Breeding Programs – Review of approaches in Australia

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Abstract
This paper discusses the range of genetic breeding programs which are available to Australian livestock industries. It presents a short history of genetic evaluation schemes and discusses the Australian Dairy Herd Improvement Scheme, BREEDPLAN for Beef Cattle, PIGBLUP, KIDPLAN, and the newly created Sheep Genetics Australia which combines wool and meat into one database. The paper concludes with an update on the Alpaca Across-Herd Genetic Evaluation (AGE) program and presents data on the traits measured to date.

Keywords
Genetics, BREEDPLAN, Australian Dairy Herd Improvement Scheme, PIGBLUP, KIDPLAN, AGE

1. Introduction

The major decision in any breeding program is to select which animals should be retained within the herd for breeding and to which sire or dam they should be mated. Historically such selection has been based on the visual assessment of the animal. In the mid twentieth century, breeding programs based on objectively selecting of animals based on measured traits was developed which have evolved into breeding programs based on genetic evaluation of these measured traits.

Phenotype and genotype are two commonly used terms in genetics and animal breeding. The physical appearance, what we see or measure is referred to as the phenotype of the animal whereas its genetic makeup is referred to as its genotype (Ponzoni 1993). Ponzoni (1993) and Tuckwell presented two papers at the 1993 AAA conference which provide a good background for the use of objective selection in alpacas. These papers covered the principles involved and how they may be applied.

The heritability of a trait is the proportion of phenotypic variation in a population that is attributable to genetic variation among individuals. Nicholas (1987) provides a table showing the heritabilities for most domestic animals and also is a reference on the use of breeding programs based on quantitative genetics.

This paper will discuss the genetic breeding programs for most of the livestock industries in Australia with particular emphasis on sheep breeding due to its emphasis on fibre production and its similarity to breeding Alpacas.

2. Breeding Programs

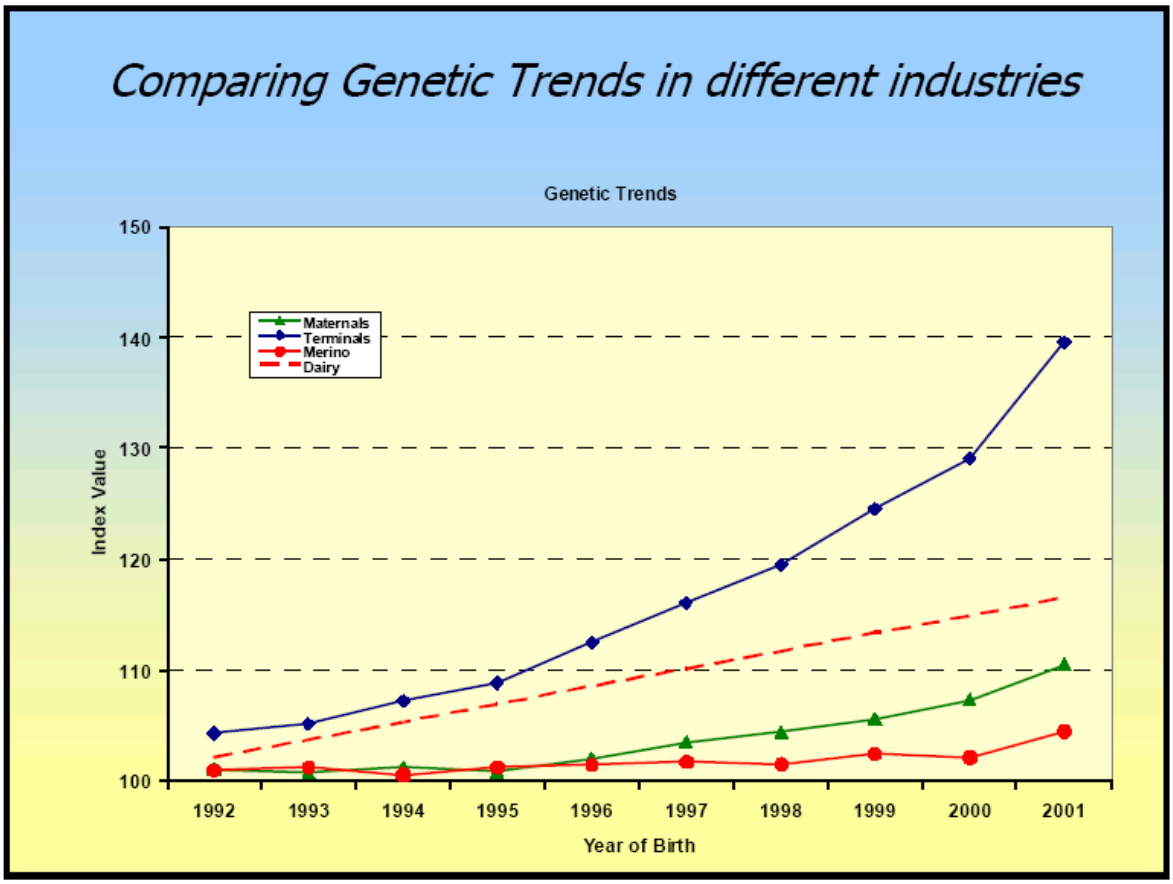
In commencing a breeding program there are two question which need to be answered before it can be commenced, these are; *Where should you aim*? and *How can you get there*? These questions will determine what the breeding program needs to be to answer these questions. For Alpacas this would require knowing where you want to be for Fibre Diameter (FD), Fleeceweight, Lustre, crimp, length, CV of FD, bodyweight, follicles per cm^2 and many more. Quantitative genetics allows the breeding objective to be achieved. Kinghorn et al (1991) summarises the breeding and selection options which are able to be used in sheep breeding.

