TOTAL GENETIC RESOURCE MANAGEMENT – APPLICATION IN THE BREEDING INDUSTRIES

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SUMMARY

LAMBPLAN has recently introduced Total Genetic Resources Management (TGRM) to assist in breeding program design. The technology is delivering significant increases in rates of genetic gain in a range of sheep breeds, and is helping breeders solve a number of design problems simply and quickly. There is scope for rapid growth in use of TGRM, which will hasten industry rationalisation and focus industry attention on critical aspects of asset management and commercialisation of genetic technology.

Keywords: TGRM, breeding program design, commercialisation

WHERE DOES TGRM FIT IN THE LAMBPLAN SYSTEM?

LAMBPLAN provides EBVs and Index Values to a range of sheep breeds (and other species). As acceptance of the LAMBPLAN system has grown, there has been increasing demand for breeding program design inputs, which have taken the form of involvement in nucleus breeding schemes (Banks 1997) and LAMBPLAN Young Sire Programs.

As these various organised breeding systems have developed, there has been increasing awareness of potential inbreeding problems, and of other operational issues such as management of heterosis and connection in group systems. Both research and "run-time" studies have highlighted the potential of Genetic Algorithms to address complex allocation problems (Meszaros 1999, Kinghorn and Shepherd 1999), and these tools have been developed for application to breeding program design issues through the Total Genetic Resources Management (TGRM) "concept".

The LAMBPLAN system has developed through a number of quite distinct phases (Table 3). Therefore TGRM is a logical (but very exciting) development in the process of continuous increase in value adding to raw pedigree and performance data. The significant step it represents is to shift decision making from the individual animal to the entire potential mating set - in effect manipulating the composition of the entire mixed model array for the population under consideration. Importantly, the potential for "local" fine-tuning is retained - the breeder can modify use of particular animals at any stage.

Table 3. Phases in the Development of the LAMBPLAN System

Phase	Time Period	Value-adding Processes	Average Rate of Gain (Index Standard Deviations per Year)
Pre-LAMBPLAN	Pre 1988	Very limited data, limited adjustment for fixed effects.	0
Sire Model, Within-Year and Flock	1988 ~1995	Steady growth in data, better adjustment for fixed effects, use of half-sib information, within-flock and within-year evaluation only.	0.13
Animal Model, Across-Flock and Year	1994 ~1999	a) Continuing growth in data, improved models, across-flock and across-year evaluation. b) Organised programs using AI	a) 0.31 b) 0.70
TGRM plus	1998 ~ ...	Continuing growth in data and better models, Across-breed evaluations, TGRM plus major gene technology plus reproductive technologies	Average c. 0.50, but full application of breeding program design tools will achieve > 1.5

This paper provides a simple outline of how TGRM is delivered, and of some operational issues arising from that delivery.

HOW IS TGRM DELIVERED?

To use TGRM, it is necessary for the breeder simply to identify mating candidates from within their flock or elsewhere, and then confirm preferences across a range of operational issues, such as inbreeding increment, costs, use of AI etc.. This component is currently handled via one-on-one "consulting", but it is expected that this will be at least partly automated as experience with delivery (and use) grows.

The breeder then receives one or more mating sets ~ a list of sire:dam combinations, giving expected merit and a range of other predicted results for the progeny of each mating. In addition, each mating set has summary information such as average inbreeding increment, average heterosis, and so on.

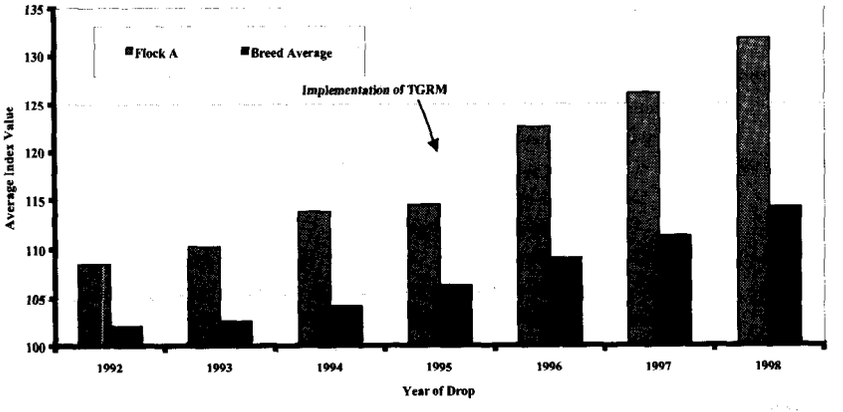
Breeders are charged for this service on a per mating basis, with the price currently based on a severely regressed estimate of the net present value of the commercial value of the improved mating set.

