AN
AUSTRALIAN
SHEEP GENETICS
SYSTEM

PART 2
GENETICS SERVICE
PROVIDERS
& COMPATIBILITY

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for

Meat & Livestock Australia

and

Woolmark Company Pty Ltd

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Contents Part 2

The more detailed descriptions and analysis in this Part on the Genetics Service Providers and Compatibility are key elements of the full Study. These sections are separated for ease of reading. Section 4.2, in particular, identifies interface issues and aims to assist understanding among readers with varying levels of QG knowledge.

To ensure Part 1 of the report flows logically, assessments on the current Service Provider arrangements and on Compatibility have been transferred into Part 1 (at points 2.3 and 3.2 respectively).

This material has been checked and cross-checked with individuals and by working back to written reports. It should be accurate, but aspects depend on information provided. Most client figures are estimates based on discussions and responses.

4   Genetics services and compatibility

As noted in Part 1, Australian sheep breeders obtain breeding and selection expertise from a mixture of sources, including:

- considerable family experience plus reading and short courses/workshops
- university degrees with genetics, animal production, marketing/ business subjects
- feedback from ram and ewe customers, stock selling agents, wool and lamb buyers
- interaction with, and specifications set by, Breed Societies and at Shows
- advice and selection services from consultant sheep classers
- advice from agricultural consultants and local agricultural departmental officers
- a range of services from specialised breeding consultants using various systems
- involvement in industry-supported selection systems and trials using QG.

As might be expected in a long established, competitive industry, a range of professional selection and advice services is available to sheep breeders to assist their selection. Sheep classers are widely used, working alongside skilled or less experienced stud owners and managers to class and select animals at several stages during a breeding year. Fleece test laboratories are widely used to obtain measurements on fleece samples that are used as a lead or a guide in sheep selection.

The others QG services, ABS, Select, AgWest, McKinnon, and Lambplan, plus a few fleece laboratories providing Rampower EPVs, plus the SRS and Elite wool consultants, all together are utilised by a fraction of Merino breeders. A larger proportion of meatsheep breeders use the services of Lambplan. Features of the following are outlined in 4.1.1 to 4.1.8.

- Lambplan
- Advanced Breeding Services
- Select Breeding Services
- Central Test Sire Evaluation
- Agriculture Western Australia
- Natural Resources & Environment, Victoria
- Mackinnon Project – University of Melbourne
- SARDI
- Independent consultants
- Soft Rolling Skins and Elite Wool systems
- Professional sheep classers and stud advisors
- Practial advisers and service providers (laboratories, scanners)

More detailed workings of these services, their data assemblies and analysis systems, including questions of compatibility are considered in section 4.2.

4.2.1   Summary of sheep genetics data collections
4.2.2   Enterprises, pedigree, accuracy, links
4.2.3   Traits recorded, measurement and data integrity
4.2.4   Data collection, delivery, processing
4.2.5   Preparing BVs, indexes, comparisons, reports

4.1   A range of genetics service providers

4.1.1   LAMBPLAN – Meat and Livestock Australia

Lambplan is a genetics information system built on quantitative genetics technology. It began in 1988 as an AMLR&DC Project, managed and co-funded by NSW Department of Agriculture.[1] The aim was to implement into practical industry use, more than 20 years' of genetics research by State Departments of Agriculture and other organisations, funded by industry levies and taxpayers.[2]

Lambplan is now an operating division, and a R&D program, of producer-owned Meat and Livestock Australia. Evolution of Lambplan is guided by an industry Advisory Committee chaired by MLA Board Member, Mr Gerald Martin. All parts of Lambplan have been transferred from NSW Agriculture.

Dr Robert Banks has developed Lambplan since 1988. Business Development Manager is Dr Alex Ball. Lambplan has an office manager, and a database manager. AGBU at UNE is contracted for technical product development and breeding value runs. Lambplan Accredited Operators, currently eight around Australia, provide ultrasound scanning of fat and muscle and some advice. Since the start of Lambplan they have run their own businesses, setting prices and scope of services in discussion with customers.

.a.   Goals, markets and customers

Commercialisation of Lambplan began in 1996-97 with introduction of fees for membership (above animal testing and data costs which Lambplan users have always paid) and across-flock EBV reporting. This was a doubly controversial move. Clients numbers declined a degree before re-building.

Lambplan reviewed and clarified its goals and priorities during 1999-2000. After years of operation through changing industry structures, mixed expectations were hindering development. A number of policy issues about its role were considered.

Lambplan Purpose and Priorities – agreed Lambplan Advisory Committee 2000

Goal 1 – Primary purpose and objective : Lambplan is to maximise profitable genetic gain in the Australian sheep industry – The Industry Development Goal

Goal 2 – Lambplan should seek to make core services reasonably understood by and generally accessible to industry levy payers (breeders, producers)
  – The MLA Service Goal

Goal 3 – Lambplan is to recover full cost of operations, and technical and market development, through income from customers, plus a balance of specific purpose funding grants from industry entities or other appropriate sources
  – The Business Goal.

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[1] This section and associated entries in section 4.2 have been checked by Lambplan for factual correctness.
[2] Substantial Meat Research funding has contributed to development of Lambplan in conjunction with NSW Agriculture since 1980. Projects included part of the NSW Meat Sheep Testing Service, the Lambplan precursor; development of BLUP software and data processing technology; accumulation of a large industry data set; evaluation of fat and muscle measuring devices and software; estimation of genetic parameters for growth, fat, reproduction, wool and carcase traits in meatsheep breeds; development of breeding objectives, selection procedures, indices; development of a national Lambplan model and national co-ordination, quality assurance, accreditation, training and advisory packages; terminal and maternal sire central progeny tests.   Lambplan has received some development funds each year.

Lambplan's clients are currently Australian meat-sheep and specialist sheep breeders, plus some Merino breeders interested in Lambplan services and/or looking to develop meat traits. At 2000, near 600 Australian studs are involved with Lambplan; 580 are breeding meatsheep. This is a good way towards a 'target market' of 800 [2.1.1]. However, adoption has been variable.

> "Lambplan has gained wide acceptance in the terminal sire and dual purpose breeds (70 to 80 per cent of rams sold with genetic information) and lower but growing acceptance in the maternal breeds (around 40%). Around 75 percent of current members rate Lambplan as essential or very important to their seedstock business and around 80 percent believe that future genetic progress will be higher with Lambplan than without Lambplan. This leaves a substantial minority of users who do not place great value on the tool." *Genetics Review for MLA 1999* [3]

Lambplan assesses that its customers supply over 70% of annual terminal sire replacements (Poll Dorset, Texel, White Suffolk) and about 11% of Border Leicester replacements. Lambplan member studs also provide about 85% of dual-purpose breed (Corriedale, Coopworth and others) ram replacements. In NSW membership is about 40% of studs of all sizes, in Victoria closer to 35%, in SA and WA, 50-60%.[4]

Lambplan membership grew from 1989, fell with introduction of fees and across-flock EBVs and has recovered and flattened. The number of new-drop animals entered into Lambplan reached 112,000 this year. 1999 numbers are still accumulating.

In recent years, the number of animals tested per flock has grown, particularly because Lambplan members are increasingly measuring and obtaining EBVs on ewe lambs as well as ram lambs, but also because some studs, mostly smaller in size, have left Lambplan for various reasons including costs and results.

LAMBPLAN custom 1988-2000

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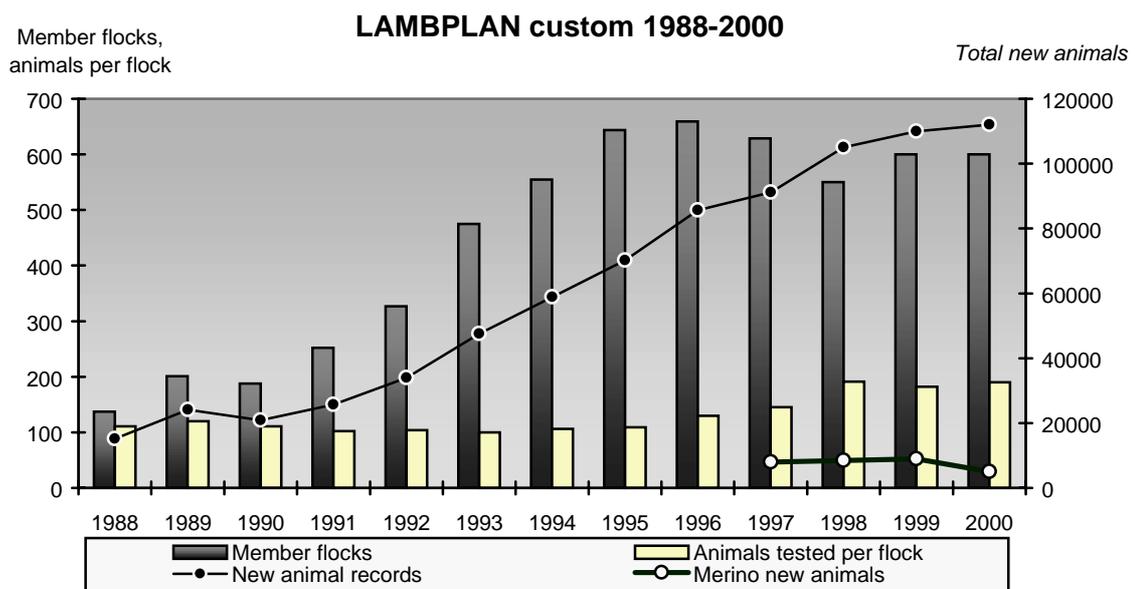
[3] *Review of Genetic Improvement Programs in the Beef and Sheepmeat Industries* 1999 for MLA., Summary.
[4] Lambplan has five New Zealand clients, and has been contacted by Canadian and USA breeders. Nine Boer Goat breeders are clients as a group through the Boer Goat Breeders' Association. A Deerplan system is available.

Lambplan considers it can provide services to the full range of Australian sheep breeders. A number of a technical adaptations for Merino breeders and advisers have been included as Lambplan has evolved, including a syndicate group facility.

Since 1996, wool trait measurements have been recorded in Lambplan's database alongside meat, growth and reproduction traits. In 1999-2000, 13 Merino and four Meat-Merino studs used Lambplan for part of their flock. About 5,000 new records are being added.

.b.   Breeding – vision and results

In explaining Lambplan, Robert Banks and Alex Ball state that their aims are: [5]
  – to help breeders to achieve very high rates of well-targeted genetic improvement, and
  – to ensure that genetic improvement is tightly integrated with on-farm management
     and the aims of commercial producer enterprises.

As for all service providers, Lambplan's perspectives on genetic advance and breeding services are demonstrated through its system, its information, its client service approach, and its business operation.   Key features are :

• Lambplan accepts and processes records for up to 40 sheep, meat and wool traits (including groups such as weights at different ages) – refer 4.2.3.

• The Lambplan database now contains records for 770,000 sheep in 23 breeds, with many pieces of information on some animals. All flock data is kept and there are numerous sire links for use in BLUP analysis.[6] In 1999, Lambplan commissioned new BLUP software (OVIS by AGBU) to enable more powerful processing using the large database, and to improve EBV calculations – 4.2.4.

• Estimated Breeding Values (EBVs) can be calculated using BLUP and Lambplan's parameters for 35 traits – 4.2.5.

• Lambplan calculates and reports all EBVs and standard Selection Index rankings on an Across-flock basis and is preparing to calculate EBVs on an across-breed basis where comparisons are technically feasible (eg. Dorsets, Texels, White Suffolks and Suffolks).

• Lambplan's Selection Indexes (SI) combine EBVs for commercially important traits into a single weighted measure of an animals' genetic merit to assist breeding decisions. Fourteen Breed and special purpose Selection Indexes have been developed. Customised SI are possible – 4.2.5.

• A set of Key Service Targets define Lambplan's service delivery aims. Changes are being made to achieve all the KSTs for database management, scanning occurrence, data transfer, EBV reporting (fortnightly), accounts, handling questions and providing advice, workshops and marketing.

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[5]   *The Australian Prime Lamb Group Compendium 2000*, p30
[6]   References to numbers such as 1,700 total flocks and 500 Poll Dorset flocks, are referring to all flocks with some
       records held in Lambplan accumulated over 12 years. .

The move to Across-Flock comparisons

Initially, Lambplan operated through a series of licensees who provided animal testing and local data processing to produce ranked EBVs using only the information on the, say, 100 young Dorsets scanned and recorded on a stud (ie. Within Flock).

In 1996, the Lambplan Committee made a policy decision to provide only Across-Flock EBVs using extensive data then consolidated in the Lambplan national database. Over 1994 and 1995, both within-flock and across-flock reports had been available to users. A member now receives EBVs (say for the 100 young Dorsets) calculated from comparisons with all possible information in the Lambplan database (across all stud flocks and across all years) for sheep in that breed type.

The Lambplan Committee's aim was to support higher levels of targeted genetic gain in the meat sheep industry. With Across-Flock EBVs, all recorded, genetically linked animals can be directly compared for their genetic value. The best animals within the flock, or within the breed, for any trait or set of traits, can be selected by breeders, and bought by commercial producers.

Breeders can also monitor whether their flock, or the breed, is advancing genetically. The average genetic merit, in terms of EBVs and Selection Indexes, of each year's sheep entered into Lambplan, should be increasing.

Lambplan's change to Across-Flock EBV reporting in 1996 was a controversial policy decision.

Within a short time it became apparent that some studs were producing many Elite listed animals and others none. To be listed as an Elite Animal each year, an animal must be in the top 150 of all animals of its category (sire, dam, young male or female) in that breed recorded in Lambplan (so, of 360,000 Dorsets). As genetic gains advance, most Elite animals are from recent drops.

Further, Lambplan's traditional 'blue dot' listings changing from ranking the 'top 25%' rams within one breeder's flock to identifying the top 25% Across-Flock animals from all young animals entering Lambplan that year. Some studs soon had few or nil 'blue dots', although some were winning show ribbons on visual appearance.

The reasons for the change to Across-Flock has been explained in many forums.

"Some breeders have questioned the decision to provide only Across-Flock EBVs and index values. This decision was taken by the full Transitional Management Committee because it is critical to ensure that Lambplan information is as simple and helpful to breeders and producers as possible. …since Lambplan began, breeders and producers have demanded the ability to know where to get the best genetics for their enterprise.

This can only be done with ACROSS-FLOCK EBVs.

Having some breeders providing Across-Flock information and others within flock, is a recipe for confusion. Obtaining reliable, accurate across-flock information is quite straight-forward, and is already being achieved by the vast majority of breeders who use Lambplan. Making Across-Flock the standard protects everyone's investment in Lambplan." *Lambplan Newsletter February 1999*

Genetic and marketplace advance

Calculations for the now over 110,000 new animals entered yearly to Lambplan's database, show substantial increases in the Terminal Meat-sheep Sire selection index in particular since Across-Flock began in 1996. The 8% Merino Wool Index calculations from 1997 also show results of selection.[7]

LAMBPLAN Genetic Trends in Meat & Dual-Purpose Sheep
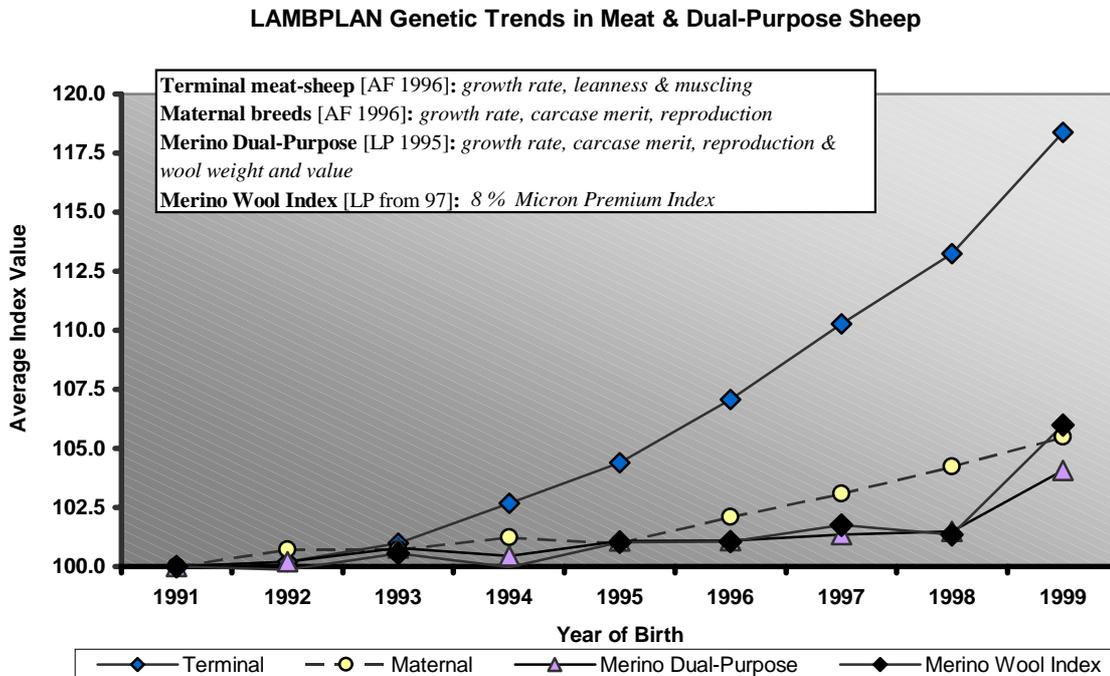
Over a decade, use of the Lambplan system has increased returns to industry enterprises along the prime lamb supply chain – from breeder to retailer.

More breeders are using Lambplan information in selecting and selling rams, though a proportion still do not use Lambplan, or advertise the results [2.2.1]. Lambplan identifies that *breeders* are receiving premiums for Lambplan rams ranging now from $60 to $200, or much more through semen sales. Terminal Sire breeders (such as Dorset studs) can make $10 to $12 per breeding ewe, each year, above Lambplan costs.

Commercial lamb producers are recognising higher performance by paying price premiums for Lambplan rams, especially for those with high EBVs and SI values. However, there are concerns about how well Lambplan and potential benefits are understood and how much weight ram purchasers are placing on Lambplan figures, compared to other factors of merit and convenience.[8]

There are also winners and losers in across-flock comparisons. A number of meatsheep breeders have been highly advantaged by the Lambplan system and its marketing, while others have been disadvantaged by the results. Some of these have left the business; others seek industry support for alternate processes.

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7 Chart prepared by Dr Robert Banks from the Lambplan database.
8 Concerns identified during Lambplan reviews 1999-2000, by the Lambplan Advisory Committee, and by the
  Review of Genetic Improvement Programs in the Beef and Sheepmeat Industries 1999 for MLA.

