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Proof of Profit from EBV based selection

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Abstract

While there are several existing products which relate genetic progress to financial outcomes for beef producers, scope remains for the estimation of the contribution of genetics to productivity gains. This project developed a tool which quantified the trend and spread on productivity gains attributable to genetic improvement. Empirical regional beef business performance data from the Australian Beef Report was used to model productivity (kilograms of beef produced per Adult Equivalent carried). Kilograms of beef produced was related to genetic trends for weaning rate, mortality rate, and sale weight provided by the BreedObject indexing software in Herefords and Brahmans. The effect of mature cow weight and female fertility on energy demand was accounted for.

The results showed that genetics has contributed to productivity gains over recent decades and that there is a considerable spread on genetic merit for productivity within years. The contribution of individual traits depends on either their relative importance in governing productivity in a given region, the magnitude of change in genetic trend, or a combination of both. The modelling was presented in an accessible format in the tool. However, the tool is best suited for use by informed trainers at workshops and other events rather than for general public access.

Executive summary

- While there are several products which assign financial values to genetic merit, there was scope to use empirical industry performance information linked to empirical genetic trends to evaluate productivity gains attributable to genetics.
- Regression analysis was used to link BreedObject objective traits to productive turnoff (kilograms of beef produced per Adult Equivalent carried). Data included results from the Australian Beef Report (Holmes *et al.* 2017) and BreedObject Objective trait trends for Herefords and Brahmans.
- An excel-based tool was developed to show the productivity gain attributed to genetics based on user-entered region, herd structure and size, and breed (Hereford or Brahman). The tool predicts the productivity gain attributable to genetics for the breed average, Top 25% and Bottom 25% on index, and user-selected genetic merit.
- The tool demonstrates that genetic improvement has made an overall contribution to productivity gains in Brahmans and Herefords in recent decades, and can be expected to do so into the future.
- Genetic gain for the Brahman breed average from 2003 to 2018 generated an additional $12/AE in Gross Profit for producers in VRD & Katherine. Similarly, Hereford producers following breed average trends in the NSW Tablelands received a $3/DSE benefit in Gross Profit over the same period. These figures can be generated for each breed, region, and cohort (Bottom 25%, Average, and Top 25% based on Index).
- Gains up until now for Brahmans have been almost solely due to growth, while each of fertility, growth, and survival trends contribute to the gains in Herefords.
- While the effect of increasing cow weight and productivity on energy demand has been accounted for, it has a minimal bearing on outcomes and is outweighed by gains in productivity traits.
- There is considerable variation in cumulative income gains within each breed as demonstrated by the difference between Top and Bottom 25%. This is particularly evident for Brahman fertility trends.
- The tool used the best available data and methodology. However, improvements in financial, production, and genetic performance recording could be expected to enable more rigorous methods to be applied in the future. Methodological advancements would include:
    - Generating technical efficiency scores for individual business units.
    - Including genetic information for individual herds as part of business benchmarking, especially for seedstock herds, and including this information in regression, data envelopment, and other analyses.

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1 Background

This project aimed to address the ‘cultural change in the application of genetics’ objective outlined in the National Livestock Genetics Consortium Call for Genetics Projects Terms of Reference (ToR). Specifically, the project addressed reproduction for Northern Beef enterprises and developed tools to make the use of genetics easier for producers; both listed as priorities in the ToR.

There are three major productivity drivers in Australian grass-fed production systems: reproductive rate, sale weight, and mortality rate (McLean *et al.* 2014). Understanding these factors enable the impact of changes to different areas of cattle performance to be investigated. For example, reproductive rate has a been an area of interest for northern Australia. The twelve-year average performance of Northern beef herds shows that 8 of 14 ABARES regions have reproductive rates of less than 60%, whereas all 11 ABARES regions for Southern herds have 70-90% reproductive rates (Holmes *et al.* 2017). It has been suggested that 80% reproductive rate is a realistic target for Northern beef herds, although current data shows few producers are achieving this level (McGowan *et al.* 2014; Holmes *et al.* 2017).

Based on models developed by Bush AgriBusiness, it is estimated that lifting reproductive rate modestly from 63% (average) to 66% (average of top 25% performing northern producers) for a station of average size and herd performance will approximately result in an income rise of $9,000 or 11%. Therefore, there is considerable scope for profitability gains from even a modest increase in reproductive rate across Northern beef herds, and even greater potential for substantial gains in the long term.

Recent findings showing considerable heritability for fertility traits has shifted the focus towards better genetic selection for fertility, although other factors such as disease prevention and nutrition management are important in controlling reproductive levels (Johnston 2013). The Northern Australian beef fertility project: CashCow identified that 46% of surveyed producers used EBVs for selecting replacement bulls (McGowan et al. 2014). It is suggested that further adoption of the use of fertility EBVs by private producers is critical to achieving reproductive rate targets in Northern Australia.

There are existing products which relate performance indicators and traits, such as weaning rate, to financial performance. Most notably, the BreedObject Selection Indexes estimate an animal’s genetic merit for profit by weighting several traits of economic importance (Barwick and Henzell 1997). Work undertaken in this project aimed to complement BreedObject Indexes by using empirical measures of beef production on-grass at the regional and herd, rather than individual animal, levels.

2 Project objectives

The project will aim to develop a spreadsheet decision support tool, along with a report detailing the development and findings. The tool would allow inputs such as current herd performance data and genetic selection information, and return a response to selection and productivity gain estimate, which would differ for southern and northern production systems. Existing models developed by Bush Agribusiness predict changes in herd productivity, income and profit based on the key drivers (reproductive rates, mortality and sale weight), using the Australian Beef Report (ABR) data. The project aims to enhance these existing models by incorporating genetic selection practices to illustrate how reproductive rate may be improved. This is possible due to existing datasets and relationships derived from AGBU research, which establishes the response to herd fertility from bull selection by fertility EBVs, such as Days to Calving. This process is similar to the development of

BREEDPLAN $indexes, though this modelling uses the ABR data to generate the financial response, which is considered credible and accurate in the Australian beef industry. Additionally, the tool will account for heifer replacement practices along with the ability to include parameters such as region and herd size.

To leverage the outputs of this project, part of the program of work will involve existing beef extension personnel in the development of the tool for functionality and usability, along with training these key staff in the use and background of the tool once complete. The demonstration and use of this tool will be incorporated into existing training packages such as Bred Well Fed Well, Breeding EDGE and Profitable Grazing systems to fully leverage the use and understanding of the tool and the implications of genetic improvement decisions. The project co-ordinators will work closely with the adoption manager for genetics to ensure alignment with the adoption strategy.

3 Methodology

3.1 Modelling productivity on herd performance indicators

Farm benchmarking data has been used to generate regression analyses on factors affecting overall farm performance for several decades (Townsley and Parker 1987). This method allows identification of performance indicators or input variables which affect an outcome variable. While regression analyses have been recognised as a legitimate means of measuring relationships between farm performance variables, the development of economic assessment methods means that more recent regression analysis of farm benchmarking data has used technical efficiency scores as the outcome variable (Fleming *et al.* 2006; Geenty *et al.* 2006). This project used kilograms of beef produced per Adult Equivalent as the outcome variable of the regression analyses for the following reasons:

- Kilograms of beef produced is a measure of all output from a beef production enterprise, and can easily be related to Gross Profit using the market value for beef.
- The AE rating is based on the energy demand of a given animal or herd, as defined by McLean & Blakeley (2014), and can thereby be adjusted for traits which influence energy demand.
- Given the measure expresses the level of beef production relative to energy demand, it can be interpreted as an efficiency measure for conversion of inputs (including the natural resource base) to beef.

Bush AgriBusiness has conducted multivariate regression analysis on herd productivity drivers using several datasets in recent years. These include the Northern Beef Report, Australian Beef Report, and Pastoral Company Benchmarking Project (McLean *et al.* 2014; Holmes *et al.* 2017; McLean *et al.* 2018). These analyses have all shown that productivity (kilograms of beef produced per Adult Equivalent carried- kg beef/AE) can be accurately predicted based on reproductive rate (natural increase), mortality rate, and sale/turnoff weight. Coefficients for these variables from each dataset indicate that producers can expect increases of:

- 0.7-1.5kg beef/AE for a 1% increase in reproductive rate
- 2-4kg beef/AE for a 1% decrease in mortality rate
- 1.5-2.2kg beef/AE for a 10kg increase in sale weight

This project aimed to use genetic trends as the input for similar productivity models in order to illustrate the potential productivity and resulting income changes associated with genetic gain. Early in the project, some time was dedicated to improving the productivity models. Initially, regional effects and interactions were not accounted for. However, they were added through an iterative process after discussions with AGBU in late 2018.

