With the delivery of its genomic prediction equations in May 2012, the Beef CRC has now achieved all the outputs planned in its 2010 Variation to Commonwealth Agreement’
Beef CRC Governing Board

**Dr Guy Fitzhardinge, Chairman**
Dr Fitzhardinge is a commercial cattle producer from NSW, a past member of the Boards of Meat Research Corporation and Meat and Livestock Australia.

**Dr Keith Steele, Deputy Chairman**
Dr Steele is a business advisor with beef R&D management experience, genomics knowledge and corporate governance and finance skills.

**Mr Rob Backus, non-executive Director**
Mr Backus brings northern beef sector and feedlot expertise and knowledge of the industry relevance of genomics to the Board.

**Ms Emma Robinson, non-executive Director**
Mrs Robinson is a commercial beef producer in central Queensland and has extensive beef enterprise technology extension experience.

**Mr Richard Rains, non-executive Director**
Mr Rains is the Chief Executive Officer of Sanger Australia Pty Ltd, an international meat trading business.

**Ms Robyn Clubb, non-executive Director**
Mrs Clubb has extensive financial, management and accounting experience as well as a strong rural background and operator of a beef cattle enterprise in southern NSW.

**Dr Jay Hetzel, non-executive Director**
Dr Hetzel has worked for over 30 years in cattle genetics and genomics research and commercialisation.

**Dr Greg Robbins, non-executive Director**
Dr Robbins is General Manager of Animal Science for the Queensland Department of Primary Industries and Fisheries (QDPI&F) and former Director of the Queensland Beef Industry Institute.

**Dr Heather Burrow, Chief Executive Officer**
Dr Burrow has extensive research management experience and a quantitative genetics research background.

**Mr Neil Scholes-Robertson, Company Secretary**
Mr Scholes-Robertson holds a Bachelor of Business and is a qualified Chartered Accountant.

**Mission**

To capture the benefits of the human and bovine genome projects and the “Livestock Revolution” by improving the profitability, productivity, animal welfare and responsible resource use of Australian and global beef businesses through worldclass gene discovery and gene expression research and accelerated adoption of beef industry technologies.
The Beef CRC research legacy

It is with very considerable disappointment, but also with an enormous sense of pride that I write this final editorial for the Beef CRC’s final Beef Bulletin.

My disappointment arises because, in spite of the enormous efforts since 2008-2009 to achieve ongoing funding for beef genomics research, we were ultimately not successful. This lack of success should not reflect poorly on any of those many people who so generously contributed their very best efforts to try to achieve new funding. Rather I believe our lack of success reflects the reality of agricultural R&D in Australia at this time, where there is a very limited amount of funding available, particularly for transformational research, in spite of the many major global challenges now faced by agricultural R&D. The need for ongoing R&D to improve the productivity and profitability of Australian beef enterprises, whilst simultaneously improving the production resource base, will not disappear just because the Beef CRC has closed its doors. Hopefully new champions in other organisations will now take up the challenge of finding the urgently needed funding to continue this research.

My pride arises from the Beef CRC’s extraordinary accomplishments over its three successive terms. Prior to the advent of the Beef CRC in 1993, I and many of the CRC’s researchers of that time were already investigating components of the issues tackled by the CRC – meat quality, feed efficiency and the possible trade-offs with reproductive performance and adaptation of the breeding herd. But we were doing so at a regional level and often in competition with other research groups across Australia. And our impact was primarily limited local uptake of our research results. And our impact was primarily level and often in competition with other research groups across Australia. And our impact was primarily limited local uptake of our research results.

The advent of the Beef CRC delivered for the very first time in the history of Australian R&D, a national focus on a major beef industry issue: “Can we guarantee the eating quality of beef from the vast array of production systems across Australia?”

Through multi-organisational, multi-disciplinary research focused entirely on delivery of benefits for all sectors of the Australian beef industry, we were able to unequivocally respond in the affirmative to that major question. Outcomes from the first two Beef CRC terms include the science underpinning Meat Standards Australia (MSA), Australia’s unique meat grading scheme that guarantees the eating quality of beef and more recently sheep meat based on consumer preferences of palatability. They also include increased genetic gains through new traits in BREEDPLAN, two new vaccines to control Bovine Respiratory Disease in cattle, crossbreeding strategies for northern Australia, pre-boosting strategies to improve performance of cattle in feedlots, growth path and transport effects on beef eating quality, cattle welfare improvement strategies, new environmental guidelines for recycling of feedlot waste, strategies to reduce pathogen loads on cattle prior to slaughter to improve food safety and entirely new under-graduate, post-graduate and vocational level educational courses.

In the Beef CRC’s third term, we markedly changed our research focus to address the new challenges of the genomics era. Our research continued to target national issues, this time to improve the productivity of beef businesses across the entire beef value chain using cattle of known genetic merit. However in the previous Beef CRC terms we were able to use the methods of very well-established, mature sciences. In the current term, we were required to simultaneously deliver our beef industry outcomes whilst also developing the new sciences of genomics and bioinformatics. Over the past seven years, the CRC encountered major challenges associated with the very rapid changes in these technologies, over what is now recognised as perhaps the most turbulent period in the history of biological science. Having overcome those major challenges and delivered the CRC’s genomic predictions (amongst many other products) to BREEDPLAN, the genomics companies and the Australian beef industry, I am now very confident that the impact of this third Beef CRC term will be every bit as transformational as the previous two Beef CRC terms, with all sectors of the Australian beef industry being primary beneficiaries.

In closing I would like to pay very generous and most sincere thanks to all those CRC staff, partners, collaborators, Directors, Advisory Committee members and sponsors of each Beef CRC term for their dedication, enthusiasm, commitment and perseverance to deliver such extraordinary outcomes for the Australian beef industry. Congratulations and well done to you all, and may you continue to practise the strong lessons learned from collaborative and innovative research, development, education and industry delivery!
Muscling all gain, little pain

NSW DPI researcher says producers should not be wary of increasing the muscling in their cow herd.
Beef cattle breeders have long regarded muscling as a double-edged sword. Increased muscling is desirable, because it increases beef yield and income. However, it is undesirable, because it is perceived to adversely affect meat quality and fertility. But it turns out that the undesirable qualities don’t really exist.

In fact, reported NSW Department of Primary Industries researcher Dr Linda Cafe, selecting for muscling in beef cattle seems to be all gain, no pain. “When you look at the positives of increasing muscling in performance and returns, there are really no drawbacks that we could find in cattle that did not carry two copies of the myostatin,” Linda said.

The Beef CRC research project took advantage of an Angus “muscle line” herd established in the early 1990s by NSW DPI researcher Bill McKiernan. The herd demonstrates extremes within the Angus breed - low muscling, high muscling cattle carrying one copy of a myostatin deletion, the “double muscling” gene that helps give the Belgian Blue breed its bodybuilder physique (the Belgian Blue breed generally carry two copies of the myostatin gene).

The high-muscle cows were joined to myostatin-carrying Angus bulls (A muscle score) and the myostatin cows were joined to highly muscled Angus bulls (B+ muscle score) that didn’t carry the myostatin gene. The low-muscle cattle were joined to Angus bulls with muscle scores around D.

The herd joined the Beef CRC research program in 2009 thanks to additional funding from MLA. Steer progeny from two year’s joinings were assessed for growth, efficiency and carcase traits and 10 years of data from heifers and cows were used to study maternal productivity traits.

The researchers’ first conclusion, confirming what beef producers already know, was that extra muscling is definitely a path to greater productivity. For every unit increase in live muscle score, steers delivered on average a 0.8 per cent increase in dressing percentage and a 1.2 per cent increase in meat yield.

Although steers from the three lines had adequate fatness, those carrying one copy of the myostatin gene showed a slight reduction in fat. For instance, a breakdown of carcase yield showed an average of 12.9 per cent fat for low-muscle steers and 12.8 per cent for high-muscle animals. Steers having one copy of the myostatin gene had an average of 10.2 per cent fat.

In feedlot trials, low-muscle steers ate more for the same gain per day as their high-muscle and myostatin counterparts, meaning that net feed efficiency improved as muscling increased.

