DUST PENETRATION IS NOT GENETICALLY AND PHENOTYPICALLY THE SAME TRAIT AS DUST CONTENT: 3 YEARS OF DATA

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SUMMARY
Dust penetration is currently used as a measure of dust content when selecting indirectly for improved yield and style of wool. Merino wool from 3160 ewe and wether hogget's over 3 years was used to estimate genetic parameters of dust and wool production traits. Dust penetration and dust index had a low genetic and phenotypic correlation (0.23 and 0.23 respectively). Dust index had a low heritability (0.20) while dust penetration had a moderate heritability (0.25). Genetic correlations between yield and wax (-0.82), suint (-0.62) or dust index (-0.59) were negative, while the correlation between yield and dust penetration was positive (0.36). It was concluded that dust penetration and dust content are genetically distinct, therefore, dust penetration should not be used as a measure of dust content. Breeders will make faster genetic gain in reducing dust content by selecting animals on the basis of higher yield rather than dust penetration. Despite having higher yields, style grades may decline as the wools may look dirtier due to increased dust penetration.
Keywords: Wool, Merino, heritability, dust, yield.

INTRODUCTION
Dust content, along with wax, suint (sweat) and vegetable matter, is a non-wool component that lowers the yield of raw wool fibre. For the last 10 years of national auction data, Western Australian wools have yielded about 3% below the national average. Lowering dust content in wool is a priority for increasing yield in a dusty Mediterranean environment. Currently, dust penetration is used as an estimation of dust content and this assumption has been challenged by Charlesworth (1970) and Ladyman *et al.* (2003). Despite these results, dust penetration is still used as a measure of dust content for wool classing and breeding purposes to improve yield and style grades.

Ladyman *et al.* (2003) and Swan *et al.* (1997) found the heritability of dust penetration to be low (0.21 and 0.01, respectively). However, yield is a highly heritable trait (Atkins 1997; Rose and Pepper 1999; Greeff and Schlink 2002; Ladyman *et al.* 2003) while its component traits, wax and suint are both moderately to highly heritable (0.40) (Mortimer and Atkins 1993; Ladyman *et al.* 2003). Hence it is reasonable to assume that dust content would also have a moderate heritability as confirmed by Ladyman *et al.* (2003). However, this heritability for dust content was based on one year of data.

This study examines the genetic relationships between dust content, dust penetration, wax content, suint content and yield. We hypothesise that dust penetration and dust content are only moderately correlated. Since dust penetration is the only dust measurement included in style and we expect dust penetration and dust content are only moderately correlated, style of wool may get worse with improvements in yield. Heritability estimates are also examined to determine the applicability of these traits in breeding programmes.

MATERIALS AND METHODS

This study was carried out on the fully pedigreed, Merino Resource flocks of the Department of Agriculture of Western Australia at Katanning. Ninety-one sires of different Merino strains were used to produce 3160 progeny born in June/July of 2000, 2001 and 2002. All progeny were reared under normal commercial conditions. The progeny were shorn as lambs and again at 15 months of age with 12 months wool growth. Mid-side wool samples were collected and analysed for total yield, wax, suint and dust content.

Wax, suint and dust content were determined in duplicate using a modification of the column extraction method outlined by Hemsley and Marshall (1984). Weight loss instead of centrifugation was used to determine the content of wax, suint and dust. Yield was expressed as the proportion of clean fleece weight relative to conditioned greasy fleece weight. Wax, suint and dust content were expressed as percentages of clean, dry wool and termed wax, suint and dust indexes. Dust penetration was objectively assessed by measuring the depth of dust on 10 wool staples per mid-side wool sample with a ruler. These measurements were averaged, and expressed as a percentage of staple length.

Phenotypic variances, heritability values, phenotypic and genetic correlations were all determined using ASREML (Gilmour *et al.* 2002). An animal model was used where age of the dam, type of birth and group were fitted as fixed effects. As males and females were managed separately, sex was confounded with group. In addition, animal was fitted as a random effect apart from error.

RESULTS

Heritability estimates for yield, wax and suint were all high (Table 1). The heritability of dust index was low (0.20±0.04), while the heritability of dust penetration (0.25±0.04) was moderate. Yield had the lowest (7%) CV while dust index had the highest CV (38%).

Table 1 Mean values, coefficient of variation (CV), phenotypic variances (Vp) and the heritability (h^2) for yield related wool traits

Trait	Mean	CV	Vp	h^2	se (h^2)
Dust index (%)	10	38	15	0.20	0.04
Dust penetration (%)	32	18	33	0.25	0.04
Yield (%)	70	7	23	0.64	0.05
Wax index (%)	21	30	39	0.63	0.05
Suint index (%)	10	27	8	0.58	0.05

Estimates of genetic correlations between yield and wax, suint or dust index were negative, while the correlation between yield and dust penetration was positive (Table 2).

