Plenary

BENCHMARKING GENETIC IMPROVEMENT IN AUSTRALIAN LIVESTOCK INDUSTRIES – A ROLE AND OPPORTUNITY FOR AAABG?

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SUMMARY
AAABG is now 25 years old (young). During the life of the organization, profound changes have taken place in Australian animal breeding, most notably the introduction of national genetic evaluations in the extensive livestock species. However, evidence suggests that in all species there is scope for much greater rates of progress than are currently being achieved. A simple genetic benchmarking system is proposed, with the suggestion that AAABG should take the lead in coordinating across industries. This will benefit all the livestock industries, and provide an intellectual foundation for continuing activity for AAABG itself.
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INTRODUCTION
The first AAABG Conference was held in August 1979, with objectives including the following:

a) To promote communication among all those interested in the application of genetics to animal production, particularly breeders and their organisations, consultants, extension workers, educators and geneticists.
b) To foster the application of genetics in animal production.
c) To promote the scientific study of animal breeding.

We are now at the 15th Conference. In the intervening period there have been some major developments in animal breeding and genetics in this country and internationally, but it is worth asking the extent to which AAABG has been effective in the fostering of genetics in animal production, and what role(s) might be available to AAABG in coming years.

Much of the impetus for this reflection comes from intensive reviewing of meat industry investment in animal breeding and genetics over the last 3-4 years, coupled with the fact that Meat and Livestock Australia (and before it the Meat Research Corporation and the Australian Meat and Livestock Research and Development Corporation) have been supporters of AAABG and the community it serves throughout the period.

AAABG represents a substantial investment for all involved. Can we judge the return on that investment, and can we increase that return?

My core message here is that AAABG should take a leadership role in monitoring and reporting genetic improvement to the Australian community, and that a simple framework should be used for doing so. Adopting that role will provide both increased focus for publishing and presenting new material at these conferences, and also help to convince the many organisations responsible for funding conference attendees that their investment is justified.

The structure of this paper includes:
a) brief outline of major changes during the 25 years since AAABG 1,
b) a suggested framework for monitoring the effectiveness of genetic improvement in Australasian livestock industries,
c) suggested ways in which AAABG could promote use of that framework.

My discussion of industry trends focuses on Australia, for reasons of more direct experience, but the key messages are applicable to both Australia and New Zealand.

DISCUSSION

Major changes in Australasian livestock improvement since 1978. Very clearly, the major change during the life of AAABG has been the introduction of industry-wide evaluation systems, based on BLUP procedures, for all major extensive industries.

Thus, the Australian Dairy Herd Improvement Scheme (ADHIS) was launched in 1981, with a unified national evaluation for production traits. Beef cattle followed soon after, with the introduction of Group BREEDPLAN in major breeds in the mid-1980's. Pigs, and meat and wool sheep began using BLUP procedures during the late 1980's, but on a within-flock basis, moving to across-flock procedures during the 1990's. All three now have national across-flock systems. In plants, moves to introduce similar systems began in Australia with the introduction of TREEPLAN during the late 1990s, and planning is now underway for a similar system for pasture plants and some other crop plants.

Alongside the introduction of across-unit evaluations in all species has been a steady focus on better understanding of breeding objectives. The various industries have differed in their timing of introduction of either standard and/or customised objectives and hence indices, but at least standard indices are now available in all the livestock industries.

As industries have embraced across-unit genetic evaluation, there has begun to be some attention paid to improving breeding program design, using a mixture of modelling-based approaches, and more recently, developing tools for breeders to "find their own solutions" through optimisation tools.
A cursory review of the papers published in AAABG over the period reflects this history – there has been considerable effort directed towards defining traits and systems for measurement, characterising the traits genetically, and understanding their genetic relationship with other evaluated traits.

If we summarise trait groupings as production (rate or amount), production (quality), reproduction, disease resistance or resilience, behaviour and structure, at various times all groups (except structure) have received attention, although most effort has gone towards production (rate/amount and quality).

This leads us to having large numbers of traits that can be evaluated – in sheep that number is now about 60, and with new models, such as random regression and/or models including genes of large effect and/or markers, under active research. At the same time, in all species, commercial producers – buyers of seedstock – still want very simple information – "as few figures as possible".

Effectively, all the major livestock industries now have sound tools for each component of genetic improvement – breeding objectives, genetic evaluation, and breeding program design. This has been achieved through significant investment of public funds, backed in most industries by the private effort of measuring animals on farms.

What has all this effort yielded? MLA recently commissioned an analysis of Return on Investment in genetic technologies in the beef industry (Farquharson et al, 2002). The results are illuminating, and I suggest, have parallels with other industries.