What the researchers didn’t find was a downside to these benefits. There was no hit to meat quality in having extra muscling, Linda said, and no meaningful difference in overall growth rates or final weights.

And counter to a long-held industry belief, there was no difference in maternal productivity between high- and low-muscle cows under a range of environmental conditions. As muscling increases, fatness decreases, but weaning rates and weights did not differ with increased muscling.

That appears to contradict another recently wrapped-up Beef CRC investigation, the Maternal Productivity Project, which found an association between the Rib Fat Estimated Breeding Value (EBV) and female fertility - the more rib fat, the higher the fertility, particularly in heifers.

But Linda pointed out that the findings on muscle and fat are not really contradictory. “Both muscle and fat provide sources of energy for an animal to draw on to maintain body function,” she said. “A higher muscled cow may have a bit less fat but will still have good body energy reserves. The Maternal Productivity and Muscling projects are both indicating that selection for more flesh is beneficial for female productivity.”

Linda’s project is also looking at female productivity under nutritional challenge. Preliminary results are indicating that the more extremely muscled cows having one copy of the myostatin gene may be at a slight disadvantage under low nutrition.

Although cows from the three lines lost the same amount of weight when run on low nutrition, after 18 months the calving rates of myostatin-carrying cows dropped below the other two lines. “We had to really push the cows in tough conditions to cause this difference. That research will continue for another year to look at longer term effects.”

There has been no indication that cows with increased muscling have had poorer survival or a higher need for supplementation under low nutrition. Linda’s conclusion: producers should not be wary of increasing the muscling in their cow herd. If they want to have the extra muscling performance that myostatin can provide, but are going to run the herd under low nutrition, she suggested that they use myostatin-carrying bulls as terminal sires. It is important though that producers avoid cattle with two copies of the myostatin gene to avoid other problems known to arise from that combination of genes.
CASE STUDY: KIDMAN AND CO

Kidman seeks an animal adapted enough for the conditions on its northern properties, but with improved fertility, growth and feedlot performance over the traditional northern breeds. They prefer polled cattle.

Kidman has followed the success of earlier breeders of tropical composite cattle, particularly NAPCO, and taken a close interest in the genetics comparative trials within the three Beef CRCs.

Given the demonstrated prospect of composite cattle delivering a significant increase in fertility while at least maintaining other traits, Kidman is developing a tropical composite focussed on the Company’s particular requirements.

Our two particular demands are:

1. **Heat tolerance.** Heat tolerance is not just to cope with the treeless grasslands of the Barkly Tablelands but also the threat of increasing summer heat during the peak northern calving period. Research by Virginia Finch and others at CSIRO Rockhampton in the early 1980s had shown the advantages of a light coloured and smooth, flat coat in resisting solar radiation heat inflow. Heat inflows to a black coat were 58% higher than to a white coat and small rises above a 38.5 degree body temperature had been shown to cause stress, limit food intake and therefore reduce weight gain and reproductive performance. Coat colour weight gain differences were up to 0.2 kg/day under high solar radiation (no shade). Kidman prefer a light coloured slick coat for their tropical cattle.

2. **Polled cattle.**

The Kidman way

A four breed composite was chosen to retain up to 75% of maximum hybrid vigour. A strong influence in the choice of breeds was the large number of Charbray cattle already in place. These cattle have Brahman content ranging from 50% to 75%, have good survivability; medium to large frames and grow out to good carcase weights. Two concerns are low fertility and slower finishing.

The two other breeds chosen are Murray Grey and Tuli to produce what is known as the Coolibah Composite, comprising approximately a quarter each of the four breeds.

The Murray Greys are well structured, docile cattle with moderate frames. They show early puberty, re-conceive readily while lactating and give a well finished high quality carcase at an early age. While a good number have light coloured slick coats, they are not tropically adapted. They are homozygous polled.

The Tulis are a tropically adapted African Sanga (Bos taurus) with early maturity, high fertility and low birth weights. Tulis have small to moderate frames, white to red slick coats, have good carcase traits and a good percentage are polled.

To progress the development of its composite, in

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“Unfortunately, poor recording among many Brahman and Charbray seedstock suppliers creates a particular difficulty for identifying those cattle likely to advance the breeds and capable of delivering selected traits into a composite breed.”

By Greg Campbell, MD, S.Kidman & Co.

"When it comes to cattle, Kidman’s eyes are wide open"
early 2007 Kidman purchased the 120 cow Tuli stud herd developed by NAPCO and is maintaining this stud at 150 cows. The Murray Grey genetics were initially sourced by contracting the Willalooka Stud to breed the F1 Tuli Greys. Willalooka was selected because of that herd’s low birthweight and good growth, having produced several pre-eminent sires within the breed. Kidman have since purchased the Willalooka stud and continue to search the breed for outcross inclusions.

The Coolibah Composite has principally been developed by crossing F1 Tuli Grey bulls with Charbray breeders. Tuli Grey heifers have also been mated to selected Charbray bulls, mostly through artificial insemination.

The Coolibah Composite cattle are being trialled in side by side comparisons with matched Brahman and Charbray cattle at two locations in the dry tropics of northern Australia; Ruby Plains (East Kimberley) and Helen Springs (Barkly Tableland). While cattle are not exposed to cattle tick, buffalo fly densities can be high in summer.

Summer heat and humidity and dry season nutritional deficits can be substantial limits to production at both locations.

Results

Five calvings of F1 Tuli Greys have been achieved from both the Tuli herd at Morney Plains (Qld Channel Country) and the Willalooka Murray Grey herd (south-east SA). Very few calving difficulties have been experienced except for an increase in the number of twins. Coat colours are even with the majority falling into the lighter grey and cream ranges, although around 25% have dark grey, red or black coats. The F1s are generally well structured, have good temperament and have moderate to slick coats. Some of the rejects have been lotted for 120 days achieving between 2.0 and 2.1 kg/day for both heifers and steers.

Three drops of full Coolibah Composite calves have now been achieved. All Coolibah calves have been born into the heat of the northern summer and heat stress mortality has been minimal and no different to that in the comparative herds. Coat scores have averaged 2.6, the same as the Charbrays. The Coolibah steers at 200 days averaged 11 kg heavier than their comparative trial mates. The 400 day weights have been 13 kg in favour of the Coolibahs. The first finished bullocks in this comparative trial are expected to turn out of the channel country in August this year. The majority of the first Coolibah heifers and their trial mates were control mated as two year olds this summer with their first preg test due in May. In an inevitable trial mishap, a small number got in calf to a Coolibah bull at 15 months and have now calved.

Challenges Ahead

The search for particular strengths in genetic traits, like low birth-weight or positive rib fat, is especially difficult.

FAST FACTS

• S. Kidman & Co is Australia’s largest private landholder and third largest beef producer.
• The Company runs approximately 80,000 Brahman/Charbray cattle in the tropical savannahs and 100,000 Santa Gertrudis cattle across northern South Australia and the Queensland channel country.
• 20-30,000 Brahman/Charbrays are transferred annually from northern properties to be grown out and fattened among the “Santas”.
• After survival, the greatest profit driver is fertility, but growth and good weight for age finishing are also critically important to business success.
• Project for the new 700K SNP chips.
The large Brahman and Charbray herds in northern Australia represent a vast gene pool which should offer great potential to advance the breeds. Unfortunately, poor recording among many Brahman and Charbray seedstock suppliers creates a particular difficulty for identifying those cattle likely to advance the breeds and capable of delivering selected traits into a composite breed.

The search for particular strengths in traits, like low birthweight or positive rib fat, is especially difficult. The limited use of BREEDPLAN will also hinder the ability of these breeds to benefit from the proposed genomic prediction equations likely to enhance the accuracies of existing BREEDPLAN traits.

By contrast, the Murray Grey herds are much smaller and hold a smaller gene pool, but the majority of seedstock producers record well, making the best of the breed’s genetics known and available and making BREEDPLAN a very useful search tool for particular trait strengths.

Tuli cattle in Australia represent a very narrow gene pool, mostly due to the immense quarantine difficulties in sourcing additional genetics from outside Australia.

