GENETIC PROGRESS IN THE AUSTRALIAN SHEEP INDUSTRY

A.A. Swan[1], D.J. Brown[1] and R.G. Banks[2]

[1]Animal Genetics and Breeding Unit*, University of New England, Armidale, NSW 2351
[2]Meat and Livestock Australia, C/- University of New England, Armidale, NSW 2351

SUMMARY

Genetic progress was estimated in the major breed groups of the Sheep Genetics database as a means of monitoring changes in the productivity of sheep enterprises. There has been substantial improvement in productivity between 1990 and 2005 based on representative breeding objectives for each breed, ranging from $10 per ewe for Border Leicesters (0.7 standard deviations of the breeding objective) to $17 per ewe for Terminal Sire breeds (2.9 standard deviations). Rates of progress have increased significantly since 2000 for the Terminal Sire, Border Leicester and Coopworth breeds, while Merinos have maintained a relatively constant and favourable rate of progress over the whole time period. Compared to simple breeding programs simulated for each breed group, Terminal Sires are exceeding the simulated potential rate of gain, Border Leicesters and Coopworths are approaching the potential gain, while Merinos are achieving only one third of the potential gain.

INTRODUCTION

Genetic progress is a key profit driver for the Australian sheep industry, and as a consequence there has been significant industry investment in performance recording and genetic evaluation systems since the late 1980's. The meat and dual-purpose maternal breeds have had access to Estimated Breeding Values (EBV's) through the LAMPLAN system since 1989, with across flock evaluations becoming available in the mid 1990's. In the wool sector, across flock evaluation began in the early 1990's through the Central Test Sire Evaluation program. Larger evaluations using on-farm data began in the late 1990's with the advent of Merino Benchmark and Merino Genetic Services. These systems, including LAMBPLAN, were merged under the banner of Sheep Genetics in 2005 (Brown *et al.* 2007). In this paper, we compare the genetic progress in predicted profitability since 1990 in the main breed groups serviced by Sheep Genetics.

MATERIALS AND METHODS

Breeding objectives. Estimates of the change in profitability were based on breeding objectives for each of the four main Sheep Genetics breed group databases: Terminal Sire, Border Leicester, Coopworth, and Merino. Breeding objectives were calculated using SheepObject (Swan *et al.* 2007), and selection indexes based on these were derived. The advantage of using SheepObject indexes is that they are expressed in dollar terms. Although these are not currently used by breeders, index values on individual sires are highly correlated with the de-facto standard indexes shown in Table 1.

Estimated genetic trends. Genetic trends were estimated using results from the December 2008 LAMBPLAN and MERINOSELECT evaluations. EBV's for sires were used to calculate SheepObject index values, and these were averaged by year of birth ranging from 1990 to 2005. Trends were expressed both as dollars per ewe per year (abbreviated to $ per ewe hereafter), and scaled by the standard deviation of the breeding objective.

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Table 1. Number of sires in each breed group, industry index, and correlation between SheepObject index and industry index values for sires

Breed group	Sires	Industry index	Correlation
Border Leicester	3,468	Border$	0.82
Coopworth	1,828	Coopworth$	0.90
Merino	9,382	M10SS	0.94
Terminal Sire	18,118	Carcass+	0.99

Predicted genetic trends. These realised industry trends were compared with predicted trends derived using the SelAction computer program (Rutten *et al.* 2002) which calculates theoretical progress achievable based on key breeding program parameters. Response to index selection on the SheepObject breeding objectives was calculated for a relatively simple breeding program, with a flock size of 500 ewes and 10 rams mated annually. There were five age classes for ewes and one for rams, with parents selected at one year and having their first progeny at two years of age. All information from relatives was assumed to be available to estimate breeding values, as would be the case for flocks recording full sire and dam pedigrees. Truncation selection across ewe age classes was practiced.

