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The Influence of Genetic Information in the Selection and Valuation of Angus Bulls: 1. Statistical Analyses of Sale Data[1]

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Abstract

Genetic information for beef cattle in Australia has been provided through BREEDPLAN since 1972. The BREEDPLAN model estimates the genetic potential of livestock using Estimated Breeding Values. There is substantial evidence proving the accuracy of the latter from programs such as the Angus Sire Benchmarking Program. While BREEDPLAN is well regarded worldwide and is being continually updated and improved, there are substantial differences in the breeding programs of seedstock producers and continuing industry-wide debate about the weight to place on phenotypic and genotypic information when assessing an animal's breeding value. Genetic information available to the industry is considered to be underutilised, leading to lower rates of genetic gain than is technically possible and causing market inefficiency with a reduced incentive to record data. This research is aimed at investigating the influence of genetic and phenotypic information in the selection of Angus bulls and the prices paid for them. In this component of the study, a statistical analysis of bull sale data, it was found that indexes of breeding values were significant variables in explaining some of the difference in prices paid for Angus bulls. However, most of the difference in prices paid for Angus bulls is the result of other factors and is not explained by either measured genetic variables or the phenotypic variables.

Keywords: Angus, bull prices, Angus Breeding Index, liveweight, average daily gain

Introduction

Genetic information about Australian beef cattle has been available to commercial producers for almost 50 years. Of the more than 100 beef cattle breeds in Australia, Angus Australia (2020) reported that almost half of all breeding females were influenced by Angus genetics. The Angus breed is used here as a case study because of its influence in the Australian beef industry and as access was available to a bank of reliable data about Angus bull sale prices and their Estimated Breeding Values (EBVs). The

[1] The authors wish to express their appreciation to the Angus seedstock producers who provided data from their sales held during 2019. The authors also thank the anonymous referee and editors for incisive and constructive comments on an earlier draft.

Angus Breeding Index (ABI)[2] is a widely recognised, single figure representation of the genetic merit of Angus cattle. The ABI is a ranking of animals in terms of their mix of key traits, weighted somewhat for owners' goals, and expressed as a single dollar index (Angus Australia, 2019a). Note that the method and weightings used in calculating the ABI have undergone significant enhancements since this research was conducted in 2019.

Despite the availability of empirical evidence about many components of the genetic merit of stud stock, many producers focus predominantly on phenotypic traits, such as live weight (LW) and average daily gain (ADG). There have been cases of top-priced bulls at a sale having a low ABI but being highly sought after for their phenotype. For example, a member of the syndicate that bought the record priced bull in 2016 was quoted as saying 'The bull had wonderful phenotype and something that we feel is missing in the breeding in the Angus society' (Woolrich, 2016). This statement is indicative of the different approaches to valuing a bull in the industry where some producers assess the phenotype of a bull without considering its EBVs, while other producers select a bull purely on genetic data without seeing the bull or judging its structure and phenotype.

Knowing about the extent to which measured estimates of genetic merit is influencing buyers' decisions in selecting their seedstock, and the extent to which market prices reflect the value of this extra information, would be helpful to stud breeders, commercial cattle producers, breed societies and the wider beef industry to inform future decisions about funding data recording, management and analysis.

There is limited research into the benefits and costs involved in the management and data recording that is required to breed bulls to put to the market with accurate EBVs. Data recorded to be entered into the BREEDPLAN model that generates EBVs include birth weight, gestation length, calving ease, 200-, 400- and 600-day weights, mature cow weight and scrotal size. Further traits that can be recorded include days to calving, carcass weight, eye muscle area, P8 fat depth, rib fat depth, intramuscular fat, docility and net feed intake. Bulls are gene-tested for susceptibility to some known genetic disorders. Many breeders also conduct carcass scanning to obtain further data for BREEDPLAN. Recently, genomic testing of DNA samples has also become available and is gradually being widely adopted to achieve greater accuracies in EBVs (SBTS, 2011; Banks, 2015). The majority of bulls for sale also undergo a service ability test which is conducted and certified by a registered veterinarian. Actual scrotal size, structural scores and live weight are also recorded and regularly supplied at sales through supplementary sheets or in-sale catalogues.

All of these practices involve a significant cost to the breeder. This recording of data is primarily to achieve greater rates of genetic gain of the key traits in the breed through selection of superior animals. The return to this investment depends on whether buyers are using information from EBVs and valuing this information in making their selection decisions. Banks (2015) notes that rates of genetic gain in beef cattle are lower than what is possible, in part because the genetics information market is operating inefficiently and these inefficiencies have a negative impact on the incentives for breeders to invest in recording.

The aim of this study was to establish the extent to which genetic information influences the prices paid for Angus bulls and, to the extent that such information influences sale prices of bulls, which traits have the most influence on sale prices. These quantitative results will allow inferences to be made regarding the role of measured information about genetic merit and the part played by phenotype characteristics in the selection decisions of buyers of bulls.

[2] Formal definitions of some of the main terms used are provided in Appendix 1.

The Australian Beef Industry

The Australian beef cattle industry has distinct southern and northern grazing systems. Southern areas are generally smaller farms with highly productive soils, higher rainfall and improved pastures that are run intensively with Bos Taurus cattle such as Angus, Herefords, Simmentals, Limousins, etc. These areas are highly productive, generating high revenue but also incurring significant costs. The Northern systems are extensive and involve large areas of low-quality soil, low rainfall, and native grass species. These areas run Bos Indicus cattle such as Brahman, Santa Gertrudis and Brangus that are heat- and tick-tolerant and can withstand the harsh conditions.

In the past, genetics has played a more significant role in southern grazing systems as these cattle are more able to reach their full genetic potential due to their environment. There is also more focus on meat quality in these breeds of cattle and there is greater capacity for artificial breeding: vital for genetic improvement. However, the influence of genetics is growing in northern areas, in particular in the areas of heat and tick tolerance and through the influence of cross-breeding programs to target better meat quality.

Angus cattle are a Bos Taurus breed that is widespread in high rainfall areas of New South Wales, Victoria, Tasmania and Western Australia and increasing in numbers in northern Australia and in lower rainfall regions (DPI, 2019a).

In 2018, Angus cattle accounted for 34.5 per cent of total beef cattle registrations. This does not include Brangus or Red Angus breeds and is far ahead of the next most-registered breed (Brahman) which accounted for 12 per cent (ARCBA, 2019).

BREEDPLAN and EBVs

The origins of BREEDPLAN trace back to 1972. At this time the National Beef Recording Scheme (NBRS) was established with support from the Australian Meat and Livestock Corporation (AMLC), now Meat and Livestock Australia (MLA), and records were maintained in a central data processing system by the Agricultural Business Research Institute (ABRI) at the University of New England (UNE) (Woolaston, 2014). The BREEDPLAN analytical software is now owned by MLA, UNE and the NSW Department of Primary Industries. Research and development is undertaken by the Animal Genetics and Breeding Unit (AGBU), also at UNE, while ABRI is the BREEDPLAN licensee (MLA, 2018).

In its early stages, the NBRS only included basic pedigree information and performance records, incorporating weight ratios with adjustments for age of dam and age at weighing. Over time, BREEDPLAN continued to be developed, advancing from within-herd to across-herd evaluation, adding new EBVs and improving accuracy, developing economically-based breeding objectives by deriving profitability traits from BREEDPLAN EBVs. Later, genomic information for multiple traits was incorporated (SBTS, 2011), which significantly improved the accuracy of EBVs, particularly in young animals before any performance data or progeny exist.

For the Angus breed, BREEDPLAN now includes pedigree, performance and genomic information to calculate EBVs for calving ease, growth, fertility, carcass, feed efficiency, temperament and structural soundness traits. It also includes (at the time of writing) four selection indexes for net profitability in a typical commercial self-replacing herd - the Domestic Index, the Heavy Grain Index and the Heavy Grass Index (Angus Australia, 2019d). The Angus Breeding Index (ABI) is not specific to a particular end market but rather identifies animals that will improve overall profitability in a range of production systems. It is therefore the most appropriate index to use for this analysis as it represents the largest range of production systems.

Effectiveness of BREEDPLAN

According to industry research, about 70 per cent of the performance of beef cattle is due to the environment and 30 per cent is due to genetics (ABRI, 2009). BREEDPLAN separates the genetic component from the environment component, allowing producers to select on real genetic differences (ABRI, 2009). Industry advice (Angus Australia, 2018a) is that 'For optimal results, it is important that selection decisions are not distracted by aesthetic features or the influence of non-genetic factors on the appearance and performance of animals.'

Angus Australia has developed and evaluated the Angus Sire Benchmarking Program (ASBP) which "… has demonstrated that there is great potential to achieve genetic improvement in Angus breeding programs by capitalising on the genetic variation that exists between Angus animals." (Angus Australia, 2018a, 1). As part of this Program, an analysis was undertaken to assess how well the BREEDPLAN EBVs of sires predicted the actual performance of their progeny. This involved estimating the difference on an individual trait between the performance of the ten highest-ranked sires and the ten lowest-ranked sires. This predicted difference in performance was then compared to the actual difference in performance of the progeny of the two groups. It was also found (Angus Australia, 2018b) that BREEDPLAN EBVs provided an accurate prediction of the performance of sires included in the ASBP.

Barnett (2017) found that over the period 2002 to 2015, "scanning records submitted to BREEDPLAN ranged from an average of 60 percent of the volume of weaning weight records in the case of Angus, to 12 percent in the case of Brahman, suggesting that in most breeds, BREEDPLAN is not being used rigorously by many users." This means that, even though the vast majority of seedstock producers are registering their cattle on BREEDPLAN and therefore have EBVs for them, they may not be actively using EBVs to inform buying decisions or target their breeding objective.

