The North Australia Program

1998 Review of Reproduction & Genetics Projects

Edited by
Shane Blakeley

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MEAT & LIVESTOCK
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Preface

Over the last 17 years, Meat & Livestock Australia has invested heavily in innovation and technology development in the north Australian beef industry. This has been done in conjunction with a large number of agency bodies and with a good deal of consultation with its producer constituency.

Undoubtedly, significant technical advances have been generated but it is generally acknowledged that uptake of these advances has been less than optimum.

Of recent years, increasing emphasis has been placed on understanding the underlying principles and praxis of adult learning and much of this new knowledge has been applied to training and educational programs within the beef industry. At the same time, management within the beef production sector is demanding greater integration of technologies with particular emphasis on placing those technologies within a commercial context with regard for their impact on other aspects of their businesses.

The challenge before those of us in the research, development and extension sector is to meet these complex and, at times, conflicting demands from our customer base and continuing to provide high quality scientific and technical progress.

Within the North Australia Program Phase 3 (1996-2001), the reporting and monitoring of projects is by the preparation of a short annual report and a peer review process. The review process is via a brief presentation of the objectives, methods, outcomes and communication activities of the projects and projected work for the year ahead, to an audience of fellow researchers/investigators from other projects within the sub-program, plus a small number of interested producers and technical people.

These annual workshops provide a valuable opportunity for those involved to review and revise both their individual projects and work within the Reproduction and Genetic field as a whole. They also provide an opportunity to further develop linkages between projects.

NAP's Sub-program 1, "Meeting Market Requirements" (within which Reproduction and Genetics projects fall) focuses on improving producers responsiveness to market demands. This peer review also incorporates projects from Sub-program 3, "Whole Property Management" which seeks to incorporate technologies and solutions into the whole of enterprise management mix. Finally, other relevant projects from outside the North Australia Program, indeed from outside of NAP have been invited to participate.

Meat and Livestock Australia's North Australia Program works in partnership with producers, state departments, CSIRO, universities, Cooperative Research Centres, agribusiness and other R&D providers. NAP Management wishes to acknowledge their help and many contributions to the North Australia Program.

We would also like to thank all workshop participants for their many contributions in making this peer review workshop so successful.

Shane Blakeley

Session 1:
Bull Fertility and Management

Session 1: Bull Fertility & Management

An Overview

MLA Project No.: DAQ 104

Project Duration: January 1995 to April 1998

Principal investigators:

(i.) Richard Holroyd, (Project Leader) Queensland Department of Primary Industries,
Tropical Beef Centre, Ibis Avenue, North Rockhampton 4701.
Telephone: 07 49238100; Facsimile: 07 49238222
Email: holroyd@dpi.qld.gov.au

(ii.) John Bertram, Queensland Department of Primary Industries,
Goondiwindi 4390
Telephone: 07 46711388; Facsimile: 07 46712782
Email: bertraj@dpi.qld.gov.au

(iii.) Brian Burns, Queensland Department of Primary Industries
Tropical Beef Centre, Ibis Avenue, North Rockhampton 4701.
Telephone: 07 49238183; Facsimile: 07 49238222
Email: burnsb@dpi.qld.gov.au

(iv.) Joanne De Faveri, Queensland Department of Primary Industries,
Mareeba 4880.
Telephone: 07 40928520; Facsimile: 07 40923593
Email: bertraj@dpi.qld.gov.au

(v.) Vivienne Doogan, Queensland Department of Primary Industries,
Animal Research Institute, Yeerongpilly 4105
Telephone: 07 336219492; Facsimile: 07 33629429
Email: dooganv@dpi.qld.gov.au

(vi.) Michael D'Occhio, Central Queensland University
Rockhampton 4701.
Telephone: 07 49306900; Facsimile: 07 49309209
Email: m.docchio@cqu.edu.au

(vii.) Lee Fitzpatrick, James Cook University,
Townsville 4811
Telephone: 07 47814168; Facsimile: 07 47791526
Email: lee.fitzpatrick@jcu.edu.au

(viii.) Geoffrey Fordyce, Queensland Department of Primary Industries
Swan's Lagoon Beef Cattle Research Station, Millaroo 4807
Telephone: 07 47849170; Facsimile: 07 47849232
Email: fordycg@dpi.qld.gov.au

(ix.) Gehan Jayawardhana, Northern Territory Department of Primary Industries and Fisheries,
Berrimah 0828
Telephone: 08 89992224; Facsimile: 08 89992043
Email: gehan.jayawardhana@dpif.nt.gov.au

(x.) Michael McGowan, University of Queensland, Pinjarra Hills 4069
Telephone: 07 33655719; Facsimile: 07 33655644
Email: m.mcgowan@mailbox.uq.edu.au

(xi.) Russell Miller, Queensland Department of Primary Industries
Rockhampton 4701
Telephone: 07 49360268; Facsimile: 07 49361484
Email: millerr@dpi.qld.gov.au

Projective Objectives

By December 1997

(i.) To improve the selection of bulls with high genetic merit (particularly growth and carcass traits) and calf getting ability by developing management packages based on identifying premating predictors of bull fertility.

(ii.) To make management recommendations on bull selection criteria that will allow producers to reduce bull joining percentages so that this risk is such that adoption is not jeopardised

Project Summary

The field work for the study was completed in 1997. A draft final report has been prepared. The major findings on structural, semen quality and serving capacity traits were presented in a series of 6 papers at the XXth World Congress on Buiatrics, Sydney, July 1998.

The results have been presented to the technical committees of the Santa Gertrudis Society and Australian Brahman Breeders Association. The results have been incorporated in 3 workshops for veterinarians, a number of field days for producers and in the Beef Genetic Improvement and Agrilink Beef Projects.

Results

These are presented in the following 7 papers:

Communication Achievements

There have been 15 media articles in various publications ranging from Beef Improvement News through to Country Life. There was one television program produced by Cross Country in October 1997. An update of results have been incorporated into 18 field days since July 1996. As well, 3 workshops for veterinarians have been conducted in the last 12 months. The major findings were presented in a series of 6 papers at the XXth World Congress on Buiatrics, Sydney, July 1998. The results were presented in the technical committees of the Santa Gertrudis Society and the Australian Brahman Breeders' Association.

Plans for the next 12 months

MLA funding for the projected ceased in April 1998. The project is in a write-up phase with a final report for MLA to be presented by December 1998.

A number of workshops and field days are planned for both veterinarians and producers

The next phase of the project is currently being developed and will address the following aspects:

- Effect of relocation on fertility
- Further quantifying herd dispersion effects
- The impact of behaviour, including dominance on calf output.

Publications in last 12 months

Bertram JD, Holroyd RG, McGowan MR and Doogan VJ (1997). Sheath and mating ability measurements and their interrelationships in Santa Gertrudis bulls. *Proc. Assoc. Advmt. Anim. Breed. Genet.* **12**:351-354

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Vankan DM. (1997). DNA fingerprinting - How it works and applications for the beef industry. The Australian Association of Cattle Veterinarians, Brisbane Conference Proceedings 1997, pp.193-6.

Holroyd RG (1998) Bull selection and use in northern Australia 1. The Bull Power project. *XXth World Assoc. Buiatrics Cong*, Sydney 1998, pp 395-6.

McGowan MR, Bertram JD, Holroyd RG, Fordyce G, Fitzpatrick LA, Miller RG, Jayawardhana GA, Doogan VJ and De Faveri J. Bull selection and use in northern Australia 2. Prepuce, testicular and other physical traits. *XXth World Assoc. Buiatrics Cong*, Sydney 1998, pp 397-400.

Bertram JD, Fordyce G, McGowan MR, Jayawardhana GA, Holroyd RG, Fitzpatrick LA, Doogan VJ and De Faveri J. Bull selection and use in northern Australia. 3. Serving capacity tests. *XXth World Assoc. Buiatrics Cong*, Sydney 1998, pp 401-5.

Fitzpatrick LA, Fordyce G, McGowan MR, Holroyd RG, Bertram JD, Miller RG, Jayawardhana GA, Doogan VJ and De Faveri J. Bull selection and use in northern Australia 4. Semen traits. *XXth World Assoc. Buiatrics Cong*, Sydney 1998, pp 407-12.

Fordyce G, Fitzpatrick LA, O'Kane J, Merrin N, Armstrong J and De Faveri J. 5. Bull : female ratios. *XXth World Assoc. Buiatrics Cong*, Sydney 1998, pp 413-15.

Holroyd RG, Doogan VJ, De Faveri J, Fordyce G, McGowan MR, Bertram JD, Vankan DM, Fitzpatrick LA, Jayahardhana GA and Miller RG. Bull selection and use in northern Australia 6. Calf output and predictors of fertility of bulls in multiple-sire herds. *XXth World Assoc. Buiatrics Cong*, Sydney 1998, pp 417-22.

The Bull Power Project

Presenter: RG Holroyd
Queensland Beef Industry Institute, Department of Primary Industries, Yeerongpilly, Qld 4105, Australia

Abstract

Studies were conducted at 12 sites in northern Australia to identify premating predictors of fertility in *Bos indicus* and *Bos indicus* derived bulls used in multiple-sire matings and to make management recommendations on bull selection criteria that will allow producers to reduce bull joining percentages without jeopardising herd fertility. The major findings are presented in the following 6 papers.

The Project

There are about 11M cattle in northern Australia (north of 29°S) and about 4M of these are breeding cows and bulls. The majority of these cattle are of *Bos indicus* or *Bos indicus* derived content. The vast majority of these cattle would be run at stocking rates of 1 adult to 5-30 ha. As a consequence, cattle on properties are spread over large areas although there tends to be a concentration of animals at stock watering points.

Little is known of the individual reproductive performance of bulls in extensive environments. Low and variable bull fertility was identified as a constraint on reproductive rates in beef cattle in an extensive, multiple-sire mating system in the Northern Territory (1). Erratic conception patterns were attributed to a high proportion of bulls with low breeding soundness evaluation scores, a large number of aged bulls and having mixed-age bull mating groups (1). This variation in bull fertility has been identified also in a study of single-sire mating groups with *Bos indicus* cross bulls in north Queensland. Even though screening tests for bull fertility were applied, 4% of mated bulls did not produce any progeny and a further 4% were associated with mating groups which had less than 20% pregnancy rates. These failures could have been due to libido or serving ability problems (2).

Herd bull replacement is a major cost for commercial cattle breeders in northern Australia. The economic impact of bull management depends on two issues. The first is the capital cost per calf branded, incurred by the bull. This is a function of the purchase price of the bull, its working life and the number of calves it produces. For example, if a $2000 bull has a working life of 5 years at a bull:cow ratio of 5%, the bull cost per calf ranges from $30 per calf at 50% branding rate down to $19 per calf at 80% branding rate (3). The second aspect of economics of bull management relates to the genetics imparted by the bull (4). Major financial benefits are achieved by using bulls whose progeny have higher productivity through improved fertility, growth, temperament, survival and carcase attributes.

The Bullpower project ran from 1992 to 1997 and was a co-operative project between Queensland Department of Primary Industries, The University of Queensland, James Cook University, Northern Territory Department of Primary Industry and Fisheries and the Meat Research Corporation. The project team was RG Holroyd, JD Bertram, BM Burns, NJ Cooper, J DeFaveri, VJ Doogan, G Fordyce, RG Miller, AJ Teakle and BK Venus (Queensland Department of Primary Industries), MR McGowan, D Baker, S Johnson, N Phillips and DM Vankan (The University of Queensland), LA Fitzpatrick, C Coleman and P Findlay (James Cook University), GA Jayawardhana (Northern Territory Department of Primary Industry and Fisheries) and MJ D'Occhio (CSIRO).

The project had 2 objectives:-

- to improve the selection of bulls with high genetic merit (particularly growth and carcase traits) and calf output by developing management packages based on identifying premating predictors of bull fertility.
- to make management recommendations on bull selection criteria that will allow producers to reduce bull joining percentage without jeopardising herd fertility.

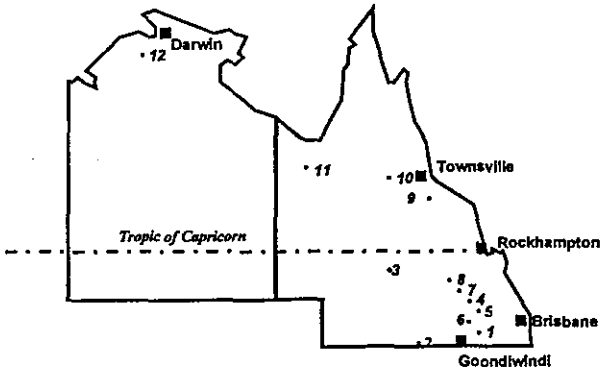
The Bull Power project was conducted on 3 research stations and 8 co-operator properties in Queensland and 1 research farm in the Northern Territory (Table 1, Figure 1). This series of papers report on studies of about 750 bulls, mainly 2- to 4-year-old Santa Gertrudis, 5/8 Brahman and Brahman bulls that were subjected to physical and reproductive examinations prior to mating. As well, a number of studies were done on the expressions of sexual behaviour in various types of serving capacity tests in these genotypes. Data on Belmont Red bulls are not presented in this series.

In 9 of these herds, the calf output was collected on 245 bulls from 37 multiple-sire mating groups using DNA typing for assigning paternity. The major findings are presented in the following 6 papers.

Table 1 Properties, locations, principal investigators and observation dates for each site.

Site	Property	Location	Nearest centre	Principal investigator	Year
1	Marrett	28° S 150° E	Goondiwindi	JD Bertram	1992/97
2	Birra Birra	28° S 148° E	Dirranbandi	JD Bertram	1993/96
3	Ravensbourne	24° S 145° E	Blackall	JD Bertram	1993/96
4	Gyranda	25° S 150° E	Theodore	MR McGowan	1992/97
5	Eidsvold Station	24° S 151° E	Eidsvold	MR McGowan	1993
6	Narayan Research Station	26° S 150° E	Mundubbera	JD Bertram	1994/97
7	Meteor Downs	24° S 148° E	Rolleston	JD Bertram	1994/96
8	Cona Creek	24° S 147° E	Springsure	RG Miller	1993/97
9	Swan's Lagoon Research Station	20° S 147° E	Ayr	G Fordyce	1994/97
10	Fletcherview Research Station	19° S 146° E	Charters Towers	LA Fitzpatrick	1995/96
11	Kamilaroi	19° S 140° E	Cloncurry	G Fordyce	1994/97
12	Douglas Daly Research Farm	13° S 131° E	Adelaide River	GA Jayawardhana	1995/97

Figure 1 Experimental Sites



Acknowledgements

The Bull Power project was jointly funded by the Queensland Department of Primary Industries, The University of Queensland, James Cook University, Northern Territory Department of Primary Industry and Fisheries and the Meat Research Corporation (Project NAP2.DAQ.104). Partial financial support was provided by the Santa Gertrudis Breeders Association (Australia). We thank the following property owners and pastoral companies for their continual support and enthusiasm throughout the project:- P Fox and M Rowe, 'Marrett'; R Hemming, 'Birra Birra'; I Walker, 'Ravensbourne'; B and L Joyce, 'Gyranda'; A and S Coates, 'Eidsvold Station'; D Wilde and A and L Cleary of the Australian Agricultural Company, 'Meteor Downs'; M Standford, 'Narayan'; C Briggs, 'Cona Creek' and J O'Kane, N Merrin and J Armstrong, Stanbroke Pastoral Co., 'Kamilaroi'.

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3 Holmes W (1993) Bull ownership costs from a commercial perspective In 'Bull Fertility' Workshop Proc Rockhampton pp 26-31, (RG. Holroyd editor) QDPI Brisbane.

4 McCosker T and Gatenby A (1993) The cost of manipulating bull management In 'Bull Fertility' Workshop Proc Rockhampton pp 26-31, (RG. Holroyd editor) QDPI Brisbane.

Prepuce, Testicular And Other Physical Traits

Presenters: MR McGowan[1], JD Bertram[2], RG Holroyd[3], G Fordyce[4], LA Fitzpatrick[5], RG Miller[6], GA Jayawardhana[7], VJ Doogan[3] and J De Faveri[8]

[1]The University Of Queensland, School of Veterinary Science and Animal Production, Pinjarra Hills Qld 4069, [2]Queensland Beef Industry Institute, Department of Primary Industries, Goondiwindi Qld 4390, [3]Queensland Beef Industry Institute, Department of Primary Industries, Animal Research Institute, Yeerongpilly Qld 4105, [4]Queensland Beef Industry Institute, Department of Primary Industries, Swan's Lagoon Beef Cattle Research Station, Millaroo Qld 4807, [5]Australian Institute of Tropical Veterinary and Animal Sciences, James Cook University, Townsville Qld 4811, [6]Queensland Beef Industry Institute, Department of Primary Industries, Rockhampton Qld 4700, [7]Northern Territory Department of Primary Industry and Fisheries, Berrimah NT 0828, [8]Queensland Department of Primary Industries, Mareeba Qld 4880, Australia

Abstract

Approximately 750 Santa Gertrudis, 5/8 Brahman and Brahman bulls were examined at 11 different properties across northern Australia. A systematic breeding soundness examination was conducted including assessment of serving capacity. A subset of bulls (n=245) were subsequently mated in groups to cows and heifers at bull:female percentages of 2.5% to 6%. The paternity of calves resulting from these joinings were determined by microsatellite DNA testing. The majority of bulls were rising 2- to 3-year-olds. Overall the incidence of physical abnormalities causing reduced reproductive performance was low (<10%). Across breed, body weight was consistently positively correlated with scrotal circumference. Also in 2-year-old bulls body weight was positively correlated with percentage normal spermatozoa. Size and conformation of the umbilicus was shown to significantly influence conformation of the prepuce in 2-year-old bulls. In 2-year-old Santa Gertrudis bulls body condition score was negatively correlated with number of serves achieved in the serving capacity test and, the percentage motile spermatozoa and morphologically normal spermatozoa. The majority of bulls which were mated were judged to be physically sound. Thus it was not surprising that physical traits were not consistently related to calf output, with only scrotal circumference and prepuce depth being significantly related to calf output in at least one mating group.

Introduction

A fundamental component of the reproductive examination of bulls prior to mating is a systematic physical examination of the animal, including a detailed examination of the internal and external sexual organs, and an evaluation of the bull's gait. In a large study (1) of primarily Hereford bulls the incidences of physical abnormalities of the eyes, locomotory system, scrotal contents, penis and prepuce and internal genitalia were 3.7%, 5.0%, 17.6%, 3.8% and 7.3% respectively. Ladds *et al.* (2) and Bagshaw and Ladds (3) examined the reproductive tracts of 550 mixed breed (Shorthorn, Brahman and Brahman cross) bulls from northern Australia. Significant testicular lesions were detected in 8.3% of bulls and seminal vesiculitis and ampullitis were found in 9.0% and 3.8% of bulls respectively. Chenoweth (4) reported an overall incidence of penile and preputial abnormalities of 11.1% in 702 young (16-31 months) Brahman, Africander, Shorthorn and crossbred bulls from Central Queensland.

Threshold values have been established for physical, semen and serving capacity traits of *Bos taurus*, *Bos indicus* and *Bos indicus* derived bulls to be used for single-sire matings (5). However these threshold values have not been validated by relating them to calf output of bulls mated in multiple-sire groups, which is the norm for northern Australia.

Between 1992 and 1997, approximately 750 Santa Gertrudis, 5/8 Brahman and Brahman bulls were examined as part of a large study evaluating the relationships between pre-mating predictors of fertility and individual bull calf output. The physical traits measured, their relationships to each other and their relationships to calf output are described below.

Materials and methods

Groups (n=17) of 2-, 3- and ≥4-year-old Santa Gertrudis bulls were examined on 6 different properties located in southern and central Queensland. Fourteen groups of 2-, 3- and ≥4-year-old 5/8 Brahman and Brahman bulls were examined on 6 different properties located in central and north Queensland, and in the Northern Territory.

At each site the bulls were initially restrained in a crush to enable the systematic physical examination as described in (5) to be conducted. The only modification was that the scoring for testicular tone was condensed to a single value for both firmness and resilience and the values for each testicle were averaged to provide a single score. The modified scoring system was as follows: 1 = soft, low resilience; 2 = moderate firmness, moderate resilience and 3 = firm, high resilience. In addition a range of measurements defining the conformation of the prepuce was also recorded. Prepuce depth was measured as the vertical distance from the ventral abdominal wall to the preputial orifice. Prepuce score was assessed with the recording format used in the national Breedplan validation project where 1 = an extremely pendulous prepuce, to 9 = an excessively trim prepuce. In Brahman and 5/8 Brahman bulls only, the angle (to the horizontal) of the preputial orifice was recorded. Two components of the umbilicus were assessed. The diameter of the umbilical cord was estimated by direct palpation and reference to a ruler. The 'rosette' or inverted fold of skin ventral to the umbilical cord was scored as 0 = absent to 3 = large (an inverted semicircle about 5 cm in diameter). The bodyweight (after overnight fasting), body condition score and age (actual from birth dates or estimated from dentition) of each bull were also recorded. Body condition was scored from 1 = emaciated, to 5 = store condition and 9 = obese. Details of semen examination and serving capacity testing are provided in accompanying papers by Fitzpatrick *et al.* (6) and Bertram *et al.* (7).

A subset of Santa Gertrudis (n=92), Brahman (n=129) and 5/8 Brahman (n=24) bulls were subsequently mated in groups to cows and heifers at bull:female percentages of 2.5% to 6%. The paternity of calves resulting from these joinings was determined by microsatellite DNA testing.

Summary statistics by breed and age were compiled and correlations (within age and breed) between the various physical trait measurements and measures of semen quality and serving capacity were calculated. The effect of age within breeds on physical trait measurements was assessed by unbalanced analysis of variance after adjustment for site and year. Repeatability of various traits was estimated by restricted maximum likelihood using the Genstat statistical package (8). Animal was treated as a random effect and time as a fixed effect. Log-linear modelling, using only measurements which had been shown to be repeatable, was used to assess the relationship between physical traits measured and calf output within each mating group of at least 8 bulls in the 1995 mating year. Full details of the log-linear modelling are presented in Holroyd *et al.* (9).

Results

The majority of bulls examined were aged 2 or 3 years except for the 5/8 Brahman bulls which were mainly 4- or ≥5-year-olds. However within each age group individual bull age at the time of examination varied by as much as ± 6 months. Most bulls were in backward store (score 4) to prime (score 7) condition. Tables 1, 2 and 3 provide means and ranges for a selection of the physical measurements recorded.

Table 1 Summary statistics of physical trait measurements from 2- (n=397) and 3-year- old (n=109) Santa Gertrudis bulls

Trait	2-year -olds		3-year-olds	
	mean	range	mean	range
Body weight (kg)	553	327-766	762	630-911
Condition score	5.2	3.0-7.0	5.5	3.0-8.0
Scrotal circumference (cm)	35.6	27.5-46.0	38.1	30.0-48.0
Testicular tone score	2.8	1.0-3.0	2.9	1.0-3.0
Prepuce depth (mm)	205	110-275	213	140-280
Prepuce score	4.6	2.0-8.0	4.8	2.0-8.0

Table 2 Summary statistics of physical trait measurements from 2- (n=108) and 3-year -old (n=59) Brahman bulls

Trait	2-year-olds		3-year-olds	
	mean	range	mean	range
Body weight (kg)	441	328-640	480	385-640
Condition score	5.2	4.0-7.0	6.3	4.0-7.0
Scrotal circumference (cm)	33.7	26.0-42.5	34.3	27.0-41.0
Testicular tone score	2.9	2.0-3.0	2.95	2.5-3.0
Prepuce depth (mm)	200	100-355	172	80-250
Prepuce score	4.7	2.0-7.0	5.1	3.0-8.0

Table 3 Summary statistics of physical trait measurements from 4- (n=9) and ≥5-year-old (n=13) 5/8 Brahman bulls

Trait	4-year-olds		≥5-year -olds	
	mean	range	mean	range
Body weight (kg)	580	536-616	673	576-762
Condition score	6.2	6.0-7.0	6.3	5.0-7.0
Scrotal circumference (cm)	33.7	30.0-37.0	36.5	31.5-41.0
Testicular tone score	2.9	2.5-3.0	3.0	3.0-3.0
Prepuce depth (mm)	142	70-230	132	80-200
Prepuce score	6.5	6.0-7.0	7.5	6.0-9.0

The repeatability of physical trait measurements recorded at intervals of 3 to 9 months was calculated for data from 3 sites (see Table 4).

Across breeds several traits were consistently correlated. In all breeds bodyweight was positively correlated with scrotal circumference ($r=0.29$ to 0.78; $P<0.05$).

Table 4 Repeatability (r) of selected physical trait measurements

Trait	r	Comment
Scrotal Circumference	0.30, 0.87, 0.92	moderate, very highly repeatable
Prepuce Depth	0.73, 0.74, 0.85	very highly repeatable
Prepuce Score	0.68, 0.60	highly repeatable

However there was no significant relationship between scrotal circumference and testicular tone score. Prepuce depth was negatively related to prepuce score ($r=-0.48$ to -0.81; $P<0.01$). Prepuce depth was also positively related to umbilical cord thickness in 2-year-old Brahman ($r=0.36$; $P<0.01$) and Santa Gertrudis ($r=0.17$; $P<0.01$) bulls.

In 2-year-old Santa Gertrudis bulls, body weight was positively correlated with number of serves achieved in the serving capacity test ($r=0.11$; $P<0.05$), the percentage motile spermatozoa ($r=0.27$; $P<0.01$) and morphologically normal spermatozoa ($r=0.15$; $P<0.05$). However body condition score was negatively correlated with these traits. Body weight was positively correlated with percentage normal spermatozoa in 2-year-old ($r=0.34$; $P<0.05$), but not 3-year-old Brahman bulls. Body condition score was not correlated with any of the testicular, semen or serving capacity traits in Brahman bulls.

In all breeds, weight and scrotal circumference increased with age ($P<0.05$). In addition, in Santa Gertrudis bulls, prepuce depth and prepuce score increased with age ($P<0.05$).

In Santa Gertrudis bulls the incidence of the following physical abnormalities was; swelling of the medial and/or lateral bursae of the hocks 27.8%, swelling of the pastern and hocks 6.8%, excessively straight hind legs ('posty-leg syndrome') 1.2%, lameness (hind or forelimb) 0.3%, upward fixation of the patella 0.5%, testicular hypoplasia 1.4%, chronic epididymitis 3%, persistent frenulum 3.4%, ventral deviation of the penis 0.5%, balanoposthitis 1.8%. The latter penile abnormalities were detected during serving capacity testing.

There was a low incidence of physical abnormalities detected in the Brahman and 5/8 Brahman bulls. Several Brahman bulls displayed upward fixation of the patella during at least one examination period. In one group of 2- to 3-year old Brahman bulls, 13/31 had expression of 'posty-leg' syndrome at some time over a 2-year period. There was no obvious associated lameness in these bulls, though hocks appeared unstable where the condition was marked ($n=2$). Bulls only expressed the condition at one examination and appeared normal at other times, except for one bull which consistently displayed marked expression of the condition.

Results of the log-linear modelling of calf output for individual mating groups revealed that, of the physical traits measured, none were consistently related to calf output. However scrotal circumference and prepuce depth were significantly related to calf output in at least one mating group. Full details of log-linear models are presented in the accompanying paper by Holroyd *et al.* (9).

Discussion

At the time of examination the majority of bulls in this study were judged to be physically and structurally sound. However there was a low incidence of physical abnormalities detected that may reduce reproductive function. The relatively high incidence of swellings of the lateral or medial bursae of the hocks in the Santa Gertrudis bulls examined is difficult to explain as most of the bulls were pasture fed. Further, in most cases the bursae swelling was mild and was not associated with lameness.

'Posty-leg' syndrome was not repeatable in young growing Brahman bulls, indicating lenience towards mild expression of the condition when selecting within this class of animal. This variation in expression of the condition over time contrasts with the descriptions (10) of the condition in young *Bos taurus* bulls.

The Australian Association of Cattle Veterinarians recommends that 2-year-old moderate to well fed bulls should have a scrotal circumference of ≥34 cm. The majority of the Santa Gertrudis bulls were considered to be on a moderate plane of nutrition although much of the study was conducted during a period of prolonged drought conditions. In 2- and 3- year old Santa Gertrudis bulls, 31% and 7% respectively had a scrotal circumference measurement <34 cm. The high incidence of 2-year-old bulls with a scrotal circumference <34 cm is probably due to the fact that at the time of examination many of the bulls were in fact aged between 18 and 25 months. If only data from bulls aged ≥24 months are used, the incidence decreases to 14%. In Brahman bulls grazing spear grass pastures in the arid tropics of northern Australia the recommendation for scrotal circumference measurement at 2 years of age is ≥28 cm. Three percent of 2-year-old Brahman bulls from sites in the arid tropics had a scrotal circumference measurement of <28 cm.

In Santa Gertrudis bulls those animals with a large umbilicus tended to have a more pendulous prepuce and achieved fewer mounts and serves in the serving capacity test. The combination of the thickened umbilical cord and enlarged 'rosette' may result in a mechanical interference in serving ability. Further research is required to more precisely define the relationship between prepuce and umbilical conformation, and calf output. This would enable practical recommendations on selection policy for these traits to be developed.

The relatively low incidence of functionally significant physical abnormalities in the bulls examined may have been due to a number of factors. Firstly most bulls had been reared in single age groups and had been well handled decreasing the likelihood of injuries due to fighting. Secondly the selection policies of the properties involved in this study included selection for normal physical conformation, adequate size testes, and selection against excessively pendulous prepuces and poor temperament.

Thus as all bulls in many of the mating groups studied were physically sound and had above threshold values for scrotal circumference and prepuce score, it was not surprising that physical traits were not consistently found to be related to calf output in the log-linear models.

Although the correlations between physical traits and seminal and serving capacity traits should be considered with some caution (because of the low magnitude of the correlation coefficients), the findings in young Santa Gertrudis bulls of a negative relationship between body condition score, seminal and serving capacity traits are similar to that reported by Coulter *et al.* (11) and consistent with field observations. The lack of correlation between physical traits and measures of serving capacity in Brahman bulls probably reflects the generally poorer response to service capacity testing of these bulls observed in this study.

Conclusion

The systematic physical examination of a bull provides the foundation of the reproductive breeding soundness examination. The moderate to high repeatabilities for key physical traits (eg. scrotal circumference) demonstrate that bulls may be selected accurately on the basis of an annual pre-breeding examination. The results of this study support the guidelines for the physical trait thresholds outlined in (5).

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Semen Traits

Presenters: LA Fitzpatrick [1], G Fordyce [2], M McGowan [3], R Holroyd [4], JD Bertram [5], RG Miller [6], GA Jayawardhana [7], VJ Doogan [4], and J De Faveri [8]

[1] Australian Institute of Tropical Veterinary & Animal Science, and Department of Physiology and Pharmacology, James Cook University, Townsville Qld 4811; [2] Queensland Beef Industry Institute, Department of Primary Industries, Swans Lagoon Beef Cattle Research Station, Millaroo Qld 4807; [3] University of Queensland, School of Veterinary Science and Animal Production, Pinjarra Hills Qld 4069; [4] Queensland Beef Industry Institute, Department of Primary Industries, Animal Research Institute, Yeerongpilly Qld 4105; [5] Queensland Beef Industry Institute, Department of Primary Industries, Goondiwindi Qld 4390; [6] Queensland Beef Industry Institute, Department of Primary Industries, Rockhampton Qld 4700; [7] Northern Territory Department of Primary Industry and Fisheries, Berrimah NT 0828; [8] Queensland Beef Industry Institute, Department of Primary Industries, Mareeba Qld 4880, Australia

Abstract

Detailed semen evaluations were carried out on approximately 750 Brahman, 5/8 Brahman and Santa Gertrudis bulls on 12 different properties across northern Australia, as part of systematic breeding soundness examinations. A subset of bulls (n=245) were subsequently mated in groups, to cows and heifers at bull:female percentages of 2.5 to 6.0%, with the paternity of resulting calves being determined by microsatellite DNA testing. Motility traits of semen and spermatozoa were moderately repeatable and correlated with each other, but were unrelated to calf output. The percentage of morphologically normal spermatozoa in ejaculates was moderately to highly repeatable (eg r=0.64). The most common sperm defects seen were midpiece abnormalities and reflex tails associated with cytoplasmic droplets. Semen quality, particularly percent normal spermatozoa, was consistently related to calf output. In general, bulls with <50% normal spermatozoa sired few calves while bulls with the highest calf outputs had >70% normal spermatozoa. The presence or absence of heparin binding proteins in semen did not influence calf output, with semen from 93% of tested bulls being positive for heparin binding proteins. These results confirm that semen examination, including sperm morphology, should be standard procedure when assessing bulls for reproductive soundness.

Introduction

There have been a number of attempts to relate semen characteristics such as motility and morphology of spermatozoa, and a range of seminal plasma proteins and other factors to fertility of bulls (1, 2, 3, 4, 5, 6). These studies have generally been carried out with *Bos taurus* cattle, particularly dairy breeds, many utilising data from bulls in AI centres.

Many tests of semen quality correlate with fertility (7, 8), however, none have been satisfactory as a predictor of superior fertility (9), and few have attempted to test the fertility of beef bulls used in multiple-sire breeding herds under conditions of extensive management (2, 3).

While some threshold values have been suggested for semen traits of *Bos taurus*, *Bos indicus* and *Bos indicus* derived bulls to be used for single-sire matings (10), these values have not been validated by relating them to calf output of bulls mated in multiple-sire groups, which is the norm for northern Australia.

Between 1992 and 1997, 284 Brahman and 5/8 Brahman bulls, and 564 Santa Gertrudis bulls were examined as part of a large study evaluating the relationships between pre-mating predictors of fertility and individual bull calf output. The physical and behavioural traits measured and their relationship to calf output are provided in accompanying papers by McGowan *et al.* (11), Bertram *et*

al. (12) and Fordyce *et al.* (13). The semen traits measured, their relationships to each other and to calf output are described below.

Materials and methods

Fourteen groups of 2-, 3- and ≥4-year-old Brahman and 5/8 Brahman bulls were examined on six properties located in central and north Queensland. Groups (n=17) of 2-, 3- and ≥4-year-old Santa Gertrudis were examined on a further six properties located in southern and central Queensland. The paternity of calves sired by a subset of these bulls (n=245) in subsequent matings was determined by microsatellite DNA testing (DNA typing) as described in an accompanying paper (14).

Semen collection

Semen was collected using either standard electroejaculation techniques, or in the case of some Santa Gertrudis bulls by massage of the ampullae (10). If a satisfactory sample could not be collected within several minutes, either further attempts were made at 5-10 minute intervals or the bull was released and a second attempt made later.

Colour

Colour, where assessed, was graded on a 0 (clear) to 5 (creamy) scale using standards described by McGowan *et al.* (10).

Mass activity

A drop of semen was placed immediately on a warm slide. Mass activity was assessed on a 0 (no activity) to 5 (rapid swirling motion) scale (10), using a phase-contrast microscope (x 40-200 power).

Percentage live

After placing a pre-warmed coverslip on the slide, the percentage of live spermatozoa in a high-power (x 400) phase contrast microscope field was estimated. Individual spermatozoa were considered to be alive if they displayed any movement at all. Alternatively, eosin-nigrosin stained semen smears under oil immersion (x 1000 power) were also used to estimate the % live spermatozoa in a semen sample (10).

Motility

Motility was determined from the same high-power microscope field as for % live. Of the spermatozoa that were judged to be alive, the percentage that were progressively motile was estimated.

Morphology

The morphology of individual sperm was determined by either examining a thin cover-slip preparation of semen preserved in 0.2% buffered gluteraldehyde or buffered formol saline using phase contrast microscopy (x 400 power), or an eosin-nigrosin stained smear under oil immersion (x 1000 power) (10). Individual spermatozoa were classified into one of five categories: 1) normal morphology, 2) abnormal head, 3) abnormal midpiece, 4) abnormal tail, or 5) having a protoplasmic droplet present.

Heparin binding proteins

At the time of collection of semen from a subset of bulls examined in 1995, a 2 ml sample of semen was placed in a sealed 5 ml tube and stored in liquid nitrogen for subsequent assay of heparin-binding proteins (5).

Statistics

Summary statistics by breed and age were compiled and correlations (within age and breed) between the various semen traits. The effect of age within breeds on semen traits was assessed by unbalanced analysis of variance after adjustment for site and year. Repeatability of semen traits was estimated by

restricted maximum likelihood using the Genstat statistical package (15). Animal was treated as a random effect and time as a fixed effect. Models relating the semen traits to calf output as measured by the number of calves sired per bull, were developed using log-linear modelling (16). In general, models were developed separately for each mating group of at least 8 bulls from the 1995 mating year (6 sites) and only traits that were shown to be repeatable were considered in the models, which are described more fully in a companion paper (14).

Results

Most of the bulls examined were 2 or 3 years of age, except for the 5/8 Brahman bulls which were mainly ≥4 years old. Within each age group, individual bull age at the time of examination varied by up to 6 months. Bulls were generally in backward store (score 4) to prime (score 7) condition.

Means and ranges for the semen traits measured are presented in Table 1. In general, motility traits of semen (mass activity) and spermatozoa (% motile and % progressively motile) were moderately repeatable and correlated with each other, but were unrelated to calf output. The percentage of morphologically normal spermatozoa in ejaculates was moderately to highly repeatable (Table 2). The most common sperm defects seen, particularly in Brahman bulls from the more northern herds, were distal midpiece or tail reflexes associated with cytoplasmic droplets.

Table 1. Summary statistics of semen traits from 2-, 3- and 4+-year old Brahman and Santa Gertrudis bulls

Breed	Age	Semen Trait (Mean, with range in parenthesis)				
		Colour (0 - 5 scale)	**Density (x 107/ml)**	**Mass Activity (0 - 5 scale)**	**% Motile**	**% Normal**
Brahman	2 years	3.0	218	2.9	66	70
	(n = 94)	(0 - 5)	(4 - 721)	(0 - 5)	(0 - 70)	(19 - 98)
	3 years	3.4	359	3.2	62	68
	(n = 50)	(0 - 5)	(13 - 267)	(0 - 5)	(10 - 90)	(9 - 93)
	4+ years	3.0	214	3.0	70	88
	(n = 23)	(1 - 4)	(4 - 499)	(0 - 5)	(40 - 90)	(63 - 97)
Santa Gertrudis	2 yrs	-	-	2.5	64	63
	(n = 399)			(0 - 5)	(0 - 96)	(? - 98)
	3 yrs			3.0	63	86
	(n = 116)	-	-	(1 - 5)	(40 - 80)	(80 - 93)
	4+ yrs			2.4	66	79
	(n = 49)	-	-	(0.0 - 4.5)	(30 - 90)	(16 - 94)

Table 2. Repeatability (r) of selected semen traits

Trait	r	Comment
Density	0.10	Low
% motile	0.44	Moderate
% normal	0.64	High

Percent morphologically normal spermatozoa was consistently related to calf output. In the log-linear models developed, percent normal spermatozoa was positively related to calf output in 11 of 16 matings, while in three of the other five matings, percent abnormal mid-pieces was negatively related

to calf output. In one mating, percent normal spermatozoa was negatively related to calf output. However, dominance exerted such a marked effect on calf output (due to the age structure of the bull group), that this result is probably spurious. When percent normal spermatozoa was considered on its own at this site, it was positively related to calf output ($P<0.001$) [See Holroyd *et al.* (14), Table 3]. In general, bulls with <50% normal spermatozoa sired few calves while bulls with the highest calf outputs had > 70% morphologically normal spermatozoa.

Heparin binding protein profiles were not related to calf output. The distribution of heparin binding protein profiles, as described by Bellin *et al.* (5, 6), for the Brahman/Brahman cross (n=46) and Santa bulls (n=27) tested in this study was: 51% A, 42% B, 4% C, 3% D. Therefore 93% of bulls were classed as positive and would not have been expected to differ in calf output, according to those authors.

Discussion

The study described here is one of few that have attempted to relate a range of common semen traits to the calf output of bulls used for multiple-sire breeding under extensive conditions. Coulter and Kozub (2), using regression modelling and blood-typing technology to determine calf parentage, demonstrated that selection of herd sires with low levels of primary sperm defects would be expected to improve fertility of beef bulls used under extensive range conditions. Holroyd *et al.* (3) demonstrated a significant correlation between % motile sperm and pregnancy rates achieved by *Bos indicus* bulls when *interse* mated in northern Australia.
The results reported by these authors are in agreement with our findings that, for most matings, percent normal spermatozoa was consistently related to calf output.

The most common morphological defects seen in the present study were "Dag"-like defects and (or) reflex midpieces and tails associated with protoplasmic droplets (17). Similar defects are commonly associated with disturbances to scrotal/testicular thermoregulation in bulls (18) and have also been observed following treatment of bulls with dexamethasone, indicating that two of the most common types of insults to spermatogenesis in bulls, heat and stress, result in similar spermiograms (19). These changes in the morphology of spermatozoa generally reflect an increase in epididymal transport time during spermiogenesis. However, Wildeus and Entwistle (20, 21), working with *Bos indicus* X *Bos taurus* bulls, reported highly variable effects on semen morphology when the scrotums of bulls were insulated for 48 hours. In the present study, the cause(s) of the defects in semen morphology recorded were not determined.

The results of the present study question the value of testing bull semen for the presence of heparin-binding proteins in sperm membranes as a measure of a bulls potential fertility as reported by Bellin *et al.* (5, 6). As 93% of the subset of 73 bulls that were tested had heparin-binding proteins in their sperm membranes, the cost effectiveness (≈A$30 per test) of identifying the 7% of bulls without heparin-binding proteins in their sperm membranes is questionable.

In a review of the significance to bull fertility of morphologically abnormal sperm, Johnson (9) concluded that while many tests of semen quality bear some relationship to fertility, none have proven to be satisfactory as a predictor of superior fertility. This tenet is supported by the findings presented here, which indicate that the focus should be on removing bulls from the herd, that are likely to be of poor calf getting ability.

The findings described here are of importance for the routine examination of bulls for reproductive soundness and confirm that semen examination including sperm morphology should be standard procedure when assessing bulls for reproductive soundness.

Conclusions

1. Semen examination, including assessment of sperm morphology, should be incorporated into bull selection programs and premating examinations to ensure that bulls have at least 70% normal sperm.

2. Fertility recommendations should not be based solely on semen or sperm motility.
3. Assessments of semen heparin-binding protein profiles are unlikely to enhance the evaluation of bull fertility.

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Serving Capacity Tests

Presenters: JD Bertram[1], G Fordyce[2], MR McGowan[3], GA Jayawardhana[4], RG Holroyd[5], LA Fitzpatrick[6], VJ Doogan[5] and J DeFaveri[7]

[1]Queensland Beef Industry Institute, Department of Primary Industries, Goondiwindi Qld 4390, [2]Queensland Beef Industry Institute, Department of Primary Industries, Swan's Lagoon Beef Cattle Research Station, Millaroo Qld 4807, [3]The University of Queensland, School of Veterinary Science and Animal Production, Pinjarra Hills Qld 4069, [4]Northern Territory Department of Primary Industry and Fisheries, Berrimah NT 0828, [5]Queensland Beef Industry Institute, Department of Primary Industries, Animal Research Institute, Yeerongpilly Qld 4105, [6]Australian Institute of Tropical Veterinary and Animal Sciences, James Cook University, Townsville Qld 4811 and [7]Queensland Department of Primary Industries, Mareeba Qld 4840, Australia.

Abstract

This paper reports on adaptations that were made to the standard serving capacity test to improve the performance of Santa Gertrudis bulls in the test and records the expressions of sexual behaviours in Santa Gertrudis, 5/8 Brahman and Brahman bulls in various serving capacity tests. Providing sexual experience to virgin Santa Gertrudis bulls increased the number of serves achieved and libido scores in a serving capacity test. Using oestrus rather than non-oestrus restrained females did not improve expressions of the various sexual behaviours of bulls. However there were more mounts achieved in serving capacity tests involving restrained rather than unrestrained females. There were greater expressions of sexual behaviours in Santa Gertrudis than in 5/8 Brahman or Brahman bulls using restrained females and in 5/8 Brahman than Brahman bulls using unrestrained females. In multiple-sire matings of 3-12 months under extensive conditions, measures of sexual behaviour in serving capacity tests were generally not important in log-linear models of calf output. Mounts plus serves was significant in only 1 mating group of the 6 considered.

Introduction

The serving capacity test has been developed in *Bos taurus* (1) breeds as a procedure to identify bulls with structural and serving problems as well as rating bulls on their sexual behaviour and libido. The serving capacity test is a yard based test. The question is, 'Does a bull with a high level of performance in a serving capacity test produce more calves under natural mating?'

There are reported differences in the value of serving capacity testing as a procedure to increase fertility in beef herds. Bulls with higher serving capacity scores were shown to achieve higher conception rates in females at first oestrus than was achieved by bulls with low scores (2). In contrast, another study (3) reported that serving capacity test scores for *Bos indicus* cross and *Bos taurus* bulls failed to predict the fertility of bulls after 3-7 weeks of single-sire mating.

In a north Queensland study of 126 *Bos indicus* cross bulls which had passed a breeding soundness examination and were mated in single-sire groups, 8% of bulls produced nil or very few progeny. These failures were possibly due to libido and or serving ability problems (4). To date, particularly with bulls used in extensive herds, there has been poor adoption of serving capacity testing in *Bos indicus* and *Bos indicus* derived genotypes for a number of reasons, namely

- the mechanics of organising and conducting the testing protocols,
- practitioner inability to consistently perform the test particularly with young bulls,
- the notion that a high proportion of *Bos indicus* bulls are shy performers particularly under close human scrutiny in a yard,
- in extensive areas, *Bos indicus* bulls can be more temperamental,
- potentially inconsistent outcomes from the test.

This paper reports on adaptations that were made to the standard serving capacity test to improve the performance of Santa Gertrudis bulls in the test, levels of expression of sexual behaviours by Santa Gertrudis, 5/8 Brahman and Brahman bulls in various tests, and the relationships of test results to calf output of bulls mated in multiple-sire herds.

Materials and methods

Adaptation of the serving capacity test.

Serving capacity testing was based on *Bos taurus* studies using females restrained in service crates (1); in most cases females were treated (using either intravaginal progesterone releasing devices or prostaglandin $F_{2\alpha}$ analogues) to synchronise oestrus. Depending on the site, between 2 and 4 restrained females in crates were used with a bull to heifer ratio of 1:1 with young bulls and 1-2:4 in older bulls. The test was for a 20 minute period from the time of first mount or for 30 minutes in the yard with the oestrus females. Prior to testing, bulls were able to view, from an adjacent yard, the activities of other bulls mounting and serving in the test yard.

Data recorded during the tests included the number of times a bull showed:

- Interest: Any form of sexual interest including flehmen, licking and false mounts.
- Mounts: Any combination of a mount with penile seeking and intromission.
- Serves: A mount, followed by intromission and ejaculation.

As well, scores were transformed into a modified libido score (5).

The following modifications to the test were made using mainly 2-year-old Santa Gertrudis bulls.

(i) Providing sexual experience to virgin bulls prior to testing.

At sites 1 and 2, bulls were allocated on weight to treatments in which they were given exposure to oestrus synchronised females. Sexual experience was at the ratio of 0, 2, 5 and 10 females per 8 bulls for 24 hours and 5 females per 8 bulls for 48 and 72 hours.

(ii) Use of restrained females either in oestrus or not in oestrus

In 1996 at sites 1 and 2, bulls were given sexual experience with oestrus females for 24 hours at 5 females per 8 bulls. Then, prior to treatment allocation, all bulls were serving capacity tested and randomly allocated to treatments based on this serving capacity test so that each treatment had bulls with a range of sexual behaviours. Mature bulls were allocated to treatments using serves alone whilst young bulls were allocated using a combination of mounts and serves.

(iii) Use of restrained or unrestrained females

At site 2, bulls were given prior sexual experience with oestrus females for 24 hours at the ratio of 5 females per 8 bulls. Performance in a serving capacity test using restrained oestrus females was used for allocation to treatments. A ratio of 1:1 bulls to females was used.

Bull age and breed effects on expressions of sexual behaviour

Data was collected from 9 sites. Bull ages ranged from 2 to 4+ years. There were over 650 Brahman, 5/8 Brahman and Santa Gertrudis bulls. Serving capacity testing was conducted either using females restrained in service crates as described above or using 8-13 oestrus females drafted into a large yard in which groups of 2 bulls were added for 20 minutes. The heifers were changed midway through the period of testing.

Calf output

A subset of Santa Gertrudis (n=92), Brahman (n=129) and 5/8 Brahman (n=24) bulls were subsequently mated in groups to cows and heifers at bull:female percentages of 2.5% to 6% and the paternity of calves resulting from these joinings determined by microsatellite DNA testing.

Statistical analyses

Analysis of variance was used to assess the effects of serving capacity treatments. Summary statistics were calculated for expressions of sexual behaviour within breed and age groups (1, 2, 3 and 4+ years). Repeatability of sexual behaviour (log transformed) was calculated at 4 sites using the method outlined in McGowan *et al.* (6). Log-linear modelling, using only measurements which had been shown to be repeatable, was used to assess the relationship between each trait measured and calf output within each mating group of at least 8 bulls from the 1995 mating year. Full details of the methods and results are presented in Holroyd *et al.* (7).

Results

Adaptation of the serving capacity test.

(i) Providing sexual experience to virgin bulls prior to testing.

Giving 2-year-old Santa Gertrudis bulls sexual experience increased the number of serves in the test from 0.5 to 1.4 ($P<0.05$) and from 1.0 to 2.2 ($P<0.05$) at the 2 sites. Respective increases in libido scores were 3.3 to 7.5 ($P<0.05$) and 7.6 to 9.0 ($P<0.05$). There was no effect of treatment on the number of times bulls showed interest or mounted without serving.

(ii) Use of restrained females either in oestrus or not in oestrus

At both sites, the oestrus status of the restrained females had no significant effect on expressions of the various sexual behaviours in the test. The overall recordings across sites and treatments, were interest (average of 3.1 to 4.2), mounts (average of 2.5 to 8.6) or serves (average of 0.4 to 1.4).

(iii) Use of restrained or unrestrained females.

More mounts were achieved when females were restrained than when they were unrestrained (6.5 *v* 3.3 respectively; $P<0.05$). However there was no difference in the expressions of interest, serves or in libido score.

At site 2 in 1996, an examination was conducted on 17 heifers the day after completion of a serving capacity test in which the heifers had been restrained. A vaginal examination with a speculum found that 13 had no visible evidence of trauma, 3 had very slight bruising and 1 had evidence of slight haemorrhage.

Bull age and breed effects on expressions of sexual behaviour

There were generally more mounts and serves and higher libido scores in serving capacity tests involving restrained rather than unrestrained heifers (Tables 1 and 3).

(i) Sexual behaviour using restrained females

There was more expression of sexual behaviour in Santa Gertrudis than in Brahman or 5/8 Brahman bulls (Table 1). In Santa Gertrudis there was a small increase in mounts, serves and libido score from 2 to 3 years of age.

