Organisational Models for Beef Recording and Genetic Evaluation in Australasia, the Americas and Southern Africa

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1. Forward

ICAR member countries and organisations focused on beef cattle share goals of improving the quantity and quality of performance recording, use of sound genetic evaluations and subsequent genetic improvement, and where appropriate, international collaboration in promoting these goals.

At the same time, there is some diversity in the organisation and implementation of all aspects of performance recording, genetic evaluation and improvement in beef cattle amongst the various member countries. This paper outlines some characteristics of the beef improvement system in a number of non-European countries, and discusses how they impact on outcomes in the commercial beef populations.

Finally, some challenges to rapid genetic improvement of beef cattle are identified, and ways outlined in which public co-investment and new roles for ICAR might assist in meeting those challenges are suggested.

2. Beef Breeding in the Territory

2.1 Background

The population of cattle (predominantly beef cattle) in Australasia, the Americas and Southern African countries of South Africa, Zimbabwe and Namibia is estimated to be around 566M head (about 40% of the world's cattle population of 1,459M). In this paper the area covered by the countries is referred to as the Territory. Commercial production of beef in the Territory is largely unsubsidized and breeding in commercial herds is predominantly (about 90%) by natural service. Because of the wide range of climatic conditions in the Territory (tropical, sub-tropical, temperate and arid) a wide range of breeds are run. Over 60 of these breeds have recording systems.

Management of data for birth recording, registrations, performance, genomic tests and genetic evaluation in these countries is undertaken predominantly by beef cattle breed associations as a service to their members. Most meet or exceed ICAR recording guidelines but see little need or benefit in applying for compliance.

Genetic evaluation services are in most cases provided by specialized service providers on a sub-contract basis to breed associations. The form of the analysis tends to be flexible to meet the needs of the particular breed and may include:

- Within breed within country evaluations
- Across breed within country evaluations
- Within breed across country evaluations
- Across breed across country evaluations

All forms of evaluation provide Estimated Breeding Values (EBVs) or Estimated Progeny Differences (EPDs) which are used by seedstock breeders to assist their selection and to market young bulls to other seedstock herds but predominantly to commercial herds. The integration of genomic test information into EBVs/EPDs in progressing rapidly. Commercial imperatives in both bull and semen selling mean that these genetic evaluations must be timely, and so they are now provided several times a year for most breeds.

Across-country genetic evaluations for a wide range of traits have been conducted on a routine basis by many breed associations in the Territory for over two decades to meet the information needs of breeders and artificial breeding companies involved in marketing of genetics between countries. These evaluations use all available pedigree, performance and genomic information of participating associations. This approach is different from that used by Interbull for the dairy industry which uses as input the EBVs calculated in participating countries.

2.2 Organisation by Countries/Regions

Table 2.1 provides information on the organisation of recording and genetic evaluation services throughout the Territory and estimates of the levels of annual recording of calves for seedstock purposes (column 3 of the Table).

There is little consistency in the way the number of seedstock calves recorded each year is reported between countries. For example some countries report the number of active seedstock females, others the number of calves entered in the herd book while Australia and Canada report the number of calves of purebred or grading up status recorded from at least one registered parent that may be used for seedstock purposes. The authors have estimated the number of recorded calves to be used for seedstock production across all countries and regions in the Territory as this provides a good measure of the contribution of breed associations to the genetic attributes of the commercial beef industries in the countries in which they are run.

Table 2.1: Organisation of Recording and Genetic Evaluation Services in the Territory				
Country/ Region	**Est. Cattle Population M head**	**Estimated Annual Beef Cattle Seedstock Recorded**	**Who provides recording / registration software**	**Who provides genetic evaluation software**
Latin America	404	880,000	Breed Associations Commercial agencies	Commercial agencies Universities BREEDPLAN Government agencies
United States of America	94	865,000	Breed Associations Commercial agencies ILR	Angus Genetics Inc American Simmental Assoc. GPS BREEDPLAN Universities
Australia	30	190,000	ILR	BREEDPLAN
Southern Africa (South Africa, Namibia & Zimbabwe)	21	173,000	ILR Logix	BREEDPLAN Logix
Canada	13	146,420	ILR Commercial agencies	BREEDPLAN US agencies Canadian agencies
New Zealand (beef cattle only)	4	36,000	ILR	BREEDPLAN Commercial agencies
Total	566M	2,290,420		