Region was added as a main effect in the models for both northern and southern Australia and interacted with each of the key productivity variables. Non-significant interaction effects were removed until a satisfactory model was derived. For the north, this meant the model included main effects for reproductive rate, mortality rate, sale weight, and region, and an interaction effect for sale weight and region. The southern model included main effects for the three productivity drivers and region, plus one-way interaction effects for region with each of the drivers. The results of this process are shown in Tables 1-4.

Table 1: Analysis of variance of productivity against key drivers and regions in northern Australia.

Term	Df	Sum Sq	Mean Sq	F value	Pr(>F)
Reproductive Rate	1	18727	18727	251.4	0
Mortality Rate	1	23637	23637	317.4	0
Sale Weight	1	18839	18839	252.9	0
Region	13	10478	806	10.82	0
SaleWt:Reg	13	1878	144.4	1.94	0.04
Residuals	94	7001	74.48	NA	NA

Table 2: Regression coefficients, standard errors and significance for the main effects of reproductive rate, mortality rate, sale weight and region with the interaction between region and sale weight for Northern Australia.

Term	Estimate	Std. Error	t value	Pr(>|t|)
(Intercept)	-25.07	27.43	-0.91	0.36
Reproductive Rate	53.87	14.16	3.8	0
Mortality Rate	-495.9	116.8	-4.25	0
Sale Weight	0.23	0.06	3.97	0
RegNT Barkly Tablelands	-54.1	60.09	-0.9	0.37
RegNT Top End	120.1	67.49	1.78	0.08
RegNT VRD & Katherine	-68.16	99.5	-0.69	0.5
RegQLD Cape York and Gulf	144.7	46.28	3.13	0
RegQLD Central North	40.07	54.31	0.74	0.46
RegQLD Central West	11.72	55.8	0.21	0.83
RegQLD Eastern Downs	-11.45	33.24	-0.34	0.73
RegQLD Northern Coastal	-73.62	43	-1.71	0.09
RegQLD Southern Coastal	34.34	59.88	0.57	0.57

RegQLD Southern Inland	30.86	59.02	0.52	0.6
RegQLD West and South West	5.32	35.24	0.15	0.88
RegWA Pilbara & Sthn Rnglnds	-44.47	58.94	-0.75	0.45
RegWA The Kimberley	22.56	52.46	0.43	0.67
SaleWt:RegNT Barkly Tablelands	0.17	0.17	1	0.32
SaleWt:RegNT Top End	-0.33	0.21	-1.55	0.12
SaleWt:RegNT VRD & Katherine	0.27	0.32	0.85	0.4
SaleWt:RegQLD Cape York and Gulf	-0.5	0.17	-2.99	0
SaleWt:RegQLD Central North	-0.11	0.13	-0.87	0.39
SaleWt:RegQLD Central West	-0.01	0.12	-0.12	0.91
SaleWt:RegQLD Eastern Downs	0.03	0.07	0.41	0.68
SaleWt:RegQLD Northern Coastal	0.2	0.1	1.96	0.05
SaleWt:RegQLD Southern Coastal	-0.1	0.13	-0.72	0.47
SaleWt:RegQLD Southern Inland	-0.1	0.13	-0.8	0.43
SaleWt:RegQLD West and South West	-0.03	0.09	-0.33	0.74
SaleWt:RegWA Pilbara & Sthn Rnglnds	0.17	0.17	0.95	0.34
SaleWt:RegWA The Kimberley	-0.03	0.15	-0.21	0.84

Table 3: Analysis of variance of productivity against key drivers and regions in southern Australia.

Term	Df	Sum Sq	Mean Sq	F value	Pr(>F)
Reproductive Rate	1	11395	11395	304.2	0
Region	9	8513	945.9	25.25	0
Mortality Rate	1	2335	2335	62.32	0
Sale Weight	1	15679	15679	418.5	0
RepRate:Reg	9	1013	112.5	3	0.01
Reg:Mort	9	938	104.2	2.78	0.01
Reg:SaleWt	9	1179	131	3.5	0
Residuals	60	2248	37.46	NA	NA

Table 4: Regression coefficients, standard errors and significance for the main effects of reproductive rate, mortality rate, sale weight and region with the interaction between region and sale weight for Southern Australia.

Term	Estimate	Std. Error	t value	Pr(>|t|)
(Intercept)	-192.4	103.9	-1.85	0.07
Reproductive Rate	318.9	115.7	2.76	0.01
RegNSW Coastal	95.88	129.7	0.74	0.46
RegNSW North West Slopes and Plains	-196.3	160.1	-1.23	0.23

RegNSW Riverina	201.5	117.2	1.72	0.09
RegNSW Tablelands	153.7	155.7	0.99	0.33
RegSA South East	-349.2	281.9	-1.24	0.22
RegTasmania	172.8	298.8	0.58	0.57
RegVIC Central North	108.7	132	0.82	0.41
RegVIC Southern and Eastern Victoria	-7.8	128.9	-0.06	0.95
RegWA South West Coastal	127.5	143.9	0.89	0.38
Mort	-1765	1054	-1.68	0.1
SaleWt	0.19	0.1	1.9	0.06
RepRate:RegNSW Coastal	-110.1	137.1	-0.8	0.43
RepRate:RegNSW North West Slopes and Plains	97.89	172.2	0.57	0.57
RepRate:RegNSW Riverina	-154	121.9	-1.26	0.21
RepRate:RegNSW Tablelands	-294	180.5	-1.63	0.11
RepRate:RegSA South East	156	233	0.67	0.51
RepRate:RegTasmania	-174.4	284.6	-0.61	0.54
RepRate:RegVIC Central North	-257.8	125.3	-2.06	0.04
RepRate:RegVIC Southern and Eastern Victoria	-78.49	135	-0.58	0.56
RepRate:RegWA South West Coastal	-291.8	144.7	-2.02	0.05
RegNSW Coastal:Mort	752.8	1461	0.52	0.61
RegNSW North West Slopes and Plains:Mort	2817	1177	2.39	0.02
RegNSW Riverina:Mort	357.5	1090	0.33	0.74
RegNSW Tablelands:Mort	175.1	1306	0.13	0.89
RegSA South East:Mort	943.8	1830	0.52	0.61
RegTasmania:Mort	878.2	2273	0.39	0.7
RegVIC Central North:Mort	2671	1797	1.49	0.14
RegVIC Southern and Eastern Victoria:Mort	747.9	1171	0.64	0.53
RegWA South West Coastal:Mort	2901	1827	1.59	0.12
RegNSW Coastal:SaleWt	0.01	0.14	0.1	0.92
RegNSW North West Slopes and Plains:SaleWt	0.19	0.11	1.72	0.09
RegNSW Riverina:SaleWt	-0.18	0.13	-1.38	0.17
RegNSW Tablelands:SaleWt	0.2	0.12	1.63	0.11
RegSA South East:SaleWt	0.49	0.23	2.15	0.04
RegTasmania:SaleWt	-0.09	0.13	-0.66	0.51
RegVIC Central North:SaleWt	0.14	0.14	1.04	0.3
RegVIC Southern and Eastern Victoria:SaleWt	0.15	0.13	1.17	0.25
RegWA South West Coastal:SaleWt	0.17	0.1	1.62	0.11

In both cases, inclusion of these effects improved the accuracy of the model and enabled the final tool to be more regionally specific. Fig. 1. and Fig. 2. show prediction summaries for the North and South datasets. The R^2 statistic for both models improved from between 0.77 and 0.80 to greater than 0.90.