Fortunately many Tuli breeders within South Africa keep good pedigree and performance records, as did a number of the breeders formerly within Zimbabwe. The pedigrees of the initial Australian imports are known and with additional work on traceback, the tracing forward into South African herds for Tuli lines not imported to Australia should be possible. Genetic imports from South Africa must come via embryos. Kidman are still three years away from proving the performance of their Coolibah Composite cattle in the tropical savannas and only at that point, would the importation of additional new Tuli genetics become a priority.

Kidman are preparing data for BREEDPLAN lodgement on the Tropical Composite (Belmont) Register for their Tuli, Tuli Grey and Coolibah stud cattle.

"Kidman are preparing data for BREEDPLAN lodgement on the Tropical Composite (Belmont) Register for their Tuli, Tuli Grey and Coolibah stud cattle."
Simultaneously Improving Productive and Adaptive Traits in Tropically Adapted Cattle

Environmental stressors such as parasites, poor nutrition and high heat and humidity affect the growth and reproductive performance of cattle grazed in tropical and sub-tropical areas. Beef CRC research shows that breeding cattle that are productive in the presence of such stressors is the best approach.

Stressors faced by cattle in the tropics and sub-tropics

Cattle grazed at pasture in tropical and sub-tropical areas experience numerous environmental stressors that reduce the growth and reproductive performance of animals and decrease their beef quality. The stressors include parasites (cattle ticks, buffalo flies, gastrointestinal helminths or worms), seasonally poor nutrition, high heat and humidity and diseases, often transmitted by parasites.

The impact of each stressor on production and animal welfare is often multiplicative rather than additive, particularly when animals are already undergoing physiological stress such as lactation. Hence under highly stressful conditions, cattle deaths can occur due to the stressors. Under extensive production systems common in the tropics it is generally not possible to control the stressors through management strategies alone. Therefore the best method of reducing the impact of the stressors to improve productivity and animal welfare is to breed cattle that are productive in their presence, without the need for managerial interventions.

Consider the impacts of productive and adaptive traits

In every production environment, factors limit beef production, meaning no one breed is best in all environments. Comparative rankings of different cattle breed types for different characteristics in tropical environments are shown in Table 1. Any cattle breeding program designed for the tropics and sub-tropics must consider the impacts of both productive and adaptive traits, even though the adaptive traits (and some productive traits) are very difficult and/or expensive to measure. However the differing impacts of environmental stressors across the breed types indicates that genetic parameters and economic weightings for use in selection indexes must be specific for each breed type and environment.

<table>
<thead>
<tr>
<th>Breed type</th>
<th>Temperate Bos taurus</th>
<th>Tropical Bos taurus (Sanga)</th>
<th>Bos indicus Brahman</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>British</td>
<td>Continental</td>
<td></td>
</tr>
<tr>
<td>Productive traits:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Growth</td>
<td>★★★★★★</td>
<td>★★★★★★★★</td>
<td>★★★★★★★★</td>
</tr>
<tr>
<td>Fertility</td>
<td>★★★★★★</td>
<td>★★★★★★★★</td>
<td>★★★★★★★★</td>
</tr>
<tr>
<td>Mature size</td>
<td>★★★★★★★★</td>
<td>★★★★★★★★</td>
<td>★★★★★★★★</td>
</tr>
<tr>
<td>Beef Quality</td>
<td>★★★★★★★★</td>
<td>★★★★★★★★</td>
<td>★★★★★★★★</td>
</tr>
<tr>
<td>Adaptive traits:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cattle ticks</td>
<td>★</td>
<td>★</td>
<td>★★★★★★★★</td>
</tr>
<tr>
<td>Worms</td>
<td>★★★★★★★</td>
<td>★★★★★★★</td>
<td>★★★★★★★</td>
</tr>
<tr>
<td>Eye disease</td>
<td>★★★★★★★</td>
<td>★★★★★★★</td>
<td>★★★★★★★</td>
</tr>
<tr>
<td>Heat</td>
<td>★★★★★★★</td>
<td>★★★★★★★</td>
<td>★★★★★★★</td>
</tr>
<tr>
<td>Drought</td>
<td>★★★★★★★</td>
<td>★★★★★★★</td>
<td>★★★★★★★</td>
</tr>
</tbody>
</table>

Comparative rankings of different breed types for productive and adaptive traits in tropical environments (the more stars the higher the value for the trait)

FAST FACTS

- There are more sources of genetic variation in tropical beef breeding programs due to environmental stressors (e.g. parasites, seasonally poor nutrition, high heat and humidity, and endemic diseases).
- Treatments to control the stressors under extensive tropical production systems are generally not possible.
- Some cattle breeds are much better adapted to the stressors but no one breed is ‘best’ in all environments.
- The best way to reduce the impacts of the stressors to improve productivity and cattle welfare is to breed cattle that are productive in their presence.
- It is possible to simultaneously genetically improve both productive and adaptive traits in tropical cattle in tropical environments without major impacts on adaptation or production.
Simultaneous Genetic Improvement of Productive and Adaptive Traits

For traits to be included in effective breeding programs, they must be under direct or indirect genetic control. Direct genetic control is assessed by estimating the heritability of traits. Indirect control is achieved through favourable or unfavourable associations (genetic correlations) between different traits.

Beef CRC and earlier research primarily from northern Australia indicates that all the key productive and adaptive traits are at least moderately heritable in tropically adapted cattle reared at pasture in tropical environments, meaning they will respond to genetic improvement through crossbreeding and within-breed selection programs. In addition, no major antagonistic relationships have been found that would preclude simultaneous genetic improvement of all the traits in tropical beef breeding objectives. Studies at Belmont Research Station near Rockhampton showed that resistance to parasites and productive attributes such as growth and reproduction are largely genetically (though not phenotypically) independent, meaning selection for parasite resistance will not genetically change productive attributes or vice versa. However resistance to heat stress and productive attributes are favourably correlated, particularly in breeds that are not as well adapted as the Brahman, meaning that selection for growth or reproduction will improve resistance to heat stress and vice versa.

Strategies to maximise adaptation and production in different environments

Based on extensive reviews of the scientific literature, the Beef CRC has developed a number of ‘rules of thumb’ to optimally match cattle ‘genotypes’ (breeds or sire lines) to their production and marketing environments. These ‘rules of thumb’ as they apply to crossbreeding systems include:

- Depending on the severity of the environment and the level of stressor challenge, 25% to 75% ‘adapted genes’ are required for optimal production. Only exceptionally stressful environments (rare in Australia) require 100% ‘adapted genes’.
- Adapted genes can be derived from Bos indicus and their derivatives as well as the tropically adapted taurine breeds, providing an opportunity to use heterosis from crossbreeding and to maximise productivity without reducing resistance to environmental stressors below levels acceptable for the production environment.
- For most tropical environments, optimal levels of productivity and adaptation will be achieved using a combination of multiple breed types (e.g. Bos indicus, tropically adapted taurine, British, Continental).
- The harsher and the wetter the environment, the greater the need for some Bos indicus content to ensure sufficient adaptation to parasites (mainly ticks and worms).

Summary

In breeds that are well adapted to their production environment, there are no major antagonistic relationships to preclude simultaneous genetic improvement of both productive and adaptive traits through selection to maximise herd profitability. The major constraint to such genetic improvement is the difficulty and expense of measuring the complete range of economically important productive and adaptive traits required to achieve a balanced breeding objective. This same constraint also applies to genomic selection using DNA-based technologies, which offers new opportunities for tropical beef producers. Until phenotypes for these traits become available, beef producers in the tropics can confidently select to improve productive attributes in their cattle, knowing they are unlikely to compromise adaptation of their herds.

“The best method of reducing the impact of the stressors to improve productivity and animal welfare is to breed cattle that are productive in their presence, without the need for managerial interventions.”

Dr Heather Burrow
Effect of Supplementation and Age of Slaughter on Marbling

To maintain market share in valuable export markets that demand a premium quality product it is crucial that Australian beef producers consistently produce high quality beef.