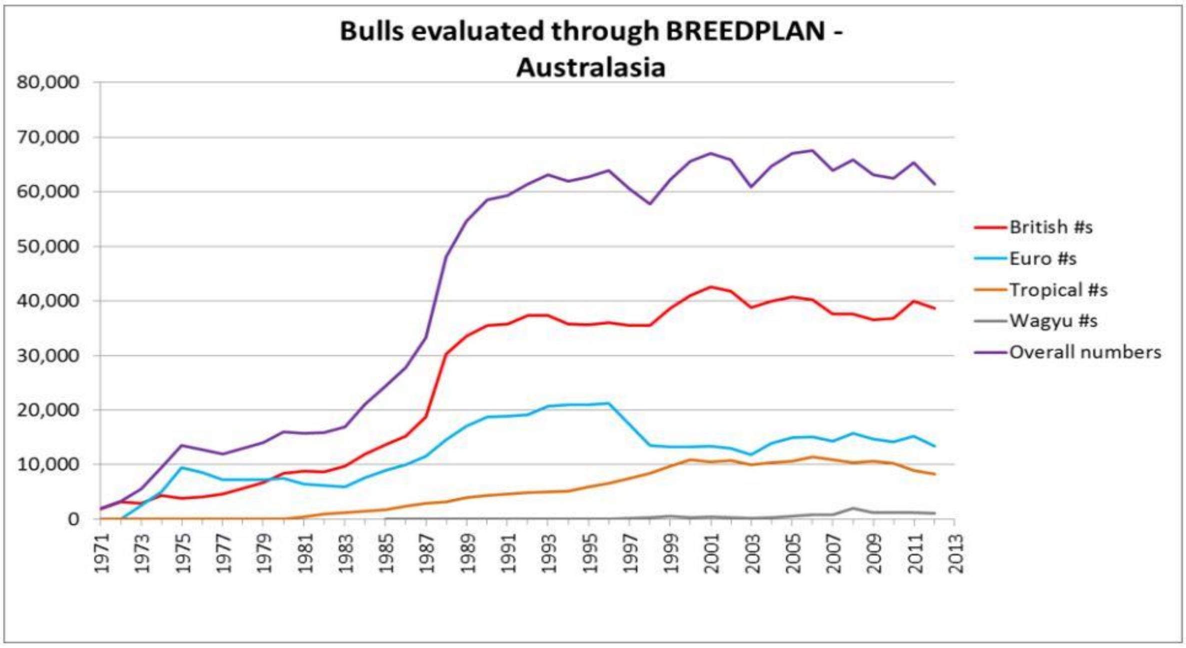
In Figure 1 the total number of bulls evaluated by BREEDPLAN in Australasia can be seen to have plateaued since about the year 2000 (Woolaston, 2014).

Adoption of BREEDPLAN EBVs is lagging in Northern beef cattle enterprises compared to Southern regions. The weighted average index for overall expected profitability of progeny in Southern breeds increased from around $19 per cow mated in 1990 to $63 per cow mated in 2012. However, in Northern breeds, the change was less significant, increasing from about $8 in the 1990 calving year to $21 in the 2013 calving year (Woolaston, 2014). This result suggests that Southern breeds have made more genetic progress due to greater adoption of BREEDPLAN EBVs.

Van Eenennaam (2012) examined the relationship between bull sale price and the long-fed $Index at six Australian Angus bull sales in 2011/2012[3]. A commercial bull was assumed to join 25 cows each year for four years for a total 100 cows joined. In a perfect market, the regression coefficient would be 100 x 0.5 = 50 for each unit increase in the $Index (as a bull contributes half of the progeny's genetics). This is unsurprising as increased slaughter prices improve producers' profitability and allows them to pay more for bulls. This means that comparison of bull quality using sale prices between years is not possible as a superior bull may sell for a lower price due to lower cattle prices than an inferior bull in a year where cattle prices are higher. Sale bull prices can only be inferred to link to quality for sales in the same year.

[3] The long fed $Index was an Index that was used to measure the overall profitability of an animal's progeny for a long-term grain feeding end market. It has since been replaced by the Heavy Grain Index and the Heavy Grain Low Feed Cost Index.

Figure 1. Number of bulls evaluated through BREEDPLAN, Australasia, 1971-2012



Source: Banks et al. (2013, unpublished)

For four sales in the north of New South Wales, targeting mostly commercial buyers, Van Eenennaam found regression coefficients of 37.9 to 71.3. The average regression coefficient of the northern sales was calculated to be about 56, indicating that commercial buyers were paying approximately the value of the genetic improvement encompassed by the $Index value. Similarly, regression coefficients of 164.9 and 171.3 were found for two sales in southern Victoria, targeting mostly seedstock buyers who were buying 'multiplier bulls'. These bulls will sire more progeny through artificial breeding practices and produce sons that will be sold into the commercial bull market and subsequently sire their own calves, leading to the higher regression coefficients. Overall, a clear relationship was found between price paid and a bull's genetic merit.

There is also some research in the area of trends in bull prices and industry wide genetic improvement. AbacusBio (2014) found that the price of breeding bulls tracks much more closely to the price of slaughter animals than to the trend in genetic progress. This relationship is demonstrated in Figure 2.

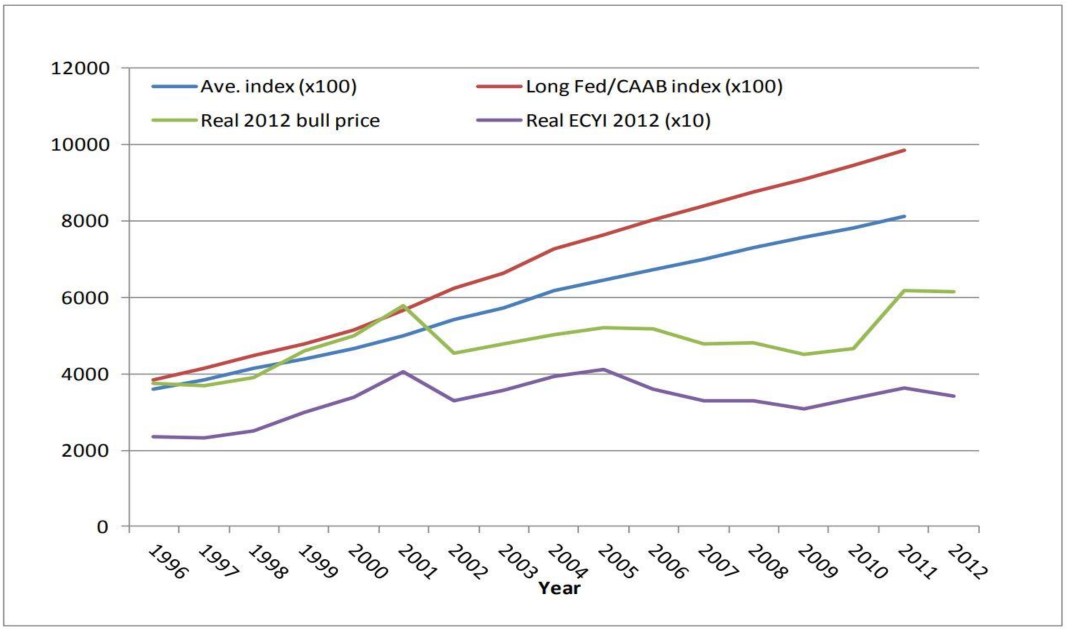
AbacusBio (2014) further analysed the relationship between sale average bull price and herd average index values for Australian Angus breeders. This relationship is shown in Figure 3. The correlation between bull sale price and value of the Long Fed/CAAB Index was calculated to be 0.37 (R^2 of 0.11). However, Banks (2015) found that analysis of Angus herd average prices indicates an r-squared of 45% for herd average bull price on herd average $Index merit. This implies a correlation coefficient of around 0.65-0.70.

Data and Method

Data requirements

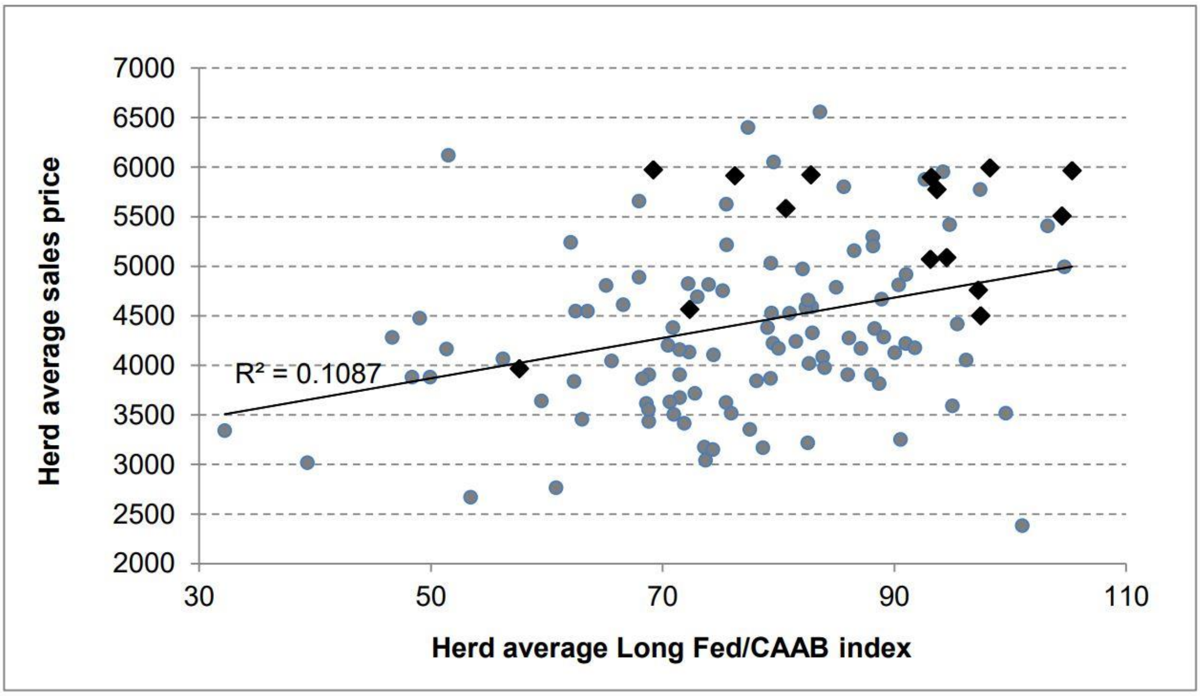
Required data for this research include breeder/sale number, ID, date of birth, lot number, live weight, scrotal size, ADG, ABI and sale price for all Angus bulls sold at live auction in 2019.

Figure 2. Evolution of Australian Angus bull prices, ECYI and average and CAAB indexes, 1996-2012



Source: AbacusBio (2014). EYCI is the Eastern Young Cattle Indicator, a seven-day rolling average of young cattle from 25 saleyards across Queensland, New South Wales and Victoria. CAAB is Certified Australian Angus Beef, a brand of Angus Australia, now discontinued.

