and rearing type. Using data from the first two years of classing ewes in the Merino Lifetime Productivity project at Pingelly, WA, moderate heritability estimates were observed for both scoring systems (0.24±0.08 for three-point and 0.17±0.07 for five-point). Both traits were moderately repeatable (0.31-0.36±0.03). Birth and rear type impacted visual scoring grades significantly, indicating that they should be accounted for when visually classing Merino sheep.

INTRODUCTION

Merino sheep breeding routinely combines objectively measured production selection and visual assessment to improve the quality and quantity of wool produced as well as improve structure and conformation. Merino sheep classing by visual selection is based on a number of subjectively assessed traits such as wool quality, quantity and conformation, assessed by professional sheep classers using different scoring systems to class animals into different categories (Brown *et al.* 2002; Robinson *et al.* 2007). When used in conjunction with estimated breeding values for production traits, visual classing can add value to selecting superior animals for replacement, with greater accuracy and efficiency than using a single method alone (Mortimer *et al.* 2010).

Genetic evaluation of Merino production data includes accounting for any fixed effects or non-genetic factors, such as birth type (whether the animal was born as a single or multiple), rear type (whether the animal was raised as a single or multiple), the age of the dam, the date of birth of the animal and whether that animal was born to a maiden or experienced mature ewe (Hadfield and Kruuk 2007; Brown *et al.* 2016). These non-genetic factors influence the phenotype of the animal and can often influence how it is classed visually. For example, twin born and reared lambs are typically smaller and produce broader and less wool than single counterparts (Swan *et al.* 2008, Thompson *et al.* 2011a,b). Accurate estimates of these fixed effects need to be included when estimating breeding values, to ensure accurate estimates of genetic merit.

Research has shown that visually assessed classer grades have a heritability between 0.12 and 0.2 and have favourable genetic and phenotypic correlations with liveweight, wool quality and structural traits (Mortimer *et al.* 2009). These subjectively measured traits are also significantly influenced by birth type, rear type and other non-genetic factors. In addition, Clarke and Thompson (2021) found that classers were influenced by subjective assessments of liveweight, clean fleece weight and fibre diameter when grading of animals. In this study non-genetic factors had a significant effect on classing outcomes such that at the first seven month old professional classing 69% of the culls were twins and only 31% were singles. Conversely 70% of the tops were singles and only 30% were twins. The current study uses an expanded data set from the Merino Lifetime

Productivity Project (Ramsay *et al.* 2019), covering more sires, seasons and repeated measures. It The hypothesis tested that classing grades are affected by non-genetic factors and that both three and five grade classing systems are heritable.

MATERIALS AND METHODS

The data analysed in this study were collected from a total of 1103 sheep born in 2016 and 2017 as part of the Merino Lifetime Productivity (MLP) Project in Pingelly, Western Australia (Ramsay *et al.* 2019). The sheep were ewes from 29 different sires and dams originating from 3 sources born over 4 years. Dams were evenly distributed to sire groups, taking into consideration ewe age, condition score and weight. The minimum number of ewes joined to each sire was 90. At approximately day 90 of pregnancy, ewes were scanned for litter size using ultrasound and divided according to whether they were single or multiple bearing. Multiple-bearing ewes were managed separately to single-bearing ewes to provide for their increased nutritional requirements based on the recommendations for pregnancy management for Merino ewes (Young *et al.* 2016). Lambing occurred in late June, with marking, tagging and DNA sampling, taken late July. All ewe progeny from each year of birth, were run together from weaning until pregnancy scanning as maidens (22 months).

All progeny were evaluated subjectively using two different visual assessments that were completed by independent sheep classers yearly, prior to shearing (at approximately 8 and 20 months of age) and according to the site breeding objective. This first classing system, called the Australian Merino Sire Evaluation Association (AMSEA) grade, sorts animals into three categories either Tops (1), Flocks (2) or Culls (3) of approximate split 25%, 50%, 25%, based on visual assessment of all traits that are present in the project's breeding objective: in this paper this system will be referred to as GRADE. The second system used a five grade system consisting of Top (1), First (2), Flock (3), Sale (4) or Cull (5), referred to as a professional classer grading (PROF) system with approximate split 2%, 10%, 58%, 20%, 10%. The classer was unaware of the progeny's parentage and birth type at classing.

Statistical Analysis. Fixed effects, variance components and genetic parameters were estimated using general linear mixed models and residual maximum likelihood methods with ASReml (Gilmour *et al*. 2009). An animal model was fitted and the animals' year of birth, age of dam at lambing (in years), birth type (litter size, how many lambs were evident at pregnancy scanning), rear type (how many lambs from the little survived to weaning), shearing number (first or second time being shorn) and dam source (where the dam was bred) were fitted as fixed effects. Birth type referred to litter size from pregnancy scanning records (coded as 1, 2 or 3), while rear type was the litter size at weaning (coded as 1 or 2 as no triplets survived). For each trait the fixed effects were tested for significance. Following each analysis, all effects that were not significant were removed from the model, until only significant fixed variables were left, (using a significance level of 5%). Animal was fitted as a random additive genetic effect and as an environmental effect to account for repeated measures on the same animal. The direct heritability was estimated by dividing the additive genetic variance with the total phenotypic variance, whereas the environmental variance component from the repeated measures was added to the direct additive genetic variance, which was then divided by the total variance to estimate the repeatability for each trait s

