Breeding Focus 2021 - Improving Reproduction

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Preface

"Breeding Focus 2021 – Improving reproduction" is the fourth workshop in the series. The Breeding Focus series was developed to provide an opportunity for exchange between industry and research across a number of agricultural industry sectors. With this goal in mind, workshops have included presentations across multiple agriculturally relevant animal species to take participants outside their area of expertise and encourage them to think outside the box. Reproduction is a main driver for profitability and genetic gain. We will discuss existing knowledge, identify gaps and explore genetic and management strategies to improve reproduction further in multiple species.

Successful reproduction is a complex characteristic comprising the formation of reproductive cells, successful mating and fertilisation, embryonic and fetal growth and eventually a successful birthing event. In livestock species, reproduction traits have mostly low heritabilities, which makes it challenging to improve reproduction as part of a multiple trait breeding objective. The complexity arises not just from the cascade of processes required to result in successful reproduction, but the relevant traits are different in males and females and they are influenced through health and fitness, nutrition, climate and other environmental and management factors.

Challenges to the improvement of reproduction can vary widely for different species. For less domesticated species such as abalone, the ability to produce and reproduce the animals in captivity presents a major challenge. In bees, reproduction has not been given great attention and little research has been undertaken to understand the underlying genetics of drone and queen reproduction. However, in all industries reproduction is recognised as the basis for genetic and economic gain. It directly influences the selection intensity that can be applied. It also determines how many animals are not required for replacement and can be sold. In all industries, irrespective of the challenge, cost-effective and easy to measure phenotypes of reasonable heritability are central. New technologies and approaches enable the development of novel phenotypes for genetic improvement which will be combined with a growing amount of genomic data in livestock species and together these developments provide new and exciting opportunities to improve reproduction further.

We would like to thank everyone who has contributed to this event for their time and effort: the authors for their contributions to the book and presentations, the reviewers who all readily agreed to critique the manuscripts. We would like to express a special thanks to Kathy Dobos for her contributions into the organisation of this workshop and the publication. Thank you!

Susanne Hermesch and Sonja Dominik

Armidale, May 2021

Examining the relative importance of female reproduction in beef breeding herds when fully accounting for production costs

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Abstract

The reproductive performance of beef females, defined as cow weaning rate (CWR), which is the number of calves weaned per cow joined per year, has been shown to be a major driver of on-farm profitability along with the survival and growth performance of progeny. There is often debate as to which trait is of higher priority when selecting replacement animals in breeding herds. When fully costed during the derivation of economic values, reproduction has a high demand for nutrient resources because it involves the feed requirements not only associated with pregnancy but that required for milk production. This can represent nearly a doubling of the nutrient demands of the cow compared to when she is in a dry state and therefore, a significant financial investment when supplementary feed needs to be supplied. The importance of CWR was examined relative to that of progeny growth, defined as finished sale liveweight (FSWT), using a breeding objective based on net return per cow mated. A base scenario involving a self-replacing commercial herd that purchases replacement bulls from seedstock herds was simulated with a herd weaning rate of 85%, producing 600 kg grass finished steers at 22 months of age and a sale price of $2.62/kg liveweight. The average mature cow weight was 600 kg and the supplementary feeding period was 6 months long with supplementary feed costing $240/tonne. The impact changes in production system characteristics such as breeding time horizon, supplementary feed cost, sale prices, FSWT and age, and mature cow weight have on this relationship were examined. Cow weaning rate increases in importance when herd fertility was lower (50-70%), animals of greater value were sold at the same age (higher FSWT, 690 kg or higher sale price, $3.05/kg liveweight), supplementary feed costs were lower ($180/tonne), mature cow weights were lower (400 kg), and genetic changes are valued over longer time horizons (20 years). When animals were sold at different ages (12 up to 32 months), the importance of CWR varies in relation to the requirement for supplementary feed. In all instances CWR has a positive economic value and often placing substantial emphasis on fertility is justified. Additionally, the precise importance of reproduction changes with the perception of the future commercial herd and production system characteristics, in particular the cost of providing supplementary feed. It follows that for the best outcomes in terms of profit improvement, the selection importance placed on reproduction should be determined on a case by case basis.

The traditional approach of focusing almost exclusively on final market endpoint(s) should be abandoned in preference to giving at least equal consideration to the impact the cow herd has on commercial profitability.

Introduction

The production characteristics that set the top 25% of Australian beef producers apart in terms of profitability or net return of production are higher reproductive performance, lower mortality rates and higher sale liveweights (FSWT; Holmes and McLean 2017). Cow weaning rate (CWR), defined as the number of calves weaned per cow joined per year, is determined by the combination of cow-herd fertility and mortality rates of progeny to weaning. Recent studies have shown weaning rates in Brahmans of 62% and 50% per female exposed from their first and second joinings (Johnston et al. 2014a). Even though research has demonstrated genetic variation and the potential to select for improvements in female puberty as well as early and lifetime reproductive performance (Johnston et al. 2014a, 2014b), there is often debate as to whether CWR or progeny growth performance should be of higher priority in a breeding program to select replacement animals. From a management perspective, the view that improved CWR is more important in production systems when animals are sold younger, i.e. weaner production, in contrast to systems where animals are finished (Barwick et al. 1995) is still commonly held.

