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A comparative analysis of genetic trends within the New Zealand sheep industry

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Abstract

This paper reports on recent genetic trends from the New Zealand sheep industry using data from the national across flock sheep genetic evaluation run by Sheep Improvement Ltd. (SIL). Results build on a previous study which found that rates of genetic progress increased substantially following the formation of SIL, and introduction of the Beef + Lamb New Zealand Central Progeny Test. This study, containing additional flocks shows that the rates of genetic progress in recent time periods were lower than previously estimated, with only modest increases in the most recent time period. Genetic trends for a sample of flocks using molecular marker technologies have increased and these flocks now sit above industry average. Current average levels of genetic merit, and rates of change achieved varied widely amongst flocks. Rates of progress achieved within New Zealand Dual Purpose flocks were comparable with Australia, whilst rates of progress for Terminal Sire flocks were lower. However, rates of gain achieved by leading Terminal Sire flocks are comparative with Australia. Opportunities exist to further increase both genetic merit and rates of gain within the New Zealand sheep industry.

Keywords: sheep; genetics; breeding

Introduction

Rates of genetic progress made by Dual Purpose and Terminal Sire flocks in the New Zealand sheep industry between 1990 and 2007 have previously been examined (Amer 2009) and showed substantial gains in the rate of progress since the introduction of Sheep Improvement Ltd. (SIL) and SIL-ACE (Advanced Central Evaluation). Key findings from this earlier study showed that the rates of genetic progress doubled following the introduction of SIL, and increased by a further 50% after the introduction of the Beef + Lamb New Zealand Central Progeny test (CPT), which effectively evaluates the performance of key industry sires, providing the multi-flock connections required for SIL-ACE analyses. It also identified that the average genetic merit, and rates of progress achieved, varied widely amongst SIL-ACE flocks. Rates of progress for some flocks were accelerating, whilst for other flocks they were decelerating, as less emphasis was put on traits within the SIL selection indexes evaluated.

Since 2007, the number of flocks participating in SIL-ACE has increased, and molecular marker technology developed by Ovita Ltd. has become commercially available for use. Breeders are now using Ovita technology to correctly identify the parentage of selection candidates, and to identify genes of economic importance such as the myostatin muscling gene (Johnson et al 2011). Genomic selection tools are also available to provide molecular estimates of genetic merit for many of the traits within the SIL selection indices.

The purpose of this study was to re-evaluate the rates of genetic progress over the last 15 years (1995–2010) using a larger number of flocks, and to assess the impact of marker technologies on the rates of genetic gain of these flocks. A comparison was also undertaken on rates of genetic progress achieved by New Zealand flocks with those reported for Australian flocks.

Materials and methods

Data were sourced from the SIL-ACE across flock and across breed evaluation run in October 2011. This included data from 174 Dual Purpose and 68 Terminal Sire flocks, which met the qualifying standard of greater than 500 animals born within the 2007–2010 period. Within the SIL-ACE evaluation, all animals are evaluated in a single analysis with both across breed and across flock genetic linkages, strengthened by the inclusion of key industry sires participating in the CPT program (Young & Newman 2009). Currently, over 3.5 million animals are included within the SIL-ACE evaluation. Flocks are evaluated for a wide range of traits, with the indexes used for this study based on the SIL Dual Purpose production index (DPP) for growth, reproduction and fleece weight; and the SIL Terminal Sire index for (TS) for growth and carcass traits. The data has been partitioned into four time intervals, and results reported according to the average annual change in genetic merit for each index and trait over each time period for Dual Purpose and Terminal Sire breeds. The time intervals applied were set in the previous study, and reflect changes due to the introduction of SIL and SIL-ACE, and include: 1995–1998 which was prior to the development of SIL; 1999–2003 which spans the period under SIL but prior to the establishment of the CPT and SIL-ACE evaluations; 2004–2006 represents the first post CPT period; and 2007–2010 which represents the most recent time period and was not included in the previous study.

Table 1 Estimated average genetic trends across four time periods for Dual Purpose Production (DPP) and Terminal Sire (TS) indexes (cents per ewe lambing per annum, within time period) according to sub-category. Gaining = Below average for current flock genetic merit, but above average for recent genetic trend; Leader = Above average for both current flock genetic merit and genetic trend in index values in the 2007–2010 period; Slipping = Above average for current flock genetic merit, but below average for recent genetic trend; Trailing = Below average for both current flock genetic merit and recent genetic trend; Ovita = Flocks known to have used Ovita technology over the last five years.

