



Annual Report 2003/2004

The Cooperative Research Centre for Cattle and Beef Quality





Mission

To develop world-class research and education programs to address the major consumer-relevant issues which hold the key to the economic future of the Australian beef industry.

Strategies

- Ensure consistent consumer-specified eating quality of domestic and export product by developing and implementing new pre- and post-slaughter practices.
- Achieve a consistent supply of consumer-specific product for both domestic and export markets using innovative genetic, nutritional and management technologies applicable to grass- and grain-finished cattle.
- Capture benefits from the worldwide expansion in genomics knowledge by strategic application of gene markers and functional genomics for genetic improvement of beef quality in Australian cattle herds.
- Add value to the beef carcass by striving to achieve increased returns for all beef cuts, based on their eating quality, not just their anatomical description.
- Strengthen domestic and export markets for Australian beef by developing and implementing, at the production and processing tiers of the industry, new technologies directed at improving health and welfare of cattle and enhancing food safety of beef and beef products.

Core Participants



Supporting Participants





CRC for Cattle & Beef Quality

"The CRC [for Cattle & Beef Quality] continues to operate, function and perform at a very high level. It has proven itself to be a top-ranking Centre with a highly successful track record"

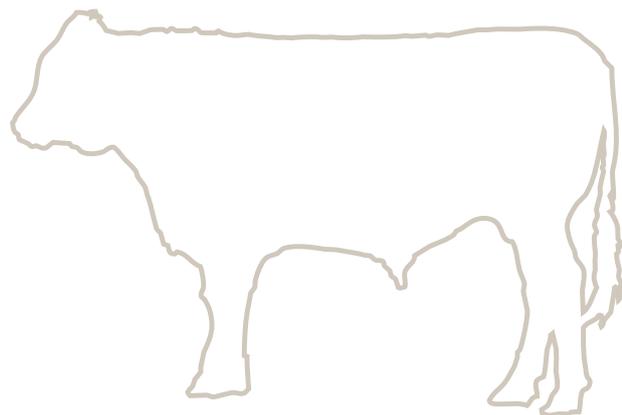
*John Vercoe, Chairman, 5th Year Review Panel
20 May 2004*

2003/2004 Annual Report

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Acknowledgements

The CRC for Cattle and Beef Quality wishes to thank ~

Core and Supporting Participants involved in the Centre

Board Members and their staff

Industry Sponsors

Cooperating Cattle Breeders

All who have contributed to the success of this Centre

A c k n o w l e d g e m e n t s

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Report of the Governing Board Chairman, Peter Frawley



Mr Peter Frawley, Governing Board Chairman

"The rewards for successful renewal are substantial - some \$30 million of Commonwealth cash and the opportunity to carry out strategic research that could influence beef sector profitability for years ahead."

A major responsibility of the Board during 2003/2004 was to oversee the Beef CRC's Round 9 Renewal Application entitled ... "The Cooperative Research Centre for Beef Genetic Technologies". If successful the new CRC would commence a 7-year term from July 2005 and would subsume the final year (2005/2006) of the (current) CRC for Cattle and Beef Quality. The Board recognises this complex undertaking has long term potential benefits for the Australian beef industry and has willingly approved considerable resources for the task. The rewards for a successful application are substantial - some \$30 million of Commonwealth cash, continued commitment and direct support by industry and an increase in the number of institutions, including some overseas, to carry out strategic research that could influence beef sector profitability for years ahead.

In the period to December 2003 the Board arranged widespread industry consultation to reach agreement on the focus of the new CRC application. Scientists from new and existing institutions and new international

partnerships then developed the scientific detail to underpin the new proposal. When the Department of Education, Science and Training announced the timetable for a 2-Stage selection process on 11 December 2003 the Renewal Committee was well-placed to prepare a Stage I Business Case which was lodged on 30 March 2004. Integral to this process was the choice of Professor James Womack, Texas A&M University and the Hon Ian Sinclair AC as scientific and industry referees, respectively, for our Case. The Board is most grateful for the involvement of these distinguished individuals in preparing objective and thorough reports to support our application. Some Board Directors had the pleasure of meeting Professor Womack during his visit to Armidale and Brisbane in February 2004. The referees were in part responsible for our successful progression to Stage II of the selection process.

As part of our CRC Renewal strategy, the Board also took steps to identify a new Chief Executive Officer to lead the new CRC in anticipation of Professor Bernie Bindon's retirement in July 2005 and in the event that it is successfully funded in December 2004. A selection process was completed in March 2004 and the "CEO Designate", Dr Heather Burrow was announced publicly in early April. The Beef CRC is fortunate to have a candidate of Dr Burrow's experience and calibre available to prepare the Stage II Business Case and take the lead at interview, should we be chosen, in September or October 2004.

The Board's final responsibility for CRC Renewal in 2003/2004 was to sign off on the comprehensive Stage II Case, lodged in late June. In the year ahead the Board looks forward to the interview process and in organising participants in the new CRC to prepare for incorporation and the business arrangements that must be completed soon after December 2004. The Board commends all CRC participants who have made inputs into the CRC Renewal Application. The outcome now rests with the CRC Selection Committee.

Meanwhile, the Board attended to the governance of the current CRC's busy program of research during 2003/2004. It is pleasing to report that favourable progress has been achieved in most aspects of research and commercialisation. As detailed elsewhere, the Year 5 Review, commissioned by the CRC Board in April 2004, recommended continued funding for this CRC to the end of its term in June 2006.

My personal thanks are extended to Board Directors, members of the Advisory Committee, Professor Bernie Bindon and staff at all levels for their commitment to CRC activities during 2003/2004.

A handwritten signature in dark ink, appearing to read "Peter Frawley". The signature is fluid and cursive, with a long horizontal stroke at the end.

Peter Frawley

Report of the Chief Executive Officer, Bernie Bindon



Prof Bernie Bindon, Chief Executive Officer

"The Beef CRC continued to publish high quality scientific papers during 2003/2004. This included, in May 2004, another landmark Special Edition of AJEA dealing with efficiency of feed utilisation by cattle and other species. This is a crucial subject for the long-term sustainability of Australia's grazing industries."

During Year 5 many staff across the CRC network have been distracted by CRC Renewal activities. These are important but do not displace our key responsibility which is to get on with projects in the current CRC, for which we are funded through to June 2006. Although some projects are winding down as the hands-on research reaches completion, we have an obligation to write up comprehensive reports and scientific papers as part of the process of delivering the outputs of research to our beef industry stakeholders.

Year 5 Review

In addition to our CRC's regular project review process in April 2004, this year we faced a statutory Year 5 (External) Review of our activities, as required by DEST. For this purpose the Board commissioned a high quality Review Panel chaired by Dr John Vercoe with representation from Professor Mal Nairn (Biosecurity CRC Chairman), Professor Frank Nicholas (University of Sydney), Mr Steve Millard (North Australian Pastoral Company) and Professor Keith Entwistle (CRC Visitor). This Review took on added importance as it doubled as an "External Review of Beef CRC Achievements", an obligatory requirement for our Stage 2 Business Case in the Round 9 selection process.

The Review Panel received detailed Progress Reports and other resource documents in advance of the three day review in late April 2004 as well as Terms of Reference and some assessment criteria. The panel was

then exposed to individual presentations by Program and Project Leaders before formulating their Report to the CRC Board.

The Review was rigorous and thorough and the Panel's recommendations both favourable and useful for individual scientists and CRC Management. The Panel's Report contains many useful comments but in the present context these are the highlights:

"... Therefore, the Panel has no reservations in recommending the following:

1. *Funding for the CRC should be continued through to Year 7.*
2. *Given the outstanding track record of the scientific outputs of this Centre, and the benefits that have resulted for the Australian Beef Industry and the Australian community, a further renewal of this CRC should be favourably considered by the Commonwealth to enable the CRC to conduct further strategic research that will continue to benefit Australia."*

Commercial highlights

Bovine respiratory disease vaccines

Two novel CRC vaccines were registered during 2003/2004. In August 2003 the "Pestigard" vaccine against Bovine Viral Diarrhoea (Pestivirus) was launched by commercial partner, CSL Pty Ltd. This disease is a causative agent of bovine infertility and predisposes cattle to bovine respiratory disease (BRD). In June 2004 a vaccine called "Bovilis-MH" was successfully registered by Intervet, another CRC commercial partner. This vaccine is directed against *Mannheimia haemolytica*, a bacterium that causes BRD, especially in feedlot cattle. These vaccines will combat two diseases that cause serious loss of profitability in Australian beef businesses.

It is interesting to note that the CRC's research for both these products was completed well before the end of CRC I (1998). The "path to commercialisation" is a long and arduous one in Australia where national registration is required for products of this type. (It is reassuring to know, however, that "proof of efficacy" is a requirement for registration in Australia - the vaccine must be effective against the targeted disease organism.)

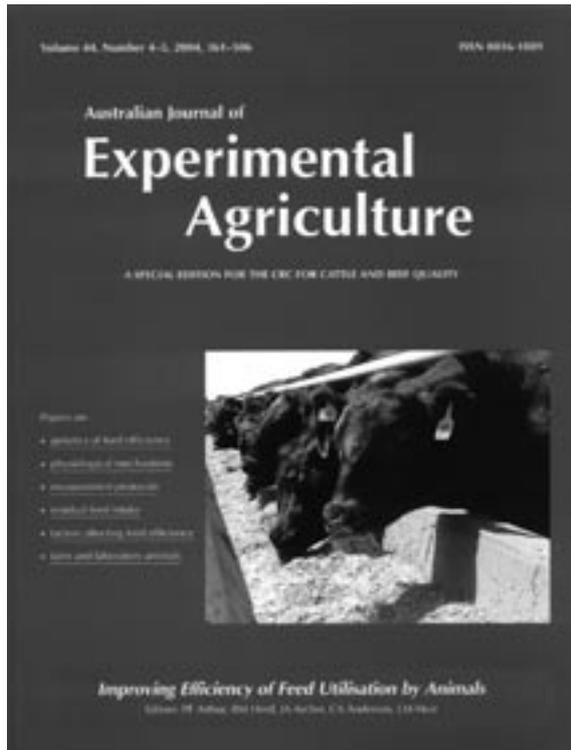
Insulin-like Growth Factor-I (IGF-I)

As detailed elsewhere in this Annual Report the CRC's research on an association between plasma levels of the hormone IGF-I and Net Feed Intake has led to the commercialisation of this test by PrimeGRO Pty Ltd, the Australian company which owns the intellectual property rights to the IGF-I test. The product was launched in Armidale in November 2003.

AJEA Special Edition on Feed Efficiency

The Beef CRC continued to publish high quality scientific papers during 2003/2004. This included, in May 2004, another landmark Special Edition of AJEA dealing with efficiency of feed utilisation by cattle and other species. This is a crucial subject for the long-term sustainability of Australia's grazing industries. The Beef CRC is proud to share international scientific leadership in this field.

Report of the Chief Executive Officer, Bernie Bindon



Special Edition of the Australian Journal of Experimental Agriculture on Feed Efficiency

CRC Renewal – International Partners

The Chairman's Report has covered some of the detail about CRC Renewal. An important feature of the new CRC proposal is the formal involvement of new international beef research agencies. In November 2003 I led a small group of CRC scientists to visit the National Livestock Research Institute of the Rural Development Administration, Suwon, Korea. There we agreed on collaborative research arrangements for beef quality, feed efficiency and gene marker technology, for inclusion as a Korean-funded commitment to CRC Renewal. This is an important research initiative for the CRC with one of Australia's major beef trading partners.

In early April 2004, following lengthy negotiations I was able to visit New Zealand to address the Board of Meat & Wool New Zealand. This was designed to secure their participation in CRC Renewal and culminated in Meat NZ signing off for generous cash resources for inclusion in our Stage 2 Business Case. This should lead to significant collaborative beef research between Australia and New Zealand in the new CRC for Beef Genetic Technologies. This successful outcome is a credit to the long-term planning by Meat NZ former Director of Research, Dr Neil Clarke, a generous supporter of the Beef CRC since 1996.



l-r: Dr Heather Burrow, Prof Bernie Bindon and Sir Graham McCamley

Tartrus 50th Anniversary Celebrations

On 8 May 2004 it was an honour for me to attend the 50th Anniversary sale of Tartrus Brahmans on the property on the McKenzie River, west of Marlborough, Queensland. At this prestigious event, which attracted some 1,800 visitors, Heather Burrow and I had the only scientific display including posters of CRC results involving Tartrus cattle generously committed by the McCamley family to the CRC's first and second terms.

My address was able to briefly recount the extraordinary participation by the McCamleys in beef research which began soon after CSIRO's early Brahman studies at Belmont, commencing in 1952. The "Brahman revolution" started back then and required visionaries like Sir Graham McCamley to move from breeding traditional British cattle in central Queensland to adopt the adaptive and production benefits of Brahman-infused cattle. The rest is history – Brahman-infused cattle now make up more than 50% of the Australian beef herd.

The success of the Beef CRC's research in northern Australia has resulted from generous collaboration and cattle resources provided by cooperating herds like Tartrus. It is a pleasure for the CRC to acknowledge the support of Sir Graham, Lady Shirley, Jenny and Jacqui McCamley for making this possible.

Acknowledgements

At the end of Year 5, CRC Management wishes to commend staff at all levels for their commitment to excellence, especially in demanding laboratory, field station and abattoir operations. The support of the Executive Committee, Board and Advisory Committee has been unflinching. In this special Renewal year it is a pleasure to acknowledge also the efforts of the CRC Renewal Committee.


Bernie Bindon

Structure & Management

Participants

The Core Participants in the Centre are the University of New England, NSW Agriculture, Queensland Department of Primary Industries and Fisheries and CSIRO Livestock Industries. The Centre has a national focus through Supporting Participants from Victoria, South Australia and Western Australia. These arrangements enhance the CRC's ability to deliver outcomes to a wide range of end-users across Australia. In each state the outcomes are being delivered by Supporting Participants, with expert local knowledge and industry linkages.

Core Partners	Supporting Participants
 <p>The University of New England Animal Genetics and Breeding Unit</p>	<p>Department of Primary Industries, Victoria</p>  <p>Department of Primary Industries</p>
 <p>CSIRO Livestock Industries</p>	<p>Department of Agriculture WA</p> 
 <p>NSW Agriculture Animal Genetics and Breeding Unit</p>	<p>Murdoch University</p>  <p>MURDOCH UNIVERSITY PERTH, WESTERN AUSTRALIA</p>
 <p>Queensland Government Department of Primary Industries</p> <p>Department of Primary Industries & Fisheries, Queensland Qld Beef Industry Institute Agency for Food and Fibre Sciences</p>	<p>South Australian Research and Development Institute</p>  <p>SARDI SOUTH AUSTRALIAN RESEARCH AND DEVELOPMENT INSTITUTE</p> <p>University of Adelaide</p>  <p>THE UNIVERSITY OF ADELAIDE AUSTRALIA</p>

Current Industry Sponsors

During the life of the CRC for Cattle and Beef Quality, generous sponsorship will come from commercial firms from across the beef business sectors.

- AgForce Queensland
- AgReserves (Kooaba Station)
- Alcoa Farmlands
- Angus Society of Australia
- Australian Agricultural Company
- Australian Brahman Breeders Association
- Australian Country Choice / Coles
- Australian Poll Hereford Society
- C & R Briggs, "Cona Creek"
- Consolidated Pastoral Company
- Elanco Animal Health Pty Ltd
- GRM International
- J & SM Halberstater, "Mandalay"
- Heytesbury Beef
- International Animal Health Pty Ltd
- S Kidman and Co
- E & GA Maynard
- GE and J McCamley, "Tartarus"
- North Australian Pastoral Company
- PrimeGro Ltd
- Ridley Corporation Ltd
- Stanbroke Pastoral Company
- Twynam Pastoral Company

Supporting Industry Organisations



Cattle Council of Australia



Australian Lot Feeders' Association



Australian Livestock Export Corporation

Funding Organisations



Meat and Livestock Australia



Australian Lot Feeders' Association



Australian Centre for International Agricultural Research

Structure & Management

Former Industry Sponsors

Generous support was received from these sponsors of the CRC for the Cattle and Beef Industry (Meat Quality).

- Australian Meat and Livestock Corporation
- Meat Research Corporation
- Australia Meat Holdings Pty Ltd
- Mitsubishi Australia Pty Ltd
- Australian Agricultural Company
- New England Artificial Breeders
- Australian Brahman Breeders Association
- Nippon Meat Packers Australia Pty Ltd
- Australian Hereford Society
- North Australian Pastoral Company
- Australian Limousin Breeders Society Ltd
- NSW Cattle Compensation Fund/
NSW Government
- Australian Poll Hereford Society
- NSW Education and Training Foundation
- Australian Simmental Breeders Society Ltd
- NSW Office of Economic Development
- Beef Improvement Association Ltd
- NSW Sugar Milling Co-operative Ltd
- Cargill Foods Australia Ltd
- Prince-Bisley Pty Ltd
- Carinya Steel Products
- Queensland Department of Business, Industry and
Regional Development
- Consolidated Pastoral Company
- Queensland and Northern Territory Pastoral
Company
- Country Industries Australia
- Ridley Corporation Ltd
- Dalton Supplies Australia Pty Ltd
- Ruddweigh Australasia Pty Ltd
- Dudley (Holdings) Pty Ltd
- Selected Seeds
- Acton Land and Cattle Company
- Shorthorn Society of Australia
- Heytesbury Pastoral Company
- Stanbroke Pastoral Company
- Hughes Grazing Company
- Stark Engineering
- ICM Farm Products Australia Pty Ltd
- Super Breeders' Group
- Killara (Quirindi) Pty Ltd
- The Angus Society of Australia Ltd
- Mackay Sugar Cooperative Association Ltd
- Twynam Pastoral Company
- Hillgrove Pastoral Company
- United Beef Breeders' Association of WA (Inc)
- Marubeni Australia Ltd
- XF Enterprises (Australia) Pty Ltd
- Massey Ferguson Australia
- 49 individual co-operating cattle breeders

The Governing Board

The Governing Board:

- determines Centre policy and all matters relating to Centre objectives and activities;
- ensures the Centre's activities are carried out in accordance with Commonwealth and Joint Venture Agreements;
- determines the Centre's research and education strategies and approves budgets;
- meets at least four times per year and out-of-session by teleconference or sub-committee as required.

Chairman

Mr Peter Frawley

Industry Representatives

Mr Malcolm Foster (*Aust Lot Feeders' Association*)
Mr Malcolm Slinger (*Aust Meat Processor Corporation Ltd*)
Mr John Wyld (*Cattle Council of Australia*)
Mr David Beak (*Beak & Johnston Pty Ltd*)
Mr Tony Nolan (*Nolan Meats Pty Ltd*)
Mr John Cox (*Stanbroke Pastoral Company*)
Mrs Lucinda Corrigan (*Rennylea Pastoral Company*,
also Chairman, CRC Advisory Committee)

Core Party Representatives

Prof Peter Flood (*University of New England*)
Dr Greg Robbins (*Qld Dept of Primary Industries*)
Dr Helen Scott-Orr (*NSW Agriculture*)
Dr Ian Purvis (*CSIRO*)

Centre CEO

Prof Bernie Bindon

Structure & Management

Advisory Committee

The Centre has established an Advisory Committee of respected industry practitioners, drawn from relevant cattle industry sectors, to work closely with the Centre scientists to ensure the industry relevance of the research. The committee meets formally twice per year and provides ongoing formal and informal advice to the projects throughout the year. The independent Chairman of the Advisory Committee is also a member of the CRC Board to ensure direct reporting capacity.

Mrs Lucinda Corrigan (Chairman)

Southern beef producer and collaborating breeder

Mr Steve Millard

Northern beef producer and sponsor (NAPCO)

Mr Geoff Maynard

Northern beef producer and collaborating breeder

Mr John Fry

Southern beef producer and WA representative

Mr Rob Backus

ALFA representative (northern) and sponsor (AACo.)

Mr Bruce Picone

ALFA representative (southern)

Mr Tim Landsberg

Former processor representative

Mr Ken Somerville

Processor and producer

Mr Michael O'Shea

Agribusiness and sponsor (Ridley Corporation)

Mr Terry Nolan

Australian Meat Industry Council

Executive Committee

The day-to-day management of the Centre is the responsibility of the Executive Committee, comprising the CEO, Deputy CEO, Finance Manager, Program Managers and three senior representatives of the Supporting Participants, designed to achieve appropriate geographic, discipline and institution balance. The Committee meets at least 12 times per year by telephone conference or physical site meetings.

Prof Bernie Bindon (Chairman)

Dr Heather Burrow

Dr Drewe Ferguson

Dr Paul Arthur

Mr Jim Walkley

Assoc Prof Julius van der Werf

Prof David Pethick

Dr Wayne Pitchford

Dr Brendan Tatham

Mr John Thomas

Research Committee

The Centre's research and education activities are planned and implemented by the Research Committee, comprising the Executive Committee plus Project Leaders. The Research Committee is directly responsible for the scientific excellence and integration of the Centre's activities and is an important vehicle in achieving collaboration across the Centre's network. The Research Committee has direct linkages to both the Board and Advisory Committee, with which it meets once a year as part of the review process.

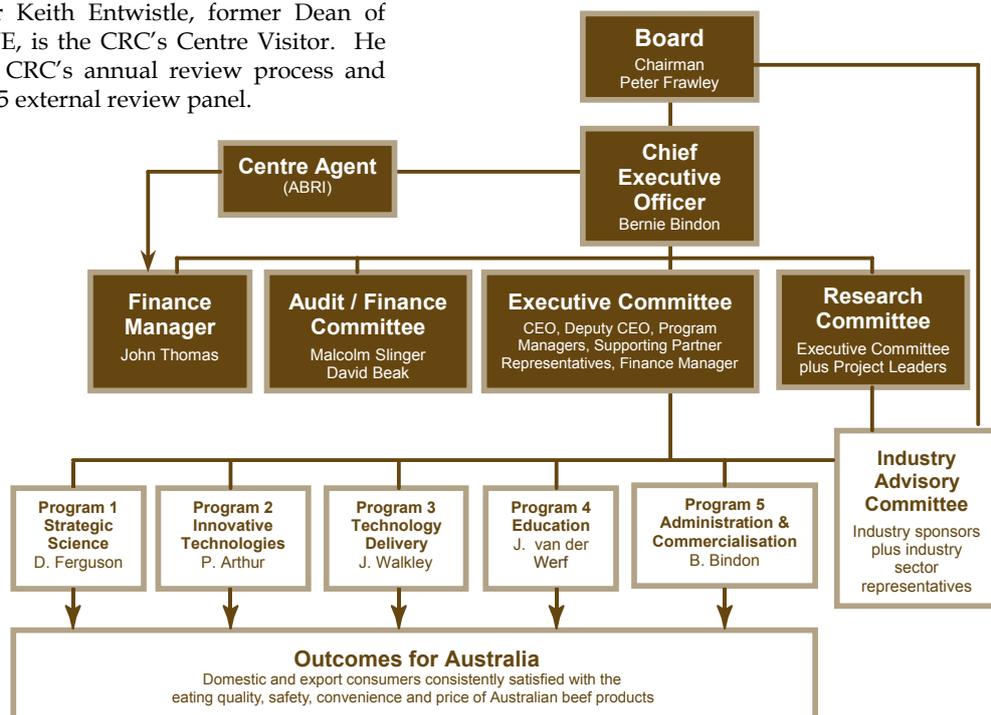
Centre Agent

The CRC's Centre Agent is the Agricultural and Business Research Institute (ABRI). ABRI administers the world's most successful beef cattle genetic improvement scheme, BREEDPLAN. ABRI is a registered research agency.

Centre Visitor

Emeritus Professor Keith Entwistle, former Dean of Sciences at the UNE, is the CRC's Centre Visitor. He participates in the CRC's annual review process and reports to the Year 5 external review panel.

CRC Management Structure



Commercialisation / Technology Transfer / Utilisation

Strategy for Technology Transfer

This CRC recognises a priority to achieve adoption of CRC outcomes by a broad range of end-users in the shortest possible time. End-users include Core and Supporting Partners, sponsors, beef producers, seedstock breeders, feedlots, beef processors, exporters and retailers, beef consumers and the community at large, students, scientists, other CRCs, red meat industry structures and agribusinesses.

To this end, the CRC has devoted an entire Program (i.e. Program 3: Delivery of Technologies to the Beef Business System) to the task of adapting, delivering and demonstrating CRC outcomes for the benefit of end-users. This is in addition to Program 4: Education and Training that provides support for technology transfer and commercialisation of CRC results by way of educational materials and development of customised training courses.

In addition to traditional methods of technology transfer (face-to-face meetings, seminars, field days together with associated documentation), the Centre is focusing on more effective use of electronic delivery methods via the Internet through partnerships such as ILRIC (the International Livestock Resource Information Centre). Activities in ILRIC are aimed at developing the CRC's Knowledge Base to facilitate technology transfer and commercialisation strategies by identifying "Profitable Business Solutions" to specific problems identified by beef business enterprises throughout Australia.

User Group	Classification	CRC Interaction
Core Partners	CSIRO DPI&F, Qld NSW Agriculture UNE	Research, education and extension providers
Supporting Partners	Dept of Agriculture, WA Murdoch University SARDI University of Adelaide DPI, Victoria	Research, education and extension expertise in Western Australia, South Australia and Victoria
Associate Partners	Australian Association of Cattle Veterinarians (AACV) Beef Improvement Association of Australia (BIAA)	Technology transfer for beef improvement
Funding Agencies	Meat and Livestock Australia (MLA) Australian Centre for International Agricultural Research (ACIAR)	Co-investment in Centre activities
Sponsors	Red Meat Industry Organisations: • Cattle Council of Australia • Australian Lotfeeders' Association • Australian Livestock Exporters Corporation	Research and Development policy and beef industry leadership
Sponsors	12 large companies and SMEs contributing cattle breeding resources for CRC activities	Commercial research involvement
Sponsors	3 large companies involved in beef retail and agribusiness products	Commercial research and consumer education
Sponsors	7 cattle breed societies linked to 5,000 seedstock herds	Research, education and technology transfer
Centre Agent	ABRI - linked to BREEDPLAN beef genetic improvement scheme (20,000 beef producer herds)	Technology transfer for beef improvement
Commercialisation partners	Genetic Solutions Pty Ltd Ruddweigh Australia Pty Ltd CSL Limited Intervet Pty Ltd PrimeGro Pty Ltd	Commercial research partners
Community	70,000 beef producers and millions of beef consumers in Australia and in 110 countries worldwide	Prosperity and satisfaction of beef producers and consumers

Commercialisation / Technology Transfer / Utilisation

Linkages to SMEs

There are 40,000 specialist beef producing enterprises in Australia and another 30,000 mixed-enterprise farming businesses that include beef. These businesses employ more than 100,000 people, the majority based in rural and regional Australia. Value-adding service providers in the feedlotting, transporting, beef processing and retailing sectors employ a further 80,000 people, also mostly from rural and regional Australia. Virtually every one of these businesses is a Small to Medium Enterprise (SME - a business employing <200 staff).

Each one of these SMEs located throughout Australia requires customised "Profitable Business Solutions" for a vast array of potential production, processing and retailing issues about which the CRC has extremely important information. The challenge of linking with each one of these SMEs is enormous because of the scale and geographical dispersion of the Australian beef industry. The Beef CRC has generated linkages to SMEs using a number of different approaches, including sector specific industry training events (breeding workshops, feeder steer schools, feedlot workshops, agents' workshops, MSA Grader courses etc), field days, integrating CRC results into industry packages delivered by other agencies (e.g. MLA EdgeNetwork, BIAA, AACV, BREEDPLAN), involvement in high profile beef industry events, customizing information for SMEs and making that information available either on the CRC website, via mailout or through the print and electronic media. The best form of engagement with SMEs has been the direct involvement of many SMEs across Australia in the conduct and funding of the CRC's research programs. We continue to expand this type of involvement to ensure adoption and utilisation of CRC technologies on a widespread basis.

Commercialisation

The experience of this CRC has been to recognise the different types of products and processes arising from CRC research and to choose the correct pathway for their commercialisation or public release.

Gene Marker Technology

A new Marbling marker patent was lodged on behalf of the consortium of CRC, CSIRO and MLA in February 2004 under the title "DNA Markers for Marbling". Negotiations are underway with the CRC's commercial partner, which has expressed interest in marketing the DNA test arising from this patent.

An agreement has been negotiated by the consortium responsible for commercializing DNA markers to sublicense to BoviGen Solutions to facilitate marketing of consortium DNA marker technologies to USA. BoviGen Solutions will contribute to the Consortium for R&D to fast-track new genetic markers. They have significant minimum sales performance obligations to meet as part of this Agreement.

"Pestigard" vaccine

The "Pestigard" vaccine, a killed vaccine against *Pasteurella hemolytica* and Pestivirus, causative agents of Bovine Respiratory Disease, developed in the first six-year term of the Beef CRC by scientists from NSW Agriculture at Camden, was officially launched at UNE by CSL on 4 September 2003. Pestivirus infects about 70% of the national cattle herd. It causes 25-50%

production losses in recently infected herds and can decimate pregnancy rates. The virus is highly infectious and persists on the farm in carrier animals that may show no sign of disease. If pregnant animals are exposed to the virus then there is a high risk of abortion, abnormal calves and weak calves. Vaccines against the disease are available overseas, but are unsuitable for Australian strains of the disease. The official launch of "Pestigard" now provides Australian producers with a practical way of controlling the virus in breeding herds and in feedlots and marks a significant milestone for the Beef CRC.

"Bovilis-MH" *Mannheimia Haemolytica* vaccine

The second of the CRC vaccines developed by CSIRO scientists at Geelong during the first six-year term of the Beef CRC received registration through the National Registration Authority in June 2004. The vaccine is registered as "Bovilis-MH" and is approved for the control of bovine respiratory disease caused by *Mannheimia Haemolytica*. The commercialising company, Intervet Australia Pty Limited, has already sold more than half a million doses of the vaccine to Australian feedlots.



IGF-I test for feed efficiency

The NSW Minister for Agriculture and Fisheries, Mr Ian McDonald, launched the IGF-I blood test for feed efficiency in Armidale in November 2003. The test is an Australian-owned and patented technology that measures the level of a protein called Insulin-like Growth Factor-I (IGF-I) in blood samples. IGF-I level is an indicator of the genetic merit of animals for efficiency of feed utilisation and in future will be used to generate Estimated Breeding Values (EBVs) for Net Feed Intake (NFI), a measure of the efficiency with which cattle utilise their feed. CRC results show the genetic correlation between IGF-I and NFI ranges from about 0.4 to 0.55, indicating about 40-55% of genes are in common for the two measurements. With the IGF-I test, breeders now have a quicker, more cost-effective way of testing large numbers of animals as an indicator of animals that are superior for NFI. The test will also be used as part of a two-step process to identify candidate animals to undergo full feed efficiency testing, a much more expensive process than IGF-I testing, but one that is still necessary in smaller numbers of animals to ensure the indirect selection process is working. The IGF-I blood-spot test was first used in the pig industry and commercialised by the Australian company PrimeGro Limited under a worldwide patent for all major livestock species.

