HELEN NEWTON TURNER MEDALLIST ORATION 2011
HOW CAN LIVESTOCK GENETIC IMPROVEMENT EVOLVE FASTER?

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It is a great honour to be the recipient of this award, given in memory of Helen Newton Turner. I only had the privilege of meeting Helen Newton Turner once, but her work informed my initial steps in the role of National LAMBPLAN Coordinator. Soon after commencing in that role, I discovered in the UNE library a report to Standing Committee of Agriculture in which she outlined the necessary key elements of a genetic improvement scheme for meat sheep in Australia. Her report was written in I think 1956, a long time before I started in LAMBPLAN, but all the fundamentals were there, and to some extent the development of LAMBPLAN followed her recommendations.

The livestock industries remain an important part of our economy, in particular our rural economy. The combined GVP is of the main livestock industries is at least $15bn pa on-farm, and the multiplier value through to domestic and overseas consumers many times that.

Breeding animals that suit Australian production systems and our markets has been a challenge since the first days of European settlement, but Australia has been blessed with active and talented animal breeders, and more recently researchers and extension personnel, and to have worked with many of them during the last 25 years has been a privilege.

In the period since the first awarding of the Helen Newton-Turner medal in 1994, there has been consolidation of national genetic evaluation systems for all major livestock species in this country, and in parallel, development and use of methods for direct genotyping. At the same time, we have with one or two exceptions achieved genetic improvement at similar rates to other countries and there is still considerable room for improvement in the effectiveness of our efforts in research, development and implementation, and in rates of improvement across all species.

What contributes to that performance gap, and what might be done about reducing it? I suggest that we need to examine a number of aspects of animal breeding research and its implementation in this country with the aim of re-balancing our efforts.

The following points are all aspects of how we think about and invest in animal genetic improvement. What we conclude on each, and how we respond, are important questions:

- Given that the principles of variation, selection and multiplication – the evolutionary algorithm – are completely confirmed, what is research?

Research by definition implies that answers are uncertain. However, this is not generally the case in the broad sense in animal breeding, since we have wide knowledge of typical parameters, and very reliable knowledge of how to apply selection. One area where uncertainty will not disappear lies in estimating the merit of new animals and in the relationships between genotypes and animal performance. In this context, new crops of animals can arguably be viewed as a research project – in the sense that their data informs genomic prediction, quite literally so.

- Genomics has been promoted as a disruptive technology, potentially ushering in a new era in which progress would be faster, directed at a much more interesting set of traits, and more glamorous – no more reliance on tedious recording of old-fashioned traits! It may well be disruptive, but very likely because its heavy dependence on data will radically transform industry structures, in ways explored and analysed by Bichard, James and others in the 1970s, and in particular, focus attention on the commercial relationships around data.

Genomic selection is making very clear the paramount importance of good data on the relevant traits on informative animals. To date in Australia in all species optimising investment in data has been left to the individual breeder, and it can be argued that much of our focus in national genetic evaluation schemes has been on making the best use of data of very variable quality. Genomic technologies allow us to uncouple recording and estimation of breeding values, and this will force attention of data quality, quantity and on efficient structures for recording and for exploiting the resulting information.

- Principles and recommendations are emerging for the technical requirements underpinning genomic selection, and are clear for parameter estimation in general. Given that these are essentially minimum data requirements, should collective funds be applied to breeds that either don't, or barely meet these minima?

As a rule of thumb, a breeding population (more typically referred to as a breed) requires approximately 5-6,000 recorded and genotyped animals per trait to achieve useful accuracy of genomic prediction. Further, as selection proceeds, this will need to be "topped up" or "refreshed" with approximately 1-2,000 plus new animals recorded and genotyped per trait per year. For many breeds of extensive livestock in this country, these numbers are close to or exceed their total current recording populations. This raises the interesting question of whether anyone should care about this, and if so, what we might do about it.

- Can we afford to conduct research on animals other than those at the apex of the breeding pyramid? Do we work closely enough with leading breeders?

Over the last 30 years in Australia there has been a steady decline in public sector support for agricultural R&D, including research stations and large-scale genetics research projects such as selection experiments. To some extent the investments in the Information Nucleus projects in beef and sheep have slowed this trend, but importantly these have involved heavy sampling of elite industry genetics.

Research scientists, together with industry and government funding bodies, will increasingly need to maximise the cost-effectiveness of research projects, and in doing so take account of time to adoption. This focus invariably means that earlier adoption is better than later, and if research is conducted on the active population, there are benefits in not having to re-estimate between the experimental and active populations.

It is hard to see that this will not lead to at least a section of the commercially and genetically active population becoming simultaneously a section of the research population, and that where possible research activities will be integrated into normal commercial breeding operations. This may require some funding flowing directly to the herds or flocks involved, but overall savings will come from speed and genetic relevance.