The value of post-weaning nutritional treatments before feedlot entry to maximise marbling was investigated by the Beef CRC in beef cattle with a high genetic capacity to marble.

What is Marbling?

- Marbling is the intramuscular fat (IMF), or adipose tissue, deposited in connective tissue seams that surround bundles of muscle fibres in beef and is visible to the human eye as ‘flecks’ or spots of fat.
- Marbling is scored visually whereas IMF percentage is the fat content of the muscle measured chemically or by ultrasound scanning.
- Large consumer studies with cooked beef confirm that marbling improves eating quality. IMF directly affects juiciness and flavour and indirectly affects tenderness.

Previous research has shown the best way of increasing marbling is to finish cattle with a genetic propensity to marble on a highly digestible, grain-based diet. This provides the highest level of net energy and promotes fat deposition.

Investigating strategic post weaning nutrition

165 six month-old steers representing either high or low marbling genotypes were used to determine whether high energy supplement during the immediate post-weaning period enhances marbling. The steers were selected using IMF Estimated Breeding Values (EBVs) provided from sire line or individual animal information.

Nutrition

In this study, steers were yard weaned and fed lucerne hay for a week on arrival at Glen Innes Research Station in NSW. Steers were then divided into two nutritional treatments for 168 days. The treatments were:

1. Pasture only – initial grazing on improved New England perennial pasture (nitrogen fertilised Cocksfoot, Tall Fescue and Phalaris) rotated with ryegrass and grazing oats.
2. Pasture + Supplement – grazing on improved New England perennial pasture plus high energy, low protein pellets (12.3 MJ ME/kg DM, 110 g CP/kg DM) at 1% live weight per day.

During the nutritional treatment the pasture available to the cattle was managed so cattle growth rates did not differ between the treatments. Steers were then backgrounded until feedlot entry at 18

FAST FACTS

- Marbling is considered “late maturing”, meaning that higher levels of marbling are usually seen later in life, as the animal matures.
- Use of a high energy supplement during the immediate post-weaning period does not enhance chiller assessed marbling after feedlotting.
- Providing feeder cattle with high quality improved pastures post-weaning and during backgrounding will maximise marbling potential.
- Use Intramuscular Fat% EBVs to select cattle with a high genetic capacity to marble if targeting export markets that pay a premium for marbled beef, for example Japan and Korea.
months of age where steers were either short-fed or long-fed for 100 and 250 days, respectively. Live weight did not differ due to nutritional treatment at any stage of the experiment.

**Slaughter**

At the following 5 time points during the trial steers from each nutritional treatment were slaughtered at the Northern Co-Operative Meat Company, Casino NSW. The time points were:

1. at weaning before commencement of the nutritional treatment (6 months)
2. at the end of the nutrition treatment (12 months)
3. at the end of backgrounding (18 months)
4. Short-fed (21 months)
5. Long-fed (26 months)

**Focus on genetics and management but not high energy supplementation**

Use of high energy supplementation immediately after weaning did not enhance chiller assessed marbling, as determined by MSA marble score (Figure 1).

Hot Standard Carcass Weight (HSCW), subcutaneous rib and P8 fat depths and MSA marble score increased with the age of the steers for genotypes selected for high or low marbling and nutritional regime.

High marbling genotype steers had a higher average MSA marble score cf. the low marbling genotype steers throughout the study.

Longer time in the feedlot (100 days vs. 250 days) was associated with increased MSA marbling score for all groups. After 100 days on feed, the high marbling genotype steers had an average MSA marbling score more than 100 points higher than the low marbling genotype steers (Table 1). After 250 days on feed, the high marbling genotype steers had an average MSA marbling score of 618 compared with 422 for the low marbling genotype steers.

**Summary**

Use of a high energy supplement during the immediate post-weaning period did not enhance marbling in Australian beef cattle with a high genetic capacity to marble. Breeding or buying steers with a high genetic capacity to marble and providing them high quality improved pastures post-weaning and during backgrounding is the most efficient way of ensuring feeder steers will reach maximum marbling potential.

However if post-weaning supplementation is required to meet market specifications, balance the diet for protein and energy rather than energy alone and select supplements depending on the stage of growth of the animal.

There is no advantage in feeding high energy rations as supplements post weaning to achieve a high marbling outcome.

**Figure 1:** Change in MSA Marble Score over time

<table>
<thead>
<tr>
<th>Marbling genotype</th>
<th>HSCW (kg)</th>
<th>Ossification Score</th>
<th>MSA marble score</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Pasture only</td>
<td>Pasture + supplement</td>
<td>Pasture only</td>
</tr>
<tr>
<td>Short-fed (100d)</td>
<td>Low</td>
<td>379</td>
<td>138</td>
</tr>
<tr>
<td></td>
<td>High</td>
<td>383</td>
<td>136</td>
</tr>
<tr>
<td>Long-fed (250d)</td>
<td>Low</td>
<td>451</td>
<td>159</td>
</tr>
<tr>
<td></td>
<td>High</td>
<td>468</td>
<td>154</td>
</tr>
</tbody>
</table>

**Table 1:** Effect of marbling genotype, post weaning nutrition and days on feed on HSCW, Ossification Score and MSA Marble Score (adjusted for initial live weight due to differences between genotypes)
BeefSpecs - a Tool to Improve Beef Cattle Market Compliance and Profitability

Failure to meet market specifications represents a significant cost to the Australian beef industry. For each market, correct carcass weight and P8 fat is critical for compliance. BeefSpecs, a simple real-time computer-based fat calculator to assist producers make on-farm animal management decisions to improve target market compliance.

The importance of meeting market specifications

Beef producers continually make management decisions that impact on both the capacity of their cattle to meet market specifications and the profitability of their beef businesses. Up to 25% of Australian cattle fail to meet targets for hot standard carcass weight (HSCW) and fat specifications, at a cost of between $15 and $30 a head, depending on the target market.

The BeefSpecs approach

BeefSpecs is based on the assumption that an animal of a given type has a defined body composition (fat and lean) when it is treated in a certain manner (management) and is achieving a certain growth rate (performance).

BeefSpecs combines the predictive powers of animal growth and compositional models with information relating to animal growth and fatness in response to changes in the production environment to calculate final liveweight and predict P8 fat.

BeefSpecs has the ability to be highly functional across a wide range of production environments. In addition, BeefSpecs requires relatively few animal inputs that are practically feasible for producers to collect on-farm.

BeefSpecs predicts the final liveweight, P8 fat (mm) and HSCW (given a dressing percentage) at the end of a feeding period, for example at slaughter, based on inputs for three areas: Animal Type, Management and Performance.

- **Animal Type** is described by frame score, sex and breed content (British, European, Bos indicus)
- **Management** describes HGP implant status (Yes or No), HGP type (androsten or oestrogen), time of implanting relative to the start of the feeding period (days) and feed type (grass or grain)
- **Performance** is based on growth rate (kg/day), time on feed (days), dressing percentage, initial weight (kg) and initial P8 fat (mm).

“The overall aim of BeefSpecs has been to assist beef producers make production decisions that assist them to manage their cattle to better meet market specifications for domestic and international markets.”

Bill McKiernan

**FAST FACTS**

- Meeting target market specifications is critical to receive the best price per kilogram
- Weight (kg) and P8 fat (mm) are major beef market specifications
- Studies show the rate of non-compliance for weight and P8 fat specifications can be over 20%
- With relatively few inputs including expected growth rate, it is possible for producers to predict future liveweight and P8 fat of their animals using BeefSpecs
- Producers can use BeefSpecs to assist making management decisions, for example manipulating growth rate, to assist in meeting target market specifications
Running BeefSpecs

BeefSpecs is a computer based tool with three input screens: “Animal Type”, “Management” and “Performance”. Screen shots demonstrate the inputs required to run the BeefSpecs calculator. On the right-hand side of each screen the liveweight, P8 fat and HSCW predictions. The RUN button needs to be pressed each time changes are made to the inputs, but because the model runs in real-time it can be used quickly and easily used in cattle yards given the right technology.