.c.   **Products, services, market response**

Lambplan's priority has been development of a low-cost, effective genetics system and marketing this to a broad-base of meat-sheep breeders. Reports and other products have been developed over the years by Lambplan managers with input from clients. In 1997, charges of $100 for membership, $225 for annual registration and $1.20 per new animal entering the database were introduced.

In a 2000 review, two product lines were developed, Lambplan Standard and Lambplan Plus.[9] Pricing was adjusted to reflect costs, user returns, market feedback and to provide choices. The new products and prices are designed to recover about 85% (60-70% now) of Lambplan's about $450,000 yearly costs, while being more attractive to smaller studs. Lambplan anticipates losing some clients as a result of price increases.

Lambplan PRODUCTS	PRICES (with GST)
Lambplan Standard Entitles members you to receive the following products and services: • One EBV report per year posted between 10 and 14 days of client data. • One National Breed Summary, including a ram marketing report for the member's flock in August each year plus an Elite Animals Summary. • Access to the Lambplan website, where you can obtain information and news from Lambplan. Plus papers and reports of interest, and Lambplan Research and Development reports. • One copy of current Pedigree Wizard computer program at time of joining. • Lambplan Newsletters – Quarterly via post.	$ Joining Fee (new clients) 110 1 Stud Service Fee 165 2 Studs Service Fee 264 3 Studs Service 297 Each additional stud 33 Per Animal Charge (invoiced when animals enter database) $ 2.20 each
Lambplan Standard Add-ons Birth & Weaning Weight EBV Report, Additional Later Weights, Add Traits Elite Animal Summaries (above 1 a year), Pedigree Wizard Updates Additional Genetic Trend Reports, Inbreeding Analysis, Accuracy Analysis Lambplan Sale Pack, Breeders' Directory, Structural Trait Analysis Listing in Lambplan AI Sire Register Flock Genetic Merit Listing	$ each 27.50 each 27.50 each 27.50 each 27.50 per sire per year 27.50 per flock per year 27.50
Lambplan Plus The ultimate products and services package which contains: • All the Lambplan Standard products and services. *Plus:* • Extra EBV Reports ~ Birth, weaning weight, later weights, additional traits • Extra copies of Elite Animal Summaries • Mate Checker Report • Pedigree Wizard Updates ~ every quarter • Structural Trait Analysis • Extra Genetic Trend Reports and/or extra traits • Inbreeding Analysis • Accuracy Analysis • Breeders Directory Updates • Packs of Lambplan Sale Cards plus Brochures • Listing in AI Register • Listing in the Lambplan Flock Genetic Merit List	$ Joining Fee (new) 110 1 Stud Service Fee 357.50 2 Studs Service Fee 572 3 Studs Service 643.50 Each additional stud 71.50 Per Animal Charge (invoiced when animals enter database) $2.20 each
Specialist Lambplan Add-ons Customised Index Development Gene Detective Analysis Advisor at a Client Field Day or Sale Lambing data entry book	$ per index 275 per report 110 per day + expenses 550 per book 27.50
Total Genetic Resource Management (TGRM) - TGRM is a mating program that considers the animals that are available for selection and breeding, and based upon a number of inputs provided by the user, suggests which sires to use, how often to use them and to which females they should be mated. TGRM clients must have Lambplan results.	*TGRM Initiation* (first use) $55 + $2.75 per ewe mated *TGRM Advantage* $165 + $6.60 per ewe mated for 3 TGRM runs.

"If under the new pricing policy you are Lambplan Plus, then you have access to elites and your animals data every month I think. It seems anyone serious about Lambplan has to take up the Plus package, or at least a lot of the add-ons." *Breeder, Greenthorpe NSW, August 2000*

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9   From the Lambplan Product and Service Catalogue 2000 and Annual Subscription Form, September 2000.
    The TGRM product is described in section 1.3.2.

Messages from the marketplace are important in development of all services. Many of the concerns summarised below are not Lambplan specific – similar comments are made about Quantitative Genetics systems generally.

The supply of advice in addition to reports, newsletters and internet 'tips and tools,' plus extension of Lambplan merits to ram buyers, is an issue. The implied expectation is that this would not incur additional charges. Lambplan's philosophy is that breeders are the main interface with commercial producers – their clients – and breeders will develop their marketplace strategy. Lambplan provides a question-answering service and periodical workshops but intensive, personalised advice, if costed fully, is an expensive exercise, *and a real cost recovery issue for all service providers.*

Lambplan after 12 years – positive features and marketplace concerns

A set of perspectives can be summarised from various MLA and Lambplan studies during 1999. These influenced Lambplan's Key Service Targets and product changes for 2000.

Lambplan's Positive features

- Recognised by breeders and scientists as a technically strong genetic improvement system

- Many breeders and producers see better future genetic progress with Lambplan

- Lambplan is used by about 40% of studs, 42% of producers surveyed in 1999 have access to selection index and EBV information, 30% use it, 52% pay more for Lambplan rams.[10]

- Lambplan has been developed by industry, for industry gain, not for commercial profit, it
- operates nationally, and is physically accessible to most breeders

- It has a track record in achieving genetic gain for many users especially with Across-Flock

- Lambplan is a reasonably straightforward system, *after* some learning

- It has a strong intellectual property base, largest sheep database in the world, with potential for expansion in sheep in Australia, including for wool traits, and to other animals.

- Lambplan has built a relatively low cost service as the industry wanted, a committed team

- Most clients are positive, and they receive services as needed, some new products have been developed in response to customer and industry feedback

Concerns and criticisms

- Needs to be more market or commercially minded, too focussed on technical genetics

- Low cost operation limits responsiveness and services, such as discussion of results

- Across-Flock favours some breeders and breeding directions, not enough information provided on what is happening in own flock

- Difficulties with indexes – lack of response to concerns about structure of indexes and fit with visual appearance (such as breed characteristics for showing)

- Selection indexes should recognise needs of different regions & markets

- Lack of understanding of Lambplan among breeders and producer ram buyers, too complex and too little explanation of data in marketing to producers

- Most clients support efforts to date, but would like clearer reports and more advice. Some have difficulty arranging scanning to suit them, and there are occasional delays and mix-ups

- Pre 2000 costs seen as 'high' especially for small breeders. Of those who have left Lambplan, 70% indicate that it is too costly, 25% that it is too complex or not useful to breeding aims.

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[10] MLA *Review of Genetic Improvement Programs in the Beef and Sheepmeat Industries* 1999

4.1.2   Advanced Breeding Services – NSW Agriculture

> "Advanced Breeding Services is now recognised as Australia's leading technical adviser to Merino breeders.
>
> Advanced Breeding Services clients include major wool industry agencies, such as the International Wool Secretariat and The Australian Association of Stud Merino Breeders, as well as ram breeders and commercial wool growers." *ABS brochure and website 2000*

ABS commenced in 1991 and is now a specialised NSW Agriculture consultancy unit based at NSW Centre for Wool and Sheepmeat Research, Orange. ABS Services include research, training to educators, service providers farmers and students as well as the major role of development of personalised wool industry breeding programs.[11]

The Advanced Breeding Services Consulting Team is Allan Casey, Unit Manager and Consultant, Dr Kevin Atkins, geneticist, a Systems Operation officer and two data analysts. All spend part of their time on ABS as required. Four regional Sheep and Wool Officers specialise in Merino breeding. ABS service is not limited to NSW.
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.a.   Goals, breeding vision, products, markets

ABS's aim was, and is, to develop an integrated technology transfer system to Merino ram breeders. Specialists provide technical consultancy support to Merino breeders. The advice and support, built on Quantitative Genetics principles, is personalised to the needs of each client.

ABS goals and markets – in summary from publications and discussions [12]

- To encourage Merino breeders and woolgrowers to define breeding objectives which emphasise fleece weight and fibre diameter as key commercially important traits.
- ABS has been involved in the Premium Wool CRC 'fining the clip' goal.

- To encourage Merino breeders and wool growers to achieve those objectives, by considering different bloodlines for breeding stock, and for stud breeders by using personalised ABS genetic services including breeding values and indexes.

  > "Co-operation with, not replacement of, the service provided by labs and other service agents, such as professional sheep classers, performance-recording suppliers is a feature of our approach to servicing clients."

- To provide advice services, recognising the practicalities of breeding and wool production, and that managers must make many breeding and production decisions.

- To recover full costs (salaries, overheads, expenses) of consulting activities via charges to clients.

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[11]   This section has been checked with ABS for factual correctness.
[12]   ABS success should contribute to the NSW Agriculture mission: *NSW Agriculture will lead food and fibre research and be recognised as the premier public provider of information and services for the food and fibre industries of NSW*. Refer website, brochures, discussions, including ABS *the No.1 Decision support service for Merino breeders.*

Advanced Breeding Services looks to provide tailored support by working closely with breeder customers with focus on the breeder's objectives and the needs of the breeder's clients. ABS provides a range of services from calculating EPVs, to mating allocation systems, to design of sire evaluation.[13]   Products include:

- *Data Processing* outside the range of on-farm or fleece measurement systems including, pedigree records (full or sire), sire evaluation, combining group/year/site data, additional traits including fibre diameter variation and visually assessed traits.
- *Genetic progress* by supplying ram breeders with "year by year" genetic progress reports, packaged in a way that can be easily transferred to flock ram clients.
- *Breeding and marketing*, recognising that ram breeders need a high quality product and also to sell it. The range of services is structured to assist marketing.
- *Customisation*: "Traits reported and the format of the report structured to suit".
- *Support* for entry into Bloodline Wether Trials [4.1.2.b], Merino Benchmark [4.1.2.c] and Central Test Sire Evaluation [4.1.4].

Some ABS business dimensions

- *In 2000, ABS has about 70 Merino ram breeder clients (including 26 with Merino Benchmark)* from NSW and elsewhere, using one or more ABS services. ABS says its clients breed 40% of NSW rams sold each year and 18% of national rams.

- An issue in tailoring services is the extensive nature of Merino flocks and difficulty of obtaining pedigree data linking a lamb with its sire and dam. Full pedigree is viewed as less necessary for highly heritable key traits – diameter, fleece weight [4.2.2].

- ABS clients have breeding objectives that on average should deliver genetic gains of +8.2% in fleece weight and 0.86 microns fibre diameter reduction to their producer clients over 10 years. ie. an increase in productivity among commercial clients of at least 1.5% per annum. *Kevin Atkins*

- ABS aims to charge clients for service time – special genetics advice $250 an hour, general ABS advice $100/hour, processing data & reports including BLUP, $60/hr.

The RAMPOWER 2000 System and BVEST BLUP software

Over 80s and 90s, NSW Agriculture developed BVEST breeding value estimation software, a BLUP system used by ABS to calculate Estimated Progeny Values (EPVs) and selection index ranks mostly within a client's flock, or for trial groups. BVEST is used for across-flock analysis for Merino Benchmark. The Rampower Parameters for Merinos are used by most geneticists. BVEST was used by Lambplan until 1999.

Features of the BVEST system, Rampower EPVs and Indexes are covered in 4.2.4 to4.2.5. NSW Ag has developed OBJECT software to assist in advising on breeding objectives. The NSW Ag policy is to share such software. Intellectual property is not an obstacle.

The Rampower 1996 and Rampower 2000 software sets, developed with support of Woolmark are data processing programs provided to fleece testing laboratories across Australia. The Rampower software includes a BVEST set for calculation of EPVs from fleece test results, particularly diameter. Usage is discussed in sections 4.1.8, 4.2.4.

.b. Industry wether trials – Bloodline comparisons

"Merino Bloodline Performance for Production, Quality and Profit from Australian wide Wether Comparisons", is a long-running project, part-funded by Woolmark and conducted by NSW Agriculture (leader Kevin Atkins) in collaboration with other state Departments of Agriculture and Wether Trial committees.

The Project "produced the first nationally relevant publication of credible bloodline genetic comparisons" and has publicised these. It set out to develop comparisons of the genetic merit of different Merino bloodlines and ram sources across Australia, to increase ram buyer awareness of the impact on profitability of different Merino rams, and to encourage 'mobility' (changing ram source). 'Profitability' is indicated by Bloodline positioning on a chart according to *average clean fleece weight* and *fibre diameter* of wethers from each bloodline, measured across a number of trial sites.[14]

Over 10 years to 1998-99, the 67 Bloodline Wether trials in NSW, SA, WA, Tasmanian and Victorian locations, compared the performance of 192 Merino bloodlines. Among these were results of high to medium accuracy on 75 bloodlines for fleece weight, average fibre diameter, yield, fibre diameter blow out (increase with age), body weight, style, length, colour, tenderness and profitability.

In particular, the trials have demonstrated that fine wool bloodlines which were traditionally restricted to cooler, wetter areas, can perform in drier regions.

> "The most striking result emerging from this work is that at today's prices there are clear opportunities for commercial producers to improve the profitability of their flock by identifying bloodlines that not only have genetic potential for lower diameter, but also for relatively large quantities of wool."

From a genetics information perspective, the Bloodlines wether trials have generated large quantities of Merino sheep data, which can be characterised as of mixed quality and usefulness for further genetic evaluations. Much of the data is production measurements or scores from wethers only specified by 'bloodline' and stud source. Trial results are reported as differences (+ or -) in traits and scores for the bloodline (averaged over number of teams entered) when compared to the 'all- bloodlines' average for each trait over the years of trials.[15]

Estimated bloodline effects for production traits (deviation from average)
components of wool type and gross margin (1993-1997 results)

Bloodlines	Code	GM/DSE (%)	CFW (%)	FD (%)	YLD (μm)	FDST (μm/yr)	BWT (%)	Style	Length	Colour	Tender	No. of Teams	Accu-racy
Gingie	212	3.7	0.0	-0.28	0.7	0.15	-2.6	2.28	1.47	1.18	1.10	6	M
Goolgumbla	47	4.4	3.7	-0.39	-0.1	0.04	6.2	2.30	1.44	1.29	1.10	6	M
GRASS Merinos	89	-8.6	-3.8	-0.30	-2.1	-0.16	7.3	2.33	13.7	1.13	1.08	4	M
Haddon Rig	1	-1.7	-4.2	-0.44	-0.6	-0.05	-1.7	2.32	1.42	1.17	10.8	62	H
Hazeldean	24	14.6	7.8	-0.41	0.1	0.25	1.2	2.33	1.29	1.18	1.12	35	H
AVERAGE		15.4	4.6	21.69	72.8	0.66	53.4	2.33	1.43	1.16	1.09	11.4	

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[14] Project report August 2000, plus *Merino Bloodline Performance report – Which bloodline will make you the most money?* Also *Agnotes: Merino Bloodlines – The Comparisons 1987-98,* and *Choosing a bloodline source.*
[15] NSW Agriculture, *Merino Bloodlines Comparisons* First edition 1998, website & *Merino Bloodline Performance* brochure.

.c.　　Merino Benchmark: across-stud

This is a Merino stud breeder initiative with ABS to develop across-flock sire evaluation which enables comparison of the performance of rams bred by some leading studs across Australia. The animals are benchmarked against two baselines of average performances in groups of fine and medium wool stud sires. These are the same fine and medium baselines used in CTSE [4.1.4].

Merino Benchmark's Public Reports are prepared annually by ABS and provide results and rankings for the animals entered into the scheme by the member studs. These results – EPVs for Greasy Fleece Weight, Clean FW, diameter and CV, body-weight, staple strength and worm egg count, are directly comparable across-flocks. ***Across-flock rankings are provided for four Selection Indexes, the three Rampower standard indexes, plus a 6% micron and high bodyweight index.***

Merino Benchmark commenced in 1996 with eight member studs, four from NSW, and one each from Victoria, SA, WA and Queensland. Eight new members joined in 1998, all from NSW. Both fine and medium wool breeders are involved. Not all are registered studs. There are now 26 members. A few sell thousands of rams or semen straws a year, most sell some hundreds, and a number have just started ram/semen marketing.

Merino Benchmark Across-flock evaluation – features [16]

Member flocks must meet Merino Benchmark Quality Assured Standards and audit requirements for entry, and have a positive approach to industry genetic improvement based on the key measured traits.

Basic system requirements are :
- That a progeny group (a flock in a mating period, or a breeding tier) is recorded at least once for greasy fleece weight and fibre diameter according to stated procedures (diameter tested through a Rampower accredited test house).
- Improved data quality is encouraged: adding sire, dam, date of birth, birth status, dam age. Incomplete pedigrees from most studs currently means genetic gains between two generations are smaller than could be achieved with more pedigree information.
- For mating, sires must be identified or an equal allocation (random) of ewes per ram.
- Animal identity must be unique across years and sites.
- Culling: only injured, mismothered and black wool progeny to be culled, all other recorded for the base traits (GFW, FD)
- Linkage: 35 progeny of more of a common sire(s) or equivalent links through other pedigree records must be recorded to become a 'sire' (before that listed as 'rams').

Members are responsible for all costs of sampling and measurement. They provide data to ABS for Benchmark processing. A new 'private' membership category from 2000 enables new members to have their on-stud data included in comparative analysis with results kept private. Of the current 26 member studs, 3 are private.

Over 5 years, data and EPVs for 105,000 progeny in on-stud mating groups have accumulated. About 40,000 were added in 2000 due to new members and new progeny. About 20,000 new animal records are expected next year from current members.

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[16] *Merino Benchmark – Australian Across Stud Evaluation*, 1999A; *Merino Benchmark Quality System Manual* May 2000

Data collected from all participating properties, plus all data in the Central Test Sire Evaluation database, are used for calculating EPVs and Indexes. The early 2000 public report was based on 1,666 progeny tested sires from Merino Benchmark and CTSE combined. This becomes 'the Benchmark' until the next annual run (the original baselines of 0.0 for an EPV and 100 for an Index stay the same). The animals are compared across-flock and are ranked in their order from a 6% MP Rampower index [4.2.5]. Breeders also receive calculations for personalised breeding objectives.

The Merino Benchmark database is held by ABS. Benchmark members may submit new data for private runs during the year, at a cost. Non-members with animals linked sufficiently to the 1,666 sires, can obtain private benchmark reports through ABS.

In a recent paper, NSW Agriculture geneticist Kevin Atkins, described the importance of across-flock analysis, and the progress of Merino Benchmark over four years.[17]

> *"Across-flock evaluation is the ultimate genetic tool to achieve gains in productivity by using both within- and between-bloodline variation.*
> The formation of Merino Benchmark in 1996 has seen across-stud performance evaluation arrive in the Merino industry. Rams used as link sires (aided by central test sire evaluation) and expanded use of pedigree recording allows the ram breeding sector to extract considerable increases in rates of genetic gain above the within-flock selection potential alone.
>
> Member flocks of Merino Benchmark are already superior to the industry base-line provided by medium-wool (MWCT) and fine-wool Central Test (FWCT) [graph]. Thus, future elite rams for the Merino industry are likely to be bred by linked flocks that are superior on current performance and extracting higher rates of gain in future through access to genes from other superior flocks."