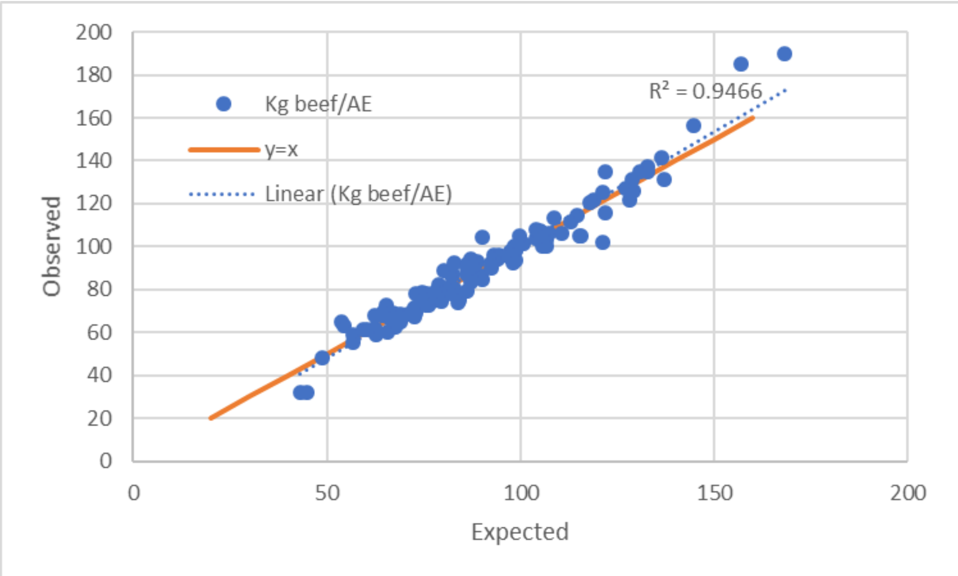

Figure 1: Observed vs expected kg beef/AE for the northern dataset presented in comparison to the line of unity (y=x).

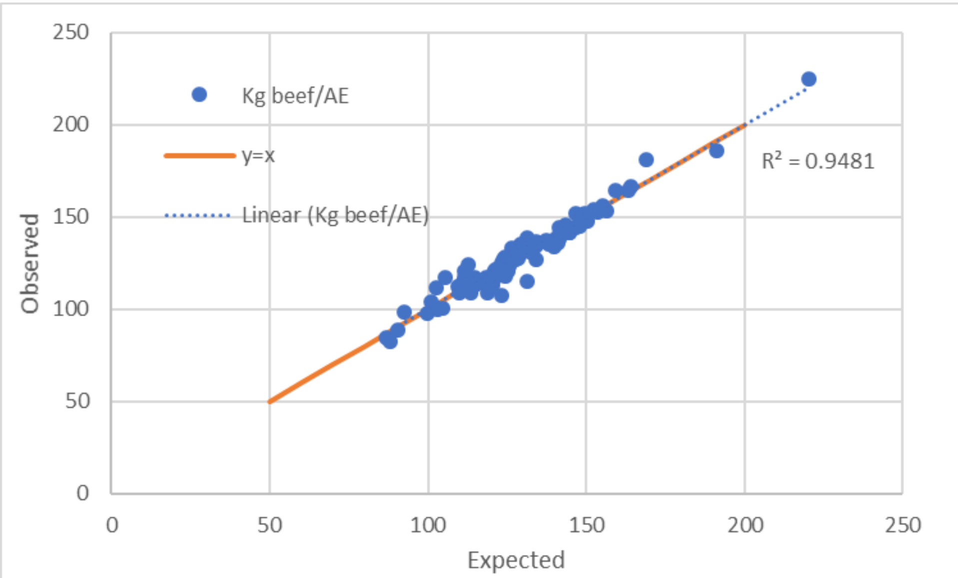

Figure 2: Observed vs expected kg beef/AE for the southern dataset presented in comparison to the line of unity (y=x).

3.2 Use of genetic trends

Genetic trends of breeding objective traits taken from BreedObject indexes that align with the herd productivity drivers were used as inputs into the productivity models. These trends were provided for the Brahman and Hereford breeds by AGBU. The trends supplied were for weaning rate, cow survival rate, feedlot entry weight, and mature cow weight. For modelling purposes, these aligned with reproductive rate, mortality rate, sale/turnoff weight, and mature cow weight, respectively. The trends supplied are shown in Tables 5 and 6.

Three trends were provided for each trait for both breeds; they were the breed average trend, and the trends for the top and bottom 25% of animals based on ranking by the respective Index. Basing the stratification on Index ranking was selected as a superior approach as compared to simply ranking the top and bottom for each trait. This decision was taken because the Index describes how an animal's genetics is anticipated to change profitability in the production system aligned to that index as well as accounting for how these traits interact to impact that profitability.

The 2000 to 2016 trends were used as opposed to 2000 to 2019 trends when modelling due to potential lower trait accuracy in the more recent years. The lower accuracy is due to a limitation of data available on the animals at younger ages. It was also identified that genetic lag would impact trends. This is due to the period of time required between receiving predicted genetic merit (EBVs) and an animal influencing the genetic composition of the herd. A three year lag was implemented to account for the average time taken to reproduce. This meant that a new data column called 'Effective Year' was added. The column showed a three-year delay, such that trait averages for the year 2005 would be effective in 2008.

3.3 User inputs

The tool is intended to be used and interpreted at the regional and herd levels. This means that some user information is required to tailor the tool output, and a range of outcomes are possible as a result. The user first navigates to the relevant breed tab, which is currently either Hereford or Brahman. Within the relevant tab, the first user-entry section is the regional drop-down box shown in Fig. 3. The available regions depend on the breed, for example the Hereford tab allows ABARES Broadacre Zones and Regions from southern Australia to be selected, while northern regions are available in the Brahman tab. The regions correspond to those used in the productivity modelling. The box to the right allows the user to nominate their relative genetic merit for each of the four traits. As described in Section 3.2, the options for genetic merit are Top 25%, Average, and Bottom 25% based on index ranking.

Select Region
NT VRD & Katherine

	Enter average no. carried	AE Rating	AE
Females <1	400	0.57	227
Females 1-2	390	0.72	274
Females 2-3	380	0.96	337
Females 3-4	350	1.18	1,414
Females 4+	1,200	1.08	431
Steers <1	400	0.60	228
Steers 1-2	380	0.78	298
Steers 2-3	120	1.02	122
Steers 3-4		1.15	0
Bulls <1		0.69	0
Bulls 1-2	5	0.96	5
Bulls 2+	50	1.24	62
Total	**3,675**		**3,397**

	Your Herd Genetic Merit
Female fertility	Bottom 25%
Growth	Top 25%
Mature cow weight	Average
Cow mortality	Average

Figure 3: User-entry section for region and average number carried by class in the tool.

The user-entry section also requires an estimate of herd size. It is generally expected that producers have a good understanding of average numbers carried by age-group, as opposed to total AE. The average numbers carried are multiplied by an AE rating for each class. The AE ratings used are determined by the region selected which denotes a level of assumed productivity. The average AE carried for each class is then shown above the total average AE carried. This information enables the tool to be relevant at the herd level.

3.4 Prediction of productivity gain attributable to genetic trends

The use of genetic trends (Objective traitss from BreedObject) means that absolute productivity (kg beef/AE) figures cannot be calculated in a given year, but gains or losses in productivity between years can. Table 5 shows the trends for each trait, the year-on-year change for each trait, the predicted kg beef/AE based on these figures and the relevant coefficients presented in Tables 2 and 4, and the resulting year-on-year gain or loss in kg beef/AE. This calculation methodology forms the basis of predicting productivity gains or losses from genetic trends over time.

Table 5: Calculation of predicted kg beef/AE and annual change in kg beef/AE based on genetic trends for Herefords in Tasmania.

Weaning Rate Trend	Feedlot Entry Wt Trend	Mortality Rate Trend	Cow Weight Trend	kg beef/AE predicted	Pred kg beef/AE change
0.0138	30.484	-0.00157	45.38	-13.05	
0.0144	31.735	-0.00124	47.24	-13.13	-0.08
0.0148	32.863	-0.0012	48.76	-12.98	0.15
0.0155	34.203	-0.00127	50.67	-12.67	0.30
0.0156	35.496	-0.00141	52.31	-12.41	0.27
0.0162	36.974	-0.00086	54.12	-12.65	-0.24
0.0173	37.912	-0.00125	55.15	-12.05	0.60
0.0181	39.223	-0.00145	56.79	-11.63	0.42
0.0183	40.321	-0.0018	58.02	-11.18	0.45
0.0192	41.581	-0.00181	59.35	-10.90	0.28
0.0202	42.212	-0.00251	59.75	-10.07	0.82
0.0206	43.644	-0.00209	61.52	-10.23	-0.16
0.0212	44.608	-0.00257	62.30	-9.62	0.62
0.0227	45.947	-0.00338	63.56	-8.54	1.08
0.0245	46.904	-0.00382	64.37	-7.80	0.74
0.0252	48.005	-0.00449	64.92	-6.99	0.81

It is also possible to calculate the annual change in productivity attributable to the genetic trend for a single trait. This is done by using the current year breed average figure for the trait of interest while using the previous year's figures for all other traits as inputs for the model. This process is shown in Table 6. Subtracting the previous year's predicted kg beef/AE gives the year-on-year gain in kg beef/AE attributable to the single trait. This calculation is shown in Table 7.