Sub Program 1 Strategic Science to Deliver Beef Quality

Project 1.1/1.2: Regulation of growth, carcass composition and beef quality

Mission

To develop a quantitative understanding of the effects of nutritional regulation of growth at specific phases of an animal's life on subsequent growth and development of carcass tissues and of factors governing muscle metabolism and structure that impact on eating quality of beef.

Goals

- Quantify nutritional, genotypic and other regulators of cellular development and metabolism of carcass tissues.
- Define key growth periods for nutritional regulation of desirable carcass attributes.
- Quantify the influence of post-mortem conditions on specificity and activity of myofibrillar and cytoskeletal substrates of known proteolytic systems.
- Evaluate different production factors that influence muscle membrane composition and functionality and determine their impact on post-mortem muscle structure and biochemistry.
- Integrate the outcomes from the above objectives into systems for improving eating quality.
- Establish feeding and management strategies to more reliably meet premium beef specifications.

Strategies and Progress

Post-weaning growth patterns of northern cattle

Calves in northern Australia are routinely weaned at the start of the dry season and undergo a period of nutrient deprivation resulting in prolonged weight stasis or loss. Alterations in nutrient supply to cattle can result in significant variations in growth and development. Evidence from cattle experiments indicates the timing of nutrient supply affects carcass composition, marbling and meat eating quality. CRCI results suggest that rapid growth in the finishing phase overcomes the negative effects of slow growth during backgrounding on toughness and eating quality. However, CRCI experiments were not designed to properly evaluate different growth path effects on beef eating quality. This study was specifically designed to investigate the effects of compensatory weight gains in Belmont Red steers at Belmont Research Station (Rockhampton) on developmental aspects of muscle that impact on carcass composition and beef quality.

One hundred and ten weaner steers were allocated to one of three diets selected to achieve substantially different growth paths (weight loss, slow growth, rapid growth; Figure 1) over 120d in the immediate post-weaning period. When

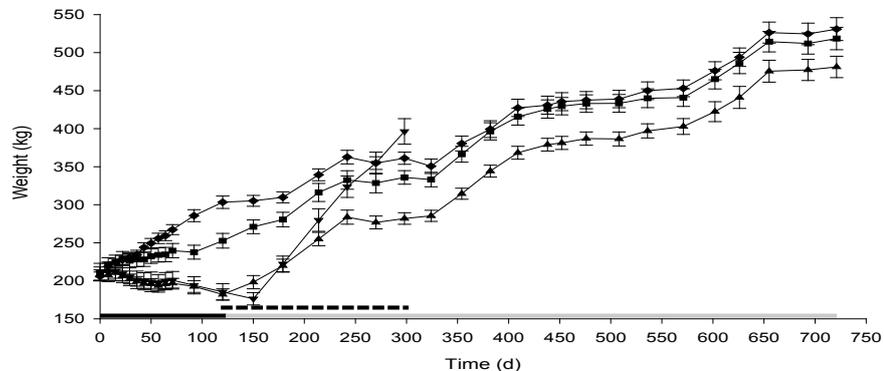


Figure 1: Mean (\pm sem) live weight of groups of similar aged Belmont Red steers on three different growth paths in the immediate post-weaning period to 721d: • rapid growth, ■ slow growth, ▲/▼ weight loss group. The black bar indicates nutrient deprivation period; grey bar pasture realimentation; dashed bar feedlot realimentation for weight loss group only.

growth rates declined during the northern dry season, pasture-fed animals were relocated to pen facilities and fed hay as a single group. The animals were slaughtered at a mean LW (\pm sem) of 511 \pm 9.2kg, 721d after the immediate post-weaning period. Samples of *m. longissimus dorsi* (LD) were collected 24h post-rigor to undertake taste-panel assessments of eating quality. Muscle biopsy samples were collected from the LD for histological examination at regular intervals throughout the experiment.

Carcass traits were measured at start of the treatment period and 120, 318 and 721 days post weaning. Table 1 shows least squares means for the steers slaughtered at 721 days post weaning. There were significant differences in live weight, carcass weight and bone mineral density between the weight loss and rapid growth groups at the end of the nutrient deprivation period.

Carcass weight and dressing percentage was not significantly different when a proportion of animals were slaughtered 316 d post-weaning. When the remaining animals from the treatment groups were slaughtered 721 days post-weaning, animals from the rapid growth group were heavier than animals from the weight loss group (531 \pm 16.8 kg vs. 481 \pm 14.0 kg respectively). Dressing percentage, marbling score, P8 fat depth, ultimate pH and EMA were not significantly different between the treatment groups 721 days post weaning.

Table 1. Carcass characteristics for steers from each treatment group slaughtered at 721d post weaning (least squares means \pm sem).

Carcass Trait	Post-weaning treatment		
	Weight loss	Slow growth	Rapid growth
Number of animals	17	16	17
Sale live weight (kg)	481 \pm 14.0 ^a	518 \pm 14.8 ^{ab}	531 \pm 16.8 ^b
Hot carcass weight (kg) [#]	243 \pm 7.9	263 \pm 8.8	265 \pm 8.2
Dressing percentage	50 \pm 0.5	50 \pm 0.5	50 \pm 0.5
P8 fat depth (mm) ^o	4.6 \pm 0.60	5.1 \pm 0.62	4.2 \pm 0.60
Ultimate carcass pH	5.7 \pm 0.03	5.6 \pm 0.03	5.7 \pm 0.03
AUS-MEAT marbling score	0.4 \pm 0.05	0.4 \pm 0.05	0.4 \pm 0.05
Eye muscle area (cm ²) ^o	62.0 \pm 1.27	63.7 \pm 1.28	64.6 \pm 1.25
AUS-MEAT fat colour	0.3 \pm 0.13 ^a	0.6 \pm 0.13 ^b	0.3 \pm 0.12 ^a
Intramuscular fat (%) ^o	2.4 \pm 0.19	1.8 \pm 0.19	2.1 \pm 0.19
Bone mineral density (g/cm ²)	0.54 \pm 0.01	0.55 \pm 0.01	0.57 \pm 0.01

Data adjusted by covariate analysis for [#] pre-slaughter LW, ^o HSCW. Means in the same row with different superscripts are significantly different (P<0.05)

Sub Program 1 Strategic Science to Deliver Beef Quality

Project 1.1/1.2: Regulation of growth, carcass composition and beef quality

Table 2. The effect of growth path on subjective MSA measures of meat quality measured on striploins from steers slaughtered 721d post-weaning (least squares means \pm sem).

	Weight loss	Treatment effect	
		Slow growth	Rapid growth
Number of animals	16	16	16
MSA Tenderness	53.6 \pm 4.0	45.9 \pm 3.9	51.0 \pm 4.0
MSA Juiciness	55.3 \pm 2.8	50.6 \pm 2.8	51.0 \pm 2.9
MSA Flavour	55.9 \pm 2.9	49.4 \pm 2.8	53.2 \pm 2.9
MSA Overall acceptance	55.1 \pm 3.3	48.2 \pm 3.2	51.6 \pm 3.3
MSA MQ4 score	54.3 \pm 3.3	47.8 \pm 3.1	51.9 \pm 3.2

The effect of nutrient deprivation in the immediate post-weaning period on subjective measures of meat eating quality is shown in Table 2. There were no significant differences between treatment groups for tenderness, juiciness, flavour, overall acceptance or clipped MQ4 score, indicating acceptable meat eating quality for all pasture-reared animals slaughtered 721d post-weaning. Generally, nutrient restriction in the immediate 120d post-weaning period had little effect on meat eating quality, dressing percentage or fatness when animals were finished on pasture for 600 days and allowed to achieve live weights of 480 to 530 kg.

Genotypic and early life nutritional influences on carcass tissues, body composition and meat quality

Research at Grafton aims to determine the extent to which nutrition early in life impacts on development of carcass tissues and beef eating quality in cattle sired by extreme genotypes for muscle development (Piedmontese) or marbling (Wagyu). The major outcome will be nutritional management practices to ensure adequate pre-natal and pre-weaning growth and development of carcass tissues to increase ability to meet premium beef specifications. This is being done by:

- Characterising the cellular basis of effects of early-life nutrition on growth and development of carcass tissues;
- Developing a mechanistic understanding of why differences occur in muscle and fat deposition in the body;
- Determining the relative contribution of early-life nutrition to growth and development of carcass tissues.

Four experimental groups of cattle were generated at Grafton Research Station: two groups of 80 steer and

Table 4. Carcass characteristics of Piedmontese (PxH) and Wagyu (WxH) x Hereford steers with divergent birth weight and pre-weaning growth as a result of high or low nutrition in utero and pre-weaning (HH, LH, HL, LL).

Steers born 2001	PxH	WxH	LSD	HH	HL	LH	LL	LSD	Effects
Number of animals	40	39	-	20	19	20	20	-	-
Hot carcass wt, kg	385	362	12	400	363	380	350	17	G,N
Dress % hot carcass wt	57.2	56.0	0.5	56.7	56.6	56.9	56.1	0.8	G
Ossification	176.2	177.2	7.3	173.0	171.8	184.5	177.5	10.4	N#
Carcass EMA, cm ²	87.8	82.5	3.5	83.9	85.0	87.8	84.0	4.8	G,W
Carcass P8 fat, mm	15.8	20.8	2.9	19.4	17.4	19.5	17.0	4.1	G,W
AUS-MEAT marbling score	1.49	2.45	0.26	1.83	1.96	1.86	2.23	0.41	G
USDA marbling score	386	536	32	450	460	455	479	45	G
Retail yield, % cold side weight	69.0	64.2	0.8	65.8	66.6	66.5	67.5	1.2	G,N

*Treatment group values are unadjusted means. Effects (P<0.05, #P<0.10) as determined by ANOVA where G = genotype and N = nutrition, or ANCOVA for carcass composition-related variables, where W = cold side wt covariate.

two groups of 80 heifer offspring. Each group contains Piedmontese- and Wagyu-sired steer or heifer calves of low (L) and high (H) birth weight (selected following divergent nutrition of pregnant cows) subjected to either low (L) or high (H) pre-weaning nutritional levels. The first experimental animals were slaughtered in February (steers) and March (heifers) 2004. Eighty heifer calves from the second breeding cycle were previously slaughtered at weaning (May 2003) to provide data on effects at completion of nutritional treatments. Eighty steer calves from the second breeding cycle will enter the feedlot in late-2004 for slaughter in 2005. Experimental animals have been genotyped for myostatin (double muscling) and TG5 (marbling) alleles and are being assessed for molecular, cellular, compositional and eating quality characteristics.

Liveweight and postweaning growth to 26 months was affected by early life nutrition. Cattle raised preweaning on low nutrition (HL, LL) grew faster than those raised on high nutrition (HH, LH). Feedlot performance of 80 core steers, slaughtered in February 2004, are shown in Table 3. HL and LL steers failed to achieve live weights of their HH counterparts at ~30 months of age, this being most evident in the LL steers. Nutritional restriction early in life limits capacity to compensate when adequate nutriment is restored.

Table 3. Feedlot performance of Piedmontese (PxH) and Wagyu (WxH) x Hereford steers with divergent birth weight and pre-weaning growth as a result of high or low nutrition in utero and pre-weaning (HH, LH, HL, LL).

Steers born 2001	PxH	WxH	LSD	HH	LH	HL	LL	LSD	Effects
Number of animals	40	39	-	20	20	19	20	-	-
Feedlot entry live wt, kg	527	512	15	562	529	499	487	22	G†,N,GxN†
Feedlot ADG, g	1420	1295	75	1388	1339	1375	1329	107	G,GxN
Weaning to feedlot exit ADG, g	713	677	24	689	664	715	712	34	G,N
Live wt at feedlot exit, kg	673	645	20	705	667	641	623	28	G,N

*Treatment group values are unadjusted means. Effects (P<0.05, †P<0.10) as determined by ANOVA where G = genotype and N = nutrition

Carcass traits and yields for the steers are shown in Table 4. Early life nutrition affected hot carcass weight with rankings similar to those for final liveweight (HH>LH>HL>LL). HH and HL steers had heaviest carcasses whilst LL steers had lightest carcasses. Retail yield from HH steers was significantly lower than for LL steers. PxH steers had heavier carcass weights than WxH, due to both heavier weights at slaughter and increased dressing percent. PxH steers also had larger eye muscles but less fat at the P8 site than WxH. WxH steers had significantly higher scores for marbling than PxH, but PxH had greater commercial retail beef yields.

Sub Program 1 Strategic Science to Deliver Beef Quality

Project 1.3: Regulation of intramuscular fat in beef cattle

Mission

To establish a mechanistic and functional understanding of the factors that determine the extent and pattern of fat development within bovine skeletal muscle, and to make this available to the beef industry so they may improve the consistency with which their cattle meet marbling specifications.

Goals

- To define the regulatory steps in the development of adipocytes in bovine muscle using molecular, cellular and physiological techniques and hence develop a mechanistic understanding of how background genetic and environmental variation impact on adipocyte number and size.
- To define the key nutritional factors that influence intramuscular fat deposition and development and hence to define the nature of genetic influence on these.
- To utilise the above knowledge in conjunction with methodologies such as candidate genes, video image analysis, real time ultrasound and novel nutritional technologies to specifically target intramuscular fat specifications in Australian beef production systems.

Strategies and Progress

This project aims to understand the biological control of marbling to develop methods of nutritionally enhancing fat cells in young animals to improve commercial expression of marbling in lot-fed cattle. Experimental work has focused on development of intramuscular fat within animals that have the genetic predisposition to express the trait. In 2003/2004, emphasis was on completing experimental work and drawing together current knowledge about marbling and presenting it in a way that is accessible to readers from industry. Two postgraduate students working with this project also had their theses accepted during this period.

Developmental milestones for marbling in cattle

The project has demonstrated unequivocally that marbling is a trait that develops steadily during an animal's growth. It is not a trait uniquely expressed by animals undergoing grain finishing, even though high-energy diets contribute to optimal expression of the trait. There is good evidence for marbling in animals of less than six months of age when those animals have a genetic predisposition to marble. The project also confirmed that genetic factors are more important than environmental factors in determining marbling phenotype. In studies using rumen by-pass lipids with purebred Wagyu, Wagyu cross and Angus cattle under both Australian and

Japanese conditions a consistent picture has emerged. Whilst the dominance of genetics in expression of marbling was implied from CRCI results, the picture is now confirmed.

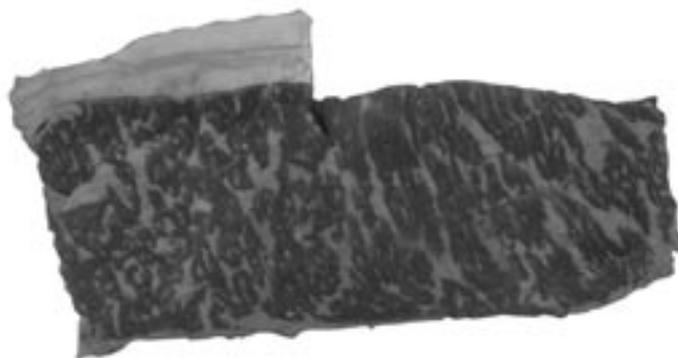
Key regulatory steps of adipogenesis and lipid-filling in muscle

This strategy has shown the significance of vitamin A in determining the marbling trait. Data have suggested specificity in its effects on intramuscular fat cells rather than subcutaneous fat cells. This research was developed in parallel with gene marker research that indicates aspects of vitamin A metabolism are genetically correlated with expression of marbling. The research has also confirmed there are important factors in the intramuscular connective tissue that influence expression of marbling, though the fundamental nature of stem cells has confounded progress towards identification of marbling-specific cellular markers.

Research is continuing to study the effects of different retinoic acid isomers on DNA transcription factor binding with a view to understanding the relationship between vitamin A depletion and marbling. Retinoic acid has been shown to be an important regulator of adipogenesis, with its effects being isomer and age specific. Before the research is complete, it will incorporate studies on the retinoic acid receptors and the PPAR factors, known to be central to fat development in other species. The central question is whether it is feasible to increase the number of preadipocytes in cattle at an early age so their lifetime potential to form marbling is increased.

Another strategy to understanding the key regulatory steps in adipogenesis is being undertaken by a postgraduate student, whose studies have two main themes. The first involves strategic science to describe how fat cells develop from precursor cells (adipogenesis) and how they remodel their own microenvironment as they develop. Working with cell cultures, he has modeled the aggregations of adipocytes that characterize marbling islands and measured one particular metabolic pathway (synthesis and degradation of hyaluronan) known to modulate cellular development in mammalian tissues. The second theme evaluates the significance of this metabolic pathway to the expression of marbling in cattle. It was hypothesized that a proportion of the variation in marbling (both visually scored and chemically

determined) could be explained by variation in the amount of hyaluronan in the muscle. Muscle samples covering a wide range of marbling scores (1 to 9; Jersey x Limousin-cross steers and long fed Wagyu-cross steers) were examined. Even though there



Marbled meat

Sub Program 1 Strategic Science to Deliver Beef Quality

Project 1.3: Regulation of intramuscular fat in beef cattle

was a strong relationship between marbling score and intramuscular fat percentage, there was only a weak relationship between the level of hyaluronan and intramuscular fat percentage or carcass weight. It was concluded that hyaluronan is likely to play a mechanistic role in development in marbling fat islands but that variation in its absolute amount is not likely to account for variance in the amount of marbling. Further experiments will examine this mechanistic role.

Novel technologies for measuring and quantifying marbling distribution

Major advances were made in development of methods for describing the distribution of marbling fat. Toni Reverter, Wes Barris, Peter Allingham and Greg Harper developed an automated procedure that works from an image of a striploin cross-section and quantifies the amount of marbling fat (this aspect is not new) as well as the distribution of that fat (which is novel in its approach and outcome) (Figure 1). Existing approaches to marbling were improved by implementing an automated spoke analysis approach to literally “find and isolate the muscle” within the image. Using 183 JPEG digital images of the eye round supplied by AUS-MEAT, the group tested its new Image Analysis

Software for characterizing the amount and distribution of marbling. Testing was organised as a 4-tiered strategy from two levels of resolution in the software settings (High and Low Resolution) and two levels of “human intervention” (automatic i.e. no intervention; and manually clipping the eye (lean) of the image). A number of statistical techniques were then employed: principal components analysis; linear modelling; and correlation analysis. Overall, the study found it was possible to estimate the percentage of marbling, the number of marbling flecks and the distribution of marbling flecks in a semi-automated way. The procedures were fast – certainly faster than manual techniques and capable of resolving very small flecks. Due to low to moderate correlations among the three parameters, principal components analysis failed to find a single combination of the parameters that explained a substantial proportion of the total variation, though it was able to account for up to 60% of the image structural variation. Although reproducibility of the image analysis procedure was very high, the software captures and describes features that are not apparent to the naked eye. Hence, an associated AUS-MEAT Marbling Score is required for proper benchmarking of the procedure, prior to a larger trial under industry conditions.

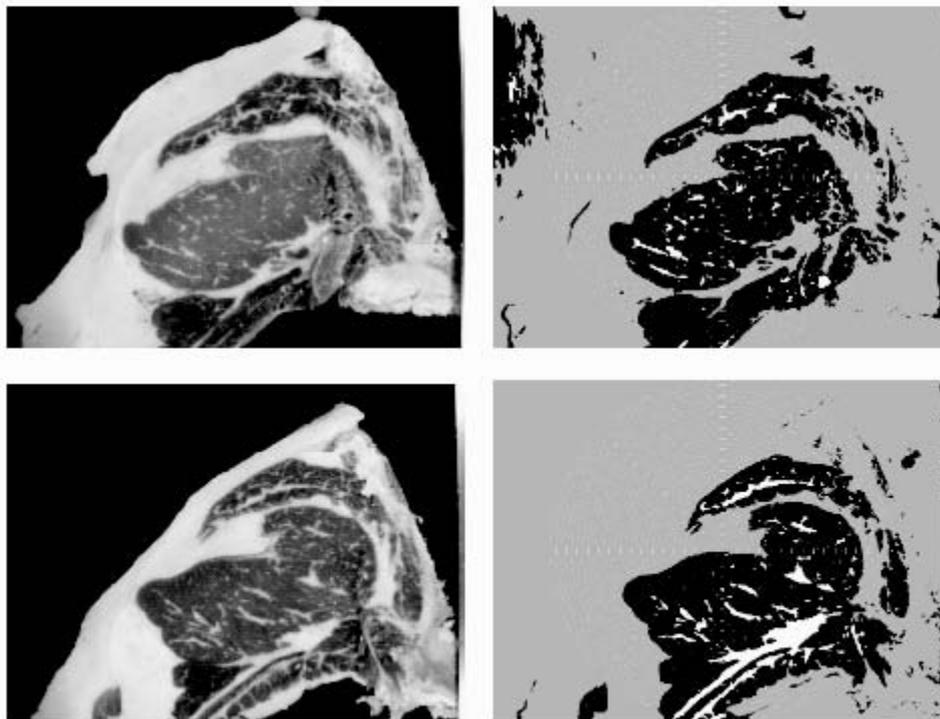


Figure 1. Comparison of actual JPEG images (left) and computerized kernel images (right) from a run with low-resolution settings and automatic clipping of the images.

Sub Program 1 Strategic Science to Deliver Beef Quality

Project 1.4: Functional genomics of beef quality

Mission

To characterise genetic, biochemical and environmental interactions that contribute to beef quality. To use this knowledge to develop gene markers and to contribute to the development of treatments and management strategies for the consistent and sustainable supply of high quality beef products.

Goals

- Establish microarray reagents using cattle muscle and adipose and fetal tissue cDNA libraries and inputs from the CRC gene mapping activities, adipogenesis and myogenesis models and other cattle EST resources.
- Characterise expression of cattle muscle and adipose tissue genes during the course of different experimental treatments imposed on cattle in projects 1.1, 1.2 and 1.3.
- Characterise expression of candidate genes identified in project 2.1.
- Establish correlations between different beef quality outcomes, treatments, genotypes and changes in gene expression patterns.
- Identify biochemical pathways and gene regulatory networks of key importance in the determination of beef quality outcomes.
- Identify possible candidate genes for beef quality outcomes.

- Use the information gained from these experiments to contribute to genetic, nutritional and other management strategies to manipulate beef quality outcomes.

Strategies and Progress

This project investigates changing gene expression patterns in different tissues on a genome-wide scale to determine the genes that are being expressed (“switched on”) or down regulated (“switched off”) during adipogenesis (development of fat) or protein turnover (development of muscle). Validation of gene expression patterns unveiled during microarray experimentation was the main thrust of the project over the past year. Gene expression patterns from the *in vitro* adipogenesis experimentation, the Holstein/Wagyu breed comparison and the short-term nutritional trial were measured using RT-PCR tests. The project also developed cell culture reagents and *in situ* hybridisation techniques for gene function studies planned for next year.

New microarray experimentation was affected by the failure of our cDNA probe set, probably caused by inappropriate storage conditions at the microarray printing facility. After an extensive period of troubleshooting, the project had no choice but to re-amplify the almost 10,000 PCR probes from stored templates, causing delays to milestones. However, the performance of the newly constructed array exceeds that of the original array and rapid progress has been made to achieving outstanding project objectives.

Gene Expression Patterns for Marbling

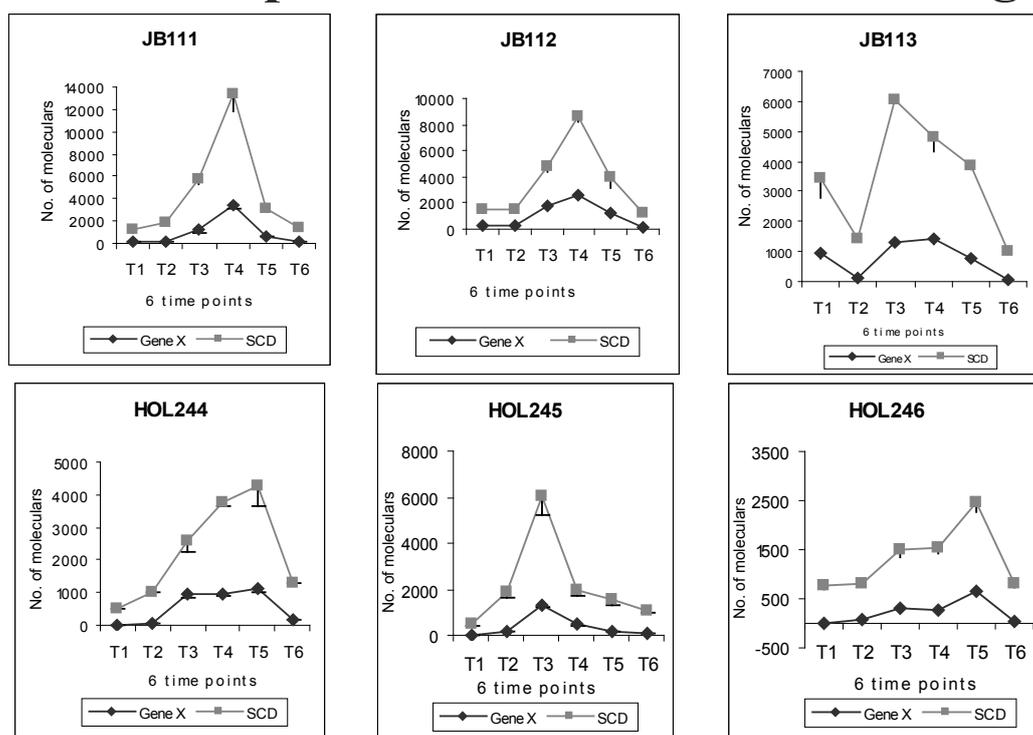


Figure 1. SCD and Gene X expression measured by RT-PCR assay in 6 animals across 6 time points. RNA copy number was established using “absolute quantification” by comparison with a standard curve generated from a synthetic template.

Sub Program 1 Strategic Science to Deliver Beef Quality

Project 1.4: Functional genomics of beef quality

Characterization of biochemical pathways affecting adipogenesis - changes in expression patterns in animal experiments

Following from microarray experimentation on Wagyu and Holstein muscle biopsy samples in Project 1.3, the expression of a number of differentially expressed genes was studied in biopsies from 5 additional time points at 3-4 month intervals to slaughter at 32 months (Figure 1). The two genes illustrated here were detected as differentially expressed at the 11-month time point. They were Stearoyl CoA Desaturase (SCD) and an interesting bovine gene (Gene X) observed in this context for the first time. Expression levels of both genes mirror each other very closely in each individual. SCD is a crucial enzyme involved in the fatty acid composition of marbled beef and genetic markers in the SCD gene have been patented by our Japanese collaborators for their association with fatty acid profile. Gene X is one of a group of genes of unknown function that may be a downstream indicator of activation of a particular regulatory axis in marbling animals. Project 2.1 is currently testing DNA markers for 6 of the differentially expressed genes from this study for their possible associations with marbling.

Characterization of biochemical pathways affecting adipogenesis - changes in expression patterns in in-vitro experiments

The analysis of the combined microarray data (TZD differentiation time course in last year's report) yielded a list of differentially expressed array elements of 708 clones. After sequencing all differentially expressed array elements and conducting bioinformatics, a list of 275 genes was derived. A large number of the genes detected were related to lipid metabolism, extracellular matrix and other well-characterised biochemical events during adipogenic differentiation. Differentially expressed elements that showed unexpected expression patterns or represented bovine genes not yet characterised were selected for further investigation. Quantitative reverse transcribed PCR (qRT-PCR) tests for 14 differentially expressed genes were developed to validate differentially expressed genes detected in the microarray study. In addition to RNA from the original TZD differentiation time course, RNA from an *in vitro* differentiation time course on bovine fibroblasts cultured from intramuscular fat islands was also studied for expression levels of the genes of interest to lend further strength to the validation.

In general, the RT-PCR data confirmed the expression profiles generated in the microarray experimentation. Following additional bioinformatics or molecular biology experimentation to determine the identity of the four remaining "unidentified" genes of interest, this work will be prepared for publication and functional studies on a subset of genes identified will be conducted.

Development of cell resources for functional studies

Clonal cell lines are an important experimental resource because they allow a uniform starting population of cells. In the context of gene function studies, this aspect is particularly important. Last year the project successfully generated immortal bovine fibroblasts from intramuscular fat islands of Angus cattle. The expression of large T Antigen in these cells is illustrated by the positive hybridization *in situ* of a large T Antigen probe (Figure 2).

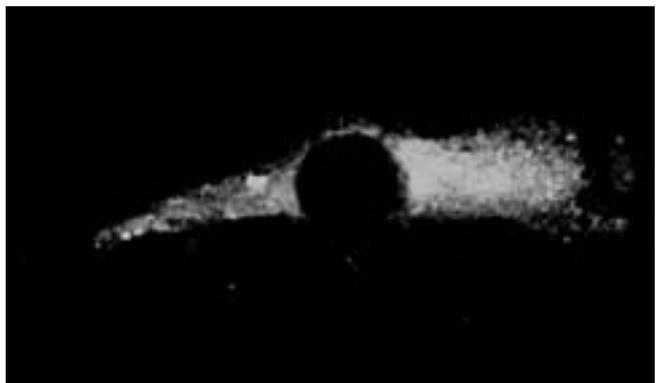


Figure 2: Large T-antigen transfected cell hybridised with a DIG labelled probe for large T-antigen visualised with a fluorescent anti-DIG antibody

Characterization of biochemical pathways affecting protein turnover

The Rockhampton postnatal growth study conducted through project 1.2 was analyzed using 24 of the new microarray slides with validation of expression patterns currently underway.

Good progress was made in validating expression profiles (RT-PCR) from the earlier Rockhampton "pilot" study by quantifying the expression of two highly expressed genes (troponin and osteonectin) and three unknown transcripts by Q-PCR in HIGH growth *vs.* LOW growth samples. Results from Q-PCR corroborate the differential expression results obtained using the microarray for four of the five genes tested. Data for troponin and two unknown transcripts show up-regulation of gene expression by 2.2-, 5.5-, and 1.3-fold respectively and are in close agreement with the microarray results. Results from Q-PCR for osteonectin show a down-regulation of approximately 4.5-fold, also similar to the microarray analysis. Finally, a 2.5-fold up-regulation of the third unknown gene between the two treatments was observed from the Q-PCR analysis, contradicting the microarray results. This was attributed to the very low average signal captured for this gene.