The transition of a beef female from a dry, growing state to one where she has reproduced and is now actively lactating represents a large change in her feed requirements. When dry, a mature 600-kg cow would be expected to consume approximately 9 kg DM/day of a diet containing 10.5 MJ ME/kg DM which would increase to approximately 17 kg DM/day of the same diet after she has reached peak lactation about 90 days after calving (Freer et al. 2007). This change in feed requirement represents a significant financial investment, particularly when supplementary feed is being supplied at a cost and cannot be ignored when deriving economic values for reproduction. Recent developments in the modelling systems used to estimate feed requirements in the BreedObject indexing software now allow for feed requirements of the cow herd (Walmsley et al. 2015) and young animals (Barwick et al. 2018) to be fully costed when developing selection indexes. In particular, these developments require a refocus away from traditional market endpoint(s) driven index development to a more balanced consideration of the contributions the carcass and cow herd make to commercial profit (i.e. income minus costs). The opportunity now exists to examine how the relative importance of reproduction and FSWT changes under different production scenarios when feed requirements are fully costed, and provide important guidance on strategies for selecting replacement animals due to the sensitivity of animal index rankings to feed costs (Walmsley et al. 2018).

In this study the importance of fertility, defined as CWR, is examined relative to progeny FSWT in a temperate self-replacing beef production system using a *Bos taurus* breed. The impact changes in production characteristics, including feed costs, have on this relationship are examined. Even though this study focuses on an example temperate production system the patterns seen in the importance of CWR relative to FSWT are considered equally valid if the production characteristics relevant to a tropical production system were varied in a similar manner.

Materials and Methods

Derivation of the selection index

The importance of cow reproduction was examined using the BreedObject software (Barwick and Henzell 2005) which is used in the BREEDPLAN genetic evaluation for deriving selection indexes (Graser et al. 2005). Developing the breeding objective for a selection index requires a vision of the production from a herd, the environment it operates in, and how the herd is structured and managed. A brief description of the underlying assumptions and models in BreedObject is provided below.

Definitions

The principal focus of deriving selection indexes in BreedObject is improving net merit, which is expressed in economic terms relevant to the commercial beef industry and is referred to as the breeding objective (Barwick and Henzell 2005). The selection criterion is an index of estimated breeding values (EBV) $\mathbf{\hat{u}}$, that are estimated for the Australian beef seedstock industry (Graser et al. 2005) as opposed to the traditional view of selection indexes as an index of phenotypes (Barwick et al. 2018). It follows that the genetic variance-covariance matrix needed for deriving the index is partitioned into variances and covariances among the EBVs, $\mathbf{G}_{11}$; the variances and covariances among the breeding objective traits, $\mathbf{G}_{22}$; and the covariances between the EBV criteria and traits in the breeding objective, $\mathbf{G}_{12}$ (= $\mathbf{G'}_{21}$; Schneeberger et al. 1992). Breeding objective trait values are estimated as $\mathbf{\hat{g}}_i = \mathbf{G}_{21}\mathbf{G}_{11}^{-1}\mathbf{G}_{11}^{-1}\mathbf{\hat{u}}_i$ for animal, i. When the index is linear, EBV weightings are derived as $\mathbf{b} = \mathbf{G}_{11}^{-1}\mathbf{G}_{11}^{-1}\mathbf{G}_{12}\mathbf{v}$, where $\mathbf{v}$ are the economic values of the breeding objective traits (Barwick et al. 2018).

The Breeding Objective

The breeding objective used here assesses net return per cow mated (i.e. returns net of all feed and management costs) over the period from weaning to sale of the finished animal and includes females being retained in the breeding herd. Traits that directly influence profitability of commercial production are contained in the breeding objective and include; calving ease-direct (%), calving ease-maternal (%), weaning liveweight (direct and maternal; kg), FSWT (kg), cow liveweight at joining (kg), cow body condition score at joining (1 to 15), CWR (%), residual feed intake of young animals at pasture (kg DM/d), carcass dressing %, carcass saleable meat %, carcass rump fat depth (mm), and carcass marble score (AUSMEAT scale, 1-12). Cow weaning rate defined as an objective trait in BreedObject is a trait of the cow not the herd. The economic values of the breeding objective traits are determined while all other breeding objective traits are held constant. Those breeding objective traits that influence feed requirement have the additional feed requirement resulting from trait change estimated, costed and included in their economic values. The economic values are thus the marginal increases in net return (i.e., Δ income - Δ feed cost - Δ management cost; Barwick et al. 2018). The time delays experienced before trait improvements in the objective traits are expressed in the herd are accounted for during derivation of the economic values using the discounting procedure of McArthur and del Bosque Gonzalez (1990). This method accounts only for the delay between birth of the improved animal and the time of the first expression in the herd which has been demonstrated to be the primary type of delay affecting the relativities of economic values (Barwick and Henzell 1999). The economic importance (EI_i) of the breeding objective traits is expressed as a percentage:

$$EI_i = (v_i \sigma_{Gi} / \Sigma |v_i \sigma_{Gi}|) \text{ x } 100$$

where $\mathbf{v}_i$ are the economic values of the traits, and $\boldsymbol{\sigma}_{Gi}$ are the genetic standard deviations of the first to *i*th breeding objective traits. Given the focus in this study on examining the relative importance of female reproduction (weaning rate) compared to FSWT the breeding objective (H) can be re-written as:

$$H = v_1 \sigma_{G1} + v_2 \sigma_{G2} + \sum_{i=1}^{n} v_i \sigma_{Gi}$$

where the $\mathbf{v}$ and $\boldsymbol{\sigma}_G$ are the economic values and genetic standard deviations, respectively, as above with traits 1 and 2 being finished sale liveweight and CWR, while traits, **i**, are the remaining breeding objective traits (Barwick et al. 1995). The importance of cow reproduction can then be expressed as:

$$REV_{CWR/FSWT} = {}^{v_2 \sigma_{G2}}/_{v_1 \sigma_{G1}}$$

where $REV_{CWR/FSWT}$ is the relative economic value of CWR compared to FSWT, and $\boldsymbol{\sigma}_{G1}$ and $\boldsymbol{\sigma}_{G2}$ are the genetic standard deviations for FSWT and CWR, respectively. When $REV_{CWR/FSWT}$ has a value of 1.0 CWR and FSWT are of equivalent importance for making improvements in net return. FSWT is of higher importance at values below 1.0 while CWR is of higher importance when values are above 1.0.