Table 6: Calculation of kg beef/AE based on the change in a selected trait (weaning rate).

Weaning Rate Trend	Feedlot Entry Wt Trend	Mortality Rate Trend	kg beef/AE- just weaning rate
-0.0035	22.81	-0.001640	
-0.0029	23.83	-0.001600	-81.14
-0.0067	24.24	-0.001380	-80.85
-0.0066	25.95	-0.001200	-80.76
-0.0056	26.61	-0.001200	-79.93
-0.0057	27.69	-0.001020	=(D32*DF4)+(L
-0.0075	28.92	-0.000840	-79.25
-0.0066	30.41	-0.000680	-78.68
-0.0071	31.38	-0.000600	-78.04
-0.0100	32.78	-0.000430	-77.75
-0.0091	32.95	-0.000490	-77.09
-0.0090	33.85	-0.000350	-76.96
-0.0068	33.95	-0.000380	-76.46
-0.0031	33.67	-0.000570	-76.20
-0.0015	35.01	-0.000480	-76.16
-0.0035	35.58	-0.000410	-75.64

Table 7: Calculation of the year-on-year gain in kg beef/AE attributable to the genetic trend for a single trait (weaning rate).

kg beef/AE	kg beef/AE- just weaning rate	Weaning rate-trend
-81.18		
-80.65	-81.14	0.03
-80.76	-80.85	-0.20
-79.99	-80.76	0.00
-79.60	-79.93	0.06
-79.16	-79.61	=AJ32-AF31
-78.73	-79.25	-0.09
-78.01	-78.68	0.05
-77.59	-78.04	-0.03
-77.13	-77.75	-0.16
-76.97	-77.09	0.05
-76.58	-76.96	0.00
-76.40	-76.46	0.12
-76.24	-76.20	0.20
-75.53	-76.16	0.09
-75.39	-75.64	-0.11

These calculations allow the cumulative productivity gain over all years attributable to each trait to be calculated, in addition to the cumulative gain resulting from all traits. The cumulative gains (or overall *improvements*) are most informative for illustrating the effect of genetic changes over time, so are used in the graphical output.

3.5 Accounting for the effect of mature cow weight

The effect of increasing mature cow weights on breeder cow efficiency has been well documented in recent times (Dollemore 2016; Walmsley *et al.* 2018).Feedback on tool development from extension officers also suggested that the effect of mature cow weight be accounted for and illustrated. Increasing mature cow weight is associated with higher maintenance requirements per breeder (Dollemore 2016; Walmsley *et al.* 2018). As an AE rating represents energy demand, it was decided that increasing the AE rating would be the best means of accounting for increasing mature cow weight. This would increase the denominator of the kg beef/AE measure, effectively creating a penalty for increasing mature cow weight. As increasing weaning rates also increases the energy demand of breeder herds, it was similarly accounted for in the AE ratings.

The calculations for the change in breeder AE rating resulting from the genetic trend for mature cow weight and weaning rate are based on the McLean & Blakeley (2014), AE rating methodology. The genetic trend for mature cow weight was added to the baseline liveweight of 450kg, and the resulting AE rating recorded for each year. This methodology is effective because liveweight has a linear relationship with AE rating (McLean and Blakeley 2014). Similarly, the trend for weaning rate was added to the baseline rate of 75%, and proportionally allocated to lactation and pregnancy rates. All other inputs to the AE rating calculation remained fixed except genotype (Bos taurus, Bos indicus, or crossbred) which varied with breed (Tables 8 and 9).

Table 8: AE rating calculations for Brahman cows accounting for the genetic trend in mature cow weight (MCW) and weaning rate.

Trend Year	Effective year	Breed	Sex	Pregnancy	Lactation	Weaning	Avg Age	MCW Trend	Avg lwt	AE Rating	AE Increase	Cumulative AE increase
Base		Bos Indicu	Female	0.8525	0.775	0.75	4		450	1.30		
2000	2003	Bos Indicu	Female	0.849	0.772	0.747	4	22.46	472.46	1.33	0.0371	0.04
2001	2004	Bos Indicu	Female	0.850	0.772	0.747	4	23.88	473.88	1.34	0.0028	0.04
2002	2005	Bos Indicu	Female	0.846	0.768	0.743	4	25.13	475.13	1.34	0.0001	0.04
2003	2006	Bos Indicu	Female	0.846	0.768	0.743	4	26.82	476.82	1.34	0.0030	0.04
2004	2007	Bos Indicu	Female	0.847	0.769	0.744	4	27.67	477.67	1.34	0.0021	0.04
2005	2008	Bos Indicu	Female	0.847	0.769	0.744	4	28.60	478.60	1.34	0.0015	0.05
2006	2009	Bos Indicu	Female	0.845	0.768	0.743	4	30.05	480.05	1.34	0.0015	0.05
2007	2010	Bos Indicu	Female	0.846	0.768	0.743	4	31.87	481.87	1.35	0.0037	0.05
2008	2011	Bos Indicu	Female	0.845	0.768	0.743	4	32.75	482.75	1.35	0.0013	0.05
2009	2012	Bos Indicu	Female	0.843	0.765	0.740	4	34.88	484.88	1.35	0.0021	0.06
2010	2013	Bos Indicu	Female	0.843	0.766	0.741	4	34.81	484.81	1.35	0.0004	0.06
2011	2014	Bos Indicu	Female	0.843	0.766	0.741	4	36.18	486.18	1.35	0.0024	0.06
2012	2015	Bos Indicu	Female	0.846	0.768	0.743	4	36.24	486.24	1.35	0.0014	0.06
2013	2016	Bos Indicu	Female	0.849	0.772	0.747	4	35.26	485.26	1.35	0.0003	0.06
2014	2017	Bos Indicu	Female	0.851	0.774	0.749	4	37.20	487.20	1.36	0.0043	0.06
2015	2018	Bos Indicu	Female	0.849	0.772	0.747	4	38.03	488.03	1.36	0.0004	0.06

Table 9: AE rating calculations for Hereford cows accounting for the genetic trend in mature cow weight (MCW) and weaning rate.

Original Trend Year	Effective Year	Breed	Sex	Details	Pregnancy	Lactation	Weaning	Avg Age	MCW Trend	Avg lwt	AE Rating	AE increase	Cumulative AE increase
Base		Bos taurus	Female	Breeding	0.79625	0.76	0.75	4		450	1.52		
2000	2003	Bos taurus	Female	Breeding	0.81004	0.77379	0.76379	4	45.23	495.23	1.62	0.10	0.10
2001	2004	Bos taurus	Female	Breeding	0.81061	0.77436	0.76436	4	47.09	497.09	1.63	0.00	0.10
2002	2005	Bos taurus	Female	Breeding	0.81109	0.77484	0.76484	4	48.60	498.60	1.63	0.00	0.10
2003	2006	Bos taurus	Female	Breeding	0.81179	0.77554	0.76554	4	50.45	500.45	1.63	0.00	0.11
2004	2007	Bos taurus	Female	Breeding	0.81186	0.77561	0.76561	4	52.10	502.10	1.64	0.00	0.11
2005	2008	Bos taurus	Female	Breeding	0.81248	0.77623	0.76623	4	53.88	503.88	1.64	0.00	0.11
2006	2009	Bos taurus	Female	Breeding	0.81354	0.77729	0.76729	4	54.96	504.96	1.64	0.00	0.12
2007	2010	Bos taurus	Female	Breeding	0.81431	0.77806	0.76806	4	56.52	506.52	1.65	0.00	0.12
2008	2011	Bos taurus	Female	Breeding	0.8145	0.77825	0.76825	4	57.77	507.77	1.65	0.00	0.12
2009	2012	Bos taurus	Female	Breeding	0.81547	0.77922	0.76922	4	59.09	509.09	1.65	0.00	0.13
2010	2013	Bos taurus	Female	Breeding	0.81641	0.78016	0.77016	4	59.90	509.90	1.65	0.00	0.13
2011	2014	Bos taurus	Female	Breeding	0.81686	0.78061	0.77061	4	61.29	511.29	1.66	0.00	0.13
2012	2015	Bos taurus	Female	Breeding	0.81748	0.78123	0.77123	4	62.20	512.20	1.66	0.00	0.13
2013	2016	Bos taurus	Female	Breeding	0.81899	0.78274	0.77274	4	63.34	513.34	1.66	0.00	0.14
2014	2017	Bos taurus	Female	Breeding	0.82074	0.78449	0.77449	4	64.06	514.06	1.66	0.00	0.14
2015	2018	Bos taurus	Female	Breeding	0.82142	0.78517	0.77517	4	65.29	515.29	1.67	0.00	0.14

'Breeder AE Change' is the annual increase in breeder cow AE rating due to increasing mature cow weight and weaning rate. This is multiplied by the proportion of AE comprised of breeding females, which is calculated by dividing the breeding female AE by the total herd AE in the user entry table. The resulting figure is the 'Herd AE Change'. The predicted kg beef/AE is divided by 1 plus the 'Herd AE Change' to give 'adjusted kg beef AE'. The difference between the adjusted and unadjusted predicted kg beef/AE figures is the penalty incurred for increasing the energy demand of the herd with genetic changes. These calculations are shown in Table 10.