Sub Program 1 Strategic Science to Deliver Beef Quality

Plans for 2004 / 2005

Project 1.1 / 1.2 ~ Regulation of growth, carcass composition and beef quality

- Complete proteomic analyses of C2C12 experimental samples from cell culture experiments with demonstrated changes in desmin modification.
- Complete cellular and molecular analyses of treatments from Rockhampton experiment.
- Complete backgrounding, feedlotting and slaughter of steers from Grafton experiment.
- Complete compositional, ossification, meat quality, cellular and molecular analyses of samples from first breeding cycle of Grafton experiment.
- Economic analyses of Rockhampton and Grafton experiments within Project 5.5.
- Extension of results of Rockhampton and Grafton experiments within Project 4.4.
- Publication of project results in peer-reviewed scientific journals.

Project 1.3 ~ Regulation of intramuscular fat in beef cattle

- Evaluate the effect of Wagyu and double-muscling genetics on the adiposity of muscle from the Grafton herds at key developmental milestones.
- Complete a provisional patent covering image analysis techniques for marbling distribution.
- Progress commercialization of a new macroscopic descriptor of marbling.
- Assess marbling distribution in muscle samples taken from Project 2.3 cattle.
- Assess marbling distributional characteristics in three dimensions in appropriate cattle.
- Complete two experiments on the effects of chilling on the visual expression of marbling.
- Investigate mechanism by which vitamin A depletion influences marbling using *in vitro* studies.
- Determine the location of the hyaluronan synthase proteins in marbling fat islands and in the perivascular regions of connective tissue generally.
- Facilitate submission of Master of Biomedical Science thesis by a student working in the project.
- Submit at least 2 papers to American Journal of Animal Science from the vitamin A experiment.
- Submit at least one paper describing the outcomes of the Rockhampton growth path experiment.
- Work with extension staff to communicate the key messages derived from the project.

Project 1.4 ~ Functional genomics of beef quality

- Conduct expression profiling experiments using bovine microarrays (different genotypes - Grafton study).
- Validate expression profiles of differentially expressed genes from the Grafton experiment.
- Conduct expression profiling experiments using bovine microarrays (Rockhampton growth study).
- Complete validation of expression profiles (qRT-PCR; Rockhampton growth study).
- Validate expression profiles of up to 10 differentially expressed genes from Vitamin A study.
- Conduct functional studies on gene networks identified in microarray studies from years 4 and 5
 - * Establish tissue *in situ* hybridization patterns of at least 3 differentially expressed genes from microarray studies.
 - * Design functional studies for two regulatory pathways.

Sub Program 2 Innovative Technologies for the Beef Supply Chain

Project 2.1: Genetic markers for production, adaptability, efficiency and beef quality

Mission

To develop genetic marker technologies that enhance selection techniques and ensure the production efficiency, product quality and consistent supply of domestic and export cattle.

Goals

- Fine scale map genes for carcase and meat quality and tropical adaptation, based on genes mapped to broad chromosome regions in CRCI and elsewhere.
- Map to broad chromosome regions and then fine scale map genes for net feed efficiency.
- Test candidates for the genes in objectives 1 and 2 or develop haplotypes of markers so these genes can be selected using DNA tests that are not specific to a single family.
- Develop single nucleotide polymorphisms (SNP) over chromosomal regions and genes identified in objectives 1-3. Develop DNA micro-arrays based on these SNP for economically typing cattle for these genes.
- Determine the effect on adaptability of genes discovered by their effect on carcase and meat quality and the effect on meat and carcase quality of genes for adaptation.
- Demonstrate the use of DNA based tests to select commercial cattle for carcase and meat quality and adaptability.

Strategies and Progress

This project aims to map, identify and commercialise DNA tests for tenderness, marbling, retail beef yield, resistance to ticks and worms and net feed efficiency.

Gene markers for carcase and beef quality

Marbling A full patent for a gene marker test in a gene that affects marbling was lodged in February 2004. It contains an evaluation of several SNP (single nucleotide polymorphisms or small sections of DNA differing in a single nucleotide base) across a positional candidate gene for marbling that belongs to the steroid/thyroid/retinoid receptor family. Genes adjacent to it, specified by the human gene map, do not show associations to

marbling. The location of this QTL for marbling has been progressively refined and a SNP in a positional candidate gene showing consistent effects on marbling was identified. Through radiation hybrid mapping, the region of the human genome closely corresponding to the QTL region was identified and candidate genes placed to that area. SNP were identified in the candidate genes and high throughput assays were developed. One of the SNP had consistent associations with marbling and intramuscular fat. Efforts were made to identify the causal mutations and 3 SNP were described and genotyped across panels of animals extreme for marbling.

Results show: 1) very high levels of linkage disequilibrium across the gene; 2) that haplotypes of these SNP contain more information than any single marker; and 3) that only haplotypes including the central intron are significantly related to marbling.

Further sequencing around this intron will be done to identify further SNP that may lead to the identification of the causal mutation(s) for marbling.

Gene marker tests in the leptin and steroyl CoA desaturase genes (patented by other international groups) have also been tested in the CRC's database and found to have no effect on marbling in Australian cattle. The result should ensure the Australian beef industry does not waste money undertaking these tests. Six genes that are more highly expressed in either Holstein or Japanese Black than in the other breed (in Projects 1.3 and 1.4) have been identified and SNP in two of the genes tested but with no effect on marbling.

Tenderness New SNP were found and evaluated in the calpastatin gene, which is the basis for the commercial GeneStar Tenderness test. Although the new SNP are associated with tenderness, they do not improve the accuracy of the current commercial test. However the results show there is more than one causal mutation in the calpastatin gene.

Gene markers for resistance to ticks

Funding for tick resistance studies in dairy cattle was obtained from Dairy Australia. The research is being channeled through the Beef CRC so that concurrent CRC research for DNA tests for resistance to ticks in Belmont AXBX cattle can proceed without compromising Intellectual Property. Dairy cattle have been tick counted in 11 Queensland herds and DNA samples processed. From the sequencing carried out in beef cattle, 30 SNP are available in genes in chromosomal regions to which tick count QTL have been mapped. These will be tested for relationships with tick count in both beef and dairy cattle.



Sub Program 2 Innovative Technologies for the Beef Supply Chain

Project 2.1: Genetic markers for production, adaptability, efficiency and beef quality

Gene markers for feed efficiency

The Davies Cattle Gene Mapping Project at the University of Adelaide included 366 Limousin x Jersey backcross calves that were measured for net feed intake (NFI). The project mapped five QTL affecting NFI to chromosomal regions, four of which were also found in mice lines divergently selected for NFI. The aim of the CRC research is to determine whether these genes segregate in commercial cattle, to map them as precisely as possible, to identify the genes responsible and to develop commercial DNA tests for genes affecting NFI.

Linkage mapping using cattle from the Trangie NFI selection lines is being carried out using microsatellites. Candidate genes in these regions are being sequenced, SNP found and the Davies Limousin x Jersey cattle are being typed with these SNP. Blood samples from 1660 Trangie Angus cattle from the NFI selection lines have been received and DNA extracted. Thirty microsatellite markers have been selected, covering the five chromosomes, and optimised for genotyping. The cattle have thus far been genotyped for 5 markers on one of the chromosomes.

132 candidate genes have been selected, based on mouse and human studies that map to the 5 chromosomal

regions with QTL for NFI. 21 are being sequenced to find SNP, 12 have SNP and 5 have been genotyped on the Davies cattle. Another 16 have public DNA sequence showing putative SNP.

Improved methods for genotyping

Over the past year, several different methods were trialed to increase efficiency of genotyping. A method was identified to greatly improve ability to simultaneously amplify DNA fragments from several genes. Clear differences between the original and new method can be seen in Figure 1. The new method radically improves simultaneous amplification of several genes and all loci perform approximately equally well. The method is being tested further but it represents a major step towards a general, parallel high throughput genotyping system.

Improvements in high throughput genotyping should increase the speed and reduce the cost of genotyping, so that large genetic projects become not only technically but also financially feasible. Several options to reduce costs of genotyping have been tested, with good progress made in these methods.

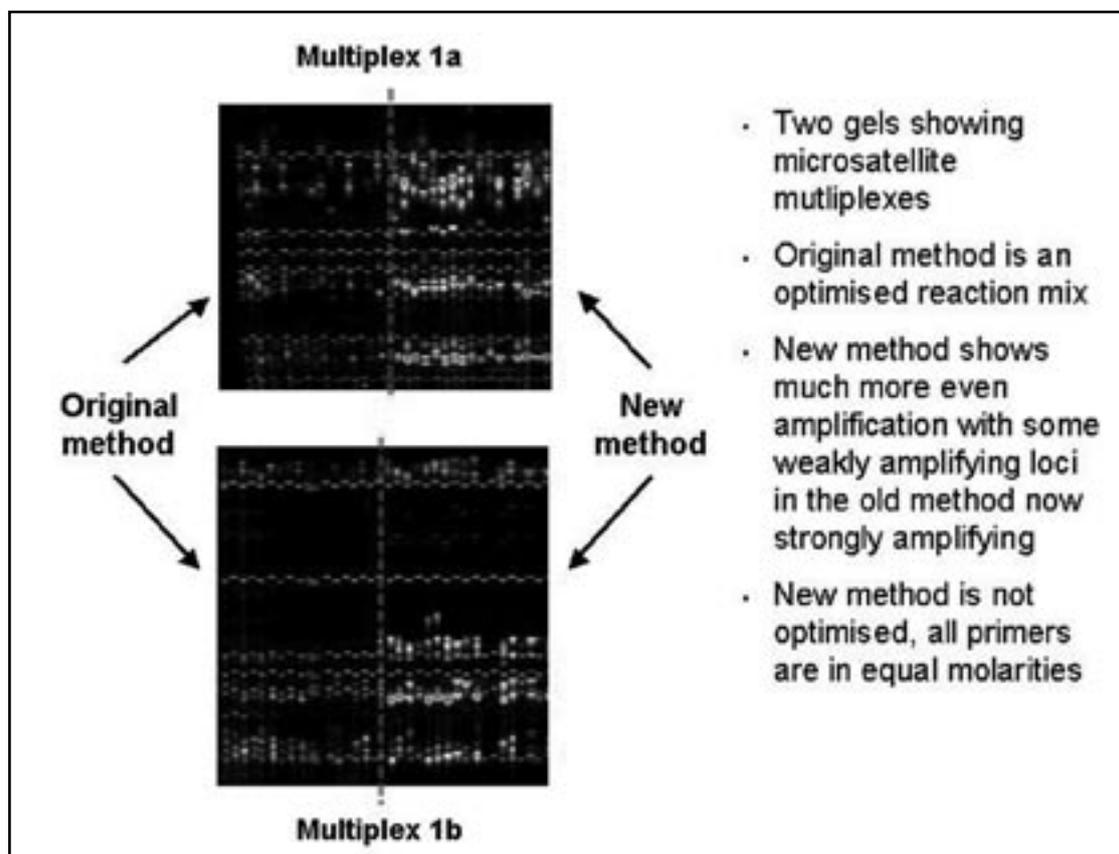


Figure 1. Tests of a new protocol for multiplexing (i.e. simultaneously testing) DNA loci

Sub Program 2 Innovative Technologies for the Beef Supply Chain

Project 2.2: Improving the efficiency of feed utilisation for beef production

Mission

To reduce the cost of beef production through genetic improvement in efficiency of feed utilisation.

Goals

- To utilise existing scientific information to develop the Net Feed Intake (NFI) technology for industry application.
- To develop and implement educational and extension strategies to improve the adoption rate of NFI technology by industry.
- To evaluate key genetic relationships between NFI and other economically important traits.
- To develop lower cost methods to identify animals that are superior for NFI.
- To develop optimal breeding designs for use by industry.

Strategies and Progress

Develop and extend NFI technology to industry

This strategy aims to foster the roll-out of NFI technology by providing support for seedstock breeders measuring NFI on their animals and through a targeted extension campaign to improve awareness and show commercial beef producers how they can improve profitability by selection on this trait. The number of animals tested by industry continued to grow, including 546 tested in 2003 (Figure 1).

Extension work focused on explaining to commercial breeders how the NFI EBV can be used with EBV for other commercially important traits to identify bulls that are superior for a number of desired characteristics. For example, analysis of the Angus 2004 Group Breedplan sire data shows a number of young industry bulls that have high genetic merit for both NFI and IMF, as well as a high \$Index (Table 1). Use of such bulls in seedstock and commercial breeding programs will make significant gains in efficiency, marbling and profitability in the Australian beef industry.

Evaluate key genetic relationships between NFI and other economically important traits

This strategy is aimed at filling the key gaps in knowledge of genetic relationships between NFI and

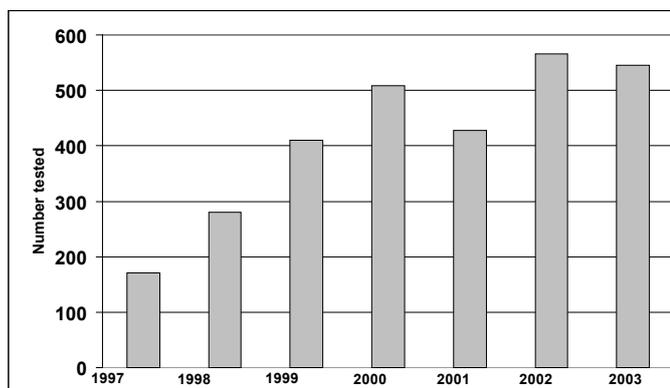


Figure 1. Numbers of cattle tested for NFI by industry to 2003.

other economically important traits. It involves work with leading seedstock breeders to provide NFI data to estimate the relationships, while at the same time assisting with implementation of the technology.

An experiment at Glen Innes confirmed that steer growth and feed efficiency at pasture are favourably associated with genetic variation in sire NFI. Initial and final liveweight of the steers and feed intake were not associated with variation in sire NFI EBV (Table 2). However, daily gain by the steers tended toward a favourable negative association with sire NFI EBV. NFI and Feed Conversion Ratio (FCR) had positive associations with sire EBV for NFI. Results show a 1 kg/day lower NFI EBV of a sire was associated with steer progeny that grew 19% faster with no increase in amount of feed eaten and a 26% lower NFI and a 41% better FCR.

Analysis of the most recent cow data from Trangie confirmed the presence of favourable genetic correlations between postweaning feed efficiency and cow traits. Postweaning records on 1781 bulls and heifers tested for feed efficiency at 267 days of age and cow records at 4 years of age on 751 of the same females were used to estimate genetic correlations between postweaning feed efficiency and cow traits. The postweaning feed efficiency traits used were NFI and FCR. Cow records were taken on non-pregnant cows after they weaned their second calf. Cow traits were daily feed intake (COWFI), ultrasound measure of rump fat depth

Table 1. EBVs, Japanese B3 \$Index and percentiles for industry identified bulls born in 2000 and 2001.

Bull	NFI		IMF		Japanese B3 Index	
	EBV	Percentile	EBV	Percentile	\$Index	Percentile
Ythanbrae New Design 036 V599	-0.95	Top 1%	1.2	Top 15%	\$106	Top 1%
Ythanbrae Precision V397	-0.71	Top 5%	1.0	Top 15%	\$87	Top 5%
Bald Blair Future Direction W79	-0.68	Top 5%	2.1	Top 1%	\$82	Top 5%
Ythanbrae Precision V984	-0.51	Top 5%	1.1	Top 15%	\$78	Top 10%
Ythanbrae Precision V212	-0.51	Top 5%	0.9	Top 20%	\$87	Top 5%
Bald Blair Future Direction W86	-0.50	Top 5%	1.5	Top 10%	\$76	Top 10%
Bald Blair New Design V86	-0.48	Top 10%	1.8	Top 5%	\$78	Top 10%
Ythanbrae New Design 036 V975	-0.47	Top 10%	2.1	Top 1%	\$87	Top 5%
Ythanbrae Precision V939	-0.45	Top 10%	0.9	Top 20%	\$82	Top 5%
Ythanbrae New Design 036 V467	-0.41	Top 10%	1.6	Top 5%	\$93	Top 1%

Sub Program 2 Innovative Technologies for the Beef Supply Chain

Project 2.2: Improving the efficiency of feed utilisation for beef production

(COWFAT), *longissimus* muscle area (COWEMA) and weight at 4 years of age (4-yWT). Genetic correlations between NFI and the cow traits were 0.74 (COWFI), 0.32 (COWFAT), 0.41 (COWEMA) and -0.03 (4-yWT). Corresponding values for FCR were 0.39 (COWFI), 0.32 (COWFAT), 0.12 (COWEMA) and -0.33 (4-yWT). Results indicate that when selection of young cattle for improved feed efficiency is based on FCR, a weak correlated response in reduced cow feed intake and increased cow weight is expected, which may not be desirable. However, when selection of young cattle is based on NFI, a strong correlated response in reduced cow feed intake is expected with no change in cow weight.

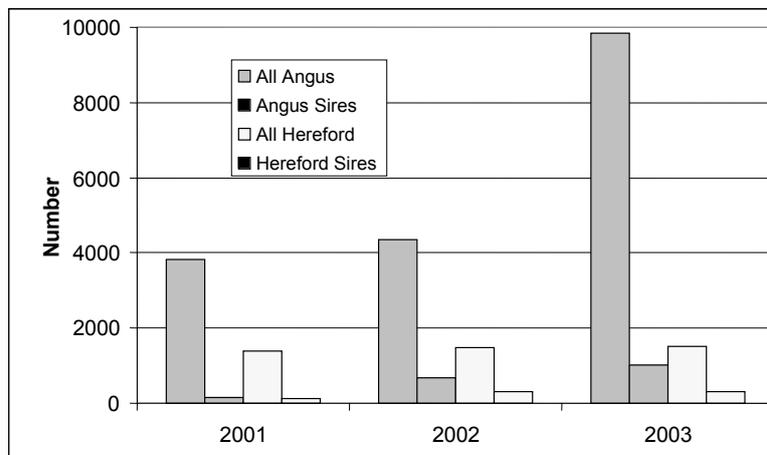


Figure 2. EBV for NFI for Angus and Hereford/Poll Hereford cattle (accuracy >19%) and for sires (accuracy >49%). IGF-I data was first used in 2003 in Angus only.

Cost-effective ways to identify animals genetically superior for NFI

This strategy focuses on finding better and more cost-effective ways of implementing NFI technology to industry, including investigation of methods to reduce costs of NFI measurement and identifying alternative "markers" related to feed efficiency. Progress in the search for genetic (DNA) markers is presented in the report for Project 2.1. The Primegro IGF-I bloodspot test to identify cattle genetically superior for feed efficiency was launched in November 2003. The impact of the test to increase the number of bulls with EBV for NFI was immediate in the Angus breed (Figure 3) and is available to all breeds. A revised NSW Agriculture Agnote on the NFI EBV, updated to include information on IGF-I, has been released.



Special Edition of Australian Journal of Experimental Agriculture

A special CRC edition of 17 research papers and reviews was published by the Australian Journal of Experimental Agriculture "Improving Efficiency of Feed Utilisation by Animals", Volume 44 Number 4-5 in June 2004. It includes revised and updated papers presented at the CRC Feed Efficiency workshop in Armidale in 2000 plus the latest research results from the current CRC and two papers using the mouse as a model species to examine the direct and correlated responses to selection for NFI.

Table 2. Mean initial and final liveweight (LW), average daily gain (ADG), feed intake, net feed intake (NFI) and feed conversion ratio (FCR) of Angus and Hereford steers on pasture in Spring to Summer of 1995 and 1997 and regression coefficients with sire estimated breeding value for NFI (EBV_{NFI}). Results are for 127 steers from 42 sires.

	Mean (\pm s.e.)	Regression coefficient (\pm s.e.)	Change for 1 kg EBV_{NFI} as % of mean
Start LW (kg)	338 \pm 5	-9 \pm 25	2.6%
ADG (kg/day)	0.84 \pm 0.02	-0.16 \pm 0.10 [†]	19%
Final LW (kg)	411 \pm 4	-23 \pm 26	5.5%
Feed intake (kg/day) ^a	8.5 \pm 0.3	1.3 \pm 1.1	15%
NFI (kg/day)	0.00 \pm 0.27	2.2 \pm 1.2*	26% ^b
FCR (kg intake/kg gain)	10.4 \pm 0.4	4.2 \pm 2.0*	41%

Probabilities of regression coefficient differing from zero: [†] <0.1; * <0.05.

^a kg 10 MJ ME/dry matter. ^b As a % mean daily feed intake.

Sub Program 2 Innovative Technologies for the Beef Supply Chain

Project 2.3: Links between the genetics of beef quality and components of herd profitability in northern Australia

Mission

To increase the knowledge of genetic relationships between components of herd profitability in northern Australian environments, in order to improve efficiency and product quality without unduly compromising breeder herd performance or adaptability.

Goals

- Determine the correlated responses to selection for retail beef yield percentage and intramuscular fat percentage on body composition, efficiency of feed utilisation, adaptability to stressors of tropical environments and female reproductive attributes and estimate the relationships between these traits in tropically adapted cattle.
- Demonstrate the use of genetic markers to select commercial cattle for carcass and meat quality and adaptability.
- Extend the Australian and South African beef genetic evaluation schemes for Belmont Red and Bonsmara breeds to estimate breeding values for traits of economic importance across both countries.

Strategies and Progress

This project targets the pivotal issue in Australia's beef genetic improvement dilemma: Can we change carcass and beef quality attributes of beef cattle without unduly compromising key fitness traits like reproductive performance and adaptation to harsh environmental stressors? Industry outcomes from the project are targeting multiple traits and multi-faceted strategies including carcass and beef quality, feed efficiency, female fertility and adaptation to tropical environments using a range of tools such as Estimated Breeding Values (EBVs), genetic markers, ultrasound scanning and meat processing and cattle management strategies that will impact on most sectors of the Australian beef industry.

Breeding and phenotyping

Good progress was achieved in the project over the past year, with identification of sires of experimental progeny exceeding expectations and with data collection exceeding the planned experimental protocol in terms of frequency of measurements recorded on experimental animals. As well, due to favourable seasonal conditions, all steers will be slaughtered 9 months ahead of schedule by September 2004. By then, it is estimated that ~1,800 steers will have individual feed intake records to add to the CRCI linked feed intake records for tropically

adapted cattle. Meat quality analyses are underway and should be complete for all steers by the end of 2004, providing a complete dataset for feed intake and carcass and beef quality attributes in project steers. In June 2003, the project transferred its slaughter arrangements to Warwick Bacon to take advantage of the whole body VIAscan unit installed in that plant with generous funding from Meat and Livestock Australia. Since then, retail beef yield has been successfully estimated using VIAscan imagery. As well, one side of each carcass has been tenderstretched and the other normally hung by the achilles tendon, to allow a comparison of genetic parameters for beef tenderness in tenderstretched *vs.* normally hung carcasses.

Female fertility attributes are recorded in heifer half sibs to determine age, weight and fatness at puberty and in heifers/cows after they have joined the breeding herd at ~2 years of age for a minimum of two breeding seasons (as maidens and first-calf heifers). Three complete heifer crops have been measured from weaning until they entered the breeding herds at 4 research stations throughout Queensland. A fourth calf crop is currently undergoing measurement prior to first joining at the end of 2004. Data from this protocol are probably the most comprehensive world-wide, with detailed measurements, including ultrasound scans for ovarian activity available on >2,200 heifers each 4-6 weeks between weaning and when heifers enter the breeding herds and thereafter at strategic points to determine post-partum returns to oestrus and re-conception.

The project database is now very functional and web-accessible for authorised project staff, who have spent considerable time this year validating the data. Analyses of data to determine phenotypic relationships between fatness attributes at start of joining and subsequent female fertility attributes to allow producers to make decisions about the economic viability of changed management practices impacting on fertility are underway. Analyses of the complete steer dataset in the live steer (growth, feed intake, flight time, IGF-I, scanned carcass traits) will commence after slaughter of the final steer cohort. Analyses of pubertal scanning and reproductive tract scores from 3 heifer crops have commenced, with practical results from all 3 datasets anticipated for industry within 12 months.

Value of DNA markers to select commercial cattle

Over the past 6 months, sires of most experimental calves were identified through a commercial DNA fingerprinting service. A few calves are still being re-tested to distinguish sires, but significantly more calves than anticipated (>96%) have now been assigned to a single CRC sire, which is an extraordinarily good result given the difficulties of controlling bulls in very large multiple-sired pastoral herds. The station managers and stock crews in all herds deserve significant credit for this extraordinary result.

Sire assignments using the CRC's panel of DNA markers associated with meat quality

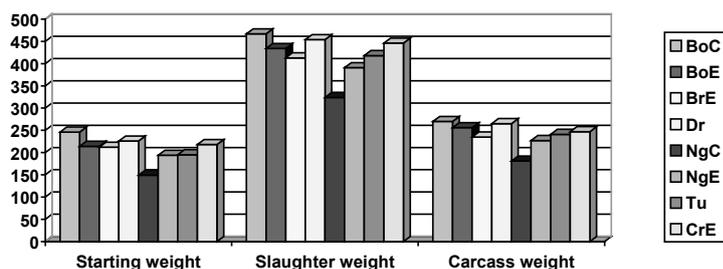


Figure 1. Average live weights (kg) of steers at feedlot entry and pre-slaughter and carcass weights within breed groupings in Phase 2 of the South African feedlot experiment (BoC-Bonsmara commercial; BoE-Bonsmara emerging; BrE-Brahman emerging; Dr-Drakensberger commercial; NgC-Nguni communal; NgE-Nguni emerging; Tu-Tuli Commercial; CrE-crossbred emerging)

Sub Program 2 Innovative Technologies for the Beef Supply Chain

Project 2.3: Links between the genetics of beef quality and components of herd profitability in northern Australia

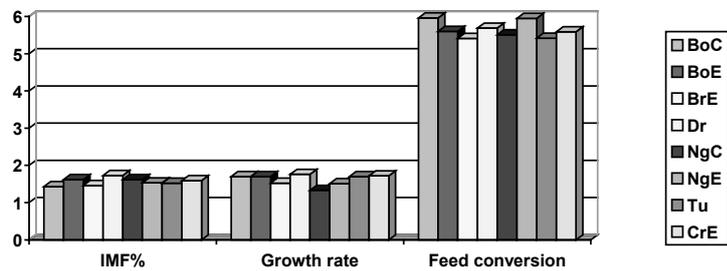


Figure 2. Average IMF% growth rates (kg/day) and feed conversion ratios kg feed/kg gain/day of steers within breed groupings in Phase 2 of the South African feedlot experiment (see Figure 1 for breed definitions)

and resistance will be compared with assignments from the commercial fingerprinting service to determine why the CRC's markers could not accurately identify sires. Assuming the DNA markers are validated using this process, the genotypes will be evaluated in conjunction with phenotypic information to determine the value of the markers for selection of commercial cattle for carcass and beef quality attributes and for other traits affecting productivity in northern Australian beef herds. An alternative approach is being used by a PhD student who recently completed genotyping all project animals for two genes associated with fatness traits. Those genotypes will be evaluated against a range of carcass and beef quality and female fertility phenotypes in the coming year.

South African collaborations

Fourteen Farmer Teams (7 each in Limpopo and North Western Provinces) now operate through the "Beef Profit Partnerships" (BPP) Project in South Africa. These farmer teams act to achieve agreed objectives, outputs and outcomes designed to impact on profit, measured by use of gross margin kits specially designed for use by project farmers. Over the past year, actions focused on key drivers such as marketing, throughput (fertility and growth) and costs of production. The capacity of farmers to market and keep records is gradually improving, with noticeable impacts on profits at both the individual farmer and community level.

Last year's report contained results from Phase 1 steers from resource poor farmer herds. Phase 2 steers were transferred to ARC's Irene Campus in July-August 2003 for comparison with steers sourced from commercial herds. Phase 1 breed (and herd) types included Brahman (emerging), Nguni (communal and emerging), non-descript crossbreds (emerging and commercial) and Bonsmara (emerging and commercial). Steers from commercial herds were used as controls to benchmark the suitability of steers from emerging and communal herds to meet specifications of commercial markets.

In Phase 2, two additional indigenous breeds from commercial farmers (Drakensberger and Tuli) and Bonsmaras from emerging farmers were included, while non-descript commercial steers were excluded.

Animals were finished on a grain-based diet. Measurements included weights, individual feed intake, flight time, ultrasound scans for carcass attributes and commercial carcass characteristics at slaughter. Full carcass and meat quality attributes were also measured.

Phase 1 results showed that growth rates and feed efficiencies of steers from emerging and communal farmer herds paralleled those from commercial herds (i.e. they entered the feedlot at a lighter weight but grew as well, with similar feed efficiencies, to achieve acceptable albeit lighter carcass weights). The incidence of disease was low in all Phase 1 steers and was similar in commercial, emerging and communal herds. Meat quality analyses indicated no differences between herd types or breeds in carcass and meat quality attributes. Based on dentition, cattle from emerging and communal herds were slightly older at slaughter than cattle from commercial herds.

Phase 2 results confirm that growth rates and feed efficiencies of steers from emerging and communal farmer herds parallel those from commercial herds (Figures 1 and 2). Weight gains in the feedlot were significantly higher for the Bonsmara (emerging and commercial), Drakensberger, Tuli and emerging crossbreds than the Brahman and both Nguni groups. The Nguni communal was very light at feedlot entry (149 kg) but the poorer performance of the Nguni emerging group for growth rate, and hence also feed conversion ratio, was atypical. Brahmans had the lowest feed intake per body weight unit, in accord with recognized breed standards.

Beef tenderness was measured by shear force values at 2 and 21 days post-slaughter, with higher values indicating tougher beef (Figure 3). Generally, consumers complain about tough meat at shear force values of 4.5 – 5.0 kg. At 2 days post mortem, meat from the Brahman (emerging) Nguni (communal) and Crossbred (emerging) was tougher than remaining groups. After 21 days ageing, meat from the Brahman (emerging) group was still at the lower end of tough shear force values. All other breed groups had very acceptable tenderness.

Except for the communal Nguni that entered the trial at very light weights, all emerging groups performed well relative to their commercial counterparts, confirming that indigenous cattle derived from emerging and communal farmer herds can meet the specifications of South Africa's commercial markets, providing a genuine opportunity for import substitution, whereby the >4 million cattle in emerging and communal herds can replace 35,000 tonnes of beef and 300,000 weaners imported annually to South Africa to overcome a shortfall in domestic market demand.

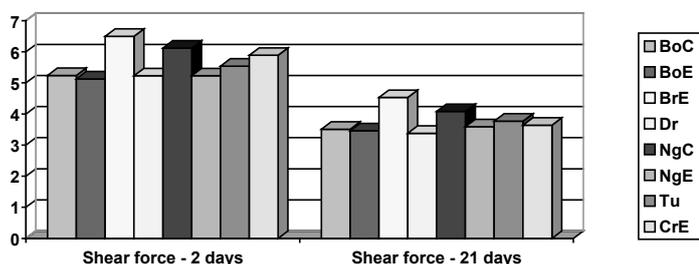


Figure 3. Shear force measures (kg) after 2 and 21 days ageing of striploin muscles within breed groupings in Phase 2 of the South African feedlot experiment (see Figure 1 for breed definitions)

Sub Program 2 Innovative Technologies for the Beef Supply Chain

Project 2.4: Managing stress to improve cattle welfare and beef quality

Mission

To enhance cattle welfare and beef quality by minimising stress with the aim of improving consumer satisfaction with Australian beef.