Santa Gertrudis bulls displayed more sexual behaviours than Brahmans except for interest only (Table 2). Between 11% and 12.5% of Santa Gertrudis bulls did not display any sexual interest during the test whilst the corresponding values for Brahmans ranged from 5% to 50%. Between 48% and 54% of Santa Gertrudis bulls displayed 1 or more serves and 7% to 26% displayed 3 or more serves in the serving capacity test. The number of serves displayed by Brahmans was lower (30% for 1 or more serves, 0-7% for 3 or more serves).

(ii) Sexual behaviour using unrestrained females

Expressions of various sexual behaviours in the serving capacity test were greater in 5/8 Brahmans than in Brahmans, particularly in mounts and serves, serves and libido score; e.g. the average number of serves in 4+-year olds was 0.4 in Brahmans compared with 1.3 for 5/8 Brahmans (Table 3). Although the differences were not significant, there was a trend in Brahmans for expressions of sexual

behaviours to increase up to 3 years of age. In 1-year-old Brahman bulls very few serves were recorded although they did show interest and mounting activity.

Table 1 Means (ranges) of sexual behaviour of bulls tested using restrained females

Breed	Brahman (1 site)		5/8 Brahman (1 site)	Santa Gertrudis (5 sites)		
Age (years)	2	4+	4+	2	3	4+
Observations (n)	42	6	22	374	108	41
Weight (kg)	482 (359-640)		635 (536-762)	553 (327-766)	762 (630-911)	861 (740-1044)
Interest	4.1 (0-17)	0.5 (0-1)	3.6 (0-7)	2.6 (0-21)	1.5 (0-17)	1.8 (0-10)
Mounts	2.3 (0-11)	3.3 (0-10)	2.2 (0-7)	5.5 (0-20)	5.7 (0-20)	4.9 (0-12)
Serves	0.4 (0-3)	0.7 (0-2)	1.0 (0-2)	0.9 (0-5)	1.3 (0-7)	1.2 (0-4)
Mounts and serves	2.7 (0-14)	4.0 (0-11)	3.2 (0-8)	6.4 (0-22)	7.1 (0-21)	6.1 (0-12)
Libido score	4.5 (0-10)	4.5 (0-10)	6.6 (0-9)	6.5 (0-11)	7.1 (0-10)	7.2 (0-11)

Table 2 Bulls (%) displaying various sexual behaviours in serving capacity tests using restrained females

Breed	Age	Bulls (n)	No Interest	Interest	Mounts	Serves =1
Santa Gertrudis	2	443	12.4	5.2	33.9	50.1
	3	99	11.1	10.1	22.2	53.6
	4+	54	12.5	1.8	37.5	48.2
Brahman	2	42	4.8	40.5	26.2	30.9
	4+	10	50.0	20.0	0.0	30.0

Table 3 Means (range) of sexual behaviours of bulls tested using unrestrained females

Breed	Brahman(2 sites)				5/8 Brahman(1 site)
Age (years)	1	2	3	4+	4+
Observations (n)	45	42	39	18	22
Weight (kg)	247 (145-318)	441 (328-640)	480 (385-640)	673 (497-886)	635 (536-762)
Interest	5.7 (0-22)	4.1 (0-14)	4.6 (0-18)	11.1 (0-26)	6.5 (1-17)
Mounts	1.4 (0-10)	1.1 (0-10)	2.9 (0-14)	0.7 (0-3)	2.0 (0-8)
Serves	0.0 (0-1)	0.3 (0-3)	0.4 (0-2)	0.4 (0-2)	1.3 (0-3)
Mounts and serves	1.4 (0-10)	1.4 (0-11)	3.4 (0-14)	1.1 (0-4)	3.3 (0-9)
Libido score	3.7 (0-7)	3.4 (0-10)	5.4 (0-9)	4.8 (0-9)	7.4 (1-10)

Repeatability of sexual behaviours

All of the sexual behaviours of Santa Gertrudis bulls at site 2 were moderately repeatable when tested at a 1 month interval (Table 4). At site 4, only serves and libido score were moderately repeatable in Santa Gertrudis bulls when tested 8 months apart. Values for 5/8 Brahman and Brahman were generally very low. The exceptions were for serves in 5/8 Brahmans using restrained females and for serves and libido score in Brahmans using unrestrained females.

Table 4 Repeatability of sexual behaviours in the serving capacity tests

Breed	Site 2 Santa Gertrudis	Site 4 Santa Gertrudis	Site 9 5/8 Brahman	Site 9 5/8 Brahman	Site 11 Brahman
Bulls (n)	72	19	12	12	34
Bull age (years)	1.5- 3	2-3	4 - 5	4 - 5	2 - 3
Interval of measurement	1 month apart in 1995	8 months apart in 1993/94	4 times over 2 years	4 times over 2 years	4 times over 2 years
Females in test	Restrained	Restrained	Restrained	Unrestrained	Unrestrained
Interest	0.42	0.00	0.00	0.00	0.20
Mounts	0.41	0.03	0.00	0.00	0.13
Serves	0.54	0.48	0.25	0.01	0.27
Mounts plus serves	0.46	0.21	0.00	0.00	0.21
Libido score	0.56	0.35	0.11	0.00	0.44

Calf output

Measures of sexual behaviour or libido score were generally not significant in the log-linear models for calf output. Mounts plus serves was significant in only 1 mating group of the 6 considered.

Discussion

The various expressions of sexual behaviour recorded in serving capacity tests in *Bos indicus* and *Bos indicus* derived genotypes support previous findings that these breeds have lower levels of expression of sexual behaviour than *Bos taurus* bulls. The mean number of serves we reported ranged from 0 to 1.3 per test compared with 3 to 4 serves per 20 minute test for *Bos taurus* bulls (8). However we found that 26%, 17% and 7% of 2-, 3- and 4+- year old Santa Gertrudis bulls and 7% of 2-year-old Brahman bulls achieved 3 or more serves. This indicates there are bulls in these breeds, albeit fewer, that achieve as many serves as *Bos taurus* breeds.

It is unusual that there was a greater expression of sexual behaviours when bulls were tested with restrained females than unrestrained females. The breeds with which we were working are supposedly more temperamental and difficult to handle than *Bos taurus* breeds. There is closer human contact with bulls in a test using restrained females than unrestrained females and this might be expected to inhibit their performance. However this appeared not to be the case. As well, when using unrestrained females, it was difficult to closely observe bulls for penile problems and to be confident that mating behaviour was not inhibited by attempted escapes of the female.

Prior sexual experience increased the expression of behaviour of Santa Gertrudis bulls in two of the three experiments. This partially supports other work (9) where there was an improvement in serving capacity test results for low serving capacity bulls when tested after one breeding season.

We still recommend the use of oestrus females when testing bulls, although there was no significant difference in expressions of sexual behaviour in experiments where oestrus and non-oestrus females were compared. We have found that when using oestrus females, there seems to be less delay in getting the test into 'full swing' on the day of testing. This is because there is quicker initiation of sexual activity in the first group of bulls to be tested and stimulation of those bulls waiting to be tested. Ultimately this reduces the time taken to test all bulls.

Even though we incorporated measures of libido score, interest, mounts as well as serves, as compared to only measures of serves with the *Bos taurus* serving capacity test (1), sexual behaviour was generally not significant in the log-linear models for calf output of the 6 mating groups in 1995. However, in other years with other matings, there were some associations, suggesting that overall there is some positive relationship between sexual behaviour and calf output but, to date, our methods of testing are not consistent enough to confirm this.

Blockey (2) showed that, as serving capacity (number of serves in a 40 minute test) of bulls increased from 1 to 7, there was a corresponding increase in heifer conception rate from 18% to 70%. The study (2) was done with stocking rates of 1 heifer to 1-2.5 ha, single-sire matings of 10 weeks and bull:female ratios of 2.5%. In contrast, our work was performed under extensive conditions of much lower stocking rates and greater herd dispersions, multiple-sire matings for longer periods (3-12 months) and higher bull:female ratios (2.5-6%). The differences in management practices may account for our poor relationship between serving capacity test results and calf output because our bulls had lower mating loads than those in Blockey (2).

Guidelines for the conduct of a serving capacity test were outlined by Bertram *et al.* (10). Based on results with Brahman and Santa Gertrudis breeds, we are not confident that we can use poor performance in these serving capacity tests as a culling criterion for bulls of these breeds unless they exhibit some clinical abnormality or lameness. Conversely we can use the test to select bulls capable of natural service.

Conclusions

Brahman and Santa Gertrudis bulls are capable of performing in a serving capacity test although the degree of expressions of sexual behaviour, particularly serves, is less than in *Bos taurus*. There are some inconsistent relationships between sexual behaviour and calf output but the main value, to date, of the serving capacity test in these breeds, is a means of identifying whether a bull is capable of serving rather than as a predictor of calf output in multiple-sire herds.

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Calf Output And Predictors Of Fertility Of Bulls In Multiple-Sire Herds

Presenters: RG Holroyd[1], VJ Doogan[1], J DeFaveri[2], G Fordyce[3], MR McGowan[4], JD Bertram[5], DM Vankan[6], LA Fitzpatrick[7], GA Jayawardhana[8] and RG Miller[9]

[1]Queensland Beef Industry Institute, Department of Primary Industries, Animal Research Institute, Yeerongpilly Qld 4105, [2]Queensland Department of Primary Industries, Mareeba Qld 4840, [3]Queensland Beef Industry Institute, Department of Primary Industries, Swan's Lagoon Beef Cattle Research Station, Millaroo Qld 4807, [4]The University of Queensland, School of Veterinary Science and Animal Production, Pinjarra Hills Qld 4069, [5]Queensland Beef Industry Institute, Department of Primary Industries, Goondiwindi Qld 4390, [6]The University of Queensland, Veterinary Blood Grouping Laboratory, St Lucia Qld 4072, [7]Australian Institute of Tropical Veterinary and Animal Sciences, James Cook University, Townsville Qld 4811, [8]Northern Territory Department of Primary Industry and Fisheries, Berrimah NT 0828. [9]Queensland Beef Industry Institute, Department of Primary Industries, Rockhampton Qld 4700, Australia.

Abstract

In 9 northern Australian herds, calf output was collected on 245 bulls (92 Santa Gertrudis, 24 5/8 Brahman and 129 Brahman) from 37 multiple-sire mating groups. Mating periods were for 3-12 months and bull mating percentages were 2.5-6%. The paternities of 4440 calves were determined using DNA microsatellite tests. 97.7% of these were solved. This included 9.5% of calves with no potential sires in any mating groups. Of mated bulls, 142 (58%) individually sired 10% or less calves in each of their respective mating groups with 17 (7%) bulls not siring any calves. In contrast, 33 (13%) bulls sired over 30% of the calves in each of the respective mating groups. When bulls were mated in groups of 8 to 24, the maximum percent of calves sired by individual bulls was 26 ± 7% (range of 11 - 36%). However when bulls were mated in groups of 2 to 7, the maximum percent of calves sired by individual bulls was 59 ± 19% (range of 24 - 94%). Calf output of bulls was moderately repeatable across years at 4 of 5 sites. Log-linear models relating premating measures of physical, seminal and behavioural traits to calf output, as measured by the number of calves sired per bull, were developed for 6 mating groups in 1995. For 2 of the 3 sites where dominance was measured, there was a strong negative relationship between dominance hierarchy and calf output in the models (the most dominant bull sired the most calves). Scrotal circumference was related to calf output in 1 of the models. The relationship of prepuce depth with calf output was not consistent. Percent normal spermatozoa was positively related to calf output in models for 3 of the 6 sites. At only one site did any measure of sexual behaviour relate to calf output. The percentage of deviance for calf output explained in the models ranged from 18% to 97%.

Introduction

In multiple-sire herds, cattle producers have no objective means of evaluating whether individual bulls are siring progeny or determining paternity of progeny. Having identified the appropriate genetics for particular markets through either investment in replacement bulls or breeding their own bulls, producers want to be able to maximise the number of progeny of selected bulls so that there can be continued selection within the herd for replacement sires or to evaluate existing sires to maintain genetic progress. Therefore, producers need to

- have a means of efficiently and cost effectively determining paternity in multiple-sire herds
- be aware of expected ranges of calf outputs of individual bulls
- know of physical and reproductive traits that are related to calf output in multiple-sire herds.

This paper addresses these issues.

Materials and methods

Over 4 years, calf output was collected on 245 bulls (92 Santa Gertrudis, 24 5/8 Brahman and 129 Brahman) from 37 mating groups on 9 properties. The number of bulls per mating group ranged from 2 to 24. Bulls were from 2 to 6 years of age and in most cases, ages within mating groups were similar or overlapped by a year, e.g. 2- and 3-year olds or 4- and 5-year olds. Joining periods were from 3 to 12 months and bull mating percentages ranged from 2.5% to 6% but most were 3% to 4%.

Each bull had been subjected to a general physical and reproductive examination (1) and, in the majority of cases, included an assessment of sexual behaviour in various serving capacity tests (2). Only bulls judged to be physically sound were used for mating and most bulls had a scrotal circumference greater or equal to recommended threshold values (1). Bulls with extremes such as very pendulous prepuces were not mated. Bulls were not selected for mating on the basis of percent normal spermatozoa.

Dominance was recorded at sites 4, 9, 10 and 11. Bulls were placed in a yard for several hours and numbers of win/loss recorded on altercations between bulls. A dominance hierarchy was calculated from a matrix developed by G Fordyce (unpublished) or, at site 4, on the procedure of Beilharz and Zeeb (3).

Blood samples for DNA typing were taken in 10 ml heparinised vacutainers. Bulls were bled from the coccygeal vein and calves were jugular bled at either branding or weaning. Samples were immediately chilled, refrigerated for 2-5 days, then centrifuged, buffy coats pipetted off and stored frozen. Microsatellite DNA testing (DNA typing) for paternity involved PCR amplification of extracted DNA, incorporation of radioactive nucleotides, denaturing polyacrylamide gel electrophoresis of the amplified fragments and autoradiation. Routine testing examined a standard panel of 12 microsatellite markers in 3 separate tests. For most calves, if paternity was unable to be resolved using the standard test panel, additional DNA markers were examined until resolution was achieved. A mathematical model was devised to provide an estimate of the reliability of results for those mating groups where there were missing sires (M. Faddy, pers. com.). The reliability estimate is the probability that the nominated sire is the true sire.

Models relating premating measures of physical, seminal and behavioural traits to calf output as measured by the number of calves sired per bull, were developed using a log-linear modelling approach (4). Models were developed separately for each mating group of at least 8 bulls from the 1995 mating year, except at site 1, where 4 mating groups totalling 10 bulls were combined. The model for site 1 included mating group as an absorbing factor. Only traits that were shown to be repeatable were considered in the models. The models were of the form:

$\log_e(\text{calf output}) = a + \sum b_i x_i$

where x_i = the ith physical, seminal or behavioural trait,

b_i = the coefficient for the ith physical, seminal or behavioural trait.

A stepwise approach was used to select a model including significant covariates and accounting for a maximum amount of deviance.

Results

Paternity testing

Overall, the paternity of 87.0% of calves could be resolved with a standard panel of 12 DNA markers (Table 1). The accuracy of paternity resolution was close to the predicted accuracy estimates where the paternity exclusion probability calculated for Brahman and Santa Gertrudis breeds was 0.99 for a single bull. The majority of unresolved paternities after testing with this standard panel were able to be resolved by testing with additional DNA markers. Paternity resolution averaged 97.7% across all

sites with a range of 96.1% to 100% although this included some sites where additional markers were not used to improve the resolution of the standard marker panel. The percentage of calves with no potential (missing) sire averaged 9.5% with a range of 0 to 50.8%. Only 11 of the 41 separate mating groups analysed had no missing sires. The numbers of missing sires varied widely between mating groups and affected the reliability of sire allocations. When the percentage of calves with no known sires was high (50.8% in one mating group), the reliability of sire allocations was only 86% whereas sire allocations were 100% reliable when there were no missing sires.

Table 1 Summary of DNA results

Site	Mean no. sires (range)	Calves n	Solved %	Solved +1, +2 %
1	3 (2-7)	400	97.3	97.3#
2	6	67	83.6	98.5
3	5 (5)	141	92.9	97.9
4a	9(5-12)	439	93.4	96.8#
4b	26	408	89.2	96.1
7	4(4)	90	74.4	100
8a	8(6-10)	194	95.4	100
8b	28	130	91.5	100
9a	4(4)	189	99.5	100
9b	24(19-34)	753	83.1	98.3
10	11	213	92.5	#
11	25(12-34)	1043	75.1	98.5
12	15 (14-15)	373	93.6	97.3
All		4440	87.0	97.7

Solved :- % of resolved paternity after testing with the standard panel of 12 markers; Solved +1, +2 :- % of resolved paternity after testing through additional marker tests. # Includes some mating groups not subjected to additional DNA tests to improve paternity resolution

Calf output of individual bulls

Of the 245 bulls mated, 142 (58%) individually sired 10% or less calves in each of their respective mating groups with 17 (7%) bulls not siring any calves. In contrast, 33 (13%) bulls sired over 30% of the calves in each of the respective mating groups.

The distribution of calves sired by size of the mating group was examined. When bulls were mated in groups of 8 to 24, the maximum percentage of calves sired by individual bulls was 26 ± 7% (range of 11-36%). However when bulls were mated in groups of 2 to 7, the maximum percentage of calves sired by individual bulls was 59 ± 19% (range of 24-94%).

Repeatability of calf output

Repeatability of calf output was calculated at 5 sites using the method outlined in McGowan *et al.* (1). Table 2 summarises all the available measures of repeatability for calf output (log transformed) as measured by number of calves sired by individual bulls in 2 consecutive matings. In 4 of the 5 sites, repeatability was moderate and in the range of 0.46 to 0.67.

Table 2 Repeatability of calf output

Site	Breed	Bulls n	r
5	Santa Gertrudis	7 (not in same group in each year)	0.46
8	Brahman	6 (out of 10 in previous year)	0.12
9	5/8 Brahman	12 (same bull group)	0.67
11	Brahman	34 (same bull group)	0.62
12	Brahman	9 (not in same group in each year)	0.54

Log-linear models of traits contributing to calf output

Table 3 presents the log-linear models for calf output from 6 of the mating groups considered. For example, at site 11, the model is:

calf output = $e^{(3.23 - 0.08 \text{ prepuce depth} + 0.018 \text{ percent normal sperm})}$

Within the 2 mating groups at site 11, dominance could not be measured because of lack of agonistic interactions between bulls. At 2 of the other 3 sites where dominance was measured, there was a strong negative relationship between dominance hierarchy and calf output in the models (the most dominant bull sired the most calves). At the other site, dominance hierarchy was not related to calf output.

Scrotal circumference was positively related to calf output in only 1 of the 6 models. In models for 3 of the 6 sites, prepuce depth was positively related to calf output, negatively related at 1 site and not related at the other 2 sites.

Semen quality was an important contributor to calf output in the models. Percent normal spermatozoa was positively related to calf output in models for 3 of the 6 sites. At 1 of the other 3 sites, percent abnormal midpieces was negatively related to calf output. At site 10 where percent normal spermatozoa was negatively related to calf output, dominance exerted such a marked effect on calf output within the model that this result is probably spurious. However it should be noted that when percent normal spermatozoa was considered on its own at site 10, it was positively related to calf output ($P < 0.001$).

At only one site were any of the measures of sexual behaviour included in a model. Here, combined mounts and serves were positively related to calf output.

The models did not explain all of the variation in calf output and the percent of deviance explained ranged from 18% to 97%. In most cases, residual deviance was significant indicating a lack of fit of the model, i.e. the traits we measured and considered in these models only partly explained the variation in calf output.

Discussion

DNA typing proved to be a powerful tool for the identification of paternity of calves resulting from multiple-sire matings. The assignment of calves to bulls matched or was better than predicted accuracy estimates. The inclusion of additional markers allowed a resolution rate in excess of 97.5% even when bull groups of up to 34 were used for the paternity analysis. These results are better than values quoted for parentage testing using blood typing which involves the additional bleeding and testing of cows (5,6). The percentage of calves with no potential sires was 9.5% across all sites indicating, even in these well managed herds, there are managerial issues such as bulls or cows jumping fences, cows pregnant before mating, precocious bull calves and the mixing of calf groups that can reduce the accuracy of sire allocation. Since problems with unknown sires producing calves exist in most mating groups, DNA typing results can also be used to monitor the effectiveness of property herd management practices.

The large variability of calf output by individual bulls is supported by other data (5,7). However our results add new information in that, providing the composition of bull mating groups remain relatively similar, then individual calf output tends to be moderately repeatable. In most of our cases, bull ages within mating groups were similar which discounts the concept that mating similar age groups of bulls evens out calf distribution from individual sires (8). Factors other than age contribute to this variability in calf output. In most cases there was no obvious clinical reason for those bulls not siring any calves.

One of the reasons that traits such as scrotal circumference were not consistently related to calf output may be that the majority of bulls used had above considered threshold values for *Bos indicus* derived bulls in northern Australia. These threshold values are ≥28 cm in 2-year-old Brahman bulls grazing native pasture or ≥34 cm for moderate to well fed 2-year-old bulls (9). Similarly with the inconsistent relationship with calf output, because there were no bulls mated with excessively pendulous prepuces, there wasn't the variation in the data to allow expression of this trait as a predictor of calf output. However, at several sites, prepuce depth was positively related to calf output suggesting that within the range of prepuce depth observations, increasing depth did not affect calf output.

Semen quality, particularly percent normal spermatozoa was important and consistently related to calf output at a number of sites. However bulls were not selected for mating on percent normal spermatozoa and the range in values in mated bulls was marked (10-92%), thus allowing the expression of this trait in the models as a predictor of calf output. Our results suggest that morphological examination of semen should be part of bull reproductive examinations. However threshold values for seminal morphological characteristics need to be refined for *Bos indicus* bulls in multiple-sire matings although 70% normal spermatozoa is a guideline for satisfactory semen quality (9).

Table 3 Log-linear models of traits contributing to calf output from 1995 mating

	Site 1	Site 4	Site 9	Site 10	Site 11	Site 11
Bulls (n)	10	8	12	10	9	23
Breed	Santa Gertrudis	Santa Gertrudis	5/8 Brahman	Brahman	Brahman	Brahman
Age	2 - 4	2	4 - 5	2 - 6	3 - 4	3 - 4
Constant	†	-7.180	3.348	7.661	3.23	1.108
Weight	ns	ns	ns	ns	ns	ns
Body condition			ns	ns	ns	ns
Dominance		ns	-0.151***	-0.483***		
Scrotal circumference	0.502**	ns	ns	ns	ns	ns
Testicular tone		ns				
Prepuce depth	0.030*	0.024*	0.050*	ns	-0.080**	ns
Prepuce angle			ns	ns	ns	ns
Skin thickness			ns		ns	
Umbilical thickness	ns	ns				ns
% motile sperm	ns	ns	ns		ns	ns
% normal sperm	ns	0.049**	ns	-0.036**	0.018*	0.019***
% abnormal midpieces			-0.090**	ns	ns	ns
Restrained						
Mounts	ns	ns				
Serves	ns	ns	ns			
Mounts + serves	ns	0.243**				
Libido score	ns	ns				
Unrestrained						
Serves					ns	ns
Libido score				ns	ns	ns
% deviance explained	71%	97%	74%	89%	79%	18%
Significance of residual deviance	<0.01	ns	<0.001	<0.05	ns	<0.001

† No constant term available since it depends on the mating group.

Not many of the measures of sexual behaviour in the various serving tests were related to calf output. These results indicate that the various expressions of sexual behaviour in a serving capacity test are of limited value as a predictor of calf output in multiple-sire herds with Brahman and Santa Gertrudis bulls. However, the value of serving capacity testing may be in determining serving ability and eliminating penile and preputial injuries rather than for ranking bulls for high or low libido.

At 2 sites there was a strong relationship between dominance hierarchy and calf output but not at the third site. This could have been due to an observer difference in recording dominance hierarchy. The inability to measure dominance hierarchy at one site because of lack of agonistic interactions suggests that better testing procedures to measure dominance need to be developed. As well there is a need to control the influence of dominance on calf output in multiple-sire herds so that selected bulls have the opportunity to sire calves.

At 5 of the 6 sites, the traits in the loglinear models explained between 71% and 97% of the deviance. This is markedly better than similar procedures used by Coulter and Kozub (6) in more intensively managed *Bos taurus* herds in Canada. Our analyses differed in that most of our models were derived from individual mating groups rather than pooled across sites and years (6). In most cases, the residual deviance was significant indicating that there were factors other than the traits we measured which were contributing to calf output.

This work has demonstrated that no one single trait can be used as a predictor of calf output. However the models did identify a number of important traits that should be incorporated into bull examination procedures. Once physical and reproductive traits are above threshold levels, there may be little value in placing an emphasis on selecting for traits such as large scrotal circumference to improve calf output of individual bulls in multiple-sire herds in extensive matings.

These studies have shown that we may not be able to identify the really high fecund bulls ('super bulls') but a systematic physical and reproductive examination will identify a large number of bulls that will be poor contributors to calf output in multiple-sire herds.

Conclusions

DNA typing is an accurate method of identifying paternity of calves resulting from multiple-sire matings. There was no one single physical or reproductive trait that was consistently related to calf output in multiple-sire herds. Even so, selecting on combinations of traits did not explain all of the variation in calf output. Bulls should be selected for physical and reproductive traits that lie above threshold values. There is a need to develop management practices in multiple-sire herds to maximise calf output of all mated bulls.

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This project was jointly funded by the Queensland Department of Primary Industries, The University of Queensland, James Cook University, Partial financial support was provided by the Santa Gertrudis Breeders Association (Australia). The station owners who provided the bulls, the station managers and staff, and technical staff at each institution that assisted in the project are gratefully acknowledged.

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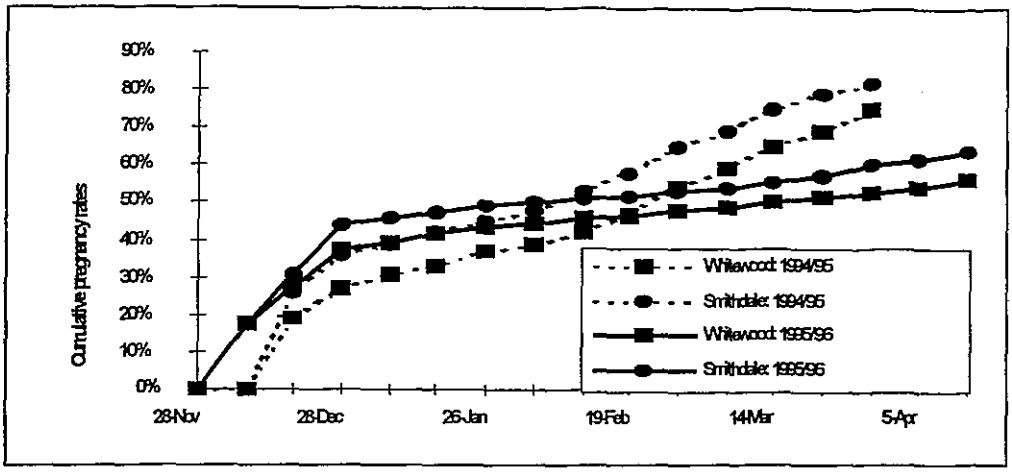
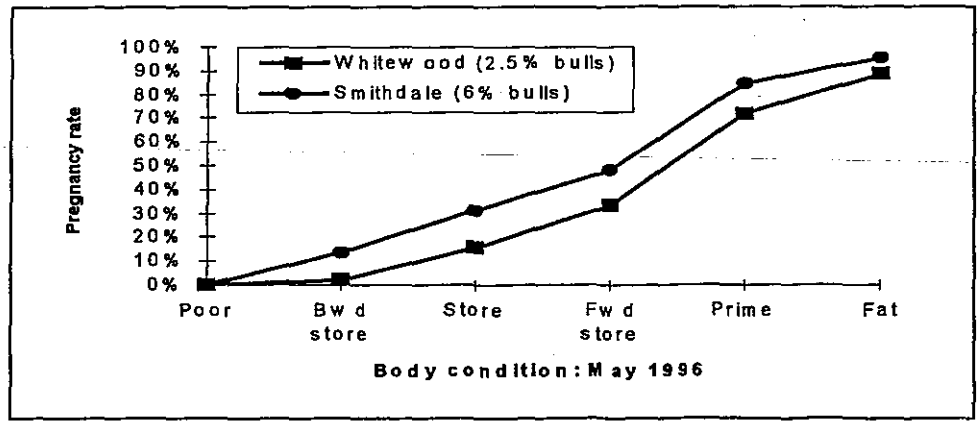
Figure 2 Cumulative pregnancy rates at Kamilaroi



In both 1994/95 and 1995/96, conception rates were 8% and 6% higher, respectively, in Smithdale (6% bulls) than in Whitewood (2.5% bulls). In May 1995, 91% and 83% of Whitewood and Smithdale heifers were pregnant, respectively. Pregnancy rates in Smithdale in May 1996 were higher than in Whitewood for all female classes: 93% *v* 88% in heifers; 89% *v* 79% in non-lactating cows; 25% *v* 9% in lactating cows.

Amongst No.94 heifers, pregnancy rates in May 1996 were unrelated to pre-mating weights except for those <275 kg in Whitewood (2.5% bulls): 84% *v* 90-93% for the 80% of heifers up to 300 kg in both paddocks ($P<0.05$). Within condition score, No.93 cows were 10% more likely to conceive in Smithdale (6% bulls) than in Whitewood (2.5% bulls) in 1995/96 (Figure 3); there was no significant independent effect of lactation status.

Figure 3 Body condition relationships with pregnancy rates of No.93 cows in May 1996 at Kamilaroi



Calf output

DNA fingerprinting determined paternity for 89% and 96% of No.96 and No.97 calves, respectively (Table 2). There were no significant differences between any conception patterns for bulls in both years within Whitewood (2.5% bulls). In Smithdale (6% bulls), only 1% of the bull conception pattern comparisons showed significant differences, and these differences were only marginal. Though total calf output was repeatable ($r=0.69$), it varied less in 1995/96 than in 1994/95; in both years, the variation in calf output was lower with a lower percentage of bulls. (Table 2; total variance of 67 *v* 193 in Smithdale and 183 *v* 344 in Whitewood in 1994/95 and 1995/96, respectively).

The 6-8 highest calf producers in each paddock made up 2% bulls:cycling females. These bulls sired 80-90% of the calves in Whitewood (2.5% bulls). In Smithdale (6% bulls), where there was a high ratio of bulls:cycling females, they sired 60% of calves. In both paddocks, the top 6-8 calf-output bulls achieved an average 1-8 pregnancies/week during peak mating (Table 3).

Table 2 Distribution of progeny

Calves sired	No. bulls at each level	
	1995/96	1996/97
Smithdale (6% bulls)		
0-6	13	8
7-20	8	12
21-33	1	3
67	1	
Whitewood (2.5% bulls)		
0-6	6	
7-20	1	3
21-33	1	3
38-45	3	3
46	1	

Table 3 Estimated numbers of bulls, within the top 6-8 calf producers, achieving each level of average pregnancies/week during peak mating

Mating	Pregnancies/week			
	1-2	3-4	5-6	7-8
Smithdale (6% bulls)				
1994/95	5	1		1
1995/96		7	1	
Whitewood (2.5% bulls)	1	5		
1994/95		4	1	2
1995/96				

Discussion

Our research shows high variability of calf output per bull in multiple-sire herds. Calf output per bull was repeatable between years. Within years, bulls had consistently low or high pregnancy rates. These results suggest that bulls can be selected and managed for high calf output in large, extensively managed herds. The selection of bulls for high calf output is considered elsewhere (5,6,7,8).

Where the bull:cycling female ratio was 6%, 80% or more of the calves were sired by the equivalent of 2% bulls. When the average cycling females per bull was low, 2% bulls sired only 60% of calves. Similarly, at another site (22 km^2 paddock; 12 bulls, 325 continuously mated females), 2% bulls sired 80% of the calves (G Fordyce, Unpublished data). Within the top 6-8 calf producers at Kamilaroi, all achieved at least 3-4 pregnancies/week during peak mating when sufficient cycling females were available, eg, in 1995/96 when ~75% of the females that conceived over mating, were cycling at the start of mating. As embryonic loss is probably 25-30% (9), there were an estimated 1.5 conceptions per confirmed pregnancy. Therefore, these bulls were impregnating at least 5-6 females/week. This provides some indication of mating potential of Brahman bulls in multiple-sire groups under extensive management; we have no indication of the number of serves required to achieve this.

In a previous study, ~90% of Brahman cross bulls, mated as single sires in the dry tropics, each sired >20 calves over 3 months (10). Sperm competition, which encompasses all functions from bull access to females through to fertilisation (11), may explain the variation in calf output in multiple-sire herds, particularly where the ratio of bulls:cycling females is high. At another site (22 km^2 paddock; 12 bulls, 325 continuously-mated females), social dominance was confirmed as a primary contributor to this

competition (G Fordyce, Unpublished data), presumably because dominant bulls achieve more services per oestrus female and better timing of services (11). A lower bull:cycling female ratio may reduce the competition for females (ie, reduce the apparent effect of dominance on calf output), thus reducing the variation in calf output between bulls as seen at Kamilaroi.

Bull:female ratios were confounded with paddock. Nutrition was generally poor due to poor seasonal conditions, and it appeared that nutrition was poorest in the paddock with 2.5% bulls, and pregnancy rates were lower, as would be expected. It appeared from the conception patterns that fewer than half of the females in each paddock were cycling at the start of mating, with a steady parallel increase in the percentage over the mating period. This strongly suggests that in the first 1-1.5 months of mating in both years at Kamilaroi, bulls in both paddocks impregnated all females cycling at that time and, over the remainder of the mating period, impregnated the constant trickle of females that commenced cycling. If the differences in conception patterns were a function of paddock nutrition, then there was no effect of bull:female ratios on conception patterns. This conclusion is supported by pregnancy frequency data. In both paddocks, bulls achieved a high frequency of pregnancies in the first 4-6 weeks; the frequency then dropped dramatically (Table 1). In 1995/96, the pregnancy frequency in Whitewood (2.5% bulls) during the last 14 weeks of mating dropped to half the level that occurred in Smithdale (6% bulls) in the first 6 weeks.

It appears, then, that reducing mating ratios to 2.5% of reproductively-sound bulls:cycling females does not affect conception patterns; 2% bulls achieve most of the conceptions, and the balance of the bulls would potentially cover reproductive failures. At another research site (22 km^2 paddock; 12 bulls, 325 continuously-mated females), bulls were shown to generally restrict their movement to ~5 km^2 (equivalent to the stocking area for ~75 females); 2 bulls per movement range at this site was also equivalent to using 2.5% bulls:cycling females (G Fordyce, Unpublished data).

Many cattlemen in north Australia, who typically use high bull percentages, presume that 'harder-working' bulls finish the mating season in poorer condition. Our study refutes this as there was no difference in condition between bulls mated at low and high percentages and no relationship within paddocks between calf output and bull condition. However, regular bull attrition occurred when 6%, but not 2.5%, bulls:females was used. Presumably, agonistic behaviour increased as the ratio of bulls:females increases. This would increase energy demand resulting in both body condition loss and bull injury. Our experience with bulls mated in paddocks of ~20-30 km^2 is that a bull:female ratio of >3.5% leads to broken fences and other problems (G Fordyce, Unpublished data).

These results suggest that it is unnecessary to mate reproductively sound Brahman bulls at >2.5% of cycling females under extensive management, even when mating loads are high. It is probable that bulls could achieve higher conception rates, but this requires demonstration.

When mating load was low, very few bulls achieved an average of >1-2 pregnancies/week; 2% bulls may have been excessive in view of mating potential as discussed. However, herd dispersion may result in bulls not being able to achieve mating potential. Dispersion is caused by multiple watering points, large herds, large paddocks, high tree density, uneven topography, and weather extremes. We have no evidence that fewer than 2.5% bulls:cycling females would have been sufficient. Though we are confident in extrapolating the recommendation for 2.5% reproductively-sound bulls in most situations, we exercise caution in recommending use of fewer bulls in large paddocks, or use of bull:female ratios as low as 2.5% in high dispersion situations until we have supporting evidence on the effects of dispersion on bull mating potential. Behavioural studies are integral to this. For example, our studies used paddocks with only sparsely located artificial waters. Most oestrus expression occurs at night (12) when cattle are dispersed (even when cattle must congregate daily on controlled watering points), thus confusing the impact of watering point distribution on the number of bulls needed.

Conclusions

Mating reproductively-sound bulls at a ratio of 2.5% of cycling females is probably adequate for Brahman cattle mated under most conditions in the tropics. Further information is needed to determine if this mating ratio is optimal where herd dispersion is very high or low.

Acknowledgments

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Social Behaviour of Bulls

Presenters: G Fordyce[1], NC Cooper[1], RG Holroyd[2], R Miller[3], MR McGowan[4], LA Fitzpatrick[5], V Doogan[2], and J De Faveri[6]

[1]Queensland Beef Industry Institute, Department of Primary Industries, Swan's Lagoon Beef Cattle Research Station, Millaroo Qld 4807 Australia, [2]Queensland Department of Primary Industries, LMB4,Moorooka Qld 4105 Australia, [3]Queensland Department of Primary Industries, Rockhampton Qld 4702 Australia, [4]Univeristy of Queensland, School of Veterinary Science and Animal Production, Pinjarra Hills Qld 4069 Australia, [5]James Cook University, Townsville Qld 4811 Australia, [6]Queensland Department of Primary Industries, Mareeba Qld 4880 Australia.

Abstract

At Swan's Lagoon Beef Cattle Research Station (dry tropics), 12-14 mixed-age, Brahman cross bulls were mated continuously to 325 Brahman cross females (3.5% bulls:females) in a 22 km^2 paddock with controlled waters. Twice-weekly observations of bull behaviour were conducted over 2 years. Dominance hierarchy was assessed at Swan's Lagoon, as well as in 3 other Queensland herds prior to mating and was subsequently related to calf output. Further observations were also made in a north Queensland herd (Kamilaroi Station) where 9-23 bulls were mated to up to 650 females. At Swan's Lagoon, most bulls restricted most of their movement to within a 500 ha area in the 22 km^2 paddock. This appeared related to social dominance. The degree of territorial behaviour was positively related to calf output. Dominance was strongly related to calf output when hierarchy could be clearly established for a bull mating group; this occurred at Swan's Lagoon and Fletcherview Stations. Distribution of bulls at Swan's Lagoon was uneven in the paddock but did not appear to have a detrimental effect on herd fertility. This, and the estimated territorial range of bulls indicated that 2.5% bulls:females was an adequate mating ratio. At Kamilaroi, regular bull attrition occurred when using 6-7% bulls:cycling females but not at 2.5-4.0% bulls:cycling females, thus further supporting the recommendation to use lower bull:female mating ratios.

Introduction

At present, there is little scientific information to substantiate recommendations on bull selection and mating practices for extensively-managed *Bos indicus* cattle. Bull:female mating ratios average 4.3% in tropical Australia (1); bulls achieve an estimated average of only one conception/week during the peak mating period. Bull cost per calf when using $1,500 bulls is less than $10 when annual calf output is high (30+), but over $100 when calf output is low (0-3).

Using fewer bulls (without reducing herd fertility) of higher breeding value will accelerate genetic improvement. The estimated annual net financial benefit of this for a typical north Australian beef producer with a 3,000 adult equivalent (AE) herd is ~$5/AE.

Improving recommendations on mating practices must be based on improved understanding of reproductive behaviour of bulls mated in multiple-sire herds using extensive management. This, and relationships of their behaviour to their calf output, are presented in this report.

Materials and methods

Location

Swan's Lagoon. The primary research was conducted in Sandalwood paddock (22 km^2) on Swan's Lagoon Beef Cattle Research Station (20° 05'S, 147° 14'E) in the subcoastal black spear grass region of north Queensland. The vegetation is open eucalypt savanna woodland with a native unimproved pasture. Low-fertility duplex soils predominate in this relatively flat paddock. 1994-95 was a very

poor season; first wet season rainfall was in late December; total rainfall was 350 mm. The subsequent 2 years were good seasons with early wet season starts (August and December) and average total rainfall (860 mm).

Other sites. These included Fletcherview Research Station west of Townsville in north Queensland, Cona Creek Station west of Springsure in central Queensland, Gyranda Station west of Eidsvold in southern Queensland, and Kamilaroi Station in NW Queensland. Fletcherview and Kamilaroi are in the dry tropics; Cona Creek and Gyranda are subtropical.

Animals and management

Swan's Lagoon. The cattle were a composite 5/8 Brahman x 3/8 Beef Shorthorn bred on the station. Mating was continuous with two annual musters in April/May and August/September. Vaccinations included campylobacteriosis (bulls), clostridial diseases, and leptospirosis. An average of 325 breeding females were present during the peak mating season (February-March) each year. In 1993/94, 14 No.88-92 bulls were used (4.4% bull:female ratio). For 1994/95 and 1995/96, four No.91 bulls replaced six older bulls (12 No.89-92 bulls: 3.6% bull:female ratio).

Cona Creek, Fletcherview, Kamilaroi. The cattle were Brahmans. In 1996 at Cona Creek, eight 2- to 4-year-old, recently-introduced bulls were mated with 200 second-calf cows for 6 months from January. In 1995 at Fletcherview, 12 mixed-age bulls which had been on the station for at least 6 months, were mated for 3 months from January to 250 cows. At Kamilaroi, bulls were mated in flat 60-84 km^2 paddocks to 300-350 cycling females (411 and ~650 females in 1994/95 and 1995/96, respectively) for 3.5-4.5 months.

Gyranda. All cattle used were Santa Gertrudis. From mid-November 1995, eight 2-year-old bulls were mated to 231 heifers for 4.5 months.

Measurement: Behaviour

Swan's Lagoon. Dominance hierarchy was estimated by recording agonistic behaviour (2) when the bull group was placed together in a yard at each muster. All interactions were entered into a matrix with dominant bulls in columns and subordinate bulls in rows. Rows and columns were then moved, while retaining the same order of bulls from the left/top, so that most interactions were beneath a diagonal from the top-left to the bottom-right of the matrix. Dominance hierarchy was then in order from the left/top.

Each two weeks at Swan's Lagoon from mid-February 1995, the location and behaviour of the bulls within the paddock were assessed between 1000 and 1200 hrs. The distribution of cows was also recorded. Movement range was estimated for each bull. Nine areas of approximate equivalent size were defined. For each bull, the number times found in each area was recorded, and ranked. A value of 1 was allocated to the highest rank through to a value of -1 for the ninth ranking. The number of times found in each area was then multiplied by the allocated value for that area. The sum of these products, divided by the total number of observations was the movement range index (MRI).

Cona Creek. Bulls were run together for 2 weeks prior to dominance hierarchy assessment which was after a 24 hr fast. Dominance was determined by introducing all possible bull pairings one at a time for ~5 min to a yard with a restricted feed access (only one bull could feed at a time).

Gyranda, Fletcherview, Kamilaroi. At Fletcherview, agonistic behaviour between bulls and dominance hierarchy was determined using the same method as at Swan's Lagoon. At Gyranda, agonistic behaviour was recorded similarly, but the dominance hierarchy was established using the procedure described by Bielharz and Zeeb (2). The attempt to establish dominance hierarchy at Kamilaroi was abandoned as the bulls exhibited almost no discernible agonistic behaviour.

Measurement: Physical traits of bulls

At musters in December 94 and August 95 (pre-mating) and May (post-mating) each year, measurements were made of weight, body condition, structural soundness, prepuce, navel, penis, testes, semen and serving capacity of each bull using standard procedures (2).

Measurement: Calf output

Blood samples from bulls and calves were used for microsatellite DNA testing to determine paternity.

Statistical analyses

Repeatability of bull traits were calculated using variance components estimated by REML (4). Log-linear modelling was used to assess the relationship of dominance and other traits of bulls with calf output in each mating group. Details of the procedure are given by Holroyd *et al.* (5).

Results

Paddock behaviour

Swan's Lagoon. Bull control was very good with no significant fence crossing. Over the 2 years, there were 2 bulls consistently found at the southern end of the paddock compared with 6 at the northern end. This may be related to the end of the paddock closest to their location between weaning and 2.5 years of age. It did not appear related to cow distribution (average: 40%, 17%, and 43% of females found in northern [44%], central [23%], and southern [33%] sectors), age, or other behaviours. Bulls in all areas were found by themselves 10-20% of the time (Table 1). Bulls working the southern end of the paddock were rarely found in a bull group and were mostly found with cows. However, bulls at the northern end of the paddock were found with cows a little over half of the time. The repeatability of time spent with cows was moderate (r=0.42).

Table 1 Proportion of time Swan's Lagoon bulls were observed in day-time social groups

Social group	Area of paddock generally found		
	North 6 bulls	Variable 4 bulls	South 2 bulls
Alone	10%	21%	10%
Bull group	34%	12%	5%
With cows	56%	68%	85%

Ten of the 12 bulls had a movement range index (MRI) >0.7 (Table 2) which corresponded to a range of ~500 ha. The two bulls with the highest MRIs each sired about 20% of the calves. The lowest-MRI bulls each sired <5% of the calves. Calf output for the other 8 bulls was generally intermediate, but variable.

Table 2 Movement range of Swan's Lagoon bulls

*: 1=Never outside one area; 0=Location random

Bull	MRI*	Calf output	
		94/95 mating	95/96 mating
890103	0.92	79	37
890272	0.51	10	8
900080	0.71	12	20
910016	0.72	22	14
910019	0.83	19	23
910124	0.88	23	50
910242	0.86	10	15
915687	0.84	12	8
915689	0.84	5	3
915703	0.84	2	11
920108	0.53	11	6
920239	0.74	21	22

Kamilaroi. Late in the 1994/95 mating, one bull went missing (dead?) in Smithdale. At similar times in 1996 and 1997 in Smithdale, a bull was found with a fractured leg. This equates to 4-5% annual bull attrition. No bull losses were recorded in Whitewood.

Dominance

Dominance hierarchy within the bull group was moderately repeatable (r=0.45). Changes in bull ranking appeared to be influenced by the test situation not matching paddock conditions, injuries to bulls, and maturing of bulls. The correlation between rankings in September 94 and May 95 was 0.36, suggesting inaccurate assessment, but was 0.92 a year later. In 1995/96, but not in 1994/95, more dominant bulls spent more time with cows than subordinate bulls did (r=-0.45) and sired more calves (b=-0.15, P<0.001; Figure 3).

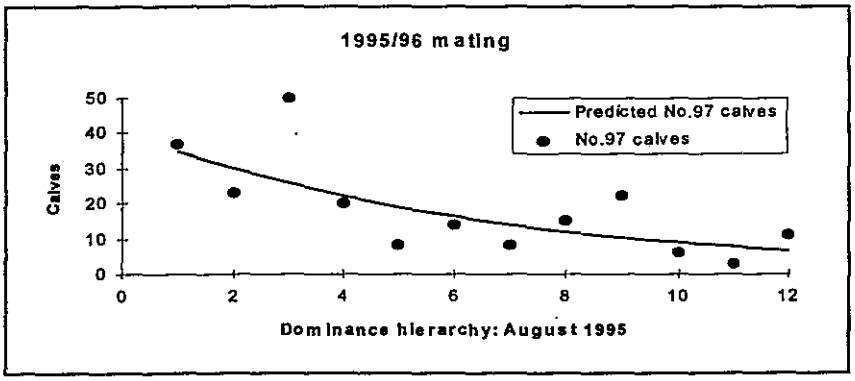
Other sites. At Fletcherview, where dominance was clearly established, it was strongly related to calf output and accounted for 75% of the deviance in calf output. The relationship was very similar to that shown in Figure 3.

When observing the Cona Creek during feeding of bulls together in a small paddock, it appeared that the dominance hierarchy established using the described method differed significantly to apparent dominance during group feeding. This strongly suggests that the technique was inappropriate. However, at the time, it had been the only way to clearly establish a dominance hierarchy within the group which had settled down well together. Subsequently calf output was not related to the measured (suspect?) dominance hierarchy.

Measurement of dominance had been difficult at Gyranda as it had at Cona Creek. And similarly, calf output was unrelated to the established hierarchy within these 2-year-old bulls.

At Kamilaroi, the dominance hierarchy could not be established. There was virtually no overt agonistic behaviour between these 2-year-old bulls which had been reared together.

Figure 3 Dominance effects on calf output at Swan's Lagoon



Discussion

At Swan's Lagoon, bulls were very territorial. The territory claimed is presumably related to dominance behaviour, thus to calf output. Mating load was low due to peak mating extending for 3-4 months which is typical for mixed-age, north Australian herds. A low proportion of bulls covered a high percentage of the cows with no apparent detrimental effects on herd pregnancy rates (~90%). This suggests that the 4% bulls:cycling females used was excessive, particularly as bulls rarely achieved an average of >1-2 pregnancies/week. The range of bulls was ~500 ha; or was it the range of ~75 females, or a range determined by bull numbers? Under the low mating load, 2 bulls per typical movement range would probably suffice; the second would be needed if the first suffers reproductive failure. This equates to 8 bulls in the paddock used or a 2.5% bull:female ratio. This supports the conclusions from concurrent studies (see accompanying report).

In a previous study, ~90% of Brahman cross bulls, mated as single sires in the dry tropics, each sired >20 calves over 3 months (6). Sperm competition, which encompasses all functions from bull access to females through to fertilisation (7), may explain the variation in calf output in multiple-sire herds, particularly where the ratio of bulls:cycling females is high. Where dominance hierarchy was clearly

established and appeared consistent with ranking during mating (Swan's Lagoon and Fletcherview), social dominance was confirmed as a primary contributor to this competition, presumably because dominant bulls achieve more services per oestrus female and better timing of services (7). A lower bull:cycling female ratio may reduce the competition for females (ie, reduce the apparent effect of dominance on calf output), thus reducing the variation in calf output between bulls as seen at Kamilaroi (see accompanying report).

Dominance hierarchy was only clearly established in mixed-age mature bull groups. The test situation used was inadequate for establishing the hierarchy within groups of young bulls which had been reared together (Gymada, Kamilaroi), or even settled down over a couple of months (Cona Creek). At Swan's Lagoon and Cona Creek there was also evidence that dominance hierarchy established in a yard test was not always highly correlated with that observed in the paddock. These observations together indicate that accurate assessment of dominance hierarchy within groups of *Bos indicus* or *Bos indicus*-derived bulls requires observation over extended periods in their normal grazing environment.

Many cattlemen in north Australia, who typically use high bull percentages, presume that 'harder-working' bulls finish the mating season in poorer condition. Our study refutes this as there was no difference in condition between bulls mated at low and high percentages at Kamilaroi and no relationship within paddocks between calf output and bull condition. However, regular bull attrition occurred when 6%, but not 2.5%, bulls:females was used at Kamilaroi. Presumably, agonistic behaviour increased as the ratio of bulls:females increases. This would increase energy demand resulting in both body condition loss and bull injury. Our experience with bulls mated in paddocks of ~20-30 km^2 at Swan's lagoon is that a bull:female ratio of >3.5% leads to broken fences and other problems.