Figure 3. Relationship between sale average bull price and herd average index values for Australian Angus breeders (Black diamonds refer to herds with high numbers (>70) of bulls sold)



Source: AbacusBio (2014)

The ID of the animal is purely for identification of individual bulls within a sale. The ID includes either 'N' for bulls born in 2017 or 'P' for bulls born in 2018 as well as a number, generally in birth order so that bulls within a herd can be distinguished. The ID will also include a breeder code made up of three letters distinguishing bulls from different herds. Therefore, every bull across all herds has a unique identification number. Date of birth was used in order to calculate ADG where it is not available. The breeder is the stud where that bull was bred. This was converted into a sale number to distinguish between multiple sales from the same breeder as well as to provide anonymity. Lot number is a representation of the order of the bulls in the sale. The live weight is the actual weight of the bull measured as close to sale date as possible. Scrotal size is the circumference of the bull's testes in centimetres, measured by a certified independent party (usually a veterinarian) during bull service ability testing. This is the stage where all bulls are tested and culled on any issues such as temperament, structure, phenotype, genetics, scrotal size and service ability before being catalogued. The ABI is one of the four selection indexes developed by Angus Australia and used in 2019 to measure an animal's overall genetic merit. The sale price is the price that the bull is sold for at the live auction, in $AUD and in $500 increments. All of these quantitative data are presented as at the date of sale.

Data sources

The secondary data used for this research were collected from publicly available websites. These are the AuctionsPlus results page (AuctionsPlus, 2019) for sale prices of bulls as well as sale date, and the "sales catalogue" page of the Angus Australia website (Angus Australia, 2019e) for ABI, lot number, date of birth, ID and breeder. Live weight, ADG and actual scrotal size data were collected from the "supplementary sheet" for each sale. This supplementary sheet is a list of all the bulls by lot number and ID that have been catalogued for the sale. It generally includes the live weight and scrotal size of each bull and sometimes includes the ADG. If ADG is not included, it can be calculated using the bull's live weight, date of birth and date of sale. The supplementary sheet also includes information about any bulls that have been withdrawn prior to the commencement of the sale or any new bulls that have been added. This information is available either on the AuctionsPlus website or on the individual stud producer's public website[4].

Withdrawn lots are not included in the analysis as they are not offered for sale. These lots can be removed from a sale for various reasons which include injury or illness, being retained by the breeder or being sold prior to the sale. However, these lots are included in the descriptive statistics to measure the overall performance of individual sales. Similarly, passed-in lots are included in the descriptive statistics but removed from the regression analysis as they cannot be numerically represented because it is impossible to determine what price that the bull would have sold for under the reserve price or if it would have sold at all. In many cases, these bulls are sold privately after the sale for a reduced price but, for accuracy and integrity purposes, they are not included in the analysis.

Study area

The collection of secondary data is of Australian stud Angus 'N' and 'P' drop bulls, born in 2017 and 2018 respectively and sold at live auction. Sales ranged in location across Tasmania, Victoria, New South Wales and Queensland from the 2nd of February to the 13th of September 2019. There were more sales after the 13th of September; however, this date was used as the cut-off time given the deadlines for the completion of the analysis. A map of sale locations is shown in Figure 4. A small number of stud breeders had multiple sales in either Autumn or Spring as well as a "Northern" sale. "Northern" sales are conducted by breeders who are based in the southern regions of Australia but host sales in Northern NSW or QLD to access a larger client base. These have been identified on the map and in the results tables.

[4] Any data not available from the sources mentioned was kindly provided by the relevant seedstock producers in accordance with UNE human ethics approval No. HE19-133.

Figure 4. Map of sale locations

Source: author's compilation

If a stud did not use AuctionsPlus for their sale, submit their sale catalogue to Angus Australia or weigh their bulls prior to sale, they were excluded from the research. Sales from Western Australia and South Australia were excluded based on lack of data in the specified time period, and the Northern Territory did not have any stud Angus sales in 2019.

Bull sale statistics from the Angus Australia website show that, as of the 6th of November 2019, there were 185 sales with 8,100 bulls sold during 2019, with a top price of $160,000 and an average of $6,197 across Australia (Angus Australia, 2019b). The data for this research cover 49 sales from 42 different Angus studs. A total of 3,070 bulls have been analysed, made up of 2,482 two-year old (N) bulls and 588 yearling (P) bulls. Scrotal size data was available for 2,226 bulls, 1,704 two-year old (N) bulls and 522 yearling (P) bulls. Scrotal size data have been analysed for correlations using Excel but been removed from the regression analysis to maintain a larger sample size.

Methods

Several forms of analysis were used to determine the variables influencing sale price. Initially, descriptive data from each sale are collated. These data include the number of catalogued, withdrawn, passed-in, for-sale and sold lots, as well as average ABI, average live weight and average ADG of each sale. Two tables of results from the descriptive analysis are included in Appendix 2.

Of note in these tables is that a scoring index for overall sale performance was developed using clearance rate and average sale price. Each individual sale’s clearance and average sale price was divided by the maximum across all sales to give it a score out of 1. Therefore, a clearance of 100 per cent was given a score of 1 and every lower clearance was given a corresponding proportion of the maximum. Average sale price was scored in the same way. Therefore, the sale with the highest average price (say $15,000) was given a score of 1 and every other average price was given a score proportionate to $15,000. These were added together to generate the overall performance score with equal weighting given to clearance and average sale price. This overall performance value allows for comparison of the relative performance among sales.

Correlation coefficients were then calculated, for each individual sale, between sale price and respectively lot number, live weight, ADG, scrotal size and ABI. Correlation coefficients were also calculated, across all sales, between number sold, clearance, average sale price, overall performance, top price, average ABI, average live weight and average ADG. Using a guide developed by Evans (1996), a correlation coefficient of 0-0.2 is described as very weak, 0.2-0.4 is weak, 0.4-0.6 is moderate, 0.6-0.8 is strong and 0.8-1.0 is very strong.

Finally, a number of multiple regression analyses were conducted. These equations examined the causal relationship between multiple independent variables (lot number, ABI, ADG, live weight and sale number) on a dependent variable (sale price). Sale numbers are included as dummy variables to take account of the influence of each individual sale. Since the equations are specified in linear form, the estimated coefficients for each independent variable measure how much the dependent variable will increase or decrease if that independent variable increases by one unit. The regression analysis was conducted using EViews 10 software, and the equations were estimated without a constant term.

Results, 2017 vs 2018 Bulls

Correlation analysis results

The results for the 2017-born bulls are displayed in Appendix Table A3.1. The correlation between ABI and sale price for each bull within that sale is shown in the far-right column. The results range from -

0.31 to 0.66 and average 0.39, which just falls into the weak positive range. Similarly, live weight ranges from 0.03 to 0.74 and averages 0.43; ADG ranges from -0.07 to 0.71 and averages 0.36; lot number ranges from -0.73 to 0.01 and averages -0.35; while scrotal size ranges from -0.36 to 0.96 and averages 0.19.

The positive correlations from ABI, live weight and ADG were expected as higher values for these performance measures is desired by buyers. The negative correlation for lot number was also expected as both competition between bidders and quality of bulls decrease later in the sale.

The correlations across all studs for the 2017-born bulls are shown in Appendix Table A3.2. They show minimal correlation between average ABI and average sale price or clearance rate. The correlations of average ABI to clearance and average sale price for all sales are both very weak positives of 0.04 and 0.01 respectively. The correlations for average weight and ADG are also greatly reduced compared to the average of the individual sale correlations. This demonstrates the effect of client loyalty between bull buyers and bull breeders whereby bull buyers are generally selecting bulls from an individual stud rather than comparing bulls from different studs.

The results for the 2018-born bulls shown in Appendix Table A3.3 show the correlation between the ABI and sale price for individual bulls within a sale range from 0.12 to 0.74 and average 0.42. This is a "moderate positive" correlation, and similar to the average for the 2017-born bulls. In comparison, the correlations for live weight to sale price range from -0.12 to 0.86 and average 0.47, those for ADG range from -0.14 to 0.82 and average 0.39, those for lot number ranged from -0.68 to 0.22 and average -0.33, while those for scrotal size ranged from -0.60 to 0.62 and averaged 0.18. The results for the 2018 bulls are similar to those of the 2017 bulls.

However, an analysis of correlations between average sale price and average ABI of each sale, rather than each individual bull, in Appendix Table A3.4 gives a very weak negative correlation of -0.08. This value is a measure of the correlation between the average ABI of an individual sale and the average sale price for that entire sale. The correlation between sale clearance and average ABI is a weak negative of -0.27. This is due to the significant influence that individual sales have on price.

Regression analysis results – 2017-born vs 2018-born bulls

The regression output for the 2017-born bull data is shown in Figure 5, with a total of 2,482 observations. The adjusted R^2 value is 0.33, and the Durbin Watson and other summary statistics are acceptable. All estimated coefficients except two are strongly statistically significant. The regression output for the 2018-born bulls is shown in Figure 6, with a total of 588 observations. The adjusted R^2 value is 0.49, and the Durbin Watson and other summary statistics do not indicate any problems with the estimation. All estimated coefficients are strongly statistically significant.

The regression outputs indicate that lot number has a negative coefficient and ABI, ADG and live weight have positive coefficients. Lot number, ABI and live weight are consistent across 2017- and 2018-born bulls as well as with all previous analysis results. Each of these variables are statistically significant. In both sets of results, ABI had a coefficient consistent with the results found by Van Eenennaam (2012), showing a clear positive influence of genetic merit to sale price. ADG was not consistent between the two age groups, being much higher for the 2018-born bulls, and was not statistically significant in the 2017-born bulls. However, the adjusted R^2 of both equations are less than 0.5 which indicates other variables than those included explain most of the variation in sale prices.