- Is it possible that industries simply do not have the capacity to benefit from quite rapid change in some traits, for instance in product quality? Is gradual improvement all that can be harvested, or does it simply fail to be detected?

Reflection on genetic and (commercial sector) phenotypic changes that have occurred in beef cattle and sheep (and probably other species as well) over the last 30 years, it appears that most changes have been gradual, which is consistent with all traditional expectations of genetic improvement. However there are signs that as genetic progress accelerates through learning and as wider genetic variation is accessed – an example being Wagyu genetics – that phenotypic changes can actually be quite dramatic. For this to really take effect, feedback of some form is essential, and that feedback needs to encompass the full range of performance. Otherwise, commercial returns will lag well behind what is possible. In industries with considerable diversity of markets and production enterprises, this inefficiency of feedback is almost certainly generating significant opportunity costs. A case could be made for making systems such as MSA universal through industry support, simply in order to maximise the efficiency of information flow.

- Genetic variation is usually the largest single definable source of phenotypic variation, yet we tend to think of it as minor. Does this affect our communications? Our investment patterns?

Most R&D and management investment over the last 50 years has been into non-genetic change, yet, especially once across-flock and across-herd genetic evaluations are in place, the range in genetic merit of bulls or rams available to commercial producers very rapidly becomes the largest proportion of improvement available to the producer. There is a strong case to be made that investment into new phenotypes should be the priority in livestock R&D, and capturing the benefits of superior genetics the focus of management investment.

- Do we need to more directly take account of the fact that the breeding businesses in our industries are both numerous and modest size? And that these structural factors mean that at a broad level, all traits are important?

Australia (and I think New Zealand) are almost unique in the number and average size of breeding sector operations within the beef and sheep industries. One senses that the resulting diversity is brushed aside as an unfortunate cost, but could it perhaps be, a la “Wisdom of Crowds” a resource? Including the possibility that it allows for recording of more traits than would otherwise be supported?

- Much of livestock production has involved applying management skills which entail adjusting the environment to suit the animal, ideally profitably. This needs to be, and will be, turned on its head. Genetically changing the animals to maximise their fit with the physical and consumer environment is not only more profitable in any but the very short term, but can now be achieved rapidly.

This extends the point above about the returns from investment in genetic and non-genetic change. But it links to the important message that for societal acceptance of livestock agriculture to be maintained, it would be far better if animals did not get diseases or require surgical intervention or potentially stressful management treatment. Breeding animals with these characteristics is simply a matter of having the data and selecting on breeding value. Industry should get on with it.

- Despite this last point, we face the problem that genetic improvement is for many an abstract concept, which hinders both adoption and investment. Making genetic improvement concrete, rapid and obvious is worthwhile.

This point needs no explanation, but it is worth remembering that simple, clear communication of the positive stories about sensible genetic improvement will maintain not only the right to farm but also the right and support to do genetics R&D.

- Finally, the field has focussed essentially on the simple mathematics of objectives, evaluation and design, all of which are well-established and in principle straightforward. New thinking is needed on the structural and business innovation needed to convert these principles into practice.

This point is perhaps rather too broad, but there is a link back to my earlier point about the structure and diversity of our extensive livestock industries' breeding sectors. These structures have survived the last 30 years of enormous changes in evaluation methods and rates of progress, but the introduction of genomic tools seems likely to usher in changes in the role(s) of breeders, their clients and their societies. Helping industry find robust, efficient and equitable models for implementation of the new approaches will require bringing economics and genetics R&D together, and likely involve insights from fields such as network analysis, value chain economics, and service model innovation.

Each of these can be explored further, but my overall message is that while we have made significant progress in the tools of genetic improvement, it is not so obvious that putting them into practice has advanced as much. This could be viewed as that we have done better at those parts of the livestock genetic improvement that do not involve humans – in simple terms, the maths and the modelling. And yet all the decisions that generate returns from the science are made by humans.

To date we have relied on simple (and sound) principles of extension, and in this country tended to avoid directly engaging with industry structural issues. This approach could be characterised as slow and gradual change by infiltration – the "virus" of genetic change has been evolved slowly and introduced rather slowly.

This is not really good enough – livestock industries need to be making improvement at 3% or more per year in profitability simply to stay in place, and this is quite achievable, as several examples demonstrate.

The next phase in the Australian livestock genetic improvement venture requires us to match the innovation and radical simplicity of much of the technical work with parallel innovation and radical simplicity in implementation, and indeed, in making the technical and the implementation simply two sides of the same coin. Each of our livestock industries has examples of methods that have achieved this, but we now need to make those examples the core of what we do, rather than limited scale trials.

Genetic improvement is far too important to leave either to chance or to the slow workings of imperfect markets. And "research" and "extension" (or implementation) cannot be separate. The industries that have made the most out of animal breeding science simply make genetic improvement and then harvest its value. For the sake of the Australian community, we must do the same.