Index	Time period	Sub-category					Average
		Gaining	Leader	Slipping	Trailing	Ovita	
Dual purpose production	Number of flocks	27	39	39	69	10	
	1995–1998	8	45	47	18	58	34
	1999–2003	43	63	71	37	54	49
	2004–2006	7	103	94	56	50	62
	2007–2010	113	108	39	40	129	68
Terminal sire	Number of flocks	29	11	14	14	5	
	1995–1998	22	34	29	18	57	21
	1999–2003	16	57	54	24	36	27
	2004–2006	-8	73	78	37	11	35
	2007–2010	131	74	26	7	120	41

Each flock within the dataset was classified into one of four subgroups according to genetic progress made in the recent 2007–2010 time period. Using the index means for both Dual Purpose and Terminal Sire groups, flocks were classified as either above or below average for both index merit and genetic trend. A fifth subgroup was applied to flocks known to have consistently used some form of Ovita technology over the last five years. The subgroups were defined as:

Gaining – below average for current flock genetic merit, but above average for recent genetic trend;

Leader – above average for both current flock genetic merit and genetic trend in index values in the 2007–2010 period;

Slipping – above average for current flock genetic merit, but below average for recent genetic trend;

Trailing – below average for both current flock genetic merit and recent genetic trend; and

Ovita – flocks known to have used Ovita technology over the last five years.

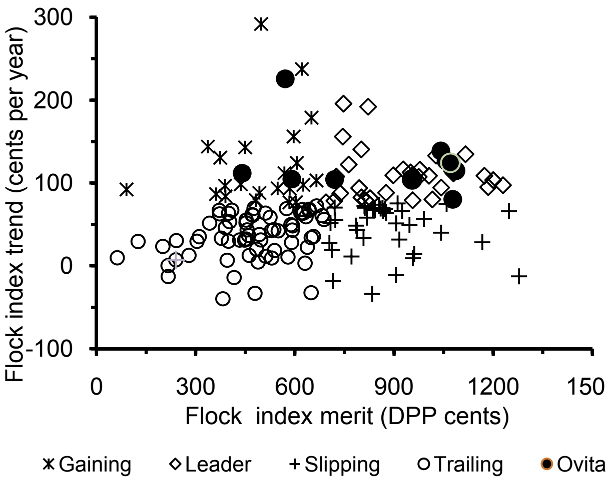
Results

The average index value of animals born within the four time periods is depicted in Table 1, with annual increases of 34, 49, 62 and 68 index cents in overall DPP index observed in the Dual Purpose flocks, and 21, 36, 37 and 31 index cents in overall TS index observed in Terminal Sire flocks. Note that sub-categories are defined according to the 2007–2010 period, with the average rates of genetic trend of the "gaining" group of flocks lower than the "slipping" flocks within the earlier time periods. These values are slightly lower than those reported by Amer (2009), where rates of genetic trend in the 1995–1998 (pre SIL), 1999–2003 (post SIL) and 2004–2007 (post CPT) were 29, 54 and 84 index cents for Dual Purpose and 20, 35 and 48 for Terminal Sire flocks respectively. Changes in average index value are likely due to the increased numbers of flocks participating within the SIL-ACE analysis, with some of these flocks being of low genetic merit relative to the original group. The October 2011 analysis included 236 Dual Purpose and 113 Terminal Sire flocks compared to the 2007 analysis which contained 140 and 62 flocks respectively.

Weightings used in standard SIL selection indexes optimised for the New Zealand sheep industry have recently been revised (Byrne 2012). While absolute values of economic weights have increased by approximately 30%, correlations between animals ranked on the latest versus that used previously are in excess of 0.97 for 2001–2010 born sires in the SIL-ACE analysis (TJ Byrne, Unpublished data), with the change in index having minimal impact on results reported within this study. Given that the standard deviation of index values has increased by a factor of 0.15, then genetic trends in the old index could be multiplied by a factor of 1.15 to get predictions of the value of genetic change in 2011 terms.