Performance recording schemes was often the first step towards objective breeding programs which measured a character for selection, for example fleeceweight. However these schemes were really only assessing the phenotypic expression of the trait without any adjustment for age, dam age, birth type, sibling performance, sire or environment.

The development of computer technology has allowed Performance Recording Schemes to become true genetic evaluation schemes as the genetic merit of an animal can be calculated based not only on its own performance but also its relatives (sire, dam and siblings) whilst adjustment is made for environmental affects.

Most Genetic services are able to combine a number of traits into a single Index or Breeding Objective to assist breeders select animals.

The following graph shows the genetic trends which have been achieved across different industries over the period 192-2002.



From Werf (2004)

3. Industry Genetic Performance Schemes

3.1 Dairy Cattle

The dairy industry was one of the first to adopt performance recording schemes and the Australian Dairy Herd Improvement Scheme (ADHIS) is managed by the Australian Dairy Farmers Federation. Benefits from its operations flow through to all dairy farmers and through productivity improvement the entire community profits from this farmer managed operation. The A.D.H.I.S commenced in 1982 as a national genetic evaluation program (Jeffries 1991).

The ADHIS database contains records of about 8 million cows and 100,000 bulls dating from the 1970's. Since the inception of ABVs, genetic merit has increased by about 0.75% per year and accounted for about 30% of production gains.

The dairy industry almost exclusively uses semen for artificial insemination from bulls identified with superior production and other traits via the ADHIS. The main traits identified for dairy cows are milk, protein, fat, lactation length and ease of calving whilst the main traits identified for bulls were those

identified for cows plus survival, conformation, milking speed, temperament, cell count, liveweight, workability and daughter fertility.

Further information can be found on the ADHIS website at www.adhis.com.au.

3.2 Beef Cattle

Performance recording of Australian beef cattle through the National Beef Recording Scheme started in 1972. BREEDPLAN commenced in 1985 as a within herd genetic evaluation scheme and expanded to an across herd evaluation in 1987 (Scheenberger et al 1991).

BREEDPLAN calculates Estimated Breeding Values (EBVs) for a range of traits including;

Weight	**Fertility**	**Carcase**
Birth weight	Scrotal Size	Carcase weight
200-day milk	Days to calving	Eye Muscle area
200, 400 & 600-day weight	Gestation length	Fat thickness
Mature cow weight	Calving ease	Meat Yield %
Feed eficiency		Marbling

Included in the calculation of EBVs are the animals own performance, the performance of known relatives, the heritability of each trait and the relationships between the traits ie; A world class genetic evaluation model, combining all traits in one analysis.

All breeds of beef cattle in Australia use BREEDPLAN. For most, the BREEDPLAN genetic evaluation system has been integrated with the respective breed association's pedigree system. Substantial genetic improvements for traits of commercial importance have been demonstrated.

Further information can be found on the BREEDPLAN website at http://breedplan.une.edu.au.

3.3 Pigs

The following information was obtained from the PIGBLUP website.