Behavioural studies are integral to confidently improving recommendations of bull mating management to maximise calf output per bull without risking lower herd fertility. Studies need to encompass herds with a high degree of dispersion which is caused by multiple watering points, large herds, large paddocks, high tree density, uneven topography, and weather extremes. For example, our principal behaviour studies used paddocks with only sparsely-located artificial waters. Most oestrus expression occurs at night (8) when cattle are dispersed (even when cattle must congregate daily on controlled watering points), thus confusing the impact of watering point distribution on the number of bulls needed. Studies using fewer than 2.5% bulls:cycling females are also required to more accurately define mating potential of *Bos indicus* bulls under extensive management.

Conclusions

Behaviour as expressed through social dominance has a significant influence on calf output of bulls in multiple-sire mated herds under extensive management systems. Bulls are very territorial, a behaviour which is presumably related to social dominance; bulls expressing this to the highest degree tended to sire more calves. The behavioural studies supported the recommendation that a mating ratio of 2.5% reproductively sound bulls is adequate for Brahman cattle in the tropics. Further information is needed to determine if this mating ratio is optimal where herd dispersion is very high or low.

Acknowledgments

This project was jointly funded by the Queensland Department of Primary Industries (Project 1297), James Cook University, University of Queensland, Stanbroke Pastoral Company, the Meat Research Corporation (Project NAP2.DAQ.104), and the Santa Gertrudis Breeders Association (Australia). We gratefully acknowledge the enthusiastic and valuable support provided by the staff on all stations in the conduct of this research.

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Session 2:
Breeder Fertility and Management

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Development of a Yearling Mating Program for Areas of Improved Nutrition

Project Duration: 1995 - 2000

Presenters: Gehan Jayawardhana, Northern Territory Department of Primary Industry and Fisheries, PO Box 990, Darwin, NT 0801. Ph: 08 89992224. Fax: 08 89992043. Mobile: 0409 699544. E-mail: gehan.jayawardhana@dpif.nt.gov.au

Summary

Yearling mating of Brahmans has been examined under improved pasture conditions in the Top End of the NT over a three year period. Pregnancy rates have ranged from 25% to 63% at one year of age when average weights have ranged from 217kg to 265 kg. Dystocia rates have been uncharacteristically high for Brahmans ranging from 15% to 30% of pregnants. The rebreeding rates for those rearing a calf have been very high too ranging from 46% to 85%. All the causal relationships have not been fully investigated as yet. However these figures indicate that high grade Brahmans are not necessarily animals of low reproductive potential.

Objectives

- To develop a method of successfully mating Brahmans as yearlings under improved pasture conditions in the Top End of the NT.
- To assess the effect of yearling mating on cow lifetime productivity.

Introduction

Swans Lagoon researchers have found that initial mating as yearlings of Brahman cross heifers which are supplemented in the dry season as weaners may increase lifetime calf output by 0.4 calves with astute mating management (Fordyce et al 1992).

Under improved pasture conditions in the Top End Brahman heifers can reach 400kg at mating at two. This seemed to indicate that the possibility of gaining an extra calf by early mating existed. If the calving rate of yearlings is sufficiently high, it may be possible in future years to cull heifers, which don't become pregnant as yearlings. Post (1984) has found that cows, which reach puberty earlier, have shorter post partum anoestrus periods in subsequent years and higher calving percentages.

Location

The study is being conducted on Douglas Daly Research Farm (DDRF) which is situated at the junction of the Douglas and Daly rivers, 250 km south of Darwin in the Top End of the Northern Territory.

The area is flat with a mixture of low fertility, sandy Blain soil and Tippera soil with higher clay content. The paddocks used are mainly fully improved, fertilised, tropical, grass/legume pastures. Predominant grasses are Buffel *(Cenchrus ciliaris)*, Sabi *(Urochloa mosambicensis)* and Jarrah *(Digitaria milanjiana)* in company with the legumes Verano stylo *(Stylosanthes hamata)*, Seca stylo *(Stylosanthes scabra)*, Wynn cassia *(Chaemecrista rotundifolia)* and Cavalcade centro *(Centrosema pascuorum)*.

The climate is dry tropical with two distinct seasons, the wet and the dry. The wet season lasts from four to six months from November to April and receives over 90% of the annual rainfall, which is 1165 mm on average. Sporadic thunderstorms start in September/October and continue through to December. Heavy, monsoonal rains generally occur in January and February. Rainfall tapers off in March and April. Cyclones are a feature of the area and can result in several days of continuous heavy rain. The dry season occurs from May to October and little or no rain is received. Generally

the distribution of rainfall is more important for pasture growth and animal production than the total amount of rainfall.

Table 1.Rainfall Summary Over First Three Years of Trial Period

	94/95 Wet	95/96 Wet	96/97 Wet
Start Date	31st October	4th October	19th October
End Date	7th April	15th April	10th March
Total Rainfall (mm)	1172	1100	1510
Total Wet Days (d)	79	88	86
Length of Wet Season	158	194	142

All three years were average or better for rainfall. However, the 96/97 season was not good for grass growth, as there was little sunlight in the rainy period and an early cutoff in March. The rainfall distribution is shown below.

Table 2. Rainfall Distribution over Trial Period

	1994-95		1995-96		1996-97		AVERAGE	
	Mth Tot	Prog Tot	Mth Tot	Prog Tot	Mth Tot	Prog Tot	Mth Tot	Prog Tot
July	0.0	0.0	0.0	0.0	0.0	0.0	3.42	3.42
Aug.	0.0	0.0	0.0	0.0	7.4	7.4	0.36	3.78
Sept.	0.0	0.0	0.0	0.0	0.0	7.4	3.69	7.47
Oct.	7.2	7.2	95.2	95.2	68.4	75.8	34.74	42.21
Nov.	84.9	92.1	167.7	262.9	128.4	204.2	109.86	152.06
Dec.	237.0	329.1	291.8	554.7	514.4	718.6	172.74	324.81
Jan.	440.4	769.5	261.0	815.7	428.4	1147.0	274.04	598.84
Feb.	182.9	952.4	148.5	964.2	250.8	1397.8	286.44	885.28
March	154.6	1107.0	99.7	1063.9	112.6	1510.4	228.88	1114.16
April	64.5	1171.5	36.4	1100.3	0.0	1510.4	39.33	1153.50
May	0.3	1171.8	0.0	1100.3	0.0	1510.4	8.24	1161.73
June	0.0	1171.8	0.0	1100.3	0.0	1510.4	3.11	1164.84

Experimental Animals and Methods

The breeding herd here consists of 250 high grade Brahman cows, ranging from 2 to 15 years of age, and 50 yearling heifers. Three hundred head are joined and the herd is reduced to two hundred and fifty at pregnancy test. The bulls are a mixture of bought and homebred. The bulls used from the 95 drop onward have been bred on the property using a mixture of artificial insemination (AI) and herd bulls.

The cows of two and over are control mated for four months from the start of January to the start of May to 4% Brahman bulls. They are mated in two groups consisting of the two and three year olds in one group and the older cows in another. The calves are weighed and mothered up at birth and are bled, for DNA testing to allocate paternity, at branding in March.

The pregnancy rates of the various age groups in this herd since its inception in 1986 are detailed in the following table. There have been three different management regimes in this period going from 1987-1992, 1993-1994 and 1995 to present.

Percentage of cows mated (total and by age) which were pregnant

* 1st mated as yearlings the previous year
From Rann *et al.* 1993
Not counting AI calves conceived before usual mating.

Cow Age	1987 **	1988 **	1989 **	1990 **	1991 **	1992 **	1993	1994	1995	1996	1997 **	1998 +
15 yrs												100
14 yrs										33	100	0
13 yrs									100	100	75	100
12 yrs								38	100	83	100	69
11 yrs							83	50	82	89	100	80
10 yrs						79	86	69	100	100	87	82
9 yrs					90	83	85	71	100	100	94	79
8 yrs				86	88	86	100	54	85	91	89	75
7 yrs			95	88	96	87	95	58	92	95	100	100
6 yrs		83	96	97	100	91	83	69	92	94	100	100
5 yrs	83	93	90	100	95	75	69	71	95	83	100	90
4 yrs	87	78	95	87	96	70	76	71	100	100	95	100
3 yrs	65	50	35	68	73	64	62	33	95	95	95	93
2 yrs	84	93	85	85	86	81	85	76	96	83*	88*	62*
1 yr	-	-	-	-	-	-	-	-	40	63	63	41
% total cow herd pregnant (excl. yearling heifers)	78	80	82	87	78	89	82	60	94	91	94	84
Bull % (excl. yearlings)	4.2	3.6	3.8	4.3	4.3	3.6	3.3	2.5	4.0	4.0	4.0	4.4
Weaning weight												
– early									166	161+	161+	
– normal	165	183	182	180	188	181	176	160	185	187+	176+	172+

The yearling heifers are artificially inseminated in mid December and are then mated to 8 to 10% yearling, homebred Brahman bulls for three months from the start of January to the start of April. The yearlings, which do not become pregnant, are culled if possible. The empty two year olds which did not calve as yearlings are definitely culled. The yearlings drop their calves in the heifer group and are control mated again as two year olds. The cow and calf performance, the calving difficulties and mortalities are assessed, as will be re-breeding rates of the yearlings.

Results

The average joining weight of the yearling heifers in 1995 was 222 kg and the pregnancy rate was 40%. If the Boran and Tuli heifers are kept out of this calculation, the average joining weight becomes 217 kg with a pregnancy rate of 25%.

The pregnant Brahmans averaging 225 kg versus an average weight of 214 kg for the empties indicate the effect of weight on the pregnancy.

Due to decreased feed when they were calves, these heifers were far too small to be joined as yearlings. We joined them to observe the maximum level of problems, which could be expected with yearling mating, and to gain experience of the minimum joining weight at which yearling mating would be advisable.

Out of the twenty heifers which became pregnant (40%) three died calving (15% of the pregnants or 6% of the total) and one lost its calf. These were the four youngest heifers, which became pregnant with an average joining weight of 219 kg. One of the two year old maiden heifers (2% of group) also died calving which is about average for DDRF two year old heifers. When this trial is completed we should be able to give a minimum joining weight below which yearling heifers should not be put to a bull.

Out of the 1995 heifers which calved in 1996 as two year olds 75% got back in calf. This gave an overall two year old pregnancy rate of 83%. Their pregnancy rate at three was 95%.

In the 1996 season the average joining weight of the yearlings (all Brahman) was 265 kg and the pregnancy rate was 63%. This is a more realistic result for joining yearling heifers of correct weight. However out of the 29 heifers which became pregnant four died calving (14% of the pregnants or 9% of the total). Two more had dead calves pulled giving a dystocia rate of 21% of pregnants or 13% of the total. A further two heifers lost their calves which is consistent with the rate in the rest of the herd.

In 1997 85% of these heifers that reared a calf at two were back in calf giving an overall two year old pregnancy rate of 88%. This is an exceptional result more reminiscent of British bred cattle in Victoria than Brahmans in the Top End of the NT. Consequently it is an important result for the Brahman breed as a whole, as it indicates that the innate fertility of the Brahman may be underestimated. On the other hand, the level of dystocia was far higher than expected for Brahmans too.

The average joining weight of the 1997 yearlings was 248kg and 63% of them became pregnant when mated to yearling, homebred bulls.

The 1997 dry season saw both the weaner heifers (97 drop) and the yearling heifers (96 drop) being put into paddocks with inadequate feed resulting in condition losses in both these classes. The results were disastrous with a 41% pregnancy in the yearlings at a 252 kg joining weight (only half the group was joined). This supports interstate results, which indicate that heifers, which lose weight after weaning, have reduced reproductive activity even after they reach target weights.

The effect on the two year old heifers was even worse as they calved in very poor condition. Out of the 33 heifers (63%) which were pregnant four died calving and six had their calves pulled (30% of the pregnants or 19% of the total. One of the AI bulls may have contributed to this as four out of five of his calves had trouble. Furthermore, the pregnancy rate of the two year old heifers that reared calves was 46% versus an average of 80% in the past two years.

This indicates that yearling mating should only be considered under very well managed conditions, as these animals are very susceptible to poor nutrition. Southern research (Norman 1998) has indicated that heifers, which experience adequate levels of feed over the first two trimesters of pregnancy, have the lowest levels of dystocia. The last group also had their pelvises measured at joining and we will see if the relationship between pelvic diameter, calf birth weight and dystocia also exists in Brahmans.

The 97 drop heifers, which became pregnant were given good feed (sorghum stubble) over the first two trimesters and are presently calving with no difficulties to date. However, their number is so small (9) that the result will not be meaningful.

The 98 drop heifers have been reared under adequate feed conditions and, if they can repeat this result, we may have found a solution to the problem. Unfortunately this trial and the associated Breeder Herd work at DDRF have been cancelled due to funding cuts and we may never gain a meaningful conclusion.

If it is possible to solve the dystocia problem yearling mating has the potential to give a major increase to herd efficiency as it means all the females in the herd are productive and purely grower heifers are not utilising pasture which can be used by a breeding animal. A roughly 20% increase in weaner number is possible in a yearling mated system versus a 2 year old mated system with cull heifers turned off at yearling. Furthermore, the heifers, which don't become pregnant at yearling, are a very saleable product for live export. When a Breedcow (Holmes 1996) simulation was run on a

herd which keeps only pregnant cows and breeds their own bulls, using an average of the initial three years data (55% pregnant and 18% mortality in pregnant yearlings), yearling mating still increased the gross margin figure by 13%.

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Heifer and Breeder Management

Part 1: Improving production efficiency in *Bos indicus* cattle through control of post-partum anoestrus and nutrition

MLA Project No.: CS/UNQ/DAQ:NAP.AP1

Project Duration: Jul 86 to Jun 89

Principle investigators: Prof Keith Entwistle (JCU), Geoffry Fordyce (QDPI), Dr Jim Hogan (CSIRO)

Objectives

Improving production efficiency in *Bos indicus* cattle through control of post-partum anoestrus and nutrition

- Advance post-partum ovarian cyclicity using exogenous hormones and through supplements and management which increase available nutrients to late-pregnant and early-lactation cows
- Enhance reproductive development and potential of heifers through supplementation as weaners
- Enhance feed utilisation by small weaners through additives to supplementary feed

Summary

Pre-calving supplementation and weaning were confirmed as potent regulators of the post-partum anoestrus interval (PPAI). The strategy of spike feeding (short-term, high-energy supplementation in late pregnancy) was developed based on detailed ovarian and endocrinological studies. It appeared that creep feeding may reduce lactation yields and advance cyclicity. Exogenous melatonin may increase conception rates in lactating cows; no other hormonal treatments were developed into applied methods for control of the PPAI. Studies of reproductive responses to heifer supplementation and of cessation and resumption of cyclicity in heifers with decreasing and rising nutritional planes were initiated; no results were available, though previous research suggested that weight x puberty relationships may be affected by pre-pubertal dry-season nutrition. Monensin and avoparcin were shown to be effective growth promotants in high-energy diets and supplements fed to weaners. Grain-based rations achieved higher production than molasses-based rations in small weaners.

Contacts

Geoffry Fordyce	QBII, Swan's Lagoon Millaroo, Qld 4807	Ph: 07 4784 9170; Fx: 07 4784 9232 Em: fordycg@dpi.qld.gov.au
Prof Keith Entwistle	UNE Armidale, NSW 2350	
Dr Jim Hogan†	Davies Laboratory Townsville, Qld 4710	

Part 2: Developing cost-effective strategies for improved fertility in *Bos indicus* cross cattle

MLA Project No.: NAP2:UNQ.009/DAQ.062

Project Duration: Jul 89 to Jun 94

Principle investigators: Prof Keith Entwistle (JCU), Geoffry Fordyce (QDPI), Dr Lee Fitzpatrick (JCU)

Objectives

Develop a range of practical and profitable management options to sustain a minimum branding rate of 75% from mating of maiden 2-year-old heifers, and to increase lactating cow conception rates by 20%.

Summary

Dry season supplementation of weaner heifers decreased average age and weight at puberty by 1.4 months and 19 kg. Conception rates in 2-year-old Brahman cross heifers will be at least 80% after 3 months if they weigh at least 250 kg at mating. Controlled yearling mating can economically improve lifetime reproductive output in north Australia. Spike feeding and wet-season nitrogen supplements may increase lactating cow pregnancy rates by ~20%; no fertility response occurs in lactating cows to short-term, post-calving supplementation, or to melatonin or oestrogen treatment. The research results were developed into new heifer management recommendations specific for the dry tropics; calf output can be increased by an average of 0.5 calves by 4.5 years of age and mortalities reduced.

Contacts

Geoffry Fordyce	QBIL, Swan's Lagoon Millaroo, Qld 4807	Ph: 07 4784 9170; Fx: 07 4784 9232 Em: fordycg@dpi.qld.gov.au
Prof Keith Entwistle	UNE Armidale, NSW 2350	
Dr Lee Fitzpatrick	AITVAS, JCU Townsville, Qld 4811	Ph: 07 4781 4168; Fx: 07 4779 1526 Em: lee.fitzpatrick@jcu.edu.au

Background

The average branding rate in north Australian breeding herds is 55%-60%, and ranges from 35% up to 85%. Annual average female mortalities are estimated to be almost 10% and range between 1% and 15%. Fertility and survival rates are both higher in better environments and with better management. However, for most of the region, better heifer and cow management strategies are required to achieve consistently higher branding rates, with conceptions concentrated into the mid-late wet season so that mortalities can be reduced.

Objective

This project aimed to develop a range of practical, efficient, and profitable management strategies, with particular emphasis on young females, which would enable beef producers to consistently achieve minimum branding rates of 75% from mating of maiden 2-year-old heifers, and to increase lactating cow conception rates by 20%.

Method

In a five-year, collaborative project involving Queensland DPI, James Cook University, CSIRO, and NSW Agriculture, 17 research tasks were implemented. Thirteen of these tasks were incorporated in DAQ.062 and UNQ.009. These covered improving fertility and management efficiency of maiden

heifers, reducing lactation anoestrus with particular emphasis on first-calf cows, and developing management systems to increase young female calf output.

Research and conclusions

Heifer fertility

Heifers as young as 2 months of age weaned each year (1,380 in 8 groups) were supplemented or not in the dry season post-weaning, vaccinated or not against androstenedione, and then mated initially as either yearlings or 2-year-olds. First evidence of cycling was recorded, as were subsequent conceptions and calf output.

This project has provided for the first time, estimates of age and weight at puberty for *Bos indicus* cross heifers in the dry tropics, how this is affected by seasons and supplementation, and the implications in relation to mating management. Though the research used 5/8 Brahman crosses, it is expected that the same principles apply to higher grade Brahman cattle.

The variation in time of puberty was large. Over several year groups within management groups, the standard deviations were about 50 kg for weight and 5 months for age.

The average age at puberty was delayed in poorer seasons, with a range of 1.5 to 2.3 years recorded. A major finding was that average weight at puberty in these 5/8 Brahman cross heifers increased as age at puberty was delayed (+4-5 kg/month). For example, when the average age at puberty was 1.5 years, the average weight was about 270 kg; when the average age was delayed to 2.3 years, the average weight increased to approximately 310 kg.

Dry season supplementation of heifers appeared to simply simulate improved seasonal conditions; ie, advanced age at puberty, and reduced average weight at puberty - a double bonus. There was no long-term effect on fertility as lactating cows.

Another major finding was that heifers weaned at a younger age reached puberty at the same age and weight as their older counterparts. This means that puberty was later in early weaners simply because they were younger at weaning. Again, there were no effects on lactating cow fertility.

Androstenedione vaccination did not consistently affect pre-pubertal development and had no significant influences on conception rates at first mating or on subsequent fertility.

Detailed hormonal studies indicated that there were no specific periods of sensitivity to undernutrition during the pre-pubertal period. Techniques which can reduce the effects of E_2-negative feedback on pre-pubertal development have yet to be developed.

From our data, and that of other reported research, a model for predicting weight at puberty has been developed (Figure 1).

Maiden heifers which conceive in the first 3 months of continuous mating have higher long-term fertility (+0.1-0.2 calves under good management and continuous mating) and survival. High conception rates in this period were achieved in supplemented heifers in all years, but were as low as 55% in one unsupplemented year group in which 80% had not reached puberty till 2.6 years of age. Obviously, early weaning further exacerbated this problem, though supplementation advanced puberty sufficiently to achieve high conception rates as maiden 2-year-olds.

Conception rate in yearling-mated heifers was a function of the proportion reaching puberty; it averaged about 30% in the first few months of mating in those which were supplemented as weaners. The conception rate was 15% higher in heifers supplemented in the post-weaning dry season than in those not supplemented. Yearling mating increased long-term calf output on average by about 0.3 calves. It was found that 2-year-old heifers calving in the latter half of the growing season often experienced dystocia.

Intensive studies simulating weight loss and recovery of heifers in their second dry season showed that cyclicity in post-pubertal heifers will cease when 16-17% of weight is lost, with more profound anoestrus when 23% of weight is lost. Cycling does not resume till heifers grow beyond the weight at which loss

commenced. This indicates that prevention of weight loss will achieve a rapid return to cyclicity which is necessary following breaks to prolonged dry seasons which occur around the time of mating.

In detailed physiological and endocrinological studies of heifers fed energy-deficient diets, profound anoestrus was achieved. Supplementation to prevent energy deficiency and sustain reproductive activity must include an appropriate protein balance.

A large number of possible strategies for contraception for controlled periods in heifers were reviewed and one tested. None was considered suitable, though implants incorporating trenbolone acetate may be worthy of further developmental research.

Lactation anoestrus

Spike feeding, the basics of which were developed in a previous project, was further evaluated in detail and at a practical level. Lifetime calf output was shown to increase by 0.3 calves on average; ie, herd branding rates increased by 5%. The approach necessary to consistently achieve a profitable response to spike feeding was defined and released in a producer-targeted publication.

Neither the use of melatonin implants in late-pregnant cows, nor the use of late-wet season creep feeding in lactating cows were found to produce any significant fertility responses. Despite reports prior to this project of potentially-good responses, these strategies are not recommended for north Australian cattle producers.

Protein levels in tropical pastures deteriorate rapidly in the wet season. Supplementation of lactating cows over the wet season with urea + sulphur was found to increase pre-weaning conception rates by up to 25%, even at very low intakes. Incorporation of N+S into wet season licks (generally based on phosphorus) throughout north Australia is recommended.

Short-term supplementation of lactating cows with 2 kg/day of a protein meal in the late wet season was found to increase pre-weaning conception rates by at least 10%. Astute timing may increase the response to 20%. However, it was clearly shown that this type of supplement in the early-mid wet season when cows are in peak lactation will not enhance fertility, despite having significant effects on both cow and calf growth.

Endocrinological studies confirmed the potency of oestrogen (E_2) negative feedback (in addition to the E_2-independent suckling effect) on recommencement of cycling in lactating cows. Short-term supraphysiological levels of E_2 were not able to counter the negative feedback. Vaccination against androstenedione (an E_2 precursor) may achieve this effect and warrants future study.

A profound negative effect of suckling on postpartum cycling was shown. The period to resumption of cycling after weaning was inversely related to body condition at weaning. Cows weaned in medium-good condition resumed ovarian cycles within about 50 days. However, ovarian cyclicity was only achieved about 30 days after an improvement in nutritional conditions in cows in poor condition when their calves were weaned. This indicates appropriate nutritional management to achieve target conception rates in lactating cows.

Calf output

A combination of high-level supplementation and yearling mating in the Burnett region was not able to achieve target growth and fertility because of prolonged severe seasonal conditions. The actual increase in calf output achieved of 0.3 calves was not profitable. The data indicated that this strategy would be profitable if calf output could be increased by 0.5 calves or that the supplement costs were reduced by 40% to achieve a 0.3 calf output increment. This is likely to be quite possible in average-good seasons.

Recommendations for beef producers to increase reproductive efficiency of breeders

A management system based on this project's findings has been developed for north Australian beef producers. The key features of this system are:

- Segregation of weaner heifers and provision of above-maintenance nutrition in the post-weaning dry season. Early-weaned heifers should be segregated from older heifers to increase efficiency of nutritional management.
- Segregation of heifers from 0.5 to 3.5 years of age in a heifer paddock(s).
- Mating the three age groups in the heifer paddock(s) for about 3 months each year commencing at a time which ensures calving starts at about the time when first storms are expected in an average year.
- Spike feeding, when seasonal conditions are appropriate, in the heifer paddock.
- Provision of wet season licks that incorporate nitrogen and sulphur to heifers and mature breeders.
- Culling/selection annually to 3.5 years of age based on economically-important traits, eg, physical traits, growth, and fertility.
- At 3.5 years of age, transfer selected heifers to the mature breeding herd.

The benefits of this system over traditional management are:

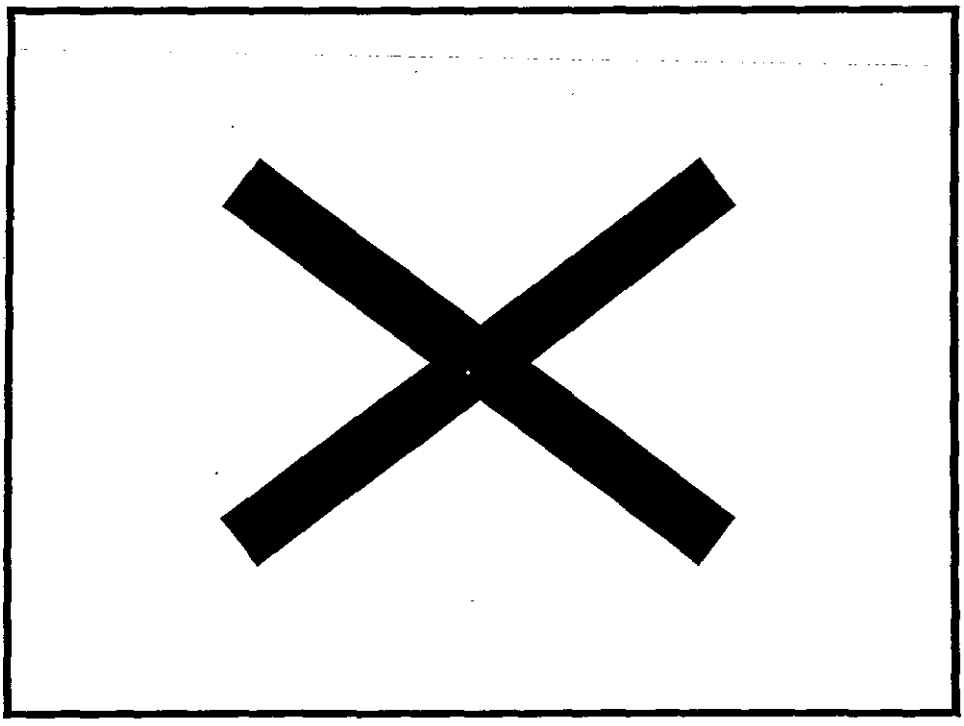
- Mortality rate is lower because of supplementation and controlled time of calving.
- Calf output to 3.5 years of age is significantly higher.
- Segregating heifers enables targeted and more efficient husbandry.
- Tight calving patterns allow efficient nutritional and weaning management.
- The highest performing heifers, which are needed as replacement breeders, are efficiently identified.
- Cull animals are efficiently identified, thus enabling targeted management for profitable marketing.

Economic evaluation for a high proportion of north Australian herds shows that incorporation of this management system will increase Gross Margins by at least $5/AE. The overall estimated increase in profitability of the north Australian beef industry, given a 20% adoption, is a minimum of $10M annually.

Continuing studies

The R&D initiated in 1986 involved study of lifetime growth and calf output of cattle. This will be completed in 1999. Detailed analyses of data is now being conducted. Scientific papers will be submitted for peer review by the end of 1999.

Figure 1. A model for puberty in heifers



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Bull:Female Ratios

Presenters: G Fordyce[1], LA Fitzpatrick[2], J O'Kane[3], N Merrin[3], J Armstrong[4] and J De Faveri[5]

[1]Queensland Beef Industry Institute, Department of Primary Industries, Swan's Lagoon Beef Cattle Research Station, Millaroo Qld 4807 Australia, [2]Australian Institute of Tropical Veterinary and Animal Sciences, James Cook University, Townsville Qld 4811 Australia, [3]Kamilaroi Station, Cloncurry Qld 4824 Australia, [4]Stanbroke Pastoral Company, PO Box 155, Brisbane Qld 4001 Australia, [5]Queensland Department of Primary Industries, Mareeba Qld 4880 Australia.

Abstract

At Kamilaroi Station (dry tropics, north Australia), conception patterns and calf output were determined for a group of 24 2- and 3-year-old Brahman bulls mated for 3.5-4.5 months in consecutive years to 300-350 cycling Brahman females (6% bulls:females). They were compared to a second group of 10 Brahman bulls selected on reproductive soundness and mated to an equivalent female group in a neighbouring paddock (2.5% bulls:females). The cattle grazed large, flat paddocks (60-84 km^2) with no natural waters. Calf output per bull was repeatable across years (r=0.7). Although calf output varied greatly between bulls within years, bulls consistently had high or low pregnancy rates. The top 6-8 calf producers (2% bulls:cycling females) in each paddock in each year sired 80-90% and 60% of calves in the 2.5% and 6% bull groups, respectively. Reproductively-sound bulls achieved an average of >4 pregnancies per week over the peak mating period when sufficient cycling females were available (2.5% bulls:females). Differences in pregnancy rates between paddocks appeared due to differences in nutrition and not bull:female ratios. Thus there were no detrimental effects on herd conception patterns when reproductively-sound bulls were expected to achieve an average of 4 pregnancies/week. Regular bull attrition occurred when using 6% bulls:females but not at the lower ratio. These observations demonstrate that under extensive north Australian conditions with controlled waters and using reproductively-sound bulls, 2.5% bulls:females is generally adequate; *cf*, current practice of an average of 4.3% bulls:females.

Introduction

At present, there is little scientific information to substantiate recommendations on bull selection and mating practices for extensively-managed *Bos indicus* cattle. Bull:female mating ratios average 4.3% in tropical Australia (1); bulls achieve an estimated average of only one conception/week during the peak mating period. Bull cost per calf when using $1,500 bulls is less than $10 when annual calf output is high (30+), but over $100 when calf output is low (0-3).

Using fewer bulls (without reducing herd fertility) of higher breeding value will accelerate genetic improvement. The estimated annual net financial benefit of this for a typical north Australian beef producer with a 3,000 adult equivalent (AE) herd is ~$5/AE.

Our research examined the hypothesis that conception pattern in extensive herds will be delayed when using reproductively-sound bulls if the bull:female mating ratio is reduced to 2.5%.

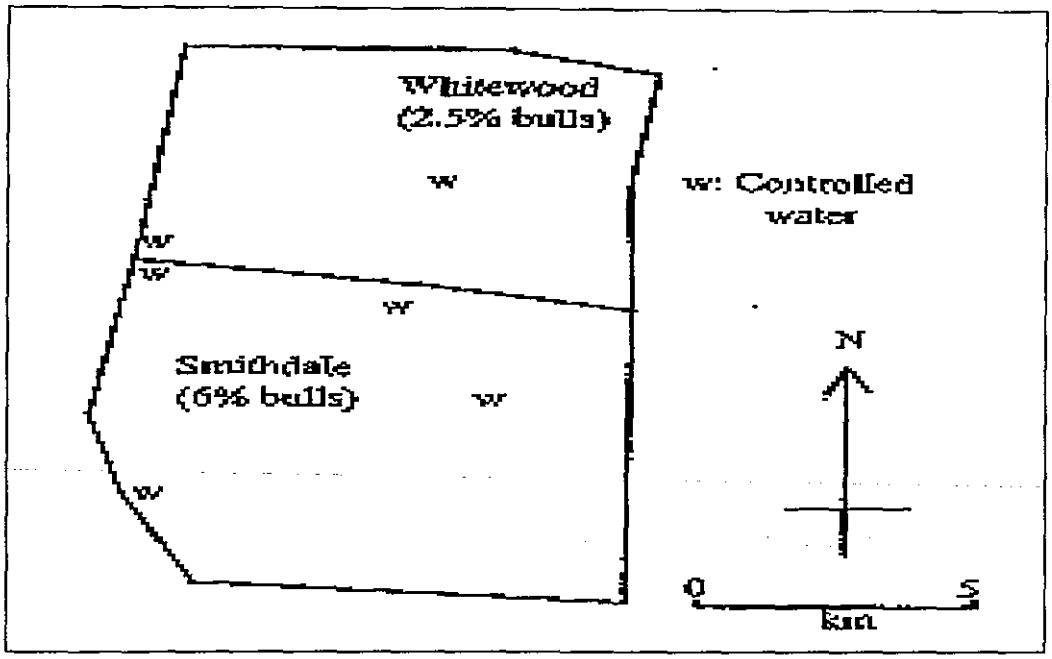
Materials and methods

Location

The study was carried out on Kamilaroi Station (140° 2'E, 19° 25'S) in the dry tropics of north Queensland's 'gulf' country. Two paddocks were used (Figure 1): Whitewood (60 km^2) and Smithdale (84 km^2). The area is flat with low-fertility, black, clay soils. Trees grow on a little over half of each paddock; an open plain covers the south-central area of Whitewood and the north-central area of

Smithdale. Average annual rainfall over the study period was 375 mm with most falling between late December and March.

Figure 1 Kamilaroi project site



Animals and management

The cattle used were all Brahmans. The 50 available No.92 (ie, born between July 1991 and June 1992) and No.93 Brahman bulls used were bred 1,000 km to the east of Kamilaroi and trucked in immediately prior to the study. Bulls were vaccinated against botulism and campylobacteriosis. The available bulls were divided into two equivalent groups based on weight and reproductive soundness One bull in the first group was removed because of his very poor temperament leaving 24 bulls for a 6% bulls:females group, representing usual heifer mating practice for the station (Smithdale paddock). Ten bulls rated as having the best reproductive soundness were selected (% normal sperm not used) from the second group of bulls for a 2.5% bulls:females group (Whitewood paddock).

Mating was for 3.5 and 4.5 months in 1994/95 and 1995/96, commencing in mid and early December, respectively. Female numbers were managed so that 300-350 were expected to cycle within the mating period in both paddocks in both years. In 1994/95, two groups of 411 heifers (2 years old, 245-390 kg, 80%<300 kg) were mated. Those conceiving within the first 3 months of mating were retained for 1995/96 when a further 350 heifers were added to each paddock.

Measurement: Females

Pregnancy diagnosis was used to estimate day of conception for each cow. In May 1996, body condition (1=emaciated, 3=poor, 5=store, 7=prime, 9=overfat) and lactation status were recorded; weigh scales were unavailable. Only No.94 heifers had individual identification.

Measurement: Physical traits of bulls

At musters in December 94 and August 95 (pre-mating) and May (post-mating) each year, measurements were made of weight, body condition, structural soundness, prepuce, navel, penis, testes, semen and serving capacity of each bull using standard procedures (2).

Measurement: Calf output

Blood samples from bulls and calves were used for microsatellite DNA testing to determine paternity. This was carried out for all No.96 calves (from 1994/95 mating), and the heaviest 250 male and 250 female No.97 calves (corresponding to the earliest 1995/96 conceptions). Monthly conceptions were

estimated for each bull; calculations used estimated conception patterns, estimated gestation lengths, calf weights, estimated calf birth weights, and paternity data.

Statistical analyses

After log transformation, repeatability of calf output was calculated using variance components estimated by REML (3). For bulls which sired at least 10 calves, differences between conception patterns were tested using survival analyses (4). Generalised linear models with binomial error structure (3) were fitted to test the effects of pre-mating weight, post-mating condition score, and lactation status on pregnancy rates in May 1996 in separate analyses for No.94 heifers and No.93 cows in Smithdale and Whitewood.

Results

Physical traits

At allocation, bulls were in backward store to store condition (373 kg average). By the end of their first mating, they were in forward condition. Bulls in both groups gained approximately 80 kg in their first year and >100 kg in 1995/96 (visual estimate: scales unavailable).

Cattle nutrition was poorer in Whitewood (2.5% bulls) than in Smithdale (6% bulls). In Whitewood (2.5% bulls), there were only 2 waters, both on the southern side; *cf*, Smithdale where there were 4 waters in the paddock (Figure 1). This resulted in much less grass in Whitewood within grazing range. This is reflected in the higher body condition scores of Smithdale cattle at the end of mating in May 1996: 7.6 *v* 7.5 for No.94 heifers; 4.7 *v* 4.4 for lactating No.93 cows; 7.4 *v* 7.3 in non-lactating No.93 cows; 7.7 *v* 7.3 in bulls. Estimated pre-weaning growth of Smithdale calves was also 4% higher than of Whitewood calves (average: 0.78 kg/day). Condition and weight of females was not recorded at the end of the 1994/95 mating, however, most heifers were in forward condition.

Late in the 1994/95 mating, one bull went missing (dead?) in Smithdale. At similar times in 1996 and 1997 in Smithdale, a bull was found with a fractured leg. This equates to 4-5% annual bull attrition. No bull losses were recorded in Whitewood.

Behaviour

Bull control was good but not absolute. One 'Smithdale' bull spent the 1994/95 mating in Whitewood. A stray mature bull also entered Whitewood; he sired 46 calves. In 1995/96, one Whitewood bull absconded at the start of mating.

Conceptions

In both years, it appeared that many females conceived in the first 4-6 weeks of mating: ~30% in 1994/95 and ~40% in 1995/96 (Figure 2). Following this period in both years, there was a steady and parallel increase in cumulative pregnancy rates in both paddocks; for heifers this was ~4% per week in 1994/95 and ~1.3% per week in 1995/96. These results are also expressed in pregnancies/bull/week (Table 1).

Table 1 Average pregnancies/bull/week at Kamilaroi

1994/95 mating	First 4 wks	Next 12 wks
Smithdale (6% bulls)	1.4	0.8
Whitewood (2.5% bulls)	2.1	1.6
1995/96 mating	First 6 wks	Next 14 wks
Smithdale (6% bulls)	1.9	0.4
Whitewood (2.5% bulls)	4.1	1.0

Part 3: Breeder Herd Management

MLA Project No.: Qld DPI project 621

Project Duration: Jul 86 to Jun 99

Principle investigators: Geoffry Fordyce (QDPI)

Objectives

Demonstrate an efficient management system for breeding herds in the dry tropics and describe its biology

Summary

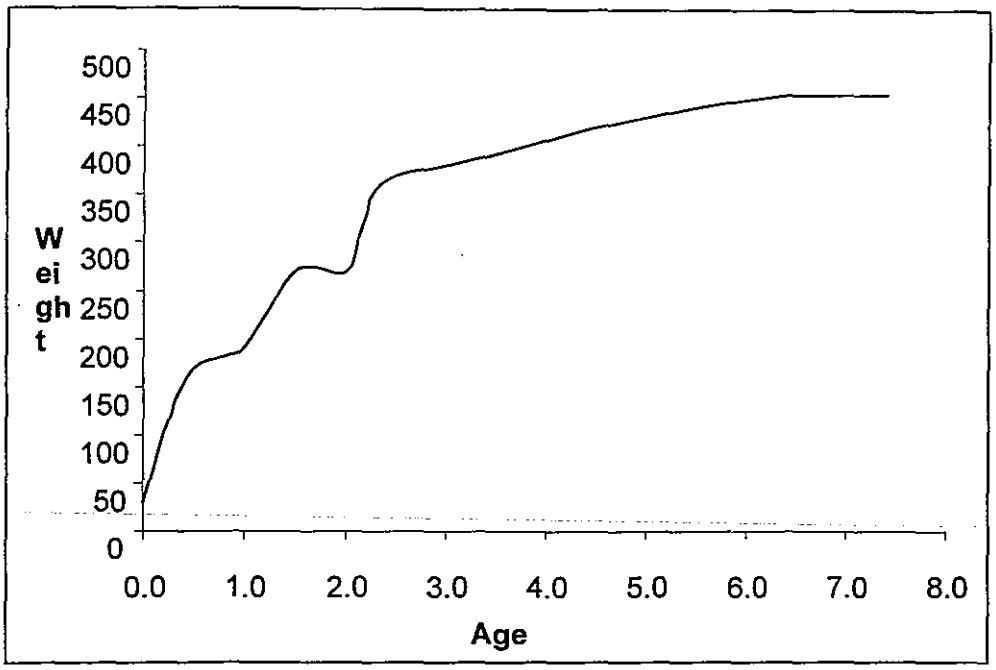
A closed herd of 5/8 Brahman cross cows (930 in the dry season and 1130 in the wet season after maiden heifers are added) is run using targeted, efficient management: continuous mating; conservative stocking rates; musters in April/May and August/September; weaning calves over 99 kg at each muster; crisis supplements to prevent mortalities; vaccinations against botulism, other clostridial diseases, leptospirosis, and campylobacteriosis; initial mating at 2 years; age culling at 9 years; objective selection of replacement breeders. An open (to the main breeder herd) bull-breeding nucleus herd (100 in the dry season and 130 in the wet season after maiden heifers are added) is managed similarly, except that mating is restricted to 5 months. The environment is a dry tropical savanna woodland with 75% of rainfall in the summer months of December to March. The predominantly duplex soils are P-deficient (average of 5.9 μg/g). Black spear, Indian couch, Golden beard, and wire grasses constitute ~70% of the pasture in approximately equal amounts.

From an average weight of 320 kg when mated as maiden 2-year-olds, cows reach an average mature weight of 450 kg (corrected for pregnancy) at 6.5 years of age; however, they reach average mature height of 1.34 m at 4.5 years of age having gained an average of 6 cm from initial mating. Branding and weaning rates average 83% (77%-92%). Cows rearing a calf to weaning are 30-60 kg (corrected for pregnancy) lighter than cows not rearing a calf. Cow mortalities average ~1.5%. Median confirmed pregnancy to weaning losses are 8%; losses average 6% and 35% for cows rearing and not rearing a calf to weaning in the previous year. Average time between 1st and 2nd conceptions is ~ 420 days. Approximately half the calves are born in November and December each year. An average of 34%, 45%, and 22% of calves weigh 100-149 kg, 150-199 kg, and over 199 kg at weaning, respectively. The proportion weaned in April/May averages 81% (71%-87%). Pre-weaning growth rates of female calves average 0.82 kg/day. Post-weaning growth in non-reproducing females averages ~100 kg/year up to 3.5 years of age. The nucleus herd is very effective in achieving breeding objectives.

Contacts

Geoffry Fordyce — QBII, Swan's Lagoon, Millaroo, Qld 4807 — Ph: 07 4784 9170; Fx: 07 4784 9232; Em: fordycg@dpi.qld.gov.au

Figure 1. Growth of 5/8 Brahman females on Swan's Lagoon (dry tropics)



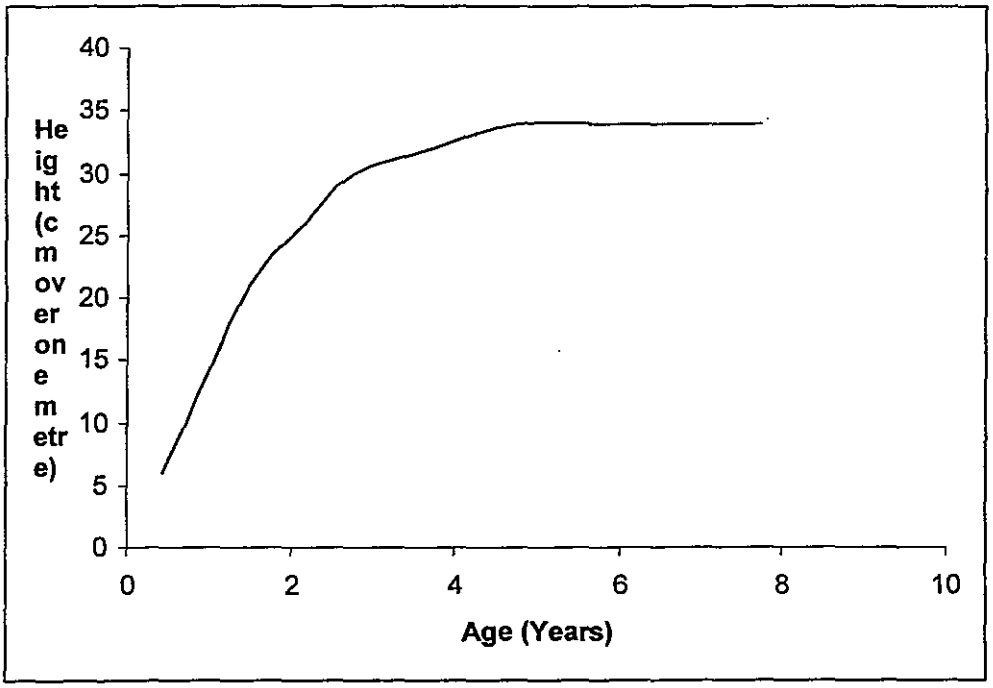


Figure 2. Average calving pattern for continuously-mated cows on Swan's Lagoon (dry tropics)

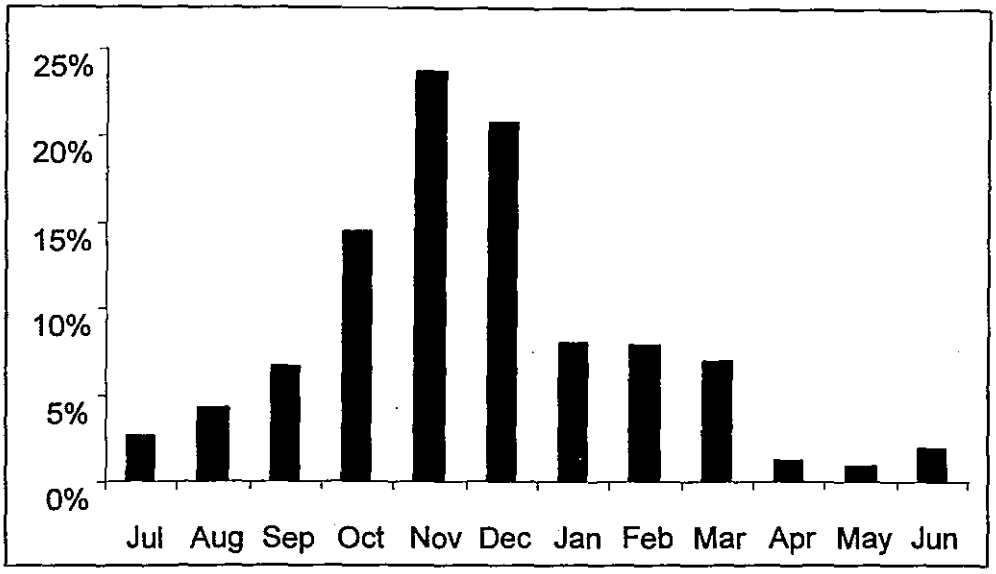
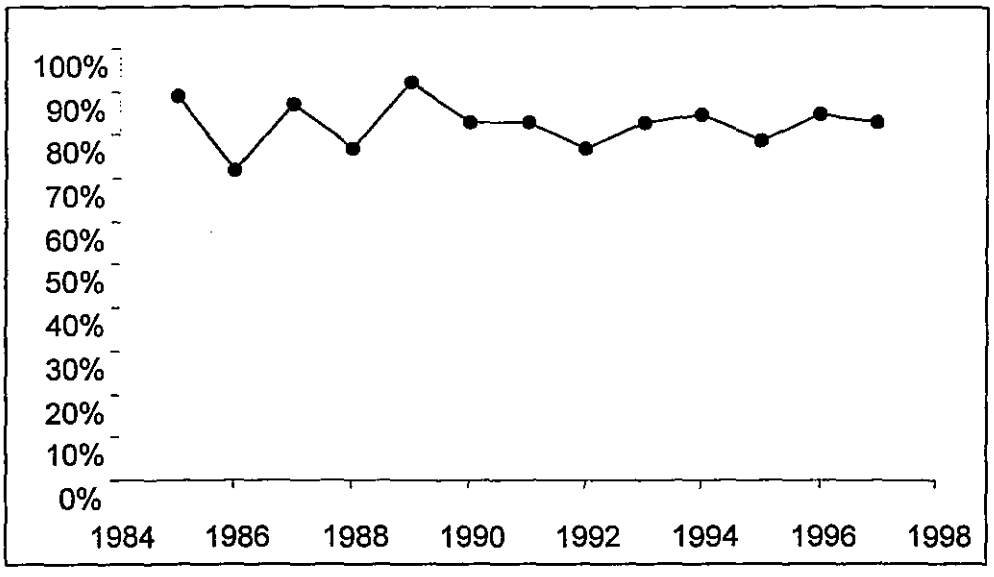


Figure 3. Branding rates (calves branded/cos mated in previous year) for the continuously-mated Swan's Lagoon herd (dry tropics)



Part 4: Northern Stocking Rate Demonstration: Swan's Lagoon Site

MLA Project No.: Qld DPI project 621

Project Duration: Jul 86 to Jun 99

Principle investigators: Geoffry Fordyce, David Smith, Kev Shaw, Peter Smith, Alan Laing (QDPI)

Objectives

Compare the production efficiency of breeder herds stocked to achieve low, optimal, and high grazing pressure on native pastures and the effects of these strategies on the pasture.

Summary

As one of 4 sites in the dry tropics of north Queensland, the Swan's Lagoon breeder herd has been allocated to 3 levels of grazing pressure on native pasture:

	SAFE	VARY	HIGH
Grazing pressure	30% wet season utilisation of pasture	50% dry season past utilisation	Representative of the region
Useable area (ha)	Sandalwood: 2160	Burns: 910	Holroyd: 950
ha/breeder unit	7.0	3.5-7.0	3.5
Av pasture (kg/ha): Apr	1870	1670	1470
Av pasture (kg/ha): Oct	1340	950	860
<500 kg/ha: Oct	44%	54%	60%
Pasture composition	Black spear, Indian couch, Golden beard, and wire grasses constitute ~70% of the pasture in approximately equal amounts; no grazing pressure effect		
Est dry seas pasture utilisation	30%	50%	70%
Opp to achieve burn objectives	Most years	Wet years	Rare
Tree basal area (m^2/ha)	3.3; no grazing pressure effect		
Weight	Standard	Standard	25-60 kg lighter
Spayed heifer growth (kg/yr)	100	100	100
Survival risk cows: Sep	Average of 33% of cows in each paddock: HIGH has fewer late pregnancies, but cows poorer		
Branding rate	85%	83%	84%
Conception/calving pattern	Standard	Standard	2-4 weeks later than standard
Calves >150 kg: Apr	68-72%	46-71%	30-55%
Profitability	Results for first 3 years available in Mar 1999		

Contacts

David Smith	QBII, Qld DPI Ayr, Qld 4807	Ph: 07 4783 2355; Fx: 07 4783 3193 Em: smithdr@dpi.qld.gov.au
Geoffry Fordyce	QBII, Swan's Lagoon Millaroo, Qld 4807	Ph: 07 4784 9170; Fx: 07 4784 9232 Em: fordycg@dpi.qld.gov.au
Peter Smith	QBII, Qld DPI Charters Towers, Qld 4820	Ph: 07 4787 2155; Fx: 07 4787 4998 Em: smithpc@dpi.qld.gov.au
Alan Laing	QBII, Qld DPI Ayr, Qld 4807	Ph: 07 4783 2355; Fx: 07 4783 3193 Em: lainga@dpi.qld.gov.au

Discussion / Comments

Q1. *In a heifer management system, at what point should there be culling for reproductive failure?*

A1. In most instances, the first culling will be at ~2.5 years for failure to conceive up to that time. However, in some situations, depending on such factors as pregnancy rates achieved and replacement heifer needs, culling can be (and is being!) conducted in yearlings.