The Genetic Variance-Covariance Matrix

The genetic variance-covariance matrix uses the partitions $\mathbf{G}_{11}$, $\mathbf{G}_{22}$ and $\mathbf{G}_{12}$ described above that relate to the relevant genotype and production system. For the Australian beef industry, the partitions of the matrix may overlap and are currently breed specific. The genetic variances in the $\mathbf{G}_{11}$ partition vary with the characteristics of the production system so the heritabilities and phenotypic coefficients of variation are constant (Barwick et al. 2018). The genetic parameters used in this study are relevant for *Bos taurus* breeds and are based on estimates used in the Australian genetic evaluation, BREEDPLAN (Graser et al. 2005). Details concerning these parameters can be requested from the author.

Modelled Production System

BreedObject Model

The commercial production system model that underpins BreedObject, as described by Barwick et al. (2018, 2019), models pasture-based feeding, concentrate-based feeding or a combination of both post-weaning. Within this construct, the cow herd and the young animals in a grazing system are potentially exposed to two periods with different levels of feed availability during an annual production cycle: 1) a period when an increase in animal feed requirement does not require additional feed to be supplied because feed availability is surplus to requirements (surplus period), and 2) a period when increases in feed animal requirement results in fed becoming limited and thus additional feed needs to be supplied (pinch period). In the pinch period, feed always has a cost above zero while feed is generally regarded as having zero cost in the surplus period, but this cost can be above zero if required. The assumed feed cost and quality of the feed supplied during the pinch period can be different for the cow herd and the young animals at pasture. The different feed requirements associated with the different functions in animal (e.g. maintenance, growth, pregnancy, lactation) and each class of animal in the herd are estimated using the equations described by Freer et al (2007).

Example Production System

An example production system (base scenario) is used in this study to illustrate the relative importance of CWR compared to FSWT in the breeding objective. This production system mirrors commonly encountered southern Australian production characteristics based around a self-replacing beef herd using a *Bos taurus* breed weaning calves at 6 months of age. The weaning rate in the production system, termed herd weaning rate, is defined as the number of calves weaned per cow joined per year and assumed to be 85%. The steers and any heifers not retained as replacement females are pasture-raised and finished at 22 and 24 months of age, respectively. This production system has a defined pinch period that extends for 6 months (Table 1) with supplementary feed costed at $240 per tonne for both the cow herd and young animals while the cost of feed for the surplus period is assumed to be zero. The sale animals were valued on a liveweight basis at a price of $2.62/kg and $2.59/kg for steers and heifers, respectively. The differences in price on a liveweight basis were due to differences in dressing percentage at the same carcass weight, carcass price and thus carcass value. Mature cow weight was assumed to be 600 kg at joining and reflect a moderate sized temperate breed cow.

Table 1. Key production characteristics of the simulated example self-replacing beef cattle production system (base scenario) using a Bos taurus breed and producing grass finished steers and heifers. Also given are the ranges over which some production characteristics are varied when examining the relative importance of cow weaning rate compared to progeny finished sale liveweight

Characteristic	Base Value	Range Examined
Financial		
Time horizon (years)	20	4 to 20
Interest rate (%)	7	
Calendar		
Month of beginning of joining	April	
Month of end of joining	June	
Month of start of period of limited feed[a]	Jan.	
Month of end of period of limited feed[a]	July	
Young animals		
Age at weaning (months)	6	
Heifer joining age (months)	14	13 to 15
Sale age, steers (months)	22	12 to 32
Sale age, heifers (months)	24	14 to 34
Cost of supplementary feed ($/tonne)	240	180 to 300
Finished steer liveweight (kg)	600	510 to 690
Finished heifer liveweight (kg)	550	470 to 630
Finished steer sale price ($/kg)	2.62	2.20 to 3.05
Finished heifer sale price ($/kg)	2.59	2.18 to 3.00
Cow herd		
Herd weaning rate (%)	85	50[#] to 99.5
Mature cow weight at joining (kg)	600	400 to 800
Cost of supplementary feed ($/tonne)	240	180 to 300

[a] All periods of the year except when feed is surplus to herd requirements (Barwick et al. 2018).

[#] Weaning rates below 50% result in herd size decreases violating the assumption of stable herd size.

Finished sale liveweight, CWR and calving ease-direct have the highest economic importance among the breeding objective traits for the base example production system (Figure 1). Reducing cow weight and residual feed intake have less but still significant economic importance with saleable meat percentage and dressing percentage having equivalent but positive economic importance.

