Breeding Technologies, Genetic Predictors and Beef Production in the United States vs Australia

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The United States is the leading beef producer in the world, with beef contributing a significant proportion of the total produce consumed (MLA, 2020). In a recent livestock outlook report by the United States Department of Agriculture (USDA) for (Knight & Taylor, 2022), beef production rose to a staggering 28.3 billion pounds (12.8 million tonnes), with production in 2023 predicted to decrease slightly to 26.3 billion (11.9 million tonnes) largely due to reduced cow slaughter. As of January 2023, the U.S. cattle herd consists of 89.3 million head across all production systems, which supplies the U.S. population of 331.9 million (Averill, 2023). To put the scale of the US industry into perspective, a report by Meat & Livestock Australia (MLA, 2022) showed the Australian beef industry steadied at 28.8 million head in 2022, with 6.7 million head slaughtered producing 2.1 million tonnes of red meat.

With beef at a constant demand, increasing production whilst improving resource efficiency is vital to ensuring the success of the industry. For ranch level producers, optimising genetic reproduction, growth performance and improving carcass quality is a key method in improving this efficiency.

The US industry has seen a shift from traditional phenotypical sire selection to an objective merit-based approach, facilitated by the development of genetic measurements and EPDs (expected progeny differences. Using objective measurements to understand an animals genotype has created opportunities to select for economically valuable traits (such as reproductive efficiency, growth rates, end-product merit and maternal ability), and when used in combination with breeding technologies including artificial insemination and embryo transfer, allows producers to source desired genetics at a low relative cost while driving on-farm performance (Garrick & Golden, 2009).

This report will include Gardiner Angus Ranch (GAR) as a case study for the use of breeding technologies and EPD's in a beef production system. Gardiner's ranch is a cow/calf operation located near a small town called Ashland in Midwest Kansas ~20 km north of the Oklahoma border. The ranch spans over 46,000 acres, comprised of 40,000 acres native pasture, 5000 acres of wheat and 1000 acres of Alfalfa pastures operating off an annual average rainfall of 18 inches. Gardiners manage 2000 commercial cows, 1500 registered cows and heifers and 4000 customer purchased steers and heifers. They also cooperate with producers involving 4 contract recipient herds (~1500 calves/yr) and 40 GAR Allied producers (~1000 calves/yr).

GAR hold 4 sales annually across fall, spring, January and May, marketing both bulls and females (often PTIC and foetal sexed). Approximately 1500 bulls are sold through these sales, with an additional 1000+ sold as private treaty. The combined annual sale includes 700 registered and 2500 commercial heifers and cows, with steers and additional cull cattle sold to processors through terminal avenues including over the hook. Cattle sold to the processors are often marketed through U.S. Premium Beef (USPB), which is a vertically integrated supply chain founded by GAR and cooperatives in 1998 in conjunction with National Beef Packing Company, LLC. The supply chain pays producers a premium on individual animals based on a quality grid and provides feedback on carcases with that feedback being utilised to inform decision making tools for genetic selection to improve production and quality within in the herd. Gardiner ranch often offer the opportunity buy back steers from customers at a market price, which are then placed on feed and sold through USPB. GAR undertook an on-farm evaluation to compare the return of profit between the live cash market and the USPB grid. They calculated the

breakeven price of a 1514 lb (687 kg) Angus steer at $2118, which included purchase and feed costs. If sold on the live market at $1.43/lb, the steer is worth $2165, returning a profit of $47 over breakeven. The same steer sold OTH through USPB at 974 lb (442 kg), YG3, Choice+, returned a profit of $375 over breakeven, which is a premium of $329. If the same carcass graded Prime, it would increase the profit return to $802 above breakeven, which is an additional $755 premium through the USPB grid compared to the live market.

Since 1964 Gardiner Angus Ranch have converted to an exclusively artificial insemination (AI) and embryo transfer (ET) breeding system. The utilisation of these technologies paired with the phasing out of natural breeding was relatively novel to the industry at the time and has continued to be quite unique to GAR compared to other producers across the US and Australian industry. The absence of accurate genetic information when selecting sires for artificial insemination limited the potential for superior genetic selection, which resulted in initial production returning little to no progress until the 1980s, when the American Angus Association released a sire evaluation report enabling the selection of individual sires based on their genetic merit and economically valuable traits. This paved the way to the genetic based predictions and EPDs offered with every bull used and purchased from Gardiner Angus Ranch.

Artificial insemination and embryo transfer have generated huge opportunities in the beef industry for producers to access superior genetics or accelerate on-farm genetic improvement. Embryo transfer has increased in popularity among beef producers and is becoming one of the most valuable tools for rapid genetic gain. In a traditional extensive management system, an average cow will produce one calf per year, equating to 10 calves in her lifetime. Embryo transfer technologies allow producers to select a genetically superior female, generate mass ovulation through hormone therapy and collect multiple eggs per cycle. These fertilised eggs can then be harvested and transferred into recipient cows. This technique can rapidly increase the number of calves that a genetically desirable cow can produce in a year and across her lifetime (Wu & Zan, 2012). This increases the attention placed on maternal selection rather than just the sire, resulting in an increased genetic gain of progeny from both parental lineages.