PIGBLUP is a PC based genetic evaluation system for pig, which analyses large data sets within minutes. PIGBLUP uses pedigree and performance date available from the breeders her recording system to derive EBVs for a number of performance and reproductive traits.

Since 2001, PIGBLUP has been the engine behind the National Pig Improvement program which provides across-herd EBVs for participating herds.

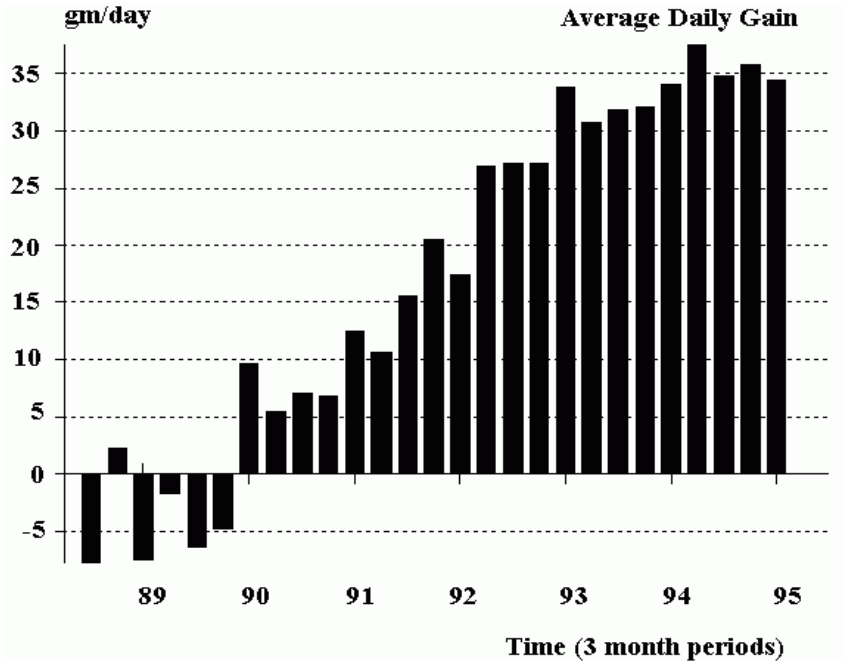
PIGBLUP calculates EBVs for:

Average Daily Gain	Carcase Fat
Feed Conversion Ratio	% Lean Meat
Gain in Test Period	Number Born Alive
Backfat (P2)	21 Day Litter Weight
Carcase Muscle	IGF1 trait (PrimeGRO)

The PIGBLUP system allows genetic and environmental trends to be graphically displayed which can be seen in the following two graphs.

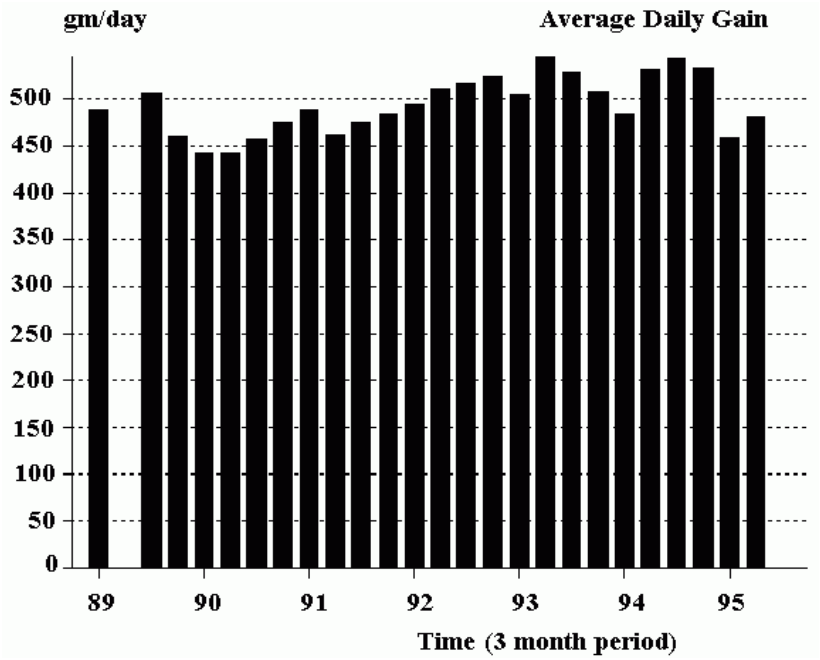
Genetic Trends are an indication of the effectiveness of a breeding program and give valuable information to the user as to the direction in which the breeding program is headed which can be seen in Figure 1.