Table 10: Data columns associated with the calculation of a productivity penalty for increasing mature cow weight and weaning rate for a Brahman herd where breeders as a proportion of AE is 0.732.

Pred kg beef/AE change	Breeder AE change	Herd AE change	kg beef/AE adj change	MCW penalty	Cumulative kg beef/AE gained	Cumulative MCW Penalty
0.23694	0.00246	0.00180	0.23651	0.00043	0.237	0.000
-0.12893	0.00218	0.00160	-0.12872	-0.00021	0.108	0.000
0.35936	0.00294	0.00215	0.35858	0.00077	0.466	0.001
0.20189	0.00147	0.00108	0.20167	0.00022	0.668	0.001
0.20372	0.00162	0.00119	0.20347	0.00024	0.872	0.001
0.15057	0.00251	0.00184	0.15029	0.00028	1.022	0.002
0.32312	0.00317	0.00232	0.32237	0.00075	1.344	0.002
0.17536	0.00153	0.00112	0.17517	0.00020	1.519	0.003
0.20863	0.00371	0.00272	0.20806	0.00057	1.727	0.003
0.07327	-0.00012	-0.00009	0.07327	-0.00001	1.801	0.003
0.12774	0.00238	0.00174	0.12751	0.00022	1.928	0.003
0.20293	0.00012	0.00009	0.20291	0.00002	2.131	0.003
0.12285	-0.00172	-0.00126	0.12300	-0.00015	2.254	0.003
0.40970	0.00338	0.00248	0.40868	0.00101	2.663	0.004
0.06544	0.00146	0.00107	0.06537	0.00007	2.728	0.004

3.6 Translating productivity to income

While herd productivity (kg beef/AE) is a useful measure for herd performance diagnostics and calculations, it seldom has tangible meaning for producers. The productivity (kg beef/AE) gain attributable to genetic gain has therefore been translated to gain in income (Gross Profit). This is effectively the 'Proof of Profit' component of the tool.

Translating productivity into a measure of income requires an assumption of value per kilogram of beef. The output of the tool is obviously quite sensitive to this assumption. It is possible to design the tool so that the user enters a value per kilogram of beef, although this may allow misleading outcomes to be shown. As a result, the regional average income per kilogram of beef figures from the Australian Beef Report have been applied. Average income/kg is listed among the descriptive statistics for each region available and is included in the calculations using 'look-up' functions based on the user-selected region. This allows additional productivity to be valued on an annual and cumulative basis, as show in Table 11.

Table 11: Calculations for translating kg beef/AE into income for a Brahman herd in 'WA The Kimberley' where the average income/kg is $1.90/kg.

Cumulative kg beef/AE gained	Cumulative MCW Penalty	Income/AE gained	Cumulative Income/AE	Regional average kg beef/AE	Regional average Income/AE	Income/AE (average + additional from genetic gain)
				71.04	$135.29	$135.29
0.237	0.000	$0.45	$0.45	71.04	$135.29	$135.74
0.108	0.000	-$0.25	$0.21	71.04	$135.29	$135.49
0.466	0.001	$0.68	$0.89	71.04	$135.29	$136.18
0.668	0.001	$0.38	$1.27	71.04	$135.29	$136.56
0.872	0.001	$0.39	$1.66	71.04	$135.29	$136.95
1.022	0.002	$0.29	$1.95	71.04	$135.29	$137.23
1.344	0.002	$0.61	$2.56	71.04	$135.29	$137.85
1.519	0.003	$0.33	$2.89	71.04	$135.29	$138.18
1.727	0.003	$0.40	$3.29	71.04	$135.29	$138.58
1.801	0.003	$0.14	$3.43	71.04	$135.29	$138.72
1.928	0.003	$0.24	$3.67	71.04	$135.29	$138.96
2.131	0.003	$0.39	$4.06	71.04	$135.29	$139.35
2.254	0.003	$0.23	$4.29	71.04	$135.29	$139.58
2.663	0.004	$0.78	$5.07	71.04	$135.29	$140.36
2.728	0.004	$0.12	$5.20	71.04	$135.29	$140.48

3.7 Adding measures of spread and user-selection of genetic merit

The methodology presented in sections 3.1 to 3.6 has been applied to the Top and Bottom 25% for each trend based on index, as described in Section 3.2.

The measures of spread also allow users to select their relative genetic merit for each 'trait'. In allowing users to nominate an estimated genetic merit for each trait, it is important that the distinction between genetic merit and performance is made clear. For example, 'Female fertility' is listed instead of 'weaning rate' as producers may consider their herd generates above average weaning rates by virtue of management, despite having an average genetic merit for fertility. Similarly, the user selected level for 'Growth' is used to determine the figures applied for feedlot entry weight as this term is more recognisable from a genetic basis.

The selected level (Top 25%, Average, or Bottom 25%) for each trait flows through the calculations. This is shown in Table 12 and Table 13 where the 'Top 25%' selection for 'female fertility' results in this trend for weaning rate being applied in the 'Selected' column.

Table 12: User selections against each area of genetic merit.

	Your Herd Genetic Merit
Female fertility	Top 25%
Growth	Top 25%
Mature cow weight	Bottom 25%
Cow mortality	Top 25%

Table 13: Lower limit, average, and upper limit for the Brahman weaning rate trend. The 'Selected' column shows the upper limit figures because 'Above average' was selected by the user in the herd genetic merit table.

Lower Limit	Trend	Upper Limit	Selected
-0.0287	-0.0035	0.0248	0.0248
-0.0306	-0.0029	0.0280	0.0280
-0.0311	-0.0067	0.0205	0.0205
-0.0344	-0.0066	0.0263	0.0263
-0.0338	-0.0056	0.0285	0.0285
-0.0341	-0.0057	0.0297	0.0297
-0.0361	-0.0075	0.0284	0.0284
-0.0364	-0.0066	0.0323	0.0323
-0.0384	-0.0071	0.0331	0.0331
-0.0389	-0.0100	0.0291	0.0291
-0.0400	-0.0091	0.0341	0.0341
-0.0396	-0.0090	0.0317	0.0317
-0.0404	-0.0068	0.0410	0.0410
-0.0446	-0.0031	0.0545	0.0545
-0.0427	-0.0015	0.0517	0.0517
-0.0422	-0.0035	0.0527	0.0527

3.8 Consultation with extension personnel

Continuing consultation with extension personnel, who are the expected users of the tool, was built into the work program. This included direct consultation early in tool development and broader engagement later in the development process. Initial consultation was completed by sending a draft version of the tool to pastoral company employees and Breeding EDGE deliverers for feedback.

When tool development was complete, a presentation was scheduled for the Beef Champions event in Adelaide. In preparation for this, Bush AgriBusiness met with AGBU in Armidale to assist with the development of the presentation of the work. Key developments included changes to the presentation of outputs such as the use of the term 'improvement' rather than 'cumulative gain' when labelling charts to better align the terminology with generally accepted genetics phrases. It was also decided that while the effect of increasing energy demand would still be retained in the calculations, it would be removed from the output graphs due to its relatively negligible impact on the charts.

The Adelaide Beef Champions event was postponed indefinitely due to the public gathering and travel restrictions imposed by the COVID-19 measures. As a result, the presentation concerning the tool was delivered via webinar in late March 2020 to 30 extension officers.