Figure 5. Regression output for 2017-born bulls

Dependent Variable: PRICE
Method: Least Squares
Date: 11/12/19 Time: 08:31
Sample: 1 2482
Included observations: 2482

Variable	Coefficient	Std. Error	t-Statistic	Prob.
LOT	-18.93947	1.811057	-10.45769	0.0000
ABI	64.31896	4.954165	12.98280	0.0000
ADG	1709.657	1620.005	1.055340	0.2914
LIVE_WEIGHT	8.525176	2.363552	3.606933	0.0003
SALE_NO_=1	-11880.23	1373.303	-8.650850	0.0000
SALE_NO_=10	-10462.37	1217.873	-8.590692	0.0000
SALE_NO_=11	-11362.37	1300.005	-8.740248	0.0000
SALE_NO_=12	-12558.32	1759.320	-7.138167	0.0000
SALE_NO_=13	-11857.21	1304.122	-9.092104	0.0000
SALE_NO_=14	-6426.979	1247.872	-5.150352	0.0000
SALE_NO_=15	-8652.369	1191.014	-7.264709	0.0000
SALE_NO_=16	-11601.86	1281.520	-9.053205	0.0000
SALE_NO_=17	-7531.282	1226.445	-6.140744	0.0000
SALE_NO_=18	-11718.82	1191.088	-9.838750	0.0000
SALE_NO_=19	-10406.77	1180.467	-8.815812	0.0000
SALE_NO_=2	-8336.838	1228.044	-6.788712	0.0000
SALE_NO_=20	-10068.12	1150.914	-8.747938	0.0000
SALE_NO_=21	-11625.38	1164.585	-9.982426	0.0000
SALE_NO_=22	-9990.166	1141.731	-8.750021	0.0000
SALE_NO_=23	-11340.27	1211.131	-9.363372	0.0000
SALE_NO_=24	-11257.34	1307.927	-8.607008	0.0000
SALE_NO_=25	-12133.98	1389.778	-8.730878	0.0000
SALE_NO_=26	-9686.117	1301.215	-7.443905	0.0000
SALE_NO_=28	-8044.948	1139.278	-7.061446	0.0000
SALE_NO_="2N"	-10591.97	1214.981	-8.717809	0.0000
SALE_NO_=3	-9259.738	1216.587	-7.611242	0.0000
SALE_NO_=30	-11668.09	1256.157	-9.288719	0.0000
SALE_NO_=31	-12196.68	1406.485	-8.671744	0.0000
SALE_NO_=32	-12090.09	1477.286	-8.183988	0.0000
SALE_NO_=33	-9075.734	1245.476	-7.286959	0.0000
SALE_NO_=34	-9820.537	1247.645	-7.871260	0.0000
SALE_NO_=35	-13992.88	1894.415	-7.386386	0.0000
SALE_NO_=36	-10049.06	1175.525	-8.548569	0.0000
SALE_NO_=37	-1304.334	1409.198	-0.925586	0.3548
SALE_NO_=38	-8191.086	1201.394	-6.817987	0.0000
SALE_NO_=39	-6381.976	1277.045	-4.997455	0.0000
SALE_NO_="3S"	-8352.582	1224.337	-6.822126	0.0000
SALE_NO_=4	-7176.532	1144.456	-6.270692	0.0000
SALE_NO_=40	-9438.138	1225.118	-7.703861	0.0000
SALE_NO_=41	-10035.86	1195.482	-8.394822	0.0000
SALE_NO_="4S"	-6315.495	1102.601	-5.727815	0.0000
SALE_NO_=5	-9190.540	1172.010	-7.841691	0.0000
SALE_NO_="5N"	-11323.43	1180.632	-9.590994	0.0000
SALE_NO_=6	-8715.266	1155.619	-7.541646	0.0000
SALE_NO_=7	-10934.89	1374.596	-7.954983	0.0000
SALE_NO_=8	-9218.921	1199.059	-7.688462	0.0000
SALE_NO_="8N"	-9978.098	1194.340	-8.354488	0.0000
SALE_NO_="8S"	-9896.910	1195.462	-8.278736	0.0000
SALE_NO_=9	-11959.30	1216.778	-9.828667	0.0000

R-squared	0.350459	Mean dependent var	6742.969
Adjusted R-squared	0.337645	S.D. dependent var	3652.057
S.E. of regression	2972.234	Akaike info criterion	18.85156
Sum squared resid	2.15E+10	Schwarz criterion	18.96640
Log likelihood	-23345.79	Hannan-Quinn criter.	18.89327
Durbin-Watson stat	1.991693		

Figure 6. Regression output for 2018-born bulls

Dependent Variable: PRICE
Method: Least Squares
Date: 11/12/19 Time: 08:30
Sample: 1 588
Included observations: 588

Variable	Coefficient	Std. Error	t-Statistic	Prob.
LOT	-23.68234	7.249577	-3.266720	0.0012
ABI	74.64797	12.60030	5.924300	0.0000
ADG	6695.800	1787.878	3.745110	0.0002
LIVE_WEIGHT	7.634403	2.526614	3.021594	0.0026
SALE_NO_=13	-16929.16	3117.392	-5.430552	0.0000
SALE_NO_=14	-14950.25	3360.993	-4.448164	0.0000
SALE_NO_=15	-14016.99	3042.238	-4.607461	0.0000
SALE_NO_=17	-12367.45	3549.580	-3.484201	0.0005
SALE_NO_=19	-17053.53	3041.122	-5.607645	0.0000
SALE_NO_=20	-16269.33	3054.044	-5.327143	0.0000
SALE_NO_=27	-16532.91	2856.437	-5.787949	0.0000
SALE_NO_=29	-16294.70	2967.758	-5.490576	0.0000
SALE_NO_=31	-17495.23	3131.769	-5.586371	0.0000
SALE_NO_=32	-19146.41	3149.673	-6.078855	0.0000
SALE_NO_=33	-16449.39	3140.774	-5.237367	0.0000
SALE_NO_=34	-15303.88	3027.825	-5.054415	0.0000
SALE_NO_=35	-19036.09	3242.051	-5.871619	0.0000
SALE_NO_=37	-7174.909	3134.383	-2.289098	0.0224
SALE_NO_=38	-12711.30	2824.531	-4.500324	0.0000
SALE_NO_=39	-11662.16	3182.227	-3.664780	0.0003
SALE_NO_="3S"	-14083.92	3230.656	-4.359462	0.0000
SALE_NO_=40	-15884.51	2891.364	-5.493777	0.0000
SALE_NO_=41	-13593.17	2848.174	-4.772591	0.0000
SALE_NO_=42	-15463.31	2958.761	-5.226277	0.0000
SALE_NO_="5N"	-15281.12	3066.667	-4.982975	0.0000
SALE_NO_="5S"	-13723.06	2560.925	-5.358633	0.0000

R-squared	0.508460	Mean dependent var	7527.211
Adjusted R-squared	0.486594	S.D. dependent var	4732.551
S.E. of regression	3390.984	Akaike info criterion	19.13884
Sum squared resid	6.46E+09	Schwarz criterion	19.33237
Log likelihood	-5600.818	Hannan-Quinn criter.	19.21424
Durbin-Watson stat	1.779396		

Finally, the calculated elasticities from these regression outputs clearly show that, of all the explanatory variables included, the ABI has the most significant influence on sale price. In the 2018-born bulls, these elasticities are 1.27 for ABI, 1.15 for ADG and 0.65 for live weight. In the 2017-born bulls, these elasticities are 1.23 for ABI and 0.99 for live weight, with ADG not significantly different from zero.

Results, North vs South Sales

It was expected that the Southern areas would have higher selection pressure on genetic traits while the Northern areas have greater selection on phenotypic traits. All sales with 2017-born bulls were labelled based on the state in which they were located. Queensland and New South Wales made up the Northern area and Victoria and Tasmania the Southern area. This provides a clear distinction between North and South and also allows for direct comparison with Van Eenennaam (2012). The Northern area included 37 sales from 34 different studs selling 1,805 bulls. The Southern area included 8 sales from 7 different studs selling 677 bulls.

Figure 7. Regression output for 2017-born bulls in the Northern region

Dependent Variable: PRICE
Method: Least Squares
Date: 11/13/19 Time: 09:08
Sample: 1 1805
Included observations: 1805

Variable	Coefficient	Std. Error	t-Statistic	Prob.
LOT	-14.46159	2.042098	-7.081728	0.0000
ABI	49.68323	5.287775	9.395867	0.0000
ADG	88.66058	1899.714	0.046670	0.9628
LIVE_WEIGHT	11.22999	2.779294	4.040592	0.0001
SALE_NO_=10	-9066.802	1279.739	-7.084886	0.0000
SALE_NO_=11	-9696.930	1351.322	-7.175886	0.0000
SALE_NO_=12	-10856.25	1734.603	-6.258639	0.0000
SALE_NO_=13	-10441.69	1342.375	-7.778520	0.0000
SALE_NO_=14	-5347.172	1333.972	-4.008460	0.0001
SALE_NO_=15	-7290.597	1254.655	-5.810839	0.0000
SALE_NO_=16	-10486.85	1331.780	-7.874311	0.0000
SALE_NO_=17	-6416.670	1310.224	-4.897385	0.0000
SALE_NO_=18	-10356.63	1243.603	-8.327926	0.0000
SALE_NO_=19	-9386.194	1253.703	-7.486773	0.0000
SALE_NO_=20	-8810.217	1207.759	-7.294678	0.0000
SALE_NO_=21	-10317.45	1227.827	-8.403015	0.0000
SALE_NO_=22	-8861.410	1208.582	-7.332073	0.0000
SALE_NO_=23	-10130.89	1262.607	-8.023786	0.0000
SALE_NO_=24	-9910.639	1335.479	-7.421038	0.0000
SALE_NO_=25	-10669.69	1435.297	-7.433786	0.0000
SALE_NO_=26	-8586.727	1347.919	-6.370356	0.0000
SALE_NO_=28	-6967.580	1221.410	-5.704536	0.0000
SALE_NO_="2N"	-9168.411	1291.576	-7.098625	0.0000
SALE_NO_=3	-7331.583	1304.750	-5.619148	0.0000
SALE_NO_=30	-10425.09	1300.818	-8.014258	0.0000
SALE_NO_=31	-10664.96	1449.952	-7.355392	0.0000
SALE_NO_=32	-10460.74	1483.694	-7.050465	0.0000
SALE_NO_=33	-7839.989	1325.688	-5.913904	0.0000
SALE_NO_=34	-8717.275	1288.363	-6.766162	0.0000
SALE_NO_=35	-12792.07	1856.513	-6.890377	0.0000
SALE_NO_=36	-8795.995	1243.478	-7.073704	0.0000
SALE_NO_=37	-256.6598	1446.900	-0.177386	0.8592
SALE_NO_=39	-5407.343	1352.169	-3.999014	0.0001
SALE_NO_="3S"	-7022.847	1293.039	-5.431271	0.0000
SALE_NO_=40	-8289.942	1293.792	-6.407476	0.0000
SALE_NO_=41	-8877.850	1259.426	-7.049123	0.0000
SALE_NO_="5N"	-9866.869	1236.579	-7.979163	0.0000
SALE_NO_=8	-7555.704	1260.095	-5.996138	0.0000
SALE_NO_="8N"	-8800.633	1270.784	-6.925357	0.0000
SALE_NO_="8S"	-8682.184	1269.308	-6.840095	0.0000
SALE_NO_=9	-10099.41	1278.212	-7.901206	0.0000

R-squared	0.375373	Mean dependent var	6606.676
Adjusted R-squared	0.361209	S.D. dependent var	3405.976
S.E. of regression	2722.207	Akaike info criterion	18.67873
Sum squared resid	1.31E+10	Schwarz criterion	18.80362
Log likelihood	-16816.55	Hannan-Quinn criter.	18.72482
Durbin-Watson stat	1.950398		

The regression output for the Northern area is shown in Figure 7. This equation has an adjusted R^2 of 0.36. When the estimated coefficients for the continuous variables are transformed into elasticities, they are 0.95 for ABI, and 1.38 for live weight, for these Northern 2017-born bulls.

