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Genetic improvement in the Australasian Merino – management of a diverse gene pool for changing markets

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Summary

The Australasian Merino population has declined significantly over the last 15 years in response to a decline in the price of apparel wool, both in absolute terms and relative to the price of sheep meat. Over the same period, a national genetic evaluation system based on BLUP methods has been introduced, that is achieving steady growth in adoption by breeders. Genetic parameter estimates for the population provide evidence for considerable genetic diversity for all recorded traits, providing ample opportunity for genetic improvement. More recently, there is considerable evidence for increasingly rapid progress, both in fleece traits and a range of meat production and adaptation traits. The Merino population is evolving towards two broad types – one focused on high quality apparel wools finer than 19 μm and used in enterprises with a wool/meat income ratio of about 3:1, and the other a more dual-purpose animal producing 19–21 μm wool and an enterprise wool/meat income ratio between 1.5:1 and 1:1. Underlying these trends is a growing focus on adaptation traits including worm resistance; reduced need for veterinary interventions; and increased early growth, fertility and mothering ability. Together these trends point to increasingly 'easy-care' sheep and exploitation of the available genetic diversity to rapidly increase profitability.

Keywords: *economics, genetic diversity, genetic improvement, wool production*

Résumé

La population des mérinos australasiens a baissé de façon considérable au cours des 15 dernières années en raison de la chute du prix de la laine cardée, en termes absolus ainsi que par rapport aux prix de la viande ovine. Au cours de la même période, on a introduit un système national d'évaluation génétique basé sur les méthodes BLUP qui est de plus en plus adopté par les sélectionneurs. Les estimations des paramètres génétiques de la population prouvent une diversité génétique considérable pour tous les caractères enregistrés, offrant ainsi de grandes opportunités d'amélioration génétique. Plus récemment, on constate des progrès rapides dans les caractères de la toison ainsi que dans un éventail de caractères de production de la viande et d'adaptation. La population de mérinos évolue vers deux grands types d'animaux: un type concentré sur la production de laine cardée de haute qualité inférieure à 19 microns et utilisé dans les entreprises ayant une ratio de revenu laine:viande d'environ 3 à 1; et un autre type d'animal plus à double fin qui produit une laine de 19-21 microns et utilisé dans des entreprises ayant une ratio de revenu laine:viande entre 1:5 et 1:1. Ces évolutions sont soulignées par la focalisation croissante sur les caractères d'adaptation comme la résistance aux vers, le besoin réduit d'interventions des vétérinaires et l'augmentation de la croissance, de la fertilité et de l'aptitude à la reproduction précoces. Toutes ces évolutions indiquent des moutons toujours plus faciles à entretenir et l'exploitation de la diversité génétique disponible pour accroître la rentabilité de façon rapide.

Mots-clés: *économie, diversité génétique, amélioration génétique, production de laine*

Resumen

La población de Merino australiano ha disminuido de forma significativa a lo largo de los últimos 15 años como respuesta a una bajada del precio de las prendas de lana, tanto en términos absolutos como en lo relativo al precio de su carne. Durante el mismo periodo de tiempo, se ha presentado un sistema nacional de evaluación genética basado en los métodos BLUP, cuya aceptación por parte de los criaderos va creciendo de forma progresiva. Los parámetros genéticos estimados para la población indican una importante diversidad genética para todos los rasgos registrados, proporcionando una gran oportunidad para la mejora genética. Más recientemente, determinadas pruebas han puesto de manifiesto un progreso, cada vez más rápido, con respecto a las características del vellón, así como a una serie de características relacionadas con la adaptación y la producción de carne. La población de Merino está evolucionando hacia dos grandes grupos – uno centrado en la producción de lana para ropa de alta calidad cuya sección de fibra es inferior a las 19 micras y utilizadas en empresas con unos ingresos en la proporción lana-carne a razón de 3 a 1 respectivamente, y otro más centrado en la cría de un animal de doble propósito que produce una fibra de lana cuya sección se encuentra entre 19 y 21 micras y utilizadas en empresas cuyos ingresos corresponden a la proporción lana:carne a razón de 1.5 a 1:1 respectivamente. Detrás de estas tendencias existe un creciente enfoque en las características de adaptación que incluyen una resistencia a parásitos, una menor necesidad de intervenciones por veterinarios, y un mayor crecimiento en edades tempranas, así como un aumento de la fertilidad y de la capacidad maternal. Juntas,