4 Results

4.1 Presentation of output

The presentation of tool output has been designed to best illustrate the effect of genetic trends on herd productivity and income in a way that is easily understandable and explainable to users. It is expected that this tool would primarily be used by extension officers delivering content such as Breeding EDGE, so that the findings can be properly framed and explained to users. Nonetheless, some background information is included on the opening sheet of the tool. It currently states:

> "The intent of this tool is to demonstrate productivity (kg beef produced per AE) gains at the farm gate that can be attributed to genetic gain over time. The tool relies on genetic trends for three productivity drivers: weaning %, mortality %, and sale weight. Currently, the breed genetic trends (national BREEDPLAN data across all regions) for two breeds, Brahman and Hereford, are available, with the Bottom 25%, Average, and Top 25% included for both breeds based on index.
>
> Productivity models have been developed from data in the Australian Beef Report, enabling region to be included as a parameter. This increases the accuracy of the prediction as the productivity drivers have varying levels of relative importance between regions.
>
> The two tabs, Hereford and Brahman, allow selection of a region from Southern and Northern Australia, respectively. There are three graphs in each tab. The first shows the gain in kg beef/AE and income/AE in absolute terms from 2003 to 2018. The second itemises the gain by specific productivity driver (weaning %, mortality %, or sale weight). While the third graph includes regional average income/AE and kg beef/AE figures to put the genetic gain in context of overall performance.
>
> For the second graph, it is important to note that gain arising from a specific productivity driver will be due to the driver's relative importance in the productivity equation for that region, the genetic trend over time for that driver, or a combination of both. For example, weaning % is a relatively more important productivity driver in NSW Central West than NSW Tablelands. However, while weaning % is a very important driver of productivity in all the northern regions, the low genetic trend in the past for weaning % in Brahmans means it has had a minimal effect on productivity gains attributable to genetics."

After this initial sheet, it is expected that the user would then navigate to the relevant breed sheet. They would be presented with the regional selection drop-down and herd structure template, as described in Section 3.3.

The results of the inputs are presented in four graphical outputs in the breed sheet, using the Brahman breed in the VRD & Katherine region as an example. The first graph Fig. 4. was intended to be a simple introduction to the concepts used. The description alongside the graph states:

> "This graph shows the total productivity (kg beef/AE) gain/loss attributable to changes in herd productivity drivers: weaning rate, mortality rate, and turnoff weight. The productivity gain/loss shown also accounts for inefficiencies associated with increasing mature cow weight. Larger cows have higher maintenance requirements, effectively increasing their AE rating.
>
> The gain/loss in productivity can be related to changes in Gross Profit (trading income) per AE attributable to genetic gain. This is calculated by multiplying additional kg beef/AE by the average income/kg for NT VRD & Katherine. The units for this are $/AE, shown on the right-hand axis."

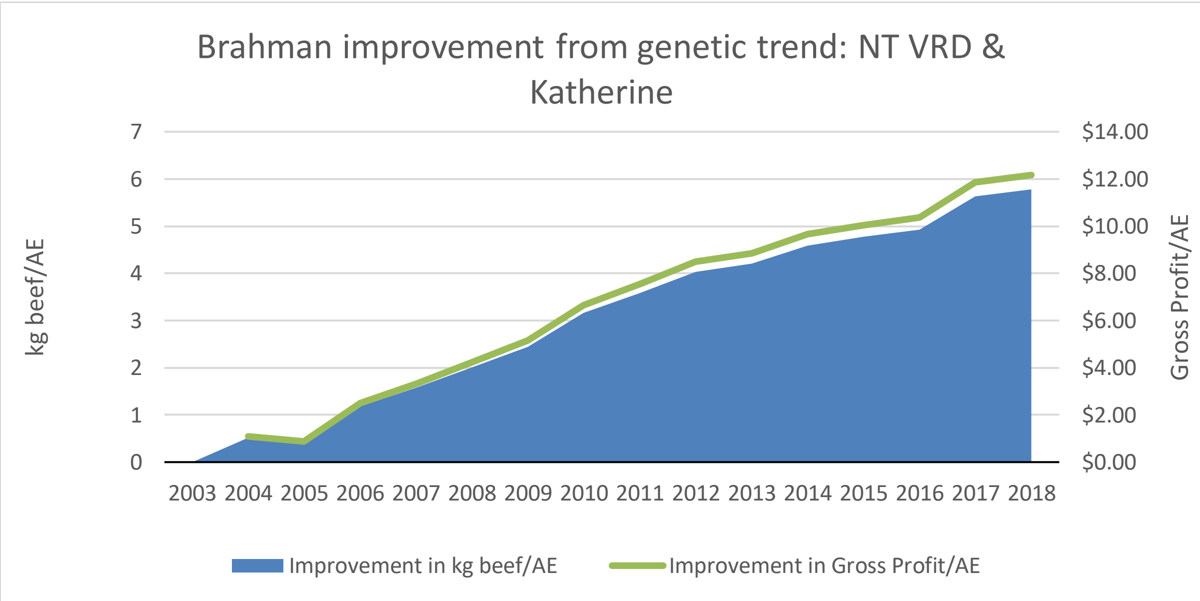

Figure 4: Cumulative productivity/AE and income/AE gain attributable to genetic trends for productivity drivers over the period shown, as illustrated in the tool.

The second chart Fig. 5. compares the productivity improvement for the breed average and selected herd (combination of genetic merit levels for each trait). It is intended to demonstrate the level of variation in genetic merit within years, depending on the inputs of the user. The accompanying text is:

> "This graph shows the same trend in kg beef/AE presented above, but in the context of a range of outcomes. Within this range, the blue line shows the trend expected for a herd of the genetic merit selected in the table above.
>
> The effect of each area of genetic merit on the trend can be tested by changing the assumptions entered in the genetic merit table.
>
> This shows the potential productivity gap that can develop between the top and bottom 25% on index."

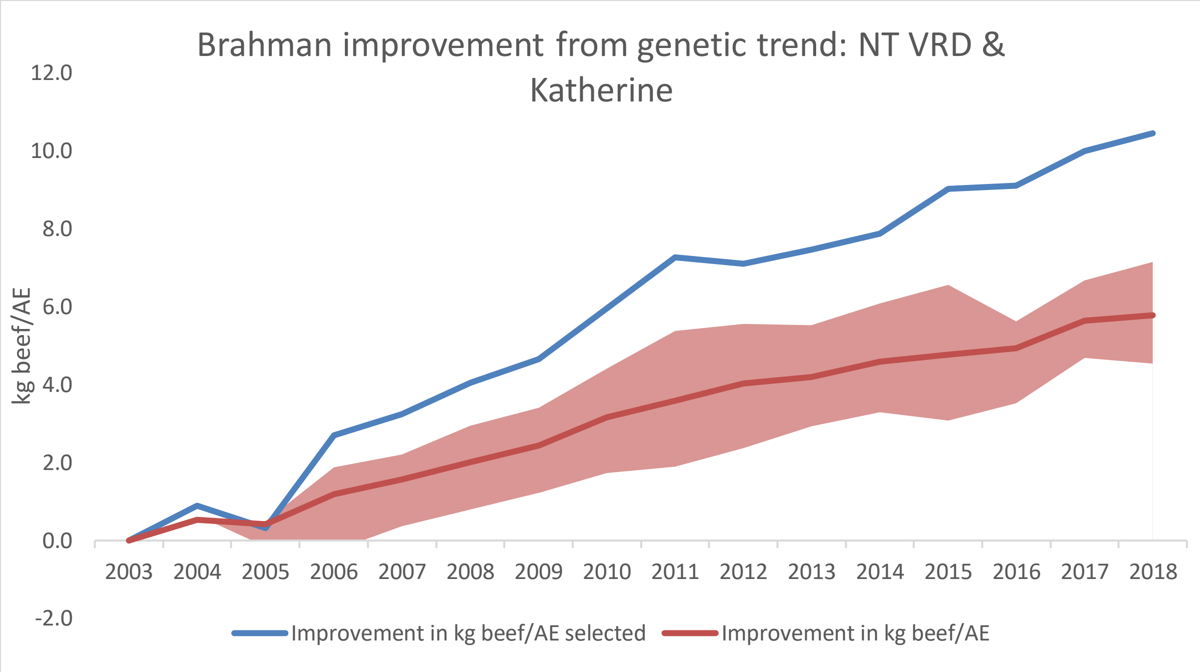

Figure 5: Comparison between breed average and user-selected herd for the improvement in productivity attributable to genetic trends for Brahmans in the VRD & Katherine Region.

