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Response to selection on BLUP of breeding values in the Grootfontein Merino stud

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A study was conducted to estimate the response to selection on BLUP of breeding values for mature body weight (BW), clean fleece weight (CFW) and mean fibre diameter (MFD) in a commercial Merino stud with a high culling rate on visual appraisal. The selection policy was to increase BW, decrease MFD and maintain CFW. The observed annual trends were +0.63 kg for BW, –0.16 µm for MFD and zero for CFW over a period of seven years. It is concluded that selection on BLUP of breeding values can lead to a marked increase in genetic progress in spite of the limitations posed by high culling rates on visual appearance.

'n Studie is onderneem om die vordering op seleksie op BLUP van teeltwaardes vir volwasse liggaamsgewig (LG), skoonvaggewig (SVG) en gemiddelde veseldikte (GVD) in 'n kommersiële Merinostoet met 'n hoë uitskottempo op visuele keuring te bepaal. Die seleksiebeleid was om LG te verhoog, GVD te verlaag en SVG konstant te hou. Die waargenome jaarlikse genetiese tendense was +0.63 kg vir LG, –0.16 µm vir GVD en nul vir SVG oor 'n periode van sewe jaar. Die gevolgtrekking word gemaak dat seleksie op BLUP van teeltwaardes kan lei tot 'n aansienlike verhoging in genetiese vordering ten spyte van die beperkings gestel deur hoë uitskotpersentasies op visuele voorkoms.

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Introduction

Selection on best linear unbiased prediction (BLUP) of breeding values obtained by Henderson's mixed model methodology is generally recommended for livestock improvement since the correlation between the predicted and true breeding value is optimized. An added advantage is that the response to selection can be determined without the use of a control population. The outcome of selection in a commercial flock can therefore be monitored. In Merino sheep selection in South Africa, it is general practice to eliminate animals on what are considered to be structural (body) or wool faults, irrespective of measured performance or any other attributes. The proportion of animals eliminated by this procedure varies according to the occurrence of such 'faults' and, especially, on the preferences of the classer. The remaining animals are then selected either visually ('hand and eye'), on measured performance or, since recently, on BLUP of breeding values of measured traits. In South Africa the traits normally measured are clean fleece weight (CFW), mature body weight (BW) and mean fibre diameter (MFD). In the Grootfontein Merino stud, founded in 1956, these three traits have been recorded on all animals since 1966. Selection was initially based on visual appraisal with possibly some attention to measured performance when it became available after 1965 but, since 1985, final selection was based on BLUP of breeding values for the three measured traits.

The purpose of this study was to compare the genetic trends obtained using these different selection methods and also, slightly different breeding objectives. Very little is known about the actual advantages of selection on BLUP of breeding values to the Merino stud breeder who must necessarily conform to other prerequisites, notably, visual acceptance, dictated by the market-place.

Material and Methods

Animals

From 1966 to 1972, the Grootfontein stud consisted of roughly 500 ewes mated to eight to 15 rams. From 1973 onwards, it was reduced to roughly 300 ewes, mated to five to 10 rams which are replaced annually. Ewes are replaced after four matings. The annual lambing percentage in the stud is roughly 120. In total, 7 151 animal records from 211 sires and 2 455 dams with recorded measurements on CFW, BW and MFD over a period of 26 years (1966 – 1991) were available. Details on how the measurements were recorded are supplied by Olivier *et al.* (1994).

It is difficult to describe the exact selection procedure and objective from 1966 to 1983. Roughly one-third of all the candidates were annually rejected for wool and structural faults. The remainder were selected for 'overall excellence' with body size, wool quality (definition of crimp and softness) and quantity being the most important criteria. Apparently, some attention was paid to measured performance, but this is difficult to quantify. The important general assumption is that the selection practised is considered to be in close agreement with that in most Merino studs in South Africa during the same period.