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estas tendencias apuntan hacia un ganado ovino cuyos cuidados son cada vez más sencillos, así como a la explotación de la diversidad genética disponible para aumentar rápidamente la rentabilidad.

Palabras clave: *economia, diversidad genética, mejora genética, producción de lana*

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Introduction

The sheep industry, and in particular the wool produced from it, has been a significant contributor to the Australian economy for most of the time since European settlement in the late 1700s. Sheep were bought to the country on the first British ships; in subsequent years further importations were made from Britain, the Indian sub-continent, Southern Africa and Europe. Many 'breeds' were introduced over a period of time characterized by much experimentation via crossing of breeds and strains, but it became apparent that the Merino was eminently suited to producing fine wool across much of Australia. This history is intensively described in Massy (2007), and captured in literature by McDonald (2005), and both works give a flavour of the enormous cultural significance of the wool industry in Australia.

Massy describes in detail the sources which contributed to the Merino gene pool via infusion, crossing, upgrading and selection and which led to the range of 'strains' which existed for much of the 20th century. In modern terminology, the Australian Merino flock comprises a number of genetically related composites or synthetics, based ultimately on Merinos deriving from Spain, but with various infusions from populations developed in a range of countries from the original Spanish, and more widely, from other sheep breeds. This history can be expected to have generated significant genetic diversity.

The combination of climate and availability of pasture for grazing meant that Australia rapidly came to dominate world wool production, especially in the finer, apparel end of the micron range (Merino wool ranges from 14 to 28 µm, with the majority of production in the 22–24 µm range for much of the period up to 2000). Exports of wool from 1800 to 1940 were focused on British markets whereas after World War II the markets in Russia, China, Italy and Japan became more important. Italy and Japan sought wools from the finer end of the Merino production spectrum, whilst the Russian and Chinese markets relied on broader wools used in the manufacture of blankets and coats for their armies. This dichotomy – finer wools used in more expensive apparel products, and broader wools used essentially as a source of warmth – underpins recent significant changes in the demand for wool.

At its height, the Australian Merino flock numbered some 180 million animals. This peak was underpinned by a price maintenance mechanism introduced by the wool industry, known as the Reserve Price scheme (Massy, 2007). This was introduced in the late 1960s after a period of decline in real wool price from its peak in the early 1950s and led to stabilisation of the real price through the 1970s and into the 1980s. In the mid-1980s the reserve price was successively raised following apparent growth in demand, and production was expanded to follow essentially guaranteed prices. After the mid-1980s this market support mechanism collapsed.

In the period since 1980 demand for the broader Merino has declined significantly to the point where production of wool above 22-µm diameter has become uneconomical. This has led to very significant reduction in the number of animals and significant concerns about Australia's ability to supply its markets for both wool and sheep meat.

The key points from this brief historical overview are the following:

- Merino wool production has been a very significant component of the overall Australian economy for most of the period since European settlement.
- The Australian Merino evolved over that period under selection from a range of source populations and as such is essentially a composite or series of genetically related composite populations, suited to particular climate-by-market niches.

This paper briefly summarises the data on the economic importance of Merino wool production, the evidence for genetic diversity within the Merino population and recent changes in both the markets for Merino wool and technological changes in Merino breeding.