Figure 8. Regression output for 2017-born bulls in the Southern region

Dependent Variable: PRICE
Method: Least Squares
Date: 11/13/19 Time: 09:06
Sample: 1 677
Included observations: 677

Variable	Coefficient	Std. Error	t-Statistic	Prob.
LOT	-25.36140	3.695333	-6.863089	0.0000
ABI	99.05288	11.47495	8.632101	0.0000
ADG	5118.011	3109.166	1.646104	0.1002
LIVE_WEIGHT	4.325783	4.451573	0.971743	0.3315
SALE_NO_=1	-18097.98	2750.751	-6.579288	0.0000
SALE_NO_=2	-14002.68	2688.465	-5.208430	0.0000
SALE_NO_=38	-11992.84	2495.488	-4.805810	0.0000
SALE_NO_=4	-12234.42	2516.646	-4.861401	0.0000
SALE_NO_="4S"	-10582.04	2418.462	-4.375526	0.0000
SALE_NO_=5	-14666.30	2581.694	-5.680880	0.0000
SALE_NO_=6	-14019.49	2438.781	-5.748564	0.0000
SALE_NO_=7	-16218.93	2731.616	-5.937487	0.0000

R-squared	0.329319	Mean dependent var	7106.352
Adjusted R-squared	0.318225	S.D. dependent var	4220.239
S.E. of regression	3484.638	Akaike info criterion	19.16768
Sum squared resid	8.07E+09	Schwarz criterion	19.24776
Log likelihood	-6476.260	Hannan-Quinn criter.	19.19868
Durbin-Watson stat	2.053320		

Live weight has the greatest influence on sale price in the Northern region while ABI has a reasonably moderate influence and ADG has no statistically significant influence in this region.

The regression output for the Southern area is reported in Figure 8. The R^2 value indicates some 32 per cent of the variation in sale price is explained by the variation in the independent variables. The elasticity of the key independent variable in the Southern region of 2017-born bulls is 1.87 for ABI. ADG and live weight were not statistically significant. These calculations suggest that ABI has the most significant influence on sale price while ADG and live weight do not have a statistically significant influence on sale price of 2017-born bulls in the Southern region.

There are clear differences between the influence of different traits on sale price in the Northern and Southern regions. The coefficient for ABI in the Southern region is double that of the Northern region, while the coefficient for live weight in the South is roughly a third of that in the North and statistically insignificant. ADG is insignificant in both regions and the influence of lot number is similar between both Northern and Southern regions. From these results we can conclude producers in the Southern region place greater emphasis on genetic merit while producers in the Northern region place greater emphasis on phenotypic traits. These results are consistent with those found by Van Eenennaam (2012).

Discussion

Influence of lot number

The order in which bulls are sold at a sale has a significant influence on the price for which they are sold. The two major factors at play are the order that the bulls appear in the catalogue, and the competition amongst bull buyers. Competition is a major factor because at the start of the sale, every buyer in attendance needs to buy a certain number of bulls. But, as those quotas are filled, the number of bidders reduces leading to less competition for bulls later in the sale. This means that even if the bulls were randomly ordered for the sale, lot number would theoretically still have a negative influence. This is the reason why breeders generally order the better bulls at the start of the sale.

This ordering of the bulls based on perceived quality is the second factor. Assuming that the breeder and the buyer value bulls in the same way, buyers are able to bid on their preferred bulls first and then are able to bid on their second-choice bull if unsuccessful on the first.

Live weight vs ADG

An interesting result from the analysis was the varying influence of live weight and ADG on sale price of bulls in different age groups. The 2017-born bulls had a higher coefficient for live weight than the 2018-born bulls, suggesting that live weight has a greater influence on sale price in two-year old bulls than yearling bulls. Conversely, the results for ADG suggest that ADG has an influence on the sale price of yearling bulls and not two-year-old bulls. This is possibly due to the preference for big, impressive two-year-old bulls and would suggest that the age of these bulls is not being accounted for accurately.

Northern region vs Southern region

There is an interesting difference in the influence of various factors on sale price between the Northern and Southern regions analysed. Van Eenennaam (2012) attributed this difference to the varying target markets, that is the breeders or the seedstock market in the South and the commercial bull market in the North. Further, commercial artificial insemination programs are more widely used in the Southern region. This means that more commercial bulls are purchased and then collected for semen for use in their commercial herds. This increases the number of calves sired by a bull over his working life and therefore improves the viability of paying more for a genetically superior bull.

Within-sale vs across-sale analysis

In the correlation analysis, the strength of the correlations between the listed variables and sale price decreased significantly in the across-sale analysis compared to the within-sale analysis. This would suggest that buyers are selecting for bulls within one sale or within a local region rather than across all bull sales. Likely reasons for this include reducing freight costs by purchasing bulls from a nearby stud and purchasing bulls that have been raised in a similar environment.

The influence of individual sales on sale price of bulls is also evident in the regression analyses as all sale number coefficients were found to be statistically significant apart from one outlier. Therefore, the independent variable, of which sale the bull is part of, has an influence on the sale price that bull will achieve if every other independent variable listed is the same. This suggests that non-measured variables such as brand or customer service influence bull sale prices. Recall that the estimated R^2 are at most 0.5, so at least half of the variance in bull prices is unexplained by the measured independent variables.

Conclusion

This research found that there is a clear positive relationship between the ABI and the price that producers are willing to pay for an Angus bull. Producers are using genetic information and selecting bulls on genetic merit. The ABI had a statistically significant relationship to sale price in all four estimated models - the 2018-born, 2017-born, Southern 2017-born and Northern 2017-born. Live weight and ADG had more varied effects and were statistically insignificant in some regression outputs. Live weight had the greatest influence on sale price in the Northern analysis.

The analyses found that live weight generally had a stronger influence on sale price than ADG. This would suggest that, contrary to what many breeders and producers say, they are not accounting for age of the bulls and are paying more for heavier live weights on sale day, rather than bulls that have been measured to gain weight early.

The clear evidence of higher prices earned from higher genetic merit bulls should be an incentive for breeders to record more data and select for genetically superior animals. This will ideally lead to higher levels of performance data recording and greater genetic gain.

References

AbacusBio (2014), Development of models for incentivisation of recording in the beef and sheep breeding sectors. Retrieved from: https://www.mla.com.au/research-and-development/search-rd-reports/final-report-details/Productivity-On-Farm/Development-of-models-for-incentivisation-of-recording-in-the-beef-and-sheep-breeding-sectors/546

ABRI (2009), BREEDPLAN International.
Retrieved from: http://breedplan.une.edu.au/brochures/International%20Brochure%20A4.pdf

Angus Australia (2018a), Capitalising on the genetic variation between Angus animals. Retrieved from: https://www.angusaustralia.com.au/content/uploads/2016/11/Ash_POC_Genetic_Variation_A4_8page.pdf

Angus Australia (2018b), EBVs Are No Bull. Retrieved from: https://www.angusaustralia.com.au/content/uploads/2017/02/Ash_POC_EBVs-No-Bull_web2.pdf

Angus Australia (2018c), Individual Sire EBV Changes. Retrieved from: https://www.angusaustralia.com.au/content/uploads/2017/07/Ash_POC_Individual_Sire_EBV_Changes_web.pdf

Angus Australia (2018d), Starting Vs Finishing EBVs – Did they change? Retrieved from: https://www.angusaustralia.com.au/content/uploads/2017/07/Ash_POC_Did_EBVs_Change_web.pdf

Angus Australia (2019a), Angus Breeding Index. Retrieved from: https://www.angusaustralia.com.au/content/uploads/2016/06/Angus_Breeding_Index.pdf

Angus Australia (2019b), 6/11/2019). Bull sale statistics. Retrieved from: https://www.angusaustralia.com.au/marketing/sale-statistics/bull-sale-statistics/

Angus Australia (2019c), Enhancements to Angus BREEDPLAN. Retrieved from: https://www.angusaustralia.com.au/category/enhancements-to-angus-breedplan/

Angus Australia (2019d), Introduction to Angus BREEDPLAN. Retrieved from: https://www.angusaustralia.com.au/breedplan/getting-started-2/introduction-to-angus-breedplan/

Angus Australia (2019e), Catalogue List. Retrieved from: https://angus.tech/catalogue/result?page=1&tql=catalogue+type+is+sale+and+is+current+and+status+is+published&sortColumnId=%7BcatTypeStr%2CsaleDate%7D&sortOrder=%7Basc%2Casc%7D

Angus Australia (2020), Angus Influences 48% of Breeding Females. Retrieved from: https://www.angusaustralia.com.au/news/angus%e2%80%afinfluences%e2%80%af48%e2%80%afof-breeding-females#:~:text=The%20results%20identified%20that%20approximately%205.6%20million%20breeding,these%20females%2C%20approximately%202.4%20million%20are%20purebred%20Angus.