Footnotes to Table 2.1:
American Simmental Association provides genetic evaluation services to a small number of breeds in the USA.
ILR stands for International Livestock Register which is the registration software licensed by the Agricultural Business Research Institute (ABRI)
Logix is the integrated pedigree/genetic evaluation software run by the SA Stud Book.
Angus Genetics Inc (AGI) is a subsidiary of the American Angus Association which provides genetic evaluation services to American Angus Association in the USA and a number of other breeds.
GPS stands for Genetic Performance Solutions which provides genetic evaluation services to a small number of breeds in the USA.
BREEDPLAN is the genetic evaluation service provided internationally from the ABRI in Australia.
Southern Africa in this paper is limited to South Africa, Namibia and Zimbabwe.

Source of registration statistics:
Latin America – based on estimates for Brazil extrapolated to the whole region
USA – from National Pedigree Livestock Council plus an allowance for missing breeds and then extrapolated to include unregistered seedstock calves.
Australia – from Australian Registered Cattle Breeders Association Inc
New Zealand – from Performance Beef Breeders New Zealand Ltd
Southern Africa – estimated from statistics published by Animal Production Institute supplemented by ABRI records.
Canada – official national statistics

Table 2.1 shows that the organisation of recording and genetic evaluation services in the Territory varies from country to country but Government has largely withdrawn from direct service provision.

In Australia and New Zealand virtually all registration and genetic evaluation work is undertaken using the same software, namely the International Livestock Register (ILR), provided by the Agricultural Business Research Institute (ABRI). ILR is linked to the BREEDPLAN genetic evaluation system. Data for the 9 main beef breeds that are run in both countries are combined for genetic evaluation which is performed on a monthly basis in most of these breeds. These evaluations include a comprehensive range of around 20 traits. ABRI is a not-for-profit company. It receives no Government support for the operation of these services but does have access to some funds for development of genetic technologies and technology transfer.

In the Southern African countries of South Africa, Namibia and Zimbabwe the market for recording, registration and genetic evaluation services is divided between the ABRI products (ILR and BREEDPLAN) and the Logix system provided through the SA Stud Book. This market depends heavily on overseas providers of both registry and genetic evaluation technologies. It is important that these technology providers make a long-term commitment to capacity building at a local level and partnership with local research and development organisations to underpin a sustainable service that is customized to local requirements.

In the USA some breed associations (such as the American Angus Association, the International Brangus Breeders Association and the American Simmental Association) have written their own breed registry software while others license software from commercial agencies including the ILR system from ABRI. Historically, a small number of Universities with animal science expertise have provided genetic evaluation services to breed associations under sub-contract. However, this work has progressively gravitated to the private sector. Today, the main service providers include Angus Genetics Inc (AGI), Genetic Performance Solutions, the American Simmental Association and the BREEDPLAN service of ABRI. With the incorporation of genomic data into genetic evaluations the current thrust is to undertake analyses more frequently. For example, the AGI provides a weekly update of EPDs to American Angus breeders.

In Canada around 65% of beef registrations are processed via licensed ILR systems. The remainder are handled by licensing of systems from other software providers. The USA is a major market for Canadian beef genetics and so Canadian and US data tends to be combined for genetic evaluation. Some of these genetic evaluations are provided by US agencies; some breeds use BREEDPLAN which also combines US and Canadian data and the remainder, albeit the minority of data, is evaluated by Canadian agencies which have limited opportunities for accessing US data.

Latin America includes a number of countries which collectively run around 404 million cattle of which 52% are in Brazil. There are a number of service providers for recording, registration and genetic evaluation services.[1] Government agencies, universities, commercial agencies and BREEDPLAN all compete for a share of this huge market.

The structure of the beef breeding industry in the Territory is very different from that in Europe and its servicing requirements reflect this.