Importance of fibre production for farmer livelihoods

Wool is produced in Australia from sheep flocks managed with a range in focus on wool – in simple terms from flocks producing finer and more valuable wool, mainly in cooler regions with shorter growing seasons, to flocks where meat production or livestock sales are more important, typically in the dryer and warmer regions (particularly in South Australia and Western Australia). The exact balance between wool and meat income varies with the actual prices, but this range is from approximately 85% of total income derived from wool down to approximately equal shares for wool and meat.

This range partly reflects the diversity of production characteristics within the Merino population which will be discussed further. The key point is that in different

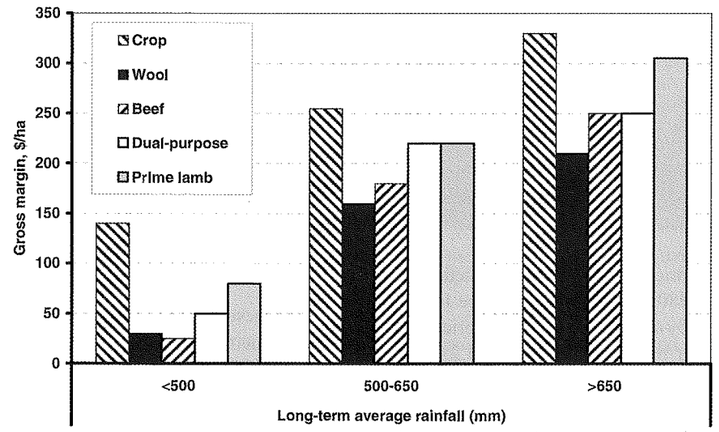

Figure 1. Enterprise economic comparison for 1999–2008. Note that many farms will have more than one enterprise, and mixed sheep and crops are common particularly in the medium and lower rainfall areas.

regions the flock structures are geared to different income mixes. Current economic performance for these regions has recently been analysed (Holmes-Sackett, 2009) and can be summarised by enterprise type and by region.

Figure 1 summarises economic performance for three sheep enterprises as well as cropping and beef production over the last 10 years. The three sheep enterprises are the following:

1. Wool, where all ewes are Merinos and are mated to Merino rams, and approximately 75% or more of enterprise income is from wool;
2. Dual purpose, where the ewes are Merinos but a portion are mated each year to non-Merino rams for either lamb or hogget (12- to 24-month-old sheep) production, and 55–65% of enterprise income is from wool; and
3. Prime lamb, where the ewes are typically not Merino, the rams are meat-breed rams, all or most progeny are sold for slaughter and 65% or more of enterprise income is from meat.

Three main points can be highlighted from Figure 1:

1. Gross margins need to be in excess of approximately $100, $150 and $200/ha in the low (<500 mm), medium (500–650 mm) and high (>650 mm) rainfall zones, respectively, for farm business sustainability. On this basis, wool-focused enterprises have not been financially viable on average over the last 10 years.
2. In all regions of Australia where sheep are run, over the last 10 years profitability from cropping exceeds that of any sheep enterprises. Note that capital requirements are usually higher for cropping as is variability between years, such that cropping is more financially risky than livestock.
3. Dual-purpose enterprise profitability has significantly exceeded that of wool focused enterprises in all regions through the last 10 years.

This situation of relatively poor returns from wool production is predominantly the result of the relative prices

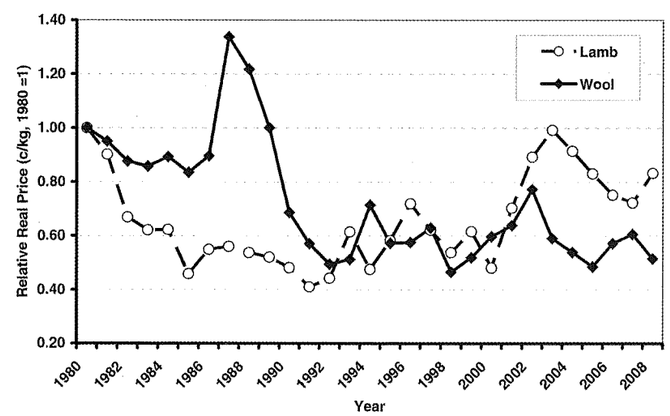

Figure 2. Relative real prices for wool and lamb, 1980–2009.

of wool and sheep meat. The prices for these have followed very different paths over the last 30 years, as illustrated in Figure 2.