Q2. *Heifer management, as advised, requires a higher level of management than often exists; concerned that implementation may be inappropriate if infrastructure and management skills are not already in place.*

A2. Agree that beef businesses must finance themselves into improved management. The primary aim of espousing the heifer management philosophy is so that:

Graziers accept the current situation with heifer reproductive development and management (yearling mating is the norm; see 1990 NAP survey) and can appreciate the opportunities using the different approach. The recipe may vary, but the general philosophy is consistent.

In the process of change, graziers have a better planning focus, thus achieving more efficient adoption of different management.

Q3. *Need to define when confirmed pregnancy to weaning foetal and calf wastage is occurring and exactly how parameters are derived.*

A3. This is being done in previous (eg, Holroyd 1987) and planned future publications.

Q4. *Why were non-reproducing cows left in the herd?*

A4. Previous research is generally based on data from herds where culling for reproductive failure is very soon after it is initially expressed. Our approach was not to cull; we can then simulate any culling strategy using real data. The data we have certainly shows the benefit of culling for reproductive failure.

Q5. *Explanation for why yearling conception increases lifetime calf output.*

A5. Most heifers that conceive as yearlings fail to conceive as lactating 2-year-olds. As dry 3-year-olds, most conceive. At 4.5 years of age they will have reared at least 2 calves and have close to mature lactating cow pregnancy rates. Compare this to the same heifers unmated till 2 years. Most will be lactating at 3.5 years with generally-low lactating cow pregnancy rates (typical first-calf cows). At 4.5 years, the number of calves raised varies between 1 and 2 (typically it is 2 minus the proportion that would have conceived as yearlings; and it is higher with better nutrition), and pregnancy rates will not be significantly higher than in the yearling-pregnancy contemporaries. Thus they have a disadvantage in calf output which remains with them.

Q6. *In view of recent studies showing vertical trans mission of abortifacient agents (eg, Neospora caninum), have the causes of foetal and calf wastage been identified in the research and to what extent might they contribute to the apparent high repeatability?*

A6. The only detailed studies of the causes of foetal and calf wastage that we have conducted was reported by Holroyd (1987). This did not include repeatability estimates.

Q7. *What happens when you do simulate culling based on failure to rear calves using the Swan's Lagoon data set?*

A7. We have yet to conduct the simulation.

Q8. *Does the data relating foetal and calf wastage as a function of previous calf rearing use heifer data?*

A8. The data set used includes only heifers mated as 2-year-old maidens. So losses as a function of previous reproductive success can only be made for cows between 3.5 and 9.5 years of age.

Q9. *An average branding rate of 83% is very good by industry standards; what is being done to achieve this?*

A9. The primary factors driving the high productivity of the Swan's Lagoon herd are:
A genotype selected for adaptation and productivity in the environment
Conservative stocking rates. Weaning twice yearly down to 100 kg at the wet/dry transition and 4 months later. Vaccination against botulism

Improving Cost-effectiveness of Supplementation Systems for Breeder Herds

Project No.: Project DAQ.098

Project Investigators: Rob Dixon, Carol Petherick, Michael D'Occhio and Geoffry Fordyce

Summary

Low level strategic supplements constitute one of the few options for northern beef producers to increase breeder productivity and profitability. Objectives of the project were to improve the cost-effectiveness of using such supplements and to improve supplement delivery systems. Urea-Based supplements fed during the dry season can substantially reduce breeder liveweight loss and increase fertility during severe dry seasons. Also when fed during the late wet season these supplements increased breeder body liveweight and increased fertility of breeders in low body condition. Intake of dry lick supplements fed *ad libitum* is apparently determined primarily by the palatability of the supplement relative to pasture; training of cattle appears to be of limited importance. Siting of supplementation points can reduce supplement intake but has little effect on grazing behavior. Economic analysis of supplementation (urea, phosphorus or molasses) and weaning strategies was based on the relative efficacy of strategies to maintain breeder body condition through the dry season. Adequate body condition of breeders in the late dry season is needed to avoid mortality from under-nutrition and achieve satisfactory fertility of breeders during the following wet season. Supplements were highly cost-effective when they reduced mortality, but economic returns were generally low when the only benefit valued in the analysis was the increased weaning rate. Additional important benefits from maintaining breeders in improved body condition include a tighter and more appropriate calving pattern and greater flexibility to manage climatic variability. These benefits would often justify strategic supplementation programs.

1. Objectives

The general objective of the project was to improve options for the producer to increase the profitability of the breeding herd managed under extensive grazing conditions in the intermediate and harsh zones of northern Australia by more cost-effective and more widespread use of strategic supplements. This was to be done by improving understanding of the consequences of strategic supplementation systems on breeder herd productivity and by developing best-bet management packages to assist decision-making.

The specific objectives of the project were:

(a) to further develop supplementation technology to improve the cost-effectiveness of using supplements to increase the performance of the breeder herd in northern Australia.

(b) to improve supplement delivery systems to achieve target intakes of supplements and reduce variability of supplement intake amongst animals, and to identify the consequences of siting of supplement feeding sites.

2. Task areas

2.1 Task 1. Effects of urea-based supplements on breeder productivity.

Urea-based dry lick supplements were fed during the dry season and/or the late wet season to breeders grazing native pasture, and measurements made of breeder body status through the year and of reproductive performance. In addition, pen trials were conducted to improve understanding of the consequences of urea-based supplements on the protein and energy status of the cattle.

2.2 Tasks 2 and 3. Supplement delivery systems.

The lithium market technique was used extensively to measure individual intakes of supplements in the field by grazing mobs of cattle for a range of supplements and classes of cattle during both the wet

and dry seasons. These techniques were also used to investigate siting and design of supplementation points, and the consequences of siting on paddock use by cattle.

2.3 Tasks 4 and 5. Economic assessment and comparison of urea-based supplements with other management options to improve breeder productivity.

The consequences on breeder productivity of using strategic supplements for breeder herds ranging in historical productivity levels and in several climatic zones were assessed. This was achieved by developing a spreadsheet model (BREEDMOD) to predict fertility and mortality changes from breeder body condition status. The outputs of this spreadsheet model were then used in the BREEDCOW herd model to examine the changes in gross margin of the breeder herd as strategic supplements were used to increase herd productivity.

2.4 Task 6. Development of management packages and technology transfer.

Early in the project a major report collated past experimentation on the nutritional management of breeders, the results of Producer Demonstration Sites and industry experience on supplement delivery systems. A management package on strategies for supplementation and weaning in the dry tropics is being developed. Technology transfer was designed to depend on producer group interaction, development of the management package, publication in the Swan's Lagoon Research Reports and rural media and as scientific publications.

3. Main results

3.1 Task 1. Responses of breeders to urea-based supplements.

(a) During severe dry season conditions (eg. With no rain from March until December) urea-based supplements substantially reduced loss of breeder body reserves during the dry season. For example, in one experiment, liveweight loss during the dry season (as a % of liveweight at the beginning of the dry season) was reduced from 29% to 23% in first-calf cows, and from 24% to 14% in second-calf cows. This increased pregnancy rate by 8 and 14% units respectively. As well as increased pregnancy rate during seasonal mating, improved nutrition due to supplementation led to an earlier and tighter calving interval in the subsequent year. However in years when there was sufficient storm rain to grow at least a "green pick" during the winter and spring there was no response to urea-based supplement, presumably because the breeders were able to meet their requirements for rumen degradable protein from this pasture.

(b) Weaning breeders in April at the commencement of the dry season conserved breeder liveweight by 10 – 15 kg per month, about twice the benefit due to feeding urea-based supplements. The benefits of earlier weaning and urea-based supplement to conserve body condition of the breeder through the dry season were generally additive.

(c) Increases in breeder fertility due to feeding urea-based supplements during the dry season were closely related to the improved liveweight and body condition of the breeders at the time of mating. For *Bos indicus* cross cows in lower than "store" body condition, fertility was increased by about 54% units for each 10 kg increase in breeder liveweight at mating.

(d) Urea-based supplements fed during the late wet season following seeding of native grasses improved liveweight status of lactating breeders and increased fertility of breeders in "backward store" or lower body condition. It did not increase fertility of those breeders which were in al least 'store' body condition at this time and where fertility was already high.

(e) The results support the model that fertility of *Bos indicus* and *Bos indicus*-cross breeder herds in the dry tropics is limited primarily by the time required for resumption of ovarian activity by t the lactating cow, and that improved breeder body condition during early lactation can markedly increase fertility. In addition fertility can be adversely affected by severe liveweight loss pre-calving during the dry season, and by sub-maintenance nutrition post-calving.

(f) Urea-based supplements increased roughage intake and microbial protein synthe4sis, by cattle consuming dry season senesced pasture. Intake of dry season pasture was increased even when very high levels of urea supplement were fed. Thus improvement in animal performance occurred over a very wide range of intakes of supplementary urea, and for maximal animal response the amount of urea supplement required is much greater than current recommendations.

(g) Inclusion of cottonseed meal in urea-based supplements fed during the dry season did not improve pasture intake or efficiency of microbial protein synthesis, but did increase voluntary intake of supplement. The benefits of including cottonseed meal in urea-based supplements are most likely due to achievement of high intakes of urea supplement rather than to any specific nutritional benefit of the small amount of cottonseed meal in the dry lick.

3.2 Task 2. Improving supplement delivery systems to achieve target intakes and reduce variability.

(a) The most important factor influencing voluntary intake of low palatability dry lick supplements fed *ad libitum* was the palatability of the supplement relative to the palatability of pasture.

(b) Classes of animals with higher requirements for nutrients usually consumed more supplement. For example lactating cows consumed more supplement than dry cows.

(c) Exposure of weaners to high palatability supplements was investigated as a means to increase intake of low palatability supplements and reduce the proportion of shy-feeders in later life. Exposure of calves or weaners to palatable (eg. Cottonseed meal) supplements improved acceptance and intake of low palatability supplements for several weeks when they were first provided, but had no long-term effects on intake of such supplements. In some experiments feeding dry lick supplement to weaners did change, while in other experiments it did not change, their subsequent intake of supplements. These differences between experiments were not resolved, but it does appear that experience of cattle with supplements has only a secondary role to modify supplement intake.

(d) The proportion of shy-feeders within a mob and the variation among individuals in intake of supplements fed *ad libitum* depended primarily on the voluntary intake of supplement and the amount of feeder space available. When palatable supplements, based on molasses or cottonseed meal, were fed with adequate trough access the proportion of shy-feeders was negligible and the variation in supplement intake was always low (coefficient of variation (CoV) 20-40%). When intake of supplements was in the range 50-200 g/head day there were often up to 20% shy-feeders and CoV was in the range 50-90%. When supplement intake was less than 50 g/day the proportion of shy-feeders was high and was inversely related to intake. Reducing access to a supplement, by for example providing one small feeder for a mob of 100 head, increased the proportion of shy-feeders to more than 40% of the mob, even when supplement intake was in the range 50-200 g/head day.

(e) No consistent relationships were observed between intake of supplement and behaviour such as social rank (dominant-subordinate) characteristics.

(f) Siting of supplements distant (eg. 2 km) from water reduced intake of block or molasses supplements by 20-30%, but did not change variability in supplement intake or the proportion of shy-feeders.

(g) Design of supplement shelter sheds (eg. Sheds enclosed on 3 sides) had little influence on voluntary intake or variability in intake of supplement. This indicates that supplements can be fed in enclosed sheds for good weather protection without adverse effects.

3.3 Task 3. Consequences of siting of supplementation points on grazing behaviour.

In cattle grazing either small paddocks or a larger paddock (200 cows and calves grazing a 700 ha paddock) changing siting of low palatability dry lick supplements had no discernible

effect on grazing behaviour. The preferred grazing areas were apparently determined principally by soil type and vegetation. Although the cattle consumed the supplement when it was provided in the established grazing areas, they would not walk to another part of the paddock to consume a low palatability supplement or change their grazing area.

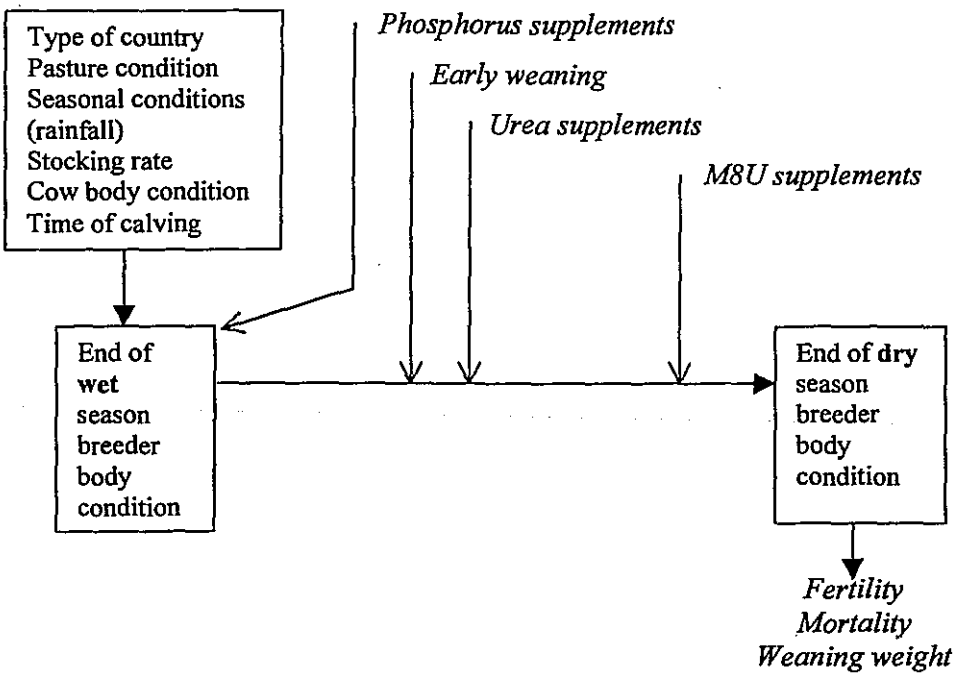


Figure 1. A schematic representation of the factors influencing breeder productivity in a semi-arid environment. It is assumed that fertility and mortality are determined primarily by breeder body condition at the end of the dry season and by the timing of the seasonal break.

3.4 Task 4. Comparison of urea-based supplements with other management options to improve breeder productivity.

For managers to choose the most appropriate management options for a specific situation it is clearly necessary to compare the efficacy and the cost-effectiveness of alternative strategies (eg. phosphorus supplements, urea supplements, earlier weaning, survival supplements). Since the most important factor influencing breeder fertility and mortality is breeder body condition status in the late dry and early wet seasons, management options were compared by their cost-effectiveness to achieve acceptable breeder liveweight at this time of the year (Figure 1).

Breeder body condition late in the dry season can be improved by:

(i) increased body condition at the end of the wet season (depending primarily on time of calving, pasture quality, seasonal conditions. phosphorus supplements), and

(ii) reduced rate of loss of body condition through the dry season (depending primarily on pasture quality, seasonal conditions, lactation status, urea supplements).

The option of using survival supplements (eg. M8U) to avert mortalities in years when there is a delayed seasonal break allows deferment of decisions until seasonal conditions are known and expenditure on supplements only in those years when it is essential.

3.5 Task 5. Economic assessment.

Changes in gross margin of the breeder herd due to strategic supplementation were highly dependent on supplementation costs to achieve an increase in the breeder body condition at the end of the dry season. The cost of urea-based supplements to increase breeder body

condition at this time was estimated from experiments conducted during the project, past experiments and industry information. The estimated cost to increase breeder body condition by one unit (eg. from "backward store" to "store" condition) ranged from about $7 (for efficient water medication) to $15 (for dry licks where it is difficult to achieve target intakes) to $30 (for some lick blocks). When urea-based supplements reduced breeder mortality they were highly cost-effective with, for example, increases in gross margin of up to $11 per animal equivalent. Where the only benefit valued in the assessment was increased number of calves weaned, and supplementation was assumed to cost $15 per breeder per annum, the increases in gross margin were generally small (eg. $-5 to $+2 pr animal equivalent). However when supplementation costs could be reduced (eg. to $7 per breeder by water medication) the gross margins due to supplementation were improved (eg. $1 to $16 per animal equivalent).

Benefits to improved management which were not valued in this economic assessment included:

(a) a tighter calving pattern earlier in the wet season leading to lines of weaners at first-round muster which are heavier and more similar in age and liveweight (this would increase the value of the weaner crop),

(b) fewer breeders lactating after first-round muster and during the dry season in continuously mated herds (leading to simpler and lower cost management of the breeder herd).

(c) much greater management flexibility in the event of a light or failed wet season and higher cull cow values because breeders are in better body condition year-round (thus reducing risk associated with variability between seasons).

The economic analysis also indicated that increases in gross margin were fairly similar for the three principal management options which can be applied within the annual seasonal cycle in the northern industry (ie. for urea-based supplements during the dry season, phosphorus supplements during the wet season and early weaning).

3.6 Task 6. Technology transfer.

A management package on the nutritional management of the breeder is being developed. This is written at a level suitable for extension officers and other technical staff servicing the cattle industry, and for leading-edge producers. A draft version is currently being circulated for comment.

Information from the project has been discussed with groups of producers at field days, NQBRC, Swan's Lagoon Committee of Management and at the Emerald Meat Profit Day. Material has been extensively made available in publications for industry (eg. Swan's Lagoon Research Report, Northern Muster newsletter, NAP3 News), incorporated into presentation material for QBII/LMA Nutrition Workshops and published in proceedings of scientific conferences.

4. Recommendations

4.1 Breeder herd nutrition

(a) The flow diagram shown in Figure 1 provides a basis to compare strategies. Urea-based supplements should be considered as only one possible strategy to improve breeder body condition. The best combination of management strategies will be highly dependent on individual circumstances.

(b) Where strategic urea-based dry season supplements reduce breeder mortality due to under-nutrition they are highly profitable. Where increased weaning rates are the only benefit from urea supplementation which is valued the returns are marginal. However there are other

benefits (eg. as reduced risk and greater management flexibility) from improving the nutrition of the breeder herd which would often justify increased inputs.

(c) Economic returns from urea-based supplements were highly sensitive to supplement input costs. With efficient water medication systems the supplement costs may be less than half the cost of dry lick systems, and one-fourth the cost of lick block systems. Even when the increased economic return depends entirely on increased weaning rate, urea supplementation using water medication could be highly profitable.

(d) Urea-based supplements are likely to be most appropriate in regions where:

(i) there is a low likelihood of storm rains during the dry season and a low variation between years in the date of the seasonal break ending the dry season,

(ii) breeder mortality from under-nutrition is expected to be high in the absence of intervention,

(iii) there is a substantial amount of dry standing feed available, and

(iv) survival supplementation systems are not appropriate or are very high in cost.

(e) Current general recommendations for amounts of supplementary urea should be retained (eg. 45-60 g urea per breeder per day during the late dry season; half these amounts during the late wet/early dry season). However, cattle will respond to a wide range in amounts of supplementary urea, and lower or higher amounts of urea supplement may often be appropriate to achieve a target animal response.

4.2 Supplement delivery systems

(a) It is clearly important to minimise supplement costs per unit of protein or phosphorus by using the lowest cost system appropriate to the specific circumstances. Generally water medication systems can be the lowest in cost, followed by dry lick and then lick block systems.

(b) Intake of dry lick supplements fed *ad libitum* is determined primarily by the palatability of the supplement compared to the palatability of pasture. Thus, supplement intake should be monitored and can be manipulated by adjusting the palatability of the supplement. Supplement intake can be reduced by up to about one-third by siting supplementation points distant from water.

(c) Exposure and familiarisation of cattle to supplements and to some specific flavours has some role in increasing acceptance. Where there are problems of acceptance by adult cattle of supplements weaners should be exposed to the range of supplements to be used subsequently.

(d) To avoid a high proportion of shy-feeders and high variation in supplement intake, average supplement intake by the mob should be at least 50 g/head/day. Supplements can be fed in three-sided sheds or similar structures that provide good weather protection without introducing a shy-feeder problem.

(e) Changing siting of low palatability dry lick supplements does not seem to change paddock utilisation by cattle.

5. Conclusions

Project DAQ.098 has substantially advanced the understanding of the role of management options, and in particular urea-based supplements and supplement delivery systems, to increase breeder herd productivity in the dry tropics of northern Australia.

- The project has collated and reviewed available information on supplementation and weaning management of the breeder herd in this environment. This material is being prepared for

publication as a comprehensive management package suitable for technical personnel servicing the northern cattle industry and for "leading-edge" producers.

- A conceptual framework, based on the fundamental relationships between breeder body status with fertility and mortality, was developed to compare the efficacy of dissimilar management strategies (e. urea-based supplements during the dry season, phosphorus supplements during the wet season, early weaning, M8U survival supplements) and to link breeder herd and pasture productivity. Although this framework is at present essentially qualitative, it provides a basis to build quantitative prediction of breeder performance, and to utilise historical information and best-available pasture and weather-forecasting Decision Support Systems. The most important phase of this conceptual model (ie. breeder body condition during the late dry season) was developed into a spreadsheet model (BREEDMOD) to estimate for a range of circumstances the consequences on breeder fertility and mortality of using management options to increase breeder body status. However, there are serious inadequacies in our ability to predict fertility from breeder liveweight and liveweight pathways. Changes in herd gross margin were used to evaluate the economic consequences of using management strategies.
- The project has improved understanding of the circumstances in the northern cattle industry where it is most appropriate to use urea-based supplements , and the likely increases in breeder productivity. Urea-based supplements are likely to be most appropriate where breeder mortality from under-nutrition is high, where there is low likelihood of winter rain and where early weaning and survival supplementation strategies are not appropriate.
- Systems to deliver strategic supplements to cattle grazing under extensive conditions were investigated with scientific rigour. Considerable progress was made to understand how target intakes of supplements can be achieved in the paddock.

Discussion / Comments

Q1. *Were there any relationships between size of grazing paddock and consumption of licks and blocks?*

A1. Licks and blocks were made available to cattle in two paddock sizes: Relatively small paddocks of 40 to 100 hectares – this was associated with a relatively low proportion of shy-feeders (<5%); Relatively large paddocks of 200 to 300 hectares – this was associated with an increased proportion of shy-feeders (*Rob did not give a %*).

Q2. *The economic returns from supplementary feeding might be questionable.*

A2. In drier areas $15/breeder would likely not be required and therefore this figure is overestimated; at Kidman Springs a benefit of approx. $50/head has been demonstrated from supplementation. The economic analyses indicate a break-even scenario if the main consideration is extra calves; a significant return on investment occurs when reduced cow mortality is the primary consideration; however, it will be important to factor other responses including improved body condition in relation to survival management.

Q3. *Wet season phosphorous supplementation is recommended, but what are the consumption patterns?*

A3. From research data and industry knowledge, intake of phosphorous can be encouraged by incorporation into supplement mixtures that are attractive or palatable to cattle; this ensures phosphorous uptake and also reduces the incidence of shy-feeders. Naturally, intake will also be influenced by the prevailing environmental circumstances.

Q4. *Have there been any difficulties with phosphorous supplementation during the wet season at Swan's Lagoon Beef Cattle Research Station?*

A4. At Swan's Lagoon, phosphorous supplementation has been given relatively late in the wet season, March/April, when cattle are more inclined to consume supplement.

Supplementation on large properties is not an exact science, but benefits have generally been demonstrated; perhaps another way of looking at the issue of supplementation is to consider the likely consequences of no supplementation?

Q5. *Weaning, supplementation etc all have an influence on body condition score; the other big benefit is native pasture; therefore, the basic response to management will be a function of the status of native pasture; could you please comment.*

A5. Agree. The quantity and quality of pasture is the underlying factor that will determine the response to any management input and/or supplementation.

Q6. *Should future research include Low, Medium and High underlying native pasture?*

A6. A Low underlying native pasture should perhaps be avoided, but it will be important to consult pasture scientists in the design of future studies that include a consideration of the status of native pasture.

Q7. *Sites of supplementary feeding lead to intense local grazing pressure and deterioration of the micro-environment; also, it is difficult to encourage cattle to change their grazing range; what can be done to continue supplementation whilst avoiding potential longer-term micro-environmental degradation?*

A7. In our studies, the placement of supplement at some distance from watering points resulted in a reduction in supplement intake; also, when supplement sites were changed, cattle retained their previous grazing patterns; however, this was with relatively low palatable supplements; perhaps similar trials should be repeated with highly palatable supplements.

Q8. *Did you analyse the drinking water in your trials, and is it possible that differences in the quality of water may have contributed to the outcomes?*

A8. The water was not analysed; however, it is considered very unlikely that differences in the water would have influenced the outcomes as all water was surface lagoon water.

Q9. *Did you analyse faecal matter in relation to general animal status?*

A9. Faecal matter was analysed but not intensively; the focus was on the measurement of faecal nitrogen in response to urea supplementation; we have obtained good data for relationships between faecal nitrogen and urea intake for cattle grazing predominantly speargrass pastures, but caution should be exercised in the extrapolation of this information for other pasture environments.

There are other flow-on benefits from phosphorous supplementation in addition to body condition, mortality and productive rates; for example, phosphorous supplementation can reduce the incidence of peg-leg.

General Discussion – Breeder Fertility and Management

Q1. *Ross Brunkhorst to Gehan Jayawardana*

I believe there is a need to elaborate on Tulis etc. of Brahmans and high grade Brahmans. MSA to see better quality. There is an opportunity to look at new breeds eg. Tulis and Tulis crosses leading to adapted Bos taurus and will outperform Brahmans. The industry needs to take a closer look at these new breeds and crosses. Northern Australia is doing so in the feedlot industry.

A1. Agrees. We need a composite of Tulis, Belmonts and Chandais, believing we need 80% adopted in the Northern Territory.

John Frish: Adaptation not confined to Brahmans alone. Other breeds that equal Brahman in adaptation are achieved through cross breeding with Tulis etc. Increased reproductive rate and increased survival through resistence to environmental stress. Increased productivity, including meat quality, through use of Bos taurus.

Mike Goddard: Posed the question to the audience "Why is there resistance to the use of Tulis etc?"

Henderson: I agree that it takes a long time to get the industry to change.

Q2. *Noel Haug to Rob Dixon*

What is the problem with the use of water medication?

A2. Rob explained the expenses involved and infrastructure needed.

Q3. *Tristin Jubb to Rob Dixon*

a) What is the guesstimate for those properties feeding supplementation with respect to its' effective use?

b) How many are using dry season supplementation cost effectively?

A3. a) 10% in the industry are using supplementation effectively
Mick Sullivan: 10% are using wet season supplementation.

c) This is the exception rather than the rule. Most people wouldn't know if it is cost effective.

Mick Sullivan: This is very routinely done, but difficult to quantify. Most people would know the cost into herds and intakes, but not know how this relates to the whole picture.

Session 3:
Reproductive Disease

Session 3: Reproductive Disease

Brief Review of Infectious Causes of Reproductive Failure in Beef Herds

Principal Investigator: M.R. McGowan
School of Veterinary Science and Animal Production
The University of Queensland

Campylobacter fetus subspecies venerealis (Vibriosis)

- Vibriosis is a commonly encountered infectious venereal disease of cattle. A survey of beef herds in the Victoria River district of the Northern Territory found 87% of herds were infected. Similarly, a high prevalence of infection has been reported for herds on the Barkley Tableland. Elsewhere in extensively managed, unvaccinated herds the disease is likely to be common. Also, a small proportion of bulls maybe concurrently infected with Tritrichomonas foetus.
- Bulls most commonly become infected by serving infected female animals. It should be noted that although most infected females eventually eliminate the infection up to 10% of infected heifers might still be infected at the time of calving. Most of these animals are free of the infection by 3 to 5 months after infection but a small proportion of infected heifers and cows remain permanent vaginal carriers of the organism. Bulls less than 4 years of age are generally considered to be more resistant to infection than older bulls; however, this statement was not supported by the findings from a study in northern Australia. Infection of the prepuce always remains strictly localized and produces no local or general symptoms. Spontaneous recovery from a natural infection occurs very rarely.
- In endemically infected herds, the highest proportion of susceptible animals is in the replacement heifer herd and hence this group experiences the greatest loss due to infection. Within a week of service by an infected bull, the campylobacter organisms have traversed the cervix into the uterus and subsequently in about 25% of heifers, the organisms reach the oviducts. The most obvious clinical indication of infection is repeated return to service, the inter-service often being prolonged to 28-35 days due to late embryonic mortality. Compared to uninfected females infected cattle on average require twice as many services to conceive and the interval from first service to conception is three times as long. In addition to a small proportion of infected females (5 to 10%) abort, most commonly between 5 and 7 months of gestation. A small proportion may be rendered sterile due to bilateral salpingitis. It has been reported that branding rates in infected heifer groups are often only 50 to 70% of those in non-infected herds.
- Females that have eliminated the infection are partly immune to reinfection and even when they do become reinfected their fertility is only marginally impaired. The organism in reinfected females is usually confined to the vagina.
- Probably the most effective method of confirming the presence of infection in a herd is by testing vaginal mucous samples for the presences of antibodies to Camphylobacter fetus ssp. venerealis. In endemically infected herds, sampling of mated heifers is most useful. Bulls must be tested repeatedly to be confirmed free of infection.

Tritrichomonas fetus (Trichomoniasis)

- Trichomoniasis is a protozoal venereal disease of cattle, characterized primarily by early pregnancy loss and, occasionally, by abortion and pyometra. The infection is seldom diagnosed in southern states and in the more intensively managed beef farming areas of Queensland and Western Australia. However, prevalence rates of 25% and 6% for bulls and cows respectively have been detected in extensively managed beef herds in far northern Australia.
  A survey of beef herds in the Victoria River district found that 66% of herds had evidence of trichomoniasis and 56% of herds had both vibriosis and trichomoniasis. There are several strains of T. foetus in Australia but their effects on female fertility seem to be similar
- The source of infection for bulls is the vagina of infected females. There are no lesions of diagnostic significance in infected bulls and the organism does not affect either semen quality or sexual behaviour. A scant purulent preputial discharge may be noted within the first 2 weeks of infection, but generally, the infected bull serves as an asymptomatic carrier. Older bulls (≥ 4 years) are more likely to become permanent carriers of the organism than younger bulls, most

likely due to the more extensive development of the epithelial crypts of the penis and prepuce in the older bulls. In one study the prevalence of infection in 2-year and 3-year old bulls was less than 5% but in 6 to 8 year old bulls it was 15% and in 10-year old plus bulls it was 30%. Under relatively low mating loads, the rate of transmission from infected bull to susceptible females is likely to approach 100%.

- Infections do not normally persist in non-pregnant females for more than a few months. In animals which conceive, the infection is sustained until abortion occurs and may then be spontaneously eliminated within 1 to 2 weeks of abortion, unless pyometra develops.
  The small proportion of cows that do carry the organism through gestation may have the ability to infect susceptible bulls during the subsequent breeding period. However most cows that have calved normally are not infected.
- A range of outcomes have been reported following infection of susceptible females:
  a) conceive and produce a normal calf;
  b) return to service at regular or irregular intervals, sometimes developing an odourless, mucofloculent discharge;
  c) conceive but abort at 2 to 3 months gestation;
  d) develop pyometra with anoestrus (this may occur in up to 5% of infected females).

  In one well-controlled study in northern Australia, a Trichomoniasis affected herd had an 18% lower calving percentage than a similarly managed non-infected herd. In beef herds with short breeding seasons, trichomoniasis may result in a high percentage of non-pregnant cows. In herds with longer breeding seasons, the percentage of cows pregnant may be relatively high, since a degree of immunity develops; however, many calves are born late.
- Following development of immunity and elimination of infection, females are generally refractory at first, but most animals may be reinfected if re-exposed after a period of 20 months. *T. foetus* persists for shorter periods after reinfection than during the primary infection.

Akabane virus

- Akabane virus infection is recognized as the major cause of the congenital abnormalities, arthropryposis and hydrancephaly. The major vector of Akabane virus is the biting midge *Culicoides brevitarsis*, which feeds on cattle, breeds in cow dung and is closely associated with cattle when virus is being transmitted. The range of *C. brevitarsis* is north of a line drawn from Eden (N.S.W.) to Broome (W.A.); however this range is significantly influenced by seasonal weather conditions. Midge numbers vary markedly from place to place influenced by stocking rate. When cattle densities were 1 beast per 31 hectares, the seroprevalence in 2-year old cattle was 20% but where the density was 1 beast per 7 hectares, the seroprevalence was 90%. Also, there is marked variation in midge numbers from season to season with a twenty-fold difference in midge numbers reported at a site just north of Brisbane between 1982-84.
- Infection is seasonal; in southeastern Australia virus transmission occurs from October to May and in northern Australia transmission occurs from May to October. The extent of loss due to Akabane virus infection in northern Australia has not been determined. However, studies have shown that there are large numbers of susceptible females entering the breeding herd during the transmission season – 45%, 66% and 48% of 2-year old females in 3 consecutive years in one large study.
- Typically following an epizootic of Akabane virus infection there is sequentially an increase in abortions and stillbirths, then the birth of calves unable to stand (encephalopathy), then calves with varying degrees of arthrogryposis (one or more limbs affected and often associated with dystocia), then blind 'dummy' calves (hydrancephaly) and finally birth of 'dummy' calves unable to stand (microcephaly). In a detailed study of the incidence of congenital deformities in calves following maternal infection with Akabane virus, 18% of infected females produced an abnormal calf. The highest incidence of abnormalities occurred following infection of cows pregnant between the 3rd to 6th month of gestation.
- After infection cattle develop strong immunity which persists for several years and possibly for life. There is no evidence of cross-immunity between Akabane and other arboviruses.

Bovine ephemeral fever virus (3-day sickness virus)

- BEF virus is transmitted by biting midges (*Culicoides spp.*) and some species of mosquito. It is normally a disease of the summer and early autumn. In the tropics rainfall appears to be the major controlling factor, but in temperate areas atmospheric temperature is the important controlling factor. Several field studies have shown that many cattle escape infection until they are mature although they live in areas where the disease is reported annually. In one report, out of season heavy winter rain in eastern Queensland resulted in a local and circumscribed epidemic of BEF 4 weeks later.
- Abortions during the last third of gestation have been associated with BEF virus infection. In one study an abortion rate of 11% was detected in a group of Brahman-cross heifers naturally infected with BEF virus during the first half of gestation. The abortions occurred between the second to seventh month of gestation.
- Following natural infection cattle generally remain immune for at least 2 years.

Bovine pestivirus (Bovine viral diarrhoea virus)

- Until recently, bovine pestivirus infection in cattle was mainly recognised as the cause of mucosal disease, a syndrome which occurred sporadically in weaned and adult cattle as a late sequel to foetal infection during the first 3-4 months of gestation. Following the development of improved diagnostic and research techniques, pestivirus has been shown to be associated with significant reproductive loss (fertilisation failure, embryonic mortality, abortion, foetal mummification, congenital malformations, stillbirths) following infection of susceptible female cattle between the time of mating through to 180 days of gestation. The principle determinant of the outcome of in-utero infection in the bovine is the age of the foetus when infection occurs but other factors, such as the biological characteristics of the virus strain, breed variation and immune status of the host may also be important
- The majority of infections occurs as a result of close contact between a persistently infected (PI) carrier and susceptible (i.e. antibody negative) cattle. PI carriers arise as a result of transplacental infection of susceptible females pregnant between 25 to 125 days of gestation. It has been estimated that approximately 1% of cattle are persistently infected with pestivirus. Epidemiological studies of pestivirus infection in the Australian beef herd indicate that approximately 60% of cattle have neutralising antibody to pestivirus and only 10% of herds are without serological evidence of previous infection. The results of experimental studies and field investigation throughout Australia demonstrate that pestivirus infection is responsible for significant reproductive loss including the birth of PI animals which frequently succumb to mucosal disease within the first 2 years of life and thus could be considered a form of delayed reproductive loss.
- Following infection cattle develop long term (possibly life-long) immunity.

Leptospira hardjo and pomona (Leptospirosis)

- Results of a 3 year survey of the prevalence of leptospirosis in Queensland cattle found a higher prevalence of antibodies to hardjo (35%) than to pomona (17%). The prevalence of pomona positive cattle was influenced by rainfall, being highest in the low rainfall areas.
- Leptospires are passed in the urine of infected animals and are able to survive for some weeks in water, mud and near neutral pH damp soils. Water holes, dams and muddy areas around troughs are believed to be the main sites where transmission occurs in animals at pasture. Hardjo has become adapted to long term survival in cattle with a small proportion of infected cattle continuing to shed the organism in their urine for months sometimes years. These carrier cattle are the major source of infection and probably are the most common means by which infection is introduced into a herd. Pomona is adapted to long term survival in pigs (particularly farmed pigs) and therefore infections in cattle are considered incidental. The organisms are able to penetrate the mucous membranes of the mouth, nose and eyes, and abraded skin.
- The role of hardjo as a significant cause of reproductive loss in beef herds is questionable. There are relatively few studies which have convincingly demonstrated an association between hardjo infection and the occurrence of abortions, stillbirths, premature births and the birth of weak calves. The evidence linking pomona to such losses is much more solid; however, the prevalence

of infection is lower. Recently strains of hardjo with a predilection to colonization of the reproductive tract have been identified. Infection with these strains of hardjo would be expected to cause reproductive losses – the signs seen, dependent on the stage of gestation infection occurred. Possibly, the greatest impact of leptospirosis in beef herds is the occurrence of associated human infections.

- Following natural infection, cattle are immune to reinfection with the homologous serovar. However the duration of immunity has not been precisely defined, but probably is of the order of 1 to 2 years.

Neospora canium (Neosporosis)

- In dairy cattle in Australia *N. caninum* (a protozoan) is the most frequently diagnosed cause of abortion. The prevalence of infection in beef cattle has not been reported. However given the recent finding that the reservoir host for this organism is the dog, investigation of the prevalence and impact of infection in beef cattle is warranted. The life cycle of *N. caninum* is similar to Toxoplasma gondii. Apparently, dogs become infected following ingestion of meat and tissues containing the infective cysts. Digestion of the cyst wall enables completion of the life cycle with the apparent intermittent shedding of oocytes in the faeces of infected dogs. Faecal contamination of pasture and prepared feedstuffs is the most likely source of initial infection in a herd. However there is increasing evidence of latent infection and vertical transmission of infection.
- The clinical picture of infection in a herd maybe one of an initial epizootic of abortions followed by continued sporadic abortions or, ongoing sporadic abortions. Abortions have been diagnosed in heifers and cows from 3 months gestation to term. In addition weak calves showing evidence of mild to severe paralysis have resulted from maternal *N. caninum* infection; but also congenitally infected calves born alive showing no clinical signs of infection and subsequent normal development have been recorded. Cattle, which ave aborted previously, have a significantly increased chance of aborting again or, giving birth to a congenitally infected calf.

Diseases Affecting Reproductive Performance in Central and Nth Qld Beef Herds

Presenters: Lee Taylor, David Pitt.

Animal and Plant Health Service, Queensland Department of Primary Industries, LMB 1, Biloela (Taylor) and Oonoonba Veterinary Laboratory, Townsville (Pitt).

Introduction

The objective of this presentation is to provide a forum for discussion of animal health surveillance as it is presently conducted in Queensland and to extend to other researchers some of the findings of this effort. It is hoped that a result of this discussion will be a greater understanding by other researchers and those within the beef industry of the nature of disease surveillance conducted by the Animal and Plant Health Service of the Queensland Department of Primary Industries. It is hoped that a result of this discussion and better understanding of the current situation will be better cooperation and collaboration in dealing with animal health and disease issues affecting the Queensland beef cattle industry in the future.

Animal Health Surveillance in Queensland

The Animal and Plant Health Service of the Queensland Department of Primary Industries currently undertakes disease surveillance activities as part of its core duties. The aims of this surveillance activity are to:

1. Support trade in livestock and livestock products, including meeting market access and disease reporting obligations.
2. Provide early warning of exotic and emerging diseases.
3. Provide a basis for protection of human health (zoonoses and food safety).
4. Support specific disease control and assurance programs (such as ovine and bovine Johne's disease, Bovine tuberculosis, Transmissible spongiform encephalopathies)
   Improve productivity of livestock.

The final objective of surveillance for production limiting diseases of livestock is not seen as a core responsibility of the Animal and Plant Health service. The primary activity is to collect disease intelligence to support trade decisions. However, in the process of doing this, information is also obtained on the productivity of Queensland beef herds and the prevalence of various diseases that are of production significance and not of trade significance.

One of the activities that has been undertaken since 1993 in North Queensland beef herds and 1994 in Central Queensland beef herds is a representative survey called "Structured Surveillance". Structured surveillance involves visiting properties and collecting specimens such as blood samples from cows and heifers and administering a questionnaire. Tests to determine previous exposure to various agents have been conducted on blood samples. The seroprevalence of various diseases has subsequently been determined and a serum bank developed. The role of the producer survey has been to collect information on herd demographics including productivity and death rates as well as information on disease control practices such as vaccination programs.

In addition to "structured surveillance" sampling, disease outbreak investigation is also undertaken. This "passive disease surveillance" is conducted by government veterinarians, stock inspectors, private veterinarians and producers who submit specimens to government veterinary laboratories for diagnostic testing. This has lead to the identification of various disease problems in beef herds that have suffered production losses.

The end result of this surveillance effort is that a large amount of data has been collected and collated. While the full benefit of this information has been obtained for the support of trade based issues, there is a huge amount of information that is of potential benefit to the beef industry as a whole, such as information on herd productivity and disease. Some of the findings with respect to reproductive diseases are presented here.

Producer perceptions about reproductive diseases

In the process of conducting surveillance work, an impression of producer knowledge of disease issues has been obtained. In many cases producers lack a general understanding of production limiting disease and the impact they might have on their herds. Producer understanding of the disease Trichomoniasis for example seems quite limited, despite research in the 1970's identifying this as a common venereal disease in northern beef herds.

Another issue is that of producer perceptions about disease control. One of the first questions producers ask when told they have a particular disease problem is "Is there a vaccine?" Unfortunately, the other means of disease control have often been greatly overlooked during extension programs. Vibriosis and Trichomoniasis for example can be effectively controlled and eradicated from beef herds without ever vaccinating animals. The impact of foetopathogenic diseases such as bovine pestivirus can be controlled by careful quarantine of introduced stock to prevent their mingling with pregnant cows. The status of properties with respect to specific diseases will become an important part of quality assurance programs in the beef industry. Industry programs such as the National Johne's Disease Market Assurance programs are a good example of present attempts at offering cattle buyers some assurance as to the freedom of their cattle from particular diseases.

Problem definition in beef herds

Many producers do not have sufficient written production records to allow appropriate problem definition when losses occur in their herds. This hinders disease investigations and anything that can be done to remedy this situation will have immense long term benefits. The appropriate use of written production records often allows a problem to be defined and only targeted and comparative testing to be undertaken. This saves time and money, especially with expensive diagnostic tests. In the case of reproductive and neonatal disease problems, it is particularly important for producers to identify when losses are occurring and which management groups are most affected. For example, heifers or second calf cows are the groups most likely to be affected by reproductive diseases, with older cows having developed some degree of immunity through previous exposure.

Many producers with adequate records do not correctly calculate production indices. This means that effective comparisons of reproductive performance between herds (benchmarking) are not possible or lack effect. For example, many producers overestimate branding rates because they do not consider all the cows that were exposed to bulls as the denominator. The same problem occurs with the calculation of pregnancy rates and death rates.

The prevalence of reproductive disease

A great deal of valuable information has been obtained on disease prevalence in Queensland beef herds during the past five years that is of direct benefit to the northern Australian beef industry. A summary of points of importance is given below:

Branding rates

General descriptive information on Central and North Queensland beef herds has been obtained by direct questionnaire including branding rates. In order to calculate branding rates producers were first asked how many cows they had and then how many calves were obtained from these cows in the previous 12 months. Branding rates are the best indication of reproductive performance in beef herds.

The branding rates in many Central Queensland beef herds running on improved buffel grass country are still around 60%. This is similar to extensive northern herds operating severe nutritional deprivation. However, some beef herds in both regions have branding rates of 80-90%. The production data obtained from structured surveillance testing in the past five years gives a good indication of the present range of reproductive performance in Central and North Queensland beef herds and could be of use in determining the effectiveness of extension programs. This data has GIS links, so the exact location of herds is also available and can be related to soil and vegetation types.

The Venereal Diseases - Vibriosis and Trichomoniasis

Surveys of northern cow herds in the 1970's showed Trichomoniasis and Vibriosis were common. Recent serosurveys for Vibriosis conducted during structured surveillance testing using a vaginal mucus ELISA test suggest that rates of infection are still high in Central Queensland beef herds, with infection being less prevalent in northern beef herds.

Further testing of one 400 cow structured surveillance herd in Central Queensland with poor reproductive rates that tested negative to Vibriosis has identified Trichomoniasis as the cause. The herd was well managed from both a reproductive and nutritional perspective. Stocking rates were adequate and the property routinely fattened purchased steers. The whole herd was routinely pregnancy tested with empty cows culled and all bulls were vaccinated annually for vibriosis. However, pregnancy rates had remained poor. In 1997, the pregnancy rate in heifers joined to newly purchased bulls was 90%, compared to a pregnancy rate of around 65% in the cow herd. Three bulls from 20 tested positive for Trich, all being older bulls running with the cow herd. This suggests that Trichomoniasis was causing a reduction in reproductive performance in this herd of between 10-20%. The pregnancy rates in both cows and heifers in 1998 were around 65%. Therefore further testing was undertaken and a further three bulls tested positive. Two of the positive bulls were newly purchased bulls running with the heifers.

The release of the "In-Pouch" test has made it much easier to test for Trichomoniasis. Improvements in bull management in most northern beef herds also mean that control of Trichomoniasis is now much more possible. Survey testing for Trichomoniasis would be best conducted on cull bulls at abattoirs rather than on farm, unless farms with poor pregnancy rates and good facilities to handle bulls could be targeted.

Leptospirosis

The seroprevalence of 14 serotypes of Leptospirosis has been examined in detail in Central Queensland, with the two serotypes present in the present vaccines having been surveyed for in North Queensland. The most prevalent serotypes in Central Queensland have been Leptospira interrogans serovar hardjo and serovar tarassovi. Serovars hardjo and pomona have been tested for in North Queensland with low seroprevalence. Therefore, the seroprevalence of Leptospirosis in beef cattle in Central and Northern Queensland appears low.

Recent work by researchers at the University of Queensland veterinary school suggests that the strain of Leptopsira hardjo most prevalent in Queensland cattle is not abortigenic. The impact of the serovar tarassovi on the productivity of cattle has not been determined, and it is not presently included in commercial vaccines.

Many producers report losses from "Lepto" but when asked to describe the nature of their losses, the problem would appear extremely unlikely to be due to leptospirosis, with a mixture of other common diseases being more likely. However, the fact that producers are willing to accept their losses are due to Leptospirosis has prevented them from conducting further testing to determine the exact nature of their losses.

Infectious Bovine Rhinotracheitis

Infectious bovine rhinotracheitis virus is a common viral infection in northern Australian beef herds, but appears to cause few losses. Approximately 80% of herds have evidence of infection. However, abortigenic strains of IBR virus are not known to occur in Australia. While not related to reproductive performance, increasing incidences of respiratory disease are being reported at weaning in Central Queensland beef herds and some of this may reasonably be attributed to the presence of this virus. This can be directly attributed to weaning calves at a younger age and in large groups. There is a need to improve producer education on weaning management to reduce the risk of losses associated with respiratory disease and other infectious diseases at weaning in large commercial beef herds.

Bovine pestivirus (Bovine Viral Diarrhoea Virus)

Bovine pestivirus is a common viral infection in northern Australian beef herds. Approximately 95% of beef herds in Central and North Queensland have cattle with antibody to this virus. Therefore, at any one point in time there are approximately 5% of beef herds that are totally naïve to pestivirus. If pestivirus is introduced to such naïve herds, herd investigations in Central and Southern Queensland beef herds have shown total production losses between 20-40% in the two years subsequent to the outbreak. In one Central Queensland beef herd, subsequent to the introduction of bovine pestivirus among 200 purchased cows, some of which were pregnant, only 511 calves survived weaning in 1997 from 877 cows joined in 1996, of which 40 were persistently infected with bovine pestivirus. A total of 645 cows were pregnancy tested in calf in July 1996. Historical records showed branding percentages of 80% in this herd with no post branding losses (ie there should have been around 700 calves branded).

This example of pestivirus losses is in line with predictions from herd models of bovine pestivirus losses produced for UK beef herds. However, such models need to be examined further to determine if they are valid in northern beef herds.

Losses in years subsequent to an outbreak of pestivirus in a beef herd depend on herd management practices. Changes in herd management are creating greater opportunities for this virus to cause losses. Segregated heifer management, cell grazing programs, intensive artificial insemination programs and intensive weaner management all create opportunities for significant production losses associated with pestivirus. Pestivirus is less likely to remain endemic in well managed beef herds because the persistently infected carriers of the virus are typically poor performers and are rapidly identified and culled. As naïve replacement heifers are kept and older cows that are immune to the virus are culled for age, the herd very quickly becomes susceptible to pestivirus once again..

All of the above mentioned management practices occurred in the case herd mentioned above and are considered good industry practices. We do not for one minute advocate that these procedures should not be undertaken, however it is important to understand that intensificaiton of herd management changes the risk of certain diseases occurring.

Neospora

Neospora caninum has been identified in other parts of Australia and worldwide as a significant cause of abortion in cattle. However, this pathogen is not routinely tested for in Queensland, so the exact extent of losses has not been determined. Attempts have been made to include surveillance in Structured Surveillance sampling. This could not be justified however as the disease is currently not of trade significance and the necessary funds to cover the cost of testing were not available.

Dystocia

Death losses from dystocia have not been widely reported by producers in Central and North Queensland beef herds. Occasionally particular beef herds suffer significant problems from dystocia. However, some of the problem with lack of reporting may be due to producer perceptions about this

disease and the lack of general supervision at calving time. Many producers will not accept that a calf was lost to dystocia unless the cow or heifer has died in the process of delivering the calf.

Neonatal diseases

Neonatal death losses can be regarded as "reproductive losses" in northern beef herds because they are recorded as reduced branding rates and often cannot be differentiated from late term pregnancy loss. Some producers would appear to be suffering significant losses from neonatal disease. However, many herds with good production records report few losses. However, it is important that the time of pregnancy testing is considered when comparing losses from pregnancy testing to branding. Considering the difficulty in extensively managed beef herds in determining the exact nature of such losses, particular disease syndromes have been identified and the "non-sucking calf syndrome" is a good example of a syndrome which remains unresolved.