The inclusion of the third graph aims to itemise the impact of each of the herd productivity drivers on the overall gain or loss Fig. 6. This graph has the most potential to be misconstrued. The accompanying explanation is therefore critical in this instance:

> "This graph shows the productivity (kg beef/AE) gain/loss attributable to each productivity driver: weaning rate, sale weight, and mortality rate over time. It also shows the penalty arising from increasing mature cow weight. The unit for productivity is kg beef/AE, shown in the left-hand axis.
>
> The line shows the additional Gross Profit (trading income) per AE resulting from the productivity gain. Units is $/AE, shown on the right-hand axis.
>
> It is important to note that gain arising from a specific productivity driver will be due to the driver's relative importance in the productivity equation for that region, the genetic trend over time for that driver, or a combination of both. While weaning % is a very important driver of productivity in all the northern regions, the low genetic trend in the past for weaning % in Brahmans means it has had a minimal effect on productivity gains attributable to genetics."

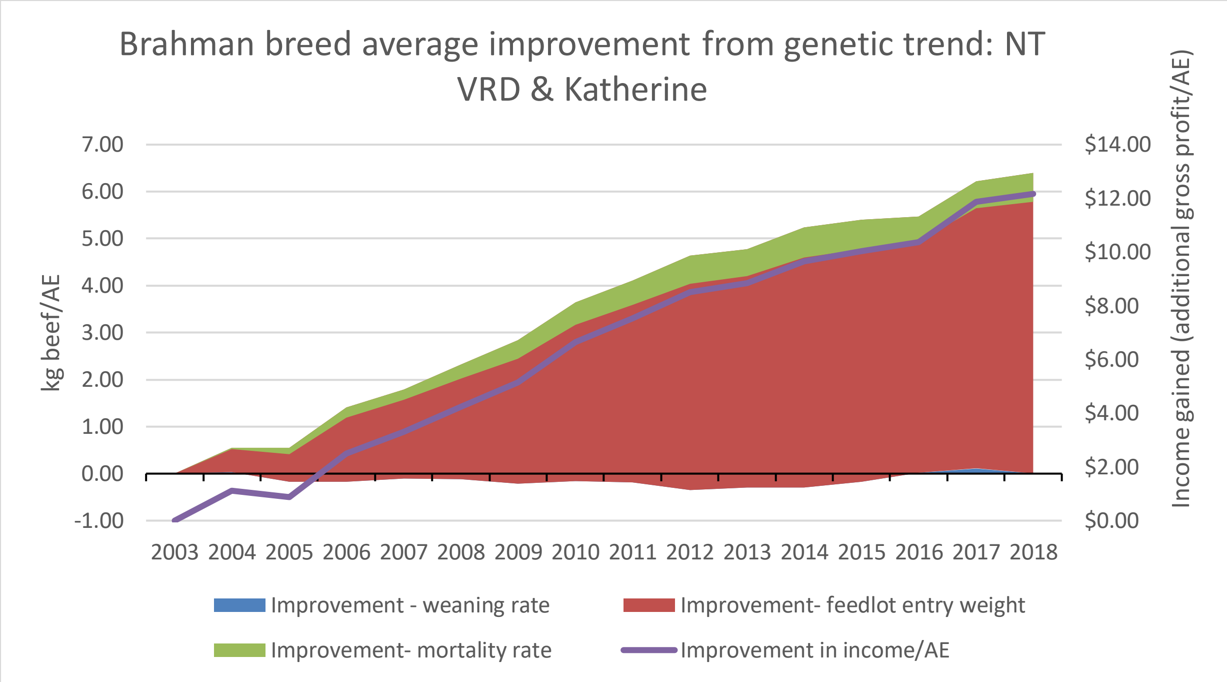

Figure 6: Cumulative productivity and income/AE gain itemised for each productivity driver over the period, as illustrated in the tool.

This graph is then repeated for the selected herd rather than the breed average.

Up to this point, the graphs show the gain/loss attributable to genetics without any context around expected baseline for productivity or income. The aim of the third graph is to provide a point of reference for the gain/loss Fig. 7. The figures included in the accompanying text are dependent on the user selected region:

> "This graph shows the results presented in the previous two graphs in the context of regional average productivity (kg beef/AE) and Gross Profit/AE. The baseline figures are the average for 2005-2016 for NT VRD & Katherine. The productivity average for NT VRD & Katherine is 68.8 and the average Gross Profit/AE is $144.90."

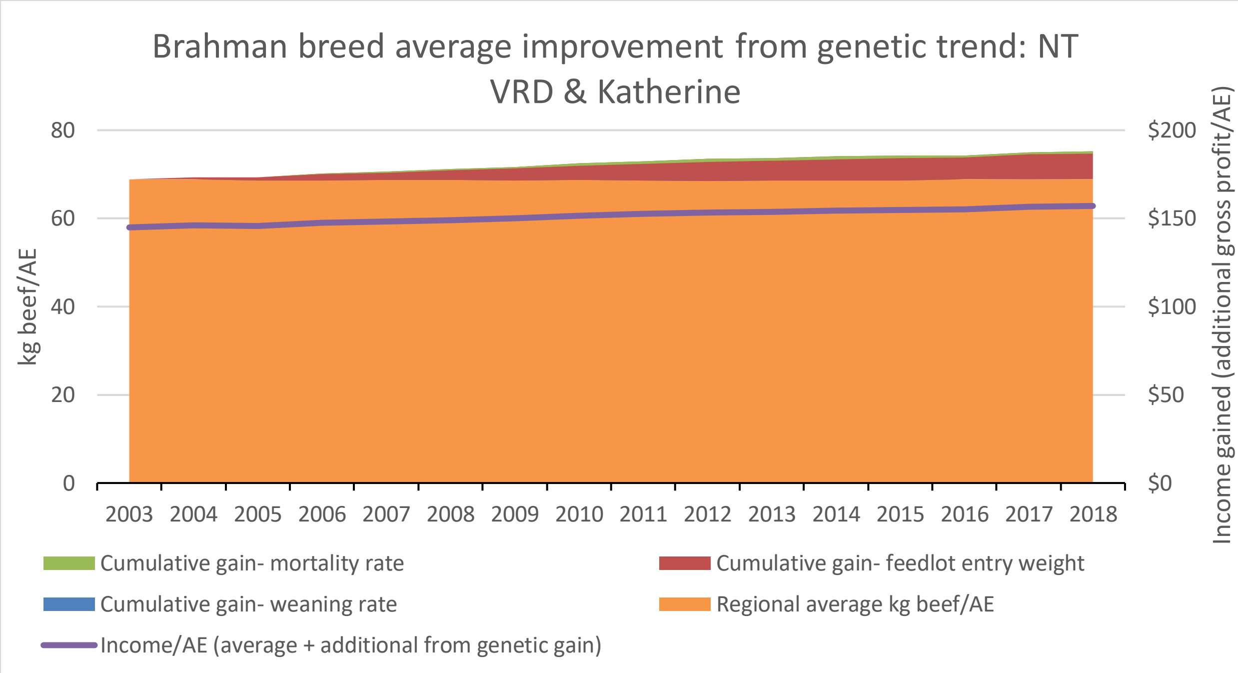

Figure 7: Cumulative productivity and income gains presented as a gain/loss from the regional average productivity and income/AE.

This chart is then repeated for the selected herd rather than the breed average.

The final graph aims to make the findings relevant to the user's herd and scale by multiplying the expected change in income/AE for each year by the number of AE run, based on the user-entered information. This graph aims to illustrate 'Proof of Profit' by illustrating expected changes in herd Gross Profit (trading income) that the user might expect by following breed genetic trends, as the accompanying text explains:

> "The final chart extends the expected additional income to the herd level, using the total AE derived from the user-entry herd numbers. The bars show the additional herd Gross Profit (trading income) that could be expected each year due to genetic gain from the previous year."