Figure 2 clearly shows the following:

- Between 1980 and 1990, real prices for wool and lamb both declined, albeit with a very steep rise in the real price of wool to 1985. The subsequent crash in wool prices was simultaneous with the collapse of the Reserve Price scheme.
- Since 1990, the real price of wool has fluctuated around 60% of its price in 1980, whereas the real price for lamb has risen to around 80% of the 1980 price. The price trends for wool and lamb for these periods are 0 and 2.4% pa., respectively. (This rise has not been smooth, because it has been affected by both widespread droughts which have affected supply and by tariff barriers in the United States in the late 1990s.) Medium-term forecasts are for demand for lamb to remain strong, and with it, prices.

Within the overall price trend for Merino wool, there are different patterns for different micron (fibre diameter) categories. Swan (2009) provides a comprehensive review of these trends and the market forces behind them. The overall effect on production has been that, although the total volume of wool finer than 20 μm rose slightly from 1991 to 2009, that for wool broader than 20 μm collapsed to approximately 25% of its former level.

Thus, whereas wool was historically a very important source of livelihood for farmers across much of Australia, over the last two to three decades that contribution has declined significantly. In response, sheep numbers (and particularly Merino sheep) have declined from the peak of 180 million in the mid-1980s to approximately 75 million sheep in 2009, with approximately 45 million of those being ewes.

Information on genetic diversity within the Merino population

As outlined earlier, the Australian Merino of the 20th century is a composite or synthetic evolved via a mixture of infusion, cross-breeding and selection to become an overall population comprising three broad types or strains:

1. Fine wool: small to medium frame sheep which produce fleeces in the fibre diameter range of 16–19 μm, with clean fleece weights averaging 2.5–3.0 kg in adult sheep grazing pastures. This strain is typically run in cooler, higher-rainfall areas and includes Saxon and Spanish bloodlines.
2. Medium wool: somewhat larger sheep producing fleeces averaging 20–22.5 μm and 3.0–3.5 kg fleece weight. These are predominantly Peppin bloodlines.
3. Strong wool: even larger sheep, producing fleeces averaging 22–24 μm and 3.0–4.0 kg fleece weight. These are predominantly South Australian bloodlines.

Note that these 'bloodlines' have typically been referred to as breeds. Particularly the Peppin and South Australian bloodlines were at times infused with genetic material from other recognized breeds (such as Lincoln). To Merino sheep breeders and producers, the distinction among these 'breeds', strains or bloodlines were quite clear; and a detailed history of the derivation of each was effectively part of industry knowledge (and folklore). In the genetic sense, there was always some limited mixing of genetic material between the broad categories. However, this has increased greatly in the last 20–30 years.

Within these types, ram-breeding studs traditionally formed a tiered structure, with parent studs at the peak of the pyramid, supplying rams to 'daughter studs' to multiply rams, who in turn supplied rams to commercial wool-growing flocks.

There is a rich literature of information from trials and experiments characterising the performance of these different types of sheep. Such work, both 'scientific' and practical, included examination of the performance of different strains under different environments, exploring genotype × environment interaction. This distinction between 'scientific' and 'practical' is made only to highlight a divide or communications gap which existed between the scientifically trained and stud breeders in particular, with rare exceptions, for much of the 20th century. Massy (2007) provides a comprehensive discussion of this issue, as well as summarising the material on strain evaluations and genotype × environment interaction.

In terms of analysing and describing genetic diversity more technically, the main approach until recently has been via genetic parameter estimates. Before summarising these estimates, it is necessary to outline a recent evolution in the broad genetic structure of the industry.