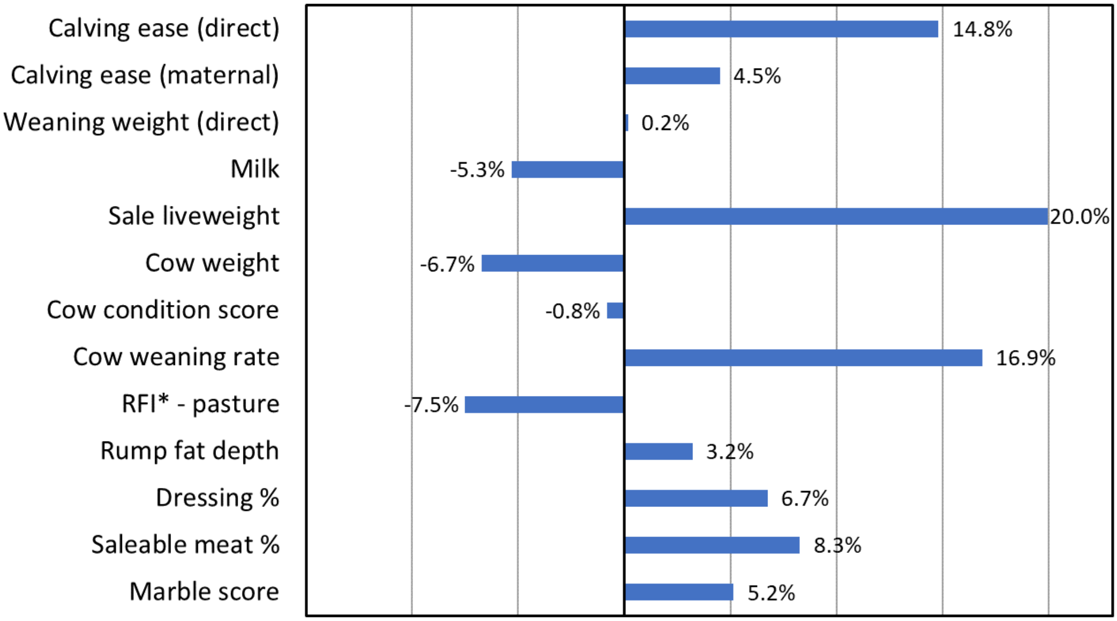


*Figure 1. Illustration of the breeding objective, encompassing trait economic values and genetic variances, showing the relative economic importance of traits for the example self-replacing production system producing grass-finished steers and heifers. *RFI is residual feed intake*

Changes in Production Characteristics

Changes in the relative importance of CWR were examined by changing the base production characteristics as listed in Table 1. These variables were changed in pairwise combinations, e.g. sale price ($/kg live weight) x feed cost ($/tonne), while the other production characteristics were held at their base values. The changes in these production characteristics were made to reflect variation commonly seen between production systems and across annual production cycles. The combinations examined were chosen because they directly impact changes in net return through either change in returns or costs, or both. For example, increases in CWR are associated with increased returns from more sale progeny and increased costs because cow feed requirements increase due to more cows reproducing and lactating. Combinations examined included; time horizon x feed cost, CWR x feed cost, CWR x sale price, sale price x feed cost, FSWT x feed cost, sale age x feed cost and mature cow weight x feed cost. The combination of CWR x feed cost x sale price was also examined. When examining the sale age x feed cost combination, steer and heifer FSWTs were varied as sale age was varied so that average daily gain to any given sale age remained equivalent to that of the base scenario.

Results and Discussion

The benefits resulting from genetic improvements in fertility accumulate slowly because they require commercial herds to purchase bulls of higher fertility which then need to produce daughters of higher fertility that breed as compared to FSWT which can be expressed relatively quickly following bull purchase. Consequently, the time horizon over which changes in fertility are expressed and therefore valued has large impacts on the benefits received. In Figure 2, when genetic change is valued over short periods of time (4-6 years) the relative importance of CWR is very low and never above 0.3. At a time horizon of 4 years, the importance of CWR is always equal to or less than 10% of the importance of FSWT. As the time horizon increases the importance of CWR increases at a diminishing rate with its highest importance (~0.85) in the base scenario occurring at 20 years. This pattern is consistent with that seen in the example described by Barwick et al. (1995) but the advancements in modelling feed requirement in BreedObject results in the relative importance of CWR being lower in this study for a comparable production system example. Time horizon also interacts with the cost of supplementary feed with lower cost of feed resulting in CWR having nearly equivalent importance (~0.97) to FSWT when the time horizon is 20 years. If feed was over costed and/or the time horizon assumed was too short, then the importance of fertility would be undervalued.