Goals

- Identify potential gene markers for adaptation, stress perception and activation of the stress response.
- Evaluate methods for assessing cattle temperament by demonstrating their relationships with measures of the stress response, cattle performance and beef quality.
- Quantify the individual variation in the stress response (behavioural and physiological) of cattle to specific stressors that influence beef quality.
- Develop methods to enhance the adaptability of cattle to stressors encountered during production.
- Develop alternative pre-slaughter (on-farm, transport and lairage) management practices that minimise stress in order to maximise beef eating quality and animal welfare.
- Integrate the outcomes from the above objectives into systems designed to improve cattle welfare and beef quality.

Strategies and Progress

Effects of temperament and handling on feedlot performance and beef quality

Stressors associated with routine handling procedures during rearing and pre-slaughter affect individual animals differentially depending on animal temperament. Hence, the effects of stress are manifested in differing behavioural and physiological responses that impact on welfare and meat quality. It is hypothesized that positive interactions between cattle and their handlers will make cattle less fearful, improve temperament and enhance their welfare and ability to cope with stressors. Furthermore, this improvement in ability to cope will be manifested in improved productivity and beef quality. This experiment tests this hypothesis and quantifies whether improvement is affected by animal temperament.

One hundred and thirty-five *Bos indicus* cross weaner steers were selected on their flight time and response to the fear of humans test. 48 weaners were allocated to one of 3 handling treatments (minimal, good or poor handling) on liveweight, flight time and 'zone average'

Table 1. Effect of lairage duration and handling treatment on MSA traits (LS means \pm se)

	Lairage Duration				Handling				
	3 hr	18 hr	Sig.	se	Good	Minimal	Poor	Sig.	se
Tenderness	51.0	49.2	ns	2.1	48.9	50.2	51.2	ns	2.1
Juiciness	55.9	52.5	ns	2.2	52.6	55.4	54.5	ns	1.7
Flavour	55.8	53.4	ns	1.8	53.2	54.7	55.8	ns	1.4
Overall	53.5	51.5	ns	2.1	51.2	52.6	53.7	ns	1.7
MQ4	53.1	50.8	ns	1.9	50.8	52.0	53.0	ns	1.7

(where the animal was, on average, in the arena during the fear of humans test). Handling treatments were applied on 6 separate occasions during backgrounding. Cattle then entered a feedlot for 80 days prior to slaughter. Flight time and response to the fear of humans arena test were used to quantify temperament during the study. At slaughter, 2 pre-slaughter treatments were applied to the animals. Half the animals, balanced for handling treatment, were subjected to the conventional lairage duration period of 18 hours whilst the other half received a shorter lairage duration of 2-3 hours. Both groups were slaughtered on the same day. The effects of handling on feedlot performance and behavioural measurements were presented in the 2002/03 report. Results herein pertain to meat quality data and MSA consumer tests.

Neither background handling treatment or lairage duration affected any meat quality variable of MSA scores. Ageing clearly influenced meat quality traits. It is concluded the handling treatments used in this study generally did not affect animal physiology, feedlot productivity or beef quality. Therefore, it would be easy to conclude that cattle are not affected by the quality of handling. However, that would be incorrect purely on animal welfare grounds. It is perhaps more appropriate to conclude the handling treatments imposed in this study were not sufficiently divergent to elicit a response. Moreover, the timing and duration of the handling treatments may have also been implicit in the lack of a response. Correlations between flight time and MSA panel scores were generally low (<0.25) but were consistently favourable.

Table 2. Effect of lairage duration, handling treatment and ageing duration on meat quality traits (LS means \pm se)

	Cooking loss (%)	Minolta meat colour			Shear force (kg)	Compression (kg)
		L*	a*	b*		
Lairage Duration						
3 h	25.16	39.17	20.86	10.07	6.21	1.74
18 h	24.87	38.80	20.50	9.83	6.69	1.76
Significance	ns	ns	ns	ns	ns	ns
se	0.24	0.34	0.34	0.20	0.23	0.02
Handling						
Good	24.94	39.18	20.62	9.89	6.44	1.75
Minimal	25.19	38.90	20.62	9.90	6.32	1.75
Poor	24.92	38.87	20.81	10.06	6.58	1.76
Significance	ns	ns	ns	ns	ns	ns
se	0.22	0.26	0.25	0.15	0.21	0.03
Ageing						
1 day	24.89	37.26	19.98	9.53	7.34	1.77
14 days	25.14	40.70	21.38	10.37	5.55	1.73
Significance	ns	<0.001	<0.001	<0.001	<0.001	<0.05
se	0.17	0.18	0.14	0.09	0.11	0.01

Sub Program 2 Innovative Technologies for the Beef Supply Chain

Project 2.4: Managing stress to improve cattle welfare and beef quality

The minimal impact of reduced lairage duration for cattle that traveled <400 km is consistent with earlier findings in this project. These results provide industry with the essential data to move towards reduced lairage periods for cattle that have traveled relatively short distances to slaughter.

GABA	Control	Agonist (mg/kg Diazepam)			Antagonist (mg/kg PTZ)			Signif.
		0.3	0.6	0.9	1	5	10	
IBT	36	32	25.6	13.8	46.4	37.6	30	ns P=0.08
Cortisol (nMol/l)	46.8	22.4	48.4	24.3	46.1	52.7	50.2	
Serotonin (5-HT)	Control	Agonist (mg/kg 8-OH-DPAT)			Antagonist (mg/kg m-CPP)			Signif.
		0.2	0.5	0.7	0.5	1	2	
IBT	15	32	37.8	29.8	28.8	23.6	20	ns P<0.001
Cortisol (nMol/l)	35.6	73.7	76.9	59.5	64.8	73.1	133.5	

Table 3. Effect of GABA and 5-HT agonist and antagonist treatments on the isolation box test (IBT) and plasma cortisol levels (nMol/l)

Characterisation of the physiological basis for the genetic correlation between temperament and beef tenderness in *Bos indicus* cattle

35 progeny from high and low EBV tenderness (shear force) and flight time Brahman sires were slaughtered in July 2003. At slaughter, the post-mortem muscle pH and temperature profile was recorded and muscle samples collected for meat quality evaluation and detailed histological and biochemical measurements. Results for tenderness are presented here.

Sire group means for shear force at 3 ageing times are shown in Figure 1. Despite the lack of a significant sire effect or sire x ageing effect there were some noteworthy trends. Contrary to expectations, the high tenderness EBV progeny groups (4461 and 4999) had low initial shear force values and aged minimally over the 14-day period. The opposite was found for the progeny groups from the low tenderness EBV sires (3795 and 4405). After 14 days ageing there were minimal differences in shear force between the sire groups. For the day-1 shear force values, there is a major disparity between CRCI results and those reported here. One plausible explanation is that the slaughter protocols were different and a much slower rate of post-mortem glycolysis was achieved in the current experiment. Previous CRC research has highlighted the effect that post-mortem rate of glycolysis

has on initial tenderness and the ageing potential of meat. Although not significant, differences in rate of ageing might be informative with respect to the differences. This is currently being investigated using more detailed measures of post-mortem proteolysis.

Neurological basis for the differences in temperament

Typically, cattle temperament is assessed using methods that measure escape/avoidance behaviour. Although these are practical, a better understanding of the neurophysiological mechanisms affecting temperament might increase our capacity to improve livestock management and production. It is hypothesized that 3 major neurophysiological pathways (γ -amino-butyric acid (GABA), serotonin (5-HT) and dopamine (DA)) are responsible for temperament differences in livestock. The role of GABA, 5-HT and DA pathways in the response to acute stress challenges in ruminants was evaluated pharmacologically using receptor agonists and antagonists as part of a CRC PhD study.

Three dose response studies were completed using GABA, 5-HT and DA receptor agonists and antagonists. Behavioural and physiological responses in Merino sheep were measured in response to the treatments. Results relating to GABA and 5-HT dose response studies are shown in Table 3. Relative to the control, the GABA agonist resulted in a reduction in agitation score in a dose dependent manner. Cortisol levels were also affected but only at the low and high doses of diazepam. There was no apparent anxiogenic effect with the GABA antagonist PTZ. Increases in agitation score and plasma cortisol levels were elicited by the 5-HT agonist and antagonist treatments. The anxiogenic action of the 5-HT agonist was contrary to expectations. The effect of the antagonist m-CPP was significant particularly at the higher dose rate. From this study, the GABA agonist diazepam and 5-HT antagonist m-CPP will be utilized in further neurophysiological studies in sheep.

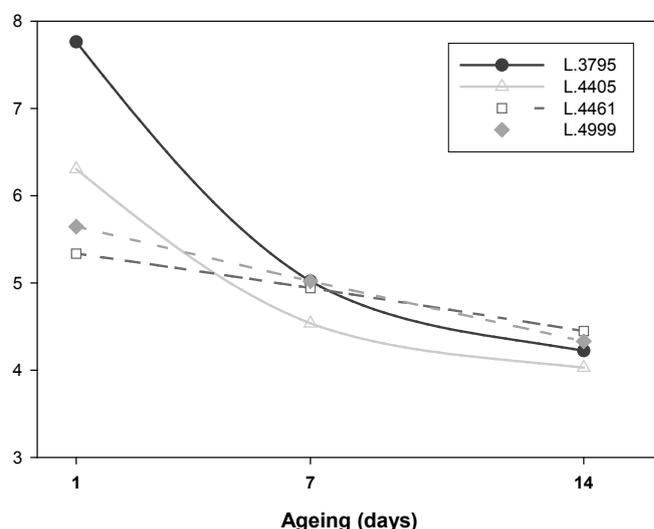


Figure 1. Sire progeny group shear force means across 3 ageing times

Sub Program 2 Innovative Technologies for the Beef Supply Chain

Project 2.5: Pre-slaughter control of pathogens affecting beef products

Mission

To develop pre-slaughter management systems that reduce the human health risk associated with animal-derived organisms contaminating beef carcasses, through a better understanding of the ecology of these organisms in the ruminant gastro-intestinal tract.

Goals

- To understand the role cattle derived *Escherichia coli* (EHEC) play in human disease such as Haemolytic Uraemic Syndrome. To serotype and genotype bovine and human isolates of EHEC to determine their relationship. To determine whether isolates of STEC from cattle have a biological effect on human enterocytes in vitro.
- To study the factors which influence food-borne pathogens (particularly EHEC) and their ecology in the live animal through various common pre-slaughter management and handling pathways to production in Australia.
- To investigate the use of probiotics as novel intervention strategies for reducing the carriage of potential food-borne pathogens in beef cattle.
- To deliver a package of recommendations to the beef industry.

Strategies and Progress

Literature Review

The literature review prepared for the CRC in June 2001 was updated and submitted for publication in a scientific journal. Highlights of the review are:

- O157:H7 identified in Australian cattle and sheep but at a lower level than in many other countries.
- Many STEC identified in Australian ruminants.
- Human cases of O157:H7 low in Australia, other STEC predominate.
- Possible on-farm interventions to reduce shedding in faeces include food and water hygiene, manure handling and composting, less crowding and mixing of animals, limiting access to other species, dietary manipulation, chlorate supplementation in feed, probiotics/ bacteriocins/ phages and vaccines.
- Vaccine research studies in USA and Canada, with the most promising being a vaccine to prevent *E. coli* O157:H7 from sticking to the gut wall and multiplying. It is not yet commercially available.

Characterisation of STEC virulence genes

- The *stx1*, *stx2* and *eaeA* characterisations are complete and three papers have been published. Studies have shown that both cattle and sheep can carry serotypes associated with human disease. Genotype studies of virulence factors have shown distinct differences between cattle and sheep STEC virulence factor genomes, particularly the Shiga toxins.
- A range of methodologies to recover STEC from cattle faeces was assessed. Laboratory work is complete and a paper is being prepared.
- The presence of urease gene (a possible useful marker to differentiate EHEC strains from other diarrheagenic *E. coli* strains) in a collection of bovine STEC was determined.

- The presence of Saa (a gene associated with attachment of bacteria to epithelial cells of the host) in a collection of bovine and human STEC was determined.

Elucidating Shiga toxin gene reservoirs in ruminants

This strategy aims to determine the primary reservoirs of Shiga toxin genes in ruminants and the environment. Main objectives of the study are to investigate:

1. the presence and maintenance of STEC inside ruminal protozoa.
2. the importance of bacteriophages (bacterial viruses) as a reservoir of Shiga toxin.
3. the use of phage therapy to control STEC.

Research over the past year aimed to determine the presence or absence of Shiga toxin genes within a) the chromosome of bacteria that are normal inhabitants of the ruminant gastro-intestinal tract and b) the ruminal phage population and to investigate the potential use of bacteriophages to control STEC.

Shiga toxin gene

- (i) Genomic DNA from 44 bacterial isolates representing a broad cross-section of normal gastro intestinal tract inhabiting bacteria was screened for the presence of *stx1* and *stx2* genes. Screening was by PCR. *stx* genes were not detected in any of the 44 isolates examined. It was concluded these genes are unlikely to be present in species outside the *Enterobacteriaceae* that make up part of the rumen flora.
- (ii) To detect *stx* containing phages in the phage population of the rumen it is necessary to determine the sensitivity of the PCR assay in terms of the minimum number of phages required to register a positive result. It was found the PCR test was not as sensitive as required, possibly causing false negative results. Methods to improve PCR sensitivity are being investigated.

Potential use of bacteriophages to control STEC

It is possible phages (bacterial viruses) could be used as a non-antibiotic pre-(or post) slaughter intervention to reduce STEC load in cattle. Virulent phages that specifically target STEC could be inoculated to cattle prior to slaughter to kill STEC in the gastrointestinal tract. Alternatively, they could be used as an aerosol to topically treat cattle in abattoirs pre-slaughter or carcasses and meat products post-slaughter. To determine the feasibility, the first step is to isolate and characterise highly virulent, lytic phages. A postgraduate student working in the project has thus far isolated 5 phages that appear to be obligately lytic and highly virulent. The phages were partially characterised by electron microscopy, restriction endonuclease digestion and pulse field gel electrophoresis. Phage TWΦ5 (Figure 1) was highly lytic and infected all strains available and it was different to the other viruses being investigated. PCR was used to ensure that none of the viruses contained *stx* genes. Phages isolated to date are promising as candidates for phage-therapy and in collaboration with Food Science Australia, will be trialed against a range of virulent STEC representing field isolates found in

Sub Program 2 Innovative Technologies for the Beef Supply Chain

Project 2.5: Pre-slaughter control of pathogens affecting beef products



Figure 1. Phage TWΦ5

Australia. Further phage will be isolated on pathogenic STEC strains that prove to be resistant to the viruses that have already been isolated.

Interventional management strategies

To demonstrate that numbers of STEC and generic *E. coli* in the hind-gut of cattle are significantly reduced by feeding roughage-based diets *cf.* grain-based diets, an initial animal trial was undertaken in 2002, as outlined in last year's report. The experiment involved 30 Brahman cross steers initially fed a high grain (80%) diet. Animals were then allocated into 3 groups of 10 animals and fed *ad libitum* (1) a high molasses + roughage + cotton seed diet (M+R); (2) a roughage diet + 20g urea/kg DM (R); and (3) a high grain diet (G). Final results accounting for the effect of lairage on concentrations of generic *E. coli* population and EHEC virulence factors are shown in Table 1.

Results show that prior to lairage, faecal *E. coli* numbers were two logs lower in R and M+R diets *cf.* G diets and this difference increased to 2.5 logs at lairage. Concentration of EHEC virulence factors in faeces decreased markedly

in *hlyA*, *eaeA* and *stx1* genes in the R and R+M diets and this trend remained at lairage. Fermentation parameters also showed evidence of a dietary-induced shift in the microbial population of the hindgut, as volatile fatty acid patterns were similar in R and M+R diets whereas increased *E. coli* numbers, decreased pH and enhanced butyrate and lactate fermentation pathways were associated with the grain diet.

Results indicate high roughage diets that have low fermentable carbohydrate reaching the hindgut significantly reduce the size of the *E. coli* population and could potentially be used to reduce the faecal concentration of pathogenic EHEC serotypes prior to and during lairage. A second animal trial has been designed to incorporate new molecular methods for enumerating EHEC populations and to determine the incidence of *E. coli* O157:H7 in faecal samples. This trial is now underway and aims to give:

- A better understanding of ration ingredients that can be used to reduce the risk of carcass contamination by STEC and specifically the O157 serotype.
- Demonstrate whether feeding diets based on roughage with low levels of soluble carbohydrate and/or molasses for short periods of time will rapidly reduce faecal *E. coli* numbers to determine whether numbers of *E. coli* can be rapidly reduced in feedlot cattle at the end of finishing even if animals have been fed high-grain diets.

Probiotic intervention strategies to reduce pathogen load

An assay was established to evaluate the ability of antimicrobial factors produced in candidate probiotic bacteria to inhibit the growth of enteric pathogenic *E. coli* such as O157. The assay involves measurements of the growth of target pathogens and is now being used to evaluate a panel of ~35 candidate probiotic bacteria.

Table 1. Mean abundance of *E. coli* and concentration of enterohaemorrhagic *E. coli* virulence factors in faeces of cattle fed either roughage hay (R), molasses plus roughage (M+R) or grain (G) diets. Faecal samples were taken when animals were preconditioned on grain (baseline grain diet) then again during pre-lairage (PL) feeding on the 3 diets and at lairage (L).

Diet	Baseline grain diet (n=25)	Roughage (n=10)		M+R (n=10)		Grain (n=9)	
		PL	L	PL	L	PL	L
<i>E. coli</i> (log ₁₀ /g digesta)	8.1 (0.2) ^a	5.6 (0.2) ^b	4.9 (0.3) ^c	5.5 (0.1) ^b	4.9 (0.2) ^c	7.9 (0.1) ^a	7.5 (0.2) ^a
Virulence gene (log ₁₀ /g digesta)	4.0 (0.8) ^a	1.6 (0.3) ^b	1.2 (0.4) ^b	1.8 (0.3) ^b	1.5 (0.3) ^b	2.8 (0.3) ^a	2.8 (0.8) ^a
enterohaemolysin (<i>hlyA</i>)							
intimin (<i>eaeA</i>)	2.3 (0.5) ^a	0.9 (0.3) ^b	0.9 (0.3) ^b	0.2 (0.1) ^b	0.2 (0.1) ^b	2.1 (0.4) ^a	0.6 (0.3) ^b
shiga toxin 1 (<i>stx1</i>)	1.3 (0.3) ^a	0.3 (0.2) ^b	0.1 (0.01) ^b	1.2 (0.3) ^a	0.6 (0.2) ^a	2.4 (0.4) ^c	1.0 (0.5) ^a
shiga toxin 2 (<i>stx2</i>)	2.1 (0.4) ^a	2.1 (0.3) ^a	1.3 (0.4) ^a	2.5 (0.3) ^a	1.8 (0.3) ^a	1.4 (0.4) ^a	2.2 (0.5) ^a

Values in rows that do not have a common letter are significantly different ($P < 0.05$). Standard errors of the means are given in parenthesis.

Sub Program 2 Innovative Technologies for the Beef Supply Chain

Plans for 2004 / 2005

Project 2.1 ~ Genetic markers for production, adaptability, efficiency and beef quality

- Discover SNP in positional candidate genes for the 3 fine mapped QTL for retail beef yield and tenderness and test them to identify diagnostic tests for the traits.
- Fine map and discover SNP in positional candidate genes for 2 QTL for tick resistance.
- Complete evaluation of coding sequence mutations in calpastatin affecting meat tenderness.
- Begin testing alleles at MARB01 for functional differences using quantitative PCR.
- Identify SNP in positional candidate genes and test these for associations to marbling and fat.
- Continue testing the identified SNP in 6 genes with differential gene expression for marbling.
- Undertake phenotyping for tick resistance and collection of DNA from dairy cattle and begin genotyping the 30 SNP from chromosomes with QTL for resistance to ticks.
- Linkage analysis for 3 chromosomes for genes affecting NFI.
- SNP genotyped on 6 genes and candidate genes affecting NFI tested in Trangie cattle.

Project 2.2 ~ Improving the efficiency of feed utilisation for beef production

- Industry workshop held on adoption of NFI; final on-farm test for NFI conducted.
- Paper on correlations between NFI and cow performance traits submitted to scientific journal.
- Models to demonstrate benefits (per hectare productivity and enterprise profitability) of incorporating selection for improved NFI into breeding programs across a range of simulated production systems completed and in use in industry extension.
- Report on correlations between seedstock and steer feedlot measures of feed efficiency completed.
- Angus progeny test steers backgrounded and measured for NFI.
- Paper reporting genetic relationships between IGF-I blood concentration in young animals and BREEDPLAN traits submitted to journal.
- Models developed for design of breeding schemes to optimize selection for NFI.

Project 2.3 ~ Links between the genetics of beef quality and components of herd profitability in northern Australia

- Undertake measurement of experimental progeny according to agreed experimental protocols.
- Define in genetic terms the best combination of traits to identify sires that produce daughters differing in age at puberty and follicular development and relationships between them and growth and body composition.
- Define the genetics of feed efficiency and related traits (IGF-I, flight time, scanned carcass attributes) and the relationships between them in tropically adapted steers.
- Define the genetics of a range of adaptive traits in tropically adapted steers and heifers.
- Identify relationships between DNA tests for fatness and traits associated with female fertility and body composition.
- Achieve project milestones in South Africa as outlined in ACIAR contract.

Project 2.4 ~ Managing stress to improve cattle welfare and beef quality

- Complete pharmacological study on the Alandale selection lines.
- Complete immunohistochemical analysis of brain sections.
- Complete analyses, prepare scientific manuscripts and disseminate results to industry from the "Effects of temperament and handling on feedlot performance and beef quality" strategy.
- Complete analyses, prepare scientific manuscripts and disseminate results to industry from the "Optimal pre-slaughter management of cattle to maximize beef quality and animal welfare" strategy.

Project 2.5 ~ Pre-slaughter control of pathogens affecting beef products

- Complete paper on assessment of a range of methodologies to recover STEC from cattle faeces.
- Improve sensitivity of PCR assay to detect *stx* genes in rumen fluid and faecal material to determine whether phage in the ruminal phage population possess Shiga toxin genes.
- Demonstrate changes in phages with toxin genes when animals change between pasture and high grain diets.
- Determine the infectivity of lytic phages against a range of virulent STEC representing the range of field isolates found in Australia.
- Identify best ration ingredients to reduce risk of carcass contamination by STEC, specifically O157 serotype.
- Demonstrate whether feeding diets based on roughage with low levels of soluble carbohydrate and/or molasses for short time periods affects faecal *E. coli* numbers.

Sub Program 3 Delivery of Technologies to the Beef Business System

Project 3.2: Best practise for consistent meat quality (MSA and beyond)

Mission

To facilitate the application by the beef industry of CRC outcomes directed to improving eating quality.

Goals

- Develop systems to optimise processing conditions and the ageing potential of beef cuts.
- Assess the effect of fibre type on glycolytic rate.
- Quantify the impact of production factors on the parameters of the cuts based model.
- Identify and resolve barriers to the implementation of MSA.
- Quantify the magnitude of the changes in palatability due to long- and short-term perturbations of growth path of cattle on eating quality.

Strategies and Progress

Industry model to predict glycolytic rate in beef carcasses

Over the past year, the final phase of a benchmark study was undertaken to quantify the impact of improvements in electrical inputs during the slaughter process on glycolytic rate in beef carcasses. Relative to an earlier benchmark, there was a marked reduction in glycolytic rate in this study. In the previous benchmark, production parameters and carcass traits had no effect on glycolytic rate. In this study though, carcass weight had a significant effect on glycolytic rate due to the improvements installed along the chain. The effect was quantified as a 5°C increase in Temp/pH6 for every extra 100kg of carcass weight. Further analysis and investigation is now required to determine how processors can use this information in a practical assessment of glycolytic potential, to ensure stimulation regimes can be utilized to correct problem carcasses.



Figure 1. Biopsy samples being collected as part of the exercise experiment

Effect of genotype and age on differences in fibre type in a range of muscles

Experiment 1 examined the importance of fibre type in genetically diverse lines of cattle on rate of glycogen repletion following exercise of mature animals. To ensure there was a difference in fibre type, animals from 3 sire types (Wagyu, Angus, and Piedmontese) were used. The animals were 36 months old and had been maintained on a high concentrate ration for 100 days prior to exercise treatment. Muscle biopsies were taken immediately before exercise, after which the cattle were exercised for 11.25 km in total at a trot (9 km/hr).

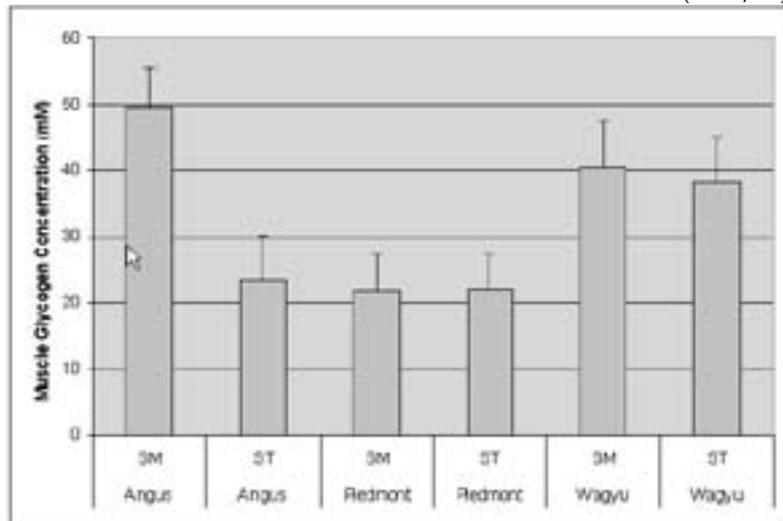


Figure 2. The amount of muscle glycogen depleted through exercise, as affected by breed and muscle type. Values are means (\pm s.e.).

The exercise was performed as 2.25 km "intervals" and after each interval the cattle were allowed to recover as judged by adequate time to drink, recovering to 90% of basal respiratory rate and continue walking voluntarily. This period was typically 10 minutes. After exercise, blood was collected intravenously from the tail for blood lactates and a muscle biopsy was taken from the rump (Figure 1). A further biopsy was collected from the rump on the other side 36 hours later, followed by a 72 h biopsy alternating sides again. Muscle glycogen depletion was highest in Angus and Wagyu and lowest in Piedmontese progeny (Figure 2). Higher pre-exercise muscle glycogen concentrations led to higher levels of muscle glycogen depletion through exercise.

Muscle glycogen repletion was not affected by sire, was higher in those animals that depleted more through exercise and was positively correlated with ME intake 72 h following exercise.

Experiment 2 examined the importance of fibre type in genetically diverse lines of cattle on insulin, adrenalin and dextrose sensitivities and the inter-relationship with muscle glycogen metabolism.

Experiment 2 examined the importance of fibre type in genetically diverse lines of cattle on insulin, adrenalin and dextrose sensitivities and the inter-relationship with muscle glycogen metabolism.

Sub Program 3 Delivery of Technologies to the Beef Business System

Project 3.2: Best practise for consistent meat quality (MSA and beyond)

Preliminary analyses show the basic methodology of hormone challenges appears sound and at this stage no differences in sensitivities are evident between breeds.

Changes in palatability of cuts due to long- and short-term perturbations of growth path

This study is ongoing and is investigating the effect of manipulation of growth path, diverse genotypes and sex of animal on meat quality and yield characteristics in beef carcasses using cattle from project 1.2. Cattle from diverse genotypes (high marbling Wagyu x Hereford and high yielding Piedmontese x Hereford) were subjected to nutritional treatments *in utero* and during the pre-weaning period. They were then grown out postweaning on high quality temperate pastures at Glen Innes before being finished in the feedlot.

Carcass assessment, commercial yield and meat quality data are available from 80 'core' weaner heifers (born 2002 and slaughtered April 2003), 81 'core' 30 month-old heifers (born 2001) and 79 'core' 30 month-old steers (born 2001).

In February 2003, 73 steers and heifers born in 2000 ('pilots' sired by Wagyu, Piedmontese and Angus) were slaughtered off pasture at ~30 months of age and data collected on chiller assessment, yield and meat quality. Following 70 days on feed, 94 steers and heifers born 2001 were slaughtered at either Casino abattoir or Brismeat abattoir. Again, chiller assessment, yield and meat quality information are available.

In October 2003, 20 heavy steers ('pilots' sired by Wagyu, Piedmontese and Angus) that had been on feed at Tullimba for ~300 days were slaughtered at Casino and detailed carcass and yield data collected.

Development of RapidpH™ method for early determination of meat ultimate pH

An experiment was undertaken to evaluate the rapid "on-line" method for determining muscle glycogen concentration based on the RapidpH™ methodology developed by AgResearch New Zealand. The investigation included a demonstration of the use of the RapidpH™ method as a tool to investigate management techniques to overcome dark cutting in beef.

Development and modification of the RapidpH™ system allowed us to estimate muscle glycogen concentrations on the slaughter floor with similar results to the laboratory glycogen assay in less than 7 minutes. The RapidpH™ method had a high RSD of 13.54, reducing its ability to pinpoint the ultimate pH of a carcass.

A discriminant analysis examined the ability of the Rapid glycogen method to predict low and high ultimate pH carcasses (i.e. ultimate pH less or greater than 5.7). Overall accuracy was about 80%. Of interest for hot grading was the misclassification rate. If the measurements predicted the carcass was low ultimate pH, then these carcasses were misclassified 18% of the time as they had an ultimate pH >5.7. Of less importance was the misclassification of the high ultimate pH group. If a carcass was predicted to be high ultimate pH then 57% of the time this was correct. But 42% of the time these carcasses had an ultimate pH <5.7.

These low misclassification rates for the Rapid glycogen method in classifying hot carcasses into low and high ultimate pH classes was encouraging, although the numbers of carcasses tested and the frequency of high pH carcasses (11%) was low. It was recommended that the transportability of the technique be validated by testing on other groups of carcasses with perhaps higher proportions of high pH carcasses.



Equipment used to carry out the Rapid pH tests

Sub Program 3 Delivery of Technologies to the Beef Business System

Project 3.3: Regional beef systems to achieve market specifications

Mission

To use combinations of genetics, nutritional pathways and best-practice management across regional Australia to improve market compliance and hence increase product value.