Figure 1. Genetic Trend for ADG (grams/day)



Environmental trends reflect changes in the environmental conditions in which the animals have performed. They also give an indication of the average production level across time. Figure 2 shows the environmental trend in average daily gain during the same period of time as for the genetic trend in Figure 1.

Figure 2. Environmental Trend for ADG (grams/day)



Further information can be found on the PIGBLUP website at
http://agbu.une.edu.au/pigs/pigblup/index1.php

3.4 Goats

Meat and Livestock Australia have launched KIDPLAN for the Boer and Meat Goat Industry.

By using pedigree and performance information, KIDPLAN provides simple, practical information on the values of an animal's genes for production, in the form of EBVs and specialised indexes.

KIDPLAN currently produces EBVs for a range of production traits including:

Weight
These are produced for the following weight/age classes:
• Birth weight
• Weaning weight (70-140 days of age)
• Maternal weaning weight (a measure of the milk and maternal value of the doe)
• Post-weaning weight (140-280 days of age)
• Yearling weight (280-400 days of age)
• Mature doe weight

Fat Depth
These describe the value of an animal's genes for fat depth at a constant weight.

Eye-Muscle Depth
These describe an animal's genetic merit for eye-muscle depth at constant weight.

Accuracy and Inbreeding
All KIDPLAN reports now come with accuracy and inbreeding levels for goats that have performance information in the KIDPLAN database.

Further information can be found on the PIGBLUP website at www.mla.com.au/kidplan/

3.5 Sheep

When looking at breeding programs within the Australian Sheep Industry it must be remembered that these have traditionally been conducted with an emphasis on fibre or meat. For an analysis of the history of adoption of genetic evaluation and performance recording in the Australian wool sheep industry see Ponzoni (1994) whilst Banks (1995) presents the history of genetic selection via LAMBPLAN within the Australian lamb industry. Safari et al (2005) has recently reviewed the genetic parameters for a range of sheep production traits from estimates published over the period 1995-2005.

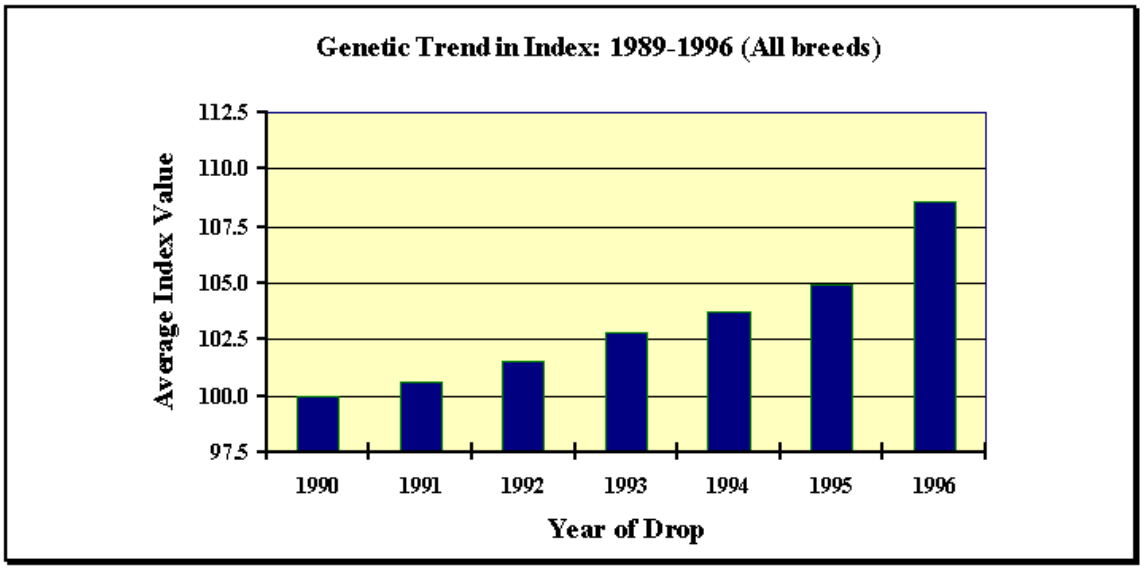
Sheep Genetics Australia (SGA) is a database which brings together objective genetic measurements for both wool and meat. SGA is a joint initiative of Australian Wool Innovation (AWI) and Meat and Livestock Australia (MLA).

a. Meat

NSW Agriculture introduced the Meat Sheep Testing Service in 1980 which measured liveweight and then in the mid 80's introduced fat measurement. After a period of evaluating the equipment, a National Performance Recording System was introduced in 1989 and called LAMBPLAN. LAMBPLAN has grown very rapidly in both the level of adoption and in the range and power of information.