In screen 1, “Animal Type,” the inputs are: frame score (estimated or measured), sex (heifer or steer) and breed type composition (actual or estimated using a graphic display). The graphic display provides a representation of how animals may look given a certain breed type composition. By moving the cursor within the bounds of the breed type triangle the animal image will morph between three breed types: European, British and Bos indicus. Comparing the animal image to cattle producers see in front of them will enable breed type composition to be captured for input into BeefSpecs.

In screen 2, “Management,” the inputs are: feed type (grain or grass) and HGP use (yes or no).

In screen 3, “Performance,” the inputs are: expected growth rate (based on producer’s past experience with the feed available), expected days on feed, expected dressing percentage, initial liveweight and initial P8 fat.

On the right hand side of each screen capture, the results section reports predicted final liveweight (kg), P8 fat (mm) and HSCW. Predictions are recalculated following changes in inputs by pressing the RUN button. For example it is possible to change the days on feed in the example shown from 120 to 90, press RUN and attain an updated prediction for final liveweight, P8 fat and HSCW.

Summary

BeefSpecs is designed to assist beef producers make production decisions that allow them to manage their cattle to better meet market specifications. Knowing predicted final liveweight and P8 fat will assist producers implement on-farm strategies to achieve a desired product for meeting market specifications with the type of cattle they currently have. In addition, BeefSpecs allows producers to investigate the impacts of long term management changes in animal type (e.g. breed type, frame score) on performance and end market compliance.

A version of BeefSpecs can be obtained by attending a BeefSpecs course run by various state agencies or from the NSW DPI website: http://www.beefspecs.agriculture.nsw.gov.au

Beef Bulletin July 2012
What is the role of DNA?

Animals and plants are made up of cells. Most cells have a nucleus, which contains the chromosomes that hold the genetic blueprint for all living cells. Chromosomes are composed of deoxyribose nucleic acid, or DNA. One copy of each chromosome pair is inherited from each parent.

The characteristics of all living organisms are determined by information contained within the DNA. Animals that have different characteristics have different DNA sequences.

DNA looks something like a long ladder twisted into a helix, or coil. The “sides” of the ladder are formed by a backbone of sugar and phosphate molecules, and the “rungs” consist of bases joined weakly in the middle as shown in Figure 1. The bases are the key to DNA functioning as a source of genetic information.

There are four different bases: A – Adenine, T – Thyamine, G – Guanine, C – Cytosine. In the double helix structure of a DNA molecule G always partners C, and A always partners T to form pairs of bases. There are approximately 3 billion base pairs in bovine (cattle) DNA. The sequence of these base pairs contains the ‘message’ in DNA. Sequence differences form the basis for differences between animals in their genetic merit.

When the sequence differs at a single nucleotide it is called a single nucleotide polymorphism (abbreviated to SNP—pronounced snip—shown in Figure 2). When the sequence occurs as a repeat of two or three base pairs—for example, CACACACACA—it is called a microsatellite.
**DNA BASICS**

**What is a Gene?**

A gene is a specific sequence of base pairs at a particular location on the chromosome. It codes for a specific product that generally has an effect on cell function. It is estimated there are between 22,000 and 28,000 genes in a beef or dairy animal. The genes are separated on the chromosome by DNA sequences that do not code for a specific product but do form part of the animal’s genetic makeup. These sequences are also referred to here as genes.

For each gene, there may be two or more forms (known as alleles) that can result in different observable phenotypes (measurements of traits in animals). For example, different alleles for one gene influencing coat colour can code for red or black pigmentation.

**What is a Gene or DNA Marker?**

A gene or DNA marker is a detectable, heritable base pair sequence at a known location that is associated with differences between animals. Mutations, microsatellites and SNPs are all terms that describe a particular type of gene marker, which differ in their frequency of occurrence and their usefulness for genetic testing. Microsatellites, for example, occur less frequently than SNPs but have many variants, which make them useful for parentage testing.

Some gene markers, such as those for coat colour, directly identify the genes influencing the trait of interest. Other gene markers, such as those for productive traits, indirectly identify the genes influencing the trait of interest because they are located in close proximity and tend to be inherited together: the closer the proximity to the actual gene causing the differences, the stronger the observed association (Figure 3). Genetic shuffling that occurs between one generation and the next or across different breeds can cause the associations between markers and the genes influencing production traits to be broken. This is one of the reasons that marker tests need to be recalibrated over time and across breeds.

As SNPs are abundant in the genome, they are ideal indirect markers for production traits. Each production trait is influenced by many genes, so inferring genetic merit for a particular trait requires the accumulated effects from many markers. As most gene markers are not within the gene that influences the trait of interest, the strength of the association between the marker and the gene will vary and therefore the value, or informative power of the marker will also vary.

**Figure 1:** Chromosomes are located within the nucleus of cells. Chromosomes comprise DNA molecules.

**Figure 2:** Cow 1 differs from cow 2 at a single nucleotide location (SNP).

**Figure 3:** Markers that are located closer to the gene will be of greater value than those that are further removed.
1. Introduction

The Beef Cooperative Research Centre (CRC) was established in July 1993 and has now completed three 7-year CRC terms as shown in the diagram and the descriptions below.

**Beef CRC timeline**

<table>
<thead>
<tr>
<th>Year</th>
<th>CRC1</th>
<th>CRC2</th>
<th>CRC3</th>
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<tbody>
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The CRC for the Cattle and Beef Industry (Meat Quality) was established in 1993 to address the need for a more consistent and predictable beef product for both domestic consumers and consumers in the newly-liberalised North Asian premium markets. Industry needed to move away from a beef commodity focus to one of producing quality-driven beef products designed to meet the exacting standards of beef consumers in Australia and its international customers. Hence the focus of the first Beef CRC term was to answer the question:

‘Can we guarantee the eating quality of beef produced across Australia’s extremely diverse beef production environments?’

The Beef CRC was a result of collaboration between scientists from CSIRO, University of New England (UNE), NSW Department of Primary Industries (NSW DPI) and the Queensland Department of Primary Industries and Fisheries (QDPI&F). Supporting partners included the Meat Industry Council, Australian Meat and Livestock Corporation, Meat Research Corporation, Cattle Council of Australia and Australian Lot Feeders’ Association. Sponsorship support was also provided by some 40 commercial firms from the beef production, processing and service sectors, 48 cooperating seedstock herds and 10 pastoral companies. The Centre undertook a comprehensive beef quality progeny test program using the contributions of more than 100 Australian scientists from different institutions across 12 research locations. It secured industry collaboration and resources to breed, grow, slaughter, measure and evaluate some 12,000 pedigreed progeny at a cost of $32 million. The CRC established and managed two new research facilities, including Australia’s premier cattle research feedlot facility ‘Tullimba’, near Armidale. Most importantly, the Beef CRC integrated meat science, molecular and quantitative genetics, animal nutrition and health and industry economics to understand the complex interacting forces that influence growth, development and beef quality to enable Australia to guarantee the eating quality of its beef.
**CRC for Cattle and Beef Quality (1999-2006)**

The CRC for Cattle and Beef Quality was established in July 1999, with its first year of operation conducted simultaneously to the seventh year of the CRC’s first term. In the second term, the CRC adopted a more national focus with the addition of Supporting Participants from Victoria (Department of Natural Resources and Environment), South Australia (SARDI and University of Adelaide) and Western Australia (Agriculture WA and Murdoch University) in addition to the continuing Core Participants (CSIRO, UNE, NSW DPI and QDPI&F). Supporting industry partners included Cattle Council of Australia, Australian Lot Feeders’ Association, Australian Livestock Export Corporation, the Northern Pastoral Group of Companies and many individual seedstock and commercial beef businesses across Australia. Meat and Livestock Australia and the Australian Centre for International Agricultural Research generously funded research in the Beef CRC’s second term.