Goals

- To develop strategies that will prepare cattle for live export and improve on-board nutritional and environmental conditions.
- To test and validate combinations of genetic, nutritional pathways and best-practice management to increase the proportions of cattle achieving market specifications across regional Australia.
- To develop and validate nutritional strategies which allow for the efficient utilisation of feed resources (including feed gap problems) to improve target market compliance.

Strategies and Progress

This is an integrated project across Australia, comprising a mix of applied science and technology transfer to increase adoption of technology and best practise by regional groups. It is jointly funded by the CRC and Meat and Livestock Australia. Because of its regional focus, cooperative arrangements have been established with producers, producer companies and a number of meat processors to facilitate local ownership and uptake of results. Goals 1 and 3 were achieved in previous years and all remaining work in this project is directed towards Goal 2.

Combinations of genetics, nutritional pathways and best-practice management to improve compliance with market specifications

A number of experimental sites were established in Queensland, NSW, Victoria, South Australia and Western Australia to investigate and / or validate combinations of genetics and growth pathways and “best practise” management strategies against current industry practise to improve the proportion of cattle achieving market specifications. Although the genetics, nutritional and management strategies and markets all differ across the various regions, there are a number of principles in common across the sites, including:

- Evaluating individual animal effects and interactions of genotype and growth path on rates of compliance to regional market specifications;
- Selecting sires to provide the range in genetic potential for variation in the carcass traits of interest (yield and marbling in particular);
- Use of contrasting growth paths at each site, achieved by nutritional and/or management to reach the target market weight;
- Determining the impact of the resulting production system on meat yield and various measures of meat quality;
- Determining profitability by economic analysis of the regional beef production systems;
- Using a “regional systems approach” to promote

ownership of outputs and adoption of new technology by beef producers by focusing on opportunities and overcoming barriers to adoption with local groups.

Use of common sires across sites and commonality of basic design features will allow a pooled data analysis across sites to quantify possible genotype x environment interactions affecting biological and economic outcomes. Sires with accurate EBVs for carcass type (yield, yield and marbling, marbling) were chosen to generate divergent progeny groups for these traits. CRCI sires were also used to provide genetic linkages to past studies and between the sites in this project to increase the power of the experimental design. Standardised meat quality sample collection and testing protocols were used at each site. Data from each site will initially be analysed separately. A subsequent across-site analysis will test genotype x environment interactions. A standard economic evaluation process will also be applied.

Individual sites are at different stages of completion of their experimental protocols. All matings are now complete. Calves of different carcass types are at different stages of the growth path and finishing phases at each site. Each site is progressing towards the generation of carcass data to examine effects on market compliance, meat yield and meat quality. Preliminary results indicate that carcass type has a major impact on the ability of cattle to meet variable and exacting market specifications. The significance of this will not be fully quantified until further testing of the carcass types under variable environments is completed.

Market specifications can be defined as incorporating market requirements for weight and fatness, eating quality and meat yield. Important findings to date indicate that high yielding types can satisfy all domestic market criteria and add value to the end product in terms of increasing total quantity of an acceptable product. The increased quantity has been estimated from project data to be conservatively valued at \$140 to \$180 per carcass. The combination of particular carcass types will most certainly increase market compliance and improve herd profitability, particularly as the beef industry moves towards a true value-based marketing system.

In terms of nutritional pathways, there are early indications of interactions between growth rate, finishing regime and expression of carcass quality attributes. Note however that data from two different sites are showing conflicting results. Victorian data agree with the commonly-held belief that fast growth rate post-weaning results in superior marbling. NSW data do not show the same relationship and also indicate a slight interaction between carcass type and growth path in the expression of marbling. These data will potentially provide new evidence to assist producers better meet market requirements through nutritional manipulation of cattle growth.

Data are also being generated in Western Australia and Victoria relating to optimum calving times for the particular environments. At both sites, weaning weights and profitability have been enhanced by selection of an

Sub Program 3 Delivery of Technologies to the Beef Business System

Project 3.3: Regional beef systems to achieve market specifications

optimum time of calving (in Victoria, autumn calving is better than spring calving whereas in Western Australia, winter calving is better than spring calving).

NSW Site

Preliminary results from the Kooba Station / Grafton Research Station site show that, for high quality domestic beef, a minimum level of marbling is required to ensure acceptable eating quality. Many breeds and types are capable of achieving this minimal level and the sires do not necessarily need to be exclusively selected for high marbling. After 100 days of feedlot finishing, progeny from Angus sires selected for high marbling EBVs displayed equivalent or higher marbling than progeny from sires of genotypes renowned for high marbling.

However, progeny from Angus sires selected for high yield EBVs did not produce carcasses that yielded as well as progeny from sires of genotypes renowned for high retail yield.

Post weaning growth (slow *vs.* high) and differences of approximately 6 months of age at slaughter do not appear to have significant effects on either eating quality or marbling.

Victorian/South Australian Site

Preliminary analyses were undertaken of 2 years growth (BREEDPLAN traits) and live animal scan data. Results are as outlined in the overall summary above.

Western Australian Site

Preliminary results for this site indicate:

- Significant economic benefits of changing the time of calving from autumn to winter.
- Younger calves with lighter birthweights performed as well as the heavier, older Autumn-born calves at weaning.
- Growth of calves which experienced weight loss or slow growth post-weaning did not affect yield or meat quality relative to fast growing animals.
- Liveweights at slaughter and carcass weights were almost always higher for animals sired by high RBV% bulls than those sired by high IMF% bulls.
- High IMF% sired animals were invariably fatter than those sired by high RBV% bulls even though the RBV% sired animals were generally heavier.
- Body composition attributes of progeny accurately reflected the EBVs of their sires (i.e. high RBV% bulls sired high yielding progeny and high IMF% bulls sired high marbling progeny).
- Dark cutting beef is a major problem with cattle finished on pasture if they are slaughtered when pasture quality is declining (a supplement of 2 kg lupins per head per day was not sufficient to address the dark cutting problem).
- Variation in submission rates to AI in association with liveweight and condition score requires further analyses.



Demonstration of CRC progeny ex Kooba Station at Grafton Field Day, February 2004

Sub Program 3 Delivery of Technologies to the Beef Business System

Plans for 2004 / 2005

Project 3.1 ~ Total Resource Management: tactical integration of genetics, nutrition and management for the beef business

- This project was terminated in 2002/2003.

Project 3.2 ~ Best practise for consistent meat quality (MSA and beyond)

- Complete data collection, analysis and report on the milk-fed veal effect experiment.
- Finalise experiments 1 (exercise challenge), 2 (insulin and catecholamine sensitivities) and 3 (slaughter) of the muscle glycogen study.
- Slaughter steers born 2002 (ex Grafton, finished at Tullimba) and undertake meat quality analyses.
- Accurately collect and process data for animals submitted for NFI testing at Tullimba.
- Provide accurate measures of carcass and meat quality traits to various projects within the CRC.

Project 3.3 ~ Regional beef systems to achieve market specifications

- Apply experimental treatments and undertake data collection of experimental progeny ex Kooba Station and in the feedlot.
- Slaughter comparative steer groups ex Kooba Station and collect carcass data.
- Apply experimental growth treatments and undertake data collection of experimental progeny at Hamilton and Struan Research Stations.
- Undertake experimental protocols on animals born at Alcoa Farmlands and subsequently transferred to Vasse Research Station.
- Conduct field days and other extension activities as appropriate to highlight the project to industry throughout Australia.
- Commence site economic analyses and formulate approach for across-site analyses of production and economic data.

Sub Program 5 Administration: Beef Research in a Business Environment

Project 5.5: Economic impact assessment

Mission

To develop and apply best-practice economic analysis modelling systems that provide sound advice to CRC management and all participants in cattle and beef production and marketing about expected returns from investments in new technologies.

Goals

- To collect, evaluate and where appropriate, integrate existing models of various aspects of the beef production and marketing system in different regions of Australia to form a suite of models for different levels of analysis.
- To undertake research to enhance the capabilities of this suite of models and to update the input data sets used in these models so as to maintain a close relationship between changes in industry structure and operation and evaluation outputs.
- To support management by providing data and commentary on the economic impact on the Australian beef industry of both completed and proposed scientific research programs and projects.
- To use the cattle production modelling systems, in conjunction with advice from the relevant researchers, to contribute to economic profitability milestones in other projects.

Strategies and Progress

Models of beef production and marketing systems

Considerable progress was made over the past year to validate whole-farm budgets and linear programming models of additional temperate area beef production systems. The project now has access to a set of whole-farm linear programming models for two regions in Victoria, one region in South Australia and the Northern Tablelands region in NSW. A gap still exists for southern NSW, but this deficiency is being addressed in collaboration with other NSW Agriculture economists. In addition the project has access to a whole-farm budget and cash-flow model for the south-west of Western Australia.

The contract between Monash University and four State Departments of Agriculture to update the MONASH model has been successfully completed. Several analyses to show how the model can be used have been completed by Monash University staff, though a contracted training course needs to be undertaken by CRC staff before the model can be implemented.

Because of the ongoing problem of identifying suitable staff to undertake research on ways of using the Beef EDM in conjunction with the CIE Global Meat and the MONASH models, the MLA contract covering this research was terminated prematurely by mutual agreement. However, through collaborative research with the Weeds CRC, methods have been developed to incorporate the outputs of partial equilibrium models (such as EDMs) into a general equilibrium framework (such as MONASH).

Applications of the modeling framework

Over the past year, separate evaluations of existing, past or proposed research outcomes were completed and published, including:

- The value of feed efficiency research in southern Australia (see summary below).
- An evaluation of the time of calving experiments in WA through project 3.3 show that changing calving from autumn to winter at an equivalent stocking rate increased the operating profit of the enterprise by ~5% and by ~45% when the stocking rate increased by 10%. This improvement in financial performance was primarily due to a reduction in cost of production in the winter calving enterprises by ~5% in an equivalent stocking rate and 12% with the increased stocking rate scenario.
- Economic evaluations to support the Beef CRC's Round 9 Renewal Proposal.

Assessment of economic, environmental and social impacts of investment in Net Feed Efficiency

Feeding cattle is a major cost of beef production. In southern Australia, beef cows and their progeny are generally run on improved pastures until they are either sold direct for slaughter or as store cattle for subsequent feeding on pasture or in feedlots. The cost of developing and maintaining improved pasture ranges between \$7.50 and \$12.86/DSE depending on area sown and stocking rate. In an Angus supermarket enterprise, the lower estimate means 60% of variable costs of production are related to feed cost. Supplementary feeding is often necessary to fill feed gaps for cows on pasture and to ensure young cattle grow to specification and this adds further to feeding costs. Feed costs are also ~70% of the variable cost of operating a feedlot to finish steers for sale.

Net feed efficiency (NFE) refers to the efficiency of feed utilisation after accounting for an animal's requirements for growth and maintenance. It is a useful way of assessing variation in feed efficiency that is independent of size and growth rate. Genetic selection for improved feed efficiency aims to reduce feed-related costs and thereby improve profitability. Since 1992/93, three separate research projects investigating feed efficiency were undertaken by NSW Agriculture, Beef CRCI/II and MLA in partnership. Total inputs to this cluster of NFE related projects were estimated at \$20.6 million.

Outcomes from these projects can be grouped as economic, environmental and social, although the main outcomes to date are economic. Research results show that genetic variation in NFE exists, the trait is moderately heritable (~0.4) and there are few adverse implications for other commercially important traits. NFE technology also has positive environmental outcomes because over time herds using NFE technology will require less feed to maintain the same herd size and farm income, effectively lowering stocking rate and may provide environmental benefits in terms of better ground cover, greater water holding capability and less grazing pressure on preferred pasture species.

Economic benefits of NFE technology at farm level were evaluated. The optimal combination of mixed beef-sheep enterprises was selected when the NFE enterprise was/was not, available over a 25-year planning horizon. Without the NFE enterprise being available, the model selected a prime lamb enterprise, a merino wether

Sub Program 5 Administration: Beef Research in a Business Environment

Project 5.5: Economic impact assessment

enterprise, and a heavy feeder steer enterprise. When the NFE enterprise was available, the various livestock enterprises adjusted to the new technology over the planning period as more of the pasture resource was freed up. By year 25, the optimal farm plan kept the same number of prime-lamb producing ewes, reduced the number of 19-micron Merino wethers and raised a herd of 147 NFE cows (an increase in cattle of 16 per cent). The net effect of these changes was an improvement in the Net Present Value per breeding cow per year over the base herd of \$6.55, evaluated at a discount rate of 4 per cent. This per cow benefit was multiplied by the number of breeding cows in the southern beef herd and by the assumed adoption rate (0.5 per cent in 2003 up to 30 per cent in 2012). An aggregate value of \$128.6 million for the cow-calf component of the southern herd was estimated.

A value of \$4.34 per breeding cow per year was also estimated for savings in feed costs in a southern Australian feedlot due to introduction of NFE cattle. This value was multiplied by the proportion of breeding cows in the southern beef herd that generate progeny for feedlots and then by the same assumed industry adoption rate, to produce an aggregate value of \$29.4 million for the southern herd. Overall, total estimated benefits from the adoption of the NFE technology were calculated to be \$158 million over the period 2003-2020.

Comparing benefits relative to costs incurred resulted in a Net Present Value of \$137.4 million, an Internal Rate of Return of 13% and a Benefit: Cost Ratio of 7.7:1.



Total estimated benefits from the adoption of NFE technology in southern Australia were estimated at \$158 million over the period 2003-2020. This represents a NPV of \$137 million and a Benefit: Cost ratio of about 8 : 1.

Plans for 2004 / 2005

Project 5.5 ~ Economic impact assessment

- Finalise and write up results on the profitability implications of evaluations undertaken for Projects 2.2, 2.3.1, 2.3.3 and 3.3.
- Meet obligations for further economic evaluations for Projects 1.1/1.2, 2.2, 2.3.1, 2.3.3 and 3.3.
- Produce further technical reports and journal submissions outlining and justifying the overall evaluation framework, progress made in the various enhancement tasks and results of each completed evaluation project.

Sub Program 4 Education and Training for the Beef Business

Project 4.1: Postgraduate Education

Mission

To achieve excellence in postgraduate training in the sciences that underpin cattle and beef quality.

Goals

- To deliver 30 new postgraduate students trained in the sciences underpinning development of progressive beef business.
- To interact with industry to facilitate employment of postgraduates in the beef business.
- To contribute to the development of new scientific outcomes of the CRC for Cattle and Beef Quality.

Strategies and Progress

Of the 28 students enrolled within the Beef CRC's postgraduate program, 6 have completed their research and submitted their theses. They are Andrew Channon, Nicholas Gabler, Mark McKay, Briana Daly, Andrew Alford and Ben Wood. Three-month extensions were granted to 3 students due to unforeseen experimental difficulties incurred during their research. They are expected to complete their studies this year as are 2 other students. One student resumed his PhD studies in April 2004 after undertaking studies towards a DipEd degree. Kim Brett (maternity leave) and Alex Pugh both suspended their enrolments during the year, Alex recommencing in March 2004 and Kim to recommence in early 2005. Karen Schutt changed from full-time to part-time enrolment following the birth of her child in June 2003. A full list of students and their projects is shown in Table 1.

Progress Reports

As part of their responsibilities to the CRC, all students provided an annual report to the Project Leader in March 2004, outlining their research progress over the last year.

Postgraduate Conference

All students enrolled in 2003 attended a postgraduate conference at Coffs Harbour in August. The conference was again combined with the Sheep CRC to broaden the range of student presentations. Students submitted abstracts prior to the conference, which were compiled in bound Proceedings and distributed at the conference. At the conference, students presented either posters and a 5 minute presentation (1st year students) or 15 minute seminars (2nd year students) to an audience of student supervisors, CRC scientists, and a CRC judging panel including Bernie Bindon, John Thompson, Heather Burrow, Julius Van der Werf, Ian Purvis, David Cottle and Nick Costa. Jenni Metcalfe (Econnect Communications) was also invited to participate on the judging panel. Students were judged on abstracts, posters, and seminars, with prizes awarded for the best student overall in the 2nd/3rd year categories (Briana Daly, Beef CRC) and 1st year category (Beth Paganoni, Sheep CRC) as well as prizes for minor placings in both categories. Generally, the standard of student presentations was excellent and consistent with the previous year. Following the conference, Jenni Metcalfe ran a day-long workshop specifically targeting extension skills required for delivery to a more applied audience. This gave all students the opportunity to step away from their more formal scientific presentations and adapt their material to a more general audience.



Delegates at the 2003 Postgraduate Students' Conference

Sub Program 4 Education and Training for the Beef Business

Project 4.1: Postgraduate Education

Student	Award	Thesis topic	University (Year commenced)	Supervisor(s)	Funding	Status
Andrew Channon	PhD	Is the efficiency of starch utilisation genetically linked?	UNE (2000)	James Rowe and Geoff Hinch	CRC Project 4.1	Submitted
Adam Kister	PhD	Bovine functional genomics.	University of Adelaide (2000)	Cynthia Bottema	University of Adelaide, CRC top-up Project 1.4	Maternity leave to 2005
Kim Brett	PhD	Characterisation of potential enterohaemorrhagic <i>Escherichia coli</i> for the presence of virulence genes.	University of Wollongong (2000)	Mark Walker, Michael Hornitzky and Steve Djordjevic	CRC Project 2.5	Accepted
Nicholas Gabler	PhD	Manipulation of pre-adipocyte differentiation and adipocyte metabolism: effects of fatty acid composition and protein turnover.	Latrobe University (2000)	Mark Jois	DNRE and CRC top-up from Project 4.1	Accepted
Briana Daly	PhD	Optimisation of the rate of pH/temperature decline in cattle.	UNE (2001)	John Thompson and Graham Gardner	CRC Project 4.1	Submitted
Mark McKay	MSc	Effects of intramuscular fat on meat quality.	University of Queensland (2001)	Greg Harper	CRC Project 4.1	Graduated
Andrew Alford	PhD	Development of bioeconomic models of Australian beef production systems.	UNE (2001)	Garry Griffith	CRC Project 5.5	Submitted
Ben Wood	PhD	Economic modelling of breeding programs.	UNE (2001)	Julius van der Werf and Jason Archer	MLA Scholarship	Submitted
Karen Schutt	PhD	Genetic models for estimation of economically important traits in tropical beef cattle.	UNE (2001)	Brian Kinghorn, Heather Burrow and John Henshall	CSIRO Livestock Industries Scholarship	Part-time enrolment
Kent Wu	PhD	Biological and molecular characterization of a probiotic consortium for intensive animal industries.	University of Wollongong (2001)	Mark Walker and James Chin	International Animal Health Scholarship + CRC top-up Project 4.1	Submitted
Siok Hwee Tan	PhD	Bovine functional genomics.	University of Queensland (2001)	Sigrid Lehnert	CRC Projects 1.4 and 4.1	Submitted
Jeisane Accioly	PhD	Decreasing shipboard ammonia levels by optimising nutrition and the environment of cattle on ship during live export.	Murdoch (2001)	Dave Pethick	CSIRO scholarship, MLA, LiveCorp, Beef CRC	Part-time enrolment
Nicholas Corbet	MSc	A comparison of Belmont Red and Bonsmara cattle breeds in diverse regions of South Africa.	Central Queensland University (2001)	Ross Shepherd and Heather Burrow	CSIRO Livestock Industries	Part-time enrolment
Peter Allingham	MBSsc	A role for hyaluronan in the development of intramuscular fat.	Monash (2001)	Tracey Brown and Greg Harper	CSIRO Livestock Industries	Part-time enrolment

Sub Program 4 Education and Training for the Beef Business

Project 4.1: Postgraduate Education

Student	Award	Thesis topic	University (Year commenced)	Supervisor(s)	Funding	Status
David Beatty	PhD	Physiology of heat stress in cattle and the efficacy of electrolyte replacement therapy.	Murdoch (2002)	Dave Pethick and Anne Barnes	CRC Project 4.1 and MLA Scholarship	
Kelly Drake	PhD	Linkages between thermoregulation, temperament and beef tenderness in <i>Bos indicus</i> cattle.	UNE (2002)	Drewe Ferguson	MLA Scholarship	
Cedric Gondro	PhD	A model for optimisation of trait interactions in breeding programs.	UNE (2002)	Brian Kinghorn	CRC Project 4.1	
Gareth Kelly	MSc	Early life nutritional and genotypic effects on cellular development of muscle.	UNE (2002)	Paul Greenwood and Greg Harper	CRC Project 4.1	
Alex Pugh	MSc	The effect of two times of calving and sire genetics on carcass and meat quality traits of progeny finished in feedlot or pasture.	Murdoch (2002)	Dave Pethick	CRC Project 4.1	
Brad Walmsley	PhD	Optimising genetic and nutritional variables in intensive beef production systems.	UNE (2002)	Brian Kinghorn and James Rowe	MLA Scholarship	
Greg Buckley	PhD	Characterisation of cellular development of carcass tissues in genotypes with extreme capacity for muscle growth and marbling and their regulation by nutrition early in life.	UNE (2002)	Paul Greenwood, Greg Harper and Graham Gardner	CRC Project 4.1	
Lysandra Slocombe	PhD	Haematological indicators of beef cattle performance.	UNE (2002)	Ian Colditz and Geoff Hinch	CRC Project 4.1	
Alvaro Simeone	PhD	Relationships between forage allowance and supplementation on production characteristics.	UNE (2002)	James Rowe	UNE and IPRS	
Michael Beer	MSc	Trends in carcass traits of the Australian beef population.	UNE (2002)	John Thompson and Graham Gardner	NSW Agriculture	
Malcolm McPhee	PhD	Modelling fat and marbling deposition.	UC (Davis) USA (2002)	James Oltjen	MLA Scholarship	
Fiona Jones	MSc	The impact of diet and antibiotics on rumen ecology and bacterial populations.	Murdoch University (2003)	Geoff Tudor and Nick Costa	CRC Project 4.1	
Scott Foster	PhD	Mapping QTL for net feed conversion efficiency.	Adelaide University (2003)	Wayne Pitchford	CRC Project 4.1	
Christopher White	PhD	Genetics of fertility in beef and dairy cattle.	Melbourne University (2003)	Mike Goddard	CRC Project 4.1	

Sub Program 4 Education and Training for the Beef Business

Project 4.2: Undergraduate education and development of electronic training materials

Mission

To attract more students into courses that equip them to meet the needs of the beef business sector.

Goals

- Use the CRC network to increase the courses available nationally that teach elements of the beef business.
- Ensure that graduates have a range of skills consistent with future developments in the beef industry.
- Develop an interactive electronic library for CRC training materials.
- Develop training games that provide a simple but exciting route to understanding the technologies underpinning innovative beef systems.
- Provide cooperative support to the CRC research programs and develop flexible and effective decision aid software.

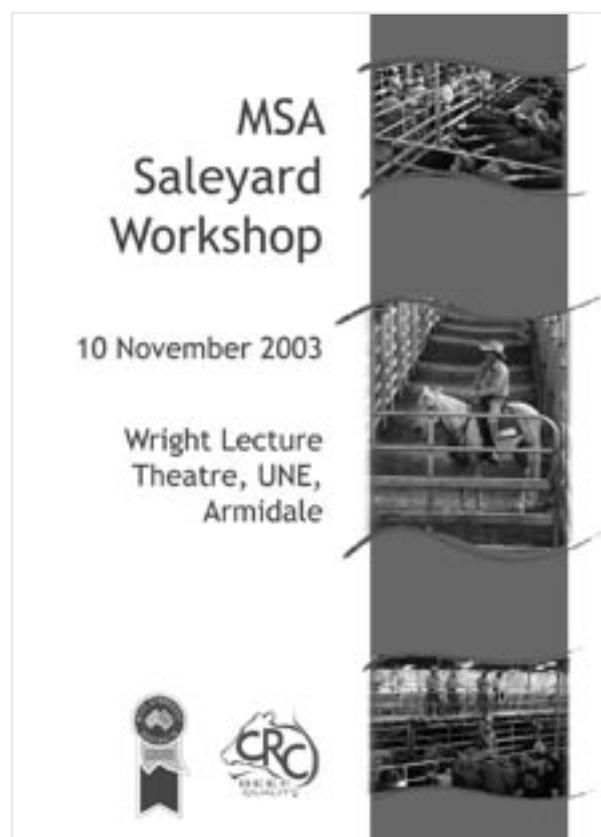
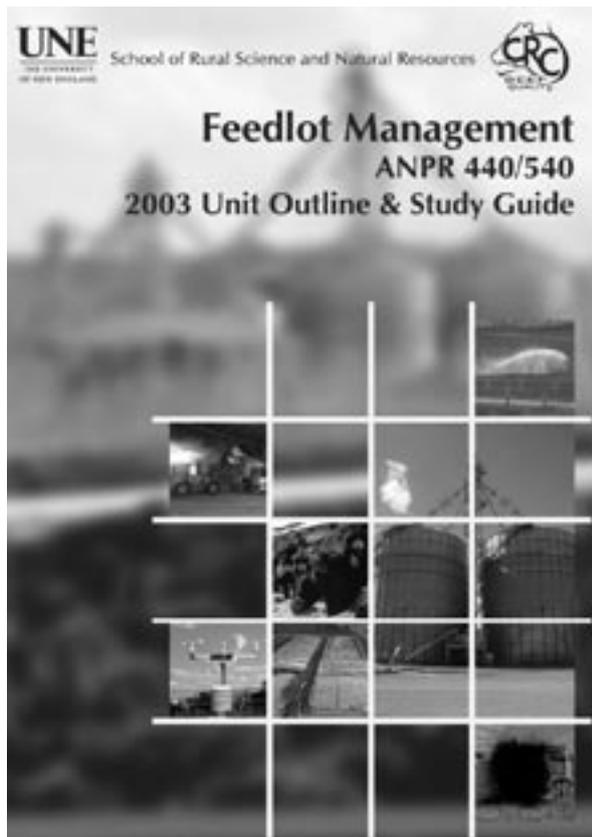
Strategies and Progress

Over the past year, MEAT418 and ANPR440 units underwent comprehensive updates, including standardization of material, up-dating and reorganization of material to include the latest Beef CRC results where applicable and inclusion of a large number of images in the re-written material. ANPR440 lectures were published in both CD-Rom and pdf formats, the

latter being printed into two volumes for distribution to the students. The MEAT418 notes were delayed because of problems with the XML system and were finally published as a CD-Rom.

A total of 53 students completed the ANPR 440/540 Feedlot Management subject as part of the Certificate in Agriculture at UNE. These students were a mix of external industry students (2/3) and internal degree students (1/3) studying rural science. This year, six students from Adelaide University studied the subject as cross-institutional enrolments. The subject and course continues to maintain strong industry support and recognition as the leading educational option for feedlot management personnel. Most of ALFA's "Young Lotfeeder of the Year" award winners have studied the Feedlot Management subject and many of the graduates now hold senior positions in the feedlot industry. MEAT418 attracted a total of 23 students over 2 semesters. Again students came from a wide range of backgrounds.

The MSA Meat Quality Manual was re-written as part of the general re-write of the MEAT418 notes. Some of this material formed the basis for the MSA Saleyard workshop held in December 2003, whilst other sections were incorporated into the new MSA CD-Rom. The MSA material will continue to be delivered through short courses and workshops as the need arises.



Sub Program 4 Education and Training for the Beef Business

Project 4.3: Knowledge management and information delivery systems

Mission

To implement knowledge management and information delivery systems enabling CRC research, education, extension and training materials to be more efficiently authored, warehoused, updated and delivered to beef industry end users.

Goals

- Create a resource of education materials and catalogued Beef CRC beef industry research information and where agreed, store or integrate with other research materials from Beef CRC partners and sponsors.
- Prepare extension and training materials in a format that allows content to be managed by topic at different levels of technicality, shared, customized and re-published in a variety of media outputs for delivery to audiences across all industry sectors.
- Achieve increased efficiency and timeliness in the collation, creation, updating, publishing and delivery of education, extension and training materials.
- Develop and maintain a CRC website that will allow efficient access by intermediaries and end users of beef industry information.

Strategies and Progress

CRC Knowledge Warehouse

This project is a joint initiative of the Beef CRC and the Australian Sheep Industry CRC and was developed within a Major National Research Facility known as ILRIC (International Livestock Resource and Information Centre). The project was planned to allow historical and current beef and sheep research information to be more readily assembled into a range of customized publications and media, facilitating more rapid dissemination and easier access and utilization by livestock industry stakeholders. It was envisaged the Knowledge Warehouse infrastructure would ultimately include a portal interface at UNE to benefit end-users.

The Knowledge Warehouse project funded by ILRIC was designed to put in place the necessary IT infrastructure and populate it with research, education, extension and training materials relevant to the beef industry. Specifically the project aimed to provide:

- An electronically accessible warehouse of research information for delivery to the beef industry through extension, training and education channels.
- Increased efficiency and collaboration in the collation, creation, updating and publishing of education and technology transfer materials by Beef CRC personnel.
- An ability to share, re-use, customize and re-badge content across different publications and courses in multiple media formats (i.e. web, CD, print), according to the needs of the end-user.

Due to the complexities of the Knowledge Warehouse project, a "Proof of Concept" was undertaken in conjunction with the Sheep CRC and UNE. The "Proof

of Concept" Pilot commenced in January 2003 and concluded with a demonstration of technical functionality of the proposed infrastructure of authoring tools, content management system and central publishing engine in July 2003. The demonstration was made to the CEOs of the Beef and Sheep CRCs, representatives of the Knowledge Warehouse Management Committee and UNE's Science Faculty and IT Directorate. The CEO of the Poultry CRC and representatives of MLA, AWI and a consultant to AWI also attended the demonstration at the invitation of the Beef and Sheep CRCs. Aspects of the following functional areas of the infrastructure were demonstrated:

- Organizational access and security of the content management system
- Project management using the proposed infrastructure
- Authoring in XML and its integration with the Content Management System and central publishing engine
- Version control of content managed by the infrastructure
- Multi-format publishing using different style sheets
- Remote access by authors and end users
- Project workflow benefits in a multi-location workplace
- Re-use and re-badging of content
- Management of multi-media objects
- Management of copyright, digital and moral rights
- Delivery of published materials from Content Management system via a demonstration ILRIC website
- Demonstration of potential of indexing, searching and navigation tools

Following the successful "Proof of Concept", a macro "Scope of Works" was undertaken to detail specifications and costs involved in providing the Knowledge Warehouse infrastructure for the Beef and Sheep CRCs. The "Scope of Works" was developed over a 3-month period and a preliminary report provided to the ILRIC Board in December 2003. As a result, the cost and complexity of the Knowledge Warehouse project is now apparent. In its original form, the project is beyond the resources of ILRIC and the Beef and Sheep CRCs. The ILRIC Board is now considering a revised and simplified version of the project.