Figure 3 demonstrates the genetic gain for the period 1989-1996 for all breeds for flocks using LAMBPLAN.

Figure 3: Genetic improvement ~ increasing the productivity and product quality of Australian lamb.



From Banks (1997)

Over 70% of rams from terminal breeds are bred in flocks which use LAMBPLAN.

b. Wool

Various state Departments of Agriculture operated performance recording services for wool traits from the 1970's. These schemes had a variety of names and initially only measured greasy fleece weight but over time various improvements have been made till now, where many traits are measured and reported with environmental differences being considered in the calculation.

In addition to the above Performance Recording Schemes there have been a number of other programs which have measured genetic merit, two of these were;

i. *Merino Central Test Sire Evaluation*
AWI funded sites across Australia with linkages between sites which allowed all sires to be compared. The results were published in a combined publication – Merino Superior Sires.

ii. *Merino Bloodline Performance Package*
This package is a tool for commercial Merino woolgrowers who want to identify the best options for their breeding objectives. The analysis takes out all environmental factors between the wether trials and years, allowing the genetic variation between bloodlines to be measured.

c. Sheep Genetics Australia (SGA)

SGA is the recently launched national genetic information and evaluation service for the meat and wool sectors of the sheep industry. SGA will calculate Australian Sheep Breeding Values (ASBVs) which will be delivered via MERINOSELECT and LAMBPLAN, which have been designated for the wool and prime lamb sectors respectively.

MERINOSELECT is for Merino ram breeders and commercial wool producers. It is the new brand name for Merino genetic information combining data from the current Merino schemes into a national system. LAMBPLAN continues as the brand name under which genetic information is delivered to terminal, maternal and dual purpose ram breeders and commercial lambs and sheep producers.

The SGA database will initially have records on around 100 million individual Merino sheep, and a similar number from the terminal and maternal sire breeds which reflects the data from more than 1000 flocks around Australia. This data has been drawn from the Merino Benchmark, LAMBPLAN, CSIRO Select Breeding Services, Merino Genetic Services, Australian Merino Sire Evaluation Association, Central Test Sire Evaluations databases and other independent providers.

There will be a wide range of ABVs reported to breeders and they will be available for the following core traits:

- wool
- growth
- carcase
- reproduction
- internal parasite resistance
- temperament.

Further information can be found on the SGA website at www.sheepgenetics.org.au/

3.6 Alpacas

The Alpaca Across-Herd Genetic Evaluation (AGE) commenced in 2004 and is jointly funded by NSW DPI, Rural Industries Research and Development Corporation (RIRDC).

Progress to date

- The first task of the project was to establish BLUP software so that data could be analysed and Alpaca AGE can be performed and reports sent to submitting breeders.
- In collaboration with alpaca breeders focus groups and the AAA AGE Working Party the traits to be evaluated were decided upon.
- AAA AGE Working Party has established the AGE database at ABRI (the major animal performance database provider in Australia). The AGE database was established along side the AAA pedigree database that has been successful managed by ABRI for several years.
- Promotional seminars were completed with seven seminars conducted in 2004 (Qld, NSW x 2, Victoria x 2, SA and WA). An additional seminar was held in NZ and this also acted as a stud breeders training workshop.
- An AGE Booklet has been developed to assist breeders to collect and submit data for analysis.
- A breeders Hands-On workshop was developed in 2005 and ten workshops conducted in 2005 (NSW = 5 (Including pilot), VIC=2, QLD, SA & WA = 1 each) with over 250 breeders having attended the workshops. The primary aim of the workshop was to take breeders through the AGE booklet so that at the end of the workshop they were able to collect and submit data to AGE.

Data Analysis

Three analyses have been conducted to date; February and November 2005, and February 2006. 485 animals from 28 studs were in the first analysis, 726 animals from 43 studs in the second and 1153 progeny from 64 studs were in the third analysis (1961 animals in 3rd analysis). New Zealand studs account for 45% of these studs.

