



Maternal productivity for the rangelands

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Abstract

Given pastoralists in arid regions have little control over season conditions and cannot easily manage stocking rate or supplementary feeding, the biggest lever of cow productivity is through genetics. Weaning rate which is a function of maximising calves born and minimising calf loss is the biggest driver of profit. Conception rate in heifers is related to joining weight and growth during joining. In cows, condition score is the key predictor. The EBV of greatest importance for reproduction is days to calving. EBVs for other traits like growth, calving ease, temperament and recently cow condition are important also. Cows in the greatest condition which show the greatest resilience are likely to have eaten more when feed was available rather than being metabolically more efficient.

Introduction

This paper reviews 35 years of research on beef cattle primarily led by the author. Although not conducted on rangelands per se, there are important insights for rangeland producers. The rangelands that I am focused on are Australia's arid zone - as defined by annual rainfall <250mm. An example of this region is Alice Springs, which has a mean annual rainfall of 285mm, but with huge variation as the median is 126mm, decile 1 6mm and decile 9 804mm (BOM 2024). The median rainfall is 90% in the summer half of the year (October-March), with winter rainfall being a greater proportion in areas to the south.

In the southern rangeland production systems described, little to no nutritional supplementation occurs.. The possible exception is hay fed to young cattle around the time of weaning. Feed supply is primarily only managed in extreme conditions and through stocking rate. Thus, once pasture management is optimised, one of the few strategic levers producers have for productivity improvements is through genetics, which mostly occurs through bull purchases. Given the region of focus is of very low humidity, the focus is on *Bos taurus* cattle. Factors associated with maternal productivity have been reviewed by Walmsley et al. (2018)

Genetic progress in Angus cattle

During the 35 years that this review relates, Angus cattle have changed significantly (Angus Australia 2024) – exemplified by a substantial increase in growth; 119kg for 600d weight and 102kg for mature cow weight. Birth weight has only increased by 4kg so there has been some improvement in calving ease. Favourable changes in other traits include: mature cow body condition, days to calving, docility, eye muscle area and intramuscular fat. However, there has been negligible change in carcass fat depth. Given that feed costs in the rangelands are low, the greater size of cows does not represent a major cost unless pasture utilisation levels are very high. All other

traits have improved in favourable directions. Although Angus breed genetics have improved significantly, commercial cattle breeders struggle to compare breeds due to breed societies controlling the databases. There is a current project running Angus, Charolais, Hereford, Shorthorn and Wagyu cattle head to head. This is tremendous but expensive relative to the approach reported by Pitchford et al. (2021).

Feed efficiency

Feed efficiency can be defined in many ways. A common method in feedlots is to focus on the cost of gain with the measure being feed conversion (feed eaten / weight gain, Koch et al. 1963). Productivity is typically measured as output per unit input. In growing beef cattle, weight gain varies more than feed intake, so both measures are maximised by the fastest growing cattle.

In an attempt to overcome the problems of ratios, Koch et al. (1963) introduced the concept of residual or net feed intake (NFI). This has become a major focus of many groups around the world. However, Pitchford et al. (2018) demonstrated that when feed is limited, there is negligible variation in NFI. The implication of this is that there is negligible variation in maintenance requirements and so genetic improvement is not possible. Additionally, Pitchford et al. (2018) reported that variation in NFI under favourable feed conditions is associated with fatness. The implication of this is that variation in NFI must be through appetite rather than efficiency *per se*. The application of this work to the rangelands is that rather than select for animals with low NFI and supposed greater efficiency, it is likely that the best animals are those that eat more when feed is available, build up condition and then are more resilient during times of feed shortage.

Accioly et al. (2018) reported the performance of lines of Angus cattle divergent for fatness or NFI from the Beef CRC Maternal Productivity project (Pitchford et al. 2014). While all cattle gained and lost condition throughout the annual production cycle of feed availability and lactation status, the High-Fat and High-NFI lines were always fatter than the Low-Fat and Low-NFI lines respectively. The impact of this during times of feed shortage was that the leaner lines were always the ones to trigger supplementary feeding. Specifically, calculations based on the data in the Accioly paper estimate that if cows lose condition at a rapid rate (1 condition score/month), then a cow with an extra 1 mm rib fat EBV would take 7.5 days longer to reach the same supplementary feeding threshold. Maintenance of healthy body condition is a crucial trait in the rangelands so selection for increased condition is likely important.

Body composition

Following the work demonstrating the relationship between fatness and cow resilience, there has been an increased emphasis of commercial producers selecting bulls with above average fat EBVs. The result of this is increased fatness of both slaughter and breeding cattle. While this is advantageous for grass-finished steers (Deland et al. 2018), it leads to greater cost of gain and lower meat yields for feedlot-finished steers.