The structure of breeds, strains and bloodlines which evolved during the 1800s and early 1900s was relatively stable until the last decades of the 1900s. In that period, distinctions between the categories began to blur, stimulated in part by somewhat uneven adoption of performance recording and more 'scientific' approaches to making selection decisions and in part by the increasing need to reduce fibre diameter. The latter led to increased use of rams from the finer categories over the broader categories. More recently the desire to breed a Merino which is more suited to a dual-purpose enterprise has resulted in some mixing in the reverse direction. This trend has led to the situation today where distinctions between categories are considerably blurred and appear to be in a state of flux.

One expression of genetic diversity is phenotypic appearance. Figure 3 compares two images of Merinos, the first from 1910; the second is a modern animal with high genetic merit and selected for dual-purpose (meat and wool) goals including easy-care attributes such as resistance to internal parasites.

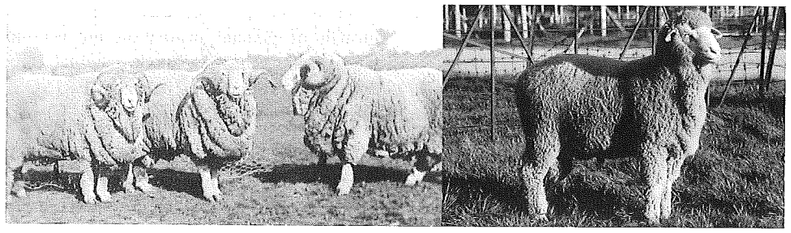

Figure 3. Phenotypic expression of diversity in Merinos – (left) three stud rams from Merribee, 1910 (Massy, 2007) and (right) Leachcim 72 (Sheep Genetics, 2009). Permission for Figs 3 & 4 is granted by Meat & Livestock Australia (2009).

Genetic parameter estimation from 1980 to 2000 suggested that there were some genetic differences between categories, as expressed by heritability estimates. Those for fibre diameter were higher in the finer wools than elsewhere, but other parameters were relatively similar across categories.

In the last 10 years, performance recording has grown, and a single national genetic evaluation is now in place for Merinos. The genetic parameters used in that analysis describe the genetic variation for the major traits. Table 1 summarises those parameters for hogget weight, hogget fleece weight and hogget fibre diameter. A comprehensive description of genetic parameters is provided in Huisman *et al.* (2008), Huisman and Brown (2008, 2009a, 2009b). Safari *et al.* (2005) published a review of genetic parameters for sheep and estimated these parameters in a large data set from research flocks (Safari *et al.*, 2007).

The parameters summarised in Table 1 are a very small subset of those estimated from the Sheep Genetics database and reflect a mixture of flocks from across the 'traditional' categories, that have become less distinct (as noted above). However, these are broadly consistent with the many sets of parameter estimates for the Australian Merino population from the literature.

The key point in the context of genetic diversity is that these three key economic traits exhibit considerable genetic variation, both in terms of heritability and absolute genetic variation. The other trait with significant economic significance (although not viewed this way by most breeders for most of the last 100 years) is reproduction, which has been intensively investigated in Merinos since the 1960s. Estimates of heritability of various aspects of reproduction in Merinos are typically in the range 0.05–0.10, and this is the finding in the current Merino data (Huisman *et al.*, 2008). Although this is suggestive of low levels of genetic variation (and hence diversity), when it is recognised that phenotypic variance for all reproduction traits is large, it becomes clear that there is substantial additive genetic variation for aspects of reproduction in Merinos, again suggestive of genetic diversity within the population.

Table 1. Genetic (co)variances for hogget body weight, fleece weight and fibre diameter in Australasian Merinos.

	Body weight	Clean fleece weight	Fibre diameter
Bodyweight	**0.41 (0.02)**	0.31 (0.01)	0.11 (0.01)
Clean fleece weight	0.06 (0.06)	**0.32 (0.02)**	0.22 (0.01)
Fibre diameter	0.21 (0.03)	0.44 (0.03)	**0.62 (0.02)**

Note: Heritabilities are on the bold type diagonal, genetic correlations are below the diagonal and phenotypic correlations are above the diagonal. Figures in parentheses are the standard errors of the estimates.
Source: Sheep Genetics database (2009).