Simple sets of selection criteria were used, including: yearling clean fleece weight, weaning weight, and post-weaning weight, fat, and muscle depth for Border Leicesters and Coopworths; yearling weight, clean fleece weight, fibre diameter, and CV of fibre diameter for Merinos; and birth weight, weaning weight, and post-weaning weight, fat, and muscle depth for Terminal Sire breeds. These traits are easily and relatively inexpensively measured early in an animal’s lifetime. It was assumed that all selection criteria were measured on all relatives.

RESULTS

Estimated genetic trends are shown in Figure 1. Between 1990 and 2005, the Terminal Sire and Coopworth breeds have improved by around $17 per ewe, while Border Leicesters and Merinos have improved by approximately $10 per ewe. However, when expressed in terms of the standard deviation of the objective, the Terminal Sires were well ahead of the other breeds, showing an improvement of almost 3 standard deviations. Coopworths have improved by 1.3 standard deviations, and Border Leicesters and Merinos by 0.7 to 0.8 standard deviations. The rate of progress shows an increase from 2000 in the Terminal Sire breeds, Coopworths and Border Leicesters, while the Merinos show relatively constant improvement over the entire period.

Standard deviations of objectives and indexes calculated in SelAction are shown in Table 2, together with index accuracy and the standard deviation observed in sire indexes. The latter are approximately double the predicted values due to a combination of higher accuracy of progeny test information included in the sire indexes, and the influence of substantial genetic differences between flocks in these databases.

Table 2. Standard deviations (SD) of objective and index and accuracy from selection index predictions, and observed standard deviation of actual sire indexes

Breed group	SD objective	SD index	Accuracy	SD sire indexes
Border Leicester	14.4	3.8	0.27	7.2
Coopworth	13.7	4.6	0.34	8.6
Merino	13.5	4.5	0.33	7.9
Terminal Sire	6.1	2.7	0.45	7.5

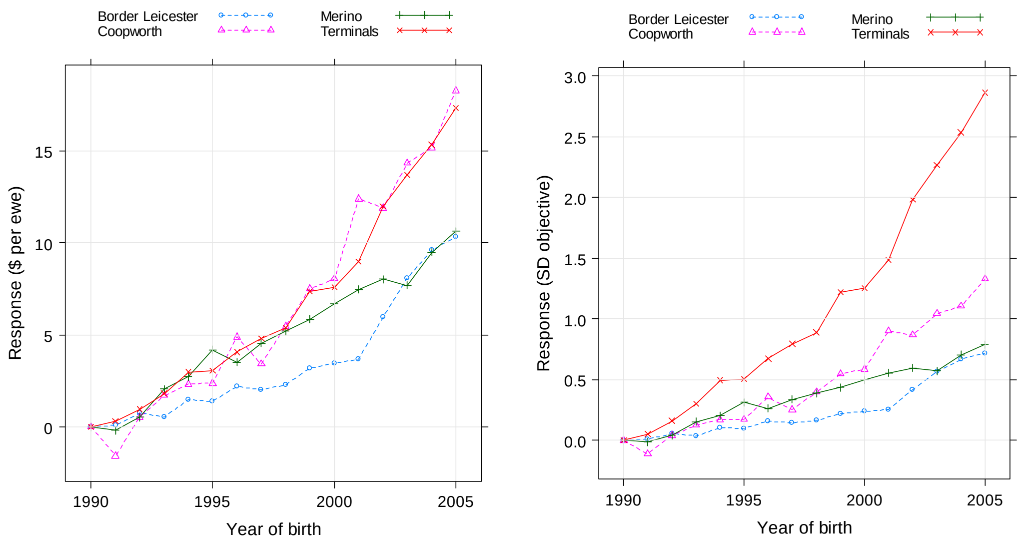

Figure 1. Genetic progress in the main Sheep Genetics breed groups between 1990 and 2005. The left panel expresses response in dollars per ewe per year, while the right has been scaled by the standard deviation of the respective breeding objectives for each breed.