Table 2 Phenotypic (r_p) and genetic (r_g) correlations between yield (%) and non-wool components

	Yield (%)			
Non-wool components	**r_p**	se	**r_g**	se
Wax index (%)	**-0.69**	0.01*	**-0.82**	0.03*
Suint index (%)	**-0.50**	0.02*	**-0.62**	0.05*
Dust index (%)	**-0.40**	0.02*	**-0.59**	0.08*
Dust penetration (%)	**0.06**	0.02*	**0.36**	0.09*

* Correlations are significantly different from zero at P<0.05

Estimates of phenotypic and genetic correlations between dust penetration and dust index were both 0.23 ($P<0.01$). Dust index was phenotypically and genetically, positively correlated to wax and suint indexes whereas dust penetration was genetically, negatively correlated to wax index and suint index (Table 3).

Table 3 Phenotypic (r_p) and genetic (r_g) correlations of dust index and dust penetration with wax and suint indexes

Trait	Dust index (%)				Dust penetration (%)			
	r_p	se	**r_g**	se	**r_p**	se	**r_g**	se
Wax index (%)	**0.32**	0.02*	**0.33**	0.10*	**-0.29**	0.02*	**-0.62**	0.07*
Suint index (%)	**0.12**	0.02*	**0.18**	0.10	**0.12**	0.02*	**-0.07**	0.01*

* Correlations are significantly different from zero at P<0.05

DISCUSSION

Breeders will make significant progress towards lowering dust index if they focus on breeding for high yielding wool, as yield has a high heritability (h^2=0.64) and a strong negative correlation with dust index (r_g=-0.59). It is not sensible for breeders to directly select for reduced dust content as greater genetic gain can be achieved from indirect selection on yield and yield is easier and cheaper to measure (AWTA 2003).

If breeders decide to increase yield one of the consequences will be an increase in dust penetration due to a positive correlation between the two traits (r_g=0.36). However, there will not be a negative impact on dust index as the genetic and phenotypic correlations between dust penetration and dust index are low (r_p = 0.23, r_g = 0.23). The phenotypic correlations between dust content and dust penetration are lower than reported by Charlesworth (1970) and Ladyman *et al.* (2003). An increase in dust penetration will lower the style grade of the wool because the wool will look dirtier. However, an increase in yield will improve style grade (Winston 1989).

If producers select for increased yield they will be indirectly selecting against wax and suint as these traits are genetically highly correlated with yield and have high heritability values. It is clear that dust penetration should not be used as an indicator for yield due to the positive correlation (r_g=0.36) between the traits and hence selecting for low dust penetration will actually result in lower yields.

The positive correlation of wax with dust index (r_g=0.33) but negative correlation between wax and dust penetration (r_g=-0.62) indicate that selecting for lower amounts of wax in the fleece will lower overall dust content in the fleece but increase the penetration of the dust that is present. This finding confirms the preliminary results of Ladyman *et al.* (2003) although the correlation between wax and dust penetration is higher in that study. It appears wax acts as a barrier to dust penetration but its sticky nature attracts dust to the tip of the staple therefore increasing dust index (Henderson 1968).

Suint had positive phenotypic and genetic correlations (0.23 and 0.51 respectively) with dust index and therefore its sticky nature will attract dust. This is very similar to the preliminary findings of Ladyman *et al*. (2003). Positive phenotypic correlations between suint and dust index are also reported by Charlesworth (1970). Therefore high levels of suint reduces yield and increases dust index, as well as contributing to yellowing of the wool which lowers style grade. As a consequence, farmers should endeavour to keep suint to a minimum by selecting for increased yield.

CONCLUSION

Dust penetration is a poor indicator of dust content in Merino wool and therefore should not be used in breeding programs to reduce dust content and improve yield. Increasing yield should be the main focus.

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REFERENCES

Atkins, KD (1997). In "The Genetics of Sheep". 17, 471 - 504, Piper, L and Ruvinsky, A, CAB International, UK.

AWTA (2003). Raw wool testing fees 2003-2004**:** 7.

Charlesworth, DH (1970). A Study of Dust Contamination in Merino Wool in Low Rainfall Areas. School of Wool and Pastoral Sciences, University of NSW.

Gilmour, AR, Gogel, BJ, Cullis, BR, Welham, SJ and Thompson, R (2002). ASReml. NSW Agriculture, VSN International Ltd.

Greeff, JC and Schlink, AC (2002). *Wool Technology and Sheep Breeding* **50**(1): 6 - 10.

Hemsley, JA and Marshall, JTA (1984). *Wool Technology and Sheep Breeding* **December/January**: 145 - 163.

Henderson, AE (1968)."Growing Better Wool". A.H. & A.W Reed, Wellington, N.Z.

Ladyman, ME, Greeff, JC, Schlink, AC, Williams, IH and Vercoe, PE (2003). Association for the Advancement of Animal Breeding and Genetics, Melbourne, Australia. 273-276.

Mortimer, SI and Atkins, KD (1993). *Australian Journal of Agricultural Research* **44**: 1523 - 1539.

Rose, M and Pepper, PM (1999). *Proceedings of the Association for the Advancement of Animal Breeding and Genetics* **13**: 114 - 117.

Swan, AA, Purvis, IW, Hansford, K and Humphries (1997). *Proceedings of the Association for the Advancement of Animal Breeding and Genetics* **12**: 153 - 157.

Winston, CR (1989). *Wool Technology and Sheep Breeding* **37**(1): 27 - 32.