RESULTS AND DISCUSSION

Birth type recorded a significant effect on both PROF in both sets of data (yearling and combined) as well as for GRADE when the second shearing measure was included in the analysis (Table 1). Rearing type was highly significant effect for PROF and GRADE and an interaction between these factors of birth and rear type for GRADE. These significance levels reflect findings by Mortimer *et al.* (2009). Dam age however was not significant effect for PROF, while it was significant for GRADE which is consistent with the findings of Mortimer *et al.* (2009). This significance declined when the second year of data was included, most likely due to the effects of many non-genetic factors reducing with the age of an animal (Asadi Fozi *et al.* 2005).

Predicted means for the visually classed traits were also calculated for the combined measures at yearling and first adult shearing (Table 1). Single born and reared lambs had lower predicted means for GRADE and PROF, meaning they are less likely to be culled. These differences were more evident in the yearling data set but had improved accuracy with lower standard errors in the combined data (Table 1). These results emphasise the importance of accounting for birth type, rear type and dam age when selecting animals based on phenotype. Animals should be classed separately based on their birth and rearing type, multiple born and raised animals shouldn't be compared phenotypically to singles as they incur phenotypic disadvantages due to non-genetic effects they are exposed to.

Table 1. Predicted least square means (with standard errors) for significant fixed effects for visually assessed traits GRADE and PROF and significance of various fixed effects at combined yearling and first shearing (P < 0.05)

		GRADE*	PROF**
Birth Type			
	1	1.88 ± 0.09	3.13 ± 0.15
	2	2.17 ± 0.09	3.50 ± 0.14
	3	2.10 ± 0.22	3.14 ± 0.34
Rear Type			
	1	2.01 ± 0.08	3.19 ± 0.13
	2	2.07 ± 0.08	3.33 ± 0.13
Shearing			
	1	2.12 ± 0.08	3.31 ± 0.13
	2	1.89 ± 0.08	3.15 ± 0.13

*GRADE Visual classing grade on a 3-point scale (Top, Flock, Cull)
**PROF Professional visual classing grade on a 5-point scale (First, Top, Flock, Sale, Cull)

Table 2. Variances and estimates of Heritability, Repeatability with standard errors for the visual traits measured at yearling age and at first adult shearing of 1100 Merino ewes

Age Stage	Variance Component	GRADE*	PROF**
Yearling	Heritability	0.21 ± 0.10	0.18 ± 0.08
Combined yearling and first adult	Heritability	0.24 ± 0.08	0.17 ± 0.07
Combined yearling and first adult	Repeatability	0.31 ± 0.03	0.36 ± 0.03

*GRADE Visual classing grade on a 3-point scale (Top, Flock, Cull)
**PROF Professional visual classing grade on a 5-point scale (First, Top, Flock, Sale, Cull)

Heritability estimates for visually assessed traits of GRADE (3-point scale) and PROF (5-point scale) were moderate at 0.21±0.10 and 0.18±0.08 respectively at yearling age and 0.24±0.08 and 0.17±0.07 for the combined years data (Table 2). The heritability for GRADE was similar to that reported by Mortimer *et al.* (2009) confirming that visual grade is a heritable trait and can be used in a selection program. The repeatability across years was estimated at 0.36±0.03 and 0.31±0.03 for PROF and GRADE, respectively. Fulloon *et al.* (2001) found GRADE to have a 0.34 repeatability supporting the finding from our study. This indicates that both GRADE and PROF are heritable and repeatable traits. The estimate of heritability for professional five-point scale (PROF) is a novel finding allowing for accurate selection of PROF which was previously unavailable to producers.

CONCLUSIONS

Non-genetic factors, in particular birth type and rear type, were found to affect the visually assessed traits significantly. This indicates there is a bias towards single born and raised lambs when visual selection is used. By accounting for non-genetic effects in visual selection, phenotypic gains can be increased. It is therefore recommended that multiple- born and raised lambs shouldn't be visually classed or compared alongside single born and raised counterparts as multiple-born animals incur phenotypic disadvantages.

Both AMSEA classer grade and professional grade, were found to have moderate heritability estimates and favourable repeatability estimates. Professional grade (five point grading system), will provide more discriminatory grading of animals as there are more classes that the traditional three point scale. The novel estimates calculated in this study for heritability and repeatability mean professional grade can now be accurately selected for to provide genetic gains in breeding programs and producers wanting a greater range of classing points.

ACKNOWLEDGEMENTS

This project is funded by Murdoch University, the University of Western Australia and Australian Wool Innovation. Australian Wool Innovation gratefully acknowledges the funds provided by the Australian government to support research, development and marketing of Australian wool. We acknowledge AMSEA and the Pingelly Breeder Site Committee for their role in the Merino Lifetime Productivity Project. Scholarships for this honours thesis were provided by the Australian Wool Education Trust, the SIBI Trust and the State Government's Science and Agribusiness Connect.

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