For the sheep born from 1984 onwards, the selection procedure was as follows: After culling on wool and structural

faults, roughly one-third of the rams were selected for 'overall excellence'. Since this stud still plays an important role in the stud industry, it was thought that the high standard achieved in visually assessed traits should be maintained. Final selection was done on animal model BLUP of breeding values for high body weight, low fibre diameter and average fleece weight. The motivation for this breeding objective was the fact that the average fibre diameter of adult sheep exceeded 26 μm. It was, therefore, decided to select for lower fibre diameter while at least maintaining fleece weight. Roughly one-third of the ewes were culled on wool and structural faults, with the final selection being the same as for the rams. Single-trait animal model runs for each of the three traits were performed annually, fitting a combination of birth status and sex, as well as year-season, as fixed effects. The heritability values used were 0.247 for body weight, 0.229 for clean fleece weight and 0.369 for mean fibre diameter. These estimates were obtained from a related flock (Erasmus et al., 1990). The full relationship matrix was employed.

Statistical analysis

The data were analysed by DFREML procedures using the program of Meyer (1989; 1991). The model and parameters utilized (slightly different to those used for selection) are discussed by Olivier et al. (1994).

Genetic trend estimates were obtained by regressing mean annual predicted breeding value on the year of birth. Two separate linear regressions were fitted, viz. from 1966 to 1984 and from 1985 to 1991, to describe the two distinct periods in which different selection procedures were applied.

Since no comparable results could be found in the literature, it was decided to compare the results obtained with the theoretically expected optimum from single trait selection. Selection, in practice, is to improve aggregate breeding value and this approach is, therefore, not very useful but it does provide the upper limit with which selection response can be compared.

To determine the theoretically expected annual response to single-trait selection, the standardized selection differential (based on a lambing percentage of 120 and a mortality rate of 5%) was calculated as 1.466. The heritability values were taken as 0.381 for BW, 0.289 for CFW and 0.626 for MFD, while the phenotypic standard deviations used were 15.73 kg for BW, 1.84 kg for CFW and 2.27 μm for MFD, estimated in this stud by Olivier et al. (1994). The generation interval, calculated as the actual average age of the parents when the progeny were born, was estimated as 3.1 years.

Results and Discussion

The genetic trends obtained for the two periods, as well as the theoretical expected annual response to single trait selection, are given in Table 1. The results are presented graphically in Figures 1, 2 & 3.

Prior to 1985, a slight positive significant ($P < 0.01$) genetic trend was observed for all three traits. Expressing the regression coefficients (Table 1) as a percentage of the least squares mean for each trait supplied by Olivier et al. (1994), the annual genetic increase was 0.41% for BW, 0.45% for CFW and 0.12% for MFD. These results show that, although very limited, some genetic progress is possible in measured

Table 1 Genetic trends (b) and standard errors (SE) for body weight (BW), clean fleece weight (CFW) and mean fibre diameter (MFD)

	Theoretical	1966 – 1984		1985 – 1991	
	b	b	R^2	b	R^2
BW	2.835	0.2048	0.8163	0.6314	0.9436
SE		0.0236		0.0691	
CFW	0.2516	0.0242	0.8736	0.0014	0.0052
SE		0.0022		0.0085	
MFD	0.6722	0.0269	0.5496	-0.1574	0.8433
SE		0.0059		0.0303	
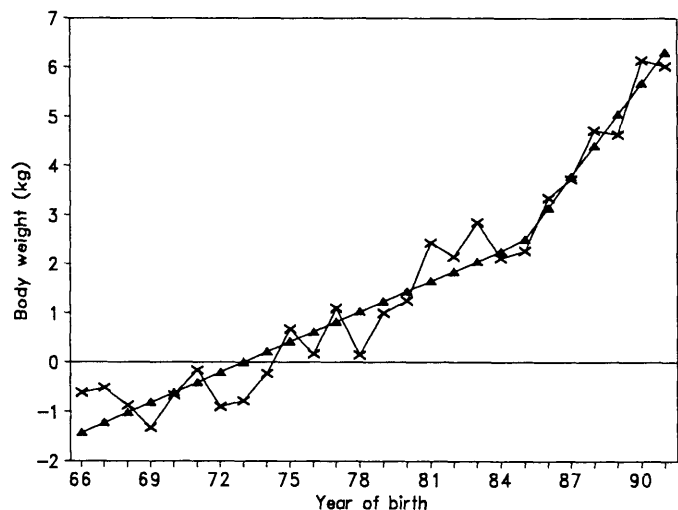
Figure 1 Mean annual genetic values and trend for body weight.
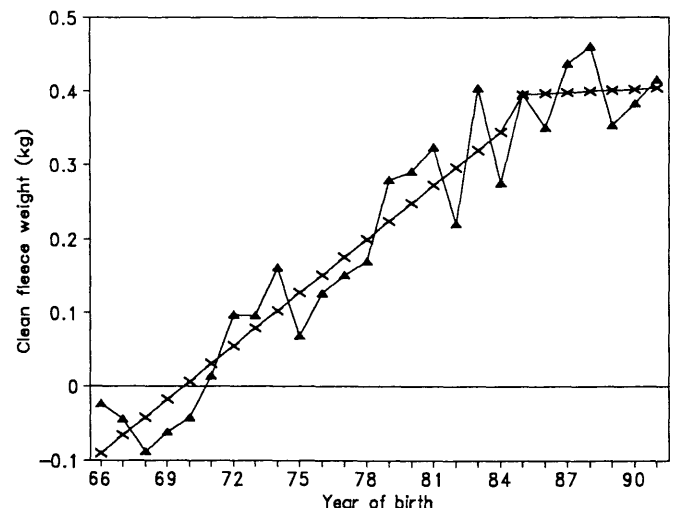
Figure 2 Mean annual genetic values and trend for clean fleece weight.