3. **Breed Associations have the financial capacity to contribute to genetic evaluation developments**

Throughout the Territory, breed associations have evolved over time from their traditional role as keepers of the herd books to diversified service providers involved in a range of activities such as:

- Maintenance of membership and herd book files,
- Breed promotion,
- Provision of internet-based information services,
- Support for sale and export of cattle,
- Graphic design services,
- Research services,
- Technical extension services,
- Progeny tests,
- Genetic evaluation services,
- Development of genomic services, and
- Marketing of branded products.

An independent survey of Australia's beef cattle breed associations published by the Australian Registered Cattle Breeders Association Inc.[2] (ARCBA) in 2010 showed that associations had an average annual income equivalent to US$70 for each seedstock calf added to the database in 2009. ARCBA strongly recommends that breed associations diversify their service provision so that the traditional sources of income from registrations, membership and transfers do not make up more than 50% of gross income. Some countries in the Territory may receive less income per calf and others a similar amount. Also, within a country there will be a range in the income per seedstock calf achieved by different breeds. The popular breeds that offer a diverse range of the services listed above tend to achieve higher-than-average income per calf. Table 3.1 below shows estimates of the gross income of beef breed associations throughout the Territory based on three assumptions of gross income per seedstock calf recorded:

Table 3.1 Estimates of Gross Income of Beef Breed Associations in the Territory

Estimated Seedstock calves recorded pa in the Territory 'M	Income per calf recorded USD	Estimate of Gross Annual Income of beef breed associations in the Territory Million USD
2.3	50	115
2.3	60	138
2.3	70	161

This analysis shows that the aggregate annual gross income of beef breed associations in the Territory is likely to be in the range USD 115M to USD 161M. While there are many demands on these funds, breed associations in the Territory (particularly those for the popular breeds) have access to substantial financial resources. This gives them the capacity to invest in developing improved genetic evaluation services and exploring the potential role of genomics in breed improvement.

This investment may be made in a number of ways including:

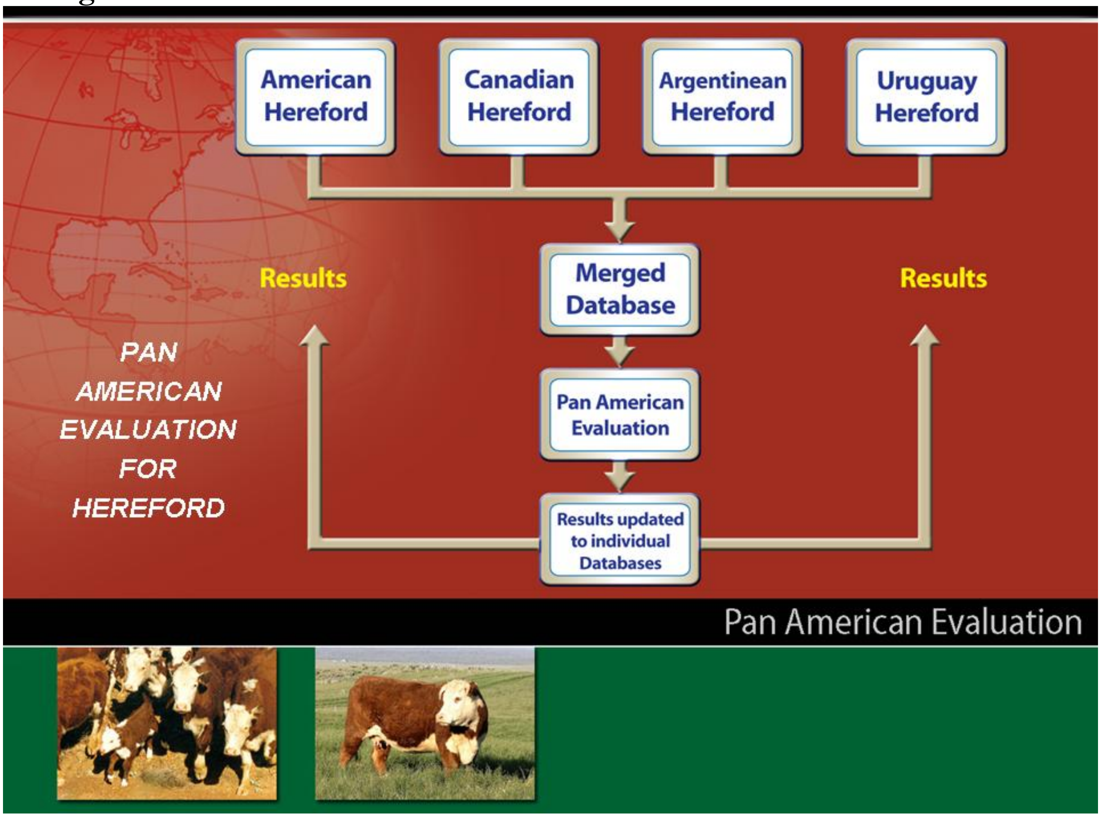
i) Investment by an association in its own genetic evaluation technology where this is seen to give the association some competitive advantage,
ii) Co-investment with other breed associations to address needs for industry-wide improvements, or
iii) Co-investment with other breed associations and industry funding agencies to address needs for industry-wide improvements.