ARCBA (2019), 2018 Australian Beef Cattle Registrations. Retrieved from: http://arcba.une.edu.au/media/1075/arcba-2018-registration-report.pdf

AuctionsPlus (2019), Auction Results. Retrieved from: https://auctionsplus.com.au/auction-results

Banks, R. G. (2015). Realising Genetic Improvement for the Extensive Livestock Industries as a Whole. Livestock Library. Retrieved from: http://aaabg.org/aaabghome/AAABG21papers/Banks21233.pdf

Barnett, R. (2017), Development of a New/Revised Commercialisation Strategy and Delivery Plan for BREEDPLAN Retrieved from: https://www.mla.com.au/research-and-development/search-rd-reports/final-report-details/Development-of-a-New-Revised-Commercialisation-Strategy-and-Delivery-Plan-for-BREEDPLAN/3745

BREEDPLAN (2015), What is an Estimated Breeding Value (EBV)? Retrieved from: https://breedplan.une.edu.au/getting-started/what-is-an-estimated-breeding-value-ebv/

Evans, J.D. (1996), Straightforward statistics for the behavioral sciences. Pacific Grove: Brooks/Cole Pub. Co. Retrieved from: https://psycnet.apa.org/record/1995-98499-000

Farquharson, R., Griffith, G., & Brunwick, S. (2002), Evaluating the returns from beef cattle genetics R&D in Australia. Retrieved from: https://www.mla.com.au/research-and-development/search-rd-reports/final-report-details/Productivity-On-Farm/Evaluating-the-returns-from-beef-cattle-genetics-RandD-in-Australia/1732

Howard, D. (2019), Angus leading the way after 100 years. The Land. Retrieved from: https://www.theland.com.au/story/6100188/angus-still-leading-the-way/

McDonald, A. (2018), Weekly Genetics Review: How much does genetic variation influence the value of a carcase? Beef Central. Retrieved from: https://www.beefcentral.com/genetics/weekly-genetics-review-how-much-does-genetic-variation-influence-the-value-of-a-carcase/#:~:text=In%20Cohort%20four%2C%20only%2021%20young%20sires%20were,the%20highest%20and%20lowest%20valued%20carcase%20was%20%242076.

MLA (2018), New BREEDPLAN software license signals system overhaul. Retrieved from: https://www.mla.com.au/news-and-events/industry-news/new-breedplan-software-license-signals-system-overhaul/

MLA (2019),The red meat industry. Retrieved from: https://www.mla.com.au/about-mla/the-red-meat-industry/

NSW DPI (2019a), Cattle breeds: Angus. Retrieved from: https://www.dpi.nsw.gov.au/animals-and-livestock/beef-cattle/breeding/beef-cattle-breeds/angus

NSW DPI (2019b), Yearling bulls - tapping their immense potential. NSW Agriculture's Better Bull Buying manual. Retrieved from: https://www.dpi.nsw.gov.au/animals-and-livestock/beef-cattle/breeding/bull-selection/yearling-bulls

SBTS (2011), A Leap Forward in Genomic Enhanced BREEDPLAN EBVs. Southern Beef Technology Services Winter 2011 Update, 1,2. Retrieved from: https://issuu.com/sbtstbts/docs/hi_res_sbts_winter_update_2011

Van Eenennaam, A. (2012), How might DNA-based information generate value in the beef cattle sector? Retrieved from: https://www.icar.org/wp-content/uploads/2015/09/VanEenennaam.pdf

Wikipedia (2019), Angus Cattle. Retrieved from: https://en.wikipedia.org/wiki/Angus_cattle

Woolaston, R.R. (2014), Review of BREEDPLAN commercialisation model (B.BFG.0064). Retrieved from: https://www.mla.com.au/download/finalreports?itemId=2789

Woolrich, N. (2016), Angus beef cattle breeders see best returns in decades, Business. ABC. Retrieved from: https://www.abc.net.au/news/2016-03-23/angus-beef-cattle-breeders-see-strong-returns/7271146

Appendix 1. Units and Definitions

Estimated Breeding Values (EBVs): An animal's breeding value can be defined as its genetic merit for each trait. While it is not possible to determine an animal's true breeding value, it is possible to estimate it. These estimates of an animal's true breeding value are called EBVs (Estimated Breeding Values). BREEDPLAN (2015).

Angus Breeding Index (ABI): The Angus Breeding Index is one of four selection indexes that are calculated for animals within the Angus BREEDPLAN analysis. The ABI estimates the genetic differences between animals in net profitability per cow joined in a typical commercial self-replacing herd using Angus bulls (Angus Australia, 2019a).

Average Daily Gain (ADG): A measure of the average weight that an animal gains each day. In this paper, this number represents daily weight gain from birth until the day the bull is sold. It has been calculated by dividing the bull's sale weight by the number of days between the sale and each bull's birth date.

Angus Sire Benchmarking Program (ASBP): An initiative of Angus Australia where bulls nominated by breeders and accepted into the program have semen collected and are used in co-operator herds. The progeny of these herds are closely monitored and recorded with extensive data feeding back into BREEDPLAN.

N & P: N and P are part of the bull's management ID and refer to the year the bull was born. The N bulls were born in 2017 and the P bulls were born in 2018.

Phenotype: The phenotype of an animal is the tangible profile of the animal which includes visual appearance as well as actual performance measures such as weight, scrotal size and carcase quality measures. Some confusion exists when phenotype is used to refer to one area and not the other.

Genotype: The genotype of an animal is their overall genetic profile of the animal including all available EBVs, pedigree and genetic disorder information.

Appendix 2. Descriptive Analysis Results

Descriptive statistics of the data for each sale are summarised in Tables A5.1 and A5.2 below. Recall that the data includes bulls of two different ages, those born in 2017 (Table A5.1) and those born in 2018 (Table A5.2).

Table A2.1. Sale performance and summary statistics of 2017-born bulls

Sale	Withdrawn	Passed in	Catalogued	For sale	Sold	Clearance	Average	Top	Low	Ave ABI	Ave Weight	ADG	Clearance	Average	Overall
Sale 1	2	11	30	28	17	60.7%	$ 5,618	$11,500	$4,000	$ 141	690	1.23	0.61	0.37	0.98
Sale 10	0	16	56	56	40	71.4%	$ 5,900	$ 9,000	$4,000	$ 118	800	1.20	0.71	0.39	1.11
Sale 11	3	24	50	47	23	48.9%	$ 5,761	$15,000	$4,000	$ 127	765	1.22	0.49	0.38	0.87
Sale 12	2	26	33	31	5	16.1%	$ 5,100	$ 8,500	$4,000	$ 124	788	1.23	0.16	0.34	0.50
Sale 13	4	3	25	21	18	85.7%	$ 4,667	$ 7,000	$4,000	$ 122	810	1.16	0.86	0.31	1.17
Sale 14	9	0	132	123	123	100.0%	$ 9,480	$34,000	$5,000	$ 123	871	1.23	1.00	0.63	1.63
Sale 15	3	0	50	47	47	100.0%	$ 7,479	$16,000	$4,000	$ 124	801	1.15	1.00	0.50	1.50
Sale 16	7	11	40	33	22	66.7%	$ 4,773	$ 8,000	$4,000	$ 113	835	1.09	0.67	0.32	0.98
Sale 17	19	1	144	125	124	99.2%	$ 8,435	$24,000	$4,000	$ 123	860	1.21	0.99	0.56	1.55
Sale 18	5	13	50	45	32	71.1%	$ 4,516	$ 7,500	$3,500	$ 126	778	1.06	0.71	0.30	1.01
Sale 19	9	15	94	85	70	82.4%	$ 4,864	$ 9,000	$4,000	$ 114	816	1.12	0.82	0.32	1.15
Sale 2	16	9	168	152	143	94.1%	$ 7,224	$42,000	$4,000	$ 141	695	1.24	0.94	0.48	1.42
Sale 2 North	14	1	100	86	85	98.8%	$ 6,412	$12,000	$4,000	$ 138	833	1.16	0.99	0.43	1.42
Sale 20	12	14	67	55	41	74.5%	$ 5,366	$11,000	$4,000	$ 122	750	1.04	0.75	0.36	1.10
Sale 21	6	23	78	72	49	68.1%	$ 4,612	$ 9,000	$4,000	$ 127	779	1.05	0.68	0.31	0.99
Sale 22	8	7	80	72	65	90.3%	$ 4,892	$10,000	$4,000	$ 108	785	1.14	0.90	0.33	1.23
Sale 23	4	2	35	31	29	93.5%	$ 4,621	$ 6,000	$4,000	$ 116	813	1.10	0.94	0.31	1.24
Sale 24	0	15	30	30	15	50.0%	$ 4,800	$ 7,500	$4,000	$ 116	776	1.09	0.50	0.32	0.82
Sale 25	1	15	33	32	17	53.1%	$ 5,941	$12,000	$4,000	$ 135	890	1.21	0.53	0.40	0.93
Sale 26	2	5	28	26	21	80.8%	$ 6,095	$10,000	$4,000	$ 101	849	1.22	0.81	0.41	1.21
Sale 28	24	0	236	212	212	100.0%	$ 6,160	$14,000	$4,000	$ 132	731	1.02	1.00	0.41	1.41
Sale 3	13	0	105	92	92	100.0%	$ 7,076	$24,000	$3,000	$ 144	708	1.22	1.00	0.47	1.47
Sale 3 Spring	4	0	51	47	47	100.0%	$ 7,681	$20,000	$3,000	$ 142	776	1.06	1.00	0.51	1.51
Sale 30	3	11	36	33	22	66.7%	$ 4,614	$ 6,500	$4,000	$ 114	798	1.10	0.67	0.31	0.97
Sale 31	3	5	24	21	16	76.2%	$ 5,969	$10,000	$4,000	$ 134	867	1.22	0.76	0.40	1.16
Sale 32	4	2	15	11	9	81.8%	$ 5,333	$ 7,500	$4,000	$ 138	787	1.10	0.82	0.36	1.17
Sale 33	4	4	87	83	79	95.2%	$ 7,905	$18,000	$4,000	$ 133	871	1.17	0.95	0.53	1.48
Sale 34	5	3	29	24	21	87.5%	$ 5,524	$ 9,500	$4,000	$ 104	807	1.13	0.88	0.37	1.24
Sale 35	0	0	4	4	4	100.0%	$ 3,500	$ 3,500	$3,500	$ 120	913	1.19	1.00	0.23	1.23
Sale 36	11	3	70	59	56	94.9%	$ 6,330	$11,000	$4,000	$ 126	816	1.07	0.95	0.42	1.37
Sale 37	2	0	16	14	14	100.0%	$ 15,000	$26,000	$6,000	$ 111	890	1.20	1.00	1.00	2.00
Sale 38	1	2	32	31	29	93.5%	$ 6,879	$10,000	$4,000	$ 103	811	1.10	0.94	0.46	1.39
Sale 39	12	3	60	48	45	93.8%	$ 10,011	$62,500	$4,000	$ 118	908	1.18	0.94	0.67	1.60
Sale 4	13	6	180	167	161	96.4%	$ 7,317	$75,000	$3,000	$ 131	673	1.14	0.96	0.49	1.45
Sale 4 Spring	11	0	120	109	109	100.0%	$ 8,853	$19,000	$4,000	$ 129	750	0.98	1.00	0.59	1.59
Sale 40	2	1	49	47	46	97.9%	$ 6,935	$15,000	$4,000	$ 122	847	1.13	0.98	0.46	1.44
Sale 41	1	1	47	46	45	97.8%	$ 5,879	$17,000	$4,000	$ 116	823	1.13	0.98	0.39	1.37
Sale 5	6	0	164	158	158	100.0%	$ 6,184	$22,000	$4,000	$ 143	683	1.15	1.00	0.41	1.41
Sale 5 North	6	8	51	45	37	82.2%	$ 5,216	$ 7,500	$4,000	$ 134	764	1.05	0.82	0.35	1.17
Sale 6	5	15	64	59	44	74.6%	$ 6,432	$13,500	$4,000	$ 123	651	1.14	0.75	0.43	1.17
Sale 7	6	17	39	33	16	48.5%	$ 5,000	$12,000	$4,000	$ 116	740	1.29	0.48	0.33	0.82
Sale 8	8	6	49	41	35	85.4%	$ 6,457	$14,000	$4,000	$ 125	719	1.17	0.85	0.43	1.28
Sale 8 North	16	2	105	89	87	97.8%	$ 6,052	$16,000	$4,000	$ 123	835	1.16	0.98	0.40	1.38
Sale 8 Spring	10	0	82	72	72	100.0%	$ 6,528	$11,000	$4,000	$ 126	844	1.13	1.00	0.44	1.44
Sale 9	3	25	68	65	40	61.5%	$ 5,450	$10,500	$4,000	$ 148	732	1.12	0.62	0.36	0.98
Total	**299**	**325**	**3106**	**2807**	**2482**										
Minimum	**0**	**0**	**4**	**4**	**4**	**16.13%**	**$ 3,500**	**$ 3,500**	**$3,000**	**$ 101**	**651**	**0.98**	**0.16**	**0.23**	**0.50**
Average	**7**	**7**	**69**	**62**	**55**	**83.05%**	**$ 6,330**	**$16,089**	**$3,978**	**$ 125**	**794**	**1.14**	**0.83**	**0.42**	**1.25**
Maximum	**24**	**26**	**236**	**212**	**212**	**100.00%**	**$ 15,000**	**$75,000**	**$6,000**	**$ 148**	**913**	**1.29**	**1.00**	**1.00**	**2.00**