In addition to implementing the results from the CRC’s first term through BREEDPLAN and the newly established Meat Standards Australia Scheme, the Beef CRC developed and commenced delivery of the CRC’s DNA marker research and commenced new research to understand possible tradeoffs in the breeding herd for delivery of high quality beef. The core focus of research in the CRC’s second term was to answer the question:

**‘Can we change carcass and beef quality attributes without unduly compromising key fitness traits like reproductive performance and adaptation to environmental stressors?’**

**CRC for Beef Genetic Technologies (2005-2012)**

The CRC for Beef Genetic Technologies was a collaborative effort between all previous and some new partners from Australia as well as new partners from USA, Canada, New Zealand, Korea, Brazil, Ireland, France and South Africa. It commenced in 2005 and focused on development of new genetic and genomic technologies to address beef industry priority issues to improve profitability, productivity, animal welfare and responsible resource use of Australian beef businesses.

The CRC for Beef Genetic Technologies targeted an additional 1.5% p.a. increase in gross revenue of the Australian beef industry over 25 years, using emerging genetic technologies based on DNA sequence information to develop new ‘products’ to enable the Australian beef industry to:

- Improve the capacity to deliver high quality beef to Australia’s 110 global markets using cattle of known genetic merit for exacting specifications, without compromising animal welfare or the environment;
- Enhance beef yield and herd reproductive efficiency, improve efficiency of resource use, reduce production costs, minimise methane emissions and avoid chemical and antibiotic residues through precise application of knowledge about the genes controlling these attributes in cattle, their rumen microorganisms and in parasites that affect cattle productivity; and
- Ensure Australia is the number one supplier of beef to meet the growing demand by neighbouring Asian countries to 2020.

**Economic impacts of Beef CRC outputs**

The economic value of outputs from the first two Beef CRC terms are assessed collectively, but differently to the way in which outputs from the Beef CRC’s third term are assessed. In the CRC’s first two terms, outputs have been realised and their impacts are, in most cases, supported by peer-reviewed scientific publications. In cases where the overall value of the product is <$50 million, or where usage figures are not precise, no attempt is made to provide current values. However in two cases (the science underpinning Meat Standards Australia and new traits in Australia’s beef genetic evaluation scheme, BREEDPLAN), updated usage values (to 2011 and 2009 respectively) were applied to the methods reported by Insight Economics in their 2006 independent evaluation of the overall CRC Program. The impacts reported for the first two Beef CRC terms are therefore reported as realised impacts, albeit the benefits continue to increase each year and are expected to do so for many years to come. No attempt has been made to directly attribute the Beef CRC’s share of these achieved benefits, though the CRC readily acknowledges the strong role played by other organisations in the commercialisation of these outputs.

Economic benefits from the Beef CRC’s third term are generally still to be realised as many products are still being delivered. These anticipated impacts were therefore assessed using estimates of production levels and costs and prices (at regional level where appropriate) derived from published information relating to each CRC product as input values to the CRC Impact Tool (developed by the Commonwealth to enable direct comparisons of multiple CRCs across diverse industries and discipline areas).

The CRC Impact Tool evaluates the impact of all the outputs relative to the input costs (cash and staff and non-staff in-kind contributions over the 7-year term of the CRC plus industry implementation costs), to estimate an overall Benefit: Cost ratio of the CRC over a 15-year time horizon. Because of long generation intervals in cattle though, most genetic benefits accrue beyond a 15-year timeframe. The structure of the CRC Impact Tool means it picks up domestic industry benefits but not wider benefits such as those achieved by export markets or consumers. And the CRC Impact Tool makes no attempt to examine the ‘with-CRC’ scenario relative to a ‘without-CRC’ scenario. Hence the CRC Impact Tool provides many of the inputs and assumptions on each of the CRC’s products necessary for a third level of evaluation.
That third level uses the DREAM benefit: cost analysis program to provide a direct assessment of progress towards the CRC’s overall targeted outcome as recorded in the Commonwealth Agreement. It evaluates the CRC’s potential impacts (i.e. those impacts now starting to accrue as a result of delivery of the outputs from this CRC term) over a 25-year timeframe, which is more appropriate for beef genetic technologies. In addition to domestic industry benefits, it also includes wider benefits such as those achieved by export markets and consumers and enables a ‘with-CRC’ and ‘without-CRC’ comparison to be made.

The table below summarises the economic impact of each one of the products over the Beef CRC’s three terms.

**Economic Impacts of Beef CRC Products (based on realised impacts for CRCs 1 and 2 and anticipated benefits through to 2020 for CRC 3)**

<table>
<thead>
<tr>
<th>Product - Beef CRC 3</th>
<th>Product use and key end-users</th>
<th>Economic Impact</th>
</tr>
</thead>
<tbody>
<tr>
<td>Genomic prediction equations for growth, feed efficiency, carcase and beef quality and reproductive performance</td>
<td>DNA-based (genomic) prediction equations for economically important traits provide beef businesses with a simple and cost-effective method of identifying animals best suited for breeding purposes. In the near future, it is likely the predictions will also be used to best manage commercial cattle to meet market specifications and improve reproductive performance of commercial cattle herds.</td>
<td>Only 4 years of benefits with an expected NPV of $12.4 million can be counted in the Impact Tool. Most genetic benefits derived from the CRC’s genomic prediction equations will accrue beyond 2020, with the non-discounted sum of genetic improvement set in train by the Beef CRC accruing between 2020 and 2030 being $251m.</td>
</tr>
<tr>
<td>DNA markers in Meat Standards Australia</td>
<td>Costs of DNA testing individual animals are still too expensive for commercial use. However CRC results provide ‘proof of concept’ that DNA markers can improve MSA compliance rates as soon as testing becomes cost-effective.</td>
<td>The economic impact of use of DNA markers in MSA will accrue through improved compliance with MSA standards (and hence be measured through ongoing evaluations of MSA).</td>
</tr>
<tr>
<td>Marker-enhanced EBVs for economically important traits</td>
<td>Genetic parameters for traits associated with beef tenderness and DNA markers for tenderness were estimated and included in a new method to calculate marker-enhanced BREEPLAN EBVs in 2008. The method has subsequently been adapted for other traits to increase the rates of genetic gain in seedstock herds.</td>
<td>The economic impact of the CRC’s new method to integrate DNA marker information and BREEPLAN EBVs accrues through use of DNA markers associated with complex traits. No attempt was made to independently quantify the impact of this new method.</td>
</tr>
<tr>
<td>Poll gene marker</td>
<td>Beef CRC commercialised a diagnostic DNA test to differentiate polled animals used for breeding that carry one (heterozygous) or two (homozygous) copies of the favourable polled marker to enable industry to more rapidly transition to a genetically polled herd.</td>
<td>Use of the poll gene marker test on 10,000 bulls five years after industry release will reduce the number of horned calves by ~300,000 head, saving $560,000 p.a. Expected NPV is $2.2 million. However the greatest benefit of this test accrues through improved animal welfare and maintaining market access threatened by animal welfare concerns.</td>
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<tr>
<td>SNP discovery from sequencing</td>
<td>Beef CRC sequenced the genomes of Brahman, Africander and Tuli bulls to discover novel SNPs for use in high-density SNP panels released by Illumina and Affymetrix in 2011. These breeds were selected to ensure the new commercial panels included SNPs from tropically adapted cattle relevant to northern Australia.</td>
<td>The economic impact of the SNP discovery from sequencing accrues through use of DNA markers associated with complex traits.</td>
</tr>
<tr>
<td>Genetic parameters for use in BREEPLAN</td>
<td>The CRC’s genetic parameters for carcase and beef quality, feed efficiency and male and female reproductive traits are being used to directly improve these traits through selection on BREEPLAN EBVs to significantly increase genetic gains and improve productivity in seedstock and commercial herds across Australia.</td>
<td>Only 4 years of benefits (independent of those derived from genomic selection) with an expected NPV of $16.2 million can be counted in the Impact Tool. Most genetic benefits derived from the CRC’s genomic prediction equations will accrue beyond 2020, with the non-discounted sum of genetic improvement set in train by the Beef CRC accruing between 2020 and 2030 being $101.5 m.</td>
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## CRC3 HIGHLIGHTS