COMMERCIAL ACCEPTANCE OF TGRM - THE LAMBPLAN EXPERIENCE

Up to February 1999, there had been a total of 17 TGRM runs completed for LAMBPLAN clients, with datasets ranging in size from 60 mating allocations to over 1,000. Between February 1999 and June 1999 it is expected that a further 30 TGRM runs will have been completed (approximately 10 % of meat-sheep clients are expected to use the service within the first year of commercial operation). These runs include terminal sire, dual-purpose, and Merino sheep flocks, as well as other species.

On average the runs that have been completed have (predicted and realised) increases in rates of genetic gain of over 10 Index points (1 Index standard deviation) per year. This equates to three times the normal rate of genetic change that flocks using LAMBPLAN are achieving.

a.



b.

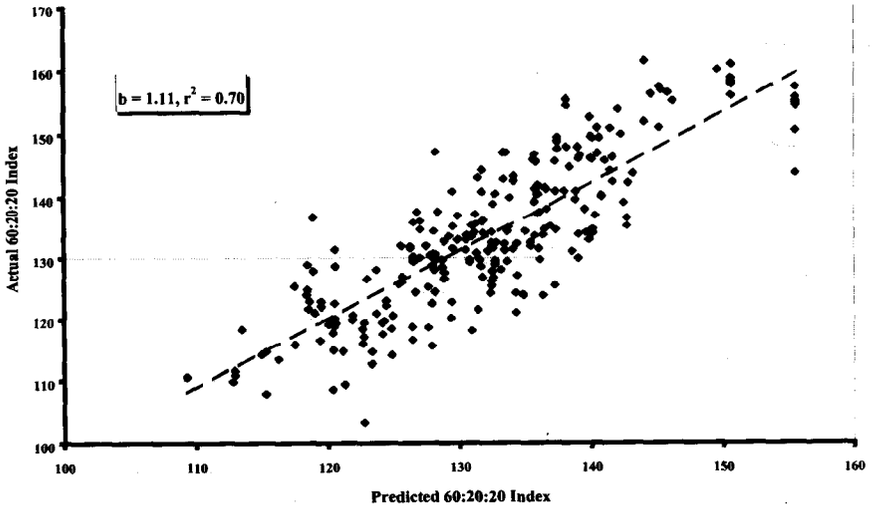


Figure 1 a) Genetic trend in a TGRM Client Flock b) Realised v Predicted Index Value for a TGRM Client Flock.

Fig 1a) show the acceleration in genetic progress in one client flock prior to and following adoption of TGRM (note that this application has involved optimisation of breed infusion and composition as well as genetic gain). Clearly TGRM depends on reliable prediction of progeny merit. Whilst this will depend on data quality, Fig 1 b) shows that the prediction is quite robust:

To date all clients who have used TGRM have relied on a standard LAMBPLAN index as the benchmark for deciding genetic merit. Whilst this has been useful some clients have experienced individual trait effects considered to be undesirable. This has been addressed with the recent inclusion of trait constraints into TGRM providing clients with more control over the final allocations made, whilst still meeting other breeding program goals.

ISSUES ARISING FROM USE OF TGRM

Successful animal breeding depends on 2 forms of investment in data: its collection and organisation, and its processing to extract information. Typically to date both investments have been collectively funded (often by the taxpayer). The information extracted is then made available at some cost (which may be nothing) to breeders for use in their selection and marketing decisions. Thus breeders (who in the case of LAMBPLAN are clients paying the full cost of data collection and processing) draw on a collective resource - the database and processing technology, in order to compete in the gene market.

TGRM depends on use of the entire database (or achieves better results when the entire database is accessible). This is also the case for advanced technologies in the area of gene detection, where use of limited samples of the recorded gene pool such as individual flocks is essentially useless. The sheep database (and the gene pool it maps) are currently viewed as public assets. Highly effective tools such as TGRM create the possibility of rapid and large-scale private benefit from such assets.

From this it is clear that the development and use of TGRM highlights policy issues that will be critical to the management of animal improvement in the 21st century:

- The first breeders to access any new technology can establish effectively permanent leads on their competitors. In animal breeding this typically accelerates rationalisation of the breeding sector, and following soon after, entire supply chains. The more effective the technology, the greater will be this effect.
- These breeders will achieve this edge at effectively no cost (at least by comparison with the cost of establishing and maintaining the database and the data processing technologies).
- Long-term success in the breeding operation(s) and hence in the R&D providers will increasingly depend on managing the entire gene pool and its database ~ earnings from sale of animals and genetic material such as semen or oocytes will pay for this.

This points to the need for clear and careful thinking about balancing cooperation and competition within and between sectors in the supply chain, and to rapid evolution in the nature and funding of the relationship between scientists and breeders. The entire development of animal breeding theory and implementation has depended on this partnership. Care will be needed in handling the increasing success of that partnership.

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