Issues to Address:

- The focus of current government funded disease surveillance activities is to facilitate trade. However, this surveillance activity has identified significant production losses in beef herds due to disease which are not being addressed, such as ongoing losses from venereal disease.
- There is a need for the integration of efforts to deal with health and production issues in northern beef herds. Greater collaboration between Institutes, CRC, Universities and other organisations such as pharmaceutical companies to more effectively deal with animal disease issues is essential.
- There is a need for a more collaborative effort between research and extension groups to handle animal health extension in Central and North Queensland beef herds.
- There is a need for a capacity to deal with new disease syndromes that are production limiting but not of trade importance (ie exotic disease agents have been ruled out). Unfortunately, current delays in obtaining necessary funding mean that appropriate cases are often not available when funding is eventually obtained. The major cost in disease outbreak investigation that cannot be budgeted for is the cost of diagnostic tests, which in the case of "new" or emerging diseases may initially need to be obtained at other "specialist" laboratories in other states or countries.

General Discussion – Reproductive Diseases

Mike McGowan initiated a discussion on the incidence and cause of loss pre and post partution in Queensland beef herds. Attention was drawn to earlier data from Swans Lagoon and Belmont by Dick Holroyd and John Frish.

Mike alluded to research with a large pastoral company which showed a high incidence of Vibrio & Trich with substantial variation within and between properties. It was also mentioned that there is possibly a considerable incidence of these diseases in Central Queensland.

Mention was made of the danger in assuming producers were aware of appropriate vaccination schedules and the role and action of vaccination in disease prevention. Inappropriate use and storage of vaccine was also highlighted as a weak area and probable cause for failure in vaccination programs.

Dick Holroyd raised the question of vaccination for Trichomoniasis, suggesting it may be worthwhile revisiting the work of twenty years ago. Mike McGowan commented that the Australian vaccine is better than the American product but David Skerman cautioned that Australian vaccine manufacturers had severe commercial impediments by way of low volume demand versus establishment and set up cost for vaccine production.

Lee Taylor insisted that other methods of disease control are important. Importation of animals to the herd is frequently a problem.

Mike McGowan asked the question, "what is the incidence of a disease that causes it to be of concern?" He said there is a need to focus on the group, eg. Naïve group and stage of infection.

Session 4:
Control of Cyclicity and Pregnancy Prevention

Session 4: Control of Cyclicity & Pregnancy Prevent

Introduction of Willis Dropped Ovary Technique for Oestrus Control in Cattle

Project Number: NAP 3.102

Project Duration: January 1997 – June 1999

Principal Investigators: Tristan Jubb, Dept of Natural Resources and Environment, Box 2500, Bendigo Mail Centre, VIC, 3554
Ph (03) 54 304509 Fax (03) 54 304520
Email Tristan.Jubb@nre.vic.gov.au

Matt Bolam, Agriculture WA, Durack Drive (PO Box 19), Kununurra, WA, 6743
Ph (08) 91 664017 Fax (08) 91 664066
Email mbolam@agric.wa.gov.au

Jim Kerr, Agriculture WA, 16 Loch St. (PO Box ??), Derby, WA, 6743
Ph (08) 91 911555 Fax (08) 91911933
Email jkerr@agric.wa.gov.au

Background

Surgical removal of the ovaries (spaying) is used in extensive beef cattle herds in northern Australia, where it has an important role in increasing survival and turn-off value of female cattle. It is estimated that between 100 000 and 200 000 female cattle are spayed each year in northern Australia depending on market factors and seasonal conditions. Flank spaying has been the predominant method used. However this method results in hide damage and carcase-trim and has been opposed by animal welfare groups.

The Willis spay instrument (WSI) is a vaginal spaying instrument developed in the USA in the early 1980s. The spaying technique is known as the Willis Dropped-Ovary Technique (WDOT) because the ovaries are dropped inside the abdomen. Compared to flank spaying, it has many advantages for the northern cattle industry. These include higher processing rates, minimal surgical complications and no hide damage or carcase trim. It avoids the need to use electroimmobilisers, and it is a more humane and aesthetically acceptable means of spaying. The instrument and the technique are described in detail by Habermehl (1993).

An innovative veterinary practitioner named Dr Charles Willis developed the Willis Dropped-Ovary technique in the early 1980s in North America. Unfortunately the technique remained unknown in Australia until it was discovered by us in mid 1996. We developed a project with the assistance of MRC funds and formally evaluated the technique in December 1997 at the Frank Wise Institute of Tropical Agricultural Research in Kununurra.

Project Objectives

The first objective of this project was to learn how to use the WSI and at the same time assess it's practicality for use in extensive areas. Secondly we aimed to educate other veterinarians and lay spayers in it's use through demonstration and extension activities. Finally we aimed to evaluate the success of the technique in the hands of experienced operators under commercial conditions. The WDOT was further assessed at Flora Valley station as a part of collaborative work investigating new technologies for the control of oestrus in cattle. A modification of the WDOT technique was also assessed in 1998.

Project Results / Achievements

1. Initial Evaluation

Prior to commencement of the initial evaluation, the technique was practiced on reproductive tracts of 11 slaughtered females obtained from an abattoir. The initial evaluation was conducted in two phases. A group of 13 Brahman cross heifers in forward store condition with a mean liveweight of 278 ± 8.0 kg (± se) were the first group spayed with the WSI. These were observed for 72 hours for complications and then a second group of 27 Brahman cross heifers in backward store condition with a mean liveweight of 212 ± 3.9 kg (± se) were spayed. These were also monitored for 72 hours for complications. This second group had been dehorned and treated for a moderate cattle tick infestation 3 weeks previously. The animals were spayed in turn by three veterinarians experienced at pregnancy testing and ovarian palpation.

There was little sign of discomfort during the procedure and none of the heifers were observed to flinch when the vaginal wall was penetrated by the WSI. The most painful part of the procedure was when the spay ear mark was applied. The technique does require good restraint to minimise sideways, and forward- rearward movement, but does not require a head bail. To successfully complete the procedure requires ovarian palpation skills sufficient to pick up and free ovaries from the mesovarium and to manipulate them into the cutting hole of the WSI. The impediments which slowed the procedure the most were difficulty penetrating vagina, locating one or both ovaries after the instrument was in place, and freeing the ovary from the mesovarium so that it dropped into the cutting hole easily.

No animals in either group were observed to be in discomfort or sick after spaying and none died. Animals in both groups had pink vulval mucous membranes 24 h post surgery and showed no evidence of weakness from anaemia. Packed cell volume (PCV) was in the normal range (25 to 48) for all except 2 animals in the first group when sampled 24 h post surgery. These 2 animals had PCVs of 49 and 52. At 3 weeks post spaying, rectal palpation did not detect adhesions of the reproductive tract or intestines.

The animals in the second group generally had lower PCVs than the first group probably as a consequence of being dehorned 3 weeks previously and suffering continuous intermittent bleeding from horn wounds. Rectal temperatures were generally high (39.5° C) both before and after spaying. This was probably a result of the high ambient temperature (40°C in the shade) at the time of measurement. Two animals in group B showing low PCVs were shot and autopsied 48 h after surgery. One animal with a PCV of 26 taken at 24 h post surgery had a 200 mL blood clot in the ventral abdomen. Another with a PCV of 27 at 24 h post surgery had two blood clots totalling 1.2L. In both animals ovariectomy was complete and no remnants of ovarian tissue were attached to the uterus. The sites in the vaginal wall where penetration occurred were small and contracted and difficult to locate. Very slight bruising and haemorrhage revealed their location. They would have posed minimal or no danger in allowing prolapse of intestines to occur. There was also no evidence of localised septic peritonitis around the penetration sites or uterus.

2. Demonstration and Extension Activities

From the experiences of the initial assessment it was concluded that the technique had considerable application for increasing animal welfare and profitability in extensive beef herds. Within a few months we had produced a training video, contracted a veterinary instrument manufacturer to produce an Australian-made instrument, and tested for modification a number of prototypes which resulted in a high quality instrument and accessories kit being produced. In conjunction with the Meat Research Corporation, QDPI, and NTDPI, and with training videos and a ready supply of instruments, we embarked on an awareness and training campaign extending across northern Australia. This included bringing to Australia Dr Norman Habermehl, a Canadian veterinarian with considerable experience in teaching the technique, to run a series of training schools for veterinarians in Queensland. Tristan Jubb attended one of these schools in May 1997 and returned to WA with a greater knowledge of the technique which was extended to spayers and cattle producers in WA in the training courses that we have run. The technique is self promoting to a large extent because it is aesthetically far superior to

flank spaying. It received much attention in the rural press and extension newsletters of agriservice providers. Two papers describing the technique and its implications were presented at the 1997 Australian Veterinary Association Conference in May 1997, where it received considerable interest and generated much discussion. Both the Australian Cattle Veterinary Association and Australian Veterinary Association policy committees which met at the conference were strongly and favourably influenced by these papers. A further paper was presented by Tristan Jubb in July 1998 at the XXth World Buiatrics Congress in Sydney.

A network of veterinary contacts has been maintained across northern Australia to provide feed back on tips, tricks and problems with the technique with AgWA in Kununurra being responsible for coordinating the information. Norman Habermehl and Charles Willis have been consulted on a number of occasions to provide advice on specific problems.

3. Assessment of the WDOT under Commercial Conditions

Numerous veterinarians and lay operators have taken on the WDOT and are offering this service to cattle producers. We felt that it was essential to critically appraise the technique in the hands of experienced operators.

In September and October 1998, Matt Bolam worked with Peter Letchford, a Kununurra based veterinarian who has spayed 12000 head this dry season, to assess the WDOT in two commercial settings. Individual animals were identified as they were spayed and their pregnancy status, body condition, lactation status and temperament recorded. The time taken to spay, the temperament of the operator, animal position and posture in the crush were also recorded along with operator comments. Animals were monitored for 72 hours post spaying and treated/necropsied as required. The holding paddocks were examined again upon removal of cattle 1-2 weeks later.

At site one, 180 females were spayed and at site two, 384 females were spayed using the WDOT. These included some animals estimated to be approximately 100 kg liveweight (no weighing facilities were available at either site). Ninety seven percent of these females were empty and dry with a mean body condition score of 2.0 (1-5 scale). Two deaths were recorded from the 564 animals spayed. These were necropsied, revealing that these animals had bled out into the abdomen from the point of ovary removal. This represents a mortality rate of 0.35 % in the monitored group. Peter averaged 35 animals per hour at site one and 40 animals per hour at site two. Females were spayed up to 4 months of pregnancy using the WDOT. This work has identified the importance of animal posture, operator temperament and care to produce a favourable outcome, as would be expected with any surgical procedure. Essential to successful use of the WDOT is the possession of excellent ovarian manipulation skills by the operator.

Further monitoring is planned to cover 1000 animals in total spayed by Peter and 1000 animals to be spayed by a lay operator (to be identified).

4. The Flora Valley Trial

As a part of collaborative work with DPI Queensland and CSIRO, a number of new technologies for the control of oestrus in cattle were trialled at Heytesbury Pastoral's Flora Valley station in the east Kimberley region of WA.

In June 1997, 90 empty heifers and cows were spayed using the WDOT. Ovariectomy was routine and the operator achieved a rate of 30 animals/hour. Over the following 12 months another 60 females from other treatment groups were spayed using this technique as they became pregnant. Of the initial 90 spayed females, 2 were subsequently found to be early pregnant and were spayed again. In both of these cases, one ovary had been incompletely severed. One cow lost considerable weight in the first 2 months post spaying, however she had gained an above average amount of weight (for her group) by the end of the trial. All females were weighed, condition scored, rectally examined and bled every two months for the following 12 months. After 12 months, one cow remained accounted for and was assumed dead resulting in a mortality rate of 0.7%.

In June 1998, 130 of the 150 females spayed using the WDOT were slaughtered and their reproductive tracts collected for examination. There was no evidence of inflammation or infection at

the site of penetration of the instrument or elsewhere in the pelvic canal. The uteri were atrophic and displayed prominent lymphatics. An obvious ovarian remnant was present in 17% of animals. Most remnants presented as a fluid filled cyst growing from a small nodule of hypertrophied ovarian tissue.

The weight changes across all treatments including controls in this trial were similar and reflected the quality of pasture on offer, except for the flank spayed heifer group which lost more weight on average after spaying and did not appear to compensate for this loss over the following 12 months.

5. The Pull-Through Technique

Through communications with Charles Willis in the US, a further modification of the WDOT was identified and was assessed in September 1998. Thirty commercial Brahman cross cows (liveweight 310 ± 8.0 kg (± se)) and thirty commercial Brahman cross heifers (liveweight 200 ± 5.7 kg (± se)) were spayed at FWITAR using a modification of the WDOT that enables the ovaries to be removed *per vaginum*. These females were monitored over the next month and examined rectally twice in this period. Although showing some promise at allowing the removal ovaries at spaying, the technique proved too difficult to use consistently and resulted in increased pelvic inflammation and scar tissue formation. In addition, complete removal of all ovarian tissue could not be guaranteed. There was no morbidity observed and no mortality resulted from the use of this technique. The cows were fed a maintenance ration only post spaying. The heifers grew at 750 g/day on average in the month after spaying grazing Pangola grass at FWITAR. It was concluded that this technique was inferior to the standard WDOT and unsuitable for use in cattle.

Project Impact

The WDOT has become the preferred method of spaying in northern Australia and more producers have adopted spaying as a management tool. Over 150 instruments were sold by the manufacturer in the first 6 months after introduction at a gross value of $40 000. Currently two companies produce the WSI. The number of spayed females could potentially double or treble as producers increase the use of spaying as a means of turning off female cattle rather than letting them die on property as unmarketable animals (currently an estimated 30 000 breeder age female cattle valued at $10 M die in the Kimberley region annually for this reason). In pastoral Australia there could be up to over 0.5 million breeder-age cattle die on property annually because of unmanaged pregnancy (some call it lack of spaying). In Queensland it is estimated that 30% of the spaying performed to date has been done using the Willis method whereas in WA and NT it has been greater than 70%. This is a large transition given the short time since its introduction. The introduction of the WDOT was the winner of the statewide Meat Program Project Award for 1997.

The method has is a significant advance in pregnancy control in the northern cattle industry with very real benefit to the welfare of animals and the industry. Spaying of cattle has almost become less of an issue for animal welfare groups and the AVA, satisfied with the use of the Willis technique, until non-surgical methods of pregnancy control become available. The complete elimination of the need for spaying as management tool in northern Australia is our ultimate aim.

Publications

Two conference papers presented at the 1997 AVA Conference
One conference paper presented at the 1998 World Buiatrics Congress
Two articles in the Kimberley Pastoral Memo
One article in the Pilbara Pastoral Memo
One article in the Queensland Country Life
One article in the NAP 3 News
One article in Agriculture WA's Primary Focus magazine
The West Australian
Elders newsletter
AgWA Animal health newsletter
Evaluation of Willis spay instrument - A report to MRC

GnRH Agonist Bioimplants for Control of Reproduction inHeifers & Cows

Presenters: Michael J. D'Occhio
Animal Sciences and Production Group, Primary Industries Research Centre, Institute for Sustainable Regional Development, Central Queensland University, Rockhampton, Queensland 4702

1.0 Summary

The aim in MRC Projects NAP3.105 and NAP3.110 was to evaluate the potential of a novel GnRH agonist bioimplant as a non-surgical approach for the control of reproduction in extensively managed heifers and cows in northern Australia. Female cattle treated with a GnRH agonist have a downregulated anterior pituitary gland and cannot initiate preovulatory surge releases of LH. Ovulation is therefore blocked during treatment with a GnRH agonist and cattle remain in a state of anoestrus; this condition can be maintained long-term. Ovarian activity returns to normal within a relatively short period after discontinuation of treatment. GnRH agonists have potential, therefore, for controlled, reversible suppression of fertility in heifers and cows. In Project NAP3.105, groups of heifers and cows on three properties

(c. Queensland; n. Queensland; n. Western Australia) were either left untreated or implanted (ear) with prototype GnRH agonist bioimplants, and grazed with bulls. The duration of the trials, and number of animals treated with GnRH agonist which were pregnant or showing ovarian activity, were: Property A (n=76): 387 days and 20 (26%); Property B (n=84): 376 days and 8 (10%); Property C (n=99): 394 days and 9 (9%). At Property C, no heifer or cow treated with GnRH agonist conceived before around Day 300. The differences between properties were due, in part, to differences in formulation of the GnRH agonist bioimplants. In Project NAP3.110, groups of mature cycling heifers were treated with graded doses of GnRH agonist and grazed with bulls. The proportion of heifers pregnant at 9 months after implanting were: Dose 1, 34/49 (69%); Dose 2, 19/49 (39%); Dose 3, 0/48. Dose 1 suppressed conception for approx. 3 months, Dose 2 for 6 months, and Dose 3 greater than 9 months. Projects NAP3.105 and NAP3.110 have contributed the first data, internationally, which demonstrate the potential of GnRH agonist bioimplants as the next-generation technology for effective and practical management of reproduction in heifers and cows. A significant feature of GnRH agonist contraception is that fertility returns to normal relatively soon after discontinuation of treatment. This has major implications for novel management of mating in breeder herds in extensive regions, in relation to future genetic improvement.

Project NAP3.105 involved collaboration with Dr G. Fordyce (Queensland Beef Industry Institute, Swan's Lagoon Beef Cattle Research Station, Millaroo, Queensland);

Dr T.F. Jubb (Agriculture Western Australia, Kununurra, Western Australia); and

Dr L.A. Fitzpatrick (James Cook University, Townsville, Queensland).

Acknowledgments:

The GnRH agonist bioimplant was developed by Peptech Animal Health, Pty Ltd,

North Ryde, Sydney (Dr T.E. Trigg, Dr P. Schober and Mr J. Walsh); Project NAP3.110 was conducted at Brigalow Research Station and we are grateful to Mr T. Barnes for his enthusiastic cooperation; other cattle, staff and facilities were generously contributed by The Australian Agricultural Company, Heytesbury Pastoral Company and Stanbroke Pastoral Company; Neil Cooper and Timothy Whyte provided valuable technical expertise.

Correspondence: Phone 07 49306900; Fax 07 49309209; Email m.docchio@cqu.edu.au

2.0 Introduction (Industry Issues)

The effective management of reproduction remains an important and unresolved issue for extensive beef cattle production in northern Australia. Reproductive management is relevant both for breeder heifers and cows, and turnoff and feeder cattle.

For breeder heifers and cows, outstanding issues include (i) undesirable pregnancy early in life which can compromise lifetime fertility and (ii) the matching of seasonal patterns of conception to annual cycles of rainfall and the availability of appropriate quality and quantity of pasture. At present, mating patterns are regulated by the control of bulls, which often proves inefficient. The management of mating patterns by the control of fertility in heifers and cows has not previously been contemplated, but can now be considered due to the recent development of new technology described in this article (Section 6).

Unwanted pregnancies in turnoff and feeder heifers and cows have traditionally been prevented by surgical procedures. Traditional surgical procedures used in northern Australia are paralumbar (flank) and vaginal (passage) ovariectomy. The concerns associated with these procedures have been extensively documented and include stress, morbidity, mortality, and loss of production. Recently, the Willis Dropped-Ovary Technique has been promoted as an alternative surgical procedure for ovariectomy. The latter would appear to be a preferred surgical approach to pregnancy prevention in cattle. All surgical procedures, however, induce permanent infertility and do not allow flexibility in reproductive management. A technology that allowed controlled, reversible suppression of fertility would provide long-term contraception, with the option of restoration of normal fertility, if required.

Meat and Livestock Australia Projects NAP3.105 and NAP3.110 examined surgical and non-surgical strategies for pregnancy prevention in heifers and cows under extensive management in northern Australia. The particularly novel technology evaluated in these projects were prototype, long-acting GnRH agonist bioimplants.

3.0 GnRH and GnRH Agonists

Gonadotrophin releasing hormone (GnRH) is secreted from the base of the brain and stimulates the anterior pituitary gland to release luteinizing hormone (LH) and follicle stimulating hormone (FSH); both LH and FSH are required for normal ovarian function in females (2, 4). Agonists of GnRH have been developed which, because of their excessive biological potency compared with natural sequence GnRH, cause a downregulation of the pituitary gland and block pulsatile secretion of LH, including inhibition of the preovulatory surge release of LH (1, 3, 5, 6, 7). Heifers and cows treated with a GnRH agonist therefore cannot ovulate and they remain in an anoestrous condition (3, 6). Normal fertility is restored by discontinuation of treatment with GnRH agonist (2, 3).

Recently, the GnRH agonist, Deslorelin, was formulated into bioimplants which release agonist over an extended period (1, 2). These GnRH agonist bioimplants were evaluated in Projects NAP3.105 and NAP3.110 as a potential practical technology to achieve controlled, reversible suppression of fertility in heifers and cows. The bioimplants were placed subcutaneously in the dorsal surface of the ear using pre-loaded, sterile syringes.

4.0 Project NAP3.105 *(Oestrous suppression and pregnancy prevention in cattle)*

4.1 Aim

The aim in Project NAP3.105 was to examine whether prototype GnRH agonist (Deslorelin) bioimplants induced long-term suppression of ovarian activity, and prevented conception, in heifers and cows maintained under extensive grazing in northern Australia.

4.2 Design and Measurements

Groups of heifers (total = 132) and cows (total = 135) on three properties in northern Australia (central Queensland; northern Queensland; northern Western Australia) were implanted with prototype GnRH agonist bioimplants and grazed together with untreated control heifers and cows, and

bulls. Reproductive status was ascertained at 2-monthly intervals. This involved measurement of plasma concentrations of progesterone, ovarian ultrasonography and rectal palpation for pregnancy.

4.3 Results

A summary of the combined results for heifers and cows, at slaughter, is presented below.

	n	Duration of trial (day of slaughter)	Number pregnant or showing ovarian activity	Approximate duration of anoestrus in heifers and cows that showed a return of ovarian activity (days)
Property A	76	387	20 (26%)	231 ± 19 (SEM)
Property B	84	376	8 (10%)	244 ± 13
Property C	99	394	9 (9%)	336 ± 3

On all three properties, untreated control heifers and cows conceived throughout the duration of the trials (data not shown). The GnRH agonist bioimplants prevented conception in all implanted heifers and cows from between 200 days (Property A) and 300 days (Property C). The differences in duration of anoestrus between properties were considered to be due to differences in formulation of the bioimplants.

4.4 Discussion

An outstanding observation was the prolonged induction of anoestrus in heifers and cows at Property C. Also significant was the return to normal fertility in heifers and cows after suppression of ovarian function for varying periods. Combined, these two observations indicated that a GnRH agonist bioimplant can be used for long-term controlled, reversible suppression of fertility in heifers and cows maintained under extensive management.

5.0 Project NAP3.110 *(Evaluation of a GnRH agonist bioimplant for oestrous suppression and pregnancy prevention in heifers)*

5.1 Aim

The aim in Project NAP3.110 was to examine dose-response relationships between the GnRH agonist, Deslorelin, and duration of suppression of fertility in heifers. Intervals between the resumption of ovarian activity and conception were also characterised.

5.2 Design and Measurements

Groups of mature, cycling heifers were treated with graded doses of GnRH agonist using a prototype bioimplant. The heifers were grazed with untreated control heifers, and bulls. Ovarian activity and pregnancy status were determined at 1-monthly intervals using ultrasonography.

5.3 Results

A summary of the results, 9 months after the commencement of treatments, is shown below.

	Follicles			Corpus luteum	Pregnant
	Small (≤ 5 mm)	Medium (6-9 mm)	Large (≥ 10 mm)		
Control	----	----	----	39/39	31/39
Dose 1	4/49	1/49	8/49	2/49	34/49
Dose 2	13/49	3/49	13/49	1/49	19/49
Dose 3	42/48	2/48	4/48	0/48	0/48

Heifers treated with Dose 1 of GnRH agonist had suppressed ovarian activity for approximately 3 months (data not shown), after which they showed a return to normal ovarian function and conceived. Heifers treated with Dose 2 had suppressed ovarian activity for around 5-6 months (data not shown) and then returned to normal reproductive function. Conceptions were recorded from 4 to 8 weeks

after the resumption of significant ovarian activity and first ovulation. The highest dose of GnRH agonist (Dose 3) continued to suppress ovarian activity at 9 months. Ovarian activity in the latter heifers was characterised by the presence of small antral follicles, which is indicative of minimal concentrations of LH and FSH in circulation. The project is scheduled to end at 11 months.

5.4 Discussion

Clear dose-response relationships have been demonstrated between GnRH agonist and duration of suppression of fertility in heifers. It has also been shown that heifers conceive relatively quickly after restoration of reproductive function subsequent to suppression of ovarian activity for different periods.

6.0 Conclusions and Future Perspective

Projects NAP3.105 and NAP3.110 have demonstrated for the first time, internationally, that GnRH agonist bioimplants suppress fertility in heifers and cows, long-term, in a dose-related manner. One bioimplant formulation, in particular, suppressed ovarian activity for approximately 300 days in all implanted heifers and cows. On the basis of these findings, the opportunity now exists to develop GnRH agonist bioimplant technology as a practical alternative to surgical intervention to prevent unwanted pregnancies in heifers and cows in northern Australia; there are other applications in a range of cattle production systems, both beef and dairy. The outstanding features of the GnRH agonist technology is that only a single treatment is required, it involves standard implanting technology, and cattle do not suffer a transient, or longer-term, reduction in growth performance which can be a feature of surgical procedures. It is anticipated that the bioimplant technology can be further developed to give effective treatment periods of 18-24 months, and possibly longer.

A significant feature of GnRH agonist contraception is that cattle return to normal fertility, and can conceive, relatively soon after discontinuation of treatment. Hence, GnRH agonists involve more than simply contraception. Rather, GnRH agonists should be regarded as a revolutionary technology that allows a paradigm shift in the conceptual framework of reproductive management of cattle in extensive grazing systems. It is now possible to consider practical management of annual cycles of mating in cattle by selectively controlling ovarian function in heifers and cows with a GnRH agonist bioimplant. This includes the prevention of undesirable early pregnancies in replacement heifers. In a recent study in northern Queensland, Zebu cross yearling heifers were implanted with relatively low doses of GnRH agonist and grazed with untreated contemporary heifers, and bulls. Approximately 9 months after treatment (18-20 months old), 20/50 (40%) of the untreated heifers were pregnant, compared with 5/50 (10%; Dose 1) and 2/50 (4%; Dose 2) for heifers treated with GnRH agonist (M.J. D'Occhio and G. Fordyce, unpublished results). The GnRH agonist bioimplants were removed after 9 months and all heifers will be mated as standard replacement heifers. It is anticipated that the groups of heifers previously treated with GnRH agonist to prevent early conception will have a normal pregnancy rate (see data for Project NAP3.110). As noted above, the GnRH agonist bioimplant provides opportunities in a range of circumstances to seasonally coordinate and synchronise mating in heifers and cows.

The ability to determine seasonal patterns of mating by controlling the fertility of heifers and cows substantially diminishes the emphasis on bull control. This will enable the adoption of previously unavailable strategies for breeder herd management, and also provides new grazing options, in the extensive environments of northern Australia. One interesting opportunity is to selectively control which heifers and cows in larger breeder herds are undergoing ovarian cycles, during particular periods, and which will be mated by selected bulls; this will be particularly relevant for future genetic improvement in extensive herds.

In summary, Projects NAP3.105 and NAP3.110 have conclusively demonstrated the potential of GnRH agonist bioimplants to revolutionise reproductive management of extensive beef herds in northern Australia. GnRH agonist bioimplants have equal application to prevent unwanted pregnancies in turnoff and feeder cattle, and breeder cattle. Applications in breeder cattle are of particular relevance for future optimisation of the synchrony between annual cycles of mating and

calving, and seasonal fluctuations in quantity and quality of pasture. This will facilitate advances in the management of breeder herds, genetic improvement, and enable greater efficiency in the alignment of beef production systems with targeted markets.

7.0 References

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Discussion / Comments

Q1. *Have you used the GnRH agonist in both pre-pubertal and post-pubertal heifers, and what have been the relative effects on fertility?*

A1. Studies have not been designed to specifically to address this question. However, it has been shown that regular ovarian cycles cease in post-pubertal heifers after implanting with GnRH agonist, and ovarian activity returns to normal and is associated with pregnancy when heifers are no longer suppressed by the GnRH agonist bioimplant. Recently, heifers were implanted before puberty (12 months) and the GnRH agonist implants were removed at around 20 months; the heifers will be mated as typical herd replacement heifers and fertility data will be available in April 1999. We do not anticipate differences in return to normal fertility after discontinuation of treatment with GnRH agonist in heifers implanted before or after puberty.

Q2. *Are there any longer-term effects on subsequent pregnancies in heifers previously treated with a GnRH agonist?*

A2. This question cannot be answered definitively at present. However, it would seem unlikely that there are longer-term effects on fertility subsequent to treatment with GnRH agonist, as heifers have shown a relatively early return to normal fertility and have conceived soon after treatment with GnRH agonist. It would be surprising if there was an effect on a subsequent pregnancy.

Q3. *What is the anticipated commercialisation time-frame?*

A3. This will be determined primarily by Peptech Animal Health Pty Ltd, within the framework of their product development portfolio.

Q4. *What will be the likely cost of treatment?*

A4. This will also be determined by Peptech Animal Health Pty Ltd, but clearly the price structure will relate to the cost of competing technologies, and relative advantages and disadvantages.

Q5. *Can the GnRH agonist bioimplant be used in bulls?*

A5. Interestingly, treatment with GnRH agonist induces an increase in testosterone secretion in bulls, which also occurs in the red deer stag, but not in males of other species studied. In fact, the classical response to treatment with GnRH agonist in males is an inhibition of testosterone secretion. The reason for increased testosterone in bulls is not fully understood and is currently being studied.

Q6. *Do GnRHagonists have uses in other mammals?*

A6. Yes. A GnRH agonist bioimplant has been developed which suppresses reproductive function in dogs for up to 24 months. In humans, GnRH agonists are used in the management of prostatic carcinoma, uterine fibroids and endometriosis. These are conditions that rely on the secretion of testicular and ovarian steroid hormones; treatment with GnRH agonist is used to block the release of sex steroids which contributes to management of the condition. In women and females of other species, GnRH agonists are also used to prevent the occurrence of the preovulatory LH surge in ovarian follicle superstimulation protocols, in conjunction with *in vitro* fertilisation programs.

Session 5:
Genetics

Session 5: Genetics

The Role of Artificial Breeding in the Northern Cattle Industry

Presenter: Dennis Boothby
QDPI

Introduction

AB [Artificial Breeding] has only a minor role in the northern beef cattle industry at the present time. This can be contrasted with its use in the dairy industry in North Queensland where AB is the preferred method of breeding cows [as it is in most parts of the dairy industry throughout Australia], and with the southern beef industry where AB usage has increased rapidly in the past decade.

AB in the cattle industry

In the fore-seeable future there is little chance that AB will become the major method of breeding the bulk of the beef cow population such as that which occurs in the dairy industry. In dairies AB usage has replaced bulls entirely on many farms and has greatly limited the use of bulls on most others. In the beef industry at best, bulls may have their use augmented by well conducted AB programs in certain situations, but bulls will never be replaced entirely.

There are many reasons for this difference in application of AB in the beef and dairy industries. The most important of these are in the areas of economics, management and technical limitations.

Economic Limitations

AB usage in the dairy industry can be economically justified [and in fact is an economic necessity] because the average dairy cow in Australia grosses over $2,000.00 per annum from milk production. At the moment AB bred animals will gross far more per lactation than those animals which were obtained by natural service, and this extra production will more than make up for the extra costs required to obtain the AB progeny. This is still the case even though at present it is estimated that about 10 straws of semen are needed to obtain and rear one heifer to the stage of commencing a lactation.

AB usage in the stud sector of beef cattle can be economically justified in some circumstances because AB bulls may gross far more when sold into the commercial industry. On the New England Tablelands some of the leading ANGUS studs at GUYRA report that their sale bulls bred by AB averaged over $900.00 more than those bulls bred by natural service. This more than compensates for the extra costs and management required to obtain AB progeny. This price differential may not be as evident in other breeds. At present the ANGUS society has approximately 40% of its registrations from AB sires, far more than any other beef breed.

AB usage in the commercial production sector of the beef industry can only be economically justified for specialist markets such as that for WAGYU [or some other high priced markets]. In most situations the extra costs needed to obtain an AB calf will not be rewarded sufficiently by increased returns for those calves when sold for slaughter or as stores to justify the use of AB. It is possible in very well managed AB programs to land a calf on the ground for under $70.00, even when all costs such as labour, mustering and all consumables are included. In most natural mating situations the bull costs per calf will be far less than this [even though they are far higher than many cattlemen realise].

Management Limitations

AB is easily applied in the dairy industry. This is because the average dairy has :-

- Intensive management, cattle are handled twice daily.
- Highly skilled managers [most Queensland Dairy farmers conduct their own AB programs]
- Improved pastures and high energy supplementation which ensures good levels of nutrition.
- Comprehensive individual cow records.
- Good cattle handling facilities and procedures.

In the beef industry AB is much harder to apply in most circumstances. Management is never as intense as it is in the dairy situation, even in stud situations in temperate areas. In the more remote northern areas management strategies are in most circumstances totally unsuited to the conduct AB programs. The minimum requirements for large scale AB operations include seasonal calving or some method of controlled mating. Many beef properties in northern Australia muster only once per year and basic infrastructure such as fences and controlled water-points are often inadequate or non-existent for any intensive management procedures.

Additionally the seasons and conditions under which beef cattle are run are far less predictable and much harsher. It is exceedingly rare in most northern situations for heifers to be well enough grown to be consistently mated to calve down as two year olds. In almost every commercial situation and even in most stud situations the economics of supplementing to boost growth or to boost conception rates is doubtful.

Technical Limitations

Even on intensively managed dairy farms one of the main causes of unsatisfactory AB program results is in the area of heat [oestrus] detection. Preliminary results from a recent major study of AB in the dairy industry demonstrate that approximately one third of cows inseminated may not have been on heat when presented for insemination. This being despite the fact that most dairy producers have been successfully inseminating their own cows for years. Additionally on most dairies individual cow ID is better than on many beef properties and the mangers are more used to heat detection routines. They are also more aware of the signs of heat cows display and usually make far greater use of records.

At this stage, despite drug company advertisements to the contrary, there is no synchronizing regime that will repeatedly give satisfactory results on large scale AB programs which does not involve heat detection. i.e. fixed time insemination programs have not been routinely successful. This means that beef producers must use heat detection of some sort to conduct their AB programs. This heat detection can be concentrated by use of synchronizing drugs and/or assisted by the use of heat detection aids such as heat pads [Bulling Beacons or Kamars] but not eliminated.

Development of new synchronizing treatments, and of management systems to apply them in extensive beef operations are needed before AB programs will be a commercially feasible proposition in most northern commercial cattle herds. At the moment most of the research into new synchronizing treatment methods is done on dairy cattle and has more of an intensive management focus than that of application to the extensive beef operations of Queensland. Additionally much of this research has a vested interest component in that it is sponsored by the drug companies who are more interested in selling large quantities of their particular product than in developing *systems* that will assist the northern cattle industry.

The need for AB in the Northern beef cattle industry.

Presently, the AB in the northern beef industry is almost exclusively restricted to its use in the stud sector. Large scale genetic assessment schemes [such as GROUP BREEDPLAN] cannot be set up and conducted except by the use of AB to provide sufficient "link sires." It is no exaggeration to say that in the future without GROUP BREEDPLAN, a breed society will find it difficult to compete and remain viable.

The most progressive breed society in Australia at present is the ANGUS breed. At the moment almost 40% of all ANGUS registrations are by AB sires.

Most of the tropical breed societies would have less than 5% of their total registrations by AB sires. This means in many cases that it is difficult to get sufficient "linkage" to conduct an accurate GROUP BREEDPLAN for some breeds. The lack of GROUP BREEDPLAN has already cost some breeds in that they were unable to participate in projects such as the CRC, and has cost the industry as a whole because opportunities for export of genetics and breeding stock were lost in some breeds. Additionally the slow uptake of this technology in the north has restricted herd improvement and may eventually lead to reduced access to certain markets for meat and products from tropical cattle.

In the medium to long term , on some of the more progressively managed commercial properties AB may become a valid method of breeding certain segments of the herd, specifically maidens. If AB technology, most especially that in the area of heat synchronizing, continues to improve and develop at the same rate as it is now, then it will become increasingly possible to land calves on the ground at prices which are close to that of using bulls for natural mating. This trend has already commenced in some southern areas where progressive commercial cattle breeders are buying special bulls for use on their maidens [usually easy calving bulls] and having them collected and processed for use in massive synchronized AB programs and then using that bull as a "clean up" bull after completion of the AB program. With continued refinement of synchronizing treatments and development of systems it may soon be possible to even economically inseminate "repeats" before turning out the "clean up" bulls.

Conclusion

If the northern beef cattle industry is to compete with southern Australia and with the beef industries of our overseas competitors then it is essential that more effort is put into development of systems to enable AB to become a routine part of the management of progressive northern cattle breeders.

(Composed by Dennis Boothby DPI

For and on behalf of presenter Russell Miller DPI)

Maximising Heterotic Advantage Using Systematic Crossbreeding

MLA Project No.: CS183A

Project Duration: 30-9-95 to 30-9-98

Principal Investigators: J.E. Frisch,
CSIRO,Tropical Beef Centre,
Rockhampton Mail Centre, 4702.
Ph. (07) 49238144
Fax (07) 49238222
E-mail John Frisch< Alan.Day@tag.csiro.au>

C.O'Neill,
CSIRO,Tropical Beef Centre,
Rockhampton Mail Centre, 4702.
Ph. (07) 49238143
Fax (07) 49238222
E-mail < Christopher.O'Neill@tag.csiro.au>

M.D'Occhio,
Central Queensland University,
Bruce Highway,
North Rockhampton, 4701.
Ph. (07) 49306900
Fax (07) 49309209
E-mail <m.docchio@cqu.edu.au>

C.Gazzola
QDPI, Tropical Beef Centre,
Rockhampton Mail Centre, 4702.
Ph. (07) 49238177
Fax (07) 49238222
E-mail < gazzolc@prose.dpi.qld.gov.au>

Project Objectives

1. To identify the most productive genotypes for any given set of market-management-environment conditions in northern Australia.
2. Produce models that will allow the prediction of productivity of any given genotype for any defined set of market-management-environment conditions.

Project Summary

Total productivity of straightbreds,and 2-way cross cows and steers generated from breeds of African (both sanga and zebu), European (both British and Continental) and Indian origins, has been measured across environments with the aim of identifying the genotypes best suited to particular combinations of environments, production systems and markets. Significant individual and maternal heterosis for production traits was generated in crosses between any of the breed groups. The productivity of all F1 cow genotypes exceeded that of all straightbred cow genotypes, in some cases by more than 20%, without the need for additional inputs. On pasture and without intervention to control parasites, not all crossbred steers had higher growth rates than Brahman contemporaries. In feedlot, crossbred steers generally had higher gains and gross efficiencies of feed conversion and produced more tender meat than Brahman contemporaries. The results demonstrate that all of the breed groups have a role in improving productivity.

Results and Discussion

The objective of developing predictive models was handed over to Scott Newman (CRC) and has resulted in Hot Cross. This devolvement has allowed greater focus on completion of data collection and analysis from the other objective of the project, the identification of the most productive genotypes for each particular set of circumstances.

Productivity at the herd level is a function of the productivity of breeding cows and of stock grown specifically for slaughter. Each is examined separately. Straightbred and crossbred cows were produced in Phase 1 of the project according to the plan shown in Table 2. AX = Belmont Red (sangaxHS, Bos taurus), B = Brahman (Indian zebu, B.indicus), Bo = Boran (African zebu), BX = interbred BxHS, Ch = Charolais (Continental, B.taurus), HS = interbred Hereford xShorthorn (British, B.taurus) and Tu = Tuli (sanga). In Phase 2, F1 cows were mated to produce 3- and 4- way cross progeny that were contemporaneous with straightbred and F1 progeny. However, all 3- and 4-way cross animals and all BX cows were sold before measurements other than of growth rates were completed. The effect on growth to 18mth of the combination of high maternal and individual heterosis and of sire breeds that differ in growth potential and resistance to environmental stresses is shown in Table 1. The same B sires were mated to B and crossbred cows to produce straightbred and 3-way cross progeny. None of the cows or their progeny was treated to control ticks or worms. The F1BxCh sires were produced by high growth EBV Ch sires.

Table 1. Live weights at 18mth of age on pasture for progeny by B and F1BxCh sires from F1 cows

	Dam Breed					
Sire Breed	B	F1(HSxBo)	F1(HSxTu)	F1(AXxBo)	F1(AXxTu)	Breed mean
B	334 (99)*	353 (16)	356 (20)	361 (27)	365 (20)	359 (83)
F1(BxCh)	-	327 (14)	340 (26)	350 (31)	340 (30)	339 (101)

* Number of animals

Mature weight of the F1HS cross cows was equal to or below that of the B cows but their progeny were 6% heavier than the straightbred B by the same B sires. F1AX cross cows were about 6% heavier than the B cows but their progeny were about 8% heavier. The differences in weight of B-sired progeny in favour of the F1 cows are therefore unrelated to any effect of mature cow weight and are real improvements in productivity. However, there was no increase in productivity if progeny were sired by F1BxCh bulls. This was despite the far higher growth potential of the F1BxCh sires compared with that of the B sires. Maternal and individual heterosis were still 100%, but because resistance of the F1BxCh progeny was less than that of B-sired progeny, full expression of individual heterosis could not occur. Real increases in productivity could therefore be expected only if the F1BxCh progeny were reared in a parasite-free environment.

The greatest effects of heterosis on cow productivity are manifest through cow fertility and calf survival. Pregnancy rates achieved over about 10 weeks by straightbred and crossbred cows are shown in Table 2. Pregnancy rates have been corrected for cow age and previous lactation status. Values in cells with common sire and dam breed of origin are values for straightbreds. All other values are for crossbred dams. Values for calving rates will not be available until the end of the current calving season in December. Pregnancy rates for the straightbreds were similar to one another and, with one exception, significantly lower than that of every F1 genotype. The expected value for the F1(BXxTu) is the mean of F1(BxTu) and F1(HSxTu), or 90%. No explanation is offered for the apparent anomaly. Pregnancy rates for Bo-sired genotypes were consistently higher than those of B-sired contemporaries suggesting that the inherent fertility of the Bo is higher than that of the B. All F1s from B dams had similar values suggesting that the non-B parental breeds have similar inherent fertilities.

Table 2. Pregnancy rates (%) for straightbreds and crossbreds

	Sire Breed of Origin						
Dam Origin	HS	AX	BX	B	Bo	Tu	Ch
HS	80 (270)*	-		90 (125)	95 (66)	89 (106)	-
AX	-	80 (129)	-	88 (127)	96 (106)	90 (112)	-
BX	-	-	-	86 (91)	91 (101)	78 (81)	-
B	87 (169)	87 (132)	78 (57)	77 (276)	89 (64)	90 (66)	90 (100)

* Number of animals

Productivity was measured for the cows of each genotype as the live weight of 18mth old progeny produced per kg. of mature cow joined during a 10weeks breeding season ('Cow Efficiency', Table 3). This measure minimises any differences in feed requirements for the different genotypes whether cows or progeny, and integrates reproduction, survival and mature weight of the cows, and growth and survival rates of their progeny, into a single value. Values in cells with common sire and dam breed of origin are values for straightbreds. All other values are for crossbred dams with crossbred progeny. eg. the cell HS dam origin x Bo sire origin is the value for F1HSxBo dams that reared 3-way cross calves by the same B sires used to produce straightbred B calves. The values shown in Table 3 do not incorporate all data. However, final analysis is not expected to significantly alter the overall result.

Table 3. 'Cow efficiency' for each genotype (kg progeny/kg cow joined)

	Sire Breed of Origin						
Dam Origin	HS	AX	BX	B	Bo	Tu	Ch
HS	.43	-		.57	.62	.73	-
AX	-	.45	-	.59	.67	.63	-
BX	-	-	-	.59	.65	.54	-
B	.62	.57	.50	.49	.60	.57	.57

Values for all straightbreds were lower than the values for every crossbred. Within the straightbreds, cow efficiency increased with increasing adaptation of the breed. This reflects the production system of minimal intervention to control parasites. However, the value for the B, the best-adapted straightbred, was still 9% lower than that of the F1BXxTu, the lowest of the F1s. The differences in favour of the crossbreds were achieved without any additional inputs and are real differences in production efficiency. High mature cow weight was not associated with high cow efficiency either in the straightbreds or crossbreds. The AX cows were 10% heavier than the B cows but had 8% lower efficiency. The F1BxCh cows were 13% heavier than the F1BxHS cows but had 8% lower efficiency. In terms of biological efficiency, there is therefore no merit in imposing selection that results in increased mature cow weight unless that increase is accompanied by improvements in other components of efficiency. Evidence from the AX, which has been selected since 1984 for high 600day weight EBV, is that while weight at all ages has increased, cow efficiency has not. Bo-sired cows had consistently higher efficiency, and Tu-sired cows were generally more efficient, than their B-sired contemporaries. These results suggest that partial substitution of B with Bo and/or Tu in crossbreeding programs will increase productivity of the breeding females.

At this stage, productivity of slaughter stock has been investigated only for steers finished in feedlot. Productivity has been assessed in terms of how rapidly the steers grew to slaughter weight (600+ kg) (Table 4), including a component of gain over 120 days in feedlot (Table 5), and how efficiently they gained in feedlot (Table 6). All breeds entered the feedlot off pasture at about 450kg live weight. They were therefore different ages, and different degrees of maturity, when they entered feedlot.

Table 4. Weight/day of age at slaughter for steers grown on pasture to 450kg and finished in feedlot

	Sire Breed						
Dam Breed	HS	AX	BX	B	Bo	Tu	Ch
HS	. 64	-		.71	.68	.65	-
AX	-	.72	-	.74	.73	.72	-
BX	-	-	.67	.69	.68	.70	-
B	.69	.73	.69	.65	.65	.67	.76

There was significant heterosis for weight/day of age (W/A) and all reciprocal crosses exceeded the better parent. Within each dam breed, W/A for taurus x taurus or indicus x indicus crossbreds equalled that of the straightbred while every indicus x taurus crossbred exceeded that of straightbred contemporaries. W/A of indicus x taurus crossbreds was closely related to the mature weight of the parental breeds. Hence, crosses containing Ch or AX had the highest gains while those based on B exceeded those based on Bo. Thus, it can be expected that F1BxCh animals would reach 600kg live weight about 10% sooner than F1BxHS contemporaries while F1HSxB animals would attain 600kg about 5% sooner than F1HSxBo contemporaries.

Table 5. Gain/day for steers (entry weight 450kg) over 120 days in feedlot

	Sire Breed						
Dam Breed	HS	AX	BX	B	Bo	Tu	Ch
HS	1.3	-	-	1.5	1.3	1.2	-
AX	-	1.6	-	1.5	1.3	1.4	-
BX	-	-	1.2	1.3	1.4	1.4	-
B	1.4	1.4	1.4	1.0	1.2	1.3	1.5

Gain/day in feedlot also consistently favoured the larger breeds and within all dam breeds except the AX, favoured crossbreds over the straightbred. Of particular note were the high gains of the AX and the low gains of the B. The effects on productivity of differences between genotypes in W/A and in gain in feedlot have not been fully analysed.

Table 6.Gross efficiency of feed conversion (kg feed/kg gain) for steers finished in feedlot

	Sire Breed						
Dam Breed	HS	AX	BX	B	Bo	Tu	Ch
HS	9.0 (30)*	-	-	7.6 (9)	8.9 (6)	10.4 (6)	-
AX	-	7.5 (15)	-	7.1 (11)	8.4 (8)	8.0 (7)	-
BX	-	-	8.7 (9)	8.9 (10)	7.8 (7)	7.6 (8)	-
B	7.9 (12)	7.6 (17)	7.7 (12)	9.8 (18)	8.9 (5)	8.0 (9)	7.0 (12)

* Number of animals

Within each dam breed, gross efficiency of feed conversion was closely correlated with gain in feedlot. Thus, the F1BxCh had higher gross efficiency than the F1BxHS while both were significantly more efficient than the B. The high correlation is expected when breeds are compared at different degrees of maturity. However, the comparison has relevance where it is necessary to grow all animals, regardless of breed, to a particular final weight (as, for example, to meet Jap. Ox specifications) rather than to a particular degree of maturity. A complete analysis of the effect of differences in gross efficiency of gain has not been conducted. However, if it is assumed that all other costs are equal, the cost of feed to produce 1kg of live weight gain under the stated conditions is about 40% higher for a B than for an F1BxCh.

Meat and carcase qualities have also been assessed. All genotypes achieved a high proportion of Jap. Ox carcases with some genotypes achieving 100%. Tenderness, whether assessed by mechanical

methods or by taste panel, of electrically stimulated and aged L.dorsi, was least for B and greatest for HS. Tenderness of meat from the sanga (Bos taurus) breeds approached that of meat from the HS. There was no significant heterosis for tenderness. In some circumstances it may therefore be desirable to partially substitute B with sanga to reduce B content to about 25% without the major loss of tropical adaptation that occurs if only European was used.

Project 'Spin-offs'

(1) Every steer slaughtered within the project had white carcase fat. This occurred regardless of age of the steers and whether they were finished on pasture or in feedlot. It is hypothesised that the result occurred because the animals were not castrated until almost18mth of age and were generally slaughtered within the next 18mth. Castration at 18mth did not appear to have any subsequent adverse effects on meat or carcase qualities. The technique is potentially a simple, low-cost and reliable method for enabling the consistent production off pasture of carcases with white fat and should be further investigated.

(2) Most Brahman sires produced progeny whose carcases were either devoid of visible marbling or which had low marble scores. However, a Brahman sire whose progeny marbled as well as the progeny of the average Tuli sire was identified. The possibility that marbling in the Brahman sire is controlled by different genes to those in taurine breeds, that the sire is a carrier of a major gene for marbling and that a marker can be found for the gene need investigation. The availability of Brahman sires with high marbling potential would allow the generation of well-adapted Brahman x taurus crossbreds with high marbling potential. Progeny of a Boran sire had the highest marbling of any breed group. The importance of this should also be further investigated.

(3) None of the taurine breeds in the project had high resistance to worms and growth of all taurine breeds and crosses was depressed by worms. However, sires were found within the normally highly worm-susceptible HS and AX lines whose progeny had extremely low worm egg counts at all ages. The form of resistance involved appears to be under control of a single gene. The phenomenon should be thoroughly investigated. A complementary approach is to investigate South American criollo (Bos taurus) breeds that may have very high resistance to worms (and to other stresses of the tropics).

Communication

1997-98. Results from the project have been presented in Australia and overseas including :-Invited (keynote) speaker at international scientific congresses and cattle producers conferences in Zimbabwe, South Africa, Paraguay, Brazil and USA, presented a paper at an international congress in Australia, invited (keynote) speaker at field days at Mt Coolon, Kynuna, Cloncurry and Richmond, and addressed groups of beef cattle producers visiting TBC. Results have also been presented on radio and television in Australia and overseas.

Plans for next 12mth

The project has effectively been terminated. Extreme uncertainty surrounds the future of several project staff and Belmont, almost all animals generated within the project have been disposed of, without consultation, and funds remaining at the end of the data collection phase of the project have been withdrawn. If I remain on staff at TBC, it is my intention to continue analysing data from the project and publishing the results.