The AGE Working Party has decided that analyses will be run in February, July and November each year.

a. Summary of Phenotypic values

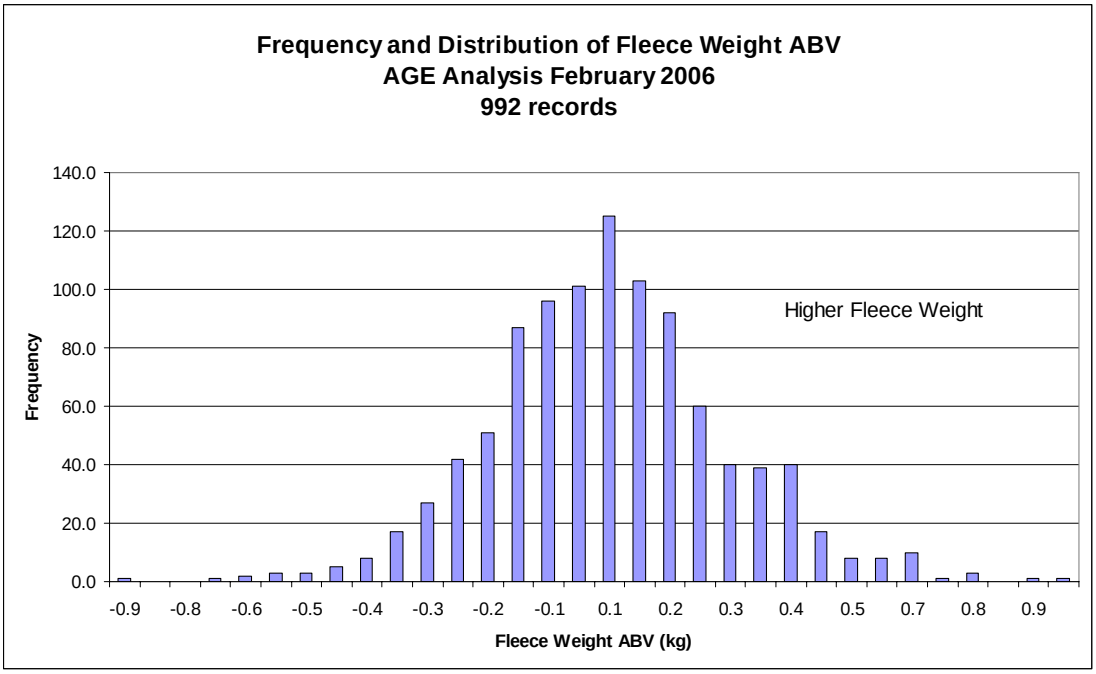
The average phenotypic values for the fibre traits were;

Greasy Fleece Weight	2.7 (kg)
Fibre Diameter	21.8 (µm)
Co-efficient of Variation	21.7 (%)
Bodyweight	50.2 (kg)
Staple Length	110.6 (mm)