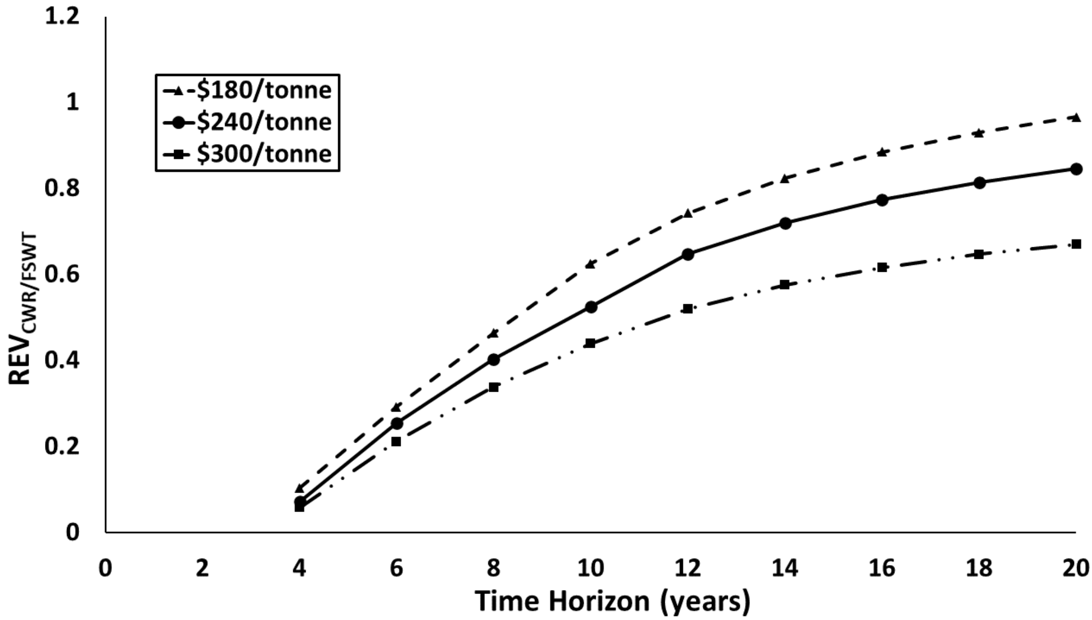
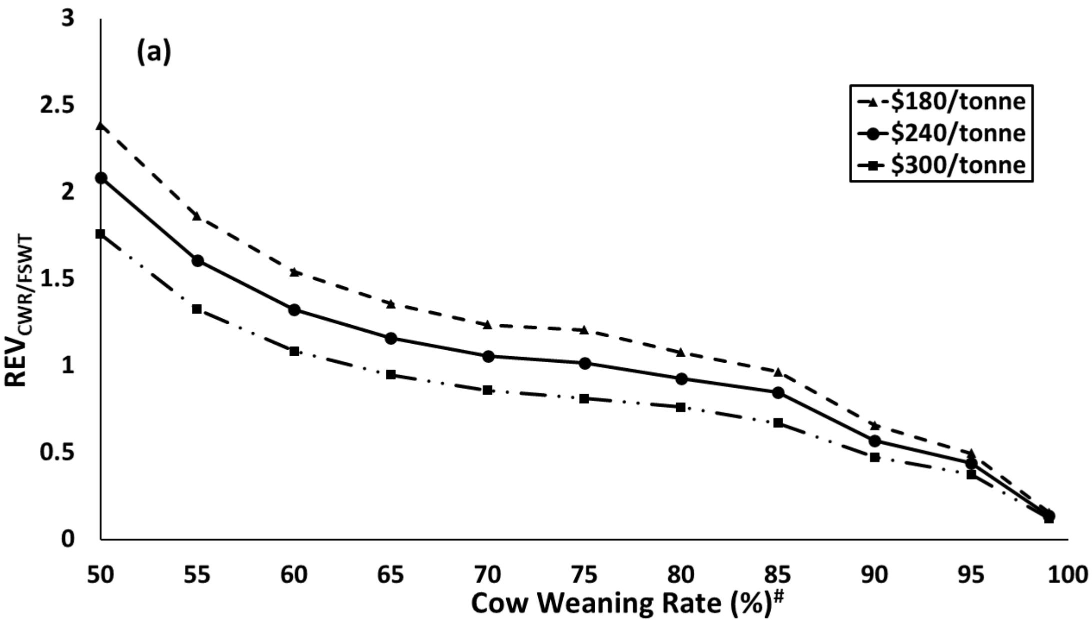
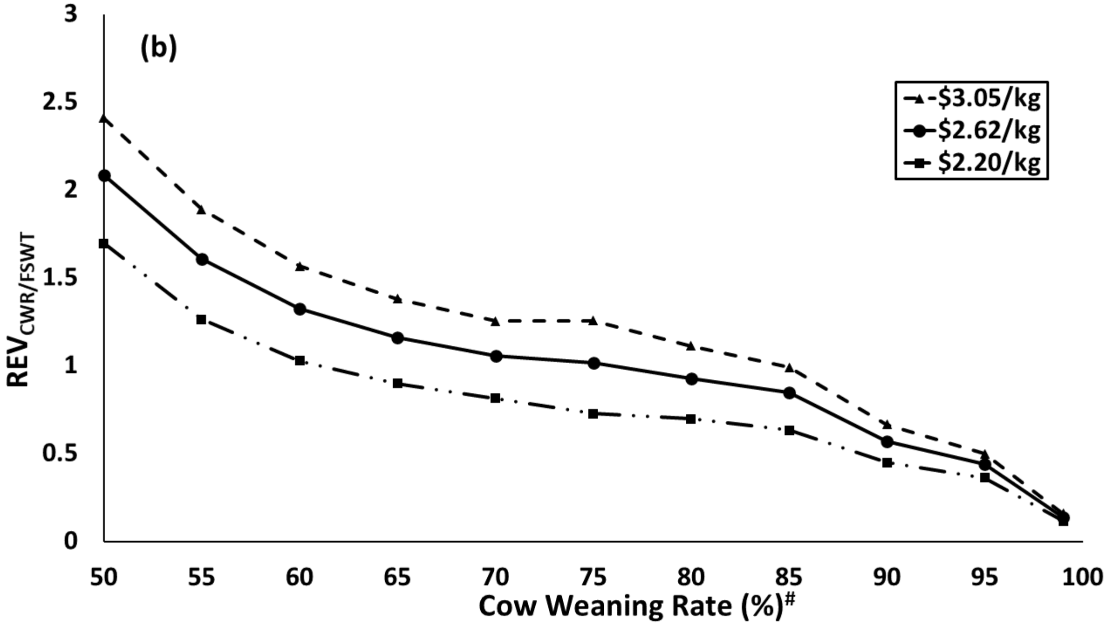


Figure 2. Effect of time horizon (years) and cost of supplementary feed ($/tonne) on the relative economic value (REV) of genetic change in cow weaning rate and finished sale liveweight

The importance of breeding for increases in CWR (objective trait) increases substantially as realised herd weaning rate (production system characteristic) decreases irrespective of the cost of supplementary feed or sale price (Figure 3a,b,c). Even when the cost of feed is low ($180/

tonne) and the sale price is high ($3.05/kg), the highest level of importance of CWR is when realised herd weaning rate is at its lowest at 50% (Figure 3c). When realised herd weaning rate is high (~99%) the relative importance of CWR is low and generally in the range of 0.1-0.2. In the base scenario, CWR is of equivalent importance to FSWT when realised herd weaning rate is 75%. The interactions between the income and cost (feed + management) components of the net return equation (i.e., Δ return - Δ feed cost - Δ management cost) influence the importance of CWR. In Figure 3a and b, increases and decreases in feed cost and the value of sale animals through sale price produced similar patterns of CWR importance indicating that the feed costs explored have an equivalent impact on the cost side of the net return equation to the impacts sale prices had on the income side of the equation. Again, this is consistent with the example described by Barwick et al. (1995). When the impacts of changes in these production characteristics are combined, as would be expected, they have larger effects with CWR having 167% higher importance than FSWT ($REV_{CWR/FSWT}$ = 2.67) when feed is at its cheapest ($180/tonne), sale price is at its highest value ($3.05/kg) and realised herd weaning rate is at its lowest level (50%).