<table>
<thead>
<tr>
<th>Product - Beef CRC 3</th>
<th>Product use and key end-users</th>
<th>Economic Impact</th>
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</table>
| Genetic and management tools to improve compliance rates and reproductive performance | CRC results have been packaged to enable: i) beef producers and feedloters to balance growth rates of animals against costs to maximise compliance with market specifications; ii) southern Australian beef producers to best target markets using combinations of genetics and management strategies; and iii) beef producers across Australia to improve the reproductive performance of their herds. | The Beef CRC has developed several genetic and management tools including:  
  - Increased compliance with MSA specifications: expected NPV $15.8m  
  - Improved maternal management in southern Australia: expected NPV $14.1m  
  - Improved weaning rates in commercial northern herds: expected NPV $20.3m  
  - New genetic and management tools to make better breeding and management decisions, excluding the BeefSpecs models: expected NPV $46.2m |
| 'BeefSpecs' calculator to increase compliance rates for grass- and grain-finished animals and to predict breeding cow herd performance | 'BeefSpecs' helps commercial beef producers predict weight and fat specifications of animals for store and premium markets to increase compliance rates for fatness and weight targets. The BeefSpecs optimisation model is customised for the feedlot sector and optimises feed and resource use relative to market specifications and return on investment across the supply chain to most profitably meet market specifications. The maternal model predicts cow herd performance and the trade-offs needed in steer performance to optimise profitability and productivity of cow-calf herds in temperate production environments. Ongoing research beyond the Beef CRC term will extend the maternal model for use in (sub) tropical systems. | The different versions of the 'BeefSpecs' tool will significantly reduce non-compliance rates in commercial herds across Australia and improve weaning rates in commercial herds in southern Australia. Total expected NPV is $74.8 million. |
| Tick vaccine candidates | Beef CRC has discovered and evaluated 14 tick vaccine candidates (antigens/peptides) for potential use in developing a commercial vaccine to control cattle ticks in Australia and internationally. Ongoing research beyond June 2012 is required to evaluate the candidates in different combinations and to deliver a commercial cattle tick vaccine. | The impact measured is the royalty stream that a commercial company will pay to the CRC partners based on a proportion of future wholesale sales revenue. The expected NPV is $1.3 million. |
| Test for acaricide resistance | The Beef CRC developed a simple diagnostic tool that is being used primarily by tick regulatory authorities to identify ticks that are resistant to synthetic pyrethroids (a class of chemicals used to control cattle ticks). | Benefits accrue through reduced costs of more effective chemical treatments, improved regulatory control and maintaining market access under threat due to inappropriate acaricide use in tick-endemic areas. No attempt was made to quantify the economic impact of the test. |
| Candidates for pro-biotic drenches and management strategies to reduce methane emissions in cattle | The CRC has discovered candidate protein targets and microbes for potential use in live microbial and/or bio-active products that restrict methane emissions by rumen microbes and maintain desirable levels of feed digestion. Once developed through further research, these candidates could be administered to cattle as a drench or a feed additive. | No economic benefits were calculated for the candidate protein targets and microbes. However there is an additional expected NPV of $4.8 million from reductions in methane emissions due to breeding more efficient cattle. |
| Objective measures of cattle welfare | The Beef CRC's objective measures of cattle welfare are being used by beef producers across Australia through voluntary or mandatory use of animal welfare protocols, standards and guidelines underpinned by the CRC's cattle welfare results. | The use of the new animal welfare guidelines to improve access to high value export markets has an expected NPV of $79.6 million. |
| Understanding and managing the welfare impacts of dehorning | Ultimately beef producers will breed polled cattle to eliminate the need for dehorning. However some dehorning is required during the transition to a polled herd. The Beef CRC developed recommendations to minimise the impact of dehorning on cattle and they have been incorporated in new draft national welfare standards and guidelines for cattle. | The cost of labour for de-horning calves is $0.17 to $0.33 per head. The value from reduced mortalities due to de-horning is $1.70 per weaner. The total value to Queensland alone from not having to de-horn calves is ~ $3.5 million per annum. The use of better management practices for de-horning procedures on 600,000 calves p.a. has an expected NPV of $2.1 million. |
## CRC3 HIGHLIGHTS

<table>
<thead>
<tr>
<th>Product - All CRC terms</th>
<th>Product use and key end-users</th>
<th>Economic Impact</th>
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<tr>
<td>Beef Profit Partnerships</td>
<td>A system of partnerships between beef businesses, value chains and the broader beef industry designed to accelerate improvements, innovations and adoption for sustainable and quantifiable impact on business profit.</td>
<td>The aggregate value to November 2011 flowing from the BPP network in Australia (i.e. excluding the BPPs in New Zealand and South Africa) is $28.76 million. The NPV estimated through to 2020 is $63.5m.</td>
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<tr>
<td>Training materials and resources to create a more skilled beef industry workforce (including Livestock Library and publications)</td>
<td>Beef CRC’s educational and training materials are freely available online and have been widely distributed to extension specialists and consultants across Australia to underpin ongoing industry delivery activities to improve profitability and productivity of Australian beef enterprises.</td>
<td>No attempt was made to quantify the economic benefits derived from a more skilled beef industry workforce.</td>
</tr>
<tr>
<td>71 PhD and 18 MSc graduates across a very broad range of sciences impacting on the Australian beef industry</td>
<td>More skilled beef industry workforce across all sectors of the Australian beef industry. More than 70% of these graduates have been retained directly in the Australian beef industry and &gt;80% have been retained in the agricultural sector more broadly.</td>
<td>No attempt was made to derive an economic impact of these additional graduates, many of whom won prestigious national and international awards during their CRC training periods.</td>
</tr>
<tr>
<td>Comprehensive beef cattle databases</td>
<td>These databases play a critical role in Australia’s BREEDPLAN and Meat Standards Australia schemes and are also essential for ongoing bovine genomics research.</td>
<td>Benefits from these comprehensive beef cattle databases are mainly for ongoing research.</td>
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<tr>
<th>Product - Beef CRC’s 1 and 2</th>
<th>Product use and key end-users</th>
<th>Economic Impact</th>
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<tr>
<td>Science underpinning Meat Standards Australia</td>
<td>Scheme to guarantee the eating quality of beef based on consumer perceptions of palatability. Key beneficiaries include commercial beef producers, feedlots and beef processors, retailers, wholesalers and domestic and international consumers.</td>
<td>Cumulative retail-level economic benefit from 1999/00 to 2010/11 was ~$523 million (excluding any additional value for MSA 4- and 5-star beef products and &gt;1.5 million lambs that have been MSA graded).</td>
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<tr>
<td>New traits in BREEDPLAN</td>
<td>BREEDPLAN is Australia’s national beef genetic evaluation scheme. The Beef CRC introduced scanned and actual carcase and beef quality traits, feed efficiency and reproductive performance to industry growth data to significantly increase the rates of genetic gain in Australian cattle herds.</td>
<td>The cumulative value of new traits in BREEDPLAN from CRCs 1 and 2 is $558 million in nominal $ values, or $673 million when those values are compounded forward to 2009 $ values at a 4% discount rate.</td>
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<td>DNA markers for beef tenderness</td>
<td>Beef CRC discovered two DNA markers for beef tenderness and licensed them to Genetic Solutions (subsequently acquired by Pfizer Animal Genetics). The markers are now used as diagnostic tests to identify carriers of favourable alleles so those carrier animals can be used for breeding to genetically improve tenderness.</td>
<td>The revenue stream from licensing these markers was not large and no attempt was made to quantify it. The real benefit of the markers was the ability to identify, for the very first time, cattle with a genetic propensity to produce tender beef. Their use by industry is reflected through improved compliance of tropically adapted cattle to MSA tenderness standards.</td>
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<tr>
<td>Increased genetic gain through crossbreeding and development of composites in northern Australia</td>
<td>Beef CRC results show that significant genetic gains and improvements in profitability can be achieved in northern Australian herds by crossbreeding or development of tropically adapted composites designed to improve product quantity and quality and reproductive performance relative to the Brahman, without compromising adaptation to environmental stressors.</td>
<td>Changing the northern Brahman herd to terminal crossbred/tropical composites increased gross margins by $76 per Adult Equivalent when sale animals were finished on grain to meet premium market specifications. At the northern industry level, changing 25% of the herd over 10 years to crossbreds or composites equated to an annual benefit in 2013 of $16m and $61m or a NPV of $88m and $342m for crossbreds and composites respectively. Additional benefits due to grain finishing translated at a northern industry level to an extra annual benefit in 2013 of $130 million (crosses) and an extra NPV (over the base model) of $730 million (composites).</td>
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**Product - Beef CRC’s 1 and 2**