Fleece weight Vs Fibre diameter (progeny values) for MERINO BENCHMARK flocks Vs Central Test

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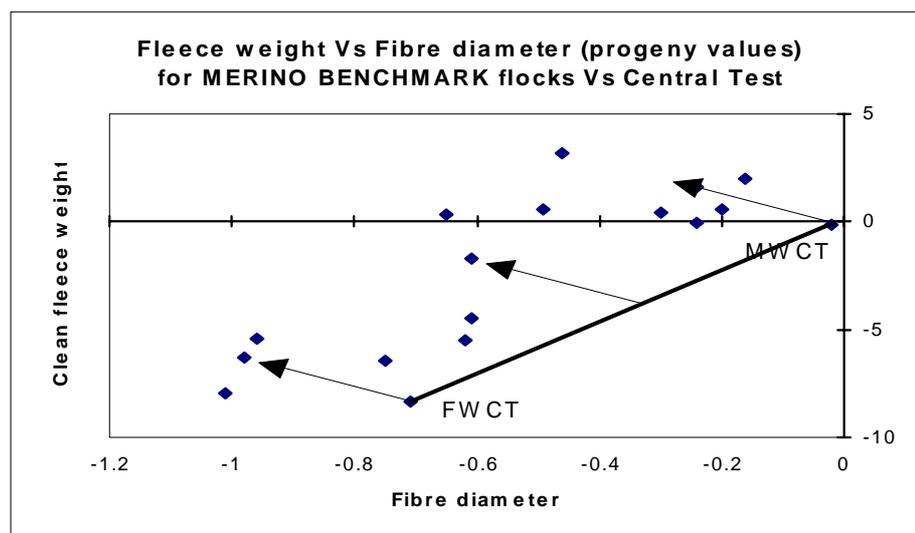
[17] The diagram shows the advance away from the baseline (FCWT to MWCT) with individual Merino Benchmark studs shown by the diamonds and trend lines (heavier cutting, finer wool sheep) shown by arrows.

4.1.3   CSIRO – Select Breeding Services and databanks

"Combining the genetic expertise of CSIRO with personal attention to your individual requirements". *Select Breeding Services Website, 2000*

"Within a framework of assisting breeders to breed, grow and market wool more profitably, the major area of work is in genetic evaluation for measured production and parasite resistance, including sire assessments, across-year analyses and estimating genetic trends." *Select Breeding Services project report August 2000*

Select Breeding Services (SBS) was launched in August 1998, with some Woolmark funds, to provide Quantitative Genetics consulting services.[18] Aims included:[19]

▪ to expand sheep breeding consultancy to the level of cost recovery by December 2000 taking advantage of developments in DNA pedigreeing, finewool flock parameter estimates, and continuing interest in breeding for worm resistance, and

▪ to provide an effective means for interaction between CSIRO researchers and breeders so that practical problems of changing breeding programs are understood by scientists, and … research outcomes are appropriately focussed and successfully incorporated into practical breeding programs.

Some Select Breeding Services business dimensions

- *Select has 15 - 20 Merino ram breeder clients, selling some 1,600 rams a year with estimated flow on effects to about one million commercial ewes and wethers.* Most clients are AAMSB registered, 5-6 are unregistered breeders.

- Half of these clients are based around Armidale. Particular effort has been made to approach potential clients in Queensland mostly by telephone. The major client is the New England Merino Sire Evaluation. Select provides organisational and data management services including genetic analysis and reports.

- A recent SBS survey of clients indicated that these breeders find SBS advisory services good and useful, with most willing to recommend SBS to certain breeders, and most finding the SBS charges 'good value for money'.[20]

- Current consulting charges are about $500 for discussion, breeding calculations and a personal report. SBS feels it should have sufficient business to cover costs by end 2001-2002. (This would appear to require substantial increases in clients and prices).

- The CSIRO Livestock Industries Division has recently reviewed SBS Services, noting developments in sheep genetics nationally, and the end of three year funding support from Woolmark. *Some changes are expected, but it is understood that CSIRO plans to continue providing genetics advice, aiming to target leading breeding enterprises.*

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[18]   The SBS Specialised Consultancy project is part of the Woolmark Rampower project set. In part SBS was to continue to service clients of the Nemesis parasite resistance project previously funded by IWS.
[19]   From SBS, CSIRO documents and website, and discussions. This has been checked with SBS for factual correctness.
[20]   Select Breeding Services, Customer Satisfaction Survey July 2000

The SBS team at CSIRO Division of Livestock Industries, Armidale NSW includes Lindsay Brash as Manager Select Breeding Services, plus on-call specialist CSIRO advisers: Drs Rob Woolaston, Sandra Eady, Ian Purvis, Andrew Swan, Laurie Piper.

Select's Products and Services – *SBS Website*

- *Flock Genetic Evaluation*: within-flock genetic evaluations which provide Estimated Progeny Values (EPVs) for individual animals in the flock on key traits (usually fibre diameter, fleece weight, and for some faecal egg counts).

- *Tailored Selection Indexes, Selection Emphasis Analysis*: After selecting young rams or ewes based on a specific Index, measurements and visual factors, a Selection Emphasis analysis shows the impact selections on the breeding direction of the flock.

- *Genetic Trend Analysis*: Reviews a breeding program after several years to map the progress of genetic improvement of a trait, for use in future breeding.

- *Choosing a Bloodline Source*: Assists growers to find a ram source with the genetics for profitability into the future, and to decide whether to pay more for better performing rams?

- *Wool Price Benchmarking*: A detailed analysis of a breeder's or grower's wool lines at auction sale to highlight strengths and weaknesses of a wool production enterprise.

- *Selecting Commercial Sheep for Lifetime Production*: Using early fleece test results to separate a sub-flock to produce finer wool to attract a market premium.

- *Breeding for Worm Resistance*: Design of a breeding program to enhance natural resistance to parasites in concert with continuous improvement in fleece value.

- *DNA Pedigree*: Accurate and flexible means of establishing the parentage of animals in a flock using blood samples for matching lambs with their parent(s) and use of the pedigree plus other information to drive a breeding program for maximum possible progress.

CSIRO data collections

SBS holds client data on its files, but not in the form of a structured database. The data belongs to clients and is used for within flock analysis. Some SBS clients could be interested in contributing their data – which should contain sire links to other Merino breeder flocks – into across-flock analysis in due course. Much of the data has limited pedigree: usually only the animals' sire is identified.

The Fine Wool Project which ran from 1990 to 2000 with Woolmark and Wool CRC support, produced a database of about 10,000 animal records, each with pedigree and subsets with a range of measured traits, including GFW, CFW, diameter distribution, length, strength, colour, body weight at five ages, plus scores for style grade, handle, crimp definition, staple size, colour, density, dust penetration at all ages. FEC, fleece rot, fly strike and reproduction measures were collected, also on large sub-sets, skin measurements and objectively measured style.   There are useful links (about 7%) with CTSE sires. More links might be identifiable, with consideration of the guarantee of anonymity provided to participating breeders.

A further data assembly, from the CSIRO Nemesis project (worm resistance) now forms a significant part of the SBS collection.

4.1.4 Central Test Sire Evaluation - Merino

The performance of individual rams is evaluated in 'across-flock' form through their progeny's results at a range of common sites, in the Central Test Sire Evaluation (CTSE). CTSE began in 1989 and uses quantitative genetics principles to provide breeding performance assessments with the aim of increasing industry usage of high genetic value sires.

A sire's breeding performance is assessed for a large number of traits important to breeders as they appear on his progeny.   Results for rams and sites are reported in Fine and Medium site groups as EPVs which describe the expected performance of the sires progeny relative to the other sires in the evaluation, all compared to Fine and Medium baselines set 10 years ago. A CFW EPV of +4%, is 104% of the base [4.2.5].

There are currently 12 CTSE sites located across Australia, six fine wool sites (NSW 2, Victoria 3, Tasmania) and six medium wool (NSW 3, SA, WA, Queensland). Each have annual AI matings of between 10 and 16 sires to a balanced allocation of ewes, to obtain 25 or more progeny from each ram.

Links across fine and medium groups are increasing as more CTSE sires are used and their offspring entered in CTSE. At least one formal "Link Sire" is mated for each 7 sires, ie. a sire already mated in a CTSE site of that type (medium or fine), with 25 progeny evaluated at least once. Link sires provide genetic connections between years and sites, enabling mathematical separation of environmental and genetic effects and comparison of all the sires.

The CTSE sites are set up and maintained by groups of breeders, who pay for entry of their sires and preparation of the annual site report. "Their forward thinking, hard work and financial backing is applauded as a milestone in merino breeding improvement".[21]   Industry organisations, including State Agriculture Departments, contribute to the running of sites, Woolmark funds Link Sires and preparation of an overall annual report, *Merino Superior Sires*. Most Sites run annual Field Days.

CTSE Traits measured and scored

Most progeny are evaluated at 10 to 16 months, then at 17 to 24 months, for : -

Measured information: Greasy Fleece Weight, Clean Fleece Weight, Fibre Diameter and CV, Body Weight. Fleece testing is carried out at a RAMPOWER accredited testing house. EPVs are calculated using Rampower software and genetic parameters.

Visual assessment: Two recognised, independent sheep classers at each site score all the traits needed to identify "tops" and "culls" – each sire is graded on proportion of 'tops' and 'culls' produced. Conformation and wool quality traits are also scored (++, +, -, --).

Additional traits. Some sites also examine and report, fleece rot resistance, internal parasite resistance and specific conformation and wool and style quality traits.

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[21]   *Merino Superior Sires, Central Test Sire Evaluation results No.6 1999*, Casey, Swan, Coelli, Atkins. Plus Website.

There are specific requirements for accreditation of a CTSE site, but as might be expected, there have been mixed views on quality and accuracy of data especially obtained under different growing conditions, including:[22]

- length and timing of evaluations and number of tests/scorings noting the high costs of keeping a test group of progeny at a site and need for commercial return.
- condition of the progeny and bodyweight at testing at different sites
- assessment and reporting of pigmentation
- number of progeny per sire per site if only one test
- need to improve across-site and across year sire links to compare site results
- data anonymity (all data to remain in report even if breeder chooses anonymity)
- standardisation and supervision of activities such as crutching.

The raising of these questions is important and clearly the CSTE sites are keen to address them, while conscious that impractical restrictions leads to decline in interest. ***It is acknowledged that imperfect data is preferable to no data at all.***

However, variability can also engender scepticism among observers of comparative exercises. This heightens the need for more link sires to enable mathematical adjustment for environmental effects, with these clearly explained.

In the Merino breeding industry, CTSE influence is now appearing. Some AI catalogues include a general description of sires with CTSE results. Some ram sellers include CTSE information in advertisements and websites [2.2.1].

.a.   CTSE information and database

The CTSE site results are processed independently by CSIRO (Dr Andrew Swan). Across-site results are reported in the annual *Merino Superior Sires* (4,500 copies of the No.6 report distributed), and on the website. Reports identify trait leaders and top 25 rams ranked on the three Rampower Standard indexes for Fine and Medium. This information is now widely available to breeders and woolgrowers looking for rams.

The combined all-sites and all-years database is held by CSIRO and ABS, with CSIRO primarily responsible for management. All CTSE sites provide their data free of charge for processing, preparation of the annual report and for the website. Over a decade, records have accumulated for over 500 sires and near 21,000 progeny. These are separated into Fine and Medium data sets with links increasing.[23]

Access to and use of the increasingly valuable data accumulating from Central Test Sire Evaluation sites years has been discussed for some years. Each site owns its data, and there is another layer of information in the Central report.

Over the 1990s, the combined data from the sites was controlled by the Sire Evaluation Committee (SEC), a sub-committee of the AASMB with most sites represented. The AASMB could make final decisions on CTSE issues. ***In April 2000, representatives of all the CTSE sites agreed to form an Australian Merino Sire Evaluation Association (AMSEA) to control and manage the central data, and possibly to administer national CTSE activity.***

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[22]   Advice from notes of CTSE stakeholder meetings.
[23]   Dr Andrew Swan. Also Milestone reports on previous stages of this Central Test Sire Evaluation 1993, 1997.

The catalyst issue was access to data by those outside the CTSE membership and the use of CTSE data in Merino Benchmark annual runs. The CTSE and site leadership considered that the "wool industry needs to be using CTSE data".[24]

The new AMSEA has a General Committee of representatives of each CTSE site and Database Management Organisations plus Woolmark, chaired by Peter Ralston.

In explaining the AASMB decision to no longer be involved, President, Mr Wal Merriman stressed concern about inclusion of unofficial results from unaccredited Merino Benchmark sites, that CTSE requires sites to run trials for 3-4 years and present figures in terms growers can understand (dollars per head, kg per head, micron), and that future sire evaluation and on-farm projects should be funded on a user pays basis.[25]

The CTSE full database was tentatively opened "for the purpose of improving the breeding progress and therefore the profitability of Merino businesses" in August 2000. Genetics advisers looking progress comparative evaluations may have access to the Merino CTSE database under certain conditions. Some potentially interested users consider these requirements put the information out of practical reach.

Access to CSTE database(s). An approved user must, in summary: [26]

- sign a Database Access Agreement
- have an approved Quality Assurance System(s) for accurate on-farm performance outcome (eg. for a new trial) and procedures for analysis and reporting of outcomes.
- use only a current Database and all of the Fine Wool and/or Medium Wool Database
- not report details of any sire in the CTSE Undisclosed Sire List, unless the breeder and owner permits.
- prepare reports from the database only listing animals evaluated on-farm and bred and owned by breeder(s) obtaining the report unless permission obtained for other sires.
- for all outputs using the CTSE Database, use the CSTE analysis procedures and presentation of results ie. the Rampower system, including genetic parameters, same units for performance reporting, and one of the two CSTE standard bases – Fine Wool Base (1990 to 1992 New England CTSE drops), or Medium Wool Base (1989 to 1991 Riverina & Macquarie CTSE drops)
- explain indexes used fully, especially if not a Rampower standard index
- make clear on any reports that on-farm data is used and they are not CSTE reports
- submit Public Report format(s) to AMSEA for approval prior to public release of any information that utilises the CTSE Database, with an Access Compliance Checklist.
- pay an access for a copy of the of the Database of $250, and $100 per breeder, maintain auditable usage records plus provide an annual statement.

"***The full potential for CTSE will be realised when it plays a pivotal role in national across-flock evaluation utilising both central test and on-farm records.***
… it is likely that technical developments in genetic analysis of measured traits, incorporating visual traits in a genetic analysis, accounting for reliability and using effective genetic groups will provide the industry with confidence in across-flock evaluation." [27]

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24 Advice on CTSE stakeholder meetings.
25 From *The Top Sire,* Newsletter of the NSW Stud Merino Breeders' Association, Jan-June 2000
26 Summarised from AMSEA *Conditions for Access and Utilisation of the CTSE Database*, August 2000
27 Kevin Atkins, Allan Casey, Kathy Coelli (1999) Sire evaluation for Merino ram breeders. Proceedings of Thirteenth Conference of Association for the Advancement of Animal Breeding and Genetics, 13: 138-143

4.1.5   Other quantitative genetics service providers

A small number of geneticists across Australia focus on providing quantitative genetics services to breeders-in-the-field.

This is occurring mostly, but not only, though State Department of Agriculture units (in addition to Lambplan, NSW Agriculture-ABS, and CSIRO-SBS).   There are a few commercial advice providers. Some advisers concentrate on services to Merino breeders, often building on laboratory fleece testing results [4.1.8].   Others are providing advice to Merino or meatsheep breeders, plus TRGM services.

.a.   Agriculture Western Australia

From a small scale start four years ago, the Agriculture WA Wool Program has been expanding its genetics advice for sheep breeders. A Business Plan has been prepared for a formal Genetics Advisory Service.[28]

Geneticist Dr Johan Greeff was joined by Dr Bronwyn Clarke in 1997 and by Dr Natalie Barnett in 2000 as demand for services has increased. Regionally based WA Agriculture officers also provide genetics advice to breeders and commercial producers. AGWEST delivers Woolmark Rampower extension workshops and assists with wether trials and CTSE.[29]

Reports and advice have been provided to ram breeders at no charge to date. The new specialised service will be expected to build business steadily and to operate on full cost recovery principles (charges of the order of $1,000 per day). It is anticipated that clients will be mostly professional ram breeders, mostly Merino with a number interested in LAMBPLAN services.

Services to be offered include:

- defining breeding objectives and indexes
- designing breeding programs
- calculating EBV and indexes using Rampower parameters as a base with small adaptations to accommodate WA results
- sire summaries, flock analysis for genetic trends
- ram pen cards for use at sales
- TGRM services for meatsheep and Merino breeders using LAMBPLAN

The AGWEST data collection consists of approximately 65,000 animal records. A large part is performance data on individual animals without pedigrees and links. Since 1998, breeder requests for ranked test results have been forwarded to Rampower accredited testing laboratories. Some calculate personalised selection indices.

With growing use of AI for mating and fleece measurements, it is suspected that a sizeable quantity of raw data sits WA breeders' shelves. A tool such as LAMBPLAN's Pedigree Wizard could be used to collect this potentially valuable information.

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[28] Advice from discussions and the Agriculture WA website. This section has been checked with Agriculture WA.
[29] *Wool Workshops Aim To Boost Productivity Through Breeding*, Woolmark breeding & selection workshops, January 2000

.b. Natural Resources & Environment, Victoria

Victoria's Department of Natural Resources and Environment (DNRE) has been progressing Woolmark breeding field days and bloodline wether trials, plus a program for commercial producers and agents aiming to improve understanding of the value of objective measures of genetic merit in selection and in ram buying.

DNRE/Agriculture Victoria is establishing a Genetics Services for Sheepbreeders based at the Pastoral and Veterinary Institute at Hamilton, to be headed by Dr Forbes Brien, with a dedicated geneticist and a DRNE officer part-time for marketing. ***The Service is to provide advice and assistance to breeders to help them optimise their genetic improvement programs.*** Services offered include:[30]

- Planning a total breeding operation
- Assistance with setting breeding objectives and customised selection indices
- Advice on establishing genetic evaluation procedures for traits - wool production & quality, meat production & quality, reproductive performance & disease resistance
- Assistance with setting up recording systems, including fleece weighing, liveweight recording, fleece-sampling, classing scores etc
- Advice on optimising flock structures and mating allocations
- Data processing for estimating breeding merit of animals
- Assistance and advice on sourcing genetic material
- Assistance with monitoring and reporting of genetic progress
- Assistance with interpretation of genetic information and presentation to ram buyers
- Assisting commercial wool producers to optimise their breeding decisions
- Assistance with optimising use of home computers for breeding and business.