Further evidence of genetic variation consistent with that from genetic parameter estimates is provided by responses to selection. There is an extensive literature on selection experiments, but one recent example illustrates the findings. In 1992, NSW Agriculture researchers initiated a selection experiment which included five selection goals (including controls) applied in three strains of Merinos (nine lines in total). The selection goals represented a range of multi-trait objectives with varying emphasis on fleece weight and fibre diameter. Ten rounds of selection were applied. A comprehensive report of the project is available (QPlus Open Day, 2006), but its results can be summarised as follows:

- Substantial improvements in clean fleece weight and fibre diameter were achieved in all selection lines *in accord with their prescribed breeding objectives* (italics inserted).
- It was demonstrated that it is possible to achieve such improvements in conjunction with maintaining performance levels for a range of visually assessed traits, suggesting that 'modern' performance-based selection approaches need not be antagonistic to more traditional aspects of Merino sheep.

A similar project was conducted from 1996 to 2009 in South Australia, using selection lines established within predominantly South Australian strong wool Merinos (Selection Demonstration Flocks, SARDI, 2009). A series of selection lines were established with a range of multi-trait objectives, and responses to selection were again

consistent with predictions based on estimated genetic parameters.

These results, together with those from many other selection experiments, provide evidence that the genetic parameters estimated in Merinos are an accurate assessment of available genetic variation and hence of genetic diversity within the population.

More recently, molecular technologies are beginning to be applied to the sheep genome, and these will shed more light on diversity within and between populations and breeds (International Sheep Genomics Consortium, 2002–2009). At time of this writing no definitive estimates of various measures of diversity (effective population size and linkage disequilibrium) were available, but early indications are that genetic diversity in Merinos sampled from Australia is high (Kijas, 2009).

Research into genetic parameters (and hence diversity) in Merino is but a part of the considerable research and development effort that has been conducted since the early years after World War II. Other aspects include the design of breeding programs, development of performance recording and evaluation schemes and extension programs to breeders and commercial producers. A most useful reference covering the full scope of that work is the Merino Improvement Programs in Australia Symposium Proceedings (McGuirk, 1987).

This section has superficially outlined the volume of results on genetic parameters in Merino sheep, focusing solely on summarising what that literature implies in terms of genetic diversity. All of the evidence suggests that, no matter what traits are considered, there is considerable diversity within the Australasian Merino gene pool. The last section will briefly describe how that diversity is being exploited more recently.

Recent developments in genetic improvement in Australasian Merino sheep

As noted earlier, the adoption of approaches to animal breeding based on quantitative genetic theory has been limited. During the period from 1950 to the 1990s, some breeders applied performance recording and developed breeding programs utilising principles derived from animal breeding theory. However, overall, their impact and hence that of animal breeding theory was small.

Beginning in the mid-1980s, the Australian lamb industry introduced a national genetic evaluation system, LAMBPLAN (Sheep Genetics, 2009), which has grown from very simple beginnings to now running large multi-trait animal model BLUP evaluations for all major 'meat breeds' and has high adoption amongst stud breeders. The development of LAMBPLAN stimulated interest from Merino breeders, initially predominantly those already convinced of the merits of performance recording. Over the period from 1995 to the present, this interest has encouraged the growth of genetic evaluation for Merinos to the point where there is now a single national across-flock genetic evaluation system in place: MERINOSELECT (Sheep Genetics, 2009).

Genetic evaluation analyses in MERINOSELECT are run monthly; include over 50 traits covering weight, carcass, fleece weight and quality, reproduction, disease and welfare; and include over 1.2 million animals in each analysis. This total is growing by approximately 80 000 new animals each year, and more than 15 000 sires are included in the data set.

