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BREEDPLAN: 40 YEARS OF ACCELERATING GENETIC PROGRESS IN THE BEEF INDUSTRY

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SUMMARY

BREEDPLAN estimated breeding values (EBVs) were first published in 1985, the analysis having continuously evolved ever since. BREEDPLAN currently analyses over 15 million animals, including more than 1 million DNA profiles included in single-step BREEDPLAN genomic evaluations. This paper reviews some of the major enhancements to BREEDPLAN over the last 40 years, including the introduction of additional EBVs for a wide range of production traits, the introduction of BreedObject selection indexes, and the inclusion of genomic information culminating with the implementation of single-step BREEDPLAN.

INTRODUCTION

BREEDPLAN is a genetic evaluation scheme developed in Australia and used by beef cattle breeders worldwide. The BREEDPLAN BLUP within-herd multi-trait animal model was developed in 1984 and first implemented in 1985. This expanded upon the Australian National Beef Recording Scheme that had been in place since 1972. BREEDPLAN software development has been conducted by the Animal Genetics Breeding Unit (AGBU) with funding support from Meat & Livestock Australia (MLA). The commercial delivery of the technology has been the responsibility of the Agricultural Business Research Institute (ABRI) since 1985.

MATERIALS AND METHODS

Since the first BREEDPLAN run in March 1985, the number of records analysed has grown to over 15 million animals from approximately 6000 herds. These herds are from 80 breed organisations and non-breed affiliated groups (including large pastoral companies) located in 13 countries with some breed organisations representing multiple countries or having members outside of their 'home' country. Starting in 1994 with the first Trans-Tasman BREEDPLAN analysis, a feature has been the ability to combine data from more than one of these sources into a single analysis. Where possible, this feature enables comparable EBVs to be produced for each breed organisation, while preserving each organisations ownership and control of their data. In 1997 BREEDPLAN introduced genetic group methodology, and in 1998, the ability to import results from external genetic evaluations so that information from animals sourced from outside of the population (e.g. imported semen or embryos) could be used to inform their starting EBVs.

While the initial BREEDPLAN analyses in 1985 only produced EBVs for growth traits, subsequent research and data submission by users has allowed the development of new BREEDPLAN EBVs for male and female reproduction, calving ease, carcase, meat quality, temperament, net feed intake and structural soundness. Group BREEDPLAN was released in 1986 and enabled individual animals to have comparable information across herds. Crucial to the early Group BREEDPLAN development was the genetic linkage provided by breed organisation sire

* A joint venture of the NSW Department of Primary Industries and Regional Development and the University of New England.

referencing schemes and was supplemented by the linkage sires used in breeder herds. Other significant research that contributed to BREEDPLAN included, but is not limited to, the three Beef CRC projects, Repronomics, Southern Multi Breed project and various breed society trials. These projects also allowed the collection of genotypes and trait data, including 'hard to measure' traits (particularly fertility, carcase and meat quality). The combination of the data collected in these trials, and those collected by individual breeder herds, has enabled AGBU to publish an average of 12.8 scientific publications a year since 2006 that specifically reference BREEDPLAN or beef cattle breeding/genetics in the article title (http://agbu.une.edu.au/publications.html). Enhancements prior to 2006 were summarised in Graser *et al.* (2005) and these scientific publications are a key component of BREEDPLAN *modus operandi* as they allowed peer review/validation of BREEDPLAN methodologies by the wider scientific community to ensure that the methods were both valid and reflected the latest developments in genetic evaluation technology.

The evolution of the BREEDPLAN technology included the first use of BLUP methodology to calculate and publish EBVs and accuracies for beef cattle in 1981. BREEDPLAN also published the first multi-country multi-trait single-step genomic evaluation in 2017. One of the more advantageous enhancements was the inclusion of all quantitative traits into a single multi-trait BLUP analysis in 1989. The multi-trait BLUP analysis used the genetic relationships between all traits to both increase individual EBV accuracy by using correlated information and remove any selection bias. Research and development in variance component estimation has paralleled the major developments of BREEDPLAN. This included the implementation of new methods, models and software for the estimation of genetic parameters that underpin the BREEDPLAN BLUP analysis.

The development in 1995 of a threshold model allowed for the analysis of categorical data including calving ease, docility and structural soundness scores. EBVs were computed on the underlying scale and transformed to the observed scale for the published BREEDPLAN EBV. The ability to include crossbred animals in a single analysis, including accounting for heterosis, was first introduced into BREEDPLAN in 1997. Recent developments have included an increase in run frequency and developments in how DNA information is incorporated into the analyses. In 2010, DNA information was included using a 'blending' method, before upgrading to single-step methodology in 2017. The total number of DNA profiles included in the single-step BREEDPLAN genomic relationship matrices have rapidly grown since 2017 and exceeded 1 million for the first time in November 2024.

The addition of BreedObject selection indexes in 1996 enabled cattle producers to identify animals that were most profitable for particular production systems and markets. This was enhanced in 2001 with BreedObject on the web allowing breeders to customise selection indexes to suit their individual needs and production systems. The BreedObject software itself has been supported by over 40 scientific publications which can found at https://breedobject.com/page/About_BreedObject.html.

All of these developments in BREEDPLAN have come at the cost of more complex computing algorithms and strategies. These increases in complexity have also occurred concurrently with the ever increasing number of traits and records, and client desire for increased run frequency. Fortunately, advancements in computer software and hardware have kept pace and enabled these developments to be implemented.