Beef CRC Website

CRC organizational information and broad details of the CRC's research, education and technology transfer programs appear on the Beef CRC web site to provide basic information about membership, structure and network arrangements of the CRC. A professional web developer has revised the entire Beef CRC website to provide a search facility for CRC publications and general information. It is anticipated the site will be completely upgraded over coming weeks.

Web address: www.beef.crc.org.au

Sub Program 4 Education and Training for the Beef Business

Project 4.4: Integration and delivery of CRC technologies and information

Mission

To optimize use of existing and new technology in the Australian beef industry to develop strong and applied expertise among Australian beef industry personnel.

Goals

- Achieve increased adoption of new technologies by raising the profile, credibility and awareness of the Centre through targeted industry activities.
- Create an improved environment for two-way information flow between the Centre and its target audiences, ensuring technology transfer activities are tailored to industry needs.
- Develop and deliver customized industry training programs for targeted sectors of the beef industry.
- Develop and produce high quality learning materials that support industry training programs and contribute to the bank of beef industry technical resources.

Strategies and Progress

Distillation of research outputs into Profitable Business Solutions

This strategy involves research, extension and industry personnel in the translation of CRC research results into applied extension messages and Profitable Business Solutions for adoption by participants of the beef supply chain. Profitable Business Solutions are concise

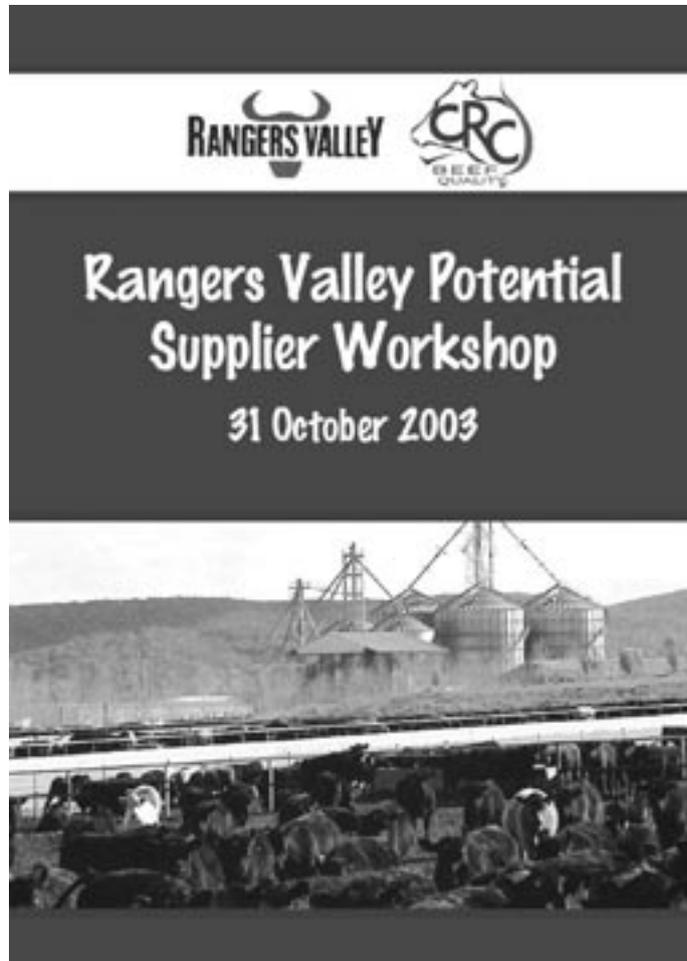
messages and technologies that can be used by individual enterprises to enhance profitability (i.e. based on "Proof and Profit"). Activities under this strategy over the past year include:

- Proceedings of an "Arm the Trainer" Workshop, including extension support material, copies of PowerPoint presentations on CD and a list of contact details for further follow up have been distributed to extension people throughout Australia. An email discussion group was established for industry technical resource people and extension staff to exchange ideas and information.
- A magazine-style publication of key CRC results was completed in April 2004 and widely distributed to beef industry stakeholders. It summarizes the main messages for beef producers from the first 10 years of the Beef CRC. A CD and web version is currently in production.
- Extension staff from NSW, Victoria and Queensland met with key CRC research staff in November 2003 to distil the main messages from the latest meat science research results. Similar workshops on growth and nutrition and marbling were conducted in May 2004. CRC genetics results were considered in detail at an MLA "Proof and Profit" workshop at Ebor, NSW.
- A "Beef CRC Research Update" is currently being produced for the CRC website, with hard copy distribution expected in August-September 2004.

Industry Training

This strategy supports the delivery of industry training events conducted by state agency extension staff. In addition, the conduct of training events and workshops with private-sector networks (e.g. MSA, BIA, stock agents and lot-feeders) are conducted on a cost-recovery basis. Training events in which the CRC participated over the past year include:

- Southern Beef School at Glenormiston, Victoria in July 2003 in conjunction with the Angus Society of Australia and the University of Melbourne (Glenormiston), with 52 delegates.
- Midwest Profitable Cattle Workshop at Dongara, WA in August 2003 in conjunction with the Beef Improvement Association, with 70 delegates.
- Meat Standards Australia Saleyard Seminar at Armidale in November 2003 in conjunction with MSA to deliver the latest CRC meat quality results and the sale of cattle through saleyards.
- Armidale Feeder Steer School was conducted in February 2004 in conjunction with the Angus Society of Australia and NSW Agriculture, with 69 delegates from NSW, QLD, Victoria, South Australia and Western Australia.



Sub Program 4 Education and Training for the Beef Business

Project 4.4: Integration and delivery of CRC technologies and information

- SARDI Activities, including CRC displays and presentations at the Lucindale Field Days, Hamilton Beef Expo, Mt Gambier Regional Rural Outlook Conference, Southern Australian Beef Research Committee and the Struan Agricultural Centre Management and Advisory Committee.

Development and delivery of integrated training packages for temperate Australia

This strategy involves integration of CRC results with other information and technologies into training packages customised for various beef industry sectors in temperate Australia. The packages include:

- Extension packages for supply chain alliances, with development and delivery of a workshop for the Hunter Natural group at Scone in October (40 participants) and a supplier's workshop for clients of Rangers Valley Feedlot, Glen Innes in November (45 participants).
- An extension package was developed and delivered to Westfarmers Landmark in July. The workshop program and proceedings will form the basis of further workshops for agents in 2004 and 2005.
- Other activities under this strategy included "Better Bull Buying" workshops at Albury, Holbrook and Coolac in March (with an updated manual containing the latest CRC genetics results) and integration of CRC genetics results into numerous BREEDPLAN extension activities.

Development and delivery of integrated training packages for (sub)tropical Australia

This strategy delivered a large number of customised activities to disseminate the outcomes of the Beef CRC research throughout northern Australia, including:

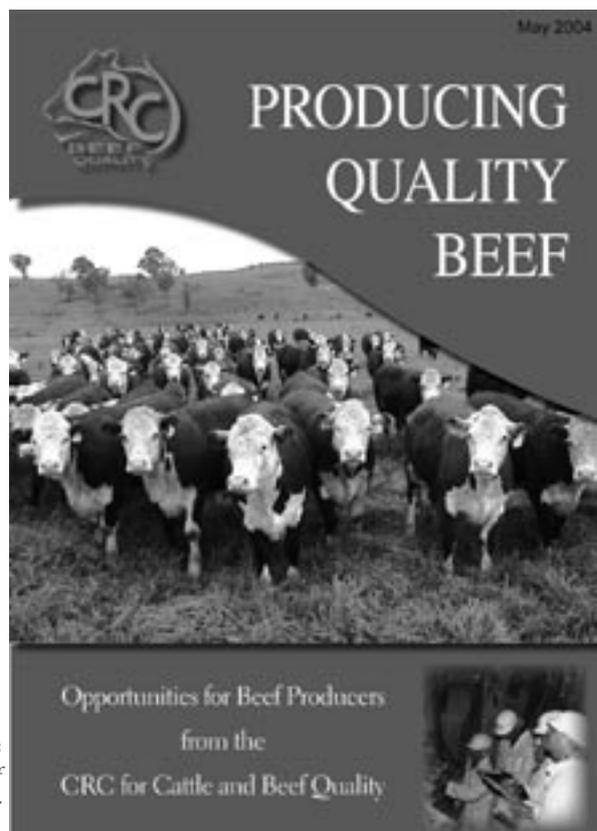
- Publication of CRC results in various regional newsletters across Queensland. Articles were published in the Northern Muster, the Country Courier and Queensland Country Life. CRC genetics results were incorporated into the revised "Bull Selection - Buying Better Bulls" publication, the new MLA Northern Breeding EDGE package and a CD package used for training Certificate and Diploma

students at Agricultural Colleges in Queensland.

- Relevant CRC results were incorporated into 11 drought workshops conducted across Queensland.
- Bull selection workshops featuring CRC results were conducted at Goondiwindi, Kingaroy, Tambo, Ayr and Charters Towers. Additional workshops were run in conjunction with the Santa Gertrudis Association, the Western Downs Beefplan group and the Blue Gum Beef Supply Chain group.
- CRC results were included in breeding and genetics training to Certificate and Diploma level competencies at Emerald and Burdekin Agricultural Colleges for approximately 100 students.
- Training in breeding objectives, EBVs, marker assisted selection and net feed intake was provided to University of Queensland Veterinary Science students.

Major Beef Industry Events

The purpose of this strategy is to promote the Beef CRC's activities and outcomes at major beef industry events via high quality displays, presentations and active participation by CRC research and technology transfer staff. The CRC was represented at the Australian Lotfeeders' Annual Conference BEEFEX in October 2003, in a display jointly shared with NSW Agriculture. New posters and technical notes were produced for the event that showcased the latest CRC research results on feed efficiency, yard weaning and growth path effects on yield and meat quality.



A magazine-style publication of key CRC results was completed in April 2004 and widely distributed to beef industry stakeholders. It summarizes the main messages for beef producers from the first 10 years of the Beef CRC.

Sub Program 4 Education and Training for the Beef Business

Plans for 2004 / 2005

Project 4.1 ~ Postgraduate education

- Annual postgraduate conference to be held.
- Annual progress reports provided by continuing scholars.

Project 4.2 ~ Undergraduate and vocational education

- Ensure that MEAT418 and ANPR440 continue to be delivered in electronic and paper formats.
- Transfer GEN210 into XML and develop appropriate multimedia objects to enhance the material.
- Extend the network of institutions using the electronic teaching and technology transfer material supported by the Beef CRC.

Project 4.3 ~ Knowledge management and information delivery systems

- Ongoing maintenance and updating of the CRC website for current content relating to the CRC.

Project 4.4 ~ Integration and delivery of CRC technologies and information

- Produce and distribute a CD containing key distilled messages, extension and research articles, pictures and graphics for industry professionals.
- Conduct further "distillation" workshops with extension and industry professionals, identifying key messages from the research and issues associated with adoption.
- Produce "Beef CRC Research Update" publications containing reports of progress and outcomes from distillation activities.
- Support state-based training initiatives within limitations of the cost-recovery policy in New South Wales, South Australia, Victoria and Western Australia.
- Enhance and deliver the feedlot workshop package to six key feedlots.
- Prepare CRC genetics results for inclusion on CRC website and CD for use by producers and extension personnel.
- Integrate CRC results into the new MLA "More Beef from Pastures" Program.
- Integrate CRC information into new workshop packages being developed by NSW Agriculture.
- Integrate CRC genetics results into BREEDPLAN extension activities.
- Conduct customized industry training workshops in northern Australia on CRC results and beef supply chain technologies.
- Conduct customized industry training workshops across Queensland on CRC results and bull selection and/or breeding for profit.
- Conduct Beef School featuring CRC results at Emerald and Burdekin Agricultural Colleges.
- Incorporate CRC results into reproduction and genetics training at Queensland Agricultural Colleges for ~150 Certificate and Diploma students.
- Conduct "Train-the-Trainer" workshops in Queensland and the NT demonstrating CRC genetic, growth and carcass results applicable to northern Australia.
- Demonstrate breeding objectives including beef quality indicators using genetic markers within the integrated genetic analyses of the Droughtmaster BREEDPLAN herd at Swans Lagoon and at least 2 other herds in northern Australia.
- Conduct Feeder Steer Schools featuring CRC results in southern downs and north Queensland.

Collaboration

Industry Linkages

The CRC network has linkages with cattle breeders, agribusiness firms, feedlots, abattoirs and the retail beef sector across the national CRC network. Several of the CRC's projects are totally dependent on commercial breeders throughout Australia to generate specifically designed cattle for their experiments. A most important feature of this particular industry linkage is that it provides the Centre with the best possible conduit of knowledge back to the breeding sector.

Linkages with Other Agencies

The Centre has developed extended linkages with agencies that are not formal participants or Core Parties in the Centre. In most cases, as listed below, the objective was to establish collaborative projects with these agencies, to extend the influence and outcomes of the Centre to other potential end-users.

Agency	Realised or potential outcome
Australian Association of Cattle Veterinarians	Centre Associate - mutual sponsor with CRC of education and extension activities.
Beef Improvement Association of Australia	Centre Associate - mutual sponsor with CRC of breed improvement activities, including industry seminars.
Genetic Solutions Pty Ltd	Commercial partner of CRC/MLA/CSIRO consortium to commercialise genetic markers developed by the consortium.
Northern Pastoral Group of Companies	Individual members are collaborating partners in specific CRC research and extension activities for northern Australia; joint participation in Centre education and extension activities.
Australian Country Choice/Coles	Collaborating partner in specific CRC research aimed at processing/retailing sectors of the beef industry.
Angus Society of Australia	Collaborating partner in specific CRC research targeting genetic improvement of feed efficiency.
PrimeGro Pty Ltd	Collaborating partner in specific CRC research targeting indirect markers for feed efficiency.
AgReserves and Alcoa Farmlands	Collaborating partners in specific CRC research investigating genotype x nutrition interactions to achieve market compliance.
Ridley Corporation	Collaborating partner in specific CRC research targeting improved feedlot performance of cattle.
International Animal Health Pty Ltd	Joint sponsor with CRC of industry education activities.
Australian Poll Hereford Society	Joint sponsor with CRC of industry education activities.

Collaboration

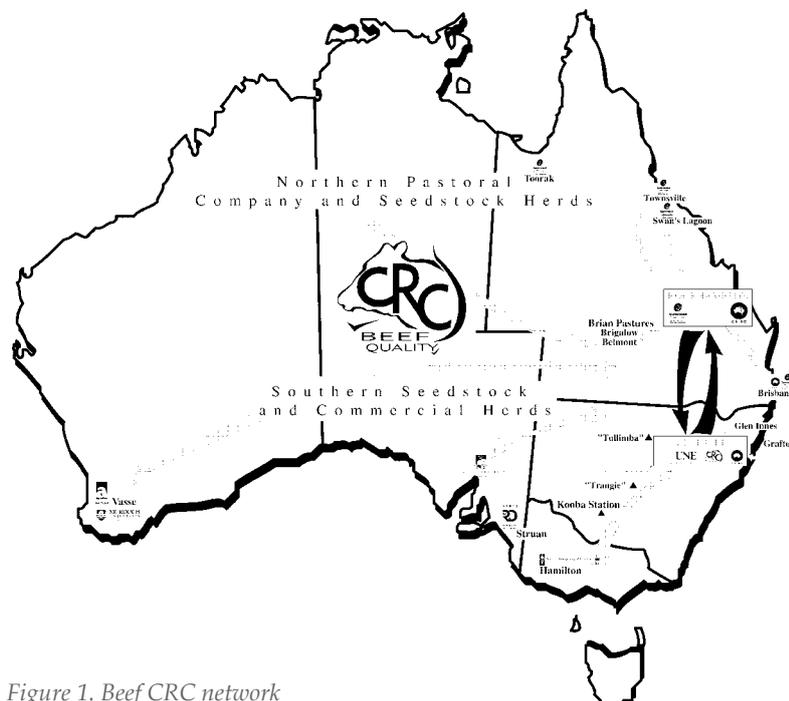


Figure 1. Beef CRC network

Collaboration

Collaborative Arrangements with Meat and Livestock Australia

Formal collaboration between the CRC and MLA occurs at three levels:

1. Membership, with CSIRO Livestock Industries, of a consortium formed to commercialise genetic marker technology developed individually or jointly by CRC and CSIRO scientists in partnership with MLA for the Australian beef industry. The consortium is managed jointly by Prof Bernie Bindon representing the CRC for Cattle and Beef Quality, Mr Shaun Coffey representing CSIRO Livestock Industries and Dr Hutton Oddy representing MLA. The consortium meets as required to further gene marker commercialisation issues.
2. Representation by MLA on the CRC's Research Committee, to provide external expertise and advice with respect to the CRC's research, education and extension portfolio. The MLA representative formally participates in the CRC's annual cycle of review held in March or April each year.
3. Co-investment by MLA in CRC research activities, as outlined in the Centre Agreement. The projects listed in the Grants and Awards section of this report form a component of MLA's commitment to the CRC of \$6.3m over the 7 years.

International Linkages

In Japan

Collaboration between the CRC and the Hyogo Prefectural Agricultural Institute builds on collaboration between CSIRO and Japan established during CRCI. It provides a unique opportunity for CRC scientists to gain access to valuable Wagyu genetic resources to understand the genetics and biochemistry of marbling.

In South Africa

Generous funding from the Australian Centre for International Agricultural Research (ACIAR) is supporting collaborative research between the CRC and a number of research institutions in South Africa, with significant benefits to both countries. In South Africa, the project is improving the profitability of resource-poor farmers by opening up commercial beef market

opportunities previously unavailable to them. As part of the project, well-adapted indigenous Sanga breeds owned by emerging farmers are benchmarked against Bonsmara (the South African "first cousin" of the Australian Belmont Red) and Brahman cattle through the South African commercial beef production system. Attributes benchmarked include feed efficiency, feedlot performance and carcass and beef quality. Results indicate that cattle derived from resource poor herds have the capacity to meet the specifications of commercial beef markets in South Africa, potentially replacing 300,000 weaners and 35,000 tonnes of beef imported each year to satisfy domestic requirements. Results are directly applicable to northern Australian herds because the Brahman and Belmont Red breeds were extremely well characterized through CRCI research.

Screening of 159 elite South African sires for GeneSTAR Marbling shows no purebred Sanga sire tested carries a copy of the TG5 gene and only a very low proportion of Sanga-derived sires carries the gene. Testing of another ~100 sires is still underway. As these breeds are known from Australian and US studies to have high marbling, it is likely the Sanga breeds have other genes for marbling than the Wagyu and Angus breeds, which have moderate to high frequencies of the TG5 gene. A high proportion of Sanga and Sanga-derived South African sires had 2 copies of the GeneSTAR Tenderness (CAST3) gene, supporting other data that show these breeds have good beef tenderness. Sires tested in this strategy are not from resource poor herds because sires in those herds were not widely used and well characterized. However, the results provide an additional economic incentive to further genetically develop the herds controlled by resource-poor farmers, to potentially develop a national and international seedstock market for superior breeds and sire lines. Semen from sires with favourable allele(s) for GeneSTAR Marbling and Tenderness is available for ongoing use by the CRC project.

These results are now being used as "Proof of Concept" of a much larger opportunity currently being developed with our South African collaborators, the South African beef industry and a major South African company, in the context of developing a third-term Beef CRC proposal.

In Korea

In 2003, the CRC undertook a large collaborative project in conjunction with Meat and Livestock Australia and the National Livestock Research Institute in Suwon, Korea to compare Korean and Australian consumers' scores for beef palatability. Specifically, the research aimed to determine if consumers in Korea differed in their grade boundaries and the accuracy with which tenderness, juiciness, flavour and overall acceptability scores combined to predict grade classification for different cooking techniques.



Participants of a training workshop in South Africa

Collaboration

An investigation of demographic and design effects (cooking technique, hanging treatment, muscle etc) on sensory responses from Korean and Australian consumers was also undertaken. Results showed that Korean and Australian consumers have similar perceptions of beef palatability, suggesting beef palatability could become an international trade description for beef.

Since completion of the study, Korea has expressed strong interest in becoming a partner in a third term Beef CRC, to continue the collaborations that arose from this earlier research. If the new CRC application is successful, Korean scientists will collaborate in new genomics and proteomics research that will examine differences in protein expression during muscle and fat cell development between breeds extremely divergent for marbling (including the Korean Hanwoo breed) and muscle growth to elucidate key regulators of these characteristics.

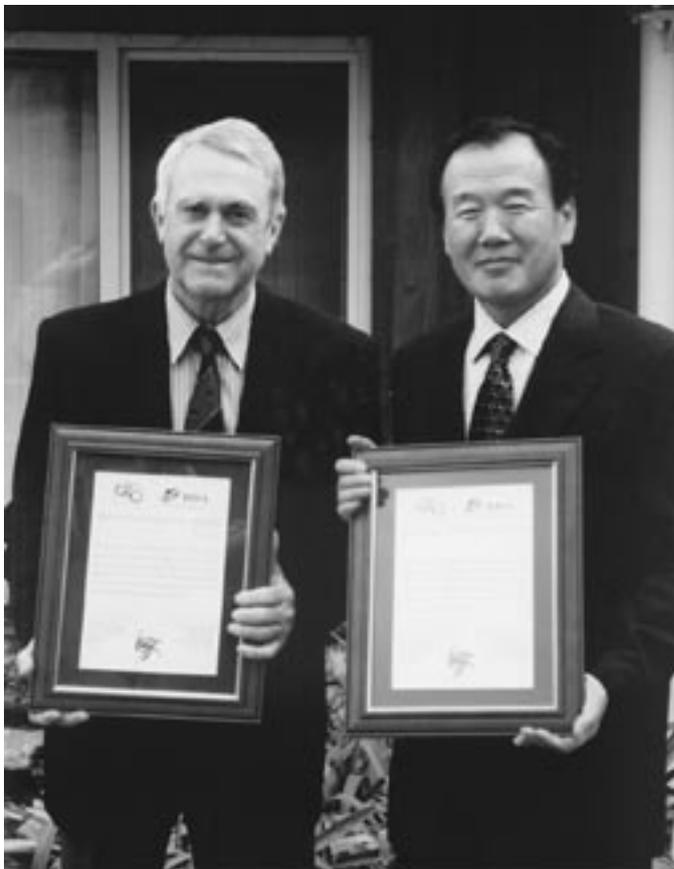
Other International Linkages developed for a third-term Beef CRC

During development of the proposed CRC for Beef Genetic Technologies, a number of new international collaborations were added to the CRC network to facilitate trade arising from jointly developed scientific outcomes beneficial to all partners. The collaborations are specifically targeting:

- Customisation of the Meat Standards Australia model in collaboration with Meat and Livestock Australia to predict palatability and grades for two

of Australia's key trading partners (Korea and the European Union). This requires extensive testing to define consumer requirements in those countries and determine their grade specifications for both domestic and export markets. The ultimate aim is that our key trading partners use a common palatability language to specify their domestic and imported beef products. Research collaborators in this initiative will be the National Livestock Research Institute in Korea along with collaborators in Europe. A preliminary experiment has been undertaken to examine differences in consumer responses between Australian and European consumers as part of a large collaborative MLA study with Queens University and the Department of Rural Development, Northern Ireland. This involved a similar experimental design to the Korean study, whereby samples produced from Australian carcasses were tested by both Australian and Northern Ireland consumers. Those Australian samples sent to Northern Ireland were mixed with samples from Northern Ireland carcasses before being fed to Northern Ireland consumers.

- Improved efficiency of feed utilization and simultaneous reduction of methane production by cattle, using genetic approaches to characterise and modify metabolic pathways in the rumen associated with feed efficiency and methane production. International collaborators will be The Ohio State University, USA and Meat and Wool New Zealand's Pastoral Greenhouse Gas Research Consortium.
- Improved reproductive performance of the beef breeding herd using new genomic approaches to specifically target post-partum re-conception in lactating cows, in conjunction with reproductive endocrinologists and geneticists from The Ohio State University.
- Commercialization of CRC outcomes: International companies including Meat and Wool New Zealand and Sygen International (USA) will become partners in a third-term Beef CRC to assist commercialization efforts internationally.



Prof Bernie Bindon, CRC for Cattle and Beef Quality and Dr Kyung-Nam Kim, National Livestock Research Institute, RDA, Korea with the signed Memorandum of Co-operative Research Project.



Sub Program 5 Administration: Beef Research in a Business Environment

Project 5.1: Secretariat

Mission

To operate an efficient and businesslike secretariat for the administration of the Centre, maintain a high standard of financial planning, reporting and management of cash and “in-kind” contributions and ensure compliance with the requirements of all relevant agencies and stakeholders.

Goals

- Ensure the Centre’s activities are carried out in accordance with the provisions of the Commonwealth Agreement and the Joint Venture Agreement and maximize the potential benefits of the CRC to industry.
- To operate an efficient and business-like secretariat for the administration of the Centre, maintain a high standard of financial planning, reporting and management of cash and “in-kind” contributions and ensure compliance with the requirements of all relevant stakeholders and agencies.

Strategies and Progress

The fifth year of Centre activities saw some projects winding down their research activities and writing up and transferring their results to industry. Remaining projects consolidated and focused in preparation for wind-down over Years 6 and 7. These activities contrasted sharply with the very intensive activity amongst the small CRC Renewal committee responsible for developing the Beef CRC’s Renewal Proposal. Activities undertaken by CRC Management during the year include:

- Launch of Pestigard vaccine at UNE by CSL in September 2003.
- Launch of IGF-I feed efficiency test in Armidale at AGBU in November 2003. The test is based on research by NSW Agriculture, PrimeGro, AGBU, MLA and the CRC.
- VIAScan measurement of retail beef yield %: Generous funding from MLA allowed installation of a VIAscan unit in Warwick Bacon’s abattoir to measure retail beef yield percentage using video imagery in lieu of one-side boneout. Research

cattle have now been processed through that plant since June 2003 and VIAscan images to measure RBY% secured without problems. Up to 370 head of research cattle have been slaughtered on a single day. This ability to slaughter so many cattle on the one day significantly enhances the power of the experimental design because there is no longer a need to allocate animals to slaughter groups of 50 head or less as was necessary in the past.

- A new Marbling marker patent was lodged on behalf of the consortium of CRC, CSIRO and MLA in February 2004 under the title “DNA Markers for Marbling”. The CRC’s commercial partner has expressed interest in marketing the DNA test arising from this patent.
- An Agreement was been negotiated by the consortium responsible for commercializing DNA markers to sub-license to BoviGen Solutions to facilitate marketing of consortium DNA marker technologies to USA. BoviGen Solutions will contribute to the Consortium for R&D to fast-track new genetic markers. They have significant minimum sales performance obligations to meet as part of this Agreement.

There were no changes to either the Governing Board or CRC Executive Committee over the past year. Mr Stuart Castricum resigned from the Advisory Committee early in Year 5, coinciding with his resignation from Coles/ACC. He was replaced on the Advisory Committee by Mr Terry Nolan of Gympie Meats, representing the Australian Meat Industry Council.

Professor Bernie Bindon continued his role as the Agriculture Sector CRC’s Representative on the CRC Association Committee, contributing to the CRC Association’s efforts to lobby Government for continued and additional funds for the CRC movement. The Committee meets four times per year under the Chairmanship of Mr Tony Staley, former MP.

CRC Management, per medium of the Chief Executive Officer and others, continues to assist in the public promotion and technology transfer of CRC activities.

Project 5.2: “Tullimba” Cattle Research (Feedlot) Facility

Mission

To contribute to a world-class research facility and maintain a high industry standard of feedlot performance and management.

Strategies and Progress

The feedlot facility at “Tullimba” continued operations during the year under the expert management of Mr Reid Geddes. Over the past year, a total of 1,526 contract cattle passed through the feedlot, comprising 349 contract research cattle, 1,145 CRC research cattle and 32 cattle on commercial contracts. There were 600 head of research cattle in the feedlot at 30 June 2004 as well as 469 head on pasture.

As at 1 July 2004, the grazing lease for “Tullimba” reverted to UNE, following the successful growout

of CRC research cattle off pasture at “Tullimba” nine months ahead of schedule.

Approximately 717 visitors passed through “Tullimba” over the past year, including groups from UNE, Wesfarmers, John Dee Pty Ltd, MLA, Ridley, The Shorthorn Society of Australia, Elanco, Department of Agriculture Western Australia, Hereford Society, commercial research organizations and international visitors from Argentina, New Zealand, South Africa, Chile and Ireland.

The Northern Pastoral Group of Companies participating in CRC Project 2.3 were invited to Tullimba in October to inspect their cattle and receive a detailed briefing on the measurements being conducted on the animals before and after slaughter. Representatives of Warwick Bacon were also present. This event provided the breeders of

Sub Program 5 Administration: Beef Research in a Business Environment

Project 5.2: "Tullimba" Cattle Research (Feedlot) Facility

the cattle with additional ownership of the research project and will help secure adoption of results when the project is completed. Later that day, the "Tullimba" facility was opened to the public. Even though most cattle on display were tropically adapted breeds not of direct interest to local cattle producers, 70 of them attended the afternoon presentations. The CRC Advisory Committee also attended the full day event to hear first-hand from the owners of the cattle and local beef producers about the value of the CRC's research.

Plans for 2004 / 2005

Project 5.1 ~ Secretariat

- The Governing Board will meet at least 4 times to determine Centre policy on issues that arise during the year.
- The Executive Committee will meet at least 12 times to address issues related to the day-to-day running of the Centre.
- The Research Committee will meet once to undertake a peer review of all CRC projects.
- The Advisory Committee will meet twice to participate in the project review process in order to advise the Governing Board on the strategic direction and industry relevance of the Centre's activities.
- The Executive Committee will implement the Governing Board's approved commercialization strategy to capture the commercial benefits of the Centre's research and education initiatives.

Project 5.2 ~ "Tullimba" Cattle Research (Feedlot) Facility

- The Executive Committee will assess commercial opportunities to maximize the use of the "Tullimba" Cattle Research (Feedlot) Facility.
- Experiments from the CRC project portfolio will be conducted in a cost-effective matter, with increased use being made of the facility for education and technology transfer.

Specified Personnel

Name	Contributing Organisation	% working time in CRC	Role in Centre
Prof Bernie Bindon	CSIRO (CRC funded)	100	CEO
Dr Heather Burrow	CSIRO	100	Deputy CEO
Dr Drewe Ferguson	CSIRO	38	Manager, Strategic Science Sub-Program
Dr Paul Arthur	NSW Agriculture	44	Manager, Innovative Technologies Sub-program
Mr Jim Walkley	DPI&F, Queensland	23	Manager, Delivery of Technologies Sub-program
Assoc Prof Julius van der Werf	UNE	15	Manager, Education and Training Sub-program

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Publication Presentations, Public Relations and Communication

Major public exhibitions and field days

Public relations through mass media

Regular press releases, radio interviews and television appearances have been used to promote CRC research results. Most coverage appears in rural-based print, radio and television media, with some broader coverage in metropolitan newspapers and radio. Rural Press publications are a major source of information used by our target audience and good exposure has been achieved in *The Land*, *Queensland Country Life*, *Stock and Land*, *Australian Farm Journal*, *Beef Improvement News* and *Today's Feedlotting*. The CRC maintains a strong industry presence through non-print media exposure. Examples include ABC Regional Radio, NBN Television, Prime Television, Radio 2UE Rural, ABC Radio National Country Hour.