Pitchford (2023) examined the relationship between mature cow body condition and carcass EBVs for growth, muscle and fat. It was demonstrated that approximately $\frac{3}{4}$ of the genetic variation in cow condition is independent of carcass composition traits. Fat and muscle measured in heifers at yearling and pre-calving were highly correlated (De Faveri et al. 2018). Fat and muscle measured in cows across lactations were also highly genetically correlated. However, the correlation between maiden pre-calving and weaning measures was much lower. Thus, rangeland producers wanting to select bulls that breed more resilient cows should focus on the mature body condition EBV rather than on carcass EBVs.

While genetic selection for growth has resulted in significantly bigger cows, Hebart et al. (2024) have shown that in current commercial cows at 4.5 years of age and adjusted to a condition score 3 (scale 1-5), the average weight was around 550kg.

Productivity and profitability

In the Beef CRC Maternal Productivity project, Hebart et al. (2018) reported nutrition and genetics effects on productivity differences and Anderton et al. (2018) reported the effects on profitability. Variation in maternal productivity defined as weight of calf weaned per unit feed intake by the cow and calf, was associated with feed intake (50%), weaning rate (37%) and only 9% due to the weight of the calf. In the rangelands with cheaper feed, weaning rate will be the strongest profit driver (McCosker et al. 2010).

Anderton et al. (2018) reported that the Low-Fat lines were more profitable than the High-Fat lines. However, the design of the project (Pitchford et al. 2018) was that when one line (always the Low-Fat line) triggered the need for supplementary feed (a single animal dropping below condition score 2, Graham 1985), both lines would be fed (Accioly et al. 2018). The idea was that treating them the same was important for design but with the benefit of hindsight this may not have been wise. The impact of the design was that the High-Fat lines were fed more and maintained in a greater condition score, so there was greater investment in feed than necessary. In rangeland conditions where there is not this level of control, it is likely that those that maintain greater body condition are more resilient, more productive and more profitable.

Reproduction

Pitchford et al. (2022) reported results from the “Black Baldy” trial run with Hereford’s Australia. The cattle were run in large mobs in northern Tasmania. While the environment is very different to the rangeland focus herein, they were run in large mobs and at high stocking rates and so provide a model for what could happen in other commercial herds. As expected, attainment of puberty in heifers prior to joining at 13-15 months was associated with the sire scrotal circumference EBV which reflects age at puberty in yearling bulls. However, this only had a weak association with weaning rate. As expected, the EBV with the strongest association with weaning rate was days to calving, a measure of the time taken from joining to calving. In naturally mated mobs, some of the variation in days to calving is associated with gestation length, but much more is associated with post-partum anoestrus and associated time to conception. The relationship was 8% more calves weaned in two joinings per day variation in the EBV. Similar results were found in the Beef CRC data (unpublished).

To address potential bias in conclusions for commercial producers coming from the Beef CRC data, a recent project on productivity of over 14,000 heifers on commercial properties has been conducted (Hebart et al. 2024). There are some key outcomes that have relevance for rangeland systems. A high aim could be to achieve 80% conception rate within two cycles (6-week joining). The two biggest factors affecting this are joining weight and during joining weight gain. If during joining gain is low, then heifers should be >350kg. However, if heifers are rapidly (>1kg/d) gaining during joining then much lighter weights will suffice. In the rangelands following a rain event, it is likely that cattle will be gaining rapidly so conception could occur at quite light weights (<300kg). As expected, conception rates of cows was most closely associated with condition score. Those with low condition due to high milk production or low feed intake will be most at risk of not conceiving.

Heterosis

Estimated from a genomic analysis, the heterosis effect in the Hereford x Angus crosses in the Black Baldy trial was 4% for pre-joining weight, 1% for pre-joining height, 6% for P8 fat and 13% for proportion pubertal (Pitchford et al. 2021). This demonstrates the value of heterosis or hybrid vigour for contributing to resilience.

Pitchford et al. (1993) reported heterosis effects on growth and reproduction in Brahman x Hereford crosses. The effect on growth was large on high-quality pasture (21%), but much less on low-quality pasture (1%). The conclusion was that the mechanism of heterosis was to increase appetite rather than metabolic efficiency as the effect can only be seen when the additional appetite was satisfied (high-quality pasture). This conclusion both guided and supported the same conclusion about the causes of biological variation in NFI (Pitchford et al. 2018). In the Brahman x Hereford crosses, the heterosis effect was large (39%) for weaning rate (Pitchford et al. 1993).

Conclusions

Given pastoralists in arid regions have little control over season conditions and cannot easily manage stocking rate or supplementary feeding, the biggest lever of cow productivity is through genetics. It is very likely that conclusions about genetic variation reported in Angus cattle in Mediterranean and Temperate grazing systems does provide valuable insights for the arid rangelands. However, the lack of multi-breed and commercial rangeland data in current genetic evaluation systems is limiting genetic progress for the rangelands. Genomics offers a significant opportunity to address this shortfall.

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