Figure 1 shows average index trend and genetic merit for Dual Purpose flocks in the 2007–2010 period coded according to the four subgroups. The numbers of flocks represented in the gaining (27) and leading (39) quadrants which are below/above average for genetic merit and above average for index trend, are lower than the number of flocks represented in the slipping (39) and trailing (69) quadrants which are above/below average for genetic merit and below average for index trend, showing

Figure 1 Classification of flocks using the Dual Purpose Production (DPP) index into subgroups according to the average flock genetic merit and genetic trend in index values in the 2007–2010 period. The subgroups are defined as: Gaining = Below average for current average flock genetic merit, but above average for recent genetic trend; Leader = Above average for current average flock genetic merit and for genetic trend in index values in the 2007–2010 period; Slipping = Above average for current average flock genetic merit, but below average for recent genetic trend; Trailing = Below average for current average flock genetic merit and for recent genetic trend; Ovita = Flocks known to have used Ovita technology over the last five years.



that there is considerable scope for increasing the index trend and genetic merit within the population as a whole. Ten flocks that were known to have used Ovita technologies within the last five years were classified amongst the seven leading and three gaining flocks. Within the Terminal Sire data, there were 29 flocks in the slipping quadrant, 11 flocks in the gaining quadrant, 14 flocks in the leading quadrant and 14 flocks in the slipping quadrant. Of the five flocks using Ovita technology one was identified in the gaining quadrant, three in the leading quadrant and one in the slipping quadrant (JA Sise, Unpublished data).

Rates of genetic trend were also evaluated relative to the standard deviation (SD) of the breeding objective applied, allowing the trend of different breed types to be compared on the same scale. The SD of the SIL-DPP breeding objective was 629 index cents, so the average gain of 68 index cents per annum was 0.11 SD for the 2007–2010 period (68/629 = 0.11). In the Terminal Sire breeding program, the standard deviation of the breeding objective was lower at 272 index cents, so that with an average gain of 41 index cents per annum, the rate of change was higher at 0.15 standard deviations compared to the 0.11 achieved by the Dual Purpose flocks.

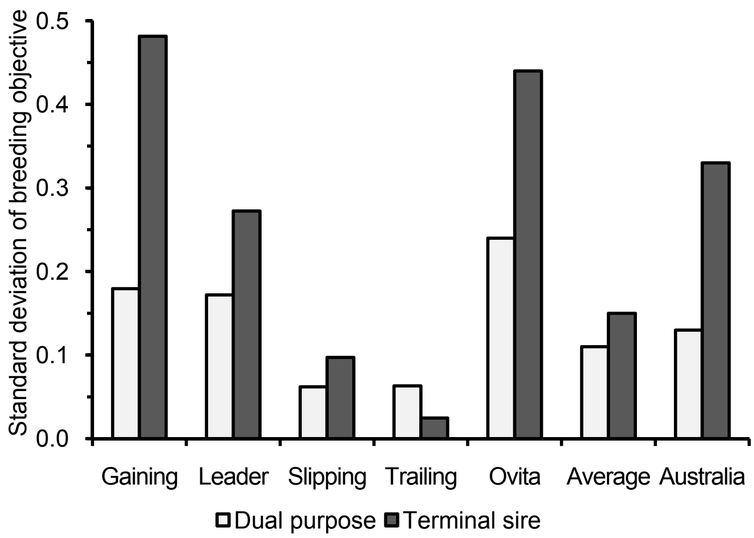
Figure 2 shows the average rates of progress estimated according to genetic trends expressed as the standard deviation of the breeding objective within the 2007–2010 period, separately for Dual Purpose and Terminal Sire flocks and compares these to progress made in Australian Dual Purpose (Coopworth) and Terminal Sire flocks between 2000 and 2005 as reported by Swan et al. (2009). Levels of progress made in Dual Purpose flocks are similar for both New Zealand (0.11) and Australia (0.13), however New Zealand Terminal Sire flocks had lower rates of gain relative to Australia, where the high rates of gain have been attributed to well-coordinated and structured Terminal Sire breeding programs (Swan et al. 2009). In New Zealand, the rates of gain achieved by the “gaining” and ” leader” Terminal Sire flocks are comparative to what was being achieved in Australia, as are the rates of gain for flocks seeking to drive genetic improvement through adoption of Ovita technologies.