Other Comments

The results, although not completely analysed, clearly demonstrate that significant improvements in productivity can be achieved, simply, rapidly and at very low cost, by utilising the genetic variation that exists between the breed groups used in the project. It would be extremely naive to expect that further improvements in productivity could not be made through better utilisation of currently

available genotypes or through use of other, as yet unavailable, genotypes. Other breed groups and breeds within the project groups should also be evaluated for their role in improving the productivity of the northern Australian herd.

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Discussion / Comments

John Frisch

Q. *How many Adaptaurs are currently out in industry?*

A. There are some, but over recent years, have been unable to release animals because of ongoing commercialisation efforts.

Q. *Your results talk only of the F_1 - we really need answers as to what happens with the F_2+.*

A. We have answers to these questions, although there are some difficulties because many of our animals were sold before data collection was complete.

Q. *I dispute your statement that crossbreeding provides a free lunch ... there is no such thing as a free lunch! Crossbreds eat more than purebreds to achieve their higher growth rates. On a fixed 1000 AE property, you would need to run fewer crossbreds than purebreds.*

A. I agree. However, 1000 head of productive animals will produce more beef than 1000 head of unproductive animals.

Q. *With restocking following the BTEC scheme, no genetic pressure has really been applied in northern herds. Should we be setting up a genetically superior herd of straightbreds before we try crossbreeding?*

A. JEF's overhead showing effects of selection + crossbreeding shows quite clearly that crossbreeding works independently of selection, but both can and should be used simultaneously.

Q. *Should we tighten up our management before we start trying to improve our genetics?*

A. No, both should be tackled on a complementary basis.

Q. *The biggest problem the northern industry faces is the lack of large numbers of suitable crossbred bulls.*

A. Industry needs to organise itself to access desirable bull genotypes, through use of contract matings etc. to produce the required number of bulls.

Q. *You say the aim of selection is to increase herd fertility, but other research shows that management is more important.*

A. Crossbreeding is often the simplest way to improve herd fertility. Breeders are wasting their time culling cows to improve commercial herd fertility. But selection must be applied at seedstock herd level.

Crossbreeding Project within Meat Quality CRC

MLA Project No.: NAP3.104

Project Duration: January 1997 to June 2000

Principal Investigator: Dr B.M. Bindon
Cooperative Research Centre for the Cattle and Beef Industry (Meat Quality)
C.J. Hawkins Homestead, University of New England, Armidale, NSW 2351
Phone: 02 6773 3501
Fax: 02 6773 3500
Email: beefcrc@metz.une.edu.au

Project Objectives

By June 1999,

- identify sires and sire breeds which rank highly for net feed conversion efficiency, as well as carcase traits, such as marbling and retail beef yield;
- identify the most profitable F_1 genotypes for grain and grass finishing for domestic, Korean and Japanese market specifications in northern and southern environments;
- estimate the differences between Estimated Breeding Value (EBV) bases of different breeds so that EBVs can be compared across breeds;
- determine the accuracy with which EBVs predict performance of crossbred offspring;
- determine the effect of *Bos indicus* content on eating quality of cattle of known genotype, growth paths, backgrounding environment, finishing regime and slaughter process to develop MSA pathways for northern cattle;
- improve the industry's ability to compete for the quality-based Asian markets;
- deliver the above outcomes to industry through the CRC's Education and Technology Transfer sub-program, the CRC's cooperating breeders, sponsors and industry-driven Board and Advisory Committee.

Project Summary

This project is part of an overall CRC breeding strategy to identify, by progeny test, the sires, breeds and crosses of Australian beef cattle best suited to the meat quality specifications of our domestic and export markets. Meat Research Corporation funding for NAP3.104 was approved late in 1996 to facilitate the completion of the Meat Quality CRC's Northern Crossbreeding project, which commenced in 1994. Specifically, $60,000 was approved in 1996/97 to assist with the artificial breeding and agistment costs to achieve the third joining of the 1,000 cow Brahman herd located at "Duckponds" and Brigalow Research Station in Central Queensland. A further $240,000 of MRC funds was approved for 1997/98 to assist with the purchase, grow-out, transport, finishing, slaughter and meat quality measurement of some 600 to 700 progeny by nine sire breeds.

Results of the Breeding Program

About 1,000 Brahman cows that were donated to the CRC by northern Australian cattle companies, individual beef producers and the Queensland Department of Primary Industries were joined at "Duckponds" and Brigalow Research Station over three joining periods to produce comparable purebred Brahman and Brahman-crossbred calves that were weaned in 1996, 1997 and 1998 at an average age of 6 months. Calves in the 96-calf crop were by 8 sire breeds (Angus, Belmont Red, Brahman, Charolais, Hereford, Limousin, Santa Gertrudis and Shorthorn), whilst calves in the 97- and 98-calf crops also included Charbray sires. Numbers of calves weaned by sire breed and sex over each of the years are shown in Table 1.

Table 1. Number of calves weaned within sire breed and sex and total number of sires represented in each breed over three calf crops

Sire Breed	No. sires	Calf Sex	Calf crop 96-crop	97-crop	98-crop	Total
Angus	10	M	28	33	27	
		F	25	20	25	158
Belmont Red	14	M	93	78	52	
		F	80	57	32	392
Brahman	14	M	95	26	43	
		F	98	30	43	335
Charbray	4	M	0	27	10	
		F	0	31	19	87
Charolais	16	M	20	41	53	
		F	24	28	66	232
Hereford	8	M	24	31	15	
		F	27	24	21	142
Limousin	14	M	43	66	51	
		F	41	60	36	297
Santa	8	M	39	16	11	
Gertrudis		F	53	16	8	143
Shorthorn	8	M	19	21	18	
		F	19	22	22	121
Total	96	M	361	339	280	1907
		F	367	288	272	

To strengthen the experimental design and ensure wider use of the data, genetic linkages were generated between the CRC's Crossbreeding project and other MLA-funded projects (CRC Straightbreeding project and Belmont, Grafton and Southern Crossbreeding projects) by use of common sires across projects. Within both the CRC crossbreeding and straightbreeding project, progeny were allocated at weaning to finishing either in northern or temperate environments, on grass or on grain and to one of three market destinations (domestic, Korean or Japanese). The experimental design of the CRC's breeding projects is shown in Figure 1.

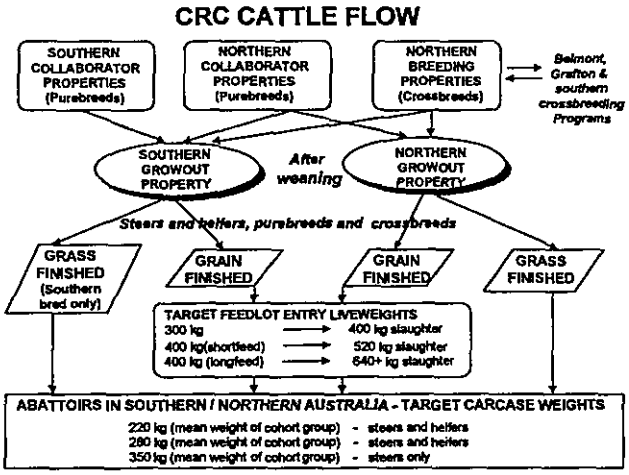


Figure 1. Cattle breeding flowchart for CRC crossbred and straightbred progeny

In spite of the effects of drought over the three breeding seasons at "Duckponds", a total of 1950 observations (matings) were recorded in the three joining periods, with a herd average pregnancy rate of 75%. Gestation length averaged 285 days and a reproductive loss from positive pregnancy test to

weaning averaged 9% of all cows mated. There were no significant differences between the properties of origin of the cows for the reproductive and mortality traits studied. Mating group, lactation status, paddock mated and year of mating were significant sources of variation on reproductive traits, and all of these effects were largely a function of nutrition and body condition.

Gestation length, combined with post-partum anoestrus (the period from birth of calf to when the cow next comes in heat) measures calving interval. A shorter gestation period allows the cow more time to begin cycling before the next mating season. This trait is important in terms of maximizing pregnancy rates when restricted joining is practiced. Property of origin of the cows was not a significant source of variation in gestation length. The trait was significantly affected by year, sire breed, date of calving, calf sex (bull calves were in utero on average 2 days longer than heifer calves) and was significantly related to calf birth weight (heavier calves were generally associated with longer gestation lengths). Table 2 shows the effect of sire breed on gestation length of calves conceived by artificial insemination (gestation length could only be measured on cows that calved to AI because an accurate time of conception [AI date] is necessary to calculate days from conception to calving.) Charolais, Limousin, Charbray and Brahman bulls sired calves with longer gestation length than the British breeds (Angus, Hereford and Shorthorn). The tropically adapted composite bulls (Belmont Red and Santa Gertrudis) sired calves with intermediate gestation length.

Table 2. Effects of sire breed on gestation length

Sire Breed	No. calves	Gestation length (days)
Angus	98	282
Belmont Red	260	285
Brahman	197	288
Charbray[1]	29	*289*
Charolais	186	286
Hereford	100	*281*
Limousin	228	287
Santa Gertrudis	103	285
Shorthorn	87	283
Total numbers	1290	285

To be significantly different, gestation lengths for sire breeds should differ by 3 days

[1] Charbray sires were not used in the first breeding season

As part of the CRC's crossbreeding program, oestrous synchronization treatments were trialed to develop a novel treatment that was practical to implement in beef cattle herds under extensive management systems and which consistently achieved a tight synchrony of oestrus and high fertility. Three separate AI programs were undertaken over two consecutive years, with groups of two-year old maiden and three-year old non-lactating Brahman females. Two standard oestrous synchronization treatments (Prostaglandin and CRESTAR®) were compared with a novel treatment that simulates MGA, an oral progestagen widely used in the USA but not registered for use in cattle in Australia. Females in the CRESTAR® and MGA simulation treatments were more often detected in oestrus on days 0 to 5 after treatment (87% and 88% respectively) than those in the Prostaglandin treatment (58%). The CRESTAR® treatment induced a much tighter synchrony of oestrus than either of the other treatments, with 95% of heifers in that treatment demonstrating oestrus over a 48-hour period. Oestrus occurred over a four-day period in the other two treatments. Prostaglandin and MGA simulation treatments resulted in significantly higher conceptions to first AI (45% and 51% respectively) than CRESTAR® (33%). MGA simulation treatment resulted in significantly higher calving rates to first AI and two rounds of AI (46% and 50%) than either Prostaglandin (27% and

43%) or CRESTAR® (28% and 38%). There were no differences between treatments for calving rates over the entire breeding season, including backup sires, being 71%, 67% and 75% for Prostaglandin, CRESTAR® and MGA simulation treatments respectively. A single ovarian scan using ultrasonography before the AI program was an effective management tool to evaluate reproductive status of a group of heifers, and hence predict the likely success of the AI program.

Liveweights to 18 months of age

Calf birth weights were recorded only at "Duckponds" for each of the three calf crops. Weaning, yearling and 18 month weights are currently available for 3, 2 and 1 calf crops respectively. Liveweights at birth, weaning, yearling and 18 months of age for each of these calf crops are shown in Table 3. Data were adjusted to a common calving date or age at weighing for weaning and subsequent weights. Sire within breed and sire breed effects were significant for all liveweight traits. Progeny of Charolais sires were heavier at birth (9%), weaning (8%), yearling (5%) and 18 months (8%) than the average of all the population. Progeny of Angus sires were lightest at birth, suggesting Angus sires may have been selected for low EBV for birth weight. Work is currently underway to determine the best method of adjusting for the effects of such sire selection, so that this suggestion can be scientifically tested. Progeny of Brahman sires (in which there is no heterosis) were lightest at weaning and 18 months of age, whilst progeny of Charbray sires were lightest at yearling age. The low yearling weights of Charbray sires was not expected and may reflect the small numbers of calves and limited numbers of sires used to produce this cross.

Table 3. Sire breed effects of birth and weaning weights (3 years of data), yearling weights (2 years of data) and weights at 18 months of age (1 year of data)

Sire Breed	Birth weight (kg)	Weaning weight (kg)	Yearling weight (kg)	18-month weight (kg)
Angus	*31.8*	201	256	392
Belmont Red	31.9	189	256	381
Brahman	32.6	*182*	242	*363*
Charbray	33.0	183	*230*	n.a.
Charolais	*36.6*	*212*	*279*	*423*
Hereford	34.4	204	266	411
Limousin	34.6	199	267	396
Santa Gertrudis	33.3	195	256	383
Shorthorn	34.3	202	262	392
Total numbers	1302	1878	876	375

Preliminary Carcase and Meat Quality Results

To date, 725 crossbred progeny (38% of calves that were bred) have been slaughtered. However, complete meat quality data are not yet available for all carcases. The majority of carcases represented in these preliminary results are derived from grainfed animals and those targeted for domestic and Korean market weights. It is likely that results will change as more data accrue from pasture finished animals slaughtered at heavier carcase weights.

Heifer progeny were slaughtered at domestic and Korean market weights, whilst steers were also slaughtered at Japanese market weights. One half of all steer progeny grown in northern Australia were implanted with repeated doses of Compudose 100® from about 15 months of age until slaughter. Steers transferred south were not implanted, but in those steers, HGP and finishing treatment were totally confounded. Heifers were not implanted. During the initial slaughters, problems occurred with electrical stimulation and the data were considered unreliable for meat tenderness measurements. These data were not included in the analysis. Exclusion of these data meant there were no meat tenderness data for pasture finished steers. Due to these problems, data were analysed within sexes. In all models, sire within breed and kill group were fitted as random effects and sire breed (8 sire breeds,

not including Charbray), market (domestic, Korean and Japanese) and finishing treatment (feedlot north, feedlot south, pasture north) were fitted as fixed effects. HGP treatment (implant, control, no treatment) was fitted to the model using steer data. Sires nested within breed were used as the error term to test breed differences.

Carcass weight was fitted as a covariate within market endpoint to adjust all data to a common carcase weight according to target market weight. This was done because, under the CRC's experimental design, the only way to validly evaluate sires is to slaughter all animals within a cohort group when the average weight of the group is at market weight (i.e. 220 kg, 280 kg and 350 kg carcase weights for domestic, Korean and Japanese markets respectively). Slaughter of all animals at an average weight of the group allows all sires an equal opportunity to perform to market specifications. However, commercial practice dictates that, to maximise returns, producers must slaughter their cattle when individual animals reach market weights. Adjusting all CRC carcase and meat quality data to a common carcase weight within market allows CRC results to be interpreted from a commercial perspective.

No interactions were fitted in the model because of missing sub-classes. Only meat quality data derived from the *M. longissimus dorsi* were used in these analyses. In additional analyses, age was fitted as a dependent variable using the same model to determine differences in ages between breeds, markets and finishing treatment at a common carcase weight. Although only preliminary data are available to date, additional analyses were conducted using steer data within market endpoints to provide an early indication of whether particular sire breeds are more suited to particular markets (domestic, Korean or Japanese). Fixed and random effects used in the earlier analyses were also applied to these analyses.

In general, sires within breed, kill group, market endpoint and finishing treatment were not significant sources of variation for any of the carcase or meat quality attributes in either steers or heifers. Steers were slaughtered at an average carcase weight of 231, 290 and 328 kg for domestic, Korean and Japanese markets respectively, while heifers were slaughtered at an average carcase weight of 220 and 284 kg for domestic and Korean markets respectively. Breed of sire was statistically significant for all carcase and meat quality attributes except for ultimate pH in steers and heifers, for cooking loss in heifers and instron compression in steers and heifers. Table 4 shows the effects of sire breed on age at slaughter and carcase and meat yield attributes in steer and heifer progeny. In both steers and heifers, European breed sires (Charolais and Limousin) produced progeny that had heavier, leaner, higher-yielding carcases than the remaining crosses. In steers, progeny of Santa Gertrudis and Angus sires had the highest subcutaneous fat cover and lowest yields. In heifers, progeny of Hereford sires had highest P8 fat depths and lowest yields, whilst progeny of Limousin sires had the lowest fat cover and highest yield of all the crosses. Over all steers, progeny of Charolais sires produced carcases that were 21% heavier than purebred Brahman controls. There was a similar margin in carcase weights of heifer progeny of both Hereford and Charolais sires relative to Brahman heifers. Differences between breeds in age at slaughter at younger ages partly reflect differences between AI and natural mate sires, as not all breeds were able to provide bulls for natural and backup mating following AI. Differences between ages at slaughter at different market endpoints also reflect differences in growth rate between for example, progeny of different sire breeds.

Table 4. Effects of sire breed on age at slaughter and carcase and meat yield attributes in steers and heifers. Except for hot carcase weight, which is unadjusted, all means are adjusted to a common carcase weight within market endpoint (domestic, Korean or Japanese).

Sire Breed	No. animals	Age at Slaughter (days)	Hot Carcase Wt (kg)	P8 Fat Depth (mm)	Eye Muscle Area (cm^2)	Retail Beef Yield (%)	Retail Primals (kg)
Steer Progeny							
Angus	23	714	295	11.8	*75.3*	66.1	*66.5*
Belmont Red	77	*696*	262	11.6	76.7	66.5	67.5
Brahman	78	705	250	10.8	76.3	66.6	67.2
Charolais	17	698	302	*9.3*	80.8	67.3	68.7
Hereford	20	717	290	10.5	76.2	66.8	67.8
Limousin	39	698	300	*9.3*	*82.1*	*68.5*	*69.6*
Santa Gertrudis	33	*720*	274	*12.9*	75.4	*65.9*	66.6
Shorthorn	15	702	289	10.8	79.3	66.0	*66.5*
Heifer Progeny							
Angus	22	*671*	266	15.7	71.0	65.3	58.2
Belmont Red	75	*652*	236	14.3	69.5	65.7	59.1
Brahman	93	670	214	14.5	68.6	65.7	59.3
Charolais	23	664	268	12.6	70.8	66.5	60.3
Hereford	26	658	271	*15.9*	*65.7*	*64.6*	*58.0*
Limousin	40	670	259	*11.5*	*74.6*	*67.7*	*61.0*
Santa Gertrudis	50	670	245	15.4	68.9	65.6	58.9
Shorthorn	18	*671*	260	15.6	69.2	65.5	58.6

Table 5 shows the effects of market endpoint on age at slaughter and carcase and meat yield attributes in steer and heifer progeny. As expected, age at slaughter, carcase weight and P8 fat depth increased from domestic to Korean to Japanese markets. However, when adjusted to a common carcase weight within market endpoint, retail beef yield percentage decreased.

Table 5. Effects of market endpoint on age at slaughter and carcase and meat yield attributes in steers and heifers. Except for hot carcase weight, which is unadjusted, all means are adjusted to a common carcase weight within market endpoint (domestic, Korean or Japanese).

Market Endpoint	No. animals	Age at Slaughter (days)	Hot Carcase Wt (kg)	P8 Fat Depth (mm)	Eye Muscle Area (cm^2)	Retail Beef Yield (%)	Retail Primals (kg)
Steer Progeny							
Domestic	115	607	231	9.4	77.3	69.1	67.7
Korean	74	742	290	11.0	78.2	66.7	68.3
Japanese	113	770	328	12.3	77.9	64.3	66.7
Heifer Progeny							
Domestic	168	607	220	12.2	65.8	67.4	59.5
Korean	178	725	284	16.7	73.8	64.2	58.9

The effect of finishing regime on age at slaughter and carcase and meat yield attributes is shown in Table 6. Steers and heifers finished in the southern feedlot environment were slightly younger at slaughter than steers and heifers finished in the northern environment. Animals finished at pasture in the north were considerably older and leaner than those finished in either feedlot environment and had larger eye muscle areas, higher retail beef yield percentages and the greatest weight of retail primals.

Table 6. Effects of finishing regime on age at slaughter and carcase and meat yield attributes in steers and heifers. Except for hot carcase weight, which is unadjusted, all means are adjusted to a common carcase weight within market endpoint (domestic, Korean or Japanese).

Finishing Regime	No. animals	Age at Slaughter (days)	Hot Carcase Wt (kg)	P8 Fat Depth (mm)	Eye Muscle Area (cm^2)	Retail Beef Yield (%)	Retail Primals (kg)
Steer Progeny							
Feedlot north	113	673	301	12.9	75.4	66.1	67.3
Feedlot south	113	641	271	11.7	74.8	66.2	66.2
Pasture north	76	805	276	8.0	83.0	67.9	69.1
Heifer Progeny							
Feedlot north	117	633	252	15.8	68.0	65.9	59.2
Feedlot south	111	626	258	13.9	65.4	64.5	58.1
Pasture north	119	739	247	13.6	76.0	67.0	60.2

Table 7 shows the effects of sire breed on intramuscular fat percentage (marbling) and measures of meat tenderness in steers and heifers. Angus, Belmont Red and Shorthorn sires consistently produced progeny with the highest intramuscular fat percentages. Based on all indicators of meat toughness (cooking loss, ultimate pH, peak force and instron compression), purebred Brahman sires produced progeny with the toughest meat. Average peak force values in both steers and heifers were above the acceptable values for tenderness, indicating that a high proportion of Brahman carcases would be deemed unacceptably tough by consumers. Sire breed differences in instron compression were not as evident as in other indicators of toughness. Instron compression is believed to be a better indicator of toughness due to collagen content than peak force measures, suggesting that collagen content is not an issue with respect to toughness in these animals, although all animals in this dataset were less than 2.5 years of age at time of slaughter.

The effects of market endpoint on intramuscular fat percentage (marbling) and indicators of meat tenderness (cooking loss, ultimate pH, peak force and instron compression) in steer and heifer progeny are shown in Table 8. As animals increased in age and slaughter weight from domestic to Korean to Japanese markets, intramuscular fat percentage increased in both steer and heifer progeny. However, meat toughness did not significantly increase with increasing age or carcase weight in either steers or heifers, although all animals in this dataset were less than 2.5 years of age at time of slaughter. The results are similar to those derived from the CRC's linked, straightbreeding project (see separate report for Project FLOT.102). They suggest that the common practice of incurring fixed costs of slaughtering animals at lighter weights for the Australian domestic market to ensure a tender product is a fallacy and suggest that considerable cost savings would accrue to processors and retailers who slaughter animals at heavier weights, without any detrimental effects on meat tenderness.

Table 7. Effect of sire breed on intramuscular fat percentage (IMF%), cooking loss, ultimate pH, peak force and instron compression in steer and heifer progeny. All means are adjusted to a common carcase weight within market endpoint (domestic, Korean or Japanese).

Sire Breed	No. animals	IMF%	Cooking Loss (%)	Ultimate pH	No. animals	Peak Force (kg)	Instron Compression (kg)
Steer Progeny							
Angus	23	*2.66*	22.5	5.57	14	*4.58*	1.72
Belmont Red	77	2.62	22.7	*5.55*	47	4.78	*1.70*
Brahman	78	1.95	*23.7*	*5.55*	50	*5.89*	1.81
Charolais	17	1.98	22.8	5.57	11	4.90	1.79
Hereford	20	2.41	22.0	5.58	11	4.64	*1.84*
Limousin	39	*1.89*	22.5	5.56	24	4.63	1.75
Santa Gertrudis	33	1.96	23.1	5.56	22	5.01	1.80
Shorthorn	15	2.62	*21.3*	*5.59*	10	4.76	1.73
Heifer Progeny							
Angus	22	*3.35*	*21.9*	5.56	21	4.54	1.77
Belmont Red	75	2.74	22.4	*5.54*	71	5.11	1.79
Brahman	93	2.16	*22.8*	*5.57*	85	*5.90*	1.86
Charolais	23	2.22	*22.8*	5.56	20	5.12	*1.87*
Hereford	26	2.52	22.6	5.55	25	*4.53*	1.78
Limousin	40	2.12	22.1	5.57	37	5.03	1.84
Santa Gertrudis	50	*1.84*	22.6	5.55	49	4.93	1.82
Shorthorn	18	3.23	*21.9*	5.55	18	4.83	*1.72*

Table 8. Effect of market endpoint on intramuscular fat percentage (IMF%), cooking loss, ultimate pH, peak force and instron compression in steer and heifer progeny. All means have been adjusted to a common carcase weight within market endpoint (domestic, Korean or Japanese).

Market Endpoint	No. animals	IMF%	Cooking Loss (%)	Ultimate pH	No. animals	Peak Force (kg)	Instron Compression (kg)
Steer Progeny							
Domestic	115	1.65	22.5	5.55	75	4.99	1.70
Korean	113	2.28	21.9	5.57	77	4.52	1.81
Japanese	74	2.85	23.3	5.59	37	5.18	1.78
Heifer Progeny							
Domestic	169	2.41	22.0	5.54	148	4.88	1.71
Korean	178	2.63	22.8	5.57	178	5.12	1.91

Table 9 shows the effect of finishing regime on intramuscular fat percentage (marbling) and indicators of meat tenderness. Grain finishing substantially increased intramuscular fat percentages in both northern and southern feedlot environments relative to pasture finishing in the north. The ultimate pH of animals finished on grain in the south was consistently lower than the ultimate pH of animals finished on either grain or at pasture in the north. This may be an effect of abattoir, as early kill groups finished in the north were slaughtered at a different abattoir to those finished in the south. Additional data are required to confirm this result. There were no reliable meat tenderness data available for steers that were finished at pasture in the north. However, heifers finished at pasture in the north were consistently tougher than heifers finished in either northern or southern feedlot environments, whether toughness was measured by peak force or instron compression. These results

confirm similar findings derived from the CRC's linked, straightbreeding project (see separate report for project FLOT.102).

Table 9. Effect of finishing regime on intramuscular fat percentage (IMF%), cooking loss, ultimate pH, peak force and instron compression in steer and heifer progeny. All means have been adjusted to a common carcase weight within market endpoint (domestic, Korean or Japanese).

Finishing Regime	No. animals	IMF%	Cooking Loss (%)	Ultimate pH	No. animals	Peak Force (kg)	Instron Compression (kg)
Steer Progeny							
Feedlot North	113	2.30	22.0	5.58	113	4.71	1.78
Feedlot South	113	2.74	22.8	5.50	76	5.09	1.75
Pasture North	76	1.74	22.9	5.62	n.a.	n.a.	n.a.
Heifer Progeny							
Feedlot North	117	2.09	21.4	5.58	117	4.77	1.67
Feedlot South	111	3.90	22.0	5.47	111	4.74	1.75
Pasture North	119	1.58	23.7	5.62	98	5.48	2.01

To determine whether some sire breeds are more suited to particular market endpoints than others, steer data were analysed separately within markets (domestic, Korean or Japanese). Table 10 shows the effects of sire breed on age at slaughter and carcase and meat yield attributes within each of the market categories, whilst Table 11 shows the same effects on intramuscular fat percentage (marbling) and indicators of meat tenderness. Because of low numbers within cells, results from these analyses must be considered as preliminary. However, based on these results, it does not appear that major re-ranking of sires breeds occurs as animals are turned off from domestic to Korean to Japanese market weight specifications. Notable points from these analyses include:

- European and British sire breeds over Brahman cows produced carcases that were consistently heavier at all market weights than progeny of tropically adapted composite sires or Brahman sires. This may change as more animals are finished at pasture in the north;
- Differences between sire breeds are relatively small for yield traits at domestic market weights, but increase from domestic to Korean to Japanese weights;
- Differences between sire breeds for intramuscular fat percentage are not being expressed in domestic market weight animals, where IMF% values are very low. At later market weights, the differences between sire breeds in IMF% are consistent;
- P8 fat depth in progeny by Large European sires (Charolais and Limousin) is adequate for domestic market specifications and is similar to that of progeny of British breed sires;
- At Korean and Japanese market weights, [Charolais x Brahman] and [Limousin x Brahman] crossbred progeny are leaner and have greater yield percentages than the remaining crossbreds;
- Based on peak force measurements, Brahman progeny consistently have the toughest meat at all market endpoints.

Table 10. Effects of sire breed on age at slaughter and carcase and meat yield attributes in steers within markets (domestic, Korean and Japanese). Except for hot carcase weight, which is unadjusted, all means are adjusted to a common carcase weight within market endpoint.

Market / Sire Breed	No. animals	Age at Slaughter (days)	Hot Carcase Wt (kg)	P8 Fat Depth (mm)	Eye Muscle Area (cm^2)	Retail Beef Yield (%)	Retail Primals (kg)
Domestic							
Angus	8	587	238	6.8	66.3	69.4	55.9
Belmont Red	29	*566*	215	7.3	66.5	69.1	55.8
Brahman	30	572	*205*	7.1	66.1	68.8	56.2
Charolais	9	574	242	6.1	71.7	69.3	56.9
Hereford	7	*594*	*246*	*6.0*	*65.4*	69.9	56.9
Limousin	15	576	242	7.7	75.1	*70.1*	*57.3*
Santa Gertrudis	12	586	218	*9.5*	65.6	*67.6*	*54.6*
Shorthorn	5	579	227	7.3	*75.3*	67.8	*54.6*
Korean							
Angus	9	752	300	13.1	76.9	65.1	*69.1*
Belmont Red	30	*734*	271	13.2	77.2	65.6	70.4
Brahman	31	753	*253*	12.3	74.3	66.0	70.7
Charolais	5	739	*328*	11.8	77.2	68.0	72.9
Hereford	6	750	297	13.8	*80.3*	65.0	69.6
Limousin	13	745	311	*10.2*	76.2	*68.9*	*73.6*
Santa Gertrudis	12	*758*	278	*14.8*	*73.8*	65.4	69.8
Shorthorn	7	736	300	11.8	74.9	*64.9*	69.2
Japanese							
Angus	6	740	351	*18.8*	*75.8*	***62.6***	*77.2*
Belmont Red	17	735	304	17.5	80.9	64.0	78.0
Brahman	18	730	*288*	15.1	78.8	63.7	78.5
Charolais	3	717	347	*10.9*	*87.2*	63.6	79.5
Hereford	7	745	334	14.5	77.4	64.2	79.0
Limousin	11	*715*	*358*	12.1	86.3	*65.8*	*81.2*
Santa Gertrudis	9	*747*	329	16.4	79.3	64.6	78.8
Shorthorn	3	744	352	16.2	82.5	64.9	79.0

Table 11. Effect of sire breed on intramuscular fat percentage (IMF%), cooking loss, ultimate pH, peak force and instron compression in steers within markets (domestic, Korean and Japanese). All means are adjusted to a common carcase weight within market endpoint.

Market / Sire Breed	No. animals	IMF%	Cooking Loss (%)	Ultimate pH	No. animals	Peak Force (kg)	Instron Compression (kg)
Domestic							
Angus	8	1.60	22.9	5.53	6	*4.42*	1.68
Belmont Red	30	1.71	22.9	5.53	19	5.17	1.67
Brahman	29	*1.33*	*23.3*	5.53	18	*5.60*	*1.74*
Charolais	9	1.53	22.8	5.55	6	5.20	1.70
Hereford	7	1.73	22.2	*5.58*	4	4.59	1.71
Limousin	15	1.68	22.5	5.53	10	4.67	1.59
Santa Gertrudis	12	1.36	22.9	*5.51*	8	5.13	1.67
Shorthorn	5	*2.05*	*21.2*	*5.58*	4	4.48	*1.54*
Korean							
Angus	9	2.42	22.3	5.55	5	4.20	*1.69*
Belmont Red	30	*2.76*	22.4	5.55	21	4.04	*1.69*
Brahman	31	2.22	*23.4*	5.55	22	*5.95*	1.84
Charolais	5	*1.53*	22.7	5.55	4	4.11	1.84
Hereford	6	2.39	21.9	*5.57*	4	*3.98*	*2.01*
Limousin	13	1.68	22.5	*5.54*	8	4.00	1.82
Santa Gertrudis	12	2.24	23.1	5.55	9	4.44	1.87
Shorthorn	7	2.59	*21.2*	*5.57*	4	4.59	1.87
Japanese							
Angus	6	*4.31*	23.1	5.55	3	5.14	1.82
Belmont Red	17	3.58	23.1	5.54	7	4.62	*1.68*
Brahman	18	2.57	*24.2*	5.54	10	*5.77*	1.80
Charolais	3	2.80	21.9	*5.53*	1	*4.32*	*1.89*
Hereford	7	3.20	22.7	*5.53*	3	5.29	1.78
Limousin	11	2.23	23.2	5.56	6	5.30	*1.89*
Santa Gertrudis	9	*2.19*	23.7	*5.59*	5	5.59	1.87
Shorthorn	3	3.25	*21.6*	5.58	2	5.37	1.82

Meat Standards Australia Eating Quality Grade Based on Consumer Taste Panel

All carcases from this experiment will be submitted to Meat Standards Australia (MSA) consumer taste panels to clearly determine the effect of *Bos indicus* content on eating quality. At this stage, there are insufficient animals tested to draw firm conclusions about all the breed crosses in the experiment. As shown in Table 12 however, the overall MSA eating quality score (i.e. the MQ4 score that combines tenderness, juiciness, flavour and overall eating quality acceptability into a single score) is significantly lower for animals of 75% and greater *Bos indicus* content (purebred Brahmans and Santa Gertrudis x Brahman crosses) than the comparable crossbred animals with lower *Bos indicus* content. Given that the MQ4 cutoff score for MSA 3-star product is 48, then we can conclude tentatively:

- Under existing MSA specifications, only [Angus x Brahman] crossbred carcases would have graded 3-star. All the other genotypes, based on small numbers, would have failed 3-star;
- [Hereford x Brahman], [Belmont Red x Brahman], [Charolais x Brahman], [Limousin x Brahman] and [Shorthorn x Brahman] carcases average between 52 and 59, indicating a proportion reaching 3-star;
- all these carcases are at least 50% *Bos indicus*, indicating that some pathways will successfully take these genotypes to satisfactory MSA grades;
- purebred Brahmans and [Santa Gertrudis x Brahman crosses] are falling below the 48 MQ4 score needed to reach 3 star grade. This is consistent with other research that shows high *Bos indicus* content carcases (≥ 75% *Bos indicus* content) are less tender than lower *Bos indicus* content carcases;
- it is possible, based on other MSA research, that processing techniques such as Tenderstretch will assist higher *Bos indicus* content animals to reach 3 star MSA grade.

Table 12. Meat Standards Australia eating quality (MQ4) scores for CRC carcases of crossbred progeny from Brahman females

Sire Breed	Number of animals	MQ4 Score
Angus	22	61 ± 3
Belmont Red	66	54 ± 3
Brahman	66	41± 3
Charolais	18	52 ± 4
Hereford	19	59 ± 4
Limousin	32	54 ± 3
Santa Gertrudis	52	46 ± 3
Shorthorn	15	56 ± 4

Overall, these results are very positive for Brahman-derived crossbreeds, because most are within striking range of achieving MSA 3-star grade. This is particularly true when it is considered the results were achieved without application of special processing techniques, such as tenderstretching and ageing for more than 14 days, that are known to increase MSA scores and reduce variation in eating quality.

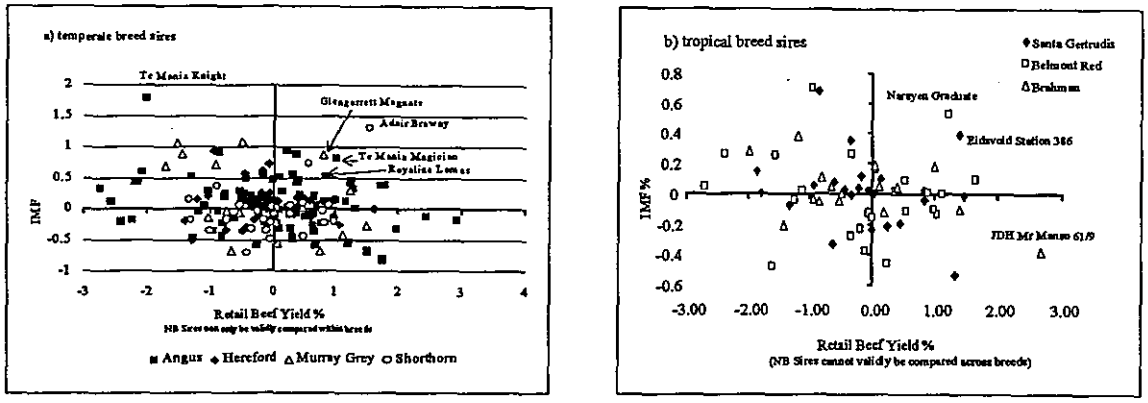
Effect of Hormonal Growth Promotants

Half the steers in this project have been treated with hormonal growth promotants (HGPs). We will thus have data on effects of HGPs on growth, carcase, meat quality and MSA eating quality in all CRC crossbred progeny. These results will be reported separately to MLA and industry in a special publication once consumer taste panel results are complete.

Linkages with FLOT.102, Straightbreeding project within Meat Quality CRC

Genetic linkages were generated between the CRC's crossbreeding and straightbreeding projects by use of common sires. Only sires that were evaluated in the CRC's straightbreeding project were used to generate progeny in the CRC's crossbreeding project. This design permits evaluation of sires for traits such as feed conversion efficiency, marbling, retail beef yield and meat tenderness and will determine the accuracy with which EBVs predict performance of crossbred offspring. However, until complete data are available for crossbred progeny, evaluation of sires within the crossbreeding project is not possible. Because the CRC's straightbreeding project began two years before the start of the crossbreeding project, sires with outstanding genetic merit for carcase and meat quality traits have already been identified in all breeds. Adjusted sire averages for retail beef yield and marbling (intramuscular fat %) for temperate and tropical breed sires used in the CRC's crossbreeding project, but derived from performance of straightbred progeny, are shown in Figure 2. As soon as feed efficiency and carcase and meat quality data are available for crossbred calves by these sires, the accuracy with which EBVs predict performance of crossbred offspring relative to purebred progeny will be determined.

Figure 2. Adjusted Sire Averages for Retail Beef Yield % and Intramuscular Fat % (Marbling) of a) temperate and b) tropical breed sires, derived from CRC straightbred progeny



Carcase results derived from donated Brahman cows

Despite their involvement in three drought-affected mating periods, during which time they weaned on average more than 2 calves per cow, the donated Brahman cows yielded carcases with good fat cover (13mm) and weight (238 kg) to gross $376 / head. Data were collected from 450 Brahman cows donated by industry to the CRC for use in the Northern crossbreeding project at "Duckponds". After participation in three consecutive joining periods, the cows were processed in Rockhampton on 6 different slaughter dates between late 1997 and mid 1998. Carcase information was compiled from AUSMEAT feedback sheets. Hot carcase weight (HCWT) averaged 238 kg and ranged from 172 kg to 333 kg. P8 fat thickness averaged 13mm and ranged from 0 mm to 50 mm. Price paid averaged $1.57 per kilogram HCWT and ranged from $1.03 to $2.00. Gross value of the carcases average $376 and ranged from $212 to $610. Carcases were graded by the processing plant according to dentition, fat cover, HCWT and butt shape. The grades can be grouped broadly into three major categories, namely Japanese, Domestic and US Cow markets. The majority (95%) of carcases met US Cow market specifications, while 1% met the premium Japanese and 1% met Domestic market requirements. A further 3% of carcases were downgraded for over-fatness (>32 mm).

HCWT was the single most important determinant of carcase value. Fat thickness, live weight when first joined at "Duckponds", year of slaughter, parity (number of calves weaned in three years), reproductive status prior to slaughter (lactating or non-lactating) and property of origin of cow were all significant sources of variation in HCWT. The relationship between fat thickness and HCWT was positive, indicating that an increase of 1mm of fat was associated with an increase of around 2kg in HCWT. Cows that weaned 0, 1 or 2 calves between first mating and slaughter had carcases that were 27kg, 22kg and 12kg heavier respectively than cows that weaned 3 calves in 3 joining periods. Carcases of cows that were not lactating prior to slaughter were 9kg heavier on average than carcases of cows that had weaned a calf prior to slaughter. The effects of parity and lactation status demonstrate a permanent environmental effect, where more productive cows partition body nutrients toward reproduction and lactation rather than body growth and hence have lower body weights and carcase weights than less productive cows.

NAP3.104 CRC Northern Crossbreeding Project ... take-home messages

- This is a genuine (sire) breed comparison, since all sires were randomized across the sample population of Brahman females in the one environment;
- Crossbreeding outcomes must be assessed on the basis of:
  - fertility, calf survival, growth and production benefits;
  - carcase weight and yield traits;
  - meat quality traits;
  - tenderness and eating quality.

- Breed of sire had large and significant effects on gestation length, liveweights between birth and slaughter and for most carcase and meat quality attributes including eye muscle area, retail beef yield percentage, weight of "primal" cuts, marbling and objective measures of meat tenderness;
- European breed sires (Charolais and Limousin) produced progeny with heavier, leaner and higher-yielding carcases than the other sire breeds. Progeny of Charolais sires had carcases that were 21% heavier than purebred Brahman controls;
- Angus, Belmont Red and Shorthorn sires consistently produced progeny with the highest intramuscular fat percentages;
- Purebred Brahman sires produced progeny with less tender meat, although sire breed differences for instron compression measurements were not as great as for other indicators of meat toughness. Instron compression is believed to be a better indicator of toughness due to collagen content than peak force measures, suggesting that collagen content is not an issue with respect to toughness in these animals, although all animals with data herein were less than 2.5 years of age at time of slaughter;
- As animals increased in age and slaughter weight from domestic to Korean to Japanese markets, intramuscular fat percentage increased in both steer and heifer progeny.
- However, contrary to expectations, meat toughness did not increase with increasing age or carcase weight in either steers or heifers, although all animals in this dataset were less than 2.5 years of age at time of slaughter. These results suggest that the common practice of incurring fixed costs of slaughtering animals at lighter weights for the Australian domestic market to ensure a tender product is a fallacy and suggest that considerable cost savings would accrue to processors and retailers who slaughter animals at heavier weights, without any detrimental effects on meat tenderness;
- Grain finishing substantially increased intramuscular fat percentages in both northern and southern feedlot environments relative to pasture finishing in the north. Crossbred progeny finished at pasture in the north were considerably older and leaner, had larger eye muscle areas, higher retail beef yield percentages and greater weight of retail primal cuts than progeny finished in either the northern or the southern feedlot environment;
- Progeny finished at pasture in the north were consistently tougher than progeny finished in either northern or southern feedlot environments, whether toughness was measured by peak force or instron compression;
- Treatment of one half of crossbred steers with hormonal growth promotants is providing new information on the effects of HGP treatment on meat tenderness and eating quality;
- Clearly, the main interest will be whether the crossbreds with superior growth and carcase traits measure up when it comes to meat tenderness and eating quality;
- Meat Standards Australia eating quality data are still being collected. Thus far, animals of 75% or higher *Bos indicus* content are falling below the 48 MQ4 score cutoff for 3-star MSA. Use of tenderstretch will improve these scores. Most other crosses (50% *Bos indicus*) in the project are achieving 3-star MSA standards.

Communication achievements

The CRC, because of its strong linkage to industry through cooperating breeders, sponsors and industry-driven Board and Advisory Committee, is able to deliver its research results directly to industry to ensure maximum end-user adoption in the shortest possible time. The CRC's Education and Technology Transfer Sub-Program, with an allocated budget of about $750K for the current financial year, is taking the lead in this delivery, by way of formal graduate and undergraduate courses, industry training events and short courses and new certificate courses. As well, a strong industry technology transfer program underpins, and is a key element of, a comprehensive and integrated nation-wide technology transfer service conducted by the Core Parties of the CRC and other organisations. Many professional and research staff of the CRC and the Core Parties contribute to this major activity. This year there has been increasing effort directed at adding value to the technology transfer activities of these organisations. CRC specific activities are indicated below.

Plans for the coming year

Slaughter of the last of the CRC's crossbred calves will not be complete until December 1999, when the No. 8 Japanese weight steers are due for turnoff. However, full carcase and meat quality data from animals targeted to the domestic and Korean market endpoints will be available within the next 12 months. Over the coming year, sires with outstanding genetic merit for net feed conversion efficiency and carcase traits will be identified within the CRC's crossbreeding project. The most profitable F_1 genotypes for grain and grass finishing for domestic and Korean market specifications in northern and southern environments will be identified and differences between Estimated Breeding Value (EBV) bases of different breeds will be estimated, so that EBVs can be compared across breeds. As well, in conjunction with MLA's Meat Standards Australia Scheme, the eating quality of all CRC crossbred calves will be determined to develop MSA pathways for cattle of high *Bos indicus* content. Finally, technology transfer efforts will be increased over the coming year, to ensure maximum industry uptake of CRC results.

List of papers, reports or media articles published in the previous 12 months
Extension articles and activities where this project was highlighted

- Confidential reports to CRC cooperating breeders and sponsors (Number 6, November 1997, 40 pages and Number 7, June 1998, 40 pages)
- CRC News – public reports to extension officers, researchers, media and other industry participants (two editions in 1997/98, distributed to 300 people, plus three special editions published for special events such as the ASAPO Conference, the Armidale Feeder Steer School and BeefEx 1998)
- CRC Annual Report circulated to CRC cooperating breeders and sponsors, industry bodies, researchers and other key industry participants (November 1997 / 1998)
- Northern Breeding Updates circulated twice a year to 600 people
- Advances in Beef Cattle Artificial Insemination Workshop, 26th August 1997
- South Burnett Meatworks Industry Day Proceedings, Murgon, 11th October 1997
- Australian Agricultural Company Managers' Seminar, November 1997
- BIA / CRC Field Day, Valinor Stud, Biloela, November 1997
- Presentations to South African visitors, "Duckponds", December 1997
- Presentations at a series of seminars throughout New Zealand, December 1997
- Presentations to visitors attending 6th World Congress Genetics Applied to Livestock Production, Tullimba via Armidale, 14th January 1998
- BIA / CRC Forum on Electronic Decision Making, Rockhampton, January 1998
- National Mutual Property Managers Seminar, Rockhampton, 19th February 1998
- Twynam Pastoral Company Tour, CRC Update, 26th February 1998
- Australian Brahman Breeders' Association Seminar, Rockhampton, 6th March 1998
- Maximising Profitability through the Beef Supply Chain, Armidale, 25th March 1998
- Meat Profit Day, Emerald, 7th April 1998
- ASAP Industry Day and CRC Research Results, Rangers Valley, 22nd April 1998
- BIA Field Day, "Elrose", Cloncurry, 29th April 1998
- CRC Field Day, Brigalow Research Station, June 1998
- Casino Beef Week Seminar, Casino, 2nd June 1998
- Beef Improvement Association of Australia, Annual General Meeting, Rockhampton, 29th July 1998
- Beef Improvement Association National Seedstock Producer of the Year Award, Mt Eugene, Jambin, 30th July 1998
- Special Briefing to Cattle Council of Australia and Meat and Livestock Australia Executive, Goonoo and Duckponds, 16th August 1998
- Special Briefing to Australian Lotfeeders Association Executive, Sydney, August 1998
- Special Briefing to Northern Australian Pastoral Companies, Brisbane, 8th September 1998
- Crossbreeding Workshop, "Melrose", Morinish, 6th October 1998
- Duckponds Open Day Proceedings, "Duckponds", Comet, 22nd October 1998
- CRC Year 5 Review Report – Stage 1 (15th and 16th July, 1998) and 2 (24th and 25th August 1998)

Papers and Scientific Reports

Corbet, N.J., Miller, R.G., Fraser, P.F., Lloyd, A.G. and Burrow, H.M. (1997) Sire breed effects on gestation length of calves in the subtropics. *Proceedings of the Association for the Advancement of Animal Breeding and Genetics*, **12**, 300-303.

Corbet, N.J., Miller, R.G., Bindon, B.M., Burrow, H.M., D'Occhio, M.J., Entwistle, K.W., Fitzpatrick, L.A., Wilkins, J. and Kinder, J.E. (1998) Comparison of three estrus synchronisation treatments in Brahman heifers grazed at pasture in the subtropics. *Theriogenology* (in press)

Hayes, B.J., Shepherd, R.K., Newman, S. and Kinghorn, B.P. (1998) A tactical approach to improving long-term response in across-breed mating plans. *Proceedings of Sixth World Congress on Genetics Applied to Livestock Production*, **25**, 439-442.

MacNeil, M.D., Newman, S., Lamberson, W.R. and Hochman, Z. (1998) Decision support systems to aid beef producers in choosing a crossbreeding strategy. *Proceedings of Sixth World Congress on Genetics Applied to Livestock Production*, **27**, 437-440.

Newman, S. and Stewart, T.S. (1997) Decision support systems for beef crossbreeding programs. *Proceedings of the Association for the Advancement of Animal Breeding and Genetics*, **12**, 774-777.

Newman, S., Stewart, T.S., Goddard, M.E. and Gregory, M. (1997) HotCross – A decision support aid for crossbreeding of beef cattle in tropical and subtropical environments. *Proceedings of the Association for the Advancement of Animal Breeding and Genetics*, **12**, 400-403.

Newman, S., Stewart, T.S., Goddard, M.E. and Gregory, M. (1998) A decision support aid for tropical beef crossbreeding. *Proceedings of Sixth World Congress on Genetics Applied to Livestock Production*, **27**, 474-474.

Newman, S., Hayes, B., Kinghorn, B.P., O'Neill, C.J. and Frisch, J.E. (1998) Prediction of optimal composites for growth from a tropical crossbreeding experiment. *Proceedings of Sixth World Congress on Genetics Applied to Livestock Production*, **23**, 235-238.

Newman, S., Burrow, H.M., Sim, W., Williams, P., Kelly, M., Menzies, D. and Farrell, E. (1998) Growth and carcass traits of F_1 steers and heifers fed for three markets at two locations in Australia. *Journal of Animal Science*, **76**, Supplement 1, 77 (Abstract)

Stewart, T.S. and Newman, S. (1998) A decision support system to deal with genotype by environment interactions. *Proceedings 89th Meeting of the American Society of Animal Science*, Nashville, TN75, Supplement 1,105 (Abstract)

Crossbreeding Project within Meat Quality CRC. Interim Report, Meat Research Corporation Project NAP3.104, August 1997

Media Articles

Numerous articles were published in the popular rural press throughout Australia and many radio and television interviews reporting project results were conducted.