The Unit will be providing genetics advice as its priority. It will use available systems where possible for breeding value calculations and is interested in the potential of a genetics calculation service. They anticipate accessing the CTSE database.

AG VIC – Genetic Services For Sheepbreeders – Schedule of Fees (March 1st, 2000)
based at Hamilton, highly mobile, visiting breeders on properties, attending group meetings.

Development of Personalised Breeding Objective	Fee $500
Initial collection of farm data, Benchmarking (phenotypic only)	
Definition of Personalised Breeding Objective, Predicted gains	
Breeding program design	Fee $200
Setting up data collection system, Design appropriate genetic evaluation	
Optimise flock/herd structure	
Within flock analysis	Fee $800
Calculation of EBVs & Indexes, Interpretation of results	
Monitoring of genetic progress	
Across flock analysis (AFA)	Fee $300
Assistance with preparation of data for AFA, Interpretation of results	
Monitoring of genetic progress	
Total Genetic Resources Management (TGRM) Service	$50/flock + $2.50 per pregnancy

The fees shown cover the majority of tasks likely to be requested by clients. Not all work fits into these categories, so fees can be calculated for specific jobs, where applicable. Travel, accommodation and meal expenses incurred in undertaking consultancies is in addition to the fees shown.

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[30] Discussions with and notes from Dr Forbes Brien, Pastoral and Veterinary Institute at Hamilton, Victoria.

.c.   Mackinnon Project – University of Melbourne

The Mackinnon Project at the University of Melbourne Werribee Centre has grown since 1982 to offer a broad range of services. Key features:

- *Mackinnon provides a 'whole-farm' consultancy service* to over 130 sheep and beef farms, holding more than 1 million sheep and 30,000 breeding beef cows.[31]

- Six full-time consultants advise on a systems approach to grazing enterprises covering all aspects of farm management from pasture development to breeding programs to financial risk. The aim of consulting and research is to of improve farm profits and enhance farm management. Research is assisted by a strong farmer network.

- The South Roxby Project was started in 1998 with Woolmark and agribusiness, as an innovative R&D program to encourage woolgrowers to adopt best practice farm management. Over 100 woolgrowers have participated in the three meetings each year on topics they nominate. The first was breeding objectives and objective selection.

- Mackinnon manages the World's Finest Ram Project (the Victorian Fine Wool Sire Evaluation Scheme which is one of the CTSE sites) on the South Roxby property. Breeding for fine wool and staple strength is emphasised. Results and some progeny are displayed at major Victorian ram sales and sheep shows.

- Genetic improvement workshops have been held for commercial wool growers and ram breeders. Approximately 40% of people who have attended have contacted a consultant regarding change to their breeding program.

Some 60 of 100 breeders and growers who attended South Roxby workshops contacted a Mackinnon consultant for breeding advice. Of the 60, 13% decided to breed rams based on index selection, BLUP, and semen from progeny tested rams in top 20 (based on 12% index) of Merino Benchmark or Merino Superior Sires. About 20% changed bloodline or are running progeny trials to compare profitable bloodlines.

Some of these Merino stud clients have continued to purchase varying levels of consultancy advice. These breeders sell over 1,200 rams to commercial growers annually. Some commercial woolgrowers have decided to breed their own rams, using measurement and AI programs, with specialist advice from Mackinnon on breeding programs. All use top rams (12% selection index) from Merino Benchmark, as these rams tend to have higher production levels than those in CTSE. Other registered stud breeders are quietly seeking programs to benchmark their genetics with an eye to marketing advantages, and advice on use of outside semen. There appears to be a growing interest in quantitative genetics services in some quarters.

Access to personal, fee-paying consultancy services is considered to have contributed to adoption of genetics technology in the region. Mackinnon aims to recover full operational costs through its consultancy charges.

Mackinnon holds a collection of client owned data for within-flock calculations and advice – now about 20,000 Merino animal records, mostly ewe data. Some animals have sire pedigree and few have identified dams. Sire linkages with CTSE (various sites) are fair and those with Merino Benchmark are good.

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[31]   Notes from University of Melbourne Mackinnon Project website, from Linda Hygate plus discussions and publications. Mackinnon Project monthly Newsletters provide whole-farm guidance. eg Strategies for reducing fibre diameter.

.d.   SARDI

The South Australian Research and Development Institute (SARDI) is a multi-disciplinary research capability which directs, funds and promotes public sector R&D in primary industries in South Australia. SARDI is part of the Department of Primary Industries and Resources (PIRSA).[32]

Collaborative research, planning and development with business and industries is emphasised. The SARDI Sheep program covers: Genetic improvement of sheep, transgenics and reproductive efficiency in sheep, wool quality, better nutrition and husbandry of sheep.

Dr Raul Ponzoni is developing and managing the major SA Merino Selection Demonstration Flocks project which is comparing 'objective', 'traditional' and 'soft-rolling skins' selection techniques in high quality flocks of South Australian Merinos, with associated education programs.

- Three selection flocks and a control flock were mated first in 1997. Four progeny sets have been recorded for a wide range of measurements and classer assessed traits.
- Over 400 stud and commercial breeders have attended project field days. Results are reported annually in newsletters. Breeders are interested in semen from trial rams.
- In 1999, a new selection line (Fibre Meat Plus) with link sires to other lines, was formed. It aims to develop enhanced meat production and related traits (reproduction rate, growth rate, carcass attributes) while maintaining wool quality and quantity for Merino sheep.

The trial database held by Raul Ponzoni now contains 3,200 Merino records, all with sire and dam pedigrees, with link sires across years. Each record has measurements or grades for a wide range of fleece and animal traits.

Breeding Values are calculated (or where not being calculated, could be) using the Rampower genetic parameters but not the Rampower system. Results are presented as EPVs but in trait units (kg, CV, micron) as preferred by the trial participants.   An 8% micron premium selection index is used.

The Sheep Development Centre at Roseworthy (Adelaide University, SARDI) managed by Cheryl Pope is establishing a Genetics Advisory Service. This Unit will develop as a breeding consultancy, extending quantitative genetics systems with practical and science-based advice to Merino and meatsheep breeders and producers. An overall aim is to build networks between farmers and researchers and so facilitate genetic improvement.

Products and more personalised advice services will be developed for Merino and meatsheep clients, utilising Rampower, Lambplan and TGRM as suits. A full-time geneticist is to be appointed and post-graduate students will likely be involved. Breeding values and Indexes will likely be calculated by SARDI. The Unit will have about 18 months to develop a client base to enable full cost recovery.

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[32] Notes from SARDI website, project reports and Newsletter, discussions with Dr Raul Ponzoni and Cheryl Pope.

.e.   Independent consultants

When reviewing Woolmark's Rampower project, Prof. David Lindsay noted that:[33]

- People who get paid to give advice to breeders should, themselves, could be expected to pay to keep their qualifications and skills regularly updated.

- However, there are not enough people yet trained in quantitative genetic methods and practice to provide the support needed for this technology to have a significant impact on the rate of genetic progress in the wool industry.

- Most such consultant-advisers are still located in government departments. Of the few possible independents, most are not sure that there is sufficient work in the present environment to devote themselves to it full-time.

- *Yet, such consultants will increasingly be the face of quantitative genetics in animal breeding at the farm gate.*

It is a longer term assumption of this study that public – and industry – resources will be increasingly directed away from activities which support individual commercial entities, especially some more than others, and towards general and public benefit projects [1.2]. Such a pattern can be expected to emerge over the next five years in State governments, CSIRO and even industry entities.

Two private consultants specialising in sheep quantitative genetics have been located.

• *Dr James Skerritt* is based in Joondalup WA. He offers specialist services to cattle and sheep stud breeders, including customising breeding objectives, breeding program design, evaluating benefits of measurements, monitoring and controlling inbreeding, advice on allocative and corrective mating, and to commercial breeders (advice on selecting ram sources and rams, and matching aims to the aim of a seed stock source).

Skerritt's notes on 'Why use and animal breeding advisor?' provide clues on difficulties breeders experience in considering use of QG, and why many are not users.

James Skerritt – Why Use an Animal Breeding Advisor? [34]

- Do you want some totally independent advice on your breeding program?
- Do all the measurements and numbers confuse you?
- Are you making the best use of Lambplan, Breedplan, Benchmark, yardstick or wether trial information? How important are all of these measurements?
- Are you sure you are using all the information you are collecting and recording?
- Would you like to make the best use of your Pedigree information?
- Do you want to breed animals to match the processor requirements, but you are not really sure what they want or how to get there?
- You have a great sire, should you use him widely with AI? Should you be buying the best semen or rams on the market? Are you better off with a cheaper sire that maybe isn't as good?
- Am I doing enough with just progeny testing or is there a better way of evaluating animals?
- Do I really need to measure all of my females?
- I want to modernise my breeding but don't want to change everything at once, where to start?
- How can I explain in simple terms to my clients why my breeding program will definitely make them more money in the long term?

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[33]   DR Lindsay, *Review of the Woolmark Company's Rampower project*, April 2000
[34]   Skerritt & Associates Breeding Services brochure Dec 1999. Also website http://skybusiness.com/skerrittbreedservices

James Skerritt's statement of mission and services, indicates that he aims to :[35]

- Educate clients to a stage where they, and their breeding programs will be able to operate without continuing advice.

- Not 'dictate' what a client's breeding goal should be, but rather to give advice on how to best formalise the breeding goal into a measurable and achievable statement.

- Only perform genetic evaluations (such as breeding values) if they can do so in a superior manner than a recognised commercial operator, or on traits not available in the industry. "*We perceive that there are benchmarking benefits to our clients if they are involved in a large nationwide evaluation system ….*"

- Have in-house expertise to independently review any evaluation or breeding program.

• *Ms Sue Jarvis* is building a private animal breeding service based in western Victoria with the aim of liaising with farmers and farmer groups and providing high level breeding advice, on a low cost basis, to stud breeders and commercial producers. All charges are negotiated with clients at moderate levels.

The Jarvis services for wool and meat sheep breeders and include:
- defining breeding objectives and developing customised selection indices
- genetic evaluation procedures for traits such as wool production & wool quality, meat production & meat quality, reproductive performance & disease resistance
- setting up recording systems, including fleece weighing, liveweight recording, fleece-sampling, classing scores
- optimising flock and herd structures and mating allocations
- data processing for estimating genetic merit of animals
- advice on sourcing genetic material, monitoring and reporting of genetic progress
- interpretation of genetic information and its presentation to ram buyers
- setting up an on-farm progeny test, and analysing the results
- planning a total breeding operation

"There are some very progressive breeders in both the meat sheep and wool sheep sectors. There are also some breeders who at times are unsure of what information and services are available to them. I believe I can provide a valuable link by helping them to understand some of the more complex technical issues. It has become obvious to me from talking to breeders that much of the controversy over alternative methods of sheep measurement and selection has arisen because some breeders do not really understand the advantages and disadvantages of various systems." *Jarvis Article, 2000*

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[35] James Skerritt charges around $150.00 per hour plus travelling time, $500 half day rate, $700 full day rate. $600 for a prepared 45-minute seminar to a group of farmers of any size. Special quotations for larger projects, such as the setting up of a new stud, or ongoing animal evaluations.

4.1.6   Soft Rolling Skins and Elite Wool systems

Adoption of the Soft Rolling Skins (SRS) selection system developed by Dr Jim Watts and the offshoot Elite Wool (EW) system of Dr Paul Swan, has expanded in recent years. A number of Merino studs directly use these techniques in contract arrangements with Watts or Swan. Many more include selection for 'elite wool' features and 'advanced merinos' in their programs, including some using QG systems.

From discussions and review of media for this Study, it appears that markedly more breeders use 'elite wool' practices than quantitative genetics methods [2.2].

Developed from work at the CSIRO Division of Wool Technology Ryde, on skin and fleece characteristics and relation to processing efficiency and results, these systems select for finer diameter and higher fleece weight plus expected processing performance, using measurements alongside grading of animals and wool.

> "I prefer a more biological approach to selection which takes into account the developmental characteristics required to most effectively combine high clean fleece weight and reduced fibre diameter as well improving manufacturing properties. The selection indices recommended in Woolplan and Rampower, and used in the various genetic databases as measures of breeding value, do not automatically select for the basic developmental conditions required to maximize the responses of the measured characteristics in the index, let alone various qualities such as softness, fibre alignment, lustre, and fibre elasticity." *Dr Jim Watts, September 2000*

It is understood that sires and ewes in a flock are selected on visual and hand classing of skin type, body and fleece traits. Measurements are used to adjust selection, with particular weight placed by Paul Swan on measuring all ewes and rams for fibre traits. Compatibility mating is used to correct some factors.

Swan uses wool weights, fibre diameter of a rump sample (so, more intense selection for diameter) plus fibre curvature, CV and histogram, and on-farm staple length translated into calculations to give indirect indicators of key follicle characteristics. Priorities are illustrated by the Case Example below.

It is also understood that most clients collect full pedigree (sire and dam) on lambs and keep detailed records, making this information a potentially valuable resource to the breeders and the industry.

Performance of the progeny of animals selected using SRS or Elite methods appears to be assessed by fleece measurements and weight plus visual inspection. Results are often translated into a Dollar Fleece value (in effect a form of selection index) and these can be compared from year to year to chart progress.

During this Study, it was frequently said that the marketing is powerful, the workshops effective and overall Watts and Swan have raised Merino breeding industry focus on breeding objectives and advance by objective selection.

Case example: To illustrate the priorities and emphasis of this breeding approach, some of the information on the Petali website (*www.newenglandmerino.com.au/petali*) is summarised below. Petali Merinos (Mr Martin Oppenheimer, principal) is recognised as an innovative, influential Merino stud, challenging traditional breeders.

Petali Merinos

A complete breeding, production and marketing strategy...
Petali Merinos produces low micron, elite wool, merino genetics, at Walcha, in the New England region of NSW, Australia.

1966: Petali established from the Mirani Stud Flock. Some introduced Merryville bloodline rams.
1991: Started breeding program for Elite wool production. Dr Jim Watts as consultant to 1998.
    1996: Dr Paul Swan engaged as textile consultant.
1993: Program of selecting sheep for genetic resistance to parasitic worms commenced using Elisa Antibody blood testing and Faecal Egg Counting (FEC).
1997: Poll Merino breeding began due to client demand. Same selection methods.

"The Petali Merinos breeding and production program is focused on producing a specific elite wool fibre. It is a system that delivers predictable breeding and production results that meet important consumer preferences.
Elite wool also enhances processing efficiencies, allows for product innovation and importantly, product differentiation."

Target Products
Petali Pure & Petali Rich – Long staple, low curvature, low micron elite wool.
Adult wools: Micron range: 17.0 - 19.0 micron, target 17.5, Length: Range 86mm -98mm, target 95
Curvature: 85-95 degrees/mm target 90, Yield: 78-83% sch.dry, target 82; N/KT range 38-55 target 50

Petali Breeding System
Distinct target fleece & sheep type
Subjective classing into skin types - Wool/Frame, Dense, Cull (Flat/Tight)
Corrective mating to make progress & increase uniformity
Selection for constitution, fertility & longevity
Careful use of objective measurement
Marketing to differentiate product & stimulate communication

Selection is targeted at –
Genetically fine diameter of primary fibres (small sweat glands in skin)
Genetically low follicle curvature (resulting low fibre curvature)
Uniformity between follicles (uniform length & diameter fibres)
Alignment (good follicle & fibre alignment)
High follicle density & small wax glands (high fleece weight, high yields)
Sheep constitution (resistance to worms, fleece rot & flystrike)
Robust frame size & shape (fertility & dual purpose sheep)
Breeding naturally polled merinos

To achieve these targets, visual & tactile selection is used first, then backed up with pedigrees, measurements and detailed trait recording.

Observations on a Petali selection trial 1996: "The elite staples are measurably better defined, and of lower crimp frequency than the other types. Thus we would expect the elite fleeces to give significantly better processing efficiency than the other types, based on CSIRO's current processing work." *Dr Paul Swan, CSIRO Division of Wool Technology, Ryde 1996.*

Consulting: Petali consults on breeding, management and marketing programs, to woolgrowers interested in breeding advanced merinos, including access to a network of leading consultants in these areas, plus sheep classers trained to select Advanced Merinos. Workshops are conducted.

.a.   Assessment: 'elite wool' methods in the marketplace

*The following points would appear to characterise these approaches
– looking from the perspective of the Merino genetics marketplace.*[36]

- ***Overall emphasis is on lower fibre diameter, higher fleece weight plus wool quality as the primary aims objectives of Merino selection*** – with alternative, comprehensible views on key wool characteristics and assessment, and studies to explain skin-follicles-diameter-style-fibre alignment-processing interactions.

- ***Within flock selection is for diameter, weights and wool type. Measurements are used as a guide, plus skin/wool assessment as a skilled, hands-on way to gauge value traits*** (especially SRS). Elite Wool uses additional measurements in selection calculations and buys in genetics as needed.

- ***They address (popular?) concerns about a simple 'few traits' approach taken by quantitative geneticists on Merino wool*** from the 1960s through to Woolplan [2.2.2b] and beyond, and that predicted QG outcomes has not been achieved, plus concerns that animal / environment interaction is a real issue in selecting animals for extensive grazing.

- ***The methods appear sensible at a first level (diameter, fleece weight, wool quality and training to visually assess this)*** and even if mysterious in detail, are no more so than quantitative genetics (eg. adjusting for groups, pedigree needed for 'accuracy', heritability, correlation, variance). *Is this a simpler, quicker way to the same targets?*

- ***Use of these genetics selection systems is expanding around the Merino breeding marketplace***, with visible results such as: numbers of clients paying sizeable consultancy fees; clients advertising use of SRS/Elite or breeding for 'elite wool', some high performing client studs in ram sales, some notable wool sale and processing results, support of at least one major buyer -processor, strong performances in wether trials with high fleece weight and lower diameter.

➣ **Looking Forward:** *The marketplace for elite wool and Quantitative Genetics techniques seems to be merging at some points, and there is a lot of common ground* (refer assessment above), noting that ABS assumes some 45% of selection weight will be placed on visual classing. Neither Watts nor Swan use Breeding Values, but some breeders using BVs also follow 'elite wool' approaches in classing. Some now selecting for 'elite wool' are using EBVs for their cattle and are interested in EBVs and across-comparisons for sheep to go with elite classing and tests.[37]

➣ *There is enough published material to indicate that 'the scientists' and history are keeping the elite and QG approaches well apart.* In discussion, Paul Swan indicated interest in achieving a common ground and that he could find an accessible databank with a range of genetic performance data of use in his genetics consulting.

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[36] From research for this report through a range of materials, plus discussions/emails with Dr Swan and Dr Watts, and discussions with a number of breeders and service providers,

[37] Dr Swan uses many currently measured traits in his work. Heritabilities are established for a number of these.