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<th>Product use and key end-users</th>
<th>Economic Impact</th>
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<tr>
<td>Vaccines to control Bovine Respiratory Disease (Bovilis MH™ and Pestigard™)</td>
<td>Beef CRC commercialised two vaccines to control Bovine Respiratory Disease (BRD) and reproductive losses resulting from Pestivirus. Key end-users are the feedlot sector across Australia which routinely uses the vaccines to control BRD and commercial beef producers who use Pestigard™ to improve reproductive performance of their breeding herds.</td>
</tr>
<tr>
<td>Pre-boosting strategies to enhance cattle performance during growing, grass- and grain-finishing and transport</td>
<td>Pre-boosting feeder steers increased gross margin by up to $33 per head with total benefits to the industry by 2001 estimated to be $8 million. Most of the &gt;1 million feeder steers in Australia now routinely undergo pre-boosting prior to feedlot entry.</td>
</tr>
<tr>
<td>Growth path, transport and genetic effects on beef eating quality and ability to cost-effectively meet beef market specifications</td>
<td>CRC results relating to combinations of growth path, transport and genetic effects on beef eating quality increased compliance of cattle to premium beef market specifications.</td>
</tr>
<tr>
<td>Cattle welfare improvement strategies</td>
<td>The CRC’s cattle welfare results were delivered to the transport, feedlot and processing sectors through practical guidelines aimed at improving animal health and welfare in intensive production systems. The practices have achieved widespread and routine uptake but no attempt has been made to estimate their economic impact.</td>
</tr>
<tr>
<td>Responsible recycling of feedlot waste to achieve a sustainable feedlot sector</td>
<td>Beef CRC research provided the essential data to allow development of new environmental guidelines for recycling of feedlot waste to ensure a sustainable Australian feedlot industry.</td>
</tr>
<tr>
<td>On-farm and pre-slaughter food safety</td>
<td>Beef CRC’s pre-slaughter measurement of enteric pathogens identified new on-farm and lairage management practices to reduce pathogen loads on beef carcases.</td>
</tr>
</tbody>
</table>

**Economic Impact**

- Total product sales of the CRC vaccines since commercial release to June 2010 were ~$20 million with sales increasing strongly through strong promotion over the past two years. Additional benefits include increased growth rates and reduced time to market of feedlot cattle; improved feed efficiency; reduced feed costs; and improved reproduction rates but these impacts could not be quantified.

Based on the DREAM analyses that examined a range of scenarios, with different adoption rates for genetic and non-genetic technologies and for northern and southern industry applications, the benefit: cost ratio for every $1 invested in the Beef CRC’s third term ranged from a worst-case scenario of 7.1:1 to a best-case scenario of 11.2:1. Our current assessment is the most-likely scenario will yield a return on investment around $9 for every $ investment in the CRC. These estimates are lower than the original (2004) estimate of 14.8:1, primarily because the genomic prediction equations took longer to deliver than originally anticipated (rather than delivering individual DNA markers on a marker-by-marker basis each year from 2007, predictions based on 800,000 markers collectively were delivered in 2012, meaning later delivery and lower adoption rates than originally anticipated for the DNA marker technologies; similarly, later delivery and lower adoption rates were experienced for the CRC’s ‘accelerated adoption’ research). As well, the accuracies of the genomic prediction equations are lower than the 2004 estimate, but they are in line with the 2010 formal Variation to the Commonwealth Agreement.

The non-genetic supply component of the CRC’s outputs contributes more than 40% of the benefits across all scenarios, consistent with the results from the Impact Tool, where in the first 15 years of the benefits stream (i.e. starting from commencement of the research in 2005), the non-genetics components heavily outweigh the genetics components. Improved market access provides a little over 30% of benefits and genetics improvement in aggregate a little under 30% across all scenarios. Both beef producers and beef consumers gain, with producers taking about 70% of the aggregate benefits across all scenarios (here, “consumers” are defined as all post farm-gate participants in the value chain).
3. **Non-economic benefits of Beef CRC outputs**

In many respects it is not possible to calculate the true value of many of the Beef CRC’s outputs. For example, how can a realistic economic value be placed on outcomes such as ‘reduced antibiotic usage’, ‘environmentally sustainable beef production systems’ and ‘improved animal welfare’, when the intrinsic value of such outcomes is based in the minds of consumers who demand that animals be treated with utmost care, almost regardless of cost; that their production environments remain ‘natural’ even if new pasture or crop species improve the sustainability of the natural resource base; and that livestock remain ‘clean and green’ regardless of improvements in productivity and guarantees of food safety following use of medicinal treatments?

Similarly, the value of education to the Australian economy is not readily quantifiable, although clear evidence exists that ongoing improvements in productivity are affected by levels of basic education and levels of continuous employee development. About 90 post-graduate students were trained over Beef CRC’s three terms, with more than 70% being retained in Australia and in the livestock sector. As well, the CRC’s undergraduate and vocational training programs have provided enhanced technical and human capacity in industry and the wider economy.

Hence, in addition to the direct economic benefits accruing from the use of Beef CRC products, significant additional social, environmental and animal welfare benefits have accrued as a result of research outputs from all three Beef CRC’s, including:

**Social benefits**
- More profitable beef enterprises across Australia;
- Unique ability to guarantee the eating quality and food safety of beef, thereby increasing consumer confidence in Australian beef products;
- Improved cattle management systems, reducing the dependence of beef businesses on scarce, skilled labour;
- Reduced antibiotic and chemical use in cattle production systems, reducing the risk of residues in beef products;
- Improved on-farm and abattoir best practice to reduce pathogen loads on beef carcases, increasing consumer confidence in beef safety;
- More skilled beef industry workforce across rural and regional Australia;
- Increased commitment, loyalty and trust across beef value chain sectors arising from the collaborations forged through all three Beef CRC terms;
- Improved beef genetic improvement opportunities through development of a common DNA marker commercialisation model across Australia, USA and Canada;
- Integration of DNA marker information into existing industry schemes such as BREEDPLAN to ensure easier use and greater understanding by industry about how best to apply the new technologies to achieve value.

**Environmental benefits**
- New environmental protection guidelines for feedlot waste management;
- Feedlot waste minimization strategies routinely applied Australia’s feedlot sector without compromising animal performance;
- A new cropping system that uses a combination of manure and inorganic fertilizers to improve crop yields, soil health and soil water storage and reduce runoff and nutrient loss to the environment;
- Reduced methane emissions per kg of beef product arising from improved productivity of beef businesses and reduced feed requirements through improved feed efficiency;
- Confidence by consumers that Beef CRC products have been extensively developed and validated under Australian beef production systems and are therefore sustainable for Australian environments;
- Improved use of the natural (grazing) resource base through improved feed efficiency and reproduction;
- Reduced chemical use in cattle production systems, reducing the risk of environmental contamination.

**Animal welfare benefits**
- New cattle welfare standards and guidelines underpinned by cattle welfare studies in all three Beef CRC phases;
- Improved production, transport and pre-slaughter lairage systems designed to improve cattle welfare;
- More resilient cattle through reduced stress and improved behaviour.

**Numerous, prestigious national and international awards (including ...)**
- Three separate Eureka Awards for Bioinformatics, Animal Welfare and Interdisciplinary Research (these awards are the Oscars of Australian science!)
- Two CRC Association national Awards for Excellence in Innovation
- The International Meat Secretariat Millennium Prize for Meat Science and Technology
The Beef CRC Legacy Website contains a wealth of information on the research and product development of the Beef CRC. It has the answers you are looking for. www.beefcrc.com

DO YOU HAVE A BEEF QUESTION YOU THINK WE CAN ANSWER?