Table A2.2. Sale performance and summary statistics of 2018-born bulls

Sale	Withdrawn	Passed in	Catalogued	For sale	Sold	Clearance	Average	Top	Low	Ave ABI	Ave Weight	ADG	Clearance	Average	Overall
Sale 13	1	4	15	14	10	71.4%	$ 5,400	$13,000	$4,000	$ 120	658	1.34	0.71	0.36	1.07
Sale 14	1	0	18	17	17	100.0%	$ 8,706	$24,000	$5,000	$ 129	769	1.40	1.00	0.57	1.57
Sale 15	1	0	26	25	25	100.0%	$ 7,360	$18,000	$4,000	$ 119	657	1.30	1.00	0.48	1.48
Sale 17	0	0	6	6	6	100.0%	$ 9,667	$24,000	$5,000	$ 128	611	1.44	1.00	0.64	1.64
Sale 5 North	1	0	9	8	8	100.0%	$ 5,563	$ 7,500	$4,500	$ 135	581	1.18	1.00	0.37	1.37
Sale 19	1	8	25	24	16	66.7%	$ 4,563	$ 9,000	$4,000	$ 119	523	1.39	0.67	0.30	0.97
Sale 20	1	3	13	12	9	75.0%	$ 5,222	$ 9,000	$4,000	$ 128	510	1.34	0.75	0.34	1.09
Sale 27	2	6	34	32	26	81.3%	$ 5,442	$ 9,000	$4,000	$ 122	627	1.27	0.81	0.36	1.17
Sale 29	5	2	41	36	34	94.4%	$ 5,765	$15,000	$4,000	$ 112	674	1.35	0.94	0.38	1.32
Sale 31	1	5	26	25	20	80.0%	$ 5,700	$12,000	$4,000	$ 126	699	1.34	0.80	0.37	1.17
Sale 32	7	22	46	39	17	43.6%	$ 4,794	$ 7,000	$4,000	$ 152	516	1.38	0.44	0.32	0.75
Sale 33	5	10	42	37	27	73.0%	$ 5,037	$ 9,000	$4,000	$ 136	651	1.20	0.73	0.33	1.06
Sale 3 Spring	15	0	114	99	99	100.0%	$ 8,434	$21,000	$4,000	$ 148	634	1.29	1.00	0.55	1.55
Sale 34	3	2	12	9	7	77.8%	$ 4,714	$ 8,000	$4,000	$ 107	644	1.22	0.78	0.31	1.09
Sale 35	3	7	39	36	29	80.6%	$ 4,862	$14,000	$3,500	$ 118	662	1.54	0.81	0.32	1.13
Sale 37	4	0	59	54	54	100.0%	$ 15,204	$40,000	$7,000	$ 116	686	1.41	1.00	1.00	2.00
Sale 38	1	0	14	13	13	100.0%	$ 6,962	$16,500	$4,000	$ 101	636	1.19	1.00	0.46	1.46
Sale 39	7	0	32	25	25	100.0%	$ 10,680	$40,000	$4,000	$ 116	738	1.35	1.00	0.70	1.70
Sale 40	1	1	23	22	21	95.5%	$ 5,524	$13,000	$4,000	$ 120	640	1.22	0.95	0.36	1.32
Sale 41	2	1	14	12	11	91.7%	$ 7,636	$14,000	$4,000	$ 129	692	1.11	0.92	0.50	1.42
Sale 42	9	10	74	65	55	84.6%	$ 6,582	$30,000	$4,000	$ 122	629	1.33	0.85	0.43	1.28
Sale 5 Spring	2	3	64	62	59	95.2%	$ 6,763	$15,000	$4,000	$ 139	542	0.99	0.95	0.44	1.40
Total	**73**	**84**	**746**	**672**	**588**										
Minimum	**0**	**0**	**6**	**6**	**6**	**43.59%**	**$ 4,563**	**$ 7,000**	**$3,500**	**$ 101**	**510**	**0.99**	**0.44**	**0.30**	**0.75**
Average	**3**	**4**	**34**	**31**	**27**	**86.84%**	**$ 6,844**	**$16,727**	**$4,227**	**$ 125**	**635**	**1.30**	**0.87**	**0.45**	**1.32**
Maximum	**15**	**22**	**114**	**99**	**99**	**100.00%**	**$ 15,204**	**$40,000**	**$7,000**	**$ 152**	**769**	**1.54**	**1.00**	**1.00**	**2.00**