Project Staff

	Meat Science	Genetics	Growth & Nutrition	Administration and Cattle Breeding
Research Staff	Aub Egan Drewe Ferguson Diana Perry John Thompson	Scott Newman Gerard Davis Mike Goddard Hans Graser Jay Hetzel David Johnston Toni Reverter Dorothy Robinson Ross Shepherd	Hutton Oddy Alex Ball Ross Dicker Bob Hunter Graeme McCrabb	Bernie Bindon Heather Burrow Andrew Chalmers Reid Geddes Russell Miller Wayne Upton
Support Staff	Andrew Blakely Elmarie Bradfield Bob Dickinson Matthew Kelly Don Menzies Paul Reynolds Janet Stark Matt Wolcott	Alison Dundon Elaine Farrell Chris Smith	Marni Matthews	Nick Corbet Brian Dunn Greg Fawcett Faye Hughes Stewart Murphy Warren Sim Susan Webeck Paul Williams

Straightbreeding Project within Meat Quality CRC

MLA Project No.: FLOT.102

Project Duration: January 1997 to June 2000

Principal Investigator: Dr B.M. Bindon
Cooperative Research Centre for the Cattle and Beef Industry (Meat Quality)
C.J. Hawkins Homestead, University of New England, Armidale, NSW 2351
Phone : 02 6773 3501
Fax : 02 6773 3500
Email : beefcrc@metz.une.edu.au

Project Objectives

By June 1999,

- estimate EBVs for meat quality traits such as marbling, beef tenderness, eating quality and retail beef yield;
- identify sires with outstanding genetic merit for net feed conversion efficiency and carcase traits, such as marbling and retail beef yield;
- determine genetic relationships between sire performance when progeny are finished at pasture or in feedlots and to different market endpoints;
- provide information to breeders to select sires best suited to domestic, Korean and Japanese beef markets;
- quantify the relative effects of nutrition and climatic environment and other non-genetic factors on the eating quality of Australian beef for domestic and export markets;
- identify nutritional management strategies during backgrounding or finishing phases to manipulate growth, fat distribution and retail meat yield;
- validate the VIASCAN® system to predict retail meat yield based on 8,000 CRC carcases dissected to measure retail beef yield;
- quantify eating quality assurance information for industry use, based on temperate and tropically adapted breeds of cattle grown out in different environments, then finished on grass or grain and slaughtered under best practice for domestic and export target weights;
- determine the nature and magnitude of genotype x environment interactions based on Belmont Red, Brahman and Santa Gertrudis cattle finished in northern and temperate feedlot and pasture environments;
- validate gene markers for meat quality traits, identified in specially designed breeding projects, in commercial cattle populations through the CRC's straightbreeding progeny testing program;
- deliver the above outcomes to industry through the CRC's Education and Technology Transfer sub-program, the CRC's cooperating breeders, sponsors and industry-driven Board and Advisory Committee.

Collectively, these outcomes, by the Year 2000, will lead to increased profitability in the feedlot and grass-finishing sectors through a 1% increase in retail beef yield, a 5% increase in meeting the specifications for Japanese B3 market, a 1% improvement in net feed conversion efficiency and a significant improvement in domestic beef eating quality, halting the rate of decline in beef consumption by 10%.

Project Summary

The CRC conducts an integrated research program into factors that affect meat quality. The three largest research streams include Genetics, Meat Science and Growth and Nutrition, and each of these programs is involved in the CRC's unique Straightbreeding Project. This is a large progeny test

involving seven breeds in which pedigreed calves, generated in industry herds, are purchased by the CRC and are managed through a complex research protocol that enables the scientists from the various disciplines to work together to quantify the various genetic, nutrition and management treatments that affect ultimate meat quality. Late in 1996, the Meat Research Corporation approved total funding of $458,450 for Project FLOT.102. Specifically, these funds were ear-marked to cover the costs of breeding (artificial insemination and natural mating) in cooperating herds, purchase of calves at weaning age, transport to CRC grow-out properties, grain and grass finishing in northern and southern environments and slaughter of CRC cattle and collection of carcase and meat quality data. The net effect of this incremental funding will be to secure the completion of the project in line with its original design and cattle numbers, to ensure maximum industry benefit of the project.

Results of Breeding Program

The CRC's core breeding projects involve purchase of straightbred cattle from cooperating breeders in northern and temperate regions of Australia. The northern breeds are referred to as "tropically adapted" and are Brahman, Belmont Red and Santa Gertrudis. The temperate breeds are British breed animals drawn from Angus, Hereford, Murray Grey and Shorthorn seedstock herds. All straightbred calves that were specifically bred for the CRC's straightbreeding project have now been delivered to the CRC's ownership. Final numbers of calves delivered to the CRC by year, breed and sex are shown in Table 1.

Table 1. Number of calves purchased by the CRC within year, breed and sex and total number of sires represented in each breed over all calf crops

Breed	No. sires	Calf Sex	Calf crop					Total
			94-crop	95-crop	96-crop	97-crop	98-crop	
Angus	125	M	208	374	440	436	157	
		F	58	98	53	24		1848
Hereford	60	M		189	281	359	175	
		F		68		50	16	1138
Murray Grey	23	M		157	121	107		
		F		31		42		458
Shorthorn	37	M	49	143	115	129	76	
		F						512
Belmont Red	64	M	124	204	218	290	180	
		F	70	137	155	210		1588
Santa Gertrudis	48	M	202	128	143	207	68	
		F	178	122	158	136		1342
Brahman	44	M	84	105	125	143		
		F	84	84	123	145		893
Total	401	M	667	1300	1443	1671	656	5737
		F	390	540	489	607	16	2042
		All	1057	1840	1932	2278	672	7779

Progress

Genetic parameters were estimated for two tenderness measurements (shear force and instron compression) on two muscles (*m. longissimus dorsi* – LD and *m.* semitendinosis – ST), yield, dressing percentage, subcutaneous and intramuscular fat and saleable meat weight. Every effort was made to minimize animal stress prior to slaughter during transport and lairage. Effective electrical stimulation was applied to all carcases within five minutes of stunning to prevent cold shortening. Heritabilities and genetic correlations were estimated using DFREML univariate and bivariate analyses and VCE by combined analyses of up to six traits. Table 2 shows numbers of animals and sires, means and

ranges of values for tropical and temperate breeds, estimated heritabilities as well as phenotypic variation and total variation for each of the traits. For tenderness, mechanical measurements can discriminate on a finer scale than the human palate, but Australian consumers consider steak with measured shear forces up to 5 kg as tender. For temperate and tropical breeds, 93% and 84% of LD samples satisfied this criterion, and overall means of 3.9 kg for temperate breeds and 4.2 kg for tropical breeds were well below the threshold of 5 kg. This is largely due to the fact that the environmental variation which occurs during the critical pre- and post-slaughter period was controlled. Estimated genetic variation of 0.01 to 0.02 for instron compression in both temperate and tropical breeds might therefore be considered negligible. Furthermore, only a small proportion of total variation in LD shear force (17% for tropical breeds and 28% for temperate breeds) could be explained by systematic effects such as breed, age, market, finish, birth herd or their interactions.

Table 2. Interim genetic parameter estimates from CRC progeny tests. Numbers of animals, sires, means, minima and maxima for each trait, total variance (TV), genetic variance (GV - σ^2_a), heritabilities (h^2), phenotypic variation (PV) and PV as a percentage of total variance (%TV)

Trait	No. animals	No. sires	Mean	Minimum	Maximum	TV	GV σ^2_a	h2 (%)	PV	%TV
Tropical breeds										
LD-sf (kg)	949	74	4.2	2.3	8.8	0.76	0.19	30	0.63	83
LD-ic (kg)	949	74	1.7	0.96	2.6	0.06	0.01	16	0.04	70
ST-sf (kg)	949	74	4.5	2.8	6.9	0.39	0.12	44	0.28	74
ST-ic (kg)	949	74	2.2	1.2	3.8	0.15	0.01	17	0.08	55
LD-fat (%)	924	74	2.5	0.1	10.3	1.8	0.27	30	0.90	49
P8 fat (mm)	1066	74	11.1	0	30	24.4	2.52	18	14.4	59
Yield (kg)	1090	74	170	90	273	954	97	36	266	28
Yield (% cwt)	1091	74	67.5	58.5	76.8	10.2	2.30	52	4.44	43
Dressing %	1092	74	52.6	43.2	59.5	7.4	1.02	37	2.74	37
Temperate breeds										
LD-sf (kg)	1322	109	3.9	2.0	8.7	0.61	0.02	4	0.44	72
LD-ic (kg)	1316	109	1.6	0.7	3.1	0.12	0.01	15	0.04	36
ST-sf (kg)	1324	109	4.8	2.8	7.6	0.53	0.03	8	0.31	60
ST-ic (kg)	1322	109	2.1	1.2	3.2	0.11	0.01	25	0.05	47
LD-fat (%)	582	70	4.1	0.5	18	4.3	0.30	15	2.02	47
P8 fat (mm)	1884	159	10.7	1	32	21.4	2.62	29	8.95	42
Yield (kg)	1925	159	172	88	270	943	57	29	199	21
Yield (% cwt)	1925	159	67	54	77.2	13.6	1.94	49	3.97	29
Dressing %	1925	159	52	44	59.3	6.12	0.33	15	2.21	36

Retail yield, as a percentage of carcase weight, was strongly dependent on market and finish, ranging from 70 to 71% for temperate and tropically adapted cattle respectively finished on pasture for the domestic market, to 64% for feedlot cattle finished for the Japanese market.

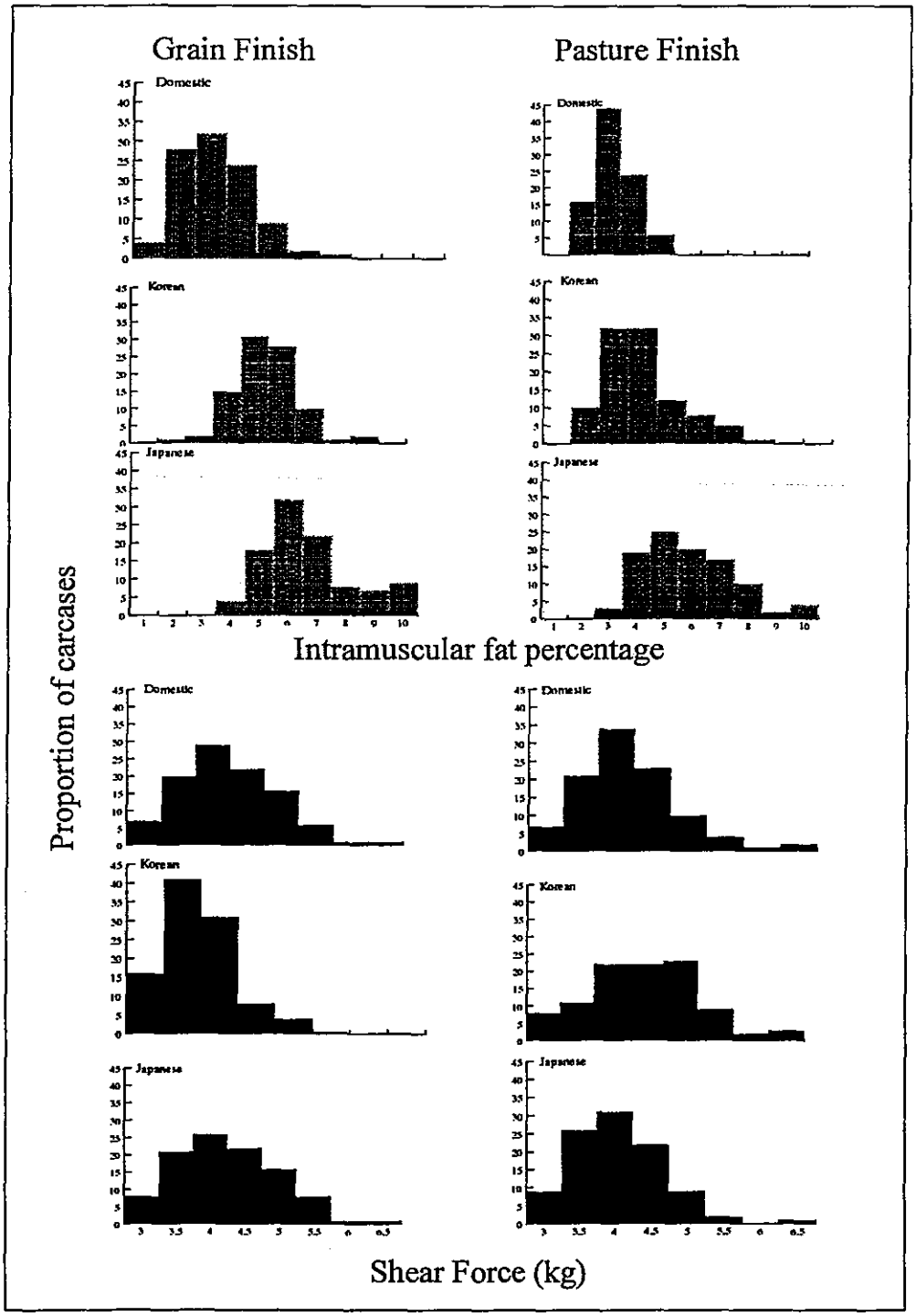
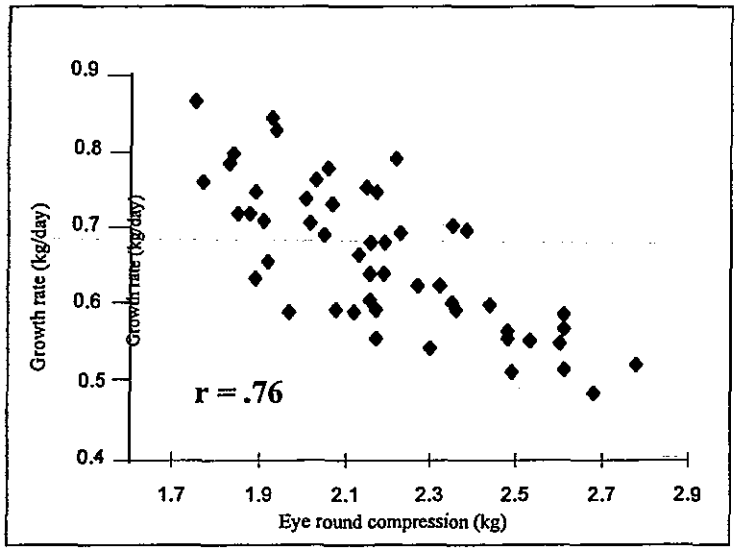


Figure 1. Tenderness and intramuscular fat percentage (marbling) of CRC carcases finished on grain or pasture to three different market (carcase) weights

Intramuscular fat percentages increased from domestic to Korean to Japanese market weights and was higher in feedlot-finished than pasture-finished cattle (Figure 1). Heifers had higher intramuscular fat percentage than steers and increased nutrition during grow-out also increased intramuscular fat percentage.

Feedlot finishing consistently produced lower peak force and compression measurements in both *L. dorsi* and *Semitendinosis* muscles and in temperate and tropically adapted cattle (see Figure 1). However, contrary to expectations, there was no increase in meat toughness as animals increased in age and carcase weight from domestic to Korean to Japanese market endpoint (Figure 1). There was llittle effect of grow-out nutrition on tenderness but a slight sex difference existed, with heifers being tougher than steers. Across groups, weight per day of age was highly correlated with tenderness (Figure 2).

Figure 2. Relationship between contemporary group means for eye round compression and growth rate (kg/day) to slaughter in tropically adapted breeds.



In the straightbred core cattle, breed differences are confounded with property of origin and so should not be used as an estimate of true breed effects. However, we have analysed breed x environment interactions to see if they appear to be important. In temperate breeds there were significant breed x market interactions, but these appear to be due to carry-over effects from the herd of origin. Among the tropically adapted breeds, there were significant interactions of breed with market, finishing system and region (north *versus* south). Again, some of these interactions appear to be due to carry-over effects of herd of origin, but some are probably true genetic effects. Relative to the other breeds, Brahmans grew best in the north on pasture and for domestic markets. By contrast, Santa Gertrudis performed best in southern feedlots for the Japanese market. These interactions may reflect the adaptation of the breeds to a stressful northern environment on the one hand and a temperate feedlot environment on the other. Interactions of sire within breed with environment were largely non-significant, but further data are needed before we conclude they are non-existent. However, at this stage, it appears that sires rank in the same order for growth rate, regardless of finishing system or market.

Adjusted sire averages (ASA - similar to estimated breeding values) for meat quality traits have now been released to industry for all breeds. In estimating ASAs, relationships between traits are considered and pedigree has an influence on the ASA. As the CRC progeny are in general from "unknown" cows, there is little information derived from the maternal side.

The CRC has also concluded a significant portfolio of research in molecular genetic approaches to beef improvement. Significant gene markers and candidate genes influencing carcase yield, tenderness, marbling, eye muscle area, meat and fat cover have already been identified. Gene markers will be especially valuable in those traits that are difficult to measure (for example, feed efficiency) or in which the animal must be slaughtered to get the measurement (that is, carcase and meat quality traits).

FLOT.102 CRC Straightbreeding Project ... take-home messages

- CRC results are providing the basis for new Estimated Breeding Values (EBVs) for carcase and meat quality traits in BREEDPLAN. They have allowed development of new BREEDPLAN carcase EBVs, including fat and eye muscle EBVs expressed on a 300 kg carcase basis, as well as carcase weight, yield percentage and marbling. This was only possible due to the CRC information that links BREEDPLAN herds to abattoir data and live animal ultrasound scans. The Australian Angus Society recently published its first sire summary containing carcase information from Angus CRC herds. Other collaborating breed societies will update their sire summaries at the time of their next BREEDPLAN analyses.
- During 1997/98, the CRC's breeding projects made further progress towards achieving the largest ever bank of knowledge about carcase and meat quality of Australian beef cattle. In the CRC database, there are now records on 5,596 carcases, comprising 2,713 animals of temperate breeds, 1,892 animals of tropically adapted breeds and 991 crossbred animals.
- These results will underpin future genetic improvement schemes for meat quality traits in Australian cattle and they are playing a key role in developing growth paths to successful achievement of Meat Standards Australia grading targets in different Australian production environments.
- The results are derived from the CRC's integrated research approach involving the Meat Science, Genetics and Growth and Nutrition sub-programs. It provides us with the best-ever opportunity to understand the genetic, environmental and meat processing factors and their interactions contributing to the eating quality of Australian beef.
- Attention is drawn to the following highlights from the Straightbreeding Project:
  - Estimates of heritability (h^2) of objectively measured tenderness are low in British breeds and are only moderate in tropically adapted breeds. Direct selection to improve this traits could not be strongly recommended.
  - Non-genetic approaches, by controlling pre- and post-slaughter practices, may be a more reliable method of guaranteeing beef tenderness.
  - Heritability estimates for marbling, as measured by intramuscular fat percentage, are slightly more promising (15% in British breeds and 30% in tropically adapted breeds). These estimates are lower than the heritability values from USA-based studies.
  - Marble score, as distinct from intramuscular fat percentage, is a less reliable measure of the trait, and in the CRC data, heritability of marble score is not significantly different from zero.
  - AUSMEAT marble score, however, is the industry gold standard and the basis of trading premiums in Australian and Japanese markets. The CRC identifies the need to bring more precision to marble score measurement, perhaps by developing an on-line, rapid measurement of intramuscular fat percentage. The two measures might be used in conjunction.
  - By contrast, retail beef yield (bone-out of one side of most CRC carcases) is an important new trait studied by the CRC. The trait is highly heritable (49 to 52%) in all breeds studied so far, and is of great potential economic value to the Australian beef industry. New opportunities for direct measurement are becoming available in Australian processing plants. VIASCAN® may provide indirect prediction of the trait.
  - Grain finishing resulted in a small, but significant, increase in tenderness compared to pasture finishing.
  - Grain finishing did not result in increased marbling (intramuscular fat percentage) of domestic-weight carcases. Grain finishing did produce significant increases (2 to 3%) in intramuscular fat percentage of Korean- and Japanese-weight carcases.
  - A comparison of objectively measured tenderness (peak force) in domestic-, Korean- and Japanese-weight carcases showed no significant difference. This was consistent for grain- and grass-finished progeny. This is despite the obvious increase in age between these three types of carcases. This outcome is contrary to expectation, given the increase in collagen content of

muscle as we progress from domestic- to Korean- to Japanese-weight carcases. (Note, however, that most CRC carcases were less than three years of age at slaughter.)

- Adjusted sire averages (similar to estimated breeding values – EBVs) for meat quality traits have been released to cooperating breeders, breed societies and now to the cattle breeding industry in general. In some cases, these results will have significant immediate impact on the seedstock industry.
- The CRC has identified an Angus sire, Te Mania Knight, whose genetic merit for marbling is about twice as good as the next best (based on over 70 progeny by this sire). Standout sires for this trait have also been identified in the Hereford, Shorthorn, Santa Gertrudis and Belmont Red breeds.
- CRC analyses have examined sire EBVs for traits thought to be antagonistic. This approach (Adjusted Sire Averages), for example, compared sires on the basis of retail yield percentage and intramuscular fat percentage (marbling), traits normally thought to be negatively genetically correlated. In all breeds studied, there is in general, a negative association between the traits. Sires with high retail yield percentage generally have lower fatness, including marbling. However, there are sires with high genetic merit for both traits:
- In the case of a Belmont Red sire (Narayen Graduate), he ranks highly for marbling, retail beef yield and tenderness. Already the market price for the semen of this animal has grown from $10 to $100 per straw, and some $70,000 of semen sales have occurred.
- The CRC Straightbreeding Project is a key component of product testing for the Meat Standards Australia grading system based on eating quality. Some 600 CRC carcases have now been assessed by consumer taste panels. These tests assess tenderness, juiciness, flavour and overall eating quality acceptability (MQ4 score). In contrast to objectively measured tenderness, the MQ4 scores are assessing other quality attributes of beef. Some important trends are emerging:
    * Breeds bred and finished in the north are achieving lower MQ4 scores than those in the south (Brahman, Belmont Red and Santa Gertrudis, mean MQ4 = 42.2; Angus, Hereford, Murray Grey and Shorthorn, mean MQ4 score = 59.8). Note that the cut-off for 3-star MSA grade is 48 and the complete confounding in this instance between breeds and breeding, growing and finishing environment;
    * Animals bred and finished in the north are achieving lower MQ4 scores than their half-sibs bred in the north and finished in the south;
    * Domestic-weight carcases achieved higher MQ4 scores (59.1) than Japanese-weight carcases (45.7) with Korean intermediate (48.2).
- In both the Straightbred and Northern Crossbreeding Projects, CRC scientists are trying to understand the relationship between growth and tenderness traits. In northern straightbred cattle, growth path expressed as kg per day from birth to slaughter, was highly (positively) correlated with tenderness. This will be a significant industry issue as the Meat Standards Australia grading system unfolds and producers design nutritional strategies to achieve 3-star ratings.

Communication achievements

The CRC, because of its strong linkage to industry through cooperating breeders, sponsors and industry-driven Board and Advisory Committee, is able to deliver its research results directly to industry to ensure maximum end-user adoption in the shortest possible time. The CRC's Education and Technology Transfer Sub-Program, with an allocated budget of about $750K for the current financial year, is taking the lead in this delivery, by way of formal graduate and undergraduate courses, industry training events and short courses and new certificate courses. As well, a strong industry technology transfer program underpins, and is a key element of, a comprehensive and

integrated nation-wide technology transfer service conducted by the Core Parties of the CRC and other organisations. Many professional and research staff of the CRC and the Core Parties contribute to this major activity. This year, there has been increasing effort directed at adding value to the technology transfer activities of these organisations. CRC specific activities are indicated below.

Plans for the coming year

Slaughter of the last of the CRC's straightbred calves will not be completed until early in the Year 2000, when the last of the grassfed Japanese weight steers are due for turnoff. However, full carcase and meat quality data from animals targeted to the domestic and Korean market endpoints will be available within the next 12 months. Over the coming year, additional sires with outstanding genetic merit for net feed conversion efficiency and carcase traits will be identified within the CRC's straightbreeding project. Genetic relationships between sire performance when progeny are finished at pasture or in feedlots and to different market endpoints will be re-estimated as data accrue. The relative effects of non-genetic factors affecting eating quality will be better quantified over the next 12 months, and the nature and magnitude of genotype x environment interactions will be defined. As well, in conjunction with MLA's Meat Standards Australia Scheme, the eating quality of all CRC straightbred calves will be determined to refine MSA pathways. Phase III of the gene marker evaluation in industry herds will occur over the next year. Finally, technology transfer efforts will be increased over the coming year, to ensure maximum industry uptake of CRC results.

List of papers, reports or media articles published in the previous 12 months

Extension articles and activities : see list provided with NAP3.104 report

Papers and Scientific Reports

Bindon, B.M. (1997) Industry benefits from outcomes of the Cattle and Beef CRC. *Proceedings of the Association for the Advancement of Animal Breeding and Genetics*, **12**, 723-729.

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Butchers, A.D.M., Ferguson, D.M., Devine, C.E. and Thompson, J.M. (1998) Interaction between preslaughter handling and low voltage electrical stimulation and the effect on beef quality. *Proceedings of the International Congress of Meat Science and Technology*, Spain.

Egan, A.F. (1997) Effects of animal production and post farmgate factors on yield and meat quality of Australian beef. *Proceedings 30th National Convention of Australian Institute of Food Service and Technology*, Perth, p439.

Egan, A.F., Ferguson, D.M., Perry, D. and Thompson, J.M. (1998) Beef quality – Australia 1998. *Animal Production in Australia*, **22**, 55-60.

Ferguson, D.M., Thompson, J.M., Skerritt, J.W. and Robinson, D.L. (1997) Preliminary heritability estimates for carcass yield and meat quality in beef cattle. *Proceedings of the Association for the Advancement of Animal Breeding and Genetics*, **12**, 730-733.

Hetzel, D.J.S. and Davis, G.P. (1997) Gene markers – a new genetic technology for cattle breeders. *Proceedings 5th World Conference of the Brown Cattle Breeders*, Lucerne, Switzerland.

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Hetzel, D.J.S. and Davis, G.P. (1997) Mapping quantitative trait loci: a new paradigm. Beef cattle genomics: past, present and future. A conference sponsored by US National Cattlemen's Beef Association and Texas A&M University.

Kelly, M.J., Thompson, J.M., Newman, S. and Ferguson, D.M. (1998) Differences between Brahman, Santa Gertrudis and Belmont Red breeds in subcutaneous fat distribution over the carcass. *Proceedings of the 6th World Congress on Genetics Applied to Livestock Production*, **23**, 109-112.

Oddy, V.H. (1997) The impact of growth in early life on subsequent growth and body composition of cattle. *Proceedings of the 5th National Beef Improvement Association Conference*, 10-11 July, 41-45.

Oddy, V.H., Ball, A.J. and Pleasants, A.B. (1997) Understanding body composition and efficiency in ruminants: a non-linear approach. In *Recent Advances in Animal Nutrition in Australia* (J.L. Corbett, M. Choct, J.V. Nolan and J.B. Rowe (eds)), Department of Animal Sciences, University of New England, Armidale, 209-222.

Oddy, V.H. , Herd, R.M., Ball, A.J., Dicker, R.W., Robinson, D.L., Skerritt, J.W., Alston, C., Hammond, A.J. and Thompson, J.M. (1997) Prior performance of cattle influences current and future performance, meat yield and quality characteristics: implications for genetic evaluation. *Proceedings of the Association for the Advancement of Animal Breeding and Genetics*, **12**, 738-741.

O'Halloran, J.M., Ferguson, D.M., Perry, D. and Egan, A.F. (1998) Mechanism of tenderness improvement in tenderstretched beef carcases. *Proceedings of 44th International Congress of Meat Science and Technology, Spain.*

Perry, D., Rymill, S.R., Hearnshaw, H., Ferguson, D.M. and Thompson, J.M. (1998) The relationship between consumer scores, trained taste panel scores and objective measures of tenderness, *Proceedings of 44th International Congress of Meat Science and Technology, Spain.*

Pleasants, A.B., Barton, R.A., Ball, A.J. and Oddy, V.H. (1998) Growth and carcass composition of Angus steers raised together from birth and managed on two post-weaning nutritional treatments. *New Zealand Society of Animal Production*, (in press).

Richardson, M.G., Thompson, J.M. and Ferguson, J.M. (1997) Influence of pre-cook muscle temperature on the objective evaluation of meat quality. *Proceedings of 44th International Congress of Meat Science and Technology, Spain.*

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Rymill, S.R., Thompson, J.M. and Ferguson, D.M. (1997) Effect of intramuscular fat percentage on the sensory evaluation of beef cooked to different degrees of doneness. *Proceedings of International Congress of Meat Science and Technology*, **43**, 212-213.

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Thompson, J.M. (1998) Meat quality. Proceedings of the 6th World Congress on Genetics Applied to Livestock Production, **25**, 147-148.

Wolcott, M.L., Thompson, J.M., Ferguson, D.M., Skerritt, J.W. and Robinson, D.L. (1997) Prediction of retail beef yield from real time ultrasound scans recorded at weaning, the commencement of finishing and pre-slaughter. *Proceedings of the Association for the Advancement of Animal Breeding and Genetics*, **12**, 734-737.

Media Articles

Numerous articles were published in the popular rural press throughout Australia and many radio and television interviews reporting project results were conducted.

Project Staff

	Meat Science	Genetics	Growth & Nutrition	Administration and Cattle Breeding
Research Staff	Aub Egan Drewe Ferguson Diana Perry John Thompson	Scott Newman Gerard Davis Mike Goddard Hans Graser Jay Hetzel David Johnston Toni Reverter Dorothy Robinson Ross Shepherd	Hutton Oddy Alex Ball Ross Dicker Bob Hunter Graeme McCrabb	Bernie Bindon Heather Burrow Andrew Chalmers Reid Geddes Russell Miller Wayne Upton
Support Staff	Andrew Blakely Elmarie Bradfield Bob Dickinson Matthew Kelly Don Menzies Paul Reynolds Janet Stark Matt Wolcott	Alison Dundon Elaine Farrell Chris Smith	Marni Matthews	Nick Corbet Brian Dunn Greg Fawcett Faye Hughes Stewart Murphy Warren Sim Susan Webeck Paul Williams

Discussion / Comments

Heather Burrow

Q1. *Will the CRC's crossbreeding database be used to produce across-breed and multibreed EBVs?*

A1. That is the aim of the project, but we need to wait until all CRC data are available before we will have sufficient information to do this. The first analysis of this kind will occur towards the end of next year. It is planned to use the CRC database to contribute to a scientifically validated crossbreeding database that will underpin BREEDPLAN's across-breed and multibreed EBVs.

Q2. *You mention that CRC animals were slaughtered at an average carcase weight of the group as a whole. Wouldn't it have been better to have slaughtered animals as they reached a constant finish?*

A2. One of the greatest sources of variation on carcase and meat quality attributes in the CRC database has been "kill-date" that encompasses all processing factors on the day of slaughter and during the subsequent chilling and boning procedures. If animals were slaughtered as individuals reached specific targets, whether they be weight, fat or a combination of both, confounding would occur between genotype, sex, and most other factors of interest and "kill-date", thereby negating the value of the whole experiment. By slaughtering at an average weight of the cohort, all sires and animals have the opportunity to perform. And because CRC have slaughtered animals over an enormous weight and fat range, the data can subsequently be statistically adjusted to provide answers with respect to specific targets.

Q3. *In the paper on the CRC's straightbreeding project, retail beef yield % is highly heritable, but marbling and tenderness is lowly heritable. Should breeders concentrate on nutritional and other methods to improve marbling and tenderness?*

A3. Analyses that were completed in the last couple of weeks have shown that retail beef yield % is even more highly heritable than the estimates shown in the straightbreeding paper, so selection for this trait is well worthwhile. The more recent heritability estimates show that both marbling and tenderness are more highly heritable with the inclusion of additional data. Hence selection is an option to improve marbling in both temperate and tropically adapted breeds. However, we know that there is a poor genetic correlation between tenderness in the *longissimus dorsi* (LD) muscle and tenderness in the *semitendinosis* (ST) suggesting that selection to improve tenderness in one muscle may decrease tenderness in the other muscle. Given that relationship, I would not be recommending that breeders select to improve meat tenderness. Rather, we should be trying to optimise processing techniques to overcome problems with meat toughness.

Q4. *For beef markets in Northern Australia, what management issues might be addressed to increase tenderness from grass-finished animals?*

A4. This can be addressed by processing techniques such as tenderstretching and ageing. On farm, the CRC is endeavouring to develop outcomes based on differences between grass vs grain finishing in the north vs south. One issue that has not been addressed in the past is the effect of growth path. Unfortunately there is no southern pasture finishing for northern-bred animals. This work is identifying critical control points along the growth path to see what management and genetic strategies can be used to improve tenderness.

Q5. *Do AUSMEAT marbling scores and intramuscular fat percentages measure the same thing?*

A5. They are two quite distinct measures. The AUSMEAT score is a subjective score based on visual fat, whereas IMF% is an objective measurement of the amount of fat extracted by chemical methods from the muscle. However the scores are correlated, with 3% IMF% being approximately equal to 1 AUSMEAT marbling score.

John Frisch: Based on CRC results, replacing Brahman or Santa Gertrudis sires with a Sanga sire will improve eating quality (MQ4 scores) without affecting adaptation and without the need, and cost, for special processing techniques such as tenderstretch and ageing beyond 14 days.

Q6. *It seems that both these projects were aimed at establishing principles rather than packages aimed at ease of implementation of crossbreeding for producers and therefore producers lack the knowledge necessary to put crossbreeding into place effectively.*

A6. Not true - the projects were definitely aimed at establishing principles, but the results have been packaged in a decision support software package (HotCross) to be demonstrated later. As part of the release of HotCross to industry, a series of workshops on crossbreeding have been organised initially throughout Queensland. Use of the package is only one component of the day-long program, and based on the initial workshops, the major deficiency identified by beef producers has been a lack of knowledge of basic genetics, and it is this deficiency that has made producers hesitant to try crossbreeding.

Meeting Post Weaning Market Specifications in Live Cattle Export Trade With SE Asia.

MLA Project No: NAP3111

Project Location: Darwin/VRD/Gulf

Project Postcode: 08 various

Project Duration: April 1998 – June 2001

Organisation: Department of Primary Industry and Fisheries, Northern Territory
GPO Box 990
Darwin NT 0801

Project Supervisor: Peter Ridley
Department of Primary Industry and Fisheries, Northern Territory
GPO Box 990
Darwin NT 0801
Phone: 08 - 8999 2362
Fax: 08 - 8999 2049

Principal Investigator: Peter Ridley
Department of Primary Industry and Fisheries, Northern Territory
GPO Box 990
Darwin NT 0801
Phone: 08 - 8999 2362
Fax: 08 - 8999 2049

Administrative Contact: Dr Hassan Bajhau
Department of Primary Industry and Fisheries, Northern Territory
GPO Box 990
Darwin NT 0801
Phone: 08 - 8999 2393
Fax: 08 - 8999 2010

Objectives

By December 2001, identify cost effective opportunities for the NT beef industry to:

- double the number of weaners and thus the number of exportable live feeder cattle available from the northern NT breeding herd,
- supply feeder cattle of suitable temperament, condition score and maturity type which meet the performance expectations of feedlot operators in SE Asia from a range of nutritional regimes and turnoff specifications, and
- avoid supplying cattle with a high probability of being too fat at turn off from SE Asian feedlots.

Results Summary

1. Breeding herd efficiency.

- so far no consistent large difference in breeding herd efficiency has emerged between the three cow genotypes,
- mature size (weight when P8 is exactly zero) of the three genotypes appears to be Brahman 400 kg, Droughtmaster 410 kg, F_1 460 kg,
- the herds at Kidman are to be changed from similar stocking rates (head/unit area) to similar grazing pressure (kg mature size/unit area).

2. *Backgrounding on improved pasture.*

- the effect of bull and ¼ Charolais content on growth rate in this phase are highly significant (+6-10%) of similar magnitude, and additive.

3. *Feedlot phase.*

- there is a highly significant interrelationship between weight, age and fatness in all genotypes (the most extensive data available is that for Brahman steers and heifers),
- in Brahmans for example, 12 months difference in age results in 130 kg difference in weight at the same target slaughter P8.
- the bull and ¼ Charolais options result in large and commercially important increases in final weight at target fatness relative to the standard Brahman steer. The ¼ Charolais heifers are mid way between Brahman steers and Brahman heifers in final weight at target fatness.

Methodology Summary

The core focus of the experimental work in this Program is to measure the biological effects of differences in cattle maturity type (potential standard reference weight, (Corbett *et al*, 1990) on:

- breeding herd efficiency (kg calf weaned/100 kg cow mated),
- post weaning pre feedlot phase efficiency (kg gain/h/yr),
- P8 fat depth at turnoff at target feeder weight (males 300 kg, cull heifers 250 kg).

The experimental differences in maturity type will be due to sex (bull vs steer vs cull heifer) and breed (Brahman vs 75% Brahman 25% Charolais vs Droughtmaster). There are nine potential sex x genotype combinations to be evaluated, with the Brahman steer being the current industry standard.

For the purpose of this Program the Brahman steer generated at Kidman by using Queensland sourced commercial purebred Brahmans, is seen as being potentially different to the current VRD/Gulf Brahman phenotypes. Experimental work will therefore include comparisons between Brahman steers from these two sources to test for this possibility. This testing has important extension implications.

The three experimental area covered in this Program are:

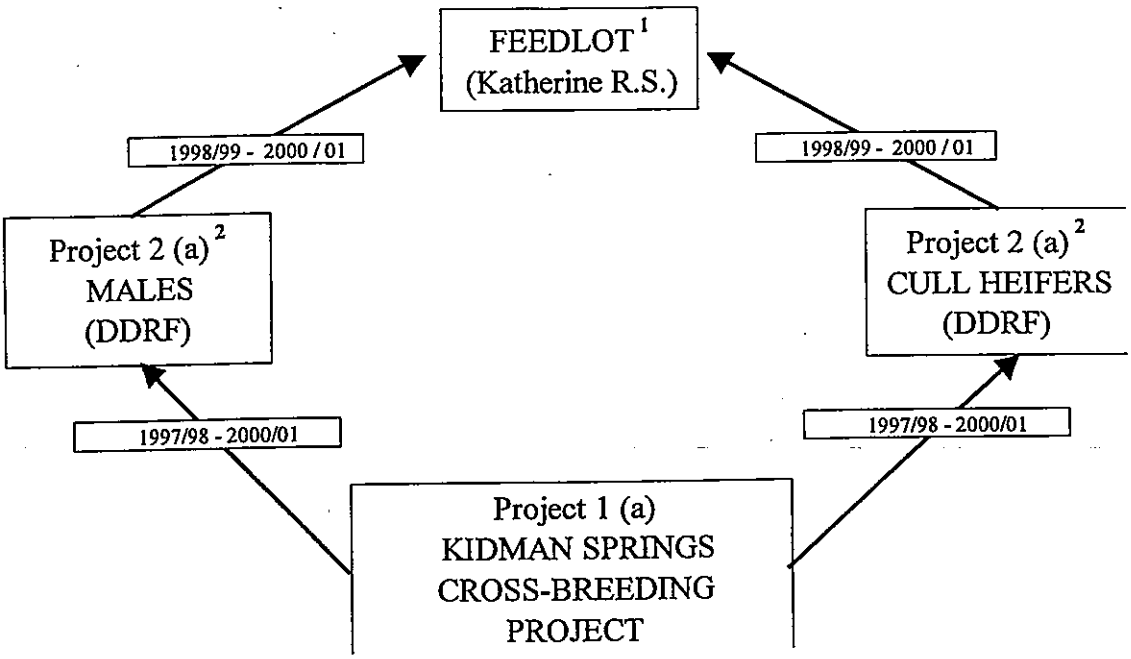
- breeding on native pasture (Table 1).
- backgrounding on improved pasture (Table 2).
- backgrounding on native pasture (Table 3).

While the feedlot work is not supported by MLA funding it provides essential evidence of the impact of age and maturity type on the carcase specifications which out clients in SE Asia will experience from the sex x genotype sets being evaluated.

Table 1: Breeding on Native Pasture

Project	Location (Pasture)	Age No./Yr	Class/Genotype	Evaluation Data
1[a]	Kidman RS (Native)	>3.5yo 260 130 130 0.5-3.5yo 84 168 84	Adult Breeders Brahman F1xBrahman Droughtmaster Replacement Breeders Brahman F1xBrahman Droughtmasters	Focus: This project cover both the adult breeder (>3.5yo) and replacement breeder (0.5-3.5yo) phases of production, and will continue beyond 2001. Efficiency = kg calf weaned/100kg cow mated at the same nominal stocking rate. Data each April and October: number, weight, ultrasonic P8 fat depth and pregnancy diagnosis for all breeders, number and weight calves weaned (<100kg), and number culled (with reasons) and missing.
1[b]	Commercial Stations (Native)	>3.5yo 3,000+	Adult Breeders Brahman	As above, mainly for herds in paddocks where pasture production and condition are being assessed in MRC supported project NTA022.

Figure 1. Livestock Movements Projects 1 (a) and 2 (a)



Notes

[1] The Katherine R.S. feedlot is not supported by MRC funds.

[2] In 1999 / 2000 Project 2 (a) becomes Project 2 (b).

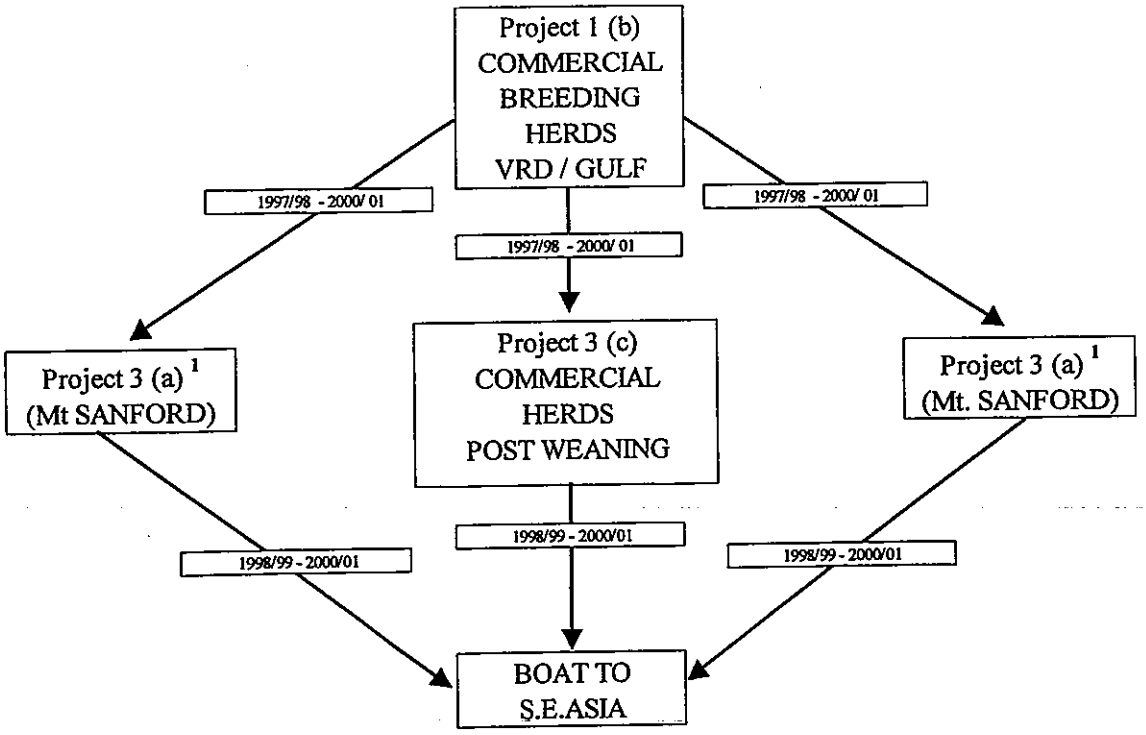
Table 2: Backgrounding on Improved Pasture

Project	Location (Pasture)	Age No./Yr	Class/Genotype	Evaluation Data
2[a]	DDRF (Buffel)	0.5-1.5yo	Weaners	Focus: kg gain/ha/yr in April weaners for 1997/98 and 1998/99.
				Turnoff at 300 kg.
		50	Brahman (RS)	Time to turnoff and P8 fat depth at turnoff.
		100	F1xBrahman	Monthly weighing.
		50	Droughtmaster	Intake dry season and wet season supplements.
				Initial and final feed on offer (kg DM/ha).
				Daily rainfall records.
2[b]	DDRF (Buffel)	0.5-1.5yo	Weaners	
		50	Brahman (RS)	As above for 1999/00 and 2000/01.
		50	Brahman (Comm)	
		50	F1xBrahman	
		50	Droughtmaster	

Brahman (RS) = Brahman weaners from Project 1(a) at Kidman RS.

Brahman (Comm) = Brahman weaners from commercial stations.

F1 = First cross Brahman x Charolais.Figure 2. Livestock Movements Projects 1 (a), 3 (a) and 3 (c)



Notes

[1] In 1999 / 2000 Project 3 (a) becomes Project 3 (b).

Figure 3. (Figures 1 and 2 Combined)

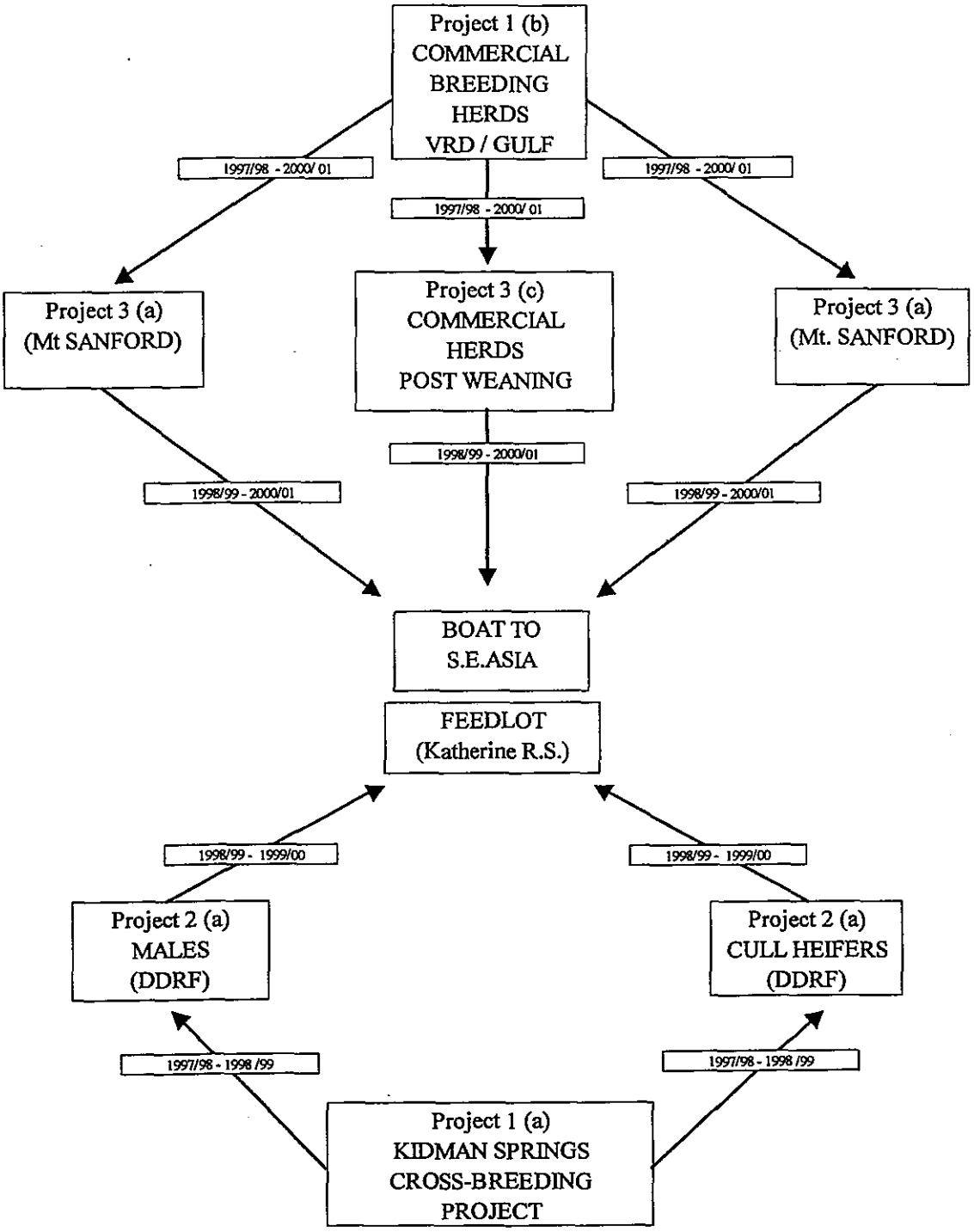
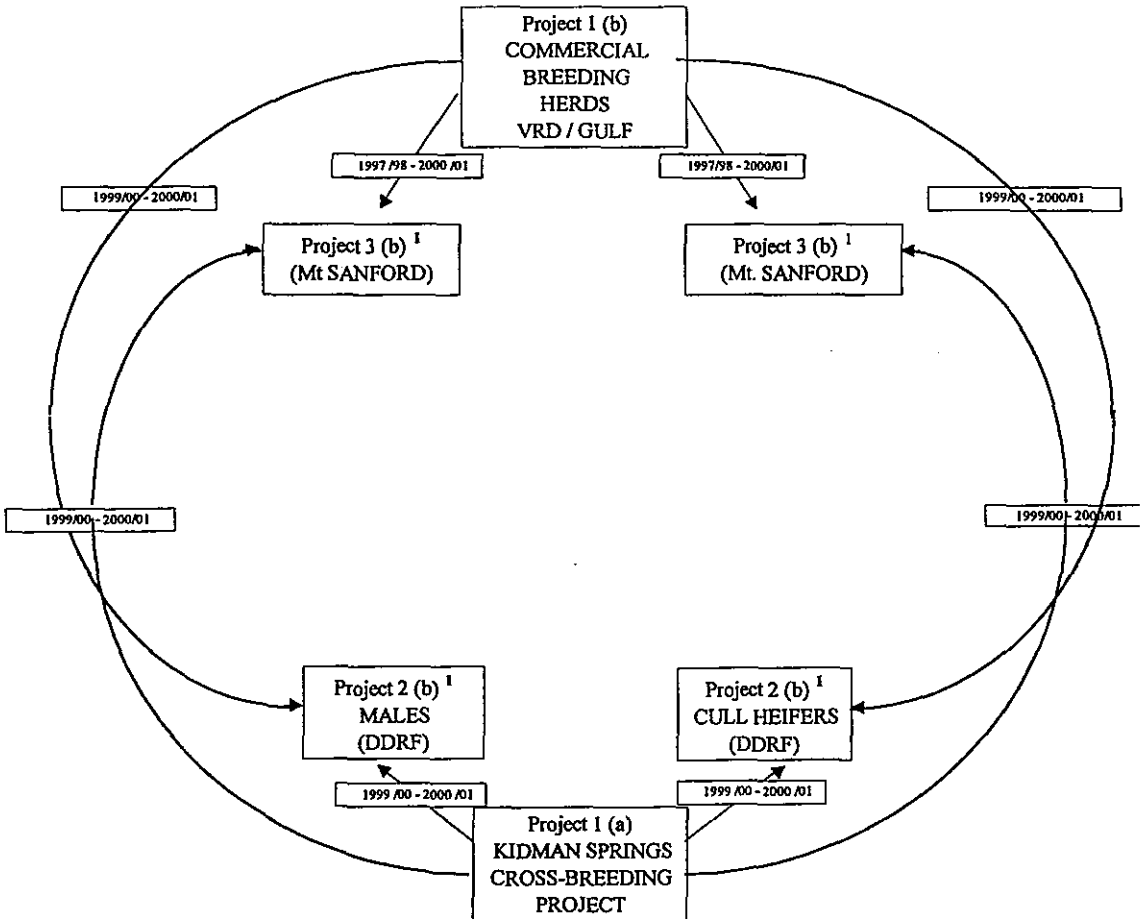


Table 3: Backgrounding of Native Pasture

Project	Location (Pasture)	Age No./Yr	Class/Genotype	Evaluation Data
3[a]	Mt Sanford (Native)	0.5-1.5yo Up to 300	Weaners Brahman	Focus: kg/gain/sq km/yr and % ≥ 280 kg. effect of weaning round (April vs October) sex (steer vs cull heifer) and weaning weight on weight at the end of the first post-weaning wet season; and P8 fat depth at turnoff pasture production and condition assessed as part Project NTA022, weighings in April and October; and duration 1998/99.
3[b]	Mt Sanford Heytsbury (Native)	0.5-1.5yo 100 40 80 40	Weaners Brahman (Comm) Brahman (RS) F1xBrahman Droughtmaster	As above for 1999/00 and 2000/01.
3[c]	Commercial Stations (Native)	0.5-1.5yo 1,000+	Weaners Brahman	As above for 1998/99, 1999/00 and 2000/01, mainly in paddocks where pasture production and condition are being assessed in MRC supported Project NTA022.