The numbers of animals being evaluated suggest a diversity of genetic material. This is reinforced by the fact that considerable research has had to be conducted into how best to handle the genetic structuring of the population within the analyses. Currently, genetic groups – broadly reflecting the historical breeds, strains and bloodlines – are included in the analytical models, whilst comprehensive pedigree information (either sire or sire plus dam information are required for inclusion into the full across-flock analyses) simultaneously accounts for the increasing mixing amongst these historical categories.

The evidence for genetic progress available from the genetic analyses is as important as the growth in numbers of animals being evaluated within the Merino population. Swan *et al.* (2009) summarise genetic trends in the range of sheep populations using LAMBPLAN and MERINOSELECT, and they present results suggesting that the rates of progress in Merinos are increasing. Figure 4, that is based on Swan *et al.* (2009), shows genetic trends in the industry for two indexes in flocks using MERINOSELECT.

The market penetration of MERINOSELECT is now estimated at approximately 35% of all Merino rams being sold. However, this proportion is rising as the overall numbers of Merino rams which are sold declines essentially in line with declining ewe numbers.

The Australasian Merino population and sheep industry are at a most interesting point in their history. The intersecting challenges and opportunities present, and the role of genetic diversity in addressing them, are outlined briefly in the concluding section.

Conclusions

There are four main messages of this brief discussion of the wool industry in Australasia and its genetic diversity:

1. The industry has been a major contributor to the economic development of both Australia and New Zealand, at times essentially the sole source of export income.
2. Over the last three decades that contribution has declined as prices for broader wools have collapsed and finer apparel wools have fallen to lower levels than historically and apparently stabilized in real terms, while returns from other enterprises have grown.
3. The Australasian Merino population has developed through sampling a range of populations coupled with selection and exhibits substantial genetic diversity at both the pedigree and molecular levels.
4. In the last decade, a comprehensive national genetic evaluation system has been established, which is being adopted by a growing proportion of stud breeders and being used with increasing effectiveness to make substantial genetic improvement in a range of production and fitness traits.

What the future holds for the Merino industry cannot be predicted, but it is clear that two trends are at play: the decline in wool prices and sheep numbers could lead to the disappearance of wool production as a viable industry. This would represent the outcome of a failure to respond to consumer signals about product quality and more broadly about the way in which the product is produced. This would be a somewhat sad end to the story of Merino sheep in Australasia. Moreover, in the context of the human contribution to that story it would represent a failure to maintain the exploratory and innovative spirit which played such a significant role in its development (Massy, 2007).

The alternative is that essentially a new generation of breeders and producers must respond positively to the challenges of ethical and environmentally sustainable production coupled with the demand for constant improvement in product quality and price competitiveness. In doing so, they will inevitably have to make intelligent use of modern breeding methods combined with traditional animal assessment skills. There is clear evidence that a significant number of breeders are meeting this challenge. Making increasingly effective use of the genetic diversity contained within the Merino population will be central to this version of the future.

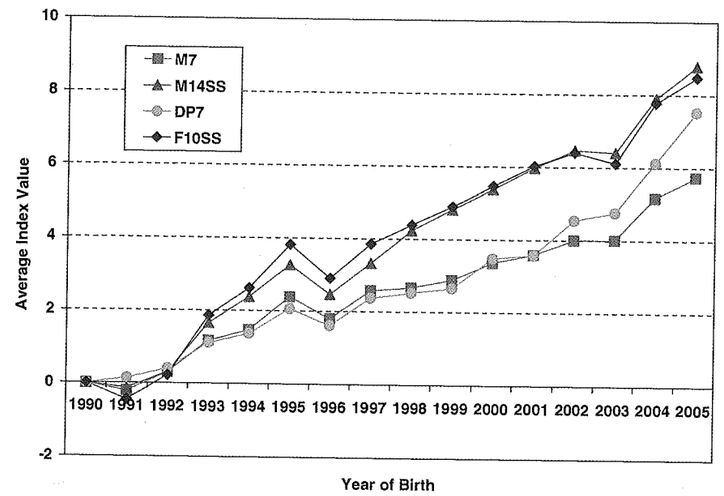

Figure 4. Genetic trends in industry flocks using MERINOSELECT (based on Swan *et al.*, 2009. A full explanation of the four indexes is provided in the reference). Permission for Figs 3 & 4 is granted by Meat & Livestock Australia (2009).