An analysis of the rationale for the private/public sector co-funding of developments in genetic improvement programs is given in section 5.

4. A Case Study of International Genetic Evaluation

Arguably, the most ambitious ongoing genetic evaluation project undertaken in the Territory is the Hereford Pan American genetic evaluation.[3] The participants are the Hereford breed associations in the USA, Canada, Argentina and Uruguay and the evaluation uses BREEDPLAN technology. This project went into production in July, 2009 following over 4 years of development work. Figure 4.1 shows how it works.

Figure 4.1: How the Pan American Genetic Evaluation for Hereford works



The research and development phase involved:

- Complete re-estimation of adjustment factors and genetic parameters for all 4 countries.
- Matching of all common animals, a huge task as almost 6 million animals are included in the joint analysis.
- Revising analytical software to handle country-specific trait definitions, adjustment factors and heritabilities.

The production run involves a huge dataset.

Table 4.1: Data set for Pan American Genetic Evaluation of Hereford

Trait	Total Records
Birth Weight*	3.0M
Weaning Weight*	3.8M
Yearling Weight*	1.7M
Final Weight	178,000
Scrotal Size	146,000
Scan REA-FAT-IMF	173,000 (x3)
Carcase (HCW, REA, FAT, MARB)	3,100 (x4)
*Direct and maternal. ▪ 5.7M animals (4.3M with a record/s) ▪ 240,000 sires. ▪ 1,870,000 dams	

The analysis provides EPDs for a wide range of traits as shown in Table 4.2:

Table 4.2: Traits for which EPDs are calculated in the Pan American Genetic Evaluation

Birth Weight	Scrotal Size
Weaning Weight	Carcass EMA
Yearling Weight	Carcass Rib Fat
Final Weight	Carcass Marble Score
Mature Cow Weight	Calving Ease Direct
Maternal Weaning Weight (Milk)	Calving Ease Daughters

Both live animal ultrasound scan information and abattoir carcass data is included in the calculation of carcass EPDs.

During 2012, genomics-enhanced EPDs will be produced as a result of collaborative work between Australian and American animal scientists. Production runs have been scheduled each six (6) months but plans are being considered to increase this to a quarterly frequency.

The benefits of this evaluation are huge. For example, some sires which had small sets of progeny in particular countries now have a combined progeny set of several thousand animals providing very accurate EPDs. These EPDs are comparable across countries thus richly enhancing the information available to breeders for selection. For example, the American Hereford Association (AHA) has already listed on the AHA Website all the Uruguayan sires that meets its accuracy criterion. The fees which ABRI charges to run this evaluation are met entirely by the participating breed associations.

5. The rationale for public investment in genetic improvement, and potential roles for ICAR

It is widely understood (but not widely analysed) that the while the majority of the costs of genetic improvement (performance recording, AI etc) accrue to the breeding sector, the majority of benefits accrue to others in the chain producers-feedlotters-processors-retailers-consumers. While details of this structure vary between countries, both the actual structure and the distribution of benefits, estimates of proportions of benefit captured are typically as shown in Table 5.1 (Zhao et al, 2002):

Table 5.1: Estimated Proportions of Benefits by sectors from Genetic Improvement

Sector	Producer (seedstock & commercial)	Feedlotter[1]	Processor	Retailer	Consumer
Share of benefit	27-33%	1%	1%	5%	60-66%

1. Individual feedlots which have built and analysed databases of feedlot profitability by genetic origin of animals have been able to achieve much higher than industry-average benefits by purchasing feeder cattle from genetic lines with a proven record of profitable feedlot performance

The share of benefit captured by the seedstock sector almost certainly varies between countries, but in Australia the seedstock and commercial producers share benefits in roughly equal proportions.