The total industry investment over the period since 1970 into "genetic improvement technology" (including extension) has averaged $8m per annum (total $350m). Over all sources, the return from genetic technologies since 1970 was estimated to be $11bn on-farm and $33bn to the community at large, against a total investment estimated at $350m. This comprised:

- $10.2bn due to infusion of Bos indicus genes into the northern herd (although note that the original importation occurred in the early 1950s),
- $315m on-farm ($944m total) due to selection,
- $85m on-farm ($245m total) due to cross-breeding in southern herds,
- $88m on-farm ($265m total) due to breed change in southern herds

Interestingly, these estimated rates of return accord with those estimated for a wide range of other agricultural technologies (Alston et al, 2000).

In discussing the prospects for further returns from beef cattle genetic technologies, the authors noted a) that further benefits were already in the pipeline, flowing from developments in new traits, b) that further scope for benefit from infusion such as the Bos indicus effect was limited, and c) that there is considerable scope for better use of crossbreeding and for accelerated genetic improvement.

I suspect that a similar situation exists in our other livestock industries. For example, the dairy industry is now tightly linked to the major international Holstein and Jersey improvement programs, so breeding

programs are progressing at about the world rate, but nowhere near as fast as might be expected from a specialist programs such as the Dutch Delta program.

The meat sheep industry benefited from the stimulus provided by the importation of Texels and US Suffolks, but as existing breeds have focused on better breeding programs (and to some extent infused the best of the exotic breeds) neither import has grown significant market share. Returns on investment in meat sheep genetic technology have come overwhelmingly from selection (Banks, unpublished).

The wool industry has had some stimulus from importation of more dual-purpose breeds from South Africa, but there remains huge scope for improved selection response. Similarly in pigs, new breeds imported to deliver specific characteristics have encouraged recording and selection, but the industry at large still has potential for faster genetic progress.

In summary, I think we can see some common features of all industries' genetic improvement effort over the last 25 years:

a) gradual – but snowballing – recording effort stimulated by and stimulating, delivery of EBVs for a growing range of traits,
b) some importation effort, but little scope left for major productivity jumps due to new importations,
c) gradually increasing focus on better data collection, encompassing the full range of traits contributing to functional, healthy and profit-generating animals, and with it, consolidation of breeding activity around those individuals, groups and breeds willing and able to manage that recording effort,
d) the beginnings of transfer of entrepreneurial effort to breeders and breeding organisations – taking responsibility for both maximizing rate of genetic improvement, and for marketing and communication of genetic products to commercial producers. This is only just beginning in any industry, and in itself represents a unique opportunity for a fascinating study into socio-technological evolution, as the relationship between scientists and industry begins to change quite rapidly.

Taking a "black hat" industry investor's view, one might conclude by saying that everything is now in place for a very active, market-driven period, with faster and faster genetic progress for total profit in all industries. What role then for industry R&D funding? What role then for an essentially cooperative, public information vehicle such as AAABG?

Benchmarking genetic improvement – A model. In almost all products and services, Australia is a small to moderate-sized, mixed economy, where policy makers and the private and public sectors continually aim to find a workable (given our funds and numbers of customers) and acceptable balance between efficiency (high return on investment) and equity (reasonable access to funds for, and returns from, investments both monetary and non-monetary).

Our stance in relation to agricultural R&D is a case in point: most R&D is publicly or industry-funded, and individual businesses are free to make their own decisions about adoption of new technologies. The

positives of this approach include widespread and cheap availability of technology (and IP). The negatives include quite slow adoption of innovations, particularly where market signals are either not clear, imprecise (i.e. very broad quality specifications) or are made less effective by production supports of any form.

In this situation the challenge of maximizing competitiveness for the industry and profitability for individual requires:

- Clear information available on animals' genetic merit and how to use it,
- Information packaged and marketed effectively to diverse decision-makers,
- Wherever possible monitoring the rate of adoption and improvement, so that under-performance is detected very rapidly and can be addressed.

AAABG has now only perhaps a role as a forum for discussion of how to achieve the first two, but can certainly work with the major industry R&D funders to achieve the third. How could that be done? Genetic improvement comes to our rescue here – the components of improvement are clear, and readily determined from the routine analyses.

The suggested overall framework for the evaluation of livestock improvement programs including some diagnostic steps is set out in Table 1 (over page).

This technical and financial evaluation of livestock improvement programs is straightforward, and there is no reason why any improvement program in any species could not be evaluated following this simple outline. Most features of the evaluation will be common, but with some scope for recognizing aspects unique to particular species and industry structures.