production traits by indirect selection for possibly correlated, visually assessed traits. During this period no attempt was made to reduce fibre diameter (or visually assessed fineness), in fact, it is believed that preference was normally given to broader crimped wools on the assumption that it would increase wool production.

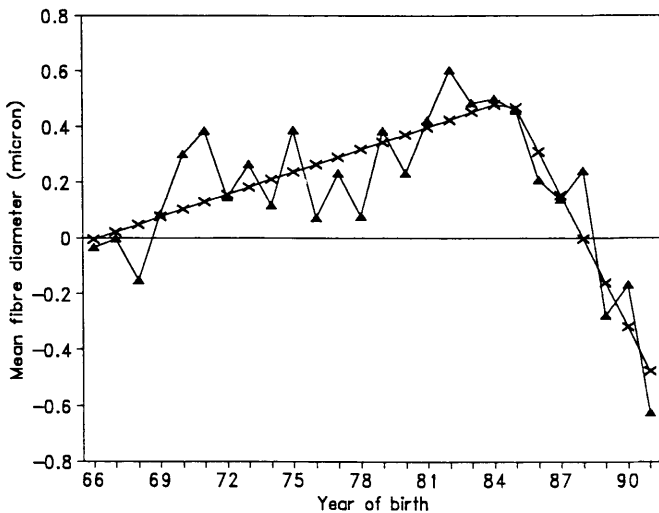Since 1985, the positive genetic trend for body weight has

Figure 3   Mean annual genetic trend for mean fibre diameter.

most probably not scientifically warranted, but the fact is, that breeders are very reluctant to deviate from so-called 'breed standards' since this is what the market dictates. Breed standards should be seen, not as a measure of what to strive for, but of what has already been achieved. In this sense, it is most intriguing that visual faults and deviations from breed standards are still prevalent to such a degree after so many generations of selection.

This study has shown that genetic progress, albeit far from optimal, is possible in measured performance by selection on BLUP of breeding values in combination with high culling rates on visual appearance. An investigation into the reasons and necessity for these high culling rates is, however, of prime importance if the efficiency of selection is to be increased.

increased more than threefold. The positive trend in MFD was transformed into a highly significant ($P < 0.001$) negative trend. The trend for CFW changed to zero. The genetic trends for BW and MFD were also smoother after 1985, as indicated by the R^2 values.

The effect of selection on BLUP *per se* can only be ascertained for BW since the selection objectives have changed for the other two traits. Comparing the gains obtained with the theoretical optimum, gives 7.2% and 22.3% of the gain expected by single trait selection for the period before and after 1985, respectively. The decrease in MFD after 1985 is 23.4% of the theorefical optimum expected for single trait selection.

Conclusions

The emphasis placed on visually assessed traits by South African Merino breeders seriously hampers possible genetic progress in production traits, as illustrated in this study. The continued high culling rates for the aforementioned traits are

Acknowledgements

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