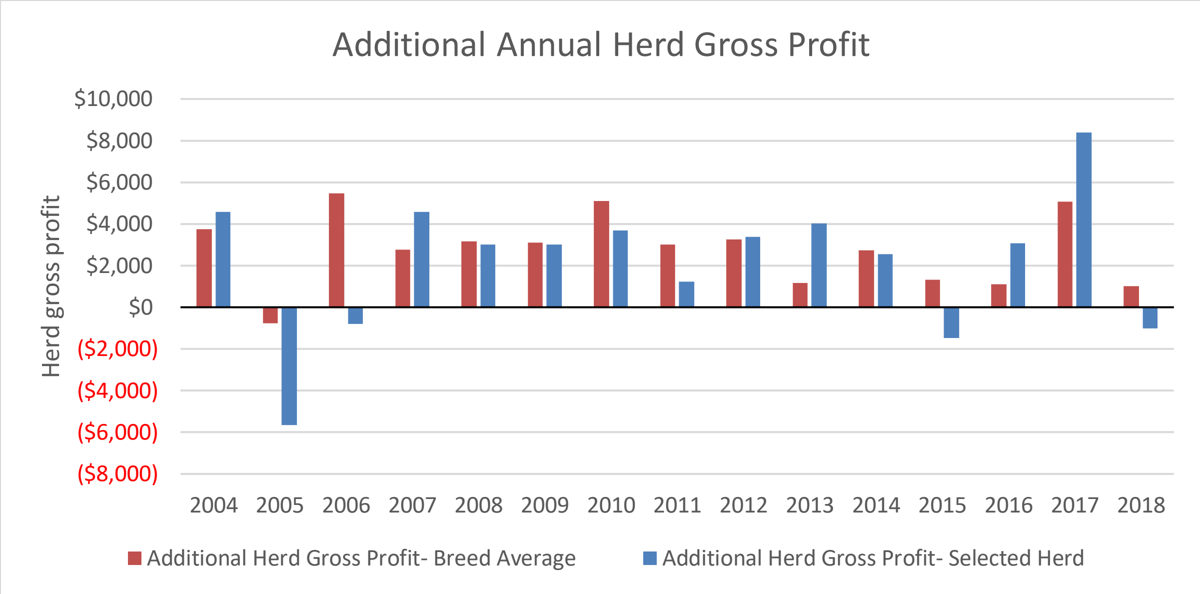

Figure 8: Annual expected income gain/loss resulting from the genetic trend for a given year, based on a herd size of 7,977 AE.

As a general note, the calculations listed in the sections above are hidden in the final tool available to users. The AE rating calculation sheets will also be hidden, and the workbook protected, in the user version. It should also be noted that cell comments have been added to each data column in the tool explaining the calculation method for that column. Error checks have also been included where possible, denoted by red shaded and outlined cells.

4.2 Consultation with extension personnel

The consultation undertaken early in tool development gave clear feedback on the output and application of the tool. Those surveyed gave the following feedback:

- That the outputs of the tool should be clear in terms of labelling and colour-coding, and the messages should be simple and demonstrable.
- The spread on merit, indicated by the range of outcomes between Top 25% and Bottom 25%, would be a useful extension tool.
- The impact of increasing mature cow weight and fertility should be included as a discussion point.
- Although the lack of recorded information for the Brahman breed limits the accuracy of outputs, it is best to work with what is available. Also, the tool demonstrates the application of recorded data and thereby demonstrates the potential benefits of recording.
- The findings are useful and could be incorporated into genetics extension material.

This feedback was encouraging and guided the development of the tool.

After the webinar in March 2020, a feedback questionnaire was distributed to registered attendees by MLA. Feedback received included presenting the Hereford tab on a per DSE, rather than AE, basis. This functionality was added to the tool in the Hereford tab. General feedback was also received on the methodology used, which has been addressed in Sections 3.1 and 6.

5 Discussion

The project successfully fulfilled the objective of developing a spreadsheet-based decision support tool, allowing current herd structure, location, and genetic merit for productivity-related traits as inputs. The tool gives some pertinent insights into the role of genetics in driving herd productivity over time. Generally, the tool shows an improvement in herd productivity attributable to genetics. This is a testament to the benefit of sound genetic selection practices and breeding decisions.

The initial inclusion of two breeds: Hereford and Brahman, has shown that Herefords have experienced a considerably higher productivity gain attributable to genetic trends than Brahmans over the period analysed. The lack of a definitive upwards trend in the genetics for weaning rate for Brahmans is likely to be at least somewhat responsible. All other genetic trends included show a linear trend, while weaning rate in Brahmans oscillates around flat before showing an upwards trend in later years. It is probable that the lack of active recording and selection for reproductive performance traits is responsible for this.

While upward mature cow weight trends for both Brahmans and Herefords have occurred, they have had a minimal effect on productivity. The penalty from increased energy demand was removed from the itemisation of improvement charts due to its relative negligibility. Although it is demonstrable that there is a productivity penalty for increasing mature cow weight, its effect is outweighed by gains attributable to other traits, especially growth to which it is correlated. However, there may be other factors associated with increasing mature cow weight beyond the increased metabolic demand which negatively impact overall herd productivity.

There is a considerable spread in possible improvement in Gross Profit/AE attributable to genetic variation, indicated by the difference between Top and Bottom 25%. For Herefords, the cumulative improvement in Gross Profit per AE for the Top 25% can be up to 1.5 times greater than the Bottom 25%, depending on the region. Brahmans provide an interesting contrast as the Bottom 25% have seen greater cumulative improvement in Gross Profit per AE then the Top 25%, despite being genetically inferior overall. In other words, the Brahman Bottom 25% are improving at a faster rate than the Top and ‘catching up’, whereas the Hereford Top 25% are continuing to diverge from the rest. This is another finding which requires nuanced interpretation.

The improvement in Gross Profit/AE generated in the tool generally follows the same trajectory as the BreedObject Indexes, allowing for differences in scope and definition of each method. This is because the relationships identified in the empirical modelling largely align with those in the BreedObject profit calculation. This gives some validation to both methods of assigning monetary values to genetic improvement and merit.

The specific application of the tool is currently limited to the Hereford and Brahman breeds. The methodology means that additional breeds can easily be included if/when the trends for relevant traits become available.

Findings for Brahmans have been somewhat limited by the sampling error evident in the trends, and the lack of discernible trends for some traits. The tool is one of many research outputs that demonstrate the need for performance recording and could incentivise more widespread recording in coming years. If this occurs, the usefulness of the tool could also be expected to improve into the future, particularly for the Brahman breed. This is because larger datasets will give more accuracy to the trends.

6 Conclusions/recommendations

The methodology applies the long-standing regression modelling method to genetic information in a novel way. The results indicate that genetics have contributed to productivity gains in the Hereford and Brahman breeds, and gives some useful and pertinent extension messages.

While the tool has used the best available data and methodology, improvements in financial, production, and genetic performance recording could be expected to enable more rigorous methods to be applied in the future. Methodological advancements would include:

- Generating technical efficiency scores for individual business units, and using these as the outcome variable of regression analyses as described in Fleming et al. (2006).
- Including genetic information for individual herds as part of business benchmarking, especially for seedstock herds, and including this information in regression, data envelopment, and other analyses (Fleming *et al.* 2006; Geenty *et al.* 2006; Bogetoft and Otto 2011).

The tool has also demonstrated the effect that low rates of performance recording have on accuracy. Higher rates of recording would give greater confidence in similar analytical exercises.

The genetic trends and EBVs used in the tool are provided by the relevant breed societies, in this case Herefords Australia and the Australian Brahman Breeders Association. The ongoing maintenance of the tool relies on permission from such organisations to continue using this information. Furthermore, the inclusion of more breeds would require permission to be granted from those breed societies.

The complete tool would be best presented by trained extension officers who are able to explain the nuances in the results. However, there are some simple outputs which could be distributed more publicly. Tool developers have worked with workshop deliverers to leverage the tool output.

7 Key messages

- An excel-based tool has been developed to demonstrate the productivity gain attributed to genetics based on user-entered region, herd structure and size, and breed (Hereford or Brahman). The tool predicts the productivity gain attributable to genetics for the breed average, Top 25% and Bottom 25% on index, and user-selected genetic merit.
- Genetic improvement has made an overall contribution to productivity gains in Brahmans and Herefords in recent decades, and can be expected to do so into the future.
- Genetic gain for the Brahman breed average from 2003 to 2018 generated an additional $12/AE in Gross Profit/AE for commercial producers in VRD & Katherine. Similarly, producers following Hereford breed average trends in the NSW Tablelands received a $3/DSE ($25/AE) benefit in Gross Profit/AE over the same period.
- There is considerable variation in the level of improvement within each breed as demonstrated by the difference between Top and Bottom 25%. Cumulative improvement in Gross Profit/AE was up to 1.5 times greater for the Top 25% than the Bottom 25% for Herefords.
- The improvement in Gross Profit/AE figures can be generated for each breed in relevant regions for the Bottom 25%, Average, and Top 25% on Index using the excel tool.

- Gains up until now for Brahmans have been almost solely due to growth providing opportunity to drive profitability further by focusing on balanced selection with other key traits like fertility. In contrast, fertility, growth, and survival trends contribute to the resulting gains in Herefords

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