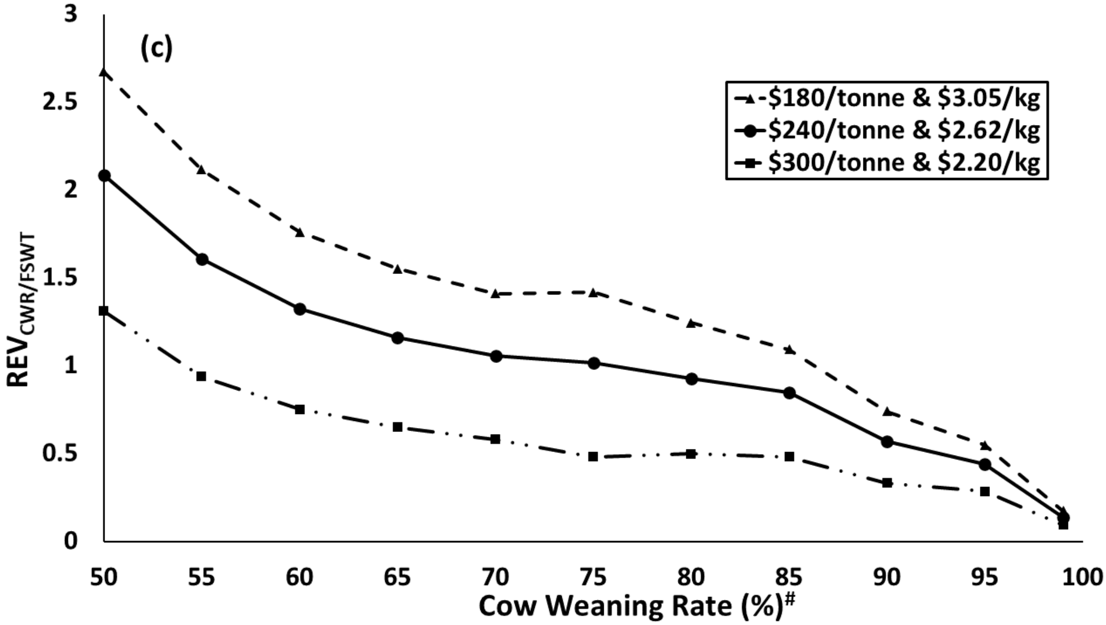


Figure 3. Effect of cow weaning rate (%) and (a) cost of supplementary feed ($/tonne), (b) sale price ($/kg liveweight), and (c) combinations of (a) and (b, $180/tonne and $3.05/kg vs $300/tonne and $2.20/kg) on the relative economic value (REV) of genetic change in cow weaning rate and finished sale liveweight. #Weaning rates below 50% result in herd size decreases violating the assumption of stable herd size

Figure 4 shows the contributions supplementary feed costs and sale price make to the interactions highlighted in Figure 3 independent of realised herd weaning rate. The impact changes in supplementary feed cost have on the importance of CWR are slightly larger than the impacts changes in sale price have. The difference in relative importance of CWR when supplementary feed costs change from \$180/tonne to \$300/tonne and sale price is held at \$2.62/kg liveweight is 0.45. When sale price changes from \$2.20/kg to \$3.05/kg liveweight and supplementary feed cost is held at \$240/tonne the difference is 0.37. In addition, the changes in the value of the sale animal can be seen to have larger impacts when supplementary feed costs are higher (\$300/tonne) highlighting the slightly higher sensitivity of CWR to the cost of production.

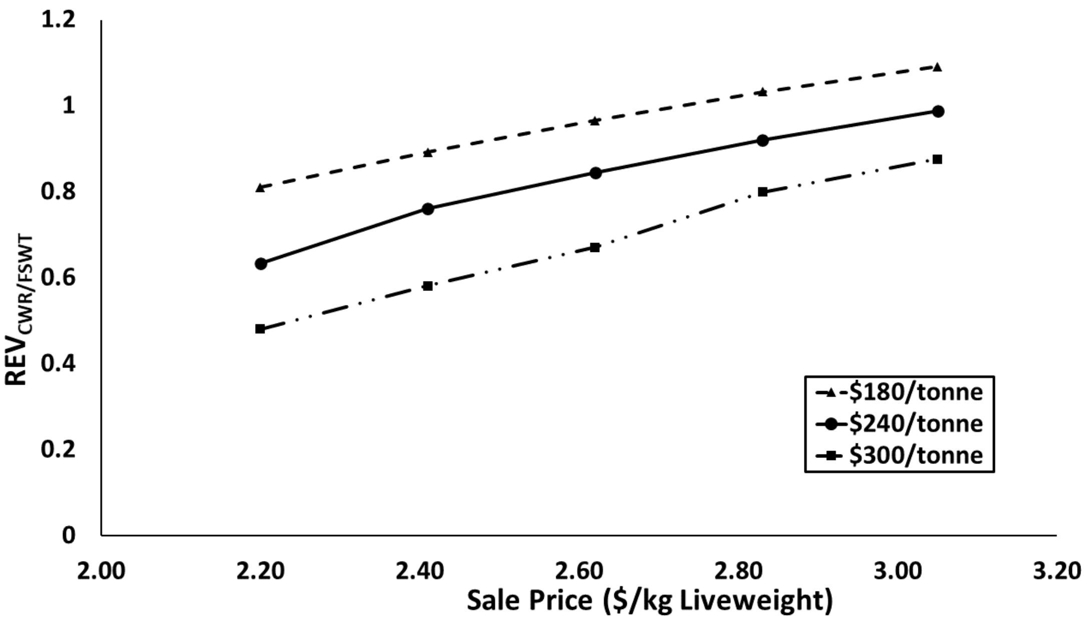


Figure 4. The effect of sale price (\$/kg liveweight) and the cost of supplementary feed (\$/tonne) on the relative economic value (REV) of genetic change in cow weaning rate and finished sale liveweight