Artificial insemination exhibits many advantages over natural breeding systems including synchronisation of oestrus, shorter calving window, little to no management of bulls and most significantly the ability to rapidly accelerate genetic improvement. Artificial insemination possesses the key advantage of sourcing semen from genetically superior bulls without the bulls being on-farm. this allows producers to introduce desired traits into their herd at a relatively lower cost than the purchase of a bull (Baruselli et al., 2018). It is estimated to take 10-20 years to dramatically improve the base genetics of a cow herd through traditional breeding methods. The incorporation of artificial insemination estimates that similar improvements can be made in ~7 years, with the combination of embryo transfer accelerating achievable change in 4-5 years.

At GAR all females are bred through either AI or ET technologies without introducing bulls and incorporating natural joining to the herd. Breeding occurs over a 60-day season, with the aim to have all calves on ground in a 45-day window. Ideally, this means all cows have calved within the first two cycles, providing them with the best chance to achieve conception after the 85-day turnaround from calving. Embryos are collected from a donor herd, which are then sold, and a new set of donor cows are selected from progeny for the following year. These donors are chosen from the registered herd based on desired pedigree, EPDs and performance data (for example growth rates, calving ease,

carcass merit and fertility). GAR transfers approximately 2000 embryos a year to recipients in the commercial herd, yielding a success rate of >60% live calves on ground. Recipient cows that don't accept the embryos are artificially inseminated, often using semen from the same bulls. These cows then enter the commercial herd with all progenies destined as replacement commercial heifers or steers. Semen sires are sourced from bulls produced by GAR or associates or selected through the sire evaluation report by the American Angus Association. This is a common practice for many producers, as breed associations provide ideal opportunities to advertise and select superior genetics (Willham, 1982). This is similar feature of both the US and Australian cattle industry. While the use of AI is common among many producers in Australia, commercial bulls are still widely incorporated into AI programs as "follow-up" bulls. These bulls are often placed with the herd to breed with any cows that didn't fall pregnant through the AI program. The total phase out of commercial bull use is a practice unique to Gardiners ranch.

The prediction of genetic potential and heritability has become a significant pathway for producers wanting to improve fertility, growth and performance, end-product value or maternal characteristics in their production system (Goddard & Hayes, 2009). EPDs have been used in the US industry for the last 40 years, with continual additions of new production traits, updated values, ease of measuring and increased accuracy are creating more options for producers to select from. Expected progeny differences or EPDs, are estimates of an animal's genetic merit for certain traits and an indication of how an animal's progeny will perform. They are often expressed as +/- numerical value relative to the breed average, and contain a percentage which correlates the accuracy or precision of the prediction (Felix, 2023). EPDs are calculated through data on the individual animal's performance, progeny performance, relatives and genomic data, which is submitted to a central database. For beef producers, a shift in consumer demand and industry movement to a grid-based pricing system has led to a focus on end-point merit and economically valuable traits, such as carcase weight, eye muscle area, fat depth, intramuscular fat % and yield % EPDs. In a seedstock production system, such as Gardiners, a combination of growth, carcass and reproductive merit is vital to ensure progeny are suitable for their desired (Bertrand et al., 2001).

GAR pride themselves on their breeding objectives to maximise reproductive efficiency, manage birthweight and improve calving ease, manage growth to market weight, reduce mature size and select for superior carcass quality. GAR rely on genetic predictors for sire and embryo donor selection for on-farm use, as well as provide EPDs on all animals sold from the ranch. All bulls are semen tested, measured for motility, scrotal circumference, ribeye and IMF ultra-sounding. These measurements are then combined with genomic information from the sire and dam to develop an EPD for the bull. GAR incorporate Method Genetics tools into their herd, which is a DNA based evaluation used in conjunction with EPDs. Method Genetics LLC assists producers with decision making tools and genetic selection to improve breed genetics, marketing and profit driven targets.