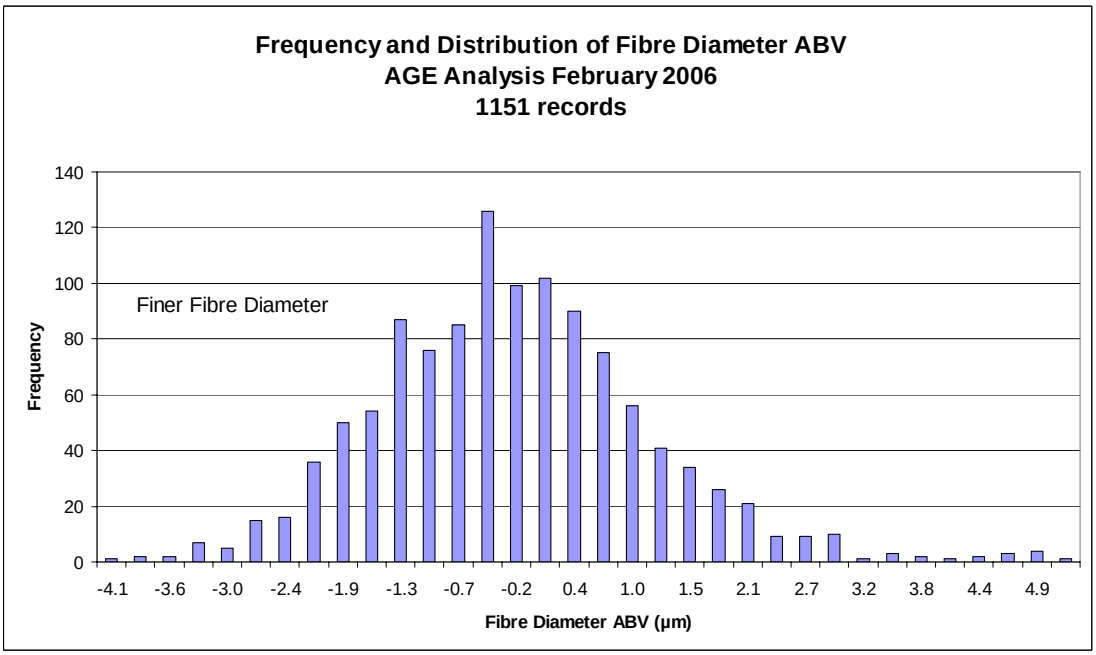
b. Breeding Values

The following graphs show the Alpaca Breeding Values for the above traits;