The characteristics of the sale animal, namely liveweight and age, have different impacts on the relative importance of CWR independent of realised herd weaning rates and sale price. They also have different interactions with the cost of supplementary feed. When sale age is held constant and FSWT changed from 510 kg to 690 kg, differences in the relative importance of CWR are small (Figure 5a) and in the range of 0.10 to 0.16 when supplementary feed is costed between \$180 and \$300/tonne. In contrast, changes in sale age have dramatic impacts on the relative importance of CWR (Figure 5b). The oscillating pattern seen in the relative importance of CWR is a function of the interaction between sale age and the window of the pinch period (grey highlight) that is exaggerated by the cost of supplementary feed. If supplementary feed cost was made cheaper than the $180/tonne assumed in this exercise there is a point when sale age would have no impact on the relative importance of CWR and the curve equivalent to those in Figure 5b would have a slope of 0. Equally, if supplementary feed cost was made more expensive, the pattern seen in Figure 5b would become more exaggerated and at a point the relative importance of CWR would become negative at older sale ages. The comparatively lower impact of changing FSWT in this example is due to changes in FSWT not interacting with the window of the pinch period even though higher net returns are achieved through increases in FSWT at the same age diluting maintenance costs. In fact, the peak in importance of CWR occurs for all costs of supplementary feed scenarios at the base sale age of 22 months used in this example. This result also highlights that in certain scenarios it is of benefit to increase FSWT at a given age in the breeding objective. This allows animals to actually be sold in the production system at younger ages but the same FSWT and the gains in net return are made by reducing the feed cost component rather than the income component. These oscillations are noticeable in the example described by Barwick et al. (1995), however, the advancements in modelling feed requirement in BreedObject result in greater cost pressures under similar production scenarios as supplementary feed costs increase, producing larger oscillations.

Cow maintenance accounts for 50% of feed costs associated with weight gain in cow-calf systems (Walmsley et al., 2018), thus mature cow weight has important implications for the cost of production and net return. However, mature cow weight has small impacts on the relative importance of CWR even when supplementary feed costs increase or decrease. In the example production system, the differences in relative importance of CWR were in the range between 0.05 and 0.15 (Figure 6), similar to those seen for FSWT in Figure 5a. This small impact is due to the increases in feed requirement associated with increases in mature cow weight being relatively smaller than the increases in feed requirement seen when CWR is increased. However, the relative importance of CWR does gradually reduce as mature cow weight increases due to the associated increases in the cost of production.