RESULTS AND DISCUSSION

A survey of 639 Australian beef producers showed that the overall producer perception of BREEDPLAN is largely positive and is driven by sentiments of trust, scientific validity and a historical reputation for efficacy (Sloane and Walker 2023). These sentiments reflect the genetic progress that users of BREEDPLAN have been able to make. Figure 1 displays the average weighted selection index for all 41 breed organisations & groups around the world who currently have

BreedObject selection indexes supplied by BREEDPLAN. Overseas values were adjusted for their exchange rate to the Australian dollar in November 2024 and averaged across countries, breeds, all selection indexes within breed, and individual herds to give an indication of the average genetic progress that has been made using BREEDPLAN (equivalent to AU$2.82 per year). So, while there are individual herds and groups that perform better than the average (up to AU$8.90 average genetic progress per year for a breed society), there is little value of comparing breed groups that have different selection indexes. With one exception (Brahman in South Africa, Namibia and Zimbabwe), each country and breed combination in BREEDPLAN has unique selection indexes that are optimised for the specific production systems and markets that use their genetics. The effects of specific production systems, including the unique genetic parameters of each breed and other population specific parameters, local conditions and pricing, on selection indexes was demonstrated in Gudex *et al.* (2023).

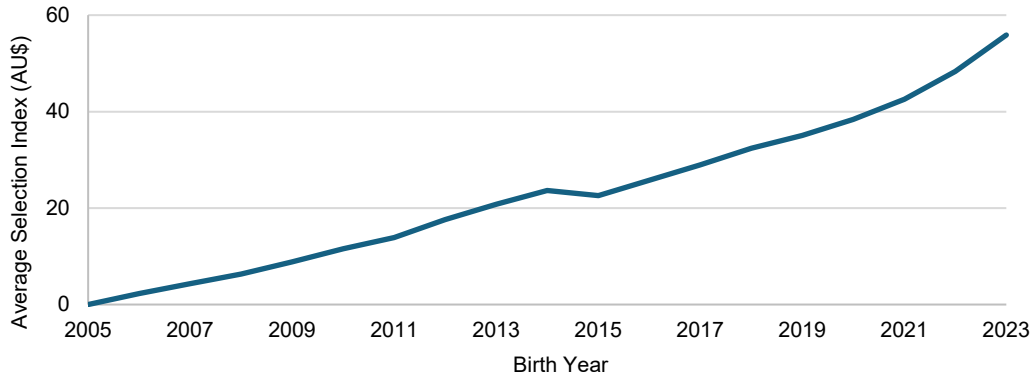

Figure 1. Average genetic progress since 2005 for breed organisations & groups with BREEDPLAN selection indexes

The staggered implementation of BREEDPLAN developments across different breeds has meant that any changes in the trend displayed in Figure 1 due to new developments is not obvious. However, such changes have been visible in studies conducted within individual breeds. Millen and Crook (2019) demonstrated an increase in genetic progress following the introduction of Hereford Single-Step BREEDPLAN for Australia, New Zealand and Namibia. The use of the single-step methodology in BREEDPLAN was validated by Johnston *et al.* (2023) using the forward cross-validation technique in their validation of the (separate) Angus, Brahman, Hereford, Santa Gertrudis and Wagyu single-step BREEDPLAN analyses. Millen *et al.* (2025, *these proceedings*) also reported that the use of single-step methodology in Australian Brahman has led to a large increase in the number of bulls being sold with BREEDPLAN EBVs.

Since 1985, there have also been numerous developments in how BREEDPLAN information is presented back to breeders. In 1989, ABRI developed and released its first iteration of herd recording software and an online sire selector in 1997. Today, websites are routinely used to view information (including pedigree and EBVs) on individual animals, sale, and semen catalogues, submit data, download reports and predict outcomes of matings, and 39% of Australian seedstock producers are using specialist herd management software (Sloane and Walker 2023). The websites also allow the results from companion products like GeneProb and Completeness of Performance to be viewed. GeneProb (Kinghorn 2000) was first provided by ABRI in 2009 and uses known gene test results and combines this with pedigree information to calculate the probability of alleles being present in untested animals. The Completeness of Performance product was first released in 2012 and provides

a summary of the amount of data that each herd has submitted to BREEDPLAN. Concerns regarding the quality of data submitted and analysed was one of the biggest factors driving negative perceptions of BREEDPLAN in Australia (Sloane and Walker 2023). This perception remains despite the presence of several data checks that include identifying and omitting extreme records within a contemporary group until the records are verified by the breeder (outliers) and only accepting data for certain traits when it is recorded by an accredited professional. MateSel (Kinghorn 2011) is another companion product to BREEDPLAN that ABRI has offered since 2012. MateSel is a tool that enables breeders to optimise breeding outcomes by creating a suggested mating list based on a group of candidate sires and dams.

With genetic evaluations being an evolving and technical space, BREEDPLAN has always had a strong emphasis on extension services to support its clients. In Australia, this started with state department beef cattle officers, progressed through the industry funded Tropical Beef Technology Services (1995 to 2021) and Southern Beef Technology Services (2005 to 2021) projects and has continued with ABRI extension services today. One of the advantages of the current ABRI extension services model is its ability to work with and support BREEDPLAN's international clients. In 2024 alone, ABRI extension services delivered ~50 online workshops, webinars and podcasts, 40+ articles, 110+ social media posts, attendance at 11 training days, field days and youth events, and technical support to numerous individual herds around the world.

CONCLUSION

BREEDPLAN has a long and proud history of providing effective genetic evaluations to the beef industry around the world. This has been possible through the continuous incorporation of the latest developments in computing, methodology and scientific knowledge into the BREEDPLAN model. Additionally, the provision of companion products and extension services have supported BREEDPLAN clients to undertake a holistic approach to animal selection and breeding and drive genetic progress in their herds. As BREEDPLAN moves into the future, the implementation of new traits, products and services will continue to assist beef producers globally to improve productivity and profitability in their beef breeding businesses.

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