4.1.7   Professional sheep classers and stud advisors

There have been huge advances in productivity of the Australian Merino since the importation of rams not long after European settlement. Sheep classers and stud advisors have been working alongside stud owners for much of that time, providing long experience and skills in visually assessing and grading animals, plus approaches such as 'corrective breeding' to address trait problems and perhaps inbreeding.

A large majority of Merino studs use external sheep classer services. In some, the stud manager carries out those functions. Some meat sheep studs use classer services; more frequently stud managers appear to take this role.

Even where measurements and breeding values are used, some sheep classing is essential. But, to what degree? Some breeders contacted for this Study referred to experiences during times when selection was carried out 'only on the numbers'. Some, who give priority to Breeding Values (for instance, basing their first round of selection on test results and BVs), then place a 50-50 weighting in their second selection round on genetic information and on sheep body and wool appearance traits.

They explain that this weighting reflects the importance of non-measured characteristics in determining the price received for rams, ewes and wool, and a practical understanding what their customers, the commercial ram buyers, expect.

'Traditional' Merino breeding systems are often categorised as those relying strongly on grading by professional sheep classers and stud advisors. Hundreds of sheep classers are thought to operate across regions, locally available to breeders and commercial producers. Some cover all States. Others are stud advisers with pastoral companies.[38] Many studs advertise the name of their classer as a selling point..

In recent years, traditional selection has been increasingly assisted by measurements for fibre diameter, CV, other fibre features and fleece weights. Features considered by Merino sheep classers as well as measured weight and diameter include: wool cover, wool handle, visual colour (yellow to lustrous white), wool condition (dry, greasy), lock (staples tippy, hairy, pencilly, round, square blocky, bundly), skin quality (tight to very pliable), conformation, front and back legs, neck wrinkles and body wrinkles.[39] QG information such as breeding values has had little influence although some classers involved trials such as QPlus are beginning to recommend BVs to some clients.

The 'Standard Merino stud industry practice' would appear now to be selection of rams and ewes on family lines, measured fleece weight and fibre diameter, plus appearance including conformation and fleece type and quality.

More studs are selecting and selling their rams on the 'traditional plus measurements' basis than use quantitative genetics or SRS/Elite together, including a significant number of enduring leading studs.

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[38]   *The Land* 27.4.00 on Mr David McGilvray, Elders Stud Stock manager. "His job was essentially one of co-ordinating and promoting ram sales and identifying elite animals that he saw as having potential to 'do a job' in another client's stud or commercial flock." Primac Pastoral Co. also advertises 'rams election and stud introductions' as part of its services.
[39]   Refer reports of trials comparing traditional and quantitative selection methods: South Australian Merino Selection demonstration flocks (also compares SRS) and the Trangie Q merino trials.

In the meat sheep stud industry, 'standard practice' is increasingly use of Lambplan results plus classing for conformation and other visual traits. Meat (and wool) sheep animals selected using visual techniques regularly win agricultural show awards, but so now do Lambplan selected animals.[40]

4.1.8 Practical services – laboratories, scanners

Fleece test laboratories and measurers

In the wool industry, the very noticeable technological advance over the last five years is the now wide use of objective measurement for key fleece characteristics on samples from individual animals. About 95% of ram breeders obtain some objective measurements of performance (fibre diameter with other fibre features on rams about a year old) plus shed fleece weight. About 65% use these as a guide to back-up their visual assessment of the animals.[41]

Most Merino stud animals are now sold with fibre measurements (not BVs). The importance of fibre diameter measurements in today's ram selling, plus potential for manipulation of an individual animal's fineness, have prompted the introduction of a 'measurement code of practice' by the NSW Stud Merino Breeders Association.

> "The NSWSMBA has recommended a series of minimum requirements to allow studs to display the code logo in promotional and publicity material. To comply, studs are required to supply the date when rams were last shorn, age of sheep, mid-side sample collection date; mean micron; standard deviation, co-efficient of variation; percentage of fibres greater than 30 microns (comfort factor); spinning fineness and to name the testing house [rams should be tested 6-8 weeks before sale]." *The Land 17.8.00*

Higher prices for finer wools have encouraged mid-side (or rump) sample testing by both stud breeders and commercial wool growers looking to separate the finest ewes and to produce a few bales of wool significantly finer than the bulk of their clip (at current prices an attractive proposition for fine clips[42]).

The majority of fleece tests are carried out in laboratories on samples collected and mailed by breeders and commercial producers – some 1.5 million tests for breeders in 1999. Most (25) fleece testing laboratories are accredited for mid-side fleece sample testing by the Woolmark Rampower project. Round trials check and standardise mid-side sample test results. Laboratories are of varying size, and located in wool areas across Australia; the largest is AWTA but others do very many tests.

The possibility of doing tests for fibre diameter and other fibre traits on-farm at shearing or selection, is seen as attractive by some breeders and growers. Laboratories and independent operators are investing up to $100,000 in mobile Laserscan or OFDA (Optical Fibre Diameter Analyser) machines, although the technology is said to be still maturing. There are costs and operational advantages and disadvantages to in-shed testing which need to be calculated by growers.

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[40] Victorian Lamb 1999, *More press Reports from a Dynamic Industry*, compendium of media reports.
[41] Ian Rogan, National Rampower co-ordinator
[42] A Vizard, Objective Classing is currently very profitable for fine clips *Mackinnon Newsletter* 4.2000

AWTA Wool Grower Services – *internet site at August 2000*

Fleece measurement	*Price $ (excl GST)*
Laserscan Diameter Only, including CVD, Curvature & histogram, (per mid-side sample)	1.50
Yield & Laserscan Diameter, including CVD, Curvature & histogram, (per mid-side sample)	3.00
Staple Length & Strength (10 Staples, per sample),	9.00
OFDA Diameter Only, including CVD & Curvature, (per mid-side sample)	2.70
Yield & OFDA Diameter, including CVD & Curvature, (per mid-side sample)	4.20
Clean Colour, (per mid-side sample)	9.90
Greasy Fleece Weight (GFW) and/or Body Weight (BWT) Data Entry (per Tag)	0.10
Minimum fee per batch of submitted samples	25.00
Reports	
Standard reports	nil
Reprint results with new group or sub-groups (no data entry), (per group), 0.10 per sheep plus	31.00

Rampower software for laboratories

The Rampower project has sponsored development of Rampower Performance Recording software by NSW Agriculture officers. The aims are to standardise computing while allowing reporting format flexibility, and to make breeding values and indexes accessible to the breeders when they receive their test results.

However, adoption of Rampower software has been limited. A few of the commercial laboratories have moved beyond testing, to calculating within-flock breeding values (as EPVs), and standard Rampower or client selection indexes. More often, if a client requests EPVs then tests results are sent to an EPV active laboratory, a Department of Agriculture or to Steve Semple at ABS.

One laboratory is actively promoting the Rampower EPV and Index service in association with testing at modest introductory cost and is experiencing increasing interest. Another laboratory with thousands of clients and willing to provide EPVs, says that 5% request EPVs, but with signs of demand increasing.

Prices for testing, Rampower EPVs and indexes

Current indicative independent laboratory prices are $1.50-$2.20 per sample *for* fibre diameter and other fibre traits using Laserscan *plus* entry of all breeder data (weights, pedigree etc) *plus* calculation of EPVs and Indexes. An extra $1 or so for yield. Length and strength measurements are provided by some ($2.50-$3.50 per test).

Alternatively, $25 may be charged for Rampower data entry and calculations on top of testing. The real cost of supplying the service is $200-$400 however it is considered that there would be few customers at this price unless part of genetics consulting advice.

Faecal egg counts are sought by a small proportion of breeders. These tests are carried out in parasitology laboratories and cost around $3 per sample.

Rampower 2000, upgraded and improved from 1996, has been completed by Steve Semple of NSW Agriculture and distributed to laboratories with training and support to those interested. If the 2000 is more user friendly, and breeder demand grows (eg. prompted by Rampower workshops), more laboratories may start providing EPVs.

However, it is unlikely that many fleece testing laboratories will position themselves as processors and genetics information providers. Most accredited labs see testing, not genetics, as their core business. They are reluctant to deal with 'fiddly software', and are not staffed to handle complex genetics queries. Even some who are interested have difficulty seeing how they would cover costs.

Data holdings: Each laboratory would have sizeable but little connected sets of sheep performance data, with ad hoc animal identifications, and little or no pedigree. However, the 3 or 4 private laboratories actively providing EPVs plus six associated with research institutions, likely hold a collection of raw Merino test data as well as within flock EPVs which could be of value. Most would be owned by clients.

Meat sheep scanners and operators

Lambplan trains, tests and accredits Operators and Advisers. Eight accredited Operators provide ultrasound scanning, weighing and data transfer across Australia. The frontline efforts of some contributed much to Lambplan development. Each Operator runs his or her own service business. They are in competition in some areas, and set their prices and scope of services in discussion with customers. Operator charges range from $2.50 to $5 per animal or higher for smaller studs where travelling costs are spread across few animals. These measurements plus the breeder's pedigree and management information and sent to Lambplan for processing.

Lambplan Operators are called upon to provide a diversity of advice to their breeder clients (who are mostly also Lambplan clients). Some restrict themselves to guidance on organising sheep for scanning and recording of results. Others provide some advice on interpretation of EBV results and on selection of animals. This is generally seen as part of the operator service to his or her clients. The Lambplan Adviser will be accredited to provide explanation of Lambplan reports and advice on animal selection through to TGRM runs (with extra charges for some services).

In a competitive industry, some meatsheep breeders are using scanning services to ranking their animals on measurement alone (as measured diameter is used to rank wool sheep). Businesses such as Stockscan from NZ, and newer Primescan Australia, offer 'alternative performance recording schemes' using muscle and fat scan results plus computerised reporting. These groups scanned some thousands of animals in 1999-2000. They might be interested in EBV services in due course.

Data processing tools

Lambplan provides members with its *Pedigree Wizard* software. Breeder or operators can enter all information collected on each animal (pedigree, birth status and weights, measurements, trait assessments). Pedigree Wizard can be used to electronically transmit information to Lambplan for processing, to receive processed results and by the breeder to prepare a range of reports using these results. Rampower software as a data collation vehicle is available at laboratory or genetic adviser stage [4.2.4].

A few independent software consultants have developed packages (such as WoolPak, Lambpak and Topstud) to assist breeders manage and organise data received from fleece testing laboratories and user records collected in sheds or yards. These could be useful tools. These enterprises do not provide breeding advice (at present).

Analysis from 4.1 – Key points and issues for this study

➢ *Considering the Australian sheep industry as a whole, and its size and importance, and assuming that quantitative genetics systems have as much to offer sheep producers as other animal industries, the overall adoption of QG and the industry's QG service arrangements are not striking.*

➢ *In the meat sheep sector, substantial investment over decades has achieved an established QG service in Lambplan, which has piloted significant genetic gain in key traits.* Lambplan services some 600 studs and likely reaches 55-60% of meat-sheep rams sold, though less than half of registered meatsheep studs are using Lambplan and membership growth has flattened. Lambplan members pay near 60% of costs. [4.1.1]

➢ *Marketplace messages and experience from Lambplan's development need to be considered in development* of any new sheep genetics system. There are implications for products, marketing, and balancing of costs and pricing.

➢ *In Merino breeding, adoption of QG is still low (less than 10% of registered studs and other ram sellers, perhaps 25% of rams sold annually) and genetic gain is considered slow in key traits* (diameter, fleece weight per animal or hectare), notwithstanding investment in quantitative genetics research and extension and development of various service providers. [4.1.2 to 4.1.5].

➢ *Positively, industry and scientific efforts during the 1990s to fine the flock have achieved results.* Marketplace money signals, backed by industry research and extension have prompted extensive individual sheep testing for diameter (especially on studs) and buying of rams from finer bloodlines.

➢ *Over 90% of Merino ram breeders do not use QG systems, or over 80% of the target market. A significant number of these use 'elite wool' approaches* [2.2.1, 4.1.6], but the majority are using of objective measurements for diameter and fibre characteristics on each ram alongside traditional sheep classing for wool quality and sheep features [4.1.7].

➢ *Wool industry QG services are provided by a few personalised consultancies. This reflects both industry experience with Woolplan and an assessed need to provide one-to-one explanation and advice* on QG and breeding programs. This, plus limited market interest [Chapter 2], means that current services are modest in scale (ABS the largest with up to 70 clients), mostly staffed by public sector officers involved in various other work.

➢ *There are no apparent far-seeing plans to lead, market and provide QG services on a wide scale to the Merino breeding industry.* There is enthusiasm but the plans of service units are limited compared to the industry's size. The Rampower software development and its supply to laboratories is a practical-level effort to take a basic EPV service closer to many breeders and growers. Interest has increased, but it has not achieved usage hoped for a range of reasons.

.... \

> *Genetics is a 'high-tech' field and clients expect explanation and advice as part of services* whether provided in Lambplan or ABS or other consultant form. Advisers are generally high cost employees, with substantial overheads, and advising takes time. Travel for property visits and workshops adds to these costs.

> *No government or industry service is charging prices that routinely cover full costs. Clients are partly or wholly subsidised.* Lambplan recovers above half. ABS feels it covers its added costs. Low cost recovery reflects: cost structures, what services think breeders will pay, breeder views on the value of services, breeder-grower expectations of low prices because of levies and taxes.

> *Independent QG service providers, existing or new, will have to compete on an uneven field* (although they do tend to have lower costs). Notably, the 'elite wool' consultants appear to charge business rates for their services and they secure and retain breeder clients.

> *NSW Agriculture has developed much of the key QG software, genetic parameters and reporting systems used by the Australian sheep industry.* Lambplan has expanded and developed on these as it has grown. NSW Ag distributes software without Intellectual Property restrictions.

> *Even so, almost all the other services groups (as well as Lambplan) choose to use a slightly different approach to parameters, system and reporting* because of assessed client preferences and also, it seems, to add-value to and competitive differentiation from the base system [4.2.5]. The different systems are confusing to industry participants.

> *Sheep data is accumulating rapidly but on different bases and into different systems* [table above], through the important Central Test Sire Evaluation, Merino Benchmark, SA Demonstration flocks, wether trials, and the various consultancies, plus Lambplan.

> *Differences and compatibility issues include* : Enterprises, pedigree, accuracy, links; traits recorded, measurement and data integrity; data collection, delivery, processing, preparing BVs, indexes, comparisons and reports [4.2].

> *There is apparent scientific agreement on the potential genetic power of a large, national, linked database providing across-flock analysis*.

> *The marketplace for quantitative genetics and 'elite wool' systems appears to be merging at some points.* There is a lot of common ground and cross-interests indicate market opportunities for a stronger genetics services entity.

> *Any new system should aim to engage and offer services to the 'elite wool' sector for both industry genetics and commercial reasons.* It now appears that scientists rather than the marketplace are keeping the approaches apart.

4.2   Current services: methods and compatibility

To assess the potential for integrated use of existing data assemblies, an understanding is needed of any 'compatibility issues' among the current performance recording, BLUP and reporting schemes.

Science based selection is more complex than sheep classing with some measurements. QG requires consistent on-farm animal ID, sampling and data records, plus an integrated support structure for measurement, data collection, processing, calculations, expert adjustment of the genetics base through to indexes, reporting back, explanation and ongoing advice.

There is potential for variation among service providers in all these areas. Some differences are more critical than others.

Compatibility, or lack there-of, among the Lambplan, ABS, and other schemes, can look like a significant obstacle to change (or equally, a major reason for moving fast to bring processes and information together).

For these reasons, a significant part of the research and interviewing for this Study has centred on investigation of details of each scheme and how they might interact.

As understanding has developed, the scale of compatibility issues has contracted.

> ➢ **Overall assessment**
>
> **W*ith investment, energy and good faith, a single, a national database for sheep genetics information could be constructed.*** Should the owners be convinced, several of the current data collections together would provide a strong start to the database, which should then grow.
>
> *There would be issues to be addressed in forming up a national database. The most important of these appear to be*:
>
> • Pedigree and accuracy: Various schemes are taking different approaches on what is practical and needed in pedigree (knowing a lamb's sire, dam) [4.2.2].
>
> • Some entrenched positions: All user groups would need to adjust to new forms of reporting. Such technology change is common nowadays. Users say they want a common system, but originators may feel differently about change [2.4, 4.2].
>
> • Investment – deriving a common system which brings together current resources voluntarily, and carefully translating key blocks of information will take time and resources, raising issues of priority and policy.

Compatibility questions are described and assessed in points below. This is an overview, and does not pretend to be a comprehensive treatise. [43] Details would need to be resolved as part of any Integration Project.

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[43]   The information in 4.2.1 to 4.2.5 has been collected from documents and many discussion with parties involved.

4.2.1 Summary of sheep genetics data collections

The following table summarises basic details about most sheep data accumulations in Australia,[44] and the relative worth of various aggregations (higher are shaded).[45] This table also provides perspective for the review of compatibility issues.

	BREEDER CLIENTS mid 2000 – Merino – other	MERINO animal records – in total (new 99-00)	NON-MERINO records – in total (new 99-00)	DATABASE Full size in animal records mid 2000	Comments
Lambplan	13 Mo 600 XB	87,000 (5,000)	830,000 (107,000)	917,000	structured database , many cross-links in meat sheep, some in Merinos, many full pedigrees
ABS client database	44 Mo (plus 26 Mo B'mk)	200,000 to 250,000 (~20,000)		200,000 to 250,000	data collection with EPVs, not structured as a database, within flock use, limited pedigrees
NSW Ag Bloodlines wether trials			large quantity of data over 10 years		usefulness limited, wethers with little pedigree. Many measurements and trait scores
ABS Merino Benchmark	26 Mo	105,000 (~20,000)		105,000	31% pedigree for sires, 15% for dams, good links to CTSE sires
Central Test Sire Evaluation		21,000 (~2,000)		21,000 500+ sires	Across-flock evaluation by trials, part pedigrees, link sires
Meatsheep Maternal Sires Central tests			9,000	9,000 91 sires	sire and dam pedigree on most, limited links, assessed for unusual traits so not in LPlan
Select Breeding Services CSIRO	15-20 Mo			~3,000	each breeder's data stored for within flock, not a database
CSIRO Fine wool project		10,000 (closed)		10,000	with pedigree and some ~ 7% links to CTSE rams
South Aust. breeding trials		2,400 Mo (600)		2400	full pedigree, links to CTSE and various studs
Trangie Q Plus trials					Closed selection flocks since 1992, full recording, few links
McKinnon project	~10 Mo	~20,000 (10,000)		~ 20,000	mostly ewe data, limited links to sire databases
WA AgServices	~20-25 Mo	65,000		65,000	Merino data by flock, pedigree & links improve post 1998
Independents	~ 1-3				limited, within flock
Laboratories, breeders, sheep classers	large numbers				many measurement records for sheep most without sire/dam, AI records a stronger resource.
Elite/SRS clients	~ 100 Mo together				Pedigrees on most? Could be interesting. Limited links.