This distribution has two important consequences:

- for much of the period of development of genetic improvement technology, it has been used to justify tax-payer contribution to the costs of R&D, since consumers (the community) receive such a significant proportion of the overall benefits
- typically beef supply chains have very inefficient flow of price signals from consumer back through to breeder. This means that breeders typically have very little direct price-based incentive to invest in recording for traits that primarily benefits sectors other than the producer. Eating quality traits are an example of this – they are increasingly important to the consumer, but direct price signals to the producer and through them to breeders are rare.
  This characteristic of beef (and other livestock) supply chains has reinforced the arguments for taxpayer support for R&D. Note that simply conducting R&D into traits affecting consumers does not automatically lead to changes in recording and selection in the breeding sector – if price signals remain weak and/or distorted, recording and selection emphasis will to a large degree remain focused on traits valued by the producer.

In Australia, the response to these consequences has been to support beef genetic improvement R&D (and much other R&D in agriculture) through a mechanism whereby levies collected from producers are matched up to specified limits by Commonwealth Government funds. This mechanism and related approaches in Australia have supported a community co-investment into beef genetic improvement of approximately $12m pa for the period 2001-2011.

This approach has been useful, but it suffers the limitation noted above that generic R&D does not automatically lead to changes in recording and selection in the breeding sector. Furthermore, a second challenge has become increasingly apparent in recent years. This is the need for large recorded populations for generating the data required to calibrate DNA tests. Numbers in the range 3,000-5,000 recorded animals per trait are needed (Goddard and Hayes, 2009), and for maximum usefulness of DNA testing, the data needs to include the traits that are not readily or routinely recorded by the stud sector, such as eating quality.

The Australian approach to addressing this problem has been to support development of so-called Information Nucleus herds (Banks et al, 2006), in which elite young sires are progeny tested for a comprehensive range of traits, and R&D funds from various sources are used to assist in meeting the costs. The final funding mechanism for this new infrastructure is still evolving, but seems likely to involve some contribution from different sectors in proportion to benefit received.

The implementation of genomic selection is in its early stages as yet, but breed associations and research scientists are exploring the value of combining data from different countries. The usefulness of this depends on the extent of GxE between countries for the traits involved, and the genomic relationship between breed populations in different countries. Funding the research needed to evaluate combining datasets will not automatically be attractive to individual countries or even the breeds within countries, and this suggests a possible role for ICAR, in helping facilitate such R&D.

The R&D funding landscape varies across countries, and is evolving quite rapidly in response to budgetary pressures faced by all governments. In this context, it will be increasingly important for breeders and breed associations across countries to examine carefully their needs and resources for a range of components of sustained genetic improvement:

- performance recording, including standards
- parameter estimation, including genomic analysis
- genetic evaluation
- investment in recording hard-to-measure traits, and whether international sharing of data enhances accuracy of genomic predictions
- optimizing genotyping within and across countries.

Traditionally ICAR has pursued the aims of enhancing genetic improvement of beef cattle through a focus on the first element in the list above, with some consideration given to the third (genetic evaluation). This paper makes clear that in a number of countries, essentially outside Europe, a "bottom-up" approach has allowed the evolution of quite effective and sophisticated performance recording and genetic evaluation. As internationalization of beef cattle breeding accelerates, it will be important for ICAR to explore the full range of ways in which international dialogue and collaborative activity could be beneficial, rather than focusing solely on standards and shared tools for evaluation. As computing power continues to increase, it will become increasingly clear that the rate-limiting factors for rapid genetic improvement of beef cattle are not databases or analytical tools, but capturing the appropriate amounts of data on the right traits, and optimizing the application of genotyping and selection thereafter.

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