Training and field day activities

The Beef CRC is involved in both specific days that are based entirely on CRC research and other events that are conducted jointly with organisations such as BIA, AACV and MLA and contribute towards broader industry programs. Some of the events conducted this year include:

- Wesfarmers Landmark Workshop for Senior Livestock Staff, Armidale, July 2003
- Beef Improvement Association of Australia Workshop, Armidale, July 2003,
- Beef CRC Southern Beef School, Glenormiston, July 2003
- Trangie Livestock Technology Day, Trangie, August 2003
- ALFA BeefEX 2003 Conference, October 2003
- Beef CRC and Rangiers Valley Potential Supplier Workshop, Glen Innes, October 2003
- MLA Beefplan Workshop, Swans Lagoon Research Station, October 2003
- Beef CRC and Meat Standards Australia Saleyard Workshop, November 2003
- Beef CRC Southern Beef Update, Wagga Wagga, November 2003
- Beef CRC Integrated Feedlot Supply Chain Workshop, Scone, November 2003
- Application of Research to the Australian Live Export Industry, Brisbane, January 2004
- Armidale Feeder Steer School, Armidale, February 2004
- Beef CRC and NSW Agriculture, Grafton ARAS Field Day, February 2004
- World Hereford Congress, Armidale, March 2004
- International Workshop on BREEDPLAN and related technologies, Armidale, March 2004
- Brian Pastures 50th Anniversary Field Day, Gayndah, April 2004

- Tartrus 50th Anniversary Field Day and Sale, Marlborough, May 2004
- Kingaroy Breeding Technology Annual Field Day, Kingaroy, May 2004
- AgForce Queensland Seminar, Rockhampton, May 2004
- Beef CRC and NSW Agriculture, Glen Innes ARAS Field Day, May 2004
- ABARE Regional Outlook Conference, Gunnedah, June 2004

Scientific conferences, industry seminars and visiting groups

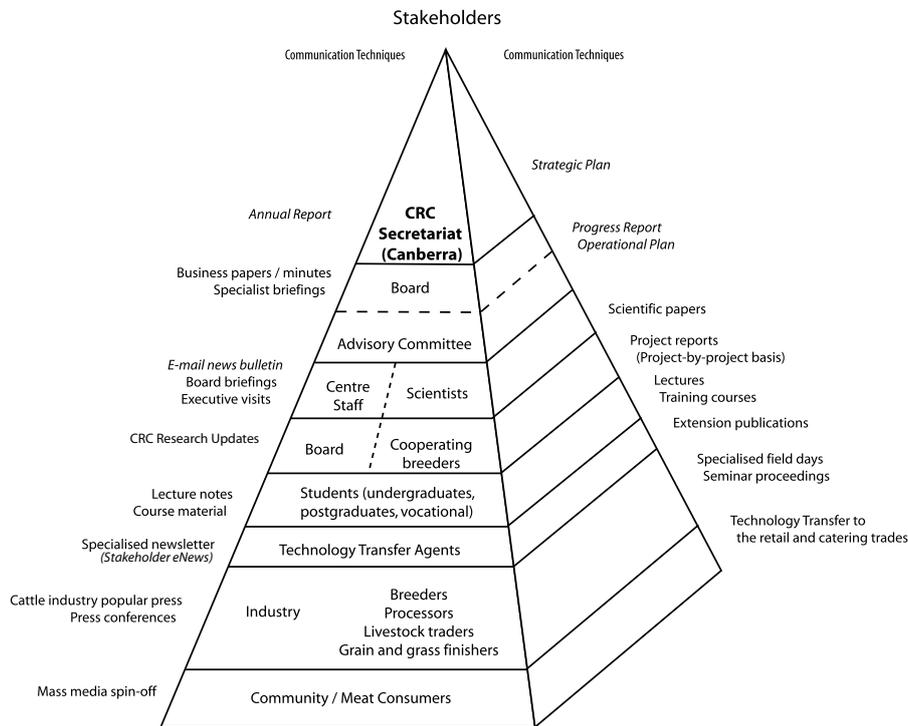
- 15th Conference, Association for the Advancement of Animal Breeding and Genetics, Melbourne, July 2003
- World Genetics Congress, Melbourne, July 2003
- 25th International Conference of Agricultural Economists, South Africa, August 2003
- MLA Advanced Genetics Solutions Workshop, Leura, August 2003
- European Association of Animal Production Meeting, Bled, Slovenia, September 2003
- Matrix Biology Society of Australia and New Zealand, September 2003
- 49th International Congress of Meat Science and Technology, Brazil, October 2003
- Joint Meeting of the Australian and New Zealand Societies for Microbiology, Auckland, New Zealand, October 2003
- FAO/IAEA Symposium on Applications of Gene-based Technologies for Improving Animal Production and Health in Developing Countries, Vienna, Austria, October 2003
- HA2003 Conference, Cleveland Ohio, USA, November 2003
- Summer Symposium in Bioinformatics, Canberra, December 2003
- International Plant and Animal Genome Meeting, San Diego USA, January 2004
- INRA-RRI Gut Microbiology 4th Joint Symposium, Clermont-Ferrand, France, June 2004

Communication Plan

The CRC's Communication Plan, originally developed in 1994 and progressively refined to suit the new CRC is shown in the diagram on the next page and discussed in the table. Extension specialists funded by the CRC or employed by the State Departments of Agriculture are involved in communication, extension and education programs. The CEO, Deputy CEO and key scientists from the Centre also perform technology transfer and commercialisation roles.

Publication Presentations, Public Relations and Communication

Communication Plan



Further detail on communication techniques and examples of major activities for various stakeholders follow.

Stakeholder	Communication Method
CRC Secretariat	Annual Report
Board Members	Business papers and minutes of Board meetings plus at least four physical meetings each year.
Advisory Committee	Operational Plan, Progress Report, Strategic Plan, project leaflets, two meetings per year with appropriate documentation.
Sponsors	This group requires early access to Centre outcomes. This is achieved by an email circular Stakeholder eNews published four times per year as well as by direct reports from the projects to their respective industry sponsors.
Centre Network Staff	Research, advisory and administrative staff from the four Core and five Supporting Partners are kept informed by brief, but frequent, in-house communication. This is based around the monthly Email News bulletin, backed up by mail where necessary. Additional information is supplied via the line management structure of the Centre and the CRC website.
Technology transfer agents, external to the Centre	This group comprises cattle breed society officers, State Government and CSIRO extension and advisory personnel, consultants, veterinarians, producer groups and educational institutions. They need relatively detailed information. One key approach is via a targeted email newsletter Stakeholder eNews and a printed publication, Beef Research Update. Other methods of communicating with this group include special seminars and the CRC website.
Cattle industry at large	Mass media is used to target this broad group of producers, processors, lotfeeders, exporters and service industry groups throughout Australia. This has been achieved through newspaper, radio, television, CRC-sponsored seminars and personal presentations by CRC staff.
Students	A wide range of new learning materials has been prepared through the Centre's Education program and delivered by the use of written, video, CD-rom and face-to-face techniques. These are delivered through courses at UNE, TAFE and other institutions.
Community	Newspaper and television presentations assist with reporting community-based outcomes from the Centre's activities.

Grants and Awards

Grants

Project (Principal Investigator)	Researcher's Organisation	Title	Source	Period of award	Value
Project 1.4 (Dr Sigrid Lehnert)	CSIRO	BSC.010 ~ Functional genomics of bovine adipocyte development within perimysium	MLA	2003-06	\$510,000
Project 2.1 (Dr Wayne Pitchford)	University of Adelaide	TR.075 ~ Gene mapping for net feed intake	MLA	2000-02	\$140,000
Project 2.1 (Dr Bill Barendse)	CSIRO	BFGEN.007 ~ Identification of the genetic factors for marbling	MLA	2002-06	\$541,500
Project 2.1 (Dr Mike Goddard)	Dept of Primary Industries, Vic	BSC.014 ~ Map and identify genes for feed intake and efficiency of beef cattle with intent to develop DNA test	MLA	2004-06	\$400,000
Project 2.1 (Dr Bill Barendse)	CSIRO	Genetic resistance of <i>Bos taurus</i> cattle to ticks	Dairy Australia	2004-06	\$488,788
Project 2.2 (Dr Paul Arthur)	NSW Agriculture	BFGEN.005 ~ Improving the efficiency of feed utilization for beef production	MLA	2001-05	\$410,888
Project 2.2 (Dr Robert Herd)	NSW Agriculture	Collaborative Research Agreement	PrimeGRO	2002-05	In-kind
Project 2.2 (Mr Ben Wood)	UNE	PhD full scholarship	MLA	2001-04	\$66,090
Project 2.3 (Dr Heather Burrow)	CSIRO	NBP.301 ~ Links between the genetics of beef quality and components of herd profitability in northern Australia	MLA	2001-06	\$1,154,701
Project 2.3 (Prof John Thompson)	UNE	NBP.301A ~ VIAScan installation at Warwick Bacon Abattoir	MLA	2003-04	\$198,500
Project 2.3 (Dr Heather Burrow)	CSIRO	BFGEN.012 ~ Consolidation of molecular and phenotypic data from the Belmont CBX herd into the CRC database	MLA	2002	\$30,000
Project 2.3 (Dr Heather Burrow)	CSIRO	AS2/1999/036 ~ Developing profitable beef business systems for previously disadvantaged farmers in South Africa	ACIAR	2001-06	\$1,296,713
Project 2.3 (Dr Heather Burrow and Mr Richard Clark)	CSIRO and DPI&F, Qld	Agricultural leadership for sustained improvement and innovation (in South Africa)	ATSE Crawford Fund	2004	\$25,000
Project 2.3 (Dr Heather Burrow)	CSIRO	Research Participation Agreement ~ CRC Project 2.3	Northern Pastoral Group of Companies	1998-2006	\$3,100,000 (cash and in-kind)
Project 2.4 (Ms Kelly Drake)	CSIRO	PhD full scholarship	MLA	2003-06	\$68,313

Grants and Awards

Grants

Project (Principal Investigator)	Researcher's Organisation	Title	Source	Period of award	Value
Project 2.5 (Dr Chris McSweeney)	CSIRO	PRMS.028 ~ Safe feeding strategies for beef production in northern Australia	MLA	2003-05	\$263,250
Project 2.5 (Mr Kent Wu)	NSW Agriculture	Research Participation Agreement (PhD studentship)	International Animal Health	2001-05	\$52,500
Project 3.1 (Prof Brian Kinghorn)	UNE	TRM.001 and TRM.004 ~ Total Resource Management	MLA	2002-03	\$310,000
Project 3.1 (Mr Brad Walmsley)	UNE	PhD full scholarship	MLA	2002-05	\$68,313
Project 3.2 (Prof John Thompson)	UNE	MSAK.001 ~ Korean sensory testing	MLA	2003	\$148,699
Project 3.3 (Dr John Wilkins, Mr John Graham and Dr Geoff Tudor)	NSW Agriculture, DPI Victoria and Dept Agriculture WA	SBP.006 and SBP.006VI ~ Regional systems to meet market specifications	MLA	2001-06	\$549,940
Project 3.3 (Dr Brian Burns)	DPI&F Qld	NBP.321 ~ Improving compliance of genetics and HGP's	MLA	2002-03	\$73,060
Project 3.3 (Dr John Wilkins)	NSW Agriculture	Research Participation Agreement	AgReserves Australia	2002-06	In-kind
Project 3.3 (Mr Malcolm McPhee)	NSW Agriculture	PhD full scholarship	MLA	2002-05	\$145,289
Project 3.3 (Mr David Beatty)	Murdoch University	PhD half scholarship	MLA	2002-05	\$34,158
Project 5.5 (Dr Garry Griffith)	NSW Agriculture	COMP.039 ~ Further development and application of the beef industry equilibrium displacement model	MLA	2002-04	\$75,000
Generic (Prof Bernie Bindon)	CRC for Cattle and Beef Quality	FLOT.215 ~ The Australian Lot Feeders' Association contribution to the CRC for Cattle and Beef Quality	ALFA	2000-06	\$630,000
Generic (Prof Bernie Bindon)	CRC for Cattle and Beef Quality	Co-investment in NFI Units at Tullimba	MLA	2002	\$74,000
Generic (Prof Bernie Bindon)	CRC for Cattle and Beef Quality	Major National Research Facility (ILRIC)	AusIndustry	2002-06	\$4,480,480 CRC Share \$750,000

Performance Measures

Nature of Indicator	Year 1 Performance 1999/2000	Year 2 Performance 2000/2001	Year 3 Performance 2001/2002	Year 4 Performance 2002/2003	Year 5 Performance 2003/2004
Objectives of the Centre					
Outcome	Economic benefits	Centre priorities aligned with beef industry imperatives. Beef industry funding secured. Successful CRC projects will lead to economic benefits for beef sector earnings and the Australian consumer.	Centre priorities aligned with beef industry imperatives. Strong working relationship with Meat and Livestock Australia and peak industry bodies to achieve co-investment in CRC research activities.	Centre priorities aligned with beef industry imperatives. Strong support evident from peak industry bodies and MLA through CRC Renewal activities. Benefits from Centre technologies recognised by CRCA Excellence in Innovation Award.	Centre priorities aligned with beef industry imperatives. Outstanding support from beef industry sectors, organisations and individual producers through CRC Renewal process.
Input	Resource inputs	Total Centre resources exceed \$83 m. Total cash resources \$25.6m.	Total budgets of ~\$4.78m (June 2001) and ~\$4.48m (June 2002) approved by Governing Board.	Total budget of ~\$3.75m approved by Governing Board (June 2003)	Total budget of \$3.39m approved by Governing Board (June 2004)
Process	Project management	Governing Board and Management agree on Operational Plans for Years 1 and 2. Peer Review process in place.	Governing Board and Management agree on Operational Plans for Year 4. Peer Review process completed.	Governing Board and Management agree on Operational Plans for Year 5. Peer Review process completed.	Governing Board and Management agree on Operational Plans for Year 6. Peer Review process completed.
Outputs	Publications	45 journal papers; 136 conference papers.	48 journal papers; 1 full patent; 1 provisional patent; 145 conference papers.	30 journal papers; 2 provisional patents; 143 conference papers	35 journal papers; 1 full patent; 194 conference papers
	Seminars	5	19	17	25
	Workshops	9	15	14	14
Quality and Relevance of the Research					
Outcome	Research quality	Year 1 visit and external participants to Peer Review process confirm quality of research portfolio.	Year 2, Stage I Review Panel commends quality of research portfolio.	Year 2, Stage II Review Panel endorses findings of Stage I Panel and supports funding of Centre to Year 5.	Year 5 External Review panel commends quality of research and supports funding of Centre to Year 7.

Performance Measures

Nature of Indicator	Year 1 Performance 1999/2000	Year 2 Performance 2000/2001	Year 3 Performance 2001/2002	Year 4 Performance 2002/2003	Year 5 Performance 2003/2004	
Quality and Relevance of the Research						
Outcome	Industry involvement in project planning and success of "Beef 2000" presentations by Centre confirm user satisfaction.	Re-investment of funds by industry and endorsement of CRC portfolio by Industry Advisory Committee confirm end-user satisfaction.	Re-investment of funds by industry and endorsement of CRC portfolio by Industry Advisory Committee confirm end-user satisfaction.	Success of "Beef 2003" presentations and outstanding support from industry for CRC Renewal activities confirm end-user satisfaction.	Exceptional support from industry for CRC Renewal and strong endorsement of external CRC Review Panel confirm end-user satisfaction.	
Input	Resources committed by Core and Supporting Partners exceed Year 1 expectation.	Total FTEs of 33.06 Professional and 14.65 Support staff close to commitment by Core and Supporting Partners.	Total FTEs of 32.9 Professional and 15.0 Support staff close to commitment by Core and Supporting Partners.	30.4 FTE Professional and 14.8 FTE Support staff contributed by Core and Supporting Partners.	26.9 FTE Professional and 16.0 FTE Support staff contributed by Core and Supporting Partners.	
Process	Research Committee Peer Review process completed.	Peer Review process completed.	Peer Review process completed.	Peer Review process completed.	Peer Review process completed.	
Advisory Committee	New Advisory Committee membership sought.	Advisory Committee met twice.	Advisory Committee met twice. Advisory committee Chairman appointed as member of CRC Board.	Advisory Committee met twice.	Advisory Committee met twice.	
Outputs	45 journal papers; 136 conference papers.	32 journal papers; 10 book chapters; 1 provisional patent; 98 conference papers.	48 journal papers; 1 full patent; 1 provisional patent; 145 conference papers.	30 journal papers; 2 provisional patents; 143 conference papers.	35 journal papers; 1 full patent; 194 conference papers.	
Utilisation and Application of the Research						
Outcome	Improved end-user uptake	Communication plan refined and electronic delivery methods expanded.	Novel customised electronic technology transfer opportunity developed in conjunction with Centrogen Pty Ltd and Telstra.	MNRF successful application leads to formation of ILRIC; technology transfer activities multiplied and delivered across Australia with emphasis on an expanded, more diversified end-user audience.	Major "Train-the-Trainer" workshop for 60 key industry technology transfer agents to achieve better dissemination of CRC results; ILRIC Proof of Concept project an outstanding technical success	Significant "distillation" of CRC research outcomes achieved, to ensure customised technology transfer messages to facilitate end-user uptake.

Performance Measures

Nature of Indicator	Year 1 Performance 1999/2000	Year 2 Performance 2000/2001	Year 3 Performance 2001/2002	Year 4 Performance 2002/2003	Year 5 Performance 2003/2004
Utilisation and Application of the Research					
Input	\$2 million for technology transfer over 7 years	\$340,000 devoted to technology transfer.	\$501,000 devoted to technology transfer.	\$530,000 devoted to technology transfer.	\$521,000 devoted to technology transfer.
	Participants' involvement in technology transfer activities.	Finalisation of CRCI data analyses provides substantially increased technology transfer opportunities.	Significant integration of delivery techniques with increased focus on improved utilisation of state-based extension services and industry organisations.	Restructure of Centre commercialisation and technology transfer activities achieves better integration with State Departments of Agriculture.	Significant "distillation" of research results into industry-friendly messages sets extension specialists up for significantly increased technology transfer activities in Years 6 and 7.
Process	Integration of technology	Process confirmed and extended to include one research program devoted to delivery of outcomes to end users.	A key component of technology transfer activities is the integration of researchers into all education and training events.	Diversified modes of delivery ensure expansion of interactive electronic learning materials to support integration of technologies across key industry sectors.	Distilled technology transfer messages integrated into industry delivery packages (e.g. MLA EdgeNetwork, BREEDPLAN, integrated supply chain workshops)
Outputs	Centre products	2 newsletters 12 website updates 5 industry seminars 2 technical seminars 6 industry reports 6 technical reports 10 demonstrations 9 workshops 6 short courses 15 contributions to industry journals	2 newsletters 8 website updates 9 industry seminars 5 technical seminars 3 industry reports 116 demonstrations 7 workshops 4 short courses 18 contributions to industry journals	12 staff newsletters 6 website updates 24 industry seminars 4 technical seminars 5 industry reports 5 workshops 8 short courses 20 contributions to industry journals	12 staff newsletters 4 stakeholder newsletters 4 website updates 18 industry seminars 7 technical seminars 8 industry reports 6 workshops 4 short courses 18 contributions to industry journals

Performance Measures

Nature of Indicator	Indicator	Year 1 Performance 1999/2000	Year 2 Performance 2000/2001	Year 3 Performance 2001/2002	Year 4 Performance 2002/2003	Year 5 Performance 2003/2004
Collaborative Arrangements						
Outcome	Cooperation in research	Linkage to 6 new beef research groups in Australia and overseas completed.	Linkages developed with 4 regional sites and beef marketing groups throughout Australia (Project 3.3). Collaborative linkages with Centrogen/Telstra alliance to develop electronic technology transfer opportunities.	Linkages across all Australian states and collaborating institutions strengthened through research and commercialisation initiatives.	Strong linkages maintained across all Australian states and collaborating institutions through research and commercialisation initiatives.	Strong linkages maintained across all Australian states and collaborating institutions through research and commercialisation initiatives.
Input	\$55 million cash and in-kind provided by core and supporting partners (7 years)	\$10.07 million	\$8.33 million	\$9.86 million	\$11.65 million	\$9.62 million
Process	37 FTEs over 7 years (professional staff)	44.09 FTEs	33.06 Professional and 14.65 Support staff (in-kind); 7.58 Professional and 13.40 Support staff (CRC funded)	32.9 Professional and 15.0 Support staff (in-kind); 8.82 Professional and 15.10 Support staff (CRC funded)	30.4 FTE Professional and 14.8 FTE Support staff (in-kind); 8.1 Professional and 16.6 Support staff (CRC funded).	26.9 FTE Professional and 16.0 FTE Support staff (in-kind); 7.0 Professional and 11.3 Support staff (CRC funded).
	... between researchers	90% of projects involve collaboration.	95% of projects involve collaboration.	95% of projects involve collaboration.	All projects involve collaboration.	All projects involve collaboration.
	... between researchers & students	All students co-supervised across institutions.	All students co-supervised across institutions.	All students co-supervised across institutions.	All students co-supervised across institutions.	All students co-supervised across institutions.
	... international	4 international collaborations initiated.	International collaborations strengthened, particularly with Japan, South Africa and New Zealand.	Centre collaborations in Japan and South Africa have very high profile in those countries. Further opportunities for collaboration explored in New Zealand.	Centre collaborations in South Africa and Korea have national profiles. New international collaborations explored through CRC Renewal process.	New international collaborations developed as part of CRC Renewal process.
	... 5.86 FTEs from Supporting Participants	6.60 FTEs	5.96 Professional and 1.62 Support staff	5.38 Professional and 2.20 Support staff.	5.34 Professional and 1.39 Support staff.	5.55 Professional and 1.58 Support staff.

Performance Measures

Nature of Indicator	Year 1 Performance 1999/2000	Year 2 Performance 2000/2001	Year 3 Performance 2001/2002	Year 4 Performance 2002/2003	Year 5 Performance 2003/2004
Collaborative Arrangements					
Outputs	Collaborating authors on 50% of papers from Centre	38%	40% (67% journal papers; 31% conference papers)	47% (67% journal papers, 42% conference papers)	39% (54% journal papers, 37% conference papers)
Education and Training					
Outcome	Postgraduate students linked to industry	3 out of 6 scholarships have industry involvement.	4 out of 8 scholarships have industry involvement.	6 out of 8 scholarships have industry involvement.	4 out of 6 scholarships have industry involvement.
	Knowledge and skills available to beef industry	CRC publication at "Beef 2000" provides technical manual to beef industry end-users.	CD-rom and hands-on practical skills developed for Feedlot Managers and Meat Science students.	CRC's Landmark Special Issue of AJEA provides scientific blueprint to guarantee eating quality of beef. CRC Marbling Symposium provides world-first industry forum focused on single production trait.	Significant re-writing of CRC educational material for ILRIC Proof of Concept project and distillation of CRC scientific papers into Profitable Business Solutions directly targeting beef industry stakeholders.
Input	Education and training resources	\$231,000 committed to education strategies.	\$250,000 committed to education strategies.	\$381,440 committed to education strategies.	\$288,925 committed to education strategies.
Process	<i>Industry training</i>				
	Postgraduate	6 scholarships offered and accepted.	9 scholarships offered, 8 accepted.	10 scholarships offered, 8 accepted.	6 scholarships offered and accepted.
	Vocational	435 industry students face-to-face training	330 students face-to-face training	378 students face-to-face training	350 students face-to-face training
Outputs	Postgraduates	Nil graduated	Nil graduated	Nil graduated	1 graduated, 5 submitted
	Vocational - industry	260 participated in short courses	196 participated in short courses	252 participated in short courses	1,066 participated in short courses
	Vocational (TAFE)	175 enrolled in Advanced Beef Certificate	134 enrolled in Advanced Beef Certificate	126 enrolled in Advanced Beef Certificate	

Performance Measures

Nature of Indicator	Year 1 Performance 1999/2000	Year 2 Performance 2000/2001	Year 3 Performance 2001/2002	Year 4 Performance 2002/2003	Year 5 Performance 2003/2004	
Management Structure						
Outcome	Continuity of long term research	Board Chair and Chief Executive Officer provide continuity of leadership. Involvement of all participants 80% achieved.	CEO provides continuity of leadership, with planned changes to Board and Advisory Committee occurring to schedule. Involvement of all participants 90% achieved.	Chairman, CEO and Executive Committee provide continuity of leadership; planned changes to Board structure complete. Involvement of all participants 95% achieved.	No changes to CRC Board, Advisory Committee or Executive. Involvement of all participants achieved.	No changes to CRC Board or Executive Committee. Minor change to Advisory Committee. Involvement of all participants achieved.
Input	Total cash and in-kind for Administration (\$4 million over 7 years)	\$178,376 cash and \$419,827 in-kind.	\$390,696 cash and \$199,038 in-kind.	\$481,039 cash and \$215,616 in-kind.	\$512,332 cash and \$147,270 in-kind.	\$488,992 cash and \$156,812 in-kind.
Process	Governing Board	5 Board meetings.	4 Board meetings.	4 Board meetings.	4 Board meetings.	4 Board meetings.
Outputs	Financial Management	Completion of CRCI activities on time and within budget.	Completion of 95% of project activities on time and within budget.	Completion of 95% of project activities on time and within budget.	Completion of >95% of project activities on time and within budget.	Completion of >95% of project activities on time and within budget.
	Quarterly and Annual Reports on time	Quarterly reporting for Year 1 delayed by one month. Year 1 budget underspent by 40%.	Financial and in-kind reporting processes streamlined. Year 2 budget underspent by 4%.	Year 3 budget underspent by 2%.	Year 4 budget underspent by 3%.	Year 5 budget underspent by 3.2%.

Assessment of Track Record

Year 5 External Review

In April 2004, the CRC for Cattle and Beef Quality underwent an External Year 5 Review. This also satisfied the requirement for an External Review of CRC Achievements, a supporting element in the CRC's Renewal Application ... "CRC for Beef Genetic Technologies". The Review Panel comprised:

Dr John Vercoe (Chair)
Professor Mal Nairn
Professor Frank Nicholas
Mr Steve Millard
Professor Keith Entwistle

Summary of Review Panel's Report

- The CRC continues to operate, function and perform at a very high level. It has proven itself to be a top-ranking Centre with a highly successful track record.
- The activities and outputs are closely aligned with the agreed strategy. This has been developed through the cooperation and commitment of the core parties and with major inputs from a number of sectors of the beef industry.
- The CRC is demonstrably the world leader in this area. It is the only organisation in the world in which geneticists, nutritionists, meat and animal scientists and economists are working on the same animals and data, on an unprecedented scale, in an integrated way and in such a fashion that the data from all disciplinary areas contribute to a holistic approach to beef cattle improvement.
- The unique database that has accumulated over the life of CRC I, and the current CRC, is a huge and invaluable resource that continues to produce information, and will continue to produce information for many years to come.
- The mechanisms and pathways to commercialisation for the products from the genetics (ABRI/Breedplan), molecular and biochemical markers (Genetic Solutions and Primegro), meat science (MSA and VIAscan) and health programmes (CSL) of the CRC are now well established and will continue to serve the goals of the CRC well beyond its scheduled life.
- The structure of the CRC - Board, Research and Advisory Committees and Executive Committee - continues to function well and has been enhanced by forging a direct link between the Advisory Committee and Board: the Advisory Committee chair is a full Board member. This has increased the perception amongst the Advisory committee that their voice is heard and acted on at the highest level.
- The management of, and accountability for, the resources of the CRC are thorough and transparent and the Panel noted that the CRC has received excellent reports on all counts throughout its life.

Conclusions

The Panel was impressed with

- i) the quality of the science,
- ii) the team-work and linkages within the CRC parties and with relevant outside agencies,
- iii) the significant outputs that have resulted and their acceptance and support by industry, and above all
- iv) the overall impact that has resulted from CRC I under the impetus and guidance of the current CRC.
- v) Both the undergraduate and postgraduate training activities have been highly productive.

Therefore, the Panel has no reservations in recommending the following:

1. Funding for the CRC should be continued through to Year 7.
2. Given the outstanding track record of the scientific outputs of this Centre, and the benefits that have resulted for the Australian Beef Industry and the Australian community, a further renewal of this CRC should be favourably considered by the Commonwealth to enable the CRC to conduct further strategic research that will continue to benefit Australia.

Summary of CRC Board's Response

- The report is accurate, fair and useful.
- Its key recommendations for continued funding to Year 7 and strong support for our CRC Renewal Application are welcome and hard-earned.
- Its incisive evaluation of each project against agreed evaluation criteria is helpful for improvement of the Centre's performance.
- The report correctly identifies a difficulty on the part of this (and other agricultural CRCs) in providing key staff in line with Commonwealth Agreements. This particularly relates to state agencies whose resources have been depleted by restructure and the horrendous droughts of 1994/5 and 2001/4. Over the remaining life of this CRC, it is anticipated that additional investments of in-kind resources will be made by the CRC partners ... bringing the in-kind staff contributions in line with our commitments.
- In the opinion of the Governing board, the Panel Report has not identified any major issue that threatens the CRC's capacity to achieve its planned outcomes by June 2006.

Budget

Statement by the Governing Board

The Co-operative Research Centre Program grant monies received by this Centre have been expended solely upon the activities of the Centre and in accordance with the Commonwealth agreement.

The information contained in this Annual Report:

- (a) gives a true and fair view of the sources and applications of funding of this Centre for the year ended 30 June 2004 and;
- (b) gives a true and fair view of the financial position of this Centre as at 30 June 2004, and
- (c) has been prepared in accordance with the requirements of the Commonwealth Agreement.

This statement is made in accordance with a resolution of the Governing Board and is signed for and on behalf of the Board by:

Mr Peter Frawley
Chairman

Prof Bernie Bindon
Chief Executive Officer

Dated: 6 September 2004

TABLE 1 - IN-KIND CONTRIBUTIONS FROM CORE AND SUPPORTING PARTIES

- The "in-kind" contribution from the Core and Supporting Parties is calculated by applying an approved multiplier to the salary of professional staff, according to the time percentages contributed. The multiplier, as detailed in Schedule 4 of the Commonwealth Agreement, when used against professional salaries, takes account of direct support costs plus on-costs, administration and overhead costs, technical support and corporate Centre costs.
- It should be noted that these multipliers have not been uniformly derived by each Core and Supporting Party but have been applied in Table 1 as provided in the Commonwealth Agreement.
- The Animal Genetics and Breeding Unit (AGBU), based at the University of New England, is funded jointly by NSW Agriculture and the University of New England. The value of the "in-kind" contribution of professional staff from AGBU has been split between NSW Agriculture and the University of New England on a 50:50 basis.