Predicted annual responses from SelAction and realised annual responses post 2000 are shown in Table 3. Under the within flock breeding programs modelled, predicted annual responses ranged from 1.8 to 2.4 dollars per ewe, or 0.14 to 0.30 objective standard deviations. Compared to these figures, the realised response in industry ranged from 30% of the predicted response for Merinos to 111% for Terminal Sire breeds. The Border Leicesters and Coopworths were intermediate achieving approximately 80% of the potential response.

Table 3. Predicted and post 2000 realised annual response in industry

Breed group	Annual response ($ per ewe)			Annual response (SD objective)		
	Predicted	Realised	Ratio (%)	Predicted	Realised	Ratio (%)
Border Leicester	2.0	1.7	85	0.14	0.11	79
Coopworth	2.4	1.8	75	0.17	0.13	76
Merino	2.3	0.7	30	0.15	0.05	33
Terminal Sire	1.8	2.0	111	0.30	0.33	110

DISCUSSION

There has been significant albeit variable genetic progress across the major breed groups in the Australian Sheep industry since 1990. This progress has led to substantial improvements in productivity, with our estimates suggesting cumulated increases of $10 to $17 per ewe depending on breed.

All breed groups made steady progress through the 1990's, more so the Terminal Sires. From 2000 on, the rate of gain in the Terminal Sire, Border Leicester, and Coopworth breeds has increased significantly. There are several possible reasons for this increase, including the introduction of young sire programs, introduction of Carcass+ and maternal dollar indexes, more widespread use of fat and muscle scanning, a greater focus on data quality, and in the case of Terminal Sires, the move to a fully across flock and across breed analysis in 1999. In Border

Leicesters and Coopworths, greater awareness of the variation available for genetic improvement was stimulated by the Maternal Central Progeny Test program (Fogarty *et al.* 2001).

These developments have allowed the Border Leicester and Coopworth breeds to approach the rates of gain predicted in our simulated breeding program, and for the Terminal Sire breeds to exceed the prediction. The latter is entirely feasible because the simulation did not model the higher selection intensities achievable when using young sire programs, or across flock and across breed effects.

Merinos on the other hand have made consistent but slow progress over the entire period of evaluation, with the rate of gain being only one third of the rate predicted in our simulation. It could be argued that the Merino is a very diverse breed, with a wide range of breeding objectives in use across flocks, and that this might be a limitation when estimating progress across the whole breed. However, apart from at the extremes, say ultra-fine compared to dual purpose sheep, the majority of breeding objectives are highly correlated. A second argument to explain slower progress is the perception that the traits are more difficult to select on, but as can be inferred from the predicted annual gain of $2.3 per ewe in Table 3, this is not the case. Although there are economic antagonisms between traits including fleece weight, fibre diameter and staple strength, these can be overcome with an appropriate breeding objective and selection index.

There are three more likely limitations to genetic progress in Merinos. First is that generation intervals are typically longer compared to the other breeds: the average age of Merino sires in Sheep Genetics is currently 3.3 years, while Terminal Sire breeds average 2.6 years. Second is that there has been a lower level of pedigree recording in the Merino: in 2000 only 30% of Merino progeny had both sire and dam recorded, and although there has been an increase to more than 50% in recent years, other breed groups are currently recording full pedigrees on more than 95% of progeny. This lower level of pedigree recording in Merinos limits progress through lower selection accuracy. The third limitation is that Merino breeders traditionally place more emphasis on traits outside of the objective, and in particular visual traits. All of these limitations can be overcome, and there is evidence that leading Merino breeders are making the necessary changes to their breeding programs.

CONCLUSIONS

Rates of genetic progress in the Australian sheep industry since 1990 have been impressive. While the Terminal Sire breeds have been the stand out performers, Border Leicesters and Coopworths have also increased their rate of gain since 2000. Merino breeders need to make a similar jump in progress.

ACKNOWLEGMENTS

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