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Genetic improvement for alpaca fibre production in the Peruvian Altiplano: the Pacomarca experience

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Summary

Pacomarca is an experimental ranch founded by the INCA group to act as a selection nucleus from which basic genetic improvement of alpaca fibre can spread throughout the rural communities in the Peruvian Altiplano. State-of-art techniques in animal science, such as performance recording or assisted reproduction including embryo transfer, are applied to demonstrate their usefulness in the Altiplano conditions. Pacomarca has developed useful software (Paco Pro) to carry out the integral processing of production and reproduction data. Mating is carried out individually, and gestation is diagnosed via ultrasound. Breeding values estimated from a modern genetic evaluation are used for selection, and embryo transfer is applied to increase the selection intensity. However, the objective of Pacomarca goes beyond, extending its advances to the small rural communities. Training courses for farmers are organised while searching for new ways of improving the performance of alpacas both technically and scientifically.

Keywords: *alpaca, fibre, genetic improvement, Peruvian Altiplano*

Résumé

Pacomarca est un ranch expérimental créé par le groupe INCA en tant que noyau de sélection pouvant répandre les bases de l'amélioration génétique pour la fibre d'alpaga dans toutes les communautés rurales du haut-plateau péruvien. A Pacomarca, on applique des techniques de pointe de la zootechnie, comme le contrôle des performances ou la procréation médicalement assistée, y compris le transfert d'embryons, pour démontrer leur utilité dans les conditions productives du haut-plateau. Pacomarca a élaboré un logiciel (Paco Pro) utile à entreprendre l'élaboration intégrale des données sur la production et sur la reproduction. Les accouplements sont réalisés de façon individuelle, la gestation est diagnostiquée par le biais de l'échographie, les valeurs génétiques, estimées par des techniques modernes d'évaluation génétique, sont utilisées pour la sélection, et le transfert d'embryons est appliqué pour accroître le taux de sélection. Cependant, l'objectif de Pacomarca va au-delà de ces activités et vise à transmettre ces progrès aux petites communautés rurales. On organise des cours de formation pour les agriculteurs tout en cherchant de nouvelles façons d'améliorer la performance des alpagas du point de vue technique ainsi que scientifique.

Mots-clés: *alpaga, fibre, amélioration génétique, Altiplano péruvien*

Resumen

Pacomarca es un rancho experimental fundado por el grupo INCA para actuar como un núcleo de selección que permita extender la mejora genética de la fibra de alpaca en el altiplano peruano. En Pacomarca se aplican técnicas estándar en producción animal, como el control de rendimientos o la reproducción asistida incluyendo la transferencia de embriones, para demostrar su utilidad en las condiciones productivas del altiplano. Pacomarca ha desarrollado una aplicación informática (Paco Pro) que permite una gestión adecuada de la información productiva, reproductiva y genealógica necesaria para llevar a cabo un programa de mejora genética: los apareamientos se llevan a cabo de forma individualizada, la gestación se diagnostica mediante ecografía, los méritos genéticos estimados mediante modernas técnicas de evaluación genética se usan para la selección de reproductores y la transferencia de embriones se utiliza para aumentar la intensidad de selección. En todo caso, el objetivo de Pacomarca se cumple esencialmente organizando periódicamente cursos de formación para miembros de pequeñas comunidades rurales del altiplano en los que se produce la diseminación de sus avances en manejo, reproducción y producción de la alpaca resultado de las experimentaciones realizadas en Pacomarca.

Palabras clave: *alpaca, fibras, mejora genética, Altiplano Peruano*

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