Selection index theory was used to model expected gains according to the proportions of animals within a flock selected for breeding. Data from the SIL-ACE analysis showed that within the 2007–2010 period, the superiority of rams used as sires in New Zealand Dual Purpose flocks was 331 cents greater than the average of all lambs born within their contemporary group, two years previously. The standard deviation of the index for rams over those years was 284 cents, resulting in an average selection intensity of 1.16. Assuming that 30% of ram lambs weaned were excluded from the selection pool, such as being culled for structural faults or failure to thrive, an intensity of 1.16 equates to selecting from the top 30% of suitable ram candidates ranked by index. If the analysis was restricted to just the “gaining” and “leading” flocks, then the superiority of rams used increases to 448 cents with a standard deviation of 289 cents, so the average intensity increases to 1.53, indicating breeders are selecting from the top 15% of ram candidates ranked on index.

Discussion

This paper builds on the previous analysis and provides further evidence that there are significant differences amongst breeders, with some breeders advancing at a much greater rate than others. This is of particular interest to industry, as it shows there is still potential for acceleration of genetic improvement in New Zealand sheep. Examination of a small sub-set of flocks using Ovita technologies shows that these flocks are mostly within the groups showing highest rates of genetic gain. This is likely to be due to both use of such technology, and desire of those breeders to invest in, and manage, their breeding operations to maximize gains. Further on-going analysis on a wider group of flocks would be worthwhile to examine more fully the impacts of genetic marker technologies.

Figure 2 Average rates of genetic trend, estimated according to standard deviations of the breeding objective using the New Zealand Dual Purpose Production and Terminal Sire indexes and the in Australian Dual Purpose (Coopworth) and Terminal Sire flocks between 2000 and 2005. Flocks were categorised into subgroups according to average flock genetic merit and genetic trend in index values in the 2007-2010 period. The subgroups are defined as: Gaining = Below average for current average flock genetic merit, but above average for recent genetic trend; Leader = Above average for current average flock genetic merit and for genetic trend in index values in the 2007–2010 period; Slipping = Above average for current average flock genetic merit, but below average for recent genetic trend; Trailing = Below average for current average flock genetic merit and for recent genetic trend; Ovita = Flocks known to have used Ovita technology over the last five years.



Average rates of genetic trend in Dual Purpose and Terminal Sire flocks have been estimated as 0.11 and 0.15 SDs of the respective breeding objective. This is in good agreement with Goddard (2001), who concluded that an annual gain of 0.15 SDs of the breeding objective should be achievable in most circumstances. The average rates of gain in New Zealand Dual Purpose flocks are slightly lower than those being realised by Australian Dual Purpose flocks. This analysis has used the SIL-DPP index which is focused on growth, reproduction and wool, and has not included other traits such as facial eczema (FE) or parasite resistance, which is recorded using faecal egg counts (FEC). Therefore it is possible that the average trends reported are lower than those observed when other index traits are included for the subset of affected flocks. However, in a previous study Amer (Unpublished data) found that the impact of using different indexes for selection was minimal. Breeders that recorded either FEC or FE, and who would therefore be selecting animals on alternate indexes, achieved higher rates of genetic gain for the indexes used in this analysis than breeders not recording these traits. Furthermore, extra gains in overall index units from accounting for FEC and FE were quite modest, with little impact on the overall rates of genetic gain.

The selection intensity applied by some breeders within New Zealand was less than optimal, with the overall average indicating Dual Purpose rams are typically selected from the top 30% of eligible candidates when ranked according to DPP index, compared to the top 15% by gaining and leader flock types. The low realised selection intensity may be due to some breeders putting more pressure on non-SIL traits such as conformation and structure, or on DNA test results, than on SIL indexes. Major improvements could be achieved by increasing the selection intensity applied within flocks classified as "slipping" or "trailing" in order to increase the genetic merit and rates of genetic gain within these flocks. Increased participation in SIL-ACE should also drive increased reliance on indexes as breeders become increasingly confident in the accuracy of genetic merit estimates, and see the need to ensure continued improvement in the highly competitive ram breeding sector.

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