New Zealand's Sheep Improvement Limited (SIL) holds a large collection of genetics data for a range of sheep breeds, some with links to Australian sires. Lambplan and SIL are exploring co-operative analysis of some datasets, with permission. SIL is interested in Australian developments and the potential for across-Tasman evaluations.

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[44] Figures are from the data managers where possible, but most would not confirm exact client numbers. The symbol ~ indicates a best estimate and is more likely to be high than low.
[45] For further information on the reasons for the data collections, and their features refer sub-sections in 4.1

4.2.2   Enterprises, pedigree, accuracy, links

In the delivery of genetics services there are as many practicalities to consider.
In the past, selecting sheep has been 'in the yards' activity, using physical assessment
through the eyes of an experienced sheep classer backed by studbook records, with
decisions mainly made on the classing day.

Quantitative genetics systems generally require collection of a range of data, some near
birth, some later, some graded, some measured on-farm or off, transfer of data to a
centre for calculation of breeding values and selection indexes, with reports sent back
some time later. QG schemes require, and been enabled by development of a range
of supporting technologies, processes and reports. Improvement of these is ongoing.

***As a general rule, the more reference data collected on an animal and the greater
the care in overall data collection, the more useful are results from a QG analysis.
Data 'accuracy' levels become more important with Across-Flock comparisons.***

Enterprise type

***The form of sheep enterprise can influence how costs-effective, practical and
hence rewarding it can be to collect additional pieces of information.*** This in
itself, can be hurdle to entry into QG schemes (such as Merino Benchmark), and an
attraction toward alternatives such as elite wool or sheep classing with ranked
measurements of fibre diameter or muscle scans (phenotype selection).

Merino stud breeding flocks are generally larger than meatsheep studs. Pedigree
(identification sire and dam) and birth status (eg. twin, early or late) information on
lambs is more difficult to collect and *is mostly not recorded in Merino Studs.* Large
groups of Merino ewes are usually mated with a number of rams, so sire may not be
known. In most studs, the information readily available on a young animal is only its
identification and on-farm and laboratory measurements and scores.[46]

Use of AI with sire and dam records is increasing but costs and non-success rates
mean that mating in paddocks will dominate for many years. Some Merino studs
have started pedigree collection systems with 'mothering up' procedures to match
ewes and lambs, showing that it can be done.

However, these studs mainly use sub-sets of their breeding flocks (say a nucleus of
300-500 ewes) so reducing the size genetic field from which they are selecting their
lead animals. There have been estimates of $15 a lamb to collect early stage data for
sub-sets of large studs. At this cost, a $25 price for a DNA pedigree [1.3.2] through a
blood matching test (on lambs and parents) starts to look attractive, but this does not
provide information on twinning or early life traits such as birth weight.

***Meatsheep breeding flocks using Lambplan average 150-200 ewes, making
collection of sire, dam and birth status information less demanding.*** Non-merino
ewes are also less likely to desert their lambs if disturbed daily during lambing.

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[46] NSW Merino studs in 1992 – 28% stud progeny had sire pedigree, 6% dam pedigree: Casey, Hygate NSW Agriculture

Data accuracy factors and pedigree

In QG, an animal's genetic merit for a specific trait (eg. fibre diameter, muscling) is calculated as its Estimated Breeding Value (EBV) – its values as a parent to the next generation. With extra and more accurate input data the estimate begins to approach the animal's True Breeding Value (TBV), and confidence in breeding results grows..

An accuracy of 85% is approaching TBV (100%). Within a flock or management group of sheep, factors which influence accuracy of a prediction (an EBV), are : [47]

- *Numbers of measurements for a trait*: A series of measurements for key traits on an animal will increase accuracy, as will measuring or scoring traits for all or most animals in a group. So, animal weights at birth, weaning, 6 months, 9 months; fibre diameter at 1 year, 2 years; diameter CV over a number of seasons.

- *Adjusting for environmental effects*: Early effects on performance include birth type (single or twin), rearing type (as twin or single), age (whether born early or late in a group), and maternal factors (age of dam, milk production). Later environmental effects include weaning time, injury, disease.

- *Pedigree information*: Knowing the performance of an animal's relatives enables more accurate prediction of an animals' genetic merit. Relatives can be earlier generations, parents and others, full or half siblings or progeny. Use of the measured or scored results for a trait from 25 identified progeny of a sire can bring that sire's EBV to 85% accuracy, and 91% at 50 progeny. Where pedigree and birth information is collected, management and recording can influence accuracy.

- *Quality of records*: Poor recording or inconsistency among measurements or scores for a trait can reduce accuracy, but it can be difficult to know [see 4.2.3].

o *Compatibility issues*

It is generally agreed that higher accuracies will enable more powerful selection and faster rates of genetic progress in the chosen traits (whether a major economic trait such as growth, or a specific interest trait to be selected strongly for a few years, such as worm egg count). However, there are differences in usage and emphasis.

o *Important sources of accuracy:* Prime lambs go to market within an year. Merino ewes and wethers are expected to produce wool (and lambs) over 4-7 years. Priorities for improving accuracy are a little different for Merinos and meat sheep.

Merinos – achieving higher accuracy	**Meatsheep – achieving higher accuracy**
1. Add performance records (same animal, 2 or more sets of measurements over time improves accuracy by 25- 48%) 2. Add pedigree information (sire, sire and dam) can improve accuracy 13-18%. 3. Add environmental information. Little benefit (2%) for rankings on older animals.	1. Add performance records (eg. series of weights, extra scans) 2. Add careful management : accurate group records, even sire groups, records of birth type etc. Measurements on all or most animals 3. Add pedigree records – sire, dam for all.

[47] References: Mortimer *et al* (1998) Improving the accuracy of prediction of genetic merit, Trangie Q Plus Merinos Report LambplanTips and Tools: How to use accuracy figures provided with EBVs (2000). *Merino Superior Sires 1999* pp 25-26

o *Weight placed on accuracy*: NSW Agriculture has purposely structured the Rampower software approach and ABS services to deal with incoming data with varying amounts of information, taking into consideration :

- that for highly heritable traits such as diameter and fleece weight, pedigree and adjustments do not increase the accuracy and usefulness of EBVs much
- difficulties and cost of collecting pedigree and birth information for Merinos
- and, that insistence on such data would be an obstacle to use of QG.

For Across-Flock comparisons in Merino Benchmark, full pedigrees or random ewes matings are required, in part to improve accuracy. These points are deterring some front-line studs from MB. In Central Test Sire Evaluation, full pedigree is not always collected, but accuracy is obtained through a sire's progeny. Only sires with 20 or more identified and measured/scored progeny are reported in CTSE *Merino Superior Sires*. Over 55 progeny gives High accuracy.

Lambplan started by gathering information from wherever it could, and caters for pedigree differences. After a decade of encouraging studs (via advice and tools such as Pedigree Wizard) to collect pedigree and environment data, Lambplan has Gold, Silver, Bronze data quality grades, and reports accuracies for clients.

Reading a LAMBPLAN report with accuracies *(from LP Tips and Tools 2000)*

LAMBPLAN reports will (soon) contain accuracy information on the key production groups.
– Growth accuracy (the average accuracy of weaning, post-weaning and yearling weight EBVs)
– Carcase accuracy (the average accuracy of fat depth and eye muscle depth EBVs)
– Reproduction accuracy (accuracy for NLW EBV), – Wool accuracy (accuracy for GFW EBV)

It is likely that the accuracies for these key areas will differ due to the fact that not all animals will get the same measurements taken, for example breeders may weigh all animals, but only scan 75% resulting in lower accuracy figures for carcase traits when compared to growth traits.
It is important that when selecting animals for breeding that you look at the accuracies of all the EBVs that are critical to your breeding objective.

ID	WWT EBV	YWT	YFAT	YEMD	NLW	GFW	Growth Accuracy	Carcase Acc'y	NLW Acc'y	Wool Acc'y
990001	3.2	5.6	-1.2	0.3	0.10	0.5	74	65	54	35

For this animal 990001, the accuracies for weaning weight and yearling weight are 74%, for fat and eye muscle depth 65%, for number of lambs weaned 54% and for wool 35%. This information is typical for a young sire that has test information on growth and carcase, with less information on relatives that have lambing records and limited information on wool weight.

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o *Reporting of accuracies*: Accuracy for EBVs can be expressed either as:
  – a percentage, with higher percentages meaning greater accuracy, or
  – a standard error, which indicates the range in which the true breeding value is likely to be, and a smaller standard error means the EBV is closer to TBV.

These Accuracy expressions are used at different times and could cause confusion although they provide different information which could be valued by some users.[48]

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[48] For example, an animal could have : EBV for yearling weight of +10 kg (estimated value of this animal's genes are + 10 kg for growth), Accuracy = 71% Standard Error = ± 2.1 kg (TBV of this animal is between +7.9 kg and + 12.1 kg). Adding more information (from the animal, or relatives) can affect all three. Its EBV will be recalculated and could change, up, down, or not at all, the EBV Accuracy (higher percent), the Standard Error of the EBV will decrease (lower range).

Links – across flocks, groups, breeds

Physical differences (phenotype) among sheep arise as much from the differences in the animal's environment and from genetic features (genotype). Environmental differences account for much variation among flocks on one or many properties, among strains or groups of Merinos or breeds of meatsheep, as well as over years and among various management groups in a stud,

Quantitative geneticists use BLUP (Best Linear Unbiased Prediction) [4.2.5] to disentangle genetic variations from environmental effects (flocks, years, sex of animal, maternal influences). To do this for different sets of animals, there need to be *genetic links* among them, mostly as related sires and their male progeny.

Links provide common genetic points for comparing animal data deriving from different circumstances. Links are used to adjust for a diversity of factors, including (when links are strong), breed or sub-breed differences and a range of environmental factors, *and* to bring different pools of data to a new common base.

For Across-Flock comparisons, which are critical for powerful genetic selection, ***sire genetic linkages are essential***. *To obtain useful linked records, pedigree recording of sires is needed, and studs involved need to be using some outside genetics*. Links have been critical to Lambplan and to Merino Benchmark in its progress toward securing "the considerable value of across-flock evaluation".[49]

> The de-regressed sire solutions for link sires were used to identify differences between flocks which were used as the basis for identifying genetic groups, that is, groups of flocks that differed significantly for l or more traits. The analysis identified 5 genetic groups each containing between 1 and 6 studs and CTSE schemes. Each genetic group was analysed separately and the animals from groups combined using an estimated genetic group effect… 15% of animals had full pedigree and 31% had sire only… the remainder had no pedigree … some still contributed to linkage by later becoming parents.

As links improve, the evaluation and comparison power in a database increases, as do the calls on software and hardware capacity. For existing data collections, the degree of animal linkage is an indication of the usefulness of the data for across-flock analysis [table 4.2.1]. Links in the Lambplan database now support reliable Across-breed reports, so ram buyers can compare Dorsets, Texels and Suffolks EBVs.

Assessment: **Better data should be a bonus not a barrier**

➢ *Developers of any single system should address realistically practicalities and costs* to studs of collecting pedigree / environment records, and prepare tools to assist. Relative value added by pedigree/environment data needs to be considered.

➢ *Using proposed Lambplan Accuracy reports bluntly for all EBV calculations could disenfranchise* many Merino breeders now involved and deter new clients.

➢ *There should be enough linked data in CTSE, Merino Benchmark, Fine wool , SA trials and Lambplan to realise a powerful single database* – all records discrete but some linked [4.2.1]. Any records from ABS' client collection and other current holdings would be welcome additions.

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[49] Casey, Atkins, Developing on-stud across-flock performance evaluation, Merino Benchmark book 1999A

4.2.3 Traits recorded, measurement and data integrity

Having enough linked data is a strong start. However, various other dimensions of any single system warrant attention, noting in advance, Professor David Lindsay's observations, from his considerable experience, that :[50]

- Collection and management of data is basically similar for wool characteristics or meat characteristics

- The software and processes for genetic evaluation and the generation of within flock and cross flock breeding values and indexes are identical (for wool or meat sheep).

In a QG system, estimated breeding values are calculated for a range of traits considered important by those who will use the BV reports to assist selection decisions. ADHIS Pty Ltd, for the Australian dairy industry, prepares ABVs on about 35 production, type, workability and appearance traits. Most key traits are measured for each bull and cow, but as many of the others are from visual scores.

The number and sort of traits for which EBVs might be prepared could be limited by:

- Capacity of the system software and hardware (for each animal, ID, pedigree and environment records, many traits with multiple records of some) [4.2.4].

- Views of the managing geneticists and industry participants on what are economically important or appropriate traits.

- Priority decisions toward important, measurable or readily scorable at a reasonable cost, higher heritability traits (so likely to respond to selection).

Current systems – sheep traits and information

The Lambplan database with *Pedigree Wizard* for on-farm input, handles records for :

pedigree - animal identification (ID), sire ID, dam ID, breed
management – birthdate, sex, birth type, rearing, management group, dam age

– plus the following trait records for EBV and associated report preparation:

body weights – birth, weaning, post-weaning, yearling, hogget, adult 3,4,5 years
carcase – scanned fat, eye muscle depth : post weaning, year old, hogget
wool – greasy/clean weights, F Diameter, CV, SD, comfort, strength, length (all at ages)
      (scoring for grade, quality, colour, handle, plus comments)
reproduction – scrotal, teats, lambs born, weaned, chances, maternal birth & weaning wts
disease resistance - faecal egg count (FEC)
animal structural traits – scoring and EBV calculation approach is near finalisation
on- farm visuals – feet, face., length, colour, skin, size, back, shoulder, horns, mouth,
           fleece, udder, hocks, pasterns, testicles

Lambplan's OVIS software (version 1.0) can analyse and produce EBVs for 35 traits:
7 for weight from birth to carcass, 5 for fat depth, 4 muscle depth, 3 greasy fleece weight (by age), 3 clean fleece weight, 3 fibre diameter, 3 FEC, 2 scrotal, lambs born / weaned.

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[50] DR Lindsay, *Review of the Woolmark Company's Rampower project*, April 2000

> *Rampower (BVEST) software* used by some laboratories to evaluate breeder and data and test results, and by some consultant advisers, handles records for :
>
> *pedigree* - animal identification* (ID), sire ID, dam ID, comments
> *management* – birthdate, sex*, birth type, shearing age*, dam age (* essential data)
>
> – plus the following trait records for EBV and associated report preparation:
>
> *wool* – greasy & clean fleece weight, F Diameter, CV (all at year/hogget/adult), strength, length, plus comments (eg, black wool)
> *body weights* – hogget, adult
> *reproduction* – reproduction rate, testis size , lambs born
> *disease resistance* - faecal egg count (FEC)
>
> Rampower's EPVs are commonly prepared for: adult clean fleece weight, adult fibre diameter and CV, hogget body weight, reproduction rate, staple strength, FEC.

Lambplan (with Pedigree Wizard) and Rampower 2000 are the widely accessible information input systems. *The traits they handle set the 'tone' of what is accepted or discouraged by current quantitative genetics systems for Australian sheep.*

However, ABS in its consulting and for Merino Benchmark, Select and the CSIRO in processing CTSE data, use the BVEST software system in its wider form, which can handle some additional traits including carcase and style score information.

- *Merino Benchmark* public reports on sires provide EPVs for GFW, CFW, F Diameter, CV, body weight, staple strength, FEC plus indexes.

- *CTSE Merino Superior Sires* reports EPVs for GFW, CFW, F Diameter, body weight, plus scores (not EPVs) for percent of 'tops' and 'culls', conformation and wool quality (4 grades).

Dr Raul Ponzoni processes the SA Demonstration Flocks records with many traits using PEST software.[51] In addition to all objectively measurable fleece, growth, carcase and reproduction traits, the sheep in these trials are scored for wool cover, handle, colour, condition, lock, skin quality, tops/culls, conformation, legs, wrinkles.

Records, measurements, and data integrity

Measurement and scoring systems which enable data to be collected for individual animals are usually developed during early stages of research projects and refined as research progresses. Research projects are usually meticulous about data recording, care with measurements and repeatable scoring against established grades.

Similarly, organised trials comparing animals (rams, wethers) from various sources, might be expected to take particular care in recording, measuring and scoring given possible financial repercussions if some information to be published in reports. Even so, trials such as CTSE face a diversity of management and recording decision which can influence the accuracy and integrity of the published results [4.1.4]. These too can be handled with appropriate BLUP analysis.

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[51] The various software packages are considered in 4.2.4.

However, every-day use of quantitative genetics systems to assist the decision making of many individual breeders, entails considerable on-farm data collection, record keeping, measuring (weights particularly) and scoring.

Concerns about two aspects of data worth are mentioned from time to time in reaction to the collection and recoding of animal information on-farm – the accuracy of the data, and its integrity (honesty).

Accuracy is an issue for all breeders using QG services, as inaccurate records or measurements could lead to significant errors in breeding values and reduce the effectiveness of selection decisions or the return on ram purchasing decisions.

Where animals are being compared Across-Flock, confidence in both accuracy and integrity of records and data is important – and maintaining such confidence can present a large challenge in a widespread industry with various service providers.

> The ram breeding industry as a whole has not been convinced that across-flock evaluation based on-stud has an industry benefit, can be achieved in practice or their fellow ram breeders can be relied on to accurately carry out the recording. [52]

The two current systems taking information from individual member studs are Merino Benchmark and Lambplan. Each faces different challenges and has approached the issues in different ways building on the experience of members.

Merino Benchmark Quality System

MB started with eight member studs and now has about 24. As it was accepted that pedigree details would not be collected by many, so balanced mating is required by participating studs. In addition, a range of weights are collected on-stud, as well as fleece samples to be sent for testing. The Merino Benchmark group:

- Commissioned ABS to prepare a detailed *Quality System Manual* which is now in Version 3 and covers quality policy, duty statements, document and data control, sheep ID, facilities and equipment, flock mating and management, wool sampling, weighing, visual scoring, culling, links, reporting, records, audits, corrective actions.

- Requires members to sign a Quality Policy Statements and to be able to implement the procedures, and identifies publicly that members are responsible for the accuracy of on-farm data.

Lambplan has some 600 member studs and addresses data quality and integrity issues in a number of ways:

- Accrediting Lambplan Operators to carry out the main measurements – scanned fat and eye muscle, plus weight at scanning and scrotal circumference.

- Providing the Pedigree Wizard software for data recording and transfer to Lambplan.