Genetic predictors and innovative breeding technologies are providing beef producers with more opportunities to improve genetic gain in their herds, but both involve challenges and limitations with these systems. One of the major constraints to smaller producers is the cost and management associated with AI and ET technologies. While initial costs are lower for purchase of semen relative to the purchase of a bull, artificial insemination and embryo transfer require higher levels of management through oestrus synchronisation, purchase and administer of required hormones, and requirement of a registered/accredited practitioner to undertake the procedure. (Baruselli et al., 2018). Genomic evaluation is another promising technology arising in the beef industry that is faced

with a number of challenges limiting the rate of adoption to the wider industry. Larger seedstock producers, such as GAR, similar extensive operations and breed associations are embracing the implementation of genomic selection in their herds, although industry adoption has been steady due to lack of tangible investment returns, producer awareness and understanding of genomic testing and interpretation of results (Rolf et al., 2014). This also applies to breed EPDs, which rely on information provided by the producer, primarily cow/calf or seedstock, to incorporate into the national breed database. If producers stopped providing genomic and performance data to the national association, it would result in a significant reduction in the reliability and accuracy of EPDs across the breed. Selection based on genetic merit would decrease resulting in a decline in the rate of genetic gain. The increased management practices of progeny, genotype testing and comprehensive record keeping limits the measurements taken by smaller producers, with the industry relying on the major producers to improve EPDs in the breeds national genetic evaluation (Hayes et al., 2009).

The advantage of genomics is the ability for producers to gain a greater insight into their entire herd genetics. Increased selection pressure is often applied on sire selection, with heifers and cows commonly selected based on phenotype. Genomics is providing significant benefits for identifying replacement heifers, allowing producers to measure health, fertility, maternal ability, calving ease and mature size. Producers can use this information to select superior females as donors, select bulls best suited for their herd and reduce the generational interval, increasing genetic gain and production over traditional phenotypic selection (Pryce & Hayes, 2012).

Beef production in Australia and the United States share many similarities, but also significant differences as an industry. The key distinction is the scale of the US industry compared to Australia. From a production volume point of view, the US is the leader in global beef production with a 17% share in global production compared to 4% for Australia. While Australia does not match US production levels, it is one of the 3 major exporters, accounting for 16% of the global market share compared to 13% of the US (MLA, 2020). The main driver for these figures is the domestic demand for beef in the US, with a significantly larger population (US: 331.9 million vs AU: 25.7 million) the national beef consumption in the United States is considerably higher than Australia (Howden & Zammit, 2019). An additional contrast between the US and Australian production systems outlined in this report is the grass-fed industry, with approximately 60% of Australian beef finished on pasture compared to 4% in the US. This could be influenced by consumer preference to white fat, higher demand for rapid turnover, reduced impact of seasonal effects and the use of corn as a dominant feed source in the US.

Similar to the United States, Australia has initiatives designed for improving genetics within the beef industry. BREEDPLAN is a national program that provides objective data and information to beef producers for the purchase or sale of livestock, with the aim to accelerate genetic gain within their herds. BREEDPLAN incorporates genomics, progeny and individual performance data to create a genetic evaluation of each animal. The information is combined to produce an estimated breeding value (EBV), which is the Australian equivalent of an EPD (Greenwood et al., 2018).

This report outlines the practices in the beef industry that place Australia as one of the world leaders for quality assurance and biosecurity. Australia has maintained a disease-free status (such as foot and mouth and bovine spongiform encephalopathy) through strict border control, management programs and traceability, such as the National Livestock Identification System (NLIS) and National Vendor Declarations (NVDs). An NLIS is a unique number given to each individual animal (often in the form of

an electronic ear tag) that provides lifetime traceability of that animal from birth to death, with NVDs used to communicate each time an animal moves along the supply chain (farm to farm, farm to processor). This identification is an area that the US industry lacks, with little to no traceability of an animal prior to slaughter. The industry has begun to develop carcass traceability, but it relatively novel industry wide. This is largely due to the issue of incorporating traceability into such a large, established industry, with producers unsure of the economic viability and costs of implementing this technology into their herd. Australia also has companies such as AUS-MEAT and Meat & Livestock Australia (MLA) that are responsible for regulating standards and quality assurance in the beef industry. Meat Standards Australia (MSA) is a grading system, similar to the USDA grade, that focusses on ensuring eating quality based off select specifications (hump height, fat depth, eye-muscle area, marbling). The MSA symbol has become globally recognised and reinforces Australia's quality produce, particularly in international markets (Greenwood et al., 2018).

The beef industry is constantly expanding and raising the bar on production levels. With producers continually striving to meet demand with consistent, quality produce, the advancements in genetic predictors and breeding technologies have allowed them to achieve this. The introduction of superior genetics, breeding of top-quality animals and the ability to identify and select animals based on genetic merit specific to the desired trait has seen as rapid increase in genetic gain across the industry. These improvements have allowed the US beef industry to grow to the scale it is today, which is an ambition the Australian industry strives to achieve. While there are many opportunities for the Australia beef industry to expand, such as wide-scale use of feedlot systems to increase production or establishing larger cattle herds or the importation of superior genetics from the US. Australia's key success is their export market, with one of the highest global reputations for consistent quality beef. Continuing to increase production quality through genetic improvements, strengthen market access and maintain quality assurance is key to ensuring the success of the Australian beef industry.

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