Partner In-Kind Contributions

"In-kind" contributions for several Core Parties (on a cumulative basis) are below committed levels due to a disproportionate contribution of support staff, rather than professional staff. It has been noted that whilst some Partners have met or exceeded "in-kind" contributions measured on a dollar basis they are behind in the commitment of Typical Year FTE's as noted in Schedule 4 to the Commonwealth Agreement. The Board of Directors is continuing to work together with these Partners to ensure that the expectations of the Commonwealth are met.

Please note that CSIRO LI have undertaken to meet the future in-kind commitments on behalf of CSIRO FSA. Accordingly this change has been reflected in the budget figures for the 2005 and 2006 financial years.

Northern Pastoral Group

The "in-kind" commitments as noted in Schedule 4 to the Commonwealth Agreement for the Northern Pastoral Group were based upon the contribution of land. This commitment has been replaced by the Group making "in-kind" contributions to the CRC for agistment of cattle on CRC controlled land. The budgeted commitments by this group (Table 2) have been more than met by these "in-kind" contributions. (Refer Table 1).

TABLE 2 - CASH CONTRIBUTIONS

Budgets

The budgets for heads of expenditure as detailed in Table 2 for Year 6 and 7 are in accordance with the Governing Board's approved budget not with the Commonwealth Agreement. The Governing Board believes that this gives a more accurate indication of expenditure for Year 6 and 7.

The budgets for cash contributions and other revenue sources are as approved by the Governing Board. The Governing Board believes that this gives a more accurate reflection of projected income for years 6 to 7.

Core and Supporting Party Contributions

Cash Contributions from several supporting Partners are less than the amounts budgeted in Schedule 4 to the Commonwealth Agreement. The Governing Board is currently working together with these Partners to find a more effective means of delivering that sponsorship. Significant progress has been made in this regard in the past twelve months. Ridley Corporation have advised CRC Management of changed company policy, which alters their investment position for the CRC. The budget figures for years 6 to 7 disclosed in Table 2 reflect their reduced overall investment. This revision will need to be endorsed by the Commonwealth in the current financial year.

During the course of the CRC, Meat and Livestock Australia have made cash contributions of \$623,000 directly to Projects of the CRC. As these contributions did not flow through the CRC account, they have not been recognised in the attached cash table.

Table 1 - In-kind contributions from Core & Supporting Parties

	ACTUAL										PROJECTED				GRAND TOTAL		
	1999/2000	2000/2001	2001/2002	2002/2003	2003/2004	CUMULATIVE TOTAL TO DATE		2004/2005	2005/2006	Projected	Projected	7 Yrs	Projected	7 Yrs	Diff		
	Actual	Actual	Actual	Actual	Actual	Actual	Agr'mt	Actual	Agr'mt	Actual	Actual	Agr'mt	Actual	Agr'mt	7 Yrs		
CSIRO FSA																	
SALARIES	592,634	436,250	613,964	306,221	-	609,024	1,949,069	3,045,120	-	609,024	-	609,024	-	609,024	1,949,069	4,263,168	(2,314,099)
CAPITAL																	
OTHER	85,042	180,298	90,149	90,149	-	90,149	445,638	450,745	-	90,149	-	90,149	-	90,149	445,638	631,043	(185,405)
TOTAL	677,676	616,548	704,113	396,370	-	699,173	2,394,707	3,495,865	-	699,173	-	699,173	-	699,173	2,394,707	4,894,211	(2,499,504)
CSIRO LI																	
SALARIES	487,976	745,112	923,055	951,620	917,058	295,760	4,024,821	1,690,257	876,300	267,276	876,300	267,276	876,300	267,276	5,777,421	2,224,809	3,552,612
CAPITAL																	
OTHER	592,483	618,525	832,549	935,869	887,482	330,646	3,866,907	1,941,278	381,994	291,845	381,994	291,845	381,994	291,845	4,630,895	2,524,968	2,105,927
TOTAL	1,080,459	1,363,637	1,755,604	1,887,488	1,804,540	626,406	7,891,728	3,631,535	1,258,294	559,121	1,258,294	559,121	1,258,294	559,121	10,408,316	4,749,777	5,658,539
TOTAL CSIRO	1,758,135	1,980,185	2,459,717	2,283,859	1,804,540	1,325,579	10,286,435	7,127,400	1,258,294	1,258,294	1,258,294	1,258,294	1,258,294	1,258,294	12,803,023	9,643,988	3,159,035
QDPI																	
SALARIES	650,874	598,993	598,037	515,813	671,930	745,481	3,035,647	3,825,435	1,140,375	745,481	1,140,375	745,481	1,140,375	745,481	5,316,397	5,316,397	0
CAPITAL																	
OTHER	485,136	644,046	644,602	640,854	641,450	648,130	3,056,088	3,244,498	742,335	648,130	742,335	648,130	742,335	648,130	4,540,758	4,540,758	0
TOTAL	1,136,010	1,243,039	1,242,639	1,156,667	1,313,380	1,393,611	6,091,735	7,069,933	1,882,710	1,393,611	1,882,710	1,393,611	1,882,710	1,393,611	9,857,155	9,857,155	0
NSW Agriculture																	
SALARIES	1,190,973	1,064,245	1,252,877	1,238,020	1,260,927	1,121,621	6,007,042	5,979,170	904,109	904,109	904,109	904,109	904,109	904,109	7,815,260	7,787,388	27,872
CAPITAL																	
OTHER	1,431,250	1,279,286	1,439,065	1,401,060	1,417,419	1,320,384	6,968,110	7,117,542	1,092,856	1,018,140	1,092,856	1,018,140	1,092,856	1,018,140	9,153,822	9,153,822	0
TOTAL	2,622,233	2,343,531	2,691,941	2,639,101	2,678,346	2,442,005	12,975,153	13,096,712	1,996,965	1,922,249	1,996,965	1,922,249	1,996,965	1,922,249	16,969,082	16,941,210	27,873
UNE																	
SALARIES	360,462	330,823	263,161	357,012	167,087	518,982	1,478,544	2,594,910	1,077,165	518,982	1,077,165	518,982	1,077,165	518,982	3,632,874	3,632,874	0
CAPITAL																	
OTHER	638,273	630,945	543,975	1,138,751	476,854	789,111	3,428,798	3,945,555	1,047,489	789,111	1,047,489	789,111	1,047,489	789,111	5,523,777	5,523,777	0
TOTAL	998,735	961,768	807,136	1,495,763	643,941	1,308,093	4,907,343	6,540,465	2,124,654	1,308,093	2,124,654	1,308,093	2,124,654	1,308,093	9,156,652	9,156,651	1
Murdoch University																	
SALARIES	98,069	96,768	154,875	85,049	132,997	103,933	567,757	519,665	103,933	103,933	103,933	103,933	103,933	103,933	775,623	727,531	48,092
CAPITAL																	
OTHER	172,386	170,100	222,673	149,500	233,783	182,700	948,442	913,500	182,700	182,700	182,700	182,700	182,700	182,700	1,313,842	1,278,900	34,942
TOTAL	270,455	266,868	377,548	234,549	366,780	286,633	1,516,199	1,433,165	286,633	286,633	286,633	286,633	286,633	286,633	2,089,465	2,006,431	83,034
Agriculture WA																	
SALARIES	32,914	70,800	38,960	65,859	53,692	108,090	262,225	540,450	247,203	108,090	247,202	108,090	247,202	108,090	756,630	756,630	0
CAPITAL																	
OTHER	83,586	162,538	88,059	146,771	109,333	274,500	590,288	1,372,500	665,606	274,500	665,606	274,500	665,606	274,500	1,921,500	1,921,500	0
TOTAL	116,500	233,338	127,019	212,630	163,025	382,590	852,512	1,912,950	912,809	382,590	912,808	382,590	912,808	382,590	2,678,130	2,678,130	(1)

Table 1 - In-kind contributions from Core & Supporting Parties

	ACTUAL										PROJECTED EXPENDITURE						GRAND TOTAL		
	1999/2000	2000/2001	2001/2002	2002/2003	2003/2004	CUMULATIVE TOTAL TO DATE		2004/2005	2005/2006	Projected	7 Yrs	Projected	7 Yrs	Projected	7 Yrs	Diff			
	Actual	Actual	Actual	Actual	Actual	Actual	Agmt	Actual	Agmt	Actual	Agmt	Actual	Agmt	Actual	Agmt	7 Yrs			
University of Adelaide																			
SALARIES	138,227	149,853	241,820	175,016	142,713	847,628	671,890	134,378	134,378	134,378	134,378	134,378	134,378	134,378	134,378	1,116,384	940,646	175,738	
CAPITAL																			
OTHER	106,667	95,418	159,780	139,402	95,170	596,437	518,485	103,697	103,697	103,697	103,697	103,697	103,697	103,697	103,697	803,831	725,879	77,952	
TOTAL	244,894	245,271	401,600	314,418	237,883	1,444,065	1,190,375	238,075	238,075	238,075	238,075	238,075	238,075	238,075	238,075	1,920,215	1,666,525	253,690	
VDPI																			
SALARIES	103,381	188,152	253,250	222,207	258,754	1,025,744	693,910	138,782	138,782	138,782	138,782	138,782	138,782	138,782	138,782	1,303,308	971,474	331,834	
CAPITAL																			
OTHER	19,564	31,789	33,193	32,732	38,298	155,576	131,315	26,263	26,263	26,263	26,263	26,263	26,263	26,263	26,263	208,102	183,841	24,261	
TOTAL	122,945	219,941	286,443	254,940	297,052	1,181,320	825,225	165,045	165,045	165,045	165,045	165,045	165,045	165,045	165,045	1,511,410	1,155,315	356,095	
SARDI																			
SALARIES	126,827	41,806	-	47,397	87,736	303,765	674,685	320,397	320,397	320,397	320,397	320,397	320,397	320,397	320,397	944,559	944,559	0	
CAPITAL																			
OTHER	142,720	47,045	-	53,336	98,730	341,832	759,235	360,549	360,548	360,548	360,548	360,548	360,548	360,548	360,548	1,062,929	1,062,929	0	
TOTAL	269,547	88,851	-	100,733	186,466	645,597	1,433,920	680,946	680,945	680,945	680,945	680,945	680,945	680,945	680,945	2,007,488	2,007,488	0	
Northern Past. Group																			
SALARIES																			
CAPITAL																			
OTHER																			
TOTAL																			
Ag-Reserves																			
SALARIES																			
CAPITAL																			
OTHER																			
TOTAL																			
GRAND TOTAL IN-KIND (T1)	7,539,454	8,124,006	8,867,200	9,935,810	8,430,721	42,897,191	43,011,145	9,719,132	7,414,374	9,602,129	7,297,374	62,218,451	57,722,893	4,495,559					
Total salary in-kind	3,782,337	3,722,802	4,339,988	3,964,214	3,692,892	19,502,243	20,235,492	4,942,642	3,664,992	4,942,641	3,664,992	29,387,526	27,565,476	1,822,050					
Total capital in-kind	-	-	-	-	-	-	990,000	-	60,000	-	-	-	-	-	-	-	-	-	-
Total other in-kind	3,757,117	4,401,204	4,527,201	5,971,596	4,737,829	23,394,947	21,785,653	4,776,490	3,689,382	4,659,488	3,632,382	32,830,925	29,107,417	3,723,508					
GRAND TOTAL	7,539,454	8,124,006	8,867,200	9,935,810	8,430,721	42,897,191	43,011,145	9,719,132	7,414,374	9,602,129	7,297,374	62,218,451	57,722,893	4,495,559					

Table 2 - Cash contributions (dollars in \$'000s)

PARTNERS	ACTUAL										PROJECTED EXPENDITURE						GRAND TOTAL							
	1999/2000		2000/2001		2001/2002		2002/2003		2003/2004		TOTAL TO DATE		2004/2005		2005/2006		Projected 7 Yrs		Diff 7 Yrs					
	Actual (\$'000)	Agmt (\$'000)	Actual (\$'000)	Agmt (\$'000)	Projected (\$'000)	Agmt (\$'000)	Projected (\$'000)	Agmt (\$'000)	(\$'000)	(\$'000)	(\$'000)	(\$'000)												
CSIRO	591	0	0	0	0	0	0	0	0	0	557	0	10	0	0	0	591	567	24	24				
NSW Ag	591	0	0	0	0	0	0	0	0	0	557	0	10	0	0	0	591	567	24	24				
QDPI	591	0	0	0	0	0	0	0	0	0	557	0	10	0	0	0	591	567	24	24				
UNE	591	0	0	0	0	0	0	0	0	0	557	0	10	0	0	0	591	567	24	24				
TOTAL CORE CASH	2364	0	0	0	0	0	0	0	0	0	2228	0	40	0	0	0	2364	2268	96	96				
Supporting Partners																								
Meat and Livestock Aust.	0	162	997	1598	1178	900	3935	4500	0	0	0	0	0	0	0	0	1048	900	671	900	5654	6300	(646)	
Twynam Pastoral Company	148	39	0	0	0	0	187	0	0	0	0	0	0	0	0	0	0	0	0	0	187	0	187	
Northern Pastoral Group	0	0	0	0	0	0	0	250	0	0	0	0	50	0	0	0	0	0	0	0	50	0	350	(350)
Colles Myer	0	0	0	0	0	0	0	120	0	0	0	0	22	0	0	0	22	0	98	0	0	120	120	0
Ridley Corp.	20	0	0	0	0	0	20	250	0	0	20	20	0	0	0	0	0	0	60	0	0	80	250	(170)
University of Adelaide	0	0	0	16	4	0	4	20	0	0	4	20	0	4	8	4	0	0	4	8	4	28	28	0
Murdoch University	0	0	0	16	0	0	16	0	4	4	16	20	0	4	8	4	0	0	4	8	4	24	28	(4)
DNRE	0	0	0	52	0	0	52	20	4	4	52	20	0	4	0	0	0	0	4	0	4	52	28	24
Ag WA	0	0	0	16	0	0	16	20	4	4	16	20	0	4	8	4	0	0	4	8	4	24	28	(4)
SARDI	0	0	0	16	4	4	20	20	4	4	20	20	0	4	8	4	0	0	4	8	4	28	28	0
TOTAL CASH FROM PARTICIPANTS	2532	201	997	1714	1186	1060	6630	7448	1070	1010	861	970	1070	1010	861	970	8561	9428	(867)	(867)				
Non-participants	0	5	0	34	0	10	39	50	0	0	0	0	0	0	0	0	0	0	0	0	0	39	70	(31)
Cattle Sales	2	315	133	22	0	0	472	0	0	0	0	0	0	0	0	0	0	0	0	0	0	472	0	472
ACIAR Grant	0	0	271	312	249	0	832	0	213	0	0	0	213	0	250	0	0	0	0	0	0	1295	0	1295
Contract Research	118	138	199	0	49	10	504	50	0	0	0	0	162	0	0	0	0	0	0	0	0	504	70	434
DRDC	0	0	0	0	0	0	97	0	0	0	0	0	0	0	0	0	0	0	0	0	0	259	0	259
Tullimba Income	171	290	571	988	713	0	2733	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2733	0	2733
Commercialisation	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Education	0	76	292	236	64	0	668	0	0	0	0	0	0	0	0	0	0	0	0	0	0	668	0	668
Interest	72	63	49	49	44	10	277	50	10	10	10	10	10	10	10	10	10	10	10	10	10	297	70	227
CRC GRANT	2500	3200	2700	2200	2200	2200	12800	12800	2200	2200	1000	1000	2200	2200	1000	1000	16000	16000	0	0				
TOTAL CRC CASH CONTRIBUTION (T2)	5395	4288	5212	5555	4602	3290	25052	20398	3655	3240	2121	2000	3655	3240	2121	2000	30828	25638	5190	5190				
Cash carried over from previous year	0	2190	1816	1648	956	0	0	0	1427	0	1591	0	0	0	0	0	0	0	0	0	0	0	0	0
Less Unspent Balance	2190	1816	1648	956	1427	0	956	0	1591	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL CASH EXPENDITURE (T3)	3205	4662	5380	6247	4131	3290	23625	20398	3491	3240	3712	2000	3491	3240	3712	2000	30828	25638	5190	5190				
ALLOCATION OF CASH EXPENDITURE BETWEEN HEADS OF EXPENDITURE																								
SALARIES	1465	1835	1851	2121	1972	1309	9244	6671	1359	1359	1800	682	1359	1359	1800	682	12403	8712	3691	3691				
CAPITAL	206	120	119	72	0	0	517	0	0	0	0	0	0	0	0	0	517	0	517	0				
OTHER	1534	2707	3410	4054	2159	1981	13864	13727	2132	1881	1912	1318	2132	1881	1912	1318	17908	16926	982	982				

Budget

Table 3 - Summary of resources applied to activities of Centre

	ACTUAL										PROJECTED						GRAND TOTAL		
	1999/2000	2000/2001	2001/2002	2002/2003	2003/2004	CUMULATIVE TOTAL TO DATE		2004/2005		2005/2006		Projected	7 Yrs	Agmt	Diff				
	Actual	Actual	Actual	Actual	Actual	Actual	Agmt	Actual	Agmt	Projected	Agmt	Projected	Agmt	7 Yrs	7 Yrs				
ALLOCATION OF TOTAL RESOURCES APPLIED TO ACTIVITIES OF CENTRE BETWEEN HEADS OF EXPENDITURE																			
GRAND TOTAL (In-kind from Table 1 (T1))	7,539,454	8,124,006	8,867,200	9,935,810	8,430,721	8,137,415	42,897,191	43,011,145	9,719,132	7,414,374	9,602,129	7,297,374	62,218,452	57,722,893	4,495,559				
GRAND TOTAL (Cash expenditure from Table 2 (T2))	3,205,000	4,662,000	5,380,000	6,247,000	4,131,000	3,290,000	23,625,000	20,398,000	3,491,000	3,240,000	3,712,000	2,000,000	30,828,000	25,638,000	5,190,000				
TOTAL RESOURCES Applied to activities of Centre (T1+T2)	10,744,454	12,786,006	14,247,200	16,182,810	12,561,721	11,427,415	66,522,191	63,409,145	13,210,132	10,654,374	13,314,129	9,297,374	93,046,452	83,360,893	9,685,559				
ALLOCATION OF TOTAL RESOURCES APPLIED TO ACTIVITIES OF CENTRE BETWEEN HEADS OF EXPENDITURE																			
TOTAL SALARIES (Cash and In-kind)	5,247,337	5,557,802	6,190,998	6,085,214	5,664,892	5,219,988	28,746,243	26,906,492	6,301,642	5,032,992	6,742,641	4,346,992	41,790,526	36,277,476	5,513,050				
TOTAL CAPITAL (Cash and In-kind)	206,000	120,000	119,000	72,000	-	60,000	517,000	990,000	-	60,000	-	-	517,000	1,050,000	(533,000)				
TOTAL OTHER (Cash and In-kind)	5,291,117	7,108,204	7,937,202	10,025,596	6,896,829	6,147,427	37,259,947	35,512,653	6,908,490	5,570,382	6,571,488	4,950,382	50,738,925	46,033,417	4,705,508				

Allocation of resources between categories of activities

PROGRAM	RESOURCE USAGE		
	\$ Cash (1)	\$ In-kind	Cash Funded Staff (2)
Research	2,066,594	6,173,817	19.70
Education	476,646	344,816	1.1
Commercialisation/Tech. Transfer	548,947	877,638	2.8
External Communications	548,947	877,638	2.8
Administration	488,992	156,812	0.5
TOTAL	4,130,126 (T3)	8,430,721 (T1)	26.9 7.0

(1) Cash from all sources, including CRC Program

(2) FTE Staff Excluding Students

List of In-Kind Professional Staff

Organisation	Total FTEs	Program (% of time)					Activity (% of time)			
		1	2	3	4	5	Research	Education	Commercialisation & Technology Transfer	Administration
CSIRO Livestock Industries	6.03	2.59	2.94	0.00	0.00	0.50	4.83	0.30	0.65	0.25
University of New England	0.64	0.00	0.05	0.28	0.32	0.00	0.15	0.25	0.24	0.00
QDPI	4.89	0.00	2.70	1.04	1.15	0.00	3.38	0.00	1.41	0.10
AGBU	0.90	0.00	0.74	0.13	0.03	0.00	0.66	0.00	0.24	0.00
NSW Agriculture	8.91	1.01	3.26	2.43	1.58	0.63	5.73	0.10	3.03	0.05
Agriculture WA	0.60	0.00	0.00	0.55	0.04	0.01	0.53	0.02	0.05	0.00
University of Adelaide	1.16	0.64	0.37	0.00	0.15	0.00	0.94	0.22	0.00	0.00
VDPI	1.85	0.56	0.58	0.55	0.16	0.00	1.80	0.00	0.05	0.00
Murdoch University	1.24	0.18	0.00	0.86	0.17	0.03	1.02	0.22	0.00	0.00
SARDI	0.70	0.10	0.00	0.60	0.00	0.00	0.70	0.00	0.00	0.00

CRC Funded Professional Staff

Organisation	Total FTEs	Program (% of time)					Activity (% of time)			
		1	2	3	4	5	Research	Education	Commercialisation & Technology Transfer	Administration
CSIRO Livestock Industries	1.27	0.24	0.03	0.00	0.00	1.00	0.37	0.00	0.40	0.50
University of New England	2.90	0.00	0.00	0.00	1.90	1.00	0.40	1.00	1.50	0.00
NSW Agriculture	0.38	0.00	0.38	0.00	0.00	0.00	0.00	0.00	0.38	0.00
University of Adelaide	0.30	0.30	0.00	0.00	0.00	0.00	0.30	0.00	0.00	0.00
ABRI	2.18	0.00	0.00	0.00	0.68	1.50	0.00	0.35	0.93	0.90

Summary of total contributions in person years ~ Professional Staff

	Total equivalent person years	Program (% of time)					Activity (% of time)			
		1	2	3	4	5	Research	Education	Commercialisation & Technology Transfer	Administration
Total contributed by Core Parties (In-kind)	21.37	3.60	9.69	3.88	3.08	1.13	14.75	0.65	5.57	0.40
Total Contributed by Supporting Parties (In-kind)	5.55	1.48	0.95	2.56	0.52	0.04	4.99	0.46	0.10	0.00
Total funded by CRC	7.03	0.54	0.41	0.00	2.58	3.50	1.07	1.35	3.21	1.40
Grand Total	33.95	5.62	11.05	6.44	6.18	4.67	20.81	2.46	8.88	1.80
Proportion of total professional staff resources in each activity	100	17	33	19	18	14	61	7	26	5

In Kind Support Staff

Organisation	Total FTEs
CSIRO Livestock Industries	3.71
University of New England	0.30
QDPI	4.98
AGBU	0.15
NSW Agriculture	5.61
Agriculture WA	0.13
University of Adelaide	0.25
VDPI	1.20

CRC Funded Support Staff

Organisation	Total FTEs
CSIRO Livestock Industries	6.19
NSW Agriculture	0.06
University of Adelaide	0.05
ABRI	5.00

Summary of Support Staff Contributions (Person Years)

Total Contributed by Core Parties	14.45
Total Contributed by Supporting Participants	1.58
Total CRC funded	11.30
TOTAL SUPPORT STAFF CONTRIBUTIONS	27.33



CKR Audit & Advisory Services

**AUDITORS REPORT TO THE CO-OPERATIVE
RESEARCH CENTRES PROGRAM
DEPARTMENT OF INDUSTRY SCIENCE
AND RESOURCES**

**REPRESENTING THE COMMONWEALTH
IN RESPECT OF
THE CO-OPERATIVE RESEARCH CENTRE
FOR CATTLE AND BEEF QUALITY**

**FINANCIAL INFORMATION FOR THE
YEAR ENDED 30 JUNE 2004**

Scope

We have audited the financial information of the Co-operative Research Centre for Cattle and Beef Quality as set out in Tables 1, 2 and 3 of the Annual Report (being the tables showing in-kind and cash contributions for each party of the CRC, and cash expenditure) for the year ended 30 June 2004. The parties to the Co-operative Research Centre are responsible for the preparation and presentation of the financial information. We have conducted an independent audit of the financial information in order to express an opinion on it to the parties to the Co-operative Research Centre for Cattle and Beef Quality.

The financial information has been prepared for the parties to the Co-operative Research Centre for Cattle and Beef Quality for the purposes of fulfilling their annual reporting obligations under clause 14(1)(f) of the Commonwealth Agreement and for distribution to the Co-operative Research Centres Program, Department of Industry, Science and Resources, representing the Commonwealth of Australia. We disclaim any assumption of responsibility for any reliance on this report or on the financial information to which it relates to any person other than those mentioned above or for any purpose other than for which it was prepared.

Our audit has been conducted in accordance with Australian Auditing Standards to provide reasonable assurance as to whether the financial information is free of material misstatement. Our procedures included examination on a test basis, of evidence supporting the amounts and other disclosures in the financial information, and the evaluation of accounting policies and significant accounting estimates. These procedures have been undertaken to form an opinion whether, in all material respects, the financial information is presented fairly in accordance with Australian Accounting concepts and standards and requirements of the Commonwealth Agreement in Terms of Clauses 4 (Contributions), 5(1), 5(2), 5(3) (Application of Grant and Contributions), 9(1), 9(5) (Intellectual Property) and 12(2) (Financial Provisions), so as to present a view of the sources of funding and the application of funding of the Cooperative Research Centre for Cattle and Beef Quality and the application of which is consistent with our understanding of its financial activities during the year and its financial position as at 30 June 2004.

While we have not performed any audit procedures upon the estimates for the next period and do not express any opinion thereon, we ascertained that they have been formally approved by the Board of Management as required under the Joint Venture Agreement. The final 2004/2005 financial year budget was adopted by the Board on 3 September 2004.

The audit opinion expressed in this report has been formed on the above basis.

An Investor Group firm 109 Jessie Street Armidale NSW 2350

Offices at: *Inverell, Glen Innes, Guyra, Wilcuba & Warialda*



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Audit Opinion:

- The multipliers adopted by the Centre to value in kind contributions other than salary costs, have a sound and reasonable basis and each partner's in kind component of the Researcher's Contributions for the year under report has been provided at least to the value for the year committed in the Budget as specified in the Agreement, with the following exceptions:

Organisation	Amount Committed	Amount Provided	Variance to Amount Committed
	\$	\$	\$
Queensland Dept of Primary Industries	1,403,611	1,313,380	90,231
Agriculture WA	386,590	163,025	223,565
SARDI	290,784	190,466	100,318
Ridley Corp	50,000	-	50,000
University of New England	1,318,093	643,941	674,152
The University of Adelaide	242,075	241,883	192

It has been noted that whilst some Partners have met or exceeded "in-kind" contributions measured on a dollar basis they are behind in the commitment of Typical Year FTE's as noted in Schedule 4 to the Commonwealth Agreement. The Board of Directors are working together with these Partners to ensure that the expectations of the Commonwealth are met.

The total value of all contributions for the year under report equalled or exceeded the amount of grant paid during the year (not including advances).

- The Researcher has used the Grant and the Researcher's contributions for the Activities of the Centre and in my professional opinion there appear to be no material reporting irregularities.
- The Researcher's allocations of the budgetary resources between Heads of Expenditure have not complied with Clause 5(2) of the Commonwealth Agreement. The following variations have not complied with the allocation in the budget by \$100,000 or 20% (whichever is the greater amount).

	20% Budget or \$100,000	Variance to Budget
Salaries	\$100,000	\$444,904
Other	\$100,000	\$749,402

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4. Capital items acquired from the Grant and Researcher's Contributions are vested as provided in the Joint Venture Agreement.
5. A statement signed by the Chief Executive Officer, to the effect that Intellectual Property in all Contract Material is vested as provided in the Joint Venture Agreement and no Intellectual Property has been assigned or licensed without the prior approval of the Commonwealth has been obtained by CKR Audit & Advisory Services.
6. Proper accounting standards and controls have been exercised in respect of the Grant and Researcher's Contributions and income and expenditure in relation to the Activities of the Centre have been recorded separately from other transactions of the Researcher.

CKR AUDIT & ADVISORY SERVICES

Chartered Accountants

Geoffrey W Allen
Partner

Armidale, dated 6 September 2004

Offices at: Inverell, Glen Innes, Guyra, Walcha & Warialda



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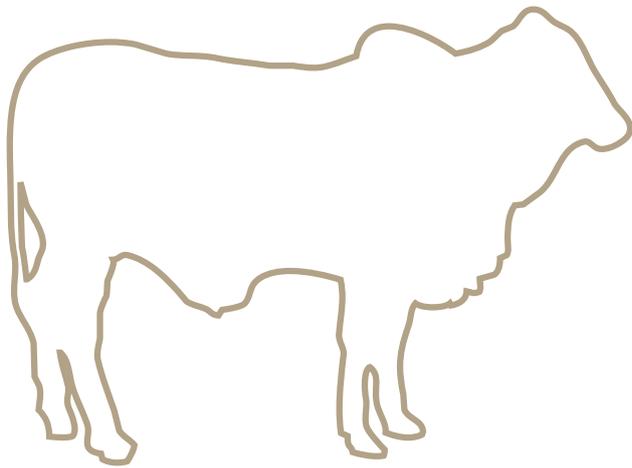
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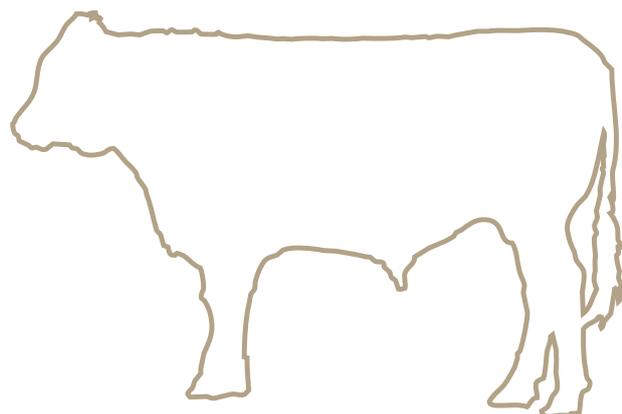
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“The CRC [for Cattle & Beef Quality] is demonstrably the world leader in this area. It is the only organisation in the world in which geneticists, nutritionists, meat and animal scientists and economists are working on the same animals and data, on an unprecedented scale, in an integrated way and in such a fashion that the data from all disciplinary areas contribute to a holistic approach to beef cattle improvement.”

*John Vercoe, Chairman, 5th Year Review Panel
20 May 2004*





www.beef.crc.org.au

The Cooperative Research Centre for Cattle and Beef Quality