Appendix 3. Correlation Analysis Results

Table A3.1. Correlations of traits to sale price for 2017-born bulls

Sale	Sold	Clearance	Average	Overall	Top	Ave ABI	Ave Weight	ADG	Lot	Weight	ADG	Scrotal	ABI
Sale 1	17	60.7%	$ 5,618	0.98	$11,500	$ 141	690	1.23	-0.177	0.344	0.231	N/A	0.497
Sale 2	143	94.1%	$ 7,224	1.42	$42,000	$ 141	695	1.24	-0.345	0.478	0.392	N/A	0.328
Sale 3	92	100.0%	$ 7,076	1.47	$24,000	$ 144	708	1.22	-0.351	0.379	0.339	N/A	0.441
Sale 4	161	96.4%	$ 7,317	1.45	$75,000	$ 131	673	1.14	-0.486	0.317	0.191	0.126	0.482
Sale 5	158	100.0%	$ 6,184	1.41	$22,000	$ 143	683	1.15	-0.539	0.618	0.379	0.136	0.516
Sale 6	44	74.6%	$ 6,432	1.17	$13,500	$ 123	651	1.14	-0.278	0.630	0.493	0.227	0.619
Sale 7	16	48.5%	$ 5,000	0.82	$12,000	$ 116	740	1.29	-0.262	0.379	0.370	-0.264	0.279
Sale 8	35	85.4%	$ 6,457	1.28	$14,000	$ 125	719	1.17	-0.247	0.247	0.194	N/A	0.633
Sale 9	40	61.5%	$ 5,450	0.98	$10,500	$ 148	732	1.12	-0.481	0.346	0.224	0.375	0.290
Sale 10	40	71.4%	$ 5,900	1.11	$ 9,000	$ 118	800	1.20	-0.413	0.418	0.475	0.103	0.191
Sale 11	23	48.9%	$ 5,761	0.87	$15,000	$ 127	765	1.22	-0.374	0.341	0.267	0.035	0.233
Sale 12	5	16.1%	$ 5,100	0.50	$ 8,500	$ 124	788	1.23	-0.359	0.166	0.107	0.956	0.521
Sale 13	18	85.7%	$ 4,667	1.17	$ 7,000	$ 122	810	1.16	-0.491	0.439	0.631	-0.252	-0.312
Sale 14	123	100.0%	$ 9,480	1.63	$34,000	$ 123	871	1.23	-0.214	0.3302	0.221	N/A	0.296
Sale 15	47	100.0%	$ 7,479	1.50	$16,000	$ 124	801	1.15	-0.378	0.310	0.366	0.222	0.602
Sale 16	22	66.7%	$ 4,773	0.98	$ 8,000	$ 113	835	1.09	-0.125	0.695	0.712	0.069	0.400
Sale 17	124	99.2%	$ 8,435	1.55	$24,000	$ 123	860	1.21	-0.548	0.644	0.535	0.226	0.197
Sale 18	32	71.1%	$ 4,516	1.01	$ 7,500	$ 126	778	1.06	-0.286	0.564	0.519	0.507	0.302
Sale 5 North	37	82.2%	$ 5,216	1.17	$ 7,500	$ 134	764	1.05	-0.040	0.605	0.509	0.497	0.519
Sale 19	70	82.4%	$ 4,864	1.15	$ 9,000	$ 114	816	1.12	-0.339	0.583	0.436	N/A	0.558
Sale 20	41	74.5%	$ 5,366	1.10	$11,000	$ 122	750	1.04	-0.727	0.461	0.222	0.363	0.239
Sale 21	49	68.1%	$ 4,612	0.99	$ 9,000	$ 127	779	1.05	-0.273	0.321	0.194	0.249	0.309
Sale 22	65	90.3%	$ 4,892	1.23	$10,000	$ 108	785	1.14	-0.653	0.481	0.416	-0.018	0.349
Sale 23	29	93.5%	$ 4,621	1.24	$ 6,000	$ 116	813	1.10	-0.235	0.339	0.281	0.185	0.324
Sale 24	15	50.0%	$ 4,800	0.82	$ 7,500	$ 116	776	1.09	-0.149	0.427	0.459	0.158	0.503
Sale 25	17	53.1%	$ 5,941	0.93	$12,000	$ 135	890	1.21	-0.266	0.309	0.276	-0.162	0.537
Sale 26	21	80.8%	$ 6,095	1.21	$10,000	$ 101	849	1.22	-0.073	0.533	0.397	0.028	0.345
Sale 2 North	85	98.8%	$ 6,412	1.42	$12,000	$ 138	833	1.16	-0.025	0.102	-0.003	N/A	0.194
Sale 8 North	87	97.8%	$ 6,052	1.38	$16,000	$ 123	835	1.16	-0.132	0.264	0.190	N/A	0.400
Sale 28	212	100.0%	$ 6,160	1.41	$14,000	$ 132	731	1.02	-0.589	0.628	0.545	0.356	0.538
Sale 30	22	66.7%	$ 4,614	0.97	$ 6,500	$ 114	798	1.10	-0.308	0.025	-0.066	-0.357	0.037
Sale 31	16	76.2%	$ 5,969	1.16	$10,000	$ 134	867	1.22	-0.314	0.403	0.393	0.090	0.620
Sale 32	9	81.8%	$ 5,333	1.17	$ 7,500	$ 138	787	1.10	-0.343	0.735	0.542	0.625	0.416
Sale 33	79	95.2%	$ 7,905	1.48	$18,000	$ 133	871	1.17	-0.224	0.543	0.560	0.190	0.139
Sale 3 Spring	47	100.0%	$ 7,681	1.51	$20,000	$ 142	776	1.06	-0.557	0.463	0.356	0.128	0.410
Sale 34	21	87.5%	$ 5,524	1.24	$ 9,500	$ 104	807	1.13	-0.541	0.500	0.558	N/A	0.495
Sale 35	4	100.0%	$ 3,500	1.23	$ 3,500	$ 120	913	1.19	N/A	N/A	N/A	N/A	N/A
Sale 8 Spring	72	100.0%	$ 6,528	1.44	$11,000	$ 126	844	1.13	-0.285	0.268	0.196	N/A	0.319
Sale 36	56	94.9%	$ 6,330	1.37	$11,000	$ 126	816	1.07	-0.414	0.556	0.447	0.061	0.656
Sale 37	14	100.0%	$ 15,000	2.00	$26,000	$ 111	890	1.20	-0.653	0.641	0.533	0.345	0.369
Sale 38	29	93.5%	$ 6,879	1.39	$10,000	$ 103	811	1.10	-0.341	0.475	0.323	N/A	0.503
Sale 39	45	93.8%	$ 10,011	1.60	$62,500	$ 118	908	1.18	-0.511	0.424	0.454	0.302	0.409
Sale 40	46	97.9%	$ 6,935	1.44	$15,000	$ 122	847	1.13	-0.578	0.329	0.345	0.183	0.258
Sale 41	45	97.8%	$ 5,879	1.37	$17,000	$ 116	823	1.13	0.008	0.072	0.107	0.334	0.468
Sale 4 Spring	109	100.0%	$ 8,853	1.59	$19,000	$ 129	750	0.98	-0.365	0.634	0.540	0.141	0.621
Minimum	**4**	**16.13%**	**$ 3,500**	**0.50**	**$ 3,500**	**$ 101**	**651**	**0.98**	**-0.73**	**0.03**	**-0.07**	**-0.36**	**-0.31**
Average	**55**	**83.05%**	**$ 6,330**	**1.25**	**$16,089**	**$ 125**	**794**	**1.14**	**-0.35**	**0.43**	**0.36**	**0.19**	**0.39**
Maximum	**212**	**100.00%**	**$ 15,000**	**2.00**	**$75,000**	**$ 148**	**913**	**1.29**	**0.01**	**0.74**	**0.71**	**0.96**	**0.66**

Table A3.2. Correlations across all studs for 2017-born bulls

	Sold	*Clearance*	*Average*	*Overall*	*Top*	*Ave ABI*	*Ave Weight*	*ADG*
Sold	1							
Clearance	0.52386	1						
Average	0.25916	0.43542	1					
Overall	0.48965	0.90714	0.77383	1				
Top	0.51864	0.33288	0.55893	0.49548	1			
Ave ABI	0.35341	0.04096	0.01205	0.03438	0.17228	1		
Ave Weight	-0.32128	0.16871	0.22289	0.22299	-0.11571	-0.39645	1	
ADG	-0.12745	-0.21008	0.17454	-0.06624	0.21149	-0.00065	0.1477749	1

Table A3.3. Correlations of traits to sale price for 2018-born bulls

Sale	Sold	Clearance	Average	Overall	Top	Ave ABI	Ave Weight	ADG	Lot	Weight	ADG	Scrotal	ABI
Sale 13	10	71.4%	$ 5,400	1.07	$13,000	$ 120	658	1.34	-0.681	0.570	0.321	0.485	0.264
Sale 14	17	100.0%	$ 8,706	1.57	$24,000	$ 129	769	1.40	-0.284	0.802	0.802	N/A	0.348
Sale 15	25	100.0%	$ 7,360	1.48	$18,000	$ 119	657	1.30	-0.652	0.610	0.467	0.439	0.541
Sale 17	6	100.0%	$ 9,667	1.64	$24,000	$ 128	611	1.44	-0.224	0.859	0.822	-0.602	0.736
Sale 5 North	8	100.0%	$ 5,563	1.37	$ 7,500	$ 135	581	1.18	-0.173	0.620	0.491	0.060	0.393
Sale 19	16	66.7%	$ 4,563	0.97	$ 9,000	$ 119	523	1.39	-0.463	0.129	-0.061	0.295	0.245
Sale 20	9	75.0%	$ 5,222	1.09	$ 9,000	$ 128	510	1.34	-0.227	0.302	0.041	0.542	0.409
Sale 27	26	81.3%	$ 5,442	1.17	$ 9,000	$ 122	627	1.27	-0.046	0.166	0.361	-0.019	0.368
Sale 29	34	94.4%	$ 5,765	1.32	$15,000	$ 112	674	1.35	-0.505	0.397	0.252	-0.040	0.443
Sale 31	20	80.0%	$ 5,700	1.17	$12,000	$ 126	699	1.34	-0.360	0.545	0.605	0.125	0.690
Sale 32	17	43.6%	$ 4,794	0.75	$ 7,000	$ 152	516	1.38	0.222	-0.121	-0.143	0.042	0.420
Sale 33	27	73.0%	$ 5,037	1.06	$ 9,000	$ 136	651	1.20	-0.462	0.498	0.261	0.078	0.412
Sale 3 Spring	99	100.0%	$ 8,434	1.55	$21,000	$ 148	634	1.29	-0.419	0.244	0.135	0.176	0.247
Sale 34	7	77.8%	$ 4,714	1.09	$ 8,000	$ 107	644	1.22	0.026	0.558	0.644	N/A	0.498
Sale 35	29	80.6%	$ 4,862	1.13	$14,000	$ 118	662	1.54	-0.579	0.656	0.640	N/A	0.502
Sale 37	54	100.0%	$ 15,204	2.00	$40,000	$ 116	686	1.41	-0.387	0.159	0.631	0.177	0.235
Sale 38	13	100.0%	$ 6,962	1.46	$16,500	$ 101	636	1.19	0.082	0.803	0.659	N/A	0.122
Sale 39	25	100.0%	$ 10,680	1.70	$40,000	$ 116	738	1.35	-0.499	0.429	0.075	-0.033	0.597
Sale 40	21	95.5%	$ 5,524	1.32	$13,000	$ 120	640	1.22	-0.547	0.606	0.442	0.225	0.463
Sale 41	11	91.7%	$ 7,636	1.42	$14,000	$ 129	692	1.11	-0.347	0.627	0.575	0.618	0.403
Sale 42	55	84.6%	$ 6,582	1.28	$30,000	$ 122	629	1.33	-0.262	0.186	0.073	0.195	0.519
Sale 5 Spring	59	95.2%	$ 6,763	1.40	$15,000	$ 139	542	0.99	-0.495	0.671	0.569	0.429	0.392
Minimum	**6**	**43.59%**	**$ 4,563**	**0.75**	**$ 7,000**	**$ 101**	**510**	**0.99**	**-0.68**	**-0.12**	**-0.14**	**-0.60**	**0.12**
Average	**27**	**86.84%**	**$ 6,844**	**1.32**	**$16,727**	**$ 125**	**635**	**1.30**	**-0.33**	**0.47**	**0.39**	**0.18**	**0.42**
Maximum	**99**	**100.00%**	**$ 15,204**	**2.00**	**$40,000**	**$ 152**	**769**	**1.54**	**0.22**	**0.86**	**0.82**	**0.62**	**0.74**

Table A3.4. Correlations across all studs for 2018-born bulls

	Sold	*Clearance*	*Average*	*Overall*	*Top*	*Ave ABI*	*Ave Weight*	*ADG*
Sold	1							
Clearance	0.27043	1						
Average	0.34017	0.59296	1					
Overall	0.34403	0.88006	0.90421	1				
Top	0.39965	0.54865	0.87899	0.80935	1			
Ave ABI	0.33404	-0.27343	-0.08328	-0.19413	-0.20280	1		
Ave Weight	0.03615	0.49744	0.44285	0.52499	0.51897	-0.36472	1	
ADG	-0.08154	-0.20245	0.17802	-0.00240	0.29869	-0.14188	0.17684	1