- Regular guidance through newsletters and the internet site on expected data quality and how to achieve it, plus public award of gold, silver and bronze quality grades.

- Checks of data entering the Lambplan system for nonsenses and impossibilities.

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[52] Casey, Atkins, Developing on-stud across-flock performance evaluation, Merino Benchmark book 1999A

Procedures notwithstanding, there are opportunities for participants in either Merino Benchmark or Lambplan to 'adjust figures', such as by feeding-up some rams or culling poor progeny, but likely no more than in any breeding regimes.

For a short time, translation of artificial effects into EBVs or EPVs could give these data some validity, but after some years of experience, many consider that such breeders will be caught out in due course on ram performance. As in most commercial arenas, integrity and reputation are key elements of a successful business.

Another potential source of concerning data inaccuracy is the measurement procedures and equipment used for testing more important traits.

With introduction of Rampower Fleece Test Laboratory accreditation, and successful performance in calibrating round trials by 25 laboratories, divergence among labs has been reduced [4.1.8] although there are rumours that 'a micron' can be bought. In addition, fleece sample taking for tests and fleece and body weighing for recording in Rampower 2000 software, are on-farm activities with room for substantial variation. Some fleece test labs remain unaccredited, and as in-shed fleece testing expands, questions of sampling procedure and equipment use (Laserscan, OFDA) arise again.

Standardising approaches in these areas would be a resource–demanding exercise, though this should build confidence in objective systems.

Lambplan accreditation of Operators who go to studs with their calibrated scanning and weighing equipment, addresses a degree of this potential difference among studs. At least one 'measurement enterprise', Genstock Pty Ltd in Western Australia, is a Rampower accredited testing lab, and has Lambplan accredited Operators [4.1.8].

Assessment: **Few compatibility issues; room for collaborative development**

➢ *Data in various collections share a few to many common traits.* A growing single database would have large subsets (fleece / carcase priorities) with rising links.

➢ *Lambplan offers the more extensive trait recording, calculation and reporting set-up* and could be further adapted, as could BVEST to an extent [4.2.4]. Rampower 2000 is designed for more streamlined usage.

➢ *Both public QG systems concentrate on measured 'objective' traits* although Lambplan can record many visual scores. Neither Lambplan or Rampower 2000 offer the developed scheme for ram and wool 'type' or 'style' (including crimp) that could be vital to wider acceptance and use of a sheep QG system [2.4.1]. Neither presents itself as open to custom by breeders using elite wool selection approaches.

➢ *Development of a practical Quality Scheme* for any single genetics system should draw on the work and experiences of Lambplan, Merino Benchmark and CTSE.

➢ *There is opportunity to build confidence in QG systems, improve data quality* and to aid breeders by practical standardisation of on-farm recording and measuring procedures. Service officers could be accredited for a range of tests. Such a high-resource effort might be realistic if a large number of potential users could benefit.

4.2.4   Data collection, delivery, processing

Quantitative genetics by its nature, looks to process through large assemblies of data, adjusting, cross-checking, computing, searching for the elite animals. The effectiveness and sophistication of QG has paralleled the development of more powerful computers. Great quantities of data extending across many environmental and group differences can now be adjusted using detailed techniques in BLUP systems to produce ranked breeding values [4.2.5].

However, before the analysis comes the challenge of logistics. Arrangements for collection, delivery and processing of the input data become increasingly demanding as quantities swell.   The issues start with animal recognition.

Sheep identification

Which animal is which? The primary data collection compatibility issue is that different sheep ID is used in various data assemblies.

There is a base system developed between Lambplan, ABS and Arthur Gilmour for BVEST. The standard sheep identification string is the Lambplan convention of BB FFFF YYYY TTTTTT (breed, stud/ flock, year of birth, birth tag ID). FFFF codes derive some the Flock Books of breeder associations, and are listed on the Lambplan website). ABS and Lambplan communicate on new FFFF identifiers where needed (eg. non-registered studs).

Merino Benchmark uses this convention, as does CTSE formally, though local identifiers are also used. BVEST and OVIS both allow users to identify animals with a shorter string, eg. an animal name only or a single digit. Breeders providing data to ABS or Select for consultations, use their own identifiers.

Rampower 2000 software also allows home ID, which is realistic, noting that the EPV information is primarily for breeders to make within flock decisions. Other trials (such as SA) and services are using their own identification systems, though key animals should be traceable to source studs.

Difficulty particularly arises from an animal's ID changing over its lifetime, with potential loss of important links. As a ram is sold and moved to a another property, or semen is used in one trial or stud, then another, ID might be changed by managers. For instance, a new FFFF for a new stud or trial, a new local TTTTT tag.

Assessment: **A basic sheep ID is established; work is needed to extend use.**

➢ *Systematic animal identification is needed for wide across-flock comparisons* and ID should look toward this. Lambplan, Merino Benchmark and CTSE are using the same sheep ID format, although the issue of changing ID can still arise.

➢ *Extending this ID scheme in a practical way for new data entering other collections, should receive priority* if a decision is made to work toward a single national database. Incentives are needed to use the ID and to retain one ID for life.

➢ *A second stage would include sorting through other current data collections,* where accessible, for links and useful data and aligning IDs and records.

From breeder to database and BV processor

Advances in desktop computing capacity and in communications through the internet, now make it feasible for breeders to collect, record, and transmit data and receive back reports electronically.

However, many on-farm sheep records are still hand written, with lists attached to samples going to a test laboratory, or given to Lambplan operators when scanning. These service providers unite animal records and test results and send them back to the breeder with a report (or on to a consultant) or into the Lambplan system.

Lambplan currently processes 110,000 new animals records a year, each with multiple items of information. It is useful to look first at how Lambplan manages this quantity of data (and number of datasets) from on-farm, through the database, to the main processing centre and back in the form of results and reports. The relevant Key Service Targets, which Lambplan is achieving or arranging to achieve are :

Data transfer: LP to provide a secure and reliable data transfer system with 99% accuracy post-client. 95% of data to be in database by day 4 after receipt from client.

EBV reports (first and subsequent): LP will send to a client, an across flock EBV report between 10 and 14 days of client providing data operator or database manager.

Breeders, operators and specialists use three software 'tools' of varying scale to progress the data from stud to AGBU for genetic analysis.
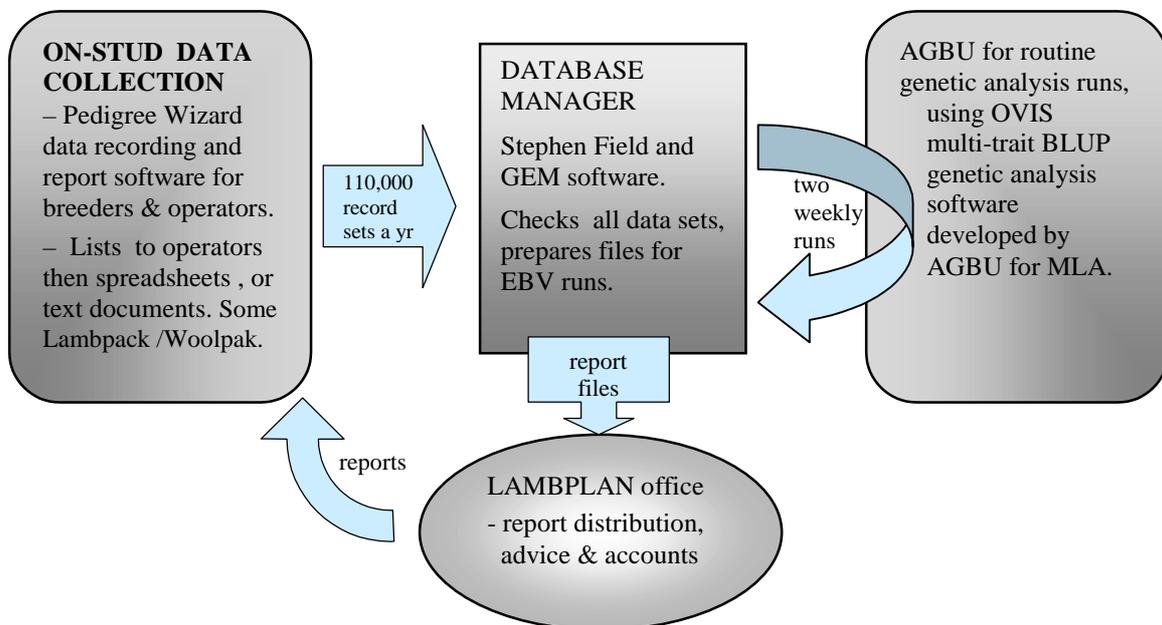
Pedigree Wizard has been developed and refined by Lambplan's database manager Stephen Field. It is a software tool for use by breeders in their own recording and selection decision-making, as well as a medium for transfer of data into Lambplan. It is flexible and will create data files in many forms, including text lists, spreadsheets, or in a form suitable for entry into BVEST, NSW Agriculture's BLUP system [below].

Three hundred copies of the latest version of Pedigree Wizard have been requested or downloaded from the internet by breeders. Some breeders (and some Lambplan Operators) have built their expertise in PW, and use many of its features, including electronic transfer of datasets and receipt of reports. *A majority still relies on Lambplan Operators for data preparation and transfer to PW and the database.*

The Lambplan database manager accepts datasets in sets in any electronic form (and until recently faxed lists). Datasets are translated into forms suitable for OVIS using GEM (Genetic Evaluation Management software developed by Stephen Field), and a range of datachecks are carried out by computer and visual examination. These can be time consuming if data from breeders or operators is not carefully prepared.

Aside from Lambplan, various PC based or manual data collection approaches are used by Genetics Service consultants and trial managers to enter small to moderate quantities of data into BLUP processing software (BVEST, PEST).

Laboratories using Rampower software to prepare EPVs on fleece diameter and CV, receive animal ID, sex and shearing time plus any other records with the samples and enter all data into *Rampower 2000*. EPV plus Index reports and test results are returned to the breeder clients. If the breeder is planing to use a QG consultant such as ABS or Ag WA, raw animal data and test results are usually sent to the consultant. Merino Benchmark members send records and test results to ABS. The CTSE sites commission groups (such as Select, Ag WA) to prepare and analyse their data.

Sheep Industry BLUP systems

BLUP (Best Linear Unbiased Prediction) is the method of choice for genetic evaluation.[53] As computing power has increased so has the accessibility of BLUP (which dates back to 1949) for commercial animal breeding. The BLUP model appears in four software forms in the Australian sheep industry.

BVEST is a flexible BLUP system written by Dr Arthur Gilmour of NSW Agriculture during the 80s and 90s, to meet expansion requirements of Lambplan, and for other sheep breeding use. BVEST was made generally available, sometimes under licence. Lambplan used BVEST for expanding across-flock evaluations from 1996 until 1999. ABS uses BVEST for its consulting reports and Merino Benchmark, CSIRO Select uses BVEST for consulting and CTSE data processing, as does Linda Hygate of the Mackinnon Project. *Rampower 2000* software includes a BVEST component for EPVs.

ASREML is a BLUP research tool also written by Arthur Gilmour. It is used by various researchers and by Dr James Skerritt in his genetics consulting.

PEST is an internationally available BLUP software package for multivariate prediction and estimation.[54] It 'needs a scientist to drive it' but offers greater flexibility to such users. PEST is used by Dr Raul Ponzoni at SARDI for trial evaluations, by Ag WA in analysis for breeders and CTSE evaluations, and by consultant Sue Jarvis.

OVIS is the new, more capacious and powerful BLUP system developed by AGBU for Lambplan to handle much larger data processing runs and additional adjustments. OVIS is an evolution from BVEST and Breedplan. It is owned by MLA and AGBU.

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[53] Julius van der Werf, 'Use of information from relatives and correlated traits', in Kinghorn, van der Werf, Ryan, Chp 6
[54] Groeneveld and Kovac M. 1990. A Generalised computing procedure for setting up and solving mixed linear models. J. Diary Sci 73:513-531

Lambplan commissioned OVIS primarily because its terminal sires database was too large in records and links, and included too many traits per animal, for monthly processing on BVEST and was to soon outgrow BVEST completely. [55]

It is generally agreed among geneticists that OVIS represents the next era of BLUP for sheep development. NSW Agriculture are interested in use of OVIS both for its potential and because investment to create a parallel system (BVEST 2) would be an inefficient use of industry finds. *The key advances with OVIS are*:

- *very much larger processing capacity* : OVIS should readily process through more than 2 billion pieces of data, 20 million animal records with associated pedigree, environment and trait data, and links.[56] OVIS can currently return EBVs for 35 traits, plus 4 accuracy readings, a wide range of indexes using the trait EBVs, inbreeding coefficients and various reports (such as Genetic Trend).[57]

- *additional data checks and adjustments*, such as standard ages and maternal traits

- *higher level of power to handle a diversity of 'genetic groups'* within the computer calculations rather than manual adjustments.

Use of OVIS for Lambplan's genetic evaluations was phased in from late 1999. Direct correlation between EBV results using BVEST and the same calculations using OVIS were monitored and was about 85-99%. Some differences arose and sparked questions which have been resolved. Most of these occurred because Lambplan used the opportunity of OVIS to recalculate its adjustments and parameters [4.2.5].

Assessment: **A foundation for data analysis exists. Data collection is a challenge.**

➢ *Differences among the OVIS, BVEST and PEST systems are not big, and do not seem to concern scientists involved in sheep industry genetics.* The larger source of potential differences among BLUP systems arises from calculation adjustments and parameters [4.2.5].

➢ *The OVIS genetic analysis system should be able to service BLUP and associated processing requirements for the sheep industry as a whole*, with data accumulating at over 500,000 animal records a year, for many years. As for all systems, improvement would continue (eg. to handle embryo transfers).

➢ *The logistics of data collection from on-farm, via measurers, and transfer to a database point, is a more challenging issue for any larger QG system for sheep.* Lambplan collects 110,000+ new animal datasets a year, through stages supported by software and some specialists. Active development of QG services could *give a data flow five times larger* – if target markets were achieved [2.1].

➢ *Should a single database system arise, the sheep industry would be very dependent on its services, management and planning.* Procedures and performance would need to develop to ensure services, using experience from Lambplan and other groups.

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[55] 1998 BVEST specifications state that it is limited to 400,000 in 400 groups in its largest form. Seven traits are assumed. The size requirement increases as the square of the number of traits. Going to 10 traits doubles memory requirements.
[56] Communications with Dr Hans Graser Director of AGB, Stephen Field. Also AGBU Final report to MLA on OVIS.,2000.
[57] Computer power is not a limiting factor. AGBU currently uses its second machine. However, at key stages some software redesign may be needed to maintain frequency and length of runs).

4.2.5   Preparing BVs, indexes, comparisons, reports

In quantitative genetics, matters are more complicated than they appear on the surface, and become more complex as they are explored. But then they clarify because there is a deal of logic in the science.

Even so, it is not surprising, that BLUP as a concept and mechanical tool can be difficult to understand except for specialists. In some ways, BLUP and QG could be seen to resemble a 'magic box' approach to listing superior and lesser animals – especially if an animal's physical appearance does not align with QG numbers.

This section looks, in summary form, at key steps from a measurement (eg. 19 micron average fibre diameter at 12 months) or a score for a trait on an specified animal, being sent to a BLUP processing system, and considers compatibility and other issues.

Estimating a breeding value using BLUP

BLUP is a mixed linear model which estimates the effects which act together on the physical appearance and measurements of an animal, and disentangles genetic effects (breeding values) from key environmental effects (flock, year, season, sex).

> "Selection on BLUP breeding values should give the highest selection response, because using all possible information maximises the accuracy of EBVs. Furthermore, the BLUP-EBVs are NOT biased by test herd, selection or assortative mating. … [but] many computational tricks are used to obtain solutions. " *Dr Julius van der Werf, UNE*

To prepare an estimated of the genetic merit or Breeding Value of an animal with an average FD of 19 micron, a BLUP program simultaneously considers a series of information on factors which could influence the 19 micron measurement at one year.

- Fixed effects: flock, year, season, sex …
- Management: group in a flock (so feeding etc) time of shearing …
- Environmental factors affecting the animal : twinning, rearing, age …
- Genetic effects : strain, breed, genetic group
- Genetic parameters : the heritability of the trait, if it is an indirect measurement (such as fat depth for muscle) then correlations, plus natural variation factors

Some corrections are made through the BLUP analysis including checks with relatives and links. Many others are addressed through sets of Adjustments and Genetic Parameters. For instance if an animal is a twin, the 1 year micron might be adjusted up by 1.0 to 20, then other factors may further change it).

This is an area where various geneticists can introduce divergences which mean that some EBVs on the same animal could be notably different. Geneticists develop sets of Adjustments and Parameters by analysing sets of data collected from animals (some sets for EBVs can be developed from a year of data on some hundreds of animals) using recognised procedures.

Genetic parameters are generally derived from research flocks with full pedigree and records, so geneticists can locate adjustments and parameter figures from various research publications or their own work, and slot these into their Adjustment and Parameter file (say if using BVEST or PEST for client calculations).

In the main, building Adjustment and Parameter files is time-consuming and detailed, so geneticists prefer to use standard files, then perhaps add. Dr Kevin Atkins has developed the Rampower Merino Parameter and Adjustments file. A comprehensive compilation of research data on parameters for Merinos has just been completed by Raul Ponzoni in collaboration with QG researchers. Lambplan has a detailed file for meat sheep animals.[58] It should be noted that the cost of research data collection and analysis is a unique feature of quantitative genetics systems.

Which Parameters ? The various quantitative genetics service providers use –

Rampower Merino Parameters:	ABS, CTSE, Merino Benchmark
	Lambplan for Merinos
	SARDI - Raul Ponzoni
	Linda Hygate Mackinnon, Sue Jarvis
Rampower Merino Parameters: ***with alterations***	Ag WA – except for CV of fibre diameter and staple strength[59]).
	CSIRO Select – uses some information from their fine wool research
	James Skerritt – obtains parameters and adjustments from various sources
Lambplan Meatsheep Parameters:	Lambplan (fully updated before use in OVIS).

Identifying 'Genetic Groups' is a further adjustment on the path to a BLUP EBV. Some sets of animals are not directly comparable and this is obvious. So, if all cattle types were directly compared for growth as kgs, using EBVs, then most animals in large types would be ranked high and fast-growing animals in smaller types used for different purposes would be ranked low, even though they are elite genetically in their group. In addition, BLUP tends to bring differences toward the centre of the analysed population. With strong links across groups, direct BLUP comparison becomes feasible, as is now occurring for the Lambplan Terminal Sires.