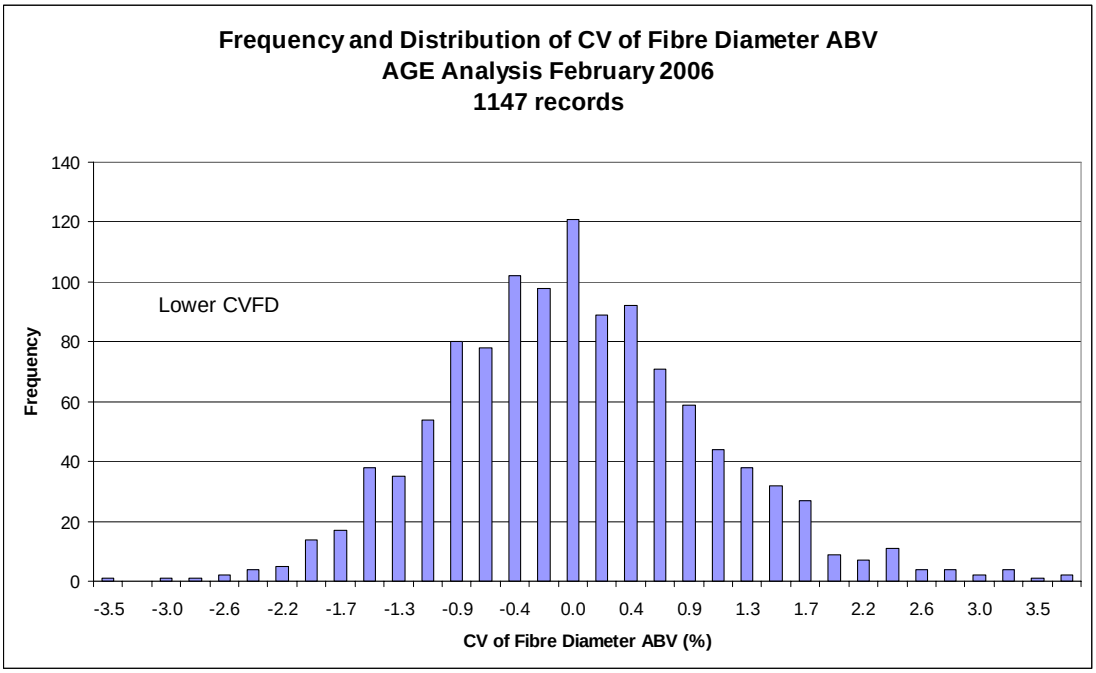
i. Fleeceweight



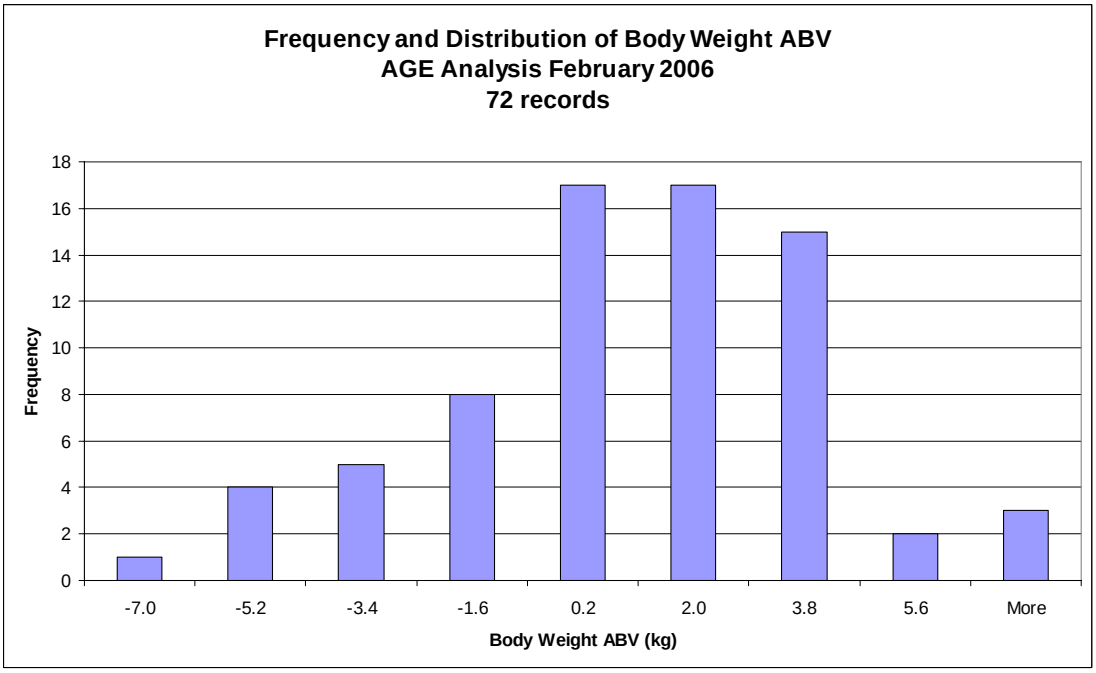
ii. Fibre Diameter



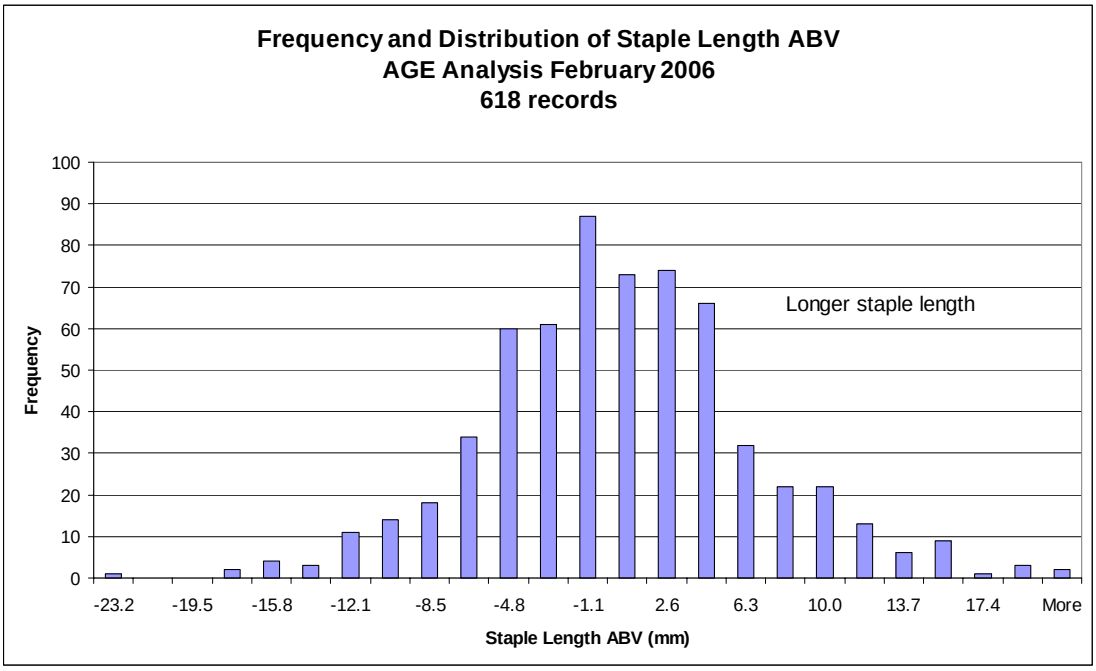
iii. CV of FD



iv. Bodyweight



v. Staple length



Conclusion

The Alpaca industry with its AGE program is well placed to make similar genetic gain to the other livestock industries in Australia. Progress gained will depend on breeders adopting and using the technology available to them.

Acknowledgements

Ie would like to acknowledge Johanne Taylor and Jennie Staples who have checked all the data and conducted the analysis for the AGE project.

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