Table 1. Framework for evaluation and diagnosis of Livestock Improvement Programs

Parameter:	**Measure**
Rate of gain:	
primary measure:	Predicted/estimated gain (in genetic standard deviations) in index and component traits
secondary measures	Selection intensities in nucleus Accuracy of selection in nucleus Generation length in nucleus
Mapping of genetic variability:	Genetic (co)variance for trait, proportion of total variance explained

Appropriateness of breeding objectives:	
	Current/recent prices/trends for traits in objective function, and their variance
Sustainability (genetic sustainability):	
Inbreeding accumulation	Numbers of new sires per year/calculated rate of inbreeding
Measures of financial performance:	
Variable costs	Cost of recording for each trait Cost of processing per breeding value estimate Cost of advisory inputs ~ to recording Cost of advisory inputs ~ to selection and mating
Fixed costs	Net investment in design, parameter estimation, system management, and training
Net performance	Net investment ~ total fixed costs Net investment ~ total variable/recording and processing costs, and total advisory costs
Financial return ~ to system	Discounted commercial expressions per nucleus animal (number) Price trends for commercial traits

MLA has initiated routine monitoring and evaluation of genetic improvement in sheep and beef cattle using this framework.

The proposal to AAABG is to extend this across species. A simple way to achieve that would be to establish a small working party within each AAABG Committee, which would request data from breeding organisations and/or industries, using a standard format modeled on that outlined in Table 1. The Working Party would need a small budget (as it would perform no analyses), and would be charged with producing a simple annual genetic improvement report, which could to be posted on the AAABG website. Assuming only a small budget, industry bodies could provide some funding support for this activity.

Questions and challenges arising from use of an across-species framework for genetic benchmarking. One response to the suggestion of a national genetic benchmarking framework and process will be "why bother"? After all, the ultimate test will be the market for use of land and resources, and industries that fail to achieve genetic improvement for sustainable profit will lose market share. There

is perhaps no core answer to this view. From a selfish, single industry viewpoint, benchmarking is good because we might learn something from competing industries, and have a better basis for directing investments within an industry. The same applies for a single business within any one industry. From a national perspective, it is presumably better to have several choices for land use – because a number of different industries are all making high rates of genetic gain and are therefore competitive, so genetic benchmarking helps "manage the portfolio".

From the point of view of those of us who work in genetic improvement in some way, there is almost a self-preservation value in the proposed framework and process. Outside our community, very few people are aware of genetic improvement in any meaningful way, even when responsible for managing investments into R&D (which provides the employment for much of AAABG). One valuable attribute of quantitative genetics is that it is relatively straightforward to estimate (or effectively, measure) the rate of genetic improvement and its components, so there is really no excuse for not detailing the results of our continuing activities for those who generally have a poor and reluctant grasp of the resulting benefits.

What other benefits might we obtain from this activity? The following are brief suggestions, all of which could be expanded.

Focus on the whole value chain of genetic improvement knowledge – not just the components: Benchmarking rate of progress, and its key determinants, heightens focus on how different tools are put together, not just on one particular element. It encourages us to remember that we are in the business of managing (juggling) selection intensity, selection accuracy, and rate of turning over the genes; not just finessing any one.

How to expose the results? Should AAABG be involved in a national genetic improvement forum, bringing together breeders, services, scientists and investors? Should benchmarking reports be lodged on the AAABG website?

Benchmarking with overseas, including estimating trends due to imports? This is a no-brainer – all investors need to know how much benefit is being obtained from imports, and at what cost, compared to the benefits deriving from local selection and multiplication effort. Many would (and do) argue that Australia would be better off simply importing genetics (and genetic technologies).

Focus on tools that are easy for ordinary farmers to use – which helps Australian farmers to compete with large vertically integrated businesses. Greater focus on genetic improvement rather than its components should help generate new, simpler ways of communicating the strengths of individual programs – making marketing superior genetics easier.

Impact on roles of people, and on directions for research. Better focus on genetic improvement itself will help us all to identify areas requiring greater skilled input, and/or areas no longer responding. In turn, this will help focus R&D and I (implementation) effort.

SUMMARY

In the last 25 years, considerable effort has been expended into establishing robust national genetic evaluations in Australia's livestock industries. Partly because of this success, there has been some re-direction of R&D funds away from genetic improvement, and in some areas, it is becoming harder to attract good candidates. National genetic benchmarking will help to address this, partly by highlighting the scope for significant increases in rates of gain (and hence community benefit) in all species. A simple model and process for achieving this is laid out. This activity will re-invigorate the AAABG community, and create a favourable environment for a new round of focused and productive engagement between industry, scientists, advisors and investors.

REFERENCES

Alston, J. M., Marra, M.C., Pardey, P.G., and Wyatt, T.J. (2000) Aust. J. Agric. Res. Economics **44**: 185.
Farquharson, R.J., Griffith, G. R., Barwick, S. A., and Banks, R. G. (2002) Proc. 7th Wld. Congr. Genet. Appl. Livestock Prod. **2**: 34