It became clear in Woolplan days that strains of Merinos are not directly comparable (eg. fine and strong wool). Further research in development of Merino Benchmark has confirmed that there can be more subtle Genetic Groups relating to bloodlines which affect animal EBV results and rankings. The effect is greatest on the elite animals (at extremes) – those of most interest to breeders in across-flock analyses.[60]

Merino Benchmark groups are updated annually. About 15 genetic groups have been identified by experience and knowledge in reviewing sets of data and results (some might argue that such parallels the selection processes of traditional breeders).

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[58] Ponzoni, Fenton, Phenotypic and genetic parameters from fine, medium and strong wool strains, June 2000
[59] WA research has shown an important correlation between low CV and higher staple strength *Good News For Ram Breeders*, Johan Greeff, Geneticist, 1998. "Woolgrowers seeking to avoid price discounts for tender wool should be able to use CV measurements with much greater confidence … CV is an indirect measure of staple strength and provided by all laboratories when testing fibre diameter. Rams with lower CV wool, breed offspring with higher staple strength."
[60] Atkins, Mortimer, Casey, Do we need to include genetics groups to improve the precision of Merino Sire evaluations? *Proc Assoc Advmt Anim Breed Genetics*, v13 1999.

EBVs or EPVs and comparisons

Take one ram from 'the Grange' in WA, Sire number 504208 1994 420223. This sire has current entries in Lambplan, Merino Benchmark and CTSE (Fine and Medium), with information provided in reports as follows.

Mo BK EPVs [61]	Prog'y Acc'y	GFW %	CFW %	FD um	CV %	BWT %	SS n/k	FEC	RP 6% Index
	314	4.5	3.8	- 0.8	- 0.2	0.5	- 0.8	0.23	124
CTSE EPVs [62]		GFW% (dev)	CFW% (dev)	FD um (dev)		BWT % (dev)	Tops % (dev)	Culls %(dev)	Wool Quality
Medium	148 H	3.7	3.4	- 1.0		- 0.2	13	- 15	++
Fine	66 H	8.3	5.4	- 0.2		- 1.2	- 5	- 2	– –
Lambplan EBVs [63]	277	H GFW	H CFW	H FD	H FD CV	H Wt	NLW	Index 8% DP	Index 8 % wool
		0.67	0.52	- 0.82	1.25	2.87	0.092	120.64	129.02

These numbers, on the same animal, and published for industry usage in 2000, appear starkly different, and demonstrate the confusion and frustration some (or many) feel, both with quantitative genetics systems and with different analysis and reporting used by different services providers [2.4].

The differences are explainable, though that explanation gets complex. For the purposes of this exercise, the main point is to acknowledge the extent of differences and likely confusion and to look at the key sources of difference (some of which are non-compatibility).

Explaining the two CTSE result lines
- Ram 420223 (a heavy cutting ram between medium and fine in micron) has been entered in some Fine CTSE sites and some Medium CTSE sites.
- The BLUP calculation, parameters and adjustments are the same for each.
- The number of progeny he has in the Fine group is smaller (66) than in the Medium (148). Both are accorded High Accuracy (H for 50+ progeny – 4.2.2). *The data from the progeny are BLUP analysed and compared against different baselines to produce the reported figures. This is the primary source of difference.*

Explaining the Merino Benchmark and CTSE results
- Ram 420223 is in the Merino Benchmark analysis both because he is in the CTSE and because 3 or 4 MB members are using his semen on their studs.
- The BLUP calculation, parameters and adjustments are the same for MB and CTSE.
- MB uses the same baselines as CTSE but provides a single, 'middle' set of results, and this accounts for some of the differences (the BWT divergence is hard to explain)
- *The ram also has more progeny (314) in this analysis and this additional information does contribute also to the different EPV figures* (high accuracy level notwithstanding).

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[61]   From Merino Benchmark Information booklet 1999A   GFW = Greasy fleece weight,   CFW = clean FW, FD = average fibre diameter in microns, and CV% of diameter. BWT or WT = body weight. SS= staple strength. FEC = faecal egg count. The RP 6% diameter/weight index is given. These differences were discussed with Dr Kevin Atkins.

[62]   From *Merino Superior Sires* CTSE Results No. 6 of 1999. T ops/ Culls re direct scores (not EPVs) as % of progeny visually classed as Tops or Culls. These are the first set of readings on the progeny of 420223 in the CTSE.

[63]   Lambplan website, Merino Genetics List August 2000. H = Hogget measurements (1 year) . NLW = number of lambs weaned. The 8% Dual purpose and wool indexes are given.

Explaining the Lambplan and CTSE and MB results

- Ram 420223 was entered into Merino Lambplan as a young animal and now has results calculated using information from 277 progeny.
- Some disparity arises from different *baselines* for results reporting (below).
- ***The main reason for difference between the Lambplan and the CTSE/MB results is the different method of reporting the BLUP estimated breeding value, and the units in which it is reported (EBVs or EPVs, kg or %).***

The key reporting differences

EBV (Estimated Breeding Value) – used in many industries and is the common expression for anticipated genetic gain. EBV describes estimated genetic difference between an animal and the average of a group. An EBV is equivalent to an animal's measured superiority after adjustments (eg. for heritability). Lambplan uses EBVs.

EPV (Expected Progeny Value) – the amount an animal's progeny are expected to be superior to the progeny of the whole group (generally half the value of the animal's EBV for the same trait). Forms of EPV are used in other industries including EPD in the USA cattle industry, to show the expected performance of an animal as a parent. EPD is established in the Merino industry, among those involved in Central Sire Test Evaluation which collects data from progeny, Merino Benchmark and in Rampower 2000.

- EPD indicates expected genetic gain as to be seen in the progeny of sire S mated with a group of unselected ewes (the average EPV for the ewes is zero, no gain added).
- Or, EBV divided by 2, is the expected gain in progeny from sire S mated to the ewes.
- If a sire EBV and a ewe EBV are known, the expected gain is (EBV~S + EBV~E)/2.
- If a sire EPV and a ewe EPV are known , the expected gain is (EPV~S + EPV~E).

Baselines : for a simple within flock analysis in one year, say for fibre diameter, EPVs or EBVs are calculated for each trait in comparison with the flock group. So the average would be 0.0 with some higher and some lower. For across year/group/flock analysis a baseline is needed for comparisons and to show progress after years of selection.

- For CTSE and MB, there is a Medium Wool base (Riverina and Macquarie 1989 to 1991 drops) and a Fine Wool base (New England 1990-1991).
- Lambplan uses a 1990 baseline from its database.

Reporting Units : *Lambplan reports all EBVs as differences from the baseline in the measurement (test or scoring) units for that trait.*

- So, Sire 420223 has an EBV for GFW of 0.67 kg higher than the base (0.0), and a Fibre Diameter EBV which is -0.82 (0.82 microns finer than the base).

CTSE, MB, Rampower 2000 reports use a mixture. Fleece and body weights are given as percentage deviation from the base. So, 420223 has an EPV of 4.5% in Merino Benchmark. If the EPV base (0.0) was 10 kg of greasy wool, then the 1999 EPV for 420223 would be + 0.45kg. *This different reporting is very difficult to compare.*

CTSE, MB and Rampower 2000, use trait units for fibre diameter (micron) CV (% deviation), staple strength (N/k) and FEC (standard units, FEC is reported as EBV).

- So, Sire 420223 has EPVs of –0.8 in MB, -1.0 in CTSE Medium, -0.82 in Lambplan.

WHAT'S in USE	EBV or EPV	Reporting units	Selection indexes
Rampower system ABS, Select	EPV	% dev'n for weights plus trait units	Rampower 3% 6% 12% & customised indexes
Merino Benchmark	EPV	as above	Rampower 3% 6% 12% 6% bodyweight indexes
CTSE	EPV	as above	
Agriculture WA	*EBV* preferred by clients	trait measurement units preferred by clients	Rampower indexes & customised for clients
SARDI for trials	EPV	trait measurement units preferred by trial participants	8% micron selection index
LAMBPLAN	*EBV* – all across-flock	measurement units for all traits	14 indexes, 3 for Merino & customised indexes

Selection Indexes

Indexes are single indicators of an animals' genetic merit, by which can be ranked or compared for selection. An index combines a number of trait EBVs or EPVs and weights them to reflect the importance of these traits to the breeder.

The Rampower system has three standard indexes

- 3% Micron Premium, to maximise fleece weight / maintain diameter
- 6 % Micron Premium, to reduce diameter / increase fleece weight
- 12 % Micron Premium, to fine diameter / maintain fleece weight

The Merino Benchmark 6% bodyweight index adds a BW component.

Lambplan has developed fourteen breed and special purpose selection indexes (SI) by working with Breed Societies, active breeders and lamb buyers. Breed SI are agreed with Breed Societies and reflect the main 'value' characteristics of that type of animal (weighting is modified about five-yearly). The key Indexes for terminal sires are:

- 60 (growth rate) : 20 (leanness) : 20 (muscling)
- 80 (growth rate) : 10 (leanness) : 10 (muscling)

Special purpose SI reflect marketplace requirements, and include the Trade Value Index (TVI) and the Export Value Index (EVI). For wool sheep, Lambplan has developed 8% and 20% micron indexes, plus an 8% dual-purpose index.

Rampower and Lambplan Standard Indexes concentrate on those traits identified as commercially important for a majority of commercial producers.

Each consulting service, including Lambplan, offers to develop customised indexes to match clients needs. However, quantitative geneticists generally have definite views on what would constitute a useful index for breeders looking to seel rams to commercial wool and sheep meat producers, ie. traits of known 'economic' value.

Reports for breeders, producers, researchers

It is generally accepted that a breeder (or producer) involved in a QG scheme retains ownership of his or her identified animal information, and that this information should not be released publicly without agreement of the owner.

This is reflected in the new procedures for external use of the CTSE database [4.1.4.a]. [64]   Merino Benchmark is based on most members allowing public reporting of their results, but a member may elect to not have their results reported.

Lambplan, in dealing with hundreds of clients, has a set of information privacy and public use procedures set out in an agreement with members, including:

- An individual LAMBPLAN report is prepared for the party to whom it is addressed, and is confidential to the Lambplan member and Lambplan. The member can choose to make public any information.

- A condition of using the LAMBPLAN service is that Members allow MLA to use the data entered by a Member for general development of LAMBPLAN (refining statistical procedures and continuing research and development) and for the purpose of Across-flock Evaluation of animals.

- It is agreed that lists high genetic merit animals will be publicly listed in summary reports (Elites). Other animals are not identified without permission.

These conditions address the more complex question of who owns records once they have been entered into a database and are processed as part of a collection of information, at some cost and with value added to the data. Logic would suggest that ownership has, in part, passed out of the breeder's hands (as for CTSE data).

Large databases are also important research tools, for geneticists and for other industry researchers and planners. "Well designed and maintained, comprehensive databases are invaluable research resources." *David Lindsay 2000*

In general, those interested in industry advance would like to see industry data being well used for research and development, however questions arise.

For instance:

- How far should the design of database take into account unforseen research needs, at potential cost to current and future users and/or the industry.

- Criteria for access to the database, use of information, in public or privately. And cost recovery or profit through research?

- If research identifies issues relating to a flock or animal how would this be handled?

- If research makes a potentially valuable discovery, such as a key gene marker, who owns such a find, in whole or part? Can any one party stop its development?

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[64]   AMSEA *Conditions for Access and Utilisation of the CTSE Database*, August 2000

Assessment: **Compatibility issues can be addressed, after top-level decisions.**

➤ *Divergences in Adjustments and Parameters for sheep BLUP processing should be minimised by a single database and BLUP evaluation*, well maintained, responsive to input and not lagging research. Various service consultants would be less inclined to define their own parameters.

➤ *A common BLUP result reporting language is needed. Current mixed use of EBVs and EPVs, in different units, adds forbidding confusion to an already complex set of concepts.* Some users will need to adjust in order to develop a system more inviting to new users. Step changes do need to occur as technologies develop.[65] Two sets of figures could run in parallel for a limited time.

➤ *From the analysis for this Study, it is recommended that a sheep industry genetics common language be built from current approaches, using*:

   – *EPVs (Expected Progeny Values)*: these are logical and understood in the Merino arena where the major market growth is sought. Lambplan users are large in number, but mostly well-experienced and should be able to adjust to EPVs. The industry could consider a new name, such as Gene Power Values.
   – *Units of measurement (test or score)* for the trait to quantify the EPV difference from a trait baseline (not % deviation). These are logical and real.

➤ *Different baselines present a challenge. Alignment of data collections with various bases can be achieved.* Genetic links among the sets would be used for alignment (advice from AGBU). A set of baselines would be needed for key sub-sets of a database. Alignment should give priority to main baselines in use (so, adjust Lambplan Merino data to CTSE bases).

➤ *Any system will need to provide within-flock and across-flock analyses and reports,* to attract and service a large part of the sheep genetics marketplace.

➤ *Selection Indexes do not need to be standardised.* A feature of SI is that they should reflect the Breeding Objectives of the user. Various service providers should develop indexes to suit general and specific client needs, but calculate SI rankings from EPVs processed in a standard way.

➤ *A set of Sheep Industry Indexes that guide selection towards marketplace driven objectives* (recognising sub-markets, and taking a forward view) would be important, if industry organisations decide to take a genetics leadership role.

➤ *There will be data ownership issues under any changed arrangements. A breeder's commercially sensitive information should be protected.* Once records enter a database, the data should be open for use in database operations, for unidentified comparisons within and outside the database, and for research.

➤ *Decisions on industry priorities and the envisaged form of an Australian Sheep Genetics System, will influence handling of these issues.* An 'Integration Project' would be needed, as part of the planned development.

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[65] In recent times, wool testing changed from an Airflow system to Laserscan with considerable associated benefits. Test results were not identical, but the change was successfully implemented and the industry adjusted. The Dairy Industry QG system (ADHIS) has also recently changed its comparison baseline, with explanation to users.

Abbreviations and Glossary

AAMSB   Australian Association of Merino Stud Breeders
ABS   Advanced breeding Services (NSW Agriculture)
AI   Artificial Insemination
BLUP   Best Linear Unbiased Prediction procedure
BV   Breeding value (estimated as an EBV or EPV)
CRC   Co-operative Research Centre (here the proposed Sheep CRC)
CTSE   Central Test Sire Evaluation
CV   Coefficient of variation of fibre diameter
EBV   Estimated breeding value
EPV   Expected progeny value
EW   Elite Wool method of sheep selection
FD   Fibre diameter (average)
MLA   Meat & Livestock Australia
QG   Quantitative genetics
QGS   Quantitative genetics system
SBS   Select breeding Services (CSIRO Livestock Industries)
SI   Selection Index
SRS   Soft Rolling Skins method of sheep selection
WM   The Woolmark Company Pty Ltd

- Glossary key source: *Animal Breeding - Use of new technologies*, 2000, eds. B Kinghorn, J van der Werf, M Ryan (with permission); Also: Agriculture Western Australia Farmnote – Genetics for sheep breeders, *David Windsor*, Ms Sue Jarvis, genetics consultant.

Across-flock: A comparison of animals from two of more different breeding flocks, generally also from different studs or properties. Within-flock refers to comparisons of a set of animals from a animals a single breeding flock usually in one year.

BLUP : Best Linear Unbiased Prediction (of breeding values) is a powerful statistical method [refer 4.2.4]. BLUP combines information on an animal's performance, the performance of its relatives and any known environmental differences to produce an Estimated Breeding Value. Can be used to separate the genetic and environmental factors influencing animal performance.

Breeding objectives relate to the goals of the breeding program - the traits to be improved. An economic approach calculated economic weights to be assigned to each important trait. A 'desired gains' approach involves defining the relative amount of genetic change desired for each trait.

Correlation: the extent to which genes that determine one trait also influence other traits (that may be more easily seen or measured).

CV FD (%), Coefficient of Variation of Fibre Diameter: The variation in the diameter of fibres counted. Compares the width of the distribution of fibre diameters for samples with different mean fibre diameters. A narrow fibre diameter distribution will have a lower CV FD

Estimated breeding value (EBV): An EBV is the estimate of an animal's breeding value – the estimated genetic difference between an animal and the average of a group. An EBV is an animal's estimated superiority after adjustments.

EPV (Expected Progeny Value): The amount by which an animal's progeny are expected to be superior to the progeny of the whole group. This is generally half the value of the animal's EBV for the same trait.

Genetic marker: A section of DNA which differs between animals, and can be tested for easily in the laboratory. Genetic markers are mostly not genes, but they are contained in genes.

Genotype: The genotype make-up of an animal. Used loosely in animal breeding to describe genetic grouping such as a breed or a trait-based classification (such as 'a fat genotype').

Heritability: The proportion of parental superiority which is expected to be transmitted to the next generation. Fibre diameter heritability is about 50%.

Inbreeding is the mating of animals which are related. Measured by the *inbreeding coefficient*, which is the probability of the 2 alleles at a randomly chosen locus being identical by descent.

Index selection involves the construction of a multiple score system, based on a number of component criteria, to give an overall selection criterion (an index) which can be used to rank animals for selection purposes. The criteria can be phenotypes of animals and their relatives (as in a classical selection index, weighted by selection index weights), or estimates of breeding values (typically from a BLUP analysis, weighted by economic weights).

Individual selection, or mass selection, is selection on animals own phenotypes alone, without use of information from relatives, or correction for environmental effects.

*OFDA, Optical Fibre Diameter Analyser***:** The OFDA measures the diameter of 2mm clean fibre snippets. Snippets are pressed between glass slides which are scanned under a microscope with a camera linked to a computer program. The computer program analyses the images and assesses the diameter. The 2mm fibre snippets are obtained by coring the mid-side fleece sample.

Phenotype is the observable merit for a given trait, as measured or recorded for an animal.

*Progeny test***:** A comparison between lambs born to a group of rams which were mated to randomly selected ewes at the same time. Pregnant ewes and progeny for all sire groups are run under identical conditions for the period of the test.

Quantitative Genetics (QG) is the science of exploiting natural genetic variation to give genetic improvement of quantitative or metric traits. It can be used for any multiple-gene inherited trait. QGS – quantitative genetics system for providing selection services.

Selection is the choice of animals to be used as parents. by ranking animals on selection criteria..

Selection accuracy is the correlation between true breeding values and estimated of breeding value. Selection response is directly proportional to selection accuracy.

Selection criterion: The information used to rank animals in order to select the best for breeding. The selection criterion is generally an estimate of breeding value, or a selection index using information (either phenotypes or BLUP EBVs) from a number of traits.

Selection Index: A multiple score system, based on a number of component criteria, to give an overall selection criterion (an index) which can be used to rank animals for selection purposes. Criteria can be phenotypes of animals (as in a classical selection index, weighted by index weights), or estimates of breeding values (from a BLUP analysis, weighted by economic weights)

Selection response is the effect of selection on merit of progeny or later descendants. It is measured as a deviation of the merit expected if parents had been chosen at random, rather than by selection on a selection criterion.