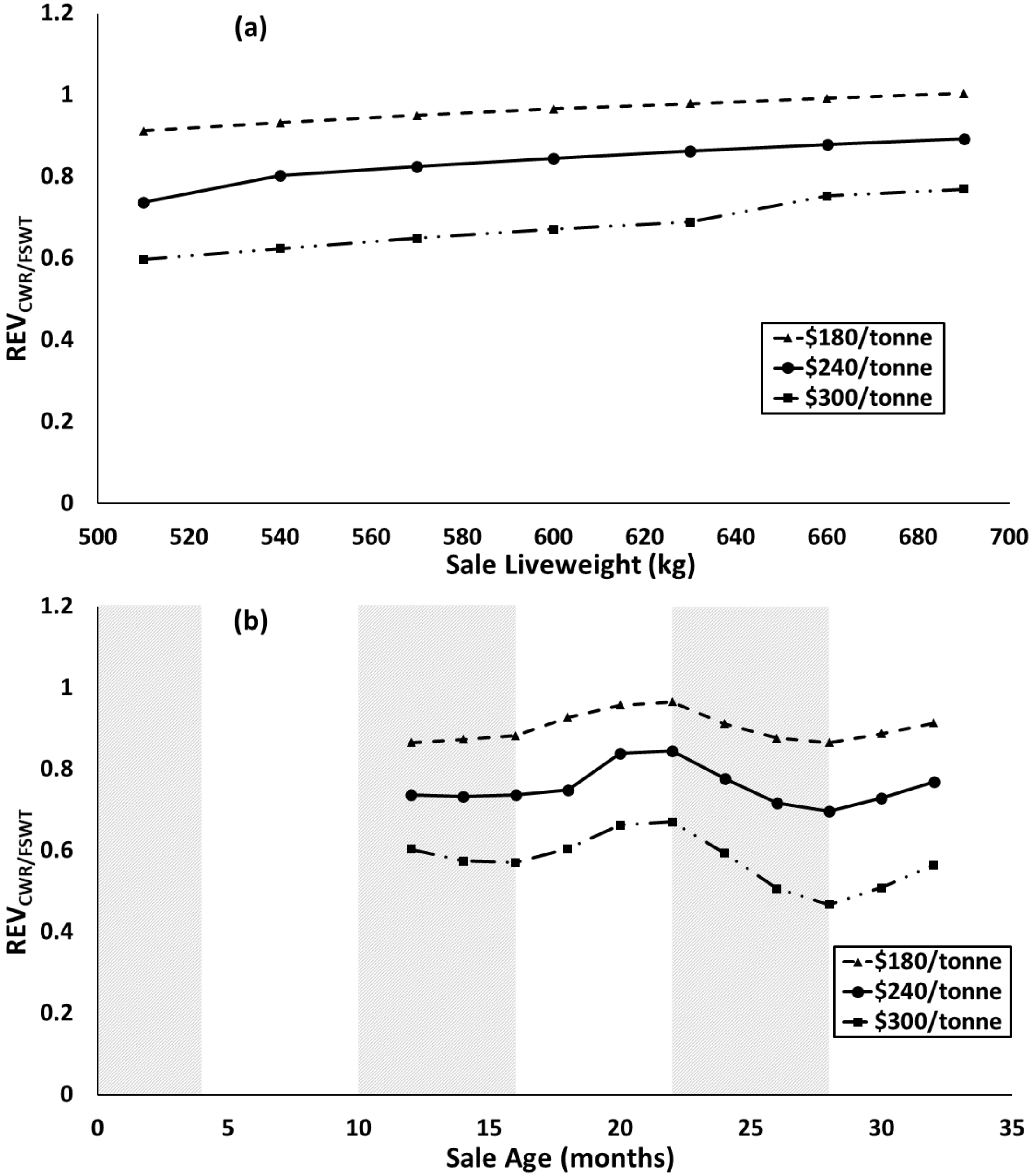


Figure 5. The effect of the cost of supplementary feed ($/tonne) and (a) finished sale liveweight (kg) and (b) sale age (months) on the relative economic value (REV) of genetic change in cow weaning rate and finished sale liveweight. The grey-shaded areas in (b) are the progeny ages that align with when supplementary feed is supplied at a cost

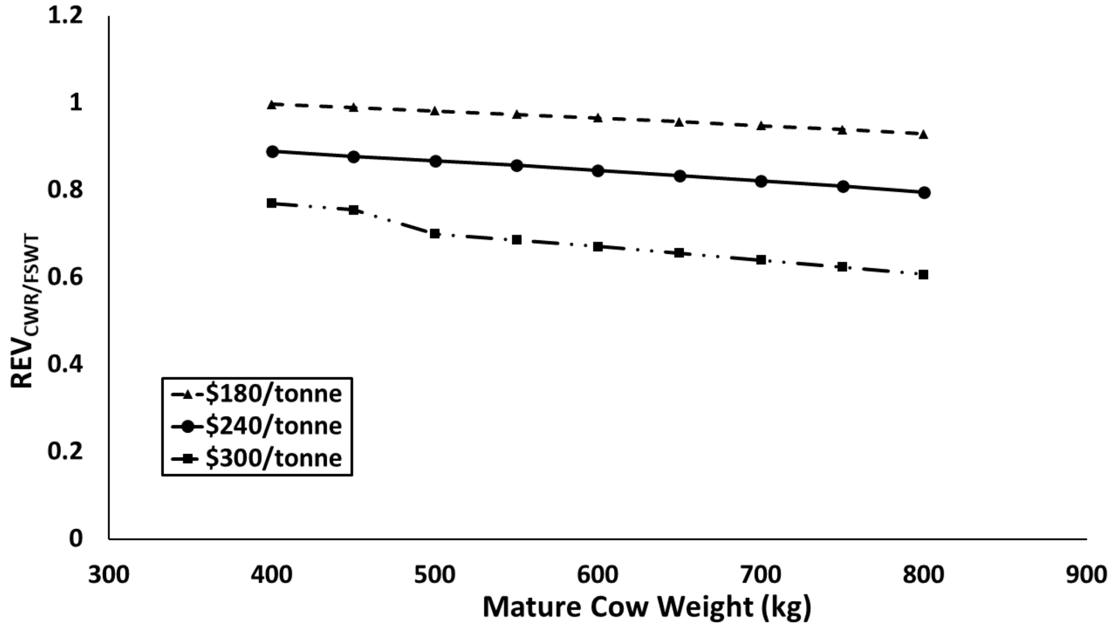


Figure 6. The effect of mature cow weight at joining (kg) and the cost of supplementary feed ($/tonne) on the relative economic value (REV) of genetic change in cow weaning rate and finished sale liveweight

These results show that there are large differences in the relative importance of CWR compared to FSWT when production characteristics change and that in some instances CWR is of greater importance for increasing net return while in others it is not. However, it is consistently observed throughout all the examples explored in this study that the economic value for CWR is always positive and that improving fertility through CWR is seen as one means of increasing net return. There are levels of production characteristics where the relative importance of CWR would become negative and net return would not be increased by improving fertility but in the scenarios explored here the income generated by additional calves weaned was always large enough to overcome the increases in feed requirement and cost generated by that calf, even if marginal in some cases. The impact changes in the cost of supplementary feed has on the relative importance of CWR is also evident in all examples explored. The feed requirements associated with reproduction, the subsequent lactation and managing the additional weaned calf above those required for cow maintenance and liveweight gain place greater pressures on the cost components of the net return equation when feed costs rise. The capacity to extract these relationships is a feature of the new modelling systems developed by Walmsley et al. (2015) and Barwick et al. (2018) and included in the BreedObject indexing software. Although not explored here these new features setup the ability to deal with future challenges such as climate change, in particular, the impacts methane costs have on the perceptions of future feed costs and the flow through to the relative importance of breeding objective traits that have feed costs included in their economic values (Barwick et al. 2019).

Conclusions

There are two major outcomes from this study. The first is that in all instances presented for this example production system CWR has a positive economic value and often placing substantial emphasis on fertility is justified. The second equally important finding is that the economic value and emphasis placed on CWR varies with the characteristics of the production system including large important impacts as a result of the cost of supplementary feed. It follows that the level of importance placed on fertility is a function of the perception of the commercial herd extending into the future for perhaps two to four generations, particularly around the cost of supplementary feed as well as the demands of the market endpoint for the carcass. For this reason, it is best that index development is applied on a case by case basis and the traditional focus on market endpoint(s) is changed to take a better account of the contribution the cow herd makes to commercial profitability.

Acknowledgements

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