Brahman (RS) = Brahman weaners from Project 1(a) at Kidman Research Station
Brahman (Comm) = Brahman weaners from commercial stations
F1 = First cross Brahman x Charolais

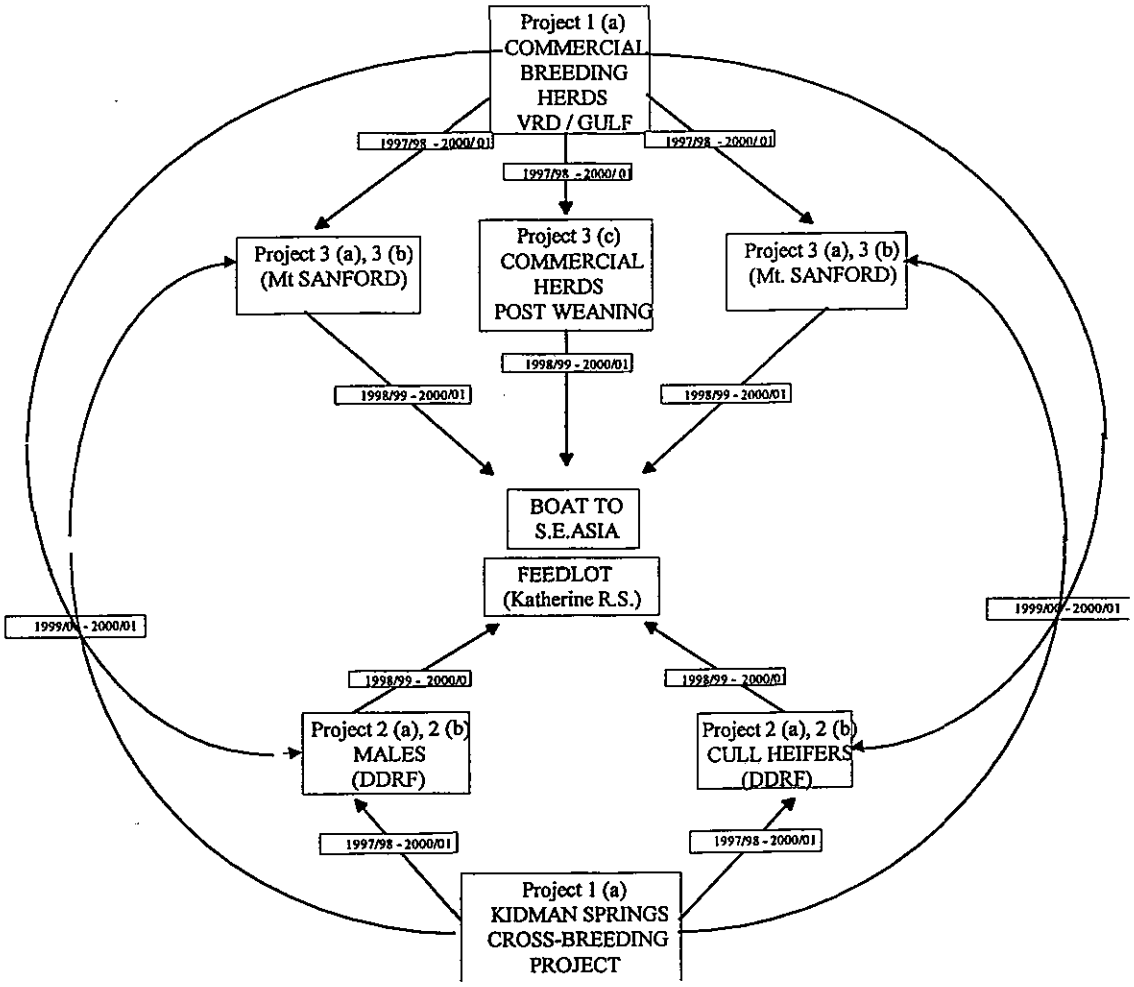
Figure 4. Livestock Movements Projects 1 (a), 1 (b), 2 (b) and 3 (b).



Notes

[1] Projects 2 (a) and 3 (a) replaced by Projects 2 (b) and 3 (b) in this diagram

Figure 5. (Figure 1, 2 and 4 combined)



RESULT HIGHLIGHTS FOR 1998

1. Breeding Herd Efficiency (Kidman)

a) Genotypes, 1998 Data

Breed Cow Calf	Bra Bra	DM DM	Bra ¼Ch	F_1 ¼Ch
χ	400	410	400	460
Cow N° Cow Wt N° x Wt ÷ 100	132 418 B	130 422 B	129 420 B	121 445 B
Weaner N° Weaner Wt N° x Wt	106 169.8 A	114 176.5 A	96 183.7 A	96 180.8 A
Efficiency $^{A}/_{B}$	32.6	36.7	32.6	32.2
Indicator Steer Gain kg/hd Index	 121 1.0	 141 1.165	 121 1.0	 111 0.917
Adjusted Efficiency	32.6	31.5	32.5	35.2

Efficiency = (kg WNR) ÷ (0.01 x kg Cow)

Future:

- Compare at same grazing pressure.
- Transition in to F_1 x Bra criss cross.

b) Adult Cows WRI 1998

ELW_{Br}	=	3.5 (P8, mm) + 400	P<.001
ELW_{DM}	=	3.2 (P8, mm) + 411	P<.001
ELW_{F1}	=	3.6 (P8, mm) + 461	P<.01

Future

- Repeat on more herds.

2. Backgrounding

a) Improved pasture DDRF

- October 1998 feedlot cattle.
- Replicated (3) 6.1 ha plots.
- Buffel pasture with Uramol and Phosrite.
- Sex x genotype sets grazed separately.
- Data to the end of the first post weaning Wet.

kg/hd/yr	Steer	Bull	Average
Brahman	161 *(100)*	175 *(109)*	168 *(100)*
¼ Charolais	173 *(108)*	182 *(113)*	177.5 *(106)*
Average	167 *(100)*	178.5 *(107)*	

kg/ha/yr	Steer	Bull	Average
Brahman	185 *(100)*	201 *(109)*	193 *(100)*
¼ Charolais	199 *(108)*	209 *(113)*	204 *(106)*
Average	192 *(100)*	205 *(107)*	

Future:

- Use steers and heifers.
- Use four stocking rates for four years.
- Use four genotypes
  - commercial Brahman
  - Kidman Brahman
  - Kidman Droughtmaster
  - Kidman ¼ Charolais

b) Native pasture (Mitchell grass, Mt Sanford)

WW Range (kg)	WR1 Steers	WR1 Heifer	WR2 Steer	WR2 Heifer
100-140	12%	10%	8%	4%
141-180	12%	10%	8%	4%
181-220	12%	-	8%	-
221-260	12%	-	-	-
Totals	48%	20%	24%	8%
	68%		32%	

Future:

- Two management regimes for four years (150 head/6km^2 in each).
  - local practice
  - best bet (local and saved pasture and burning)
- All turned off at the end of the first post-weaning wet season.
- Weight and percentage of weaners making a range of nominated turnoff weights be the end of their first post-weaning wet season.
- Steers
  - commercial Brahman 4% + 2%
  - Kidman Brahman 4% + 2%
  - Kidman Droughtmaster 4% + 2%
  - Kidman ¼ Charolais 4% + 2%

3. Tropical Feedlot Phase (Katherine Research Station)

a) Brahman Steers

- N° = 29
- P8 = 1.5 - 17.0mm
- Age = 10.5-21.6 months

ELW	=	3.3 (P8, mm) + 10.8 (Age, mo) + 115.9	$r^2 = 0.87$
HCW	=	2.1 (P8, mm) + 6.2 (Age, mo) + 54.3	$r^2 = 0.90$
HCW	=	0.57 (ELW, kg) - 4.45	$r^2 = 0.98$

b) Brahman Heifers

- N° = 29
- P8 = 4-16mm
- Age = 10.1-20.6 months

ELW	=	2.1 (P8, mm) + 9.4 (Age, mo) + 108.6	$r^2 = 0.77$
HCW	=	1.6 (P8, mm) + 5.0 (Age, mo) + 60.0	$r^2 = 0.82$
HCW	=	4.6 (P8, mm) + 118.4	$r^2 = 0.33$

c) The effect of sex and genotype alternatives to the Brahman steer, on final empty live weight (ELW) and hot carcase weight (HCW).

Geno	Sex(n)	Final ELW kg	Final HCW kg	Carcase P8 mm	Final Age mo	ELW Change kg	HCW change kg
Bra	B (9) H (10)	441 293	234 164	8.8 10.0	20.6 18.9	+74 -60	 +32 -24
¼Ch	B (9) S (9) H (10)	16 428 329	299 242 186	9.3 10.4 8.1	23.0 22.2 19.6	+121 +38 (+73) -25	+78 +23 (+45) -12

There was little difference between the final age, weight and fatness specifications of the Brahman and Droughtmaster steers.

This sample of ¼ Charolais steers gave less benefit than expected.

Future:

- Full growth curves for all sex x genotype combinations with slaughter age up to 36 months.

COMMUNICATIONS EVENTS 1998

1. Field Day Kidman Springs March 27th

Topics:
- Adult Breeders
- Backgrounding DDRF
- Entry in to the Feedlot at KRS

2. Meeting of Management Committee (November 1998)

Progress reports:
- Adult Breeders Kidman
- Adult Breeders Mt Sanford
- Backgrounding DDRF
- Backgrounding Mt Sanford
- Feedlot 1998 Feeders Katherine Research Station

These reports will form the basis of 10 or so articles in the Katherine Rural Review.

During this meeting the Management Committee, which incorporates the Katherine Pastoral Industry Advisory Committee, will be involved in setting the final specifications for the two management regimes to be used in the project Backgrounding of Feeder Cattle on Native Pasture (Mt Sanford).

3. Progress Report to MLA (December)

4. Peer Review Workshop

5. Ad hoc enquires to advisers and from visitors to Katherine Research Station (eg. ACIAR Committee, producers, visiting international vets, etc.)

6. A scientific paper is being prepared dealing with the interrelationship between weight, age and fatness in Brahman steers and Brahman heifers, based on the equations derived in the feedlot phase of the live export cattle production system. This is not an MLA supported activity.

Other Comments

MLA funding only became available in mid 1998 and since that time 10 plots requiring water supplies and approximately 10 km of fencing have been completed.

Unsatisfactory progress has been made in recruiting commercial herds in to projects 1(b) to assess the weight distribution of weaners (WR1 and WR2) and 3(c) to record the percentage of weaners that fail to reach 280 kg by the end of the first post-weaning wet.

The main problem we are experiencing is the lack of the technical officer originally requested. We need two weighing teams operating at WR1 and WR2 to cope with the vagaries of station work programs. We only have one in addition to those staff operating the Kidman and Mt Sanford sites.

As a consequence of this problem, fewer commercial properties will be involved in projects 1(b) and 3(c) than Tables 1 and 3 indicate. At present the commercial breeding groups at WR1 1999 will comprise:

Mt Sanford	1400 hd
Rosewood	300 hd
Innesvale	500 hd
Cave Creek	300 hd
Elsey	500 hd

The Mt Sanford breeding group will supply the commercial Brahman weaners used in projects 2(b), 3(a), and 3(b).

It is unlikely that much of the information generated in the project will be adopted by industry, until differential prices for different male sex x genotype and age combinations emerge in the market.

It is unlikely that such price differentials will emerge in the short term unless key SE Asia feedlot operators are exposed to:

- the different weight gain potential of alternative male feeder cattle,
- a value based description system which provides a framework for describing and monitoring consignment requirements.

In our original submissions, MRC was not prepared to make funds available for this work. NT DPIF does not possess adequate funding to ensure a high probability of success in attempting such work. The work has strong support from the Program's industry management committee. We are therefore likely to attempt to undertake the task but are approximately $100,000 short of operating funds necessary to provide an appropriate prospect of success.

Molecular Genetics Project – Meat Quality CRC

Principal Investigators: Dr. Steven Moore
CSIRO Tropical Agriculture, Molecular Animal Genetics Centre, Level 3, Gehrmann Laboratories, University of Queensland, St. Lucia 4072
Phone: (07) 3214 2440
Facsimile: (07) 3214 2480
E-mail: Steve.Moore@tag.csiro.au

Dr. Scott Newman
Meat Quality CRC, CSIRO Tropical Agriculture, Box 5545, Rockhampton Mail Centre 4702
Phone: (07) 4923 8100
Facsimile: (07) 4923 8222
E-mail: Scott.Newman@tag.csiro.au

Project Objectives

- To develop genetic/gene marker technologies which enable the beef industry to more rapidly and cost effectively breed cattle which better meet market specifications.
- To identify, isolate and characterise genes responsible for genetic variation in meat yield, tenderness and marbling traits.

Project Summary

Gene markers detect the different forms in which genes can exist and which is the source of genetic variation across and within breeds. Gene markers will be valuable in traits that are difficult to measure (eg feed efficiency) or in which the animal must be slaughtered to retrieve a measurement (eg carcass and meat quality traits). The Meat Quality CRC is using two strategies to locate genes affecting economically important traits: (1) mapping these genes using linkage to genetic markers; and (2) the study of candidate genes. Markers expressing relationships with tenderness, marbling and yield have been evaluated in progeny from CRC sires representing tropically adapted and temperate breeds. All markers tested were informative (heterozygous) but vary considerably in their relative utility. Candidate gene research has concentrated on functional mutation analysis of genes associated with tenderness, eye muscle area and marbling.

Genetic Markers for Meat Quality

The project will evaluate markers linked to genes causing variability in meat tenderness, carcass yield, fat distribution including marbling and growth in a cross-section of breeding herds from the most important beef breeds.

The first phase of this study involved the analysis of markers from six chromosome regions in selected CRC purebred herds. The six regions consisted of two associated with marbling, two with tenderness and two with yield. A third region for tenderness was added after the project commenced due to its promising nature in detection studies. Based on the results of the May 1997 analysis of the CBX experiment, the six regions contained genes or Quantitative Trait Loci (QTL) causing variability in particular traits associated with meat quality.

Sire families greater than 20 progeny were selected from the CRC DNA bank in June '97. These pedigrees were genotyped for between three and four markers per region amounting to a total of sixteen markers. Progeny were only genotyped for a marker if their sire was heterozygous (informative).

Phenotype data was extracted from the CRC database for all animals within the breed being analysed. Not all progeny in the DNA bank had phenotypes by the time of data analysis. Thus many families ended up with less than 20 individuals.

Three tropical breeds (Santa Gertrudis, Brahman and Belmont Red) and three temperate breeds (Angus, Murray Grey and Hereford) had at least one sire with more than twenty progeny in the DNA bank when the study commenced.

The number of sires, progeny per sire and average percentage of informative markers per sire in each breed is shown in Table 1. There were an insufficient number of sires to be representative of any one breed. Thus the sires were considered as samples from tropical and temperate breed groups. The proportion of sires heterozygous for all markers is a measure of the "informativeness" of the markers. As shown in Table 1, on average temperate breeds expressed 50% heterozygosity (informativeness) whilst for the tropical breeds the figure is 72%. The greater informativeness of the markers in tropical breeds reflects a higher level of genetic variation when compared to the temperate breeds. This result means that a greater number of markers must be tested for any region of interest in temperate breeds in order to implement a marker assisted selection program.

The marker evaluation analysis is carried out in a number of steps. Firstly, the marker inheritance patterns (from sire to offspring) for each of the regions is determined for each sire. The inheritance pattern is then converted to individual QTL Transmission Probabilities (QTP) that describe the probability of an individual inheriting a particular QTL allele from the sire. It is assumed that only two forms (alleles) of the QTL are present in the population. For each sire, the regression of progeny phenotype on QTP is estimated and its significance determined. Sires that have a significant regression are considered to be informative for QTL. The regression coefficient provides an estimate of the size of the effect of the region on the trait.

A number of traits were measured in each of the groupings representing yield, tenderness, marbling and other traits. However, results are only presented for one trait in each group as being representative. Yield is represented by saleable meat yield, tenderness by the tenderness index (a combination of cooking loss, peak force and instron compression), marbling by intramuscular fat % and fatness by subcutaneous fat measured at the 12/13th rib site.

Table 1: Numbers of sires, range in progeny per sire and proportion of informative markers for the first phase of the marker evaluation project.

Breed	Number of sires	Number of progeny	Informativeness of markers (%)
Tropical			
Santa Gertrudis	14	9-30	71
Brahman	5	23-41	73
Belmont Red	11	16-43	73
Temperate			
Angus	6	14-41	46
Hereford	1	38	57
Murray Grey	1	30	64

The results in Table 2 indicate that the markers analysed are detecting between zero and 60% sires as informative (heterozygous) for the QTL under a two-allele model. For most regions, between 20 and 30% sires were informative. Although each grouping only represents a small sample of sires the results are encouraging since it expected that a maximum of 50% of purebred sires is likely to be informative for any QTL. In practice, most sires are likely to be evaluated for a number of traits and therefore a number of QTL. Thus it is likely that markers for at least some QTL will be useful for each sire.

Table 2: The percentage of informative sires for each trait/region analysed in the first phase of the marker evaluation experiment.

Trait	Chromosome region	Tropical sires		Temperate sires	
Saleable meat yield	A	17		25	
Saleable meat yield	B1	23		0	
Subcutaneous fat	B2	20		0	
Subcutaneous fat	C	17		38	
Intramuscular fat %	B1	3		17	
Intramuscular fat %	D	10		60	
		Muscle type			
		LD	ST	LD	ST
Tenderness index	B2	13	10	13	38
Tenderness index	C	23	0	0	13
Tenderness index	E	21	24	-	-

The markers for intramuscular fat may have higher utility in the temperate breeds. For example three of the five Angus sires were informative for the QTL in region D. If these results are found in a larger sample of sires, these particular markers will have widespread utility. By contrast the markers tested for yield and tenderness may be more useful in tropical breeds.

There appear to be some regions analysed that may be informative in tropical sires but not in temperate sires and vice versa. These regions need further investigation before deciding to eliminate a set of markers as not being useful in a particular breed or a particular breed group.

Table 3 shows the percentage of sires that were informative for up to five QTL. Most sires (70% for tropical and 87% for temperate) were informative for between one and three QTL. In the case of the tropical sires three sires were informative for four or more QTL out of the six tested.

Table 3: Percentage of sires informative for multiple QTL.

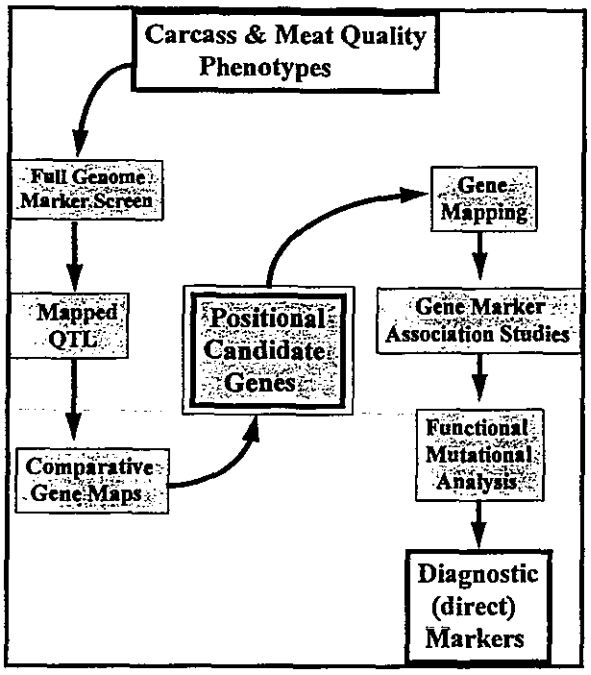
Breed	Number of informative QTL					
group	0	1	2	3	4	5
Tropical	20	33	27	10	7	3
Temperate	13	38	25	25	0	0

The second phase of the marker evaluation project involves examining five regions that have been shown in the final analysis of the CBX experiment to affect marbling. For this phase the phenotypic data was initially extracted from the CRC database and families that have more than twenty progeny with phenotypes were selected for the evaluation. Sires from all breeds have been screened with a panel of markers and the most informative markers selected for genotyping on the progeny.

Candidate Genes for Meat Quality

In an earlier phase, the candidate gene project characterised a number of genes that were thought to have a major influence on carcass and meat quality traits. However now that the CBX study has identified many chromosome regions containing genes/quantitative trait loci (QTL) responsible for variation in these traits, an additional 'positional candidate gene' strategy can now be pursued. The steps associated with this strategy are outlined in the figure below.

Figure 1. A positional candidate gene approach for the development of diagnostic markers for carcass and meat quality traits in beef cattle.



This strategy has been applied to five chromosomes that are known to contain QTL for the following traits:

Trait	Chromosome
Tenderness	A
Tenderness	B
Tenderness	C
Eye muscle area	D
Marbling	E

Work within each QTL region has been developed and managed as subprojects.

The steps involved in defining genes for each QTL include:

- create fine scale linkage maps around each QTL region,
- remap the QTL on the fine scale map,
- compile comparative maps between the cattle, human and mouse genomes,
- select candidate genes for the QTL based on expected position,
- develop polymorphic markers and map the gene(s),
- conduct a population association study for the gene/phenotype,
- assess the gene for functional mutations that may be the basis of the genetic variation,
- Develop a diagnostic marker system for the trait based on the function mutations.

Fine scale linkage maps have been produced for the 5 chromosome regions that contain QTL for meat tenderness, yield, marbling and colour. Comparative maps with human and mice have led to the selection of ten positional candidate genes for the QTL. Bovine gene sequence has been obtained for seven of the genes. Following the definition of polymorphisms and in some cases mapping in the CBX pedigrees, five genes remain as viable candidates.

cDNA, genomic libraries and mutation analysis resources are being established to define functional mutations within promising genes leading to the development of diagnostic markers.

Establishment and maintenance of a DNA bank for animals in the CRC core breeding program

This project will collect and store DNA from all animals produced in the CRC core breeding program plus their sires ie from both the purebreeding and crossbreeding projects. The DNA Bank thus produced will be used to evaluate genetic markers identified in other CRC projects or from other studies around the world. In addition, if exceptional sires or other animals are observed as part of the core breeding program, DNA samples will automatically be available for analysis.

The collection and storage of DNA from CRC core breeding program has continued throughout the year including animals from both the crossbreeding and purebreeding projects. Through the year DNA samples have been collected from a further 90 northern sires and 2800 progeny. The DNA bank now comprises samples from 380 sires, 800 Brahman cows and 9200 offspring. It is anticipated that the majority of the 12,000 animals from the purebreeding and crossbreeding projects will be stored in the DNA Bank by mid 1998.

Discussion / Comments

Scott Newman

Q1. *Most traits that you mentioned have QTL - are they additive or threshold in their effect?*

A1. Some are additive, some are multiplicative - there are others that have an overlay effect. (Mike Goddard's comment: they are additive, until someone proves otherwise)

Q2. *How do you match heritability estimates with marker information?*

A2. Heritabilities are ratios of variances, estimated with some error, including fixed and non-genetic effects that are in effect noise in the model. QTL are markers independent of this noise. However, with QTL, a lot of what we see might be due to small numbers of animals being tested, and the responses may change as the numbers of progeny increase. We need to wait until sufficient information is available before we can be sure of the QTL.

Q3. *With respect to Gerard Davis' proposed (hypothetical) use of markers - how are we to interpret the issue of heterozygosity and its use with phenotypic information?*

A3. Cannot really answer this question. The more information that is available, the more accurate the EBV. The marker information enhances the EBV. A lot more information of markers is still needed. (Mike Goddard's comment: For an individual gene, say a sire is heterozygous, progeny will inherit either type A or type B, with type A resulting in a 0.5 marbling score better than type B. Of course, lots of genes influence marbling, so type A is only going to push towards increased marbling, not guarantee increased marbling.)

Q4. *Based on the results you presented, you show that 4 genes affect marbling, but only 1 affects intramuscular fat percentage. Do you believe this?*

A4. No

Q5. *Your results show that there are markers for tenderness in the LD muscle and other markers for tenderness in the ST muscle. Are there any markers that affect tenderness in both muscles?*

A5. Some time ago, the answer to that question was no. (Mike Goddard's comment: Given the poor correlations between tenderness of the different muscles in the CRC's straightbreeding project and different markers for tenderness, this diminishes the value of these markers and any efforts at selection to improve tenderness.)

Q6. *Given the extreme superiority for marbling of bulls like Te Mania Knight, have breeders in northern Australia attempted to use these sires to improve marbling scores of animals finished at pasture?*

A6. (Heather Burrow's comment: Narayen Graduate has produced progeny with AUSMEAT marbling score 5 off pasture, and he has been used in northern Australia to improve marbling. He has the advantage that he is from a tropically adapted breed.)

Q7. *Will marker assisted selection do away with the need for progeny testing?*

A7. No, phenotypic information will still be needed for progeny.

Discussion / Comments – Genetics Session

Q1. *What is meant by the term "adapted" - we need some information in industry terms.*

A1. One way to define this is in terms of origins of the different breed groups and their ability to withstand the stressors of the particular environment. There are numerous publications available that show the relative resistances of the different breeds to particular stressors. As well, HotCross can be used to demonstrate these principles. Industry must recognise there is a difference between adaptation of a breed to an environmental stressor and acclimatisation of individual bulls after transfer.

Q2. *The results presented here today seem to fly in the face of other results attributed to CSIRO that suggest there is no heterosis in harsh environments.*

A2. For particular traits, evidence from the literature suggests that heterosis is higher in harsh environments than in benign environments (e.g. heterosis for growth is higher in the tropics than in temperate areas). However, differences between the performance of the F_1 and that of the better adapted parent gets closer in harsher environments.

Q3. *What is your vision of how quantitative genetics will come together with marker assisted selection in 5-10 years time? For example, 10 years ago, tick control was achieved almost entirely through use of chemicals. Now it is almost exclusively controlled by genotype. What impact is marker assisted selection likely to have?*

A3. Our best guess is that this technology will not be available before a 3-5 year timeframe. Then QTL markers will be commercialised by industry partners who provide services to industry in the form of gene marker profiles which are then incorporated into BREEDPLAN. For candidate genes, the information can simply be thrown into sale catalogues etc. showing the animals carry particular variants of the gene. (Mike Goddard's comments: he sees 2 cases i) information on a gene with no other information [e.g. Pompes Disease] where direct selection for homozygous normal animal occurs; and ii) traits where other information is available [e.g. marbling, where ultrasound scans, progeny test and gene marker profiles will all provide separate information for the one trait] and where it will be best to include all available information into an EBV because otherwise the user will encounter lots of difficulties trying to appropriately weight all the different sources of information in selection programs. Mike also believes it will be essential to largely replace linked markers with direct genes, because linked markers will be very difficult to commercialise for use in widespread breeding programs.

Session 6:
Technology Transfer and Adoption

Session 6: Technology Transfer & Adoption

BREEDPLAN - Tropical Breeds Technical Officer

MLA Project No.: NAP3 BREEDPLAN

Project Duration: September 1998 – September 2001

Technical Officer: Richard Apps
Tropical Cattle Technology Services
PO Box 809
Rockhampton Q 4700
Ph: (07) 4927 6066 Fax: (07) 4927 6036
Email: richard.apps@tcts.une.edu.au

Management Committee:

Shane Blakeley NAP Program Coordinator
PO Box 1910 Toowoomba Q4350
Ph: (07) 4639 4204 Fax: (07) 4639 4140
Email: rpsagri@icr.com.au

John Croaker General Manager
Australian Brahman Breeders' Association Ltd
PO Box 796
Rockhampton Q 4700
Ph: (07) 4927 7799 Fax: (07) 4922 5805
Email: brahman@rocknet.net.au

Neil Donaldson Operations Manager
Droughtmaster Stud Breeders' Society Ltd
PO Box 978
Kenmore Q 4069
Ph/Fax: (07) 4637 2199
Email: droughtmaster@b022.aone.net.au

Burnett Joyce
Gyranda Pastoral Co MS 324
Theodore Q 4719
Ph: (07) 4993 7144 Fax: (07) 4992 7182

Arthur Rickards OAM
Managing Director
Agricultural Business Research Institute
University of New England
Armidale NSW 2351
Ph: (02) 6773 3555 Fax: (02) 6772 5376
Email: arthur.rickards@abri.une.edu.au

Project Objectives:

- Double the use of BREEDPLAN by Tropical Breeds, over four years.
- Establish GROUP BREEDPLAN analyses for Droughtmaster and Brangus by year 2000.
- Improve the quality of data submitted for analysis.

- Assist all tropical breeds to run GROUP BREEDPLAN and further develop current analyses to include growth, fertility and carcase.
- Liaise with Meat Standards Australia to develop pathways for higher Bos Indicus content cattle.
- Assist breeders with farm computers.
- Contribute to field days on beef breeding, selection, meat quality, marketing etc.
- Liaise with industry groups such as the Tropical Beef Centre, Q.D.P.I. Beef Genetic Improvement Project and the Beef C.R.C. (Meat Quality) to assist in extension of findings.
- Assist breeders with development of strategic marketing alliances.

Project Summary:

Nine beef cattle Herd Book societies; Belmont Red, Braford, Brahman, Brangus, Charbray, Droughtmaster, Sahiwal, Santa Gertrudis and Simbrah; North Australia Program 3 and the Agricultural Business Research Institute agreed that there was a need for specialised technical support and extension to enhance the uptake of advanced breeding technologies in the northern beef cattle industry.

The project has a management committee consisting of three representative from the contributing societies (currently from Brahman, Droughtmaster and Santa Gertrudis), one from NAP3 and one from ABRI.

This committee was responsible for development of project goals, seeking applicants and selecting the appointee. Tropical Cattle Technology Services was adopted as the trading name.

Increasing utilisation of BREEDPLAN genetic evaluation technology by seedstock breeders and their commercial clients was identified as the key objective. Improving data quality and development of EBVs for other traits are integral to this goal to achieve a quality analysis of growth, fertility and carcase traits.

A number of *bos taurus* breed societies have had dedicated technical staff for some time. The effect of their extension and support of BREEDPLAN can clearly be seen in the significantly higher level of uptake in these breeds.

Despite servicing a significant proportion of the (northern) beef industry tropical breed societies have, in general, lacked the size to support dedicated technical staff. This, coupled with the extended run of poor seasons in the early 1990's, has contributed to a relatively low uptake of BREEDPLAN.

For example, in 1996 81% of registered Angus calves were recorded on BREEDPLAN while Brahman had 19%, Santa Gertrudis 21% and Droughtmaster 4%.

Project funding is committed for three years with NAP3 contributing 24%, breed societies 32% and ABRI 36% with the remaining 8% expected to be generated from fee for service work. Breed society contributions are proportional to their rolling three year average of registrations.

At the end of the three year term NAP3 support ceases and it is expected that the service will continue with funding from the breed societies, ABRI and fee for service income.

This commitment is illustrated by the formal review targets being at the end of four years.

An annual review is to be held in August coinciding with the Brisbane Exhibition. Representatives from all contributing parties are invited to this review.

Communication:

Current communication has concentrated on introduction of TCTS to breed society and industry personnel. This has been achieved by;

- National press release via Rural Press.
- Introductory articles in breed society magazines and newsletters, including Santa Gertrudis New Zealand. These publications have a wide circulation to commercial breeders.

- NAP News.
- Northern Muster, published by QDPI.
- Direct mail letter of introduction to all current BREEDPLAN users among tropical breeds, QDPI BGIP personnel, stud stock agents, Meat Standards Australia and major pastoral companies.

Ongoing communication will include;

- Continued contact with industry bodies (QDPI, CRC, MSA etc).
- Breed society Councils and sub-committees.
- Breed society publications.
- BREEDPLAN news.
- Direct contact with breeders to develop new users and enhance current usage.
- Discussion groups and training workshops.
- Northern Muster

Activity to Date:

TCTS is only seven weeks old. This project is still in the planning and development stage. Activity to date has been heavily weighted to establishing contacts with breed society personnel and members, and industry. Project planning meetings are yet to be held with four of the nine societies. Planning input from all societies will be completed by mid December 1998.

Following is detail of events attended and meetings held to date to meet northern industry people and seek project input, as applicable.

July 1998	BIAA AGM & Seedstock Producer of the Year field day, Rockhampton.
August 1998	Brisbane Exhibition: 1st Annual Project Meeting, Santa Gertrudis AGM & Council Meeting, Droughtmaster AGM, Composite Breeders Discussion Group, ARCBA annual meeting, breed judging. BREEDPLAN Version 4.1 workshop, Animals Genetics and Breeding Unit, UNE, Armidale. BREEDPLAN Technical Advisory Group Meeting, Armidale. NAPIC Meeting 98/2, Charters Towers.
September 1998	Western Integrated Ranch/Farm Education (WIRES) workshop, Charters Towers. Animal Genetics and Breeding Unit Consultative Committee Meeting. Belmont Red Society Sale, Rockhampton. Red Angus & Red Composite Sale, Emerald Ag. College.
October 1998	Brahman Week, Rockhampton. Carol Livingstone, Secretary, Charbray Society. Brangus Society AGM, Committee Meeting & Sale, Rockhampton. Santa Gertrudis Technical Committee Meeting, Brisbane. Droughtmaster Technical Committee Meeting, Brisbane. Dr M Tierney, Leader, QDPI Beef Genetic Improvement Project. Beef CRC northern breeding project open day, 'Duckponds', Comet. Rhonda Jones, Executive Director, Braford Society, Rockhampton.
November 1998	Council Meeting, Belmont Red Society Council, Rockhampton. Santa Gertrudis Breed Development Committee Meeting, Brisbane. Don Nicol, former (first) BREEDPLAN National Coordinator and northern beef industry consultant. Brahman Technical Committee Meeting, Rockhampton.

It is clear from communication to date that the first priority from participating societies is establish a society BREEDPLAN, establish their first GROUP BREEDPLAN or stimulate new users and enhance their analysis, as their current situation dictates.

Specific Activity Currently Scheduled:

November 1998	QDPI Genetic Improvement Workshop, Gympie Brangus Society Field Day, Eidsvold. Project Meeting, Charbray Society Council, Rockhampton. NAP3 Grazing Management & Biodiversity Workshop, Brisbane. Herd Magic PC Training, C.Q. Brahman Breeders
December 1998	Project Meeting, Braford Society Council, Rockhampton. On farm visits, current & potential BREEDPLAN users, NSW.
January 1999	Santa Gertrudis National Junior Show*, Warwick. Droughtmaster Breeders' Annual Seminar, Brisbane. Droughtmaster Board Meeting, Brisbane.
February 1999	Santa Gertrudis Cattle Evaluation School*, Northam, WA. Santa Gertrudis Classification Field Day, Hannaford. Droughtmaster Handlers School*, Gympie.
March 1999	Droughtmaster Futurity Exhibition, Gatton. Santa Gertrudis National Expo, Tamworth.

** Hosted by but open to people other than society members.*

Project Work Plan

From project planning meetings to date the following areas of activity have been identified for 1999;

- Contribute articles to Society publications (magazines and newsletters) and industry newsletters.
- Commence a 'door knock' program with likely BREEDPLAN users (as identified by Society staff, Committee members and fellow breeders).
- BREEDPLAN workshops: current user discussion groups and introductory seminars for potential users.
- Establish contact with Agricultural Colleges to determine current position re BREEDPLAN in their curriculum. If low or non existent offer course material, and presentation if required.
- Increase knowledge of BREEDPLAN among agents, particularly stud stock. Invite to seminars and, if receptive, run agents training workshops.
- Contribute to society field days and cattle evaluation days:- utilisation of BREEDPLAN, farm computers, communicate the practical application of current research (eg. Beef CRC, Bull Power).
- Test GROUP run for Droughtmaster, December/January with goal of releasing a GROUP BREEDPLAN analysis in mid 1999.
- Test GROUP run for Brangus, following completion of integrated pedigree/performance database with goal of releasing a GROUP BREEDPLAN analysis in mid 1999.
- Contribute to Society committees (Technical, Breed Development) as required.
- Review Society databases and data collection to identify potential upgrades and requirements to allow evaluation of new traits.
- Herd Magic user training workshops and one-on-one support as required.

- Represent tropical breeds at BREEDPLAN Technical Advisory Group (BTAG) meetings.
- Make contact with current marketing alliances.
- Assist societies with collection of feedlot and carcase data.
- Participate in Society youth development events.
- Contribute to QDPI programs as appropriate.
- Establish contacts with North Australia Beef Research Council and RBRC's.

Discussion / Comments

Q1. *hat activities are taking place in relation to BREEDOBJECT?*

A1. BREEDOBJECT is a package developed by ABRI, which puts economic weightings on traits according to the breeding objectives of the producer. To date the tropical breeds have relied almost solely on growth traits. A BGIP workshop at Bowen recently included a session on BREEDOBJECT.

Q2. *What sort of objective data was being used by the 30% of producers who identified that they were using objective information in their selection decisions?*

A2. They indicated that they were using objective information across the whole range of traits available.

Q3. *In the survey, producers did not list BREEDOBJECT as a priority area.*

A3. Producers probably did not have much knowledge of BREEDOBJECT as such, or as being separate from the weightings they currently put on traits. Also, they probably put a higher priority on individual traits.

Q4. *There was a rapid uptake of BREEDPLAN early on, but this then slowed dramatically.*

A4. The trend in Queensland in the early 90's was similar to the national trend. It was estimated that about 20% of herds with over 30 breeders enrolled. Also a lot of large herds were enrolled, so the herds represented well over 20% of stud cattle.

Q5. *Could the group be more effective outside of DPI, as private consultants? Also queried the emphasis on getting Droughtmasters into GROUP BREEDPLAN when they represent only 4% of enrolments.*

A5. The project aims at delivering workshops, field days, etc over a wide range of producers throughout the state. This coverage would be very difficult with a private consultancy arrangement.

With respect to the Droughtmasters, they currently have low enrolments but are a numerically strong breed.

Some of Richard Apps' work will be on a private consultancy basis.

Q6. *What was the size of the sample population in the survey?*

A6. It was 60 producers selected throughout the state from all sectors, as well as 20 producer organisations.

Q7. *There is some concern about the accuracy of scanning information.*

A7. To be used in EBV calculations, scanners who have passed a rigorous accreditation process must carry out scanning.

Raw scanning data from non-accredited scanners can be used, but the data may not be as accurate.

Scanning now covers fat, eye muscle area and intra-muscular fat.

Q8. *There has probably been more progress with stock agents than acknowledged.*

A8. Agents tend to seek information about BREEDPLAN when their clients demand it.

Q9. *GROUP BREEDPLAN in northern Australia will help northern producers appreciate the genetics bred on their own properties relative to relocation of bulls, grain feeding, etc.*

A9. The Producer Demonstration Sites which have been run show clearly the benefits of the technology in the north and that BREEDPLAN is not too difficult to use in the north.

Q10. *Worried that there are too many objectives for one person to do. Need to do something very different to CSIRO and DPT. Provide a 1 on 1 service to members of breed societies.*

A10. Yes, agree 1 to 1. Setup program and work through results. 1 on 1 or groups of 3 to 6 of peers. Not only to get to sign on line. Intend to move onto next couple of steps.

Q11. *Ongoing problem with data quality. Group of cows rated in 1 paddock and progeny stay there – not tell which is best sire – confounding.*

A11. Yes (Richard) agrees. Acknowledge work by Michael Brofield.

Q12. *Don't forget clients west of Camooweal.*

A12. Yes, agree that will get over there occasionally.

Q13. *Use of indicator cattle with respect to meeting paddock problems.*

A13. Probably not a good idea for studs. Could think about doing it, but probably not very attractive.

Q14. *What is possibility of rationalizing list with other players, no some of players forgetting issues and do away with duplication.*

A14. Key focus is performance recording issues. If at home can pick up on them.

Wish list came from a number of breed societies. Breed Societies are allocated a number of days.

Q15. *Stock agents are a difficult area and still regarded as a key group to target.*

A15. Agree that need to target them.

Beef Genetic Improvement Project

Project Presenters: M.L.Tierney[1] and J.D. Bertram[2]
[1]Queensland Department of Primary Industries, Animal Research Institute, Moorooka, Qld 4105
[2]Queensland Department of Primary Industries, Goondiwindi, Qld 4390

Summary

The Queensland Beef Genetic Improvement Project is an extension project aimed at encouraging greater use of objective measurement in selection procedures in the Queensland beef industry. The early years of the project involved an increasing awareness of the benefits of objective selection in both the stud and commercial sectors of the industry. This resulted in an increased use of BREEDPLAN and GROUP BREEDPLAN and an awareness of the need for breeding programs aimed at meeting market specifications.

A new phase of the project involves working with industry groups to assist them to develop extension packages relevant to their respective sectors of the industry in the areas of breeding and genetics, selection and mating plans, meeting market requirements and reproduction. These modules assist producers to define their current production system, define the market for which they are breeding and develop a selection and breeding program to move from their current end product to their desired end product.

Introduction

The Queensland Beef Genetic Improvement Project was established in 1988, with funding from the Queensland Department of Primary Industries and the Meat Research Corporation, as an extension project aimed at encouraging greater use of objective measurement and selection procedures within the Queensland beef industry.

The early stages of the project were described by Strachan (1990) who reported that to change the attitudes of stud breeders and their behaviour towards selection an adult education approach to learning was required. Overnight forums and discussion groups were used to encourage participants to describe what was important to them in the selection and breeding of cattle, to assess what benefits may be available through using BREEDPLAN as an aid in their selection and to overcome any perceived problems and barriers to adoption through a better understanding of the new technology.

The project to date

The first stage of the project involved a series of forums and workshops aimed at creating a greater awareness and adoption of BREEDPLAN technology by Queensland stud breeders and the stud stock selling agents. This provided a basis for the second stage of the project which was to encourage commercial beef producers to look for objective data when buying bulls.

This second phase of the project was conducted in 1992 and 1993 and involved a series of approximately 100 "Buying Better Bulls" field days which were held throughout the state and were attended by about 2,000 producers. These field days focused not only on the use of the BREEDPLAN data by producers (the users of the technology) but also on the need for them to seek objective data on all aspects of performance when buying bulls. Other areas covered in detail were structural soundness, reproductive performance and carcase traits of bulls.

The third phase of the project, which commenced in 1994, encouraged producers to look critically at the markets for which they were ultimately breeding cattle and to define the breeding system which would best help them to breed the cattle required for those markets. This phase of the project involved a series of "Breeding for Profit" field days, which were conducted throughout the state. To date, approximately 650 producers have attended close to 30 of these field days.

Results

Over a period of three years (1988 - 1991) the number of studs enrolled in BREEDPLAN in Queensland increased from 55 to 254, or 19% of all studs with 30 or more breeders.

Bertram (1991) reported that despite this rapid increase in the number of stud herds in Queensland enrolling in BREEDPLAN, the numbers effectively using the technology were not as great.

Of the major tropical breeds of cattle in Queensland, the Brahman, Belmont Red and Santa Gertrudis breeds now have GROUP BREEDPLAN analyses being conducted each year while the Droughtmaster breed is actively working towards establishing a group analysis. Brahman cattle constitute a very significant number of cattle in the Queensland beef industry and therefore the BREEDPLAN analysis constitutes a large benefit to overall beef production. A number of other tropical breeds, including the Braford and Brangus breeds are now exploring the potential of GROUP BREEDPLAN for their breeds.

Taylor *et al.* (1995), reported the results of a survey of producers and producer organisations concerning their attitudes towards objective measurement and selection and potential relationships with the Queensland Department of Primary Industries' Beef Genetic Improvement Project (QBGIP).

Eighty-seven percent of organisations considered that the QBGIP could provide a training service for their staff, members or members' clients. They identified the areas of facilitation, extension, field days, technical updates and meetings as areas of QBGIP activities. In excess of 30% of producers reported that they were using objective information in relation to growth rate in making their bull buying decisions. Slightly less than 30% were using objective information in their decision making in relation to carcase and fertility traits.

Sixty percent of the producers surveyed had previous experience with QBGIP activities. All except one rated the QBGIP activities as useful to extremely useful. Topics that producers identified as being of interest included bull selection, bull soundness, serving capacity testing, general bull fertility, growth rate assessment (particularly BREEDPLAN), carcase selection, crossbreeding, breed selection, breeding for markets, herd fertility, female selection and selection for calving ease.

The current project

A revised QBGIP has now being put in place.

Short term objectives. This project has short-term objectives, which include, the wider adoption of GROUP BREEDPLAN by the numerically influential breed societies, the development and enhancement of information packages in beef genetics and the evaluation of emerging technologies in beef genetics. The QBGIP continues to encourage increased use of objective selection of bulls in planned breeding programs - using either straight breeding or crossbreeding.

Long term objectives. The long term objectives include the release of GROUP BREEDPLAN evaluations by other tropically adapted breed societies, an increase of at least 10% in the use of BREEDPLAN by seedstock producers and the use of objective selection strategies in the breeding of the majority of commercial Queensland cattle. Consistent with these objectives is support for crossbred breeding values for genetic evaluation and selection in crossbred herds, as these evaluations become available. The project supports the increased use of objective recording packages consistent with the Beef Trading Information Systems principles. The time frame for these long-term objectives is the year 2000.

The process involved. The project now has a greater focus on client definition and identification of client needs. This involves active participation with various industry organisations, such as breed societies and producer groups who are interested in cooperating in the extension of advanced breeding and genetics technology to improve industry awareness and the eventual adoption of this improved technology. This does not preclude the already established practice of dealing with unaffiliated groups of commercial producers on a local basis through the provision of workshops, field days and other activities those groups of producers.

The process used focuses on adult learning principles with the producers within the groups identifying their issues and needs, recognising their current experiences and eventually planning an improved breeding program using objective selection that satisfies their needs.

To assist this process, a range of modules are offered in the areas of breeding and genetics, selection and mating plans, meeting market requirements and reproduction. These modules will assist producers to define their current production system, define the market at which they are aiming their production and develop a selection and breeding program to move from their current end product to their desired end product.

The proposed activities are being promoted to potential collaborating organisations with an offer to discuss in detail the range of activities that can be offered under the project. This will allow the particular activities with each group to be tailor-made to meet the requirements of the group.

Examples of activities with different groups, to date, include seedstock and client surveys with the Angus and Murray Grey societies, development of GROUP BREEDPLAN with the Droughtmaster society, development of a strategic plan with the Belmont Red society, BREEDPLAN and bull selection workshops with the Brahman and Santa Gertrudis societies and groups such as Beef Improvement Association branches and the development of a progeny testing program with the Bluegum Beef Association.

While a number of the activities in the project involve the continuation of existing activities, there are a number of areas which involve the development of new extension packages to support the areas of using crossbred breeding values (when they become available), adoption of computer based data collection systems, using feedlot and carcase feedback data in making breeding decisions, adoption of crossbreeding decision support software, targeting markets through selection for growth and carcase traits and using market alliances to promote efficient marketing and collection of data for breeding program design.

In these areas the project will also be providing extension delivery for outputs from other projects such as the Storelink Project, the Value Based Trading Project and the CRC crossbreeding program and decision support software.

Benefits. The benefits of these extension modules will be reflected in increased profitability by beef producers and awareness of the need to develop breeding strategies to meet specific market requirements. An ongoing development will be a recognition and adoption by producers of computer based data collection systems and the use of crossbreeding and crossbred breeding values in the development of these breeding systems.

The project will be a major avenue for the extension of the Beef CRC genetics results in Queensland, as these become available.

References

Bertram, J.D. (1991) Proc. Aust. Assoc. Anim. Breed. Genet. 9:200
Strachan, R.T. (1990) Proc. Aust. Assoc. Anim. Breed. Genet. 8:427
Taylor, K., Whittle, R., Bertram, J. and Thompson, R. (1995) "Queensland Beef Genetic Improvement Project Marketing Plan." QDPI Brisbane.

GENAB: (A Resource Kit for Teaching GENetics & Animal Breeding Principles)

MLA Project No.: DAQ- 099

Due Date for Project Completion & Final Report: 1st July 1998

Principal Investigators:

	Location	Phone	Fax	E-mail
Rod Thompson	P.O. Box 1085, Townsville, Q 4810	07 47222689	07 47782970	ThompsonR@dpi.qld.gov.au
Mick Carrick	Formerly QDPI Ann Street Brisbane, Q 4001	Resigned 1996		Now Victorian Dept of Agric.
Kathy Wheeler	P.O. Box 6014 Rockhampton M.C.4702	07 49360248	07 49361418	DelaneK@prose.dpi.qld.gov.au
		Maternity leave & resignation		

Project Objectives

To develop a saleable resource kit that contains: topic/lesson notes, over-head projection transparencies, videos computer simulations and a Computer-Aided Learning (CAL) tutorial, and run workshops with various target groups to test the kit.

Summary

MRC identified the one of the factors resulting in the slow adoption of performance recording and Breedplan, was a lack of understanding of basic genetics and animal breeding by producers and extension staff. The GENAB kit was aimed at compiling existing resources to enhance formalised training (as opposed to general extension activities such as Field days and PDS) at University, Agricultural College and Agri-High Schools, producer and training provider in-service workshops). Considerable consultation with agricultural teachers, University lecturers, extension and MRC staff was undertaken before developing the project proposal. One hundred (100) beta-test versions of the GENAB kit have been released to agricultural colleges, universities and Agricultural schools. Extensive training has been completed including:

- Twelve (12) in-service Teacher training workshops involving over 200 agricultural college and Ag High School teachers, in the area from Cairns to Katoomba.
- Seven (7) producer workshops with 120 producers attending
- Two (2) DPI staff training workshops (10 BGIP staff 5 other DPI staff)
- One (1) Australian Cattle Vet's workshop (25 vets)
- Four (4) BVSc and BAgSc University undergraduate courses (500 students)
- One post-graduate MSc/PhD course (20 students)
- One AusAid Short Course (eight Chinese researchers)

The kit now forms the basis of the Inter-School Genetic Challenge which was first conducted as a lead up to BEEF 97. This activity highlighted several software problems. Many of the computer programs used in GENAB are pre-Windows (ie DOS based) and cause memory/sharing violations. The problems are

being addressed with users preferring a WEB based interface. Professional editing /printing is underway currently with launch expected in June 1999. User- pays /fee recovery workshops are planned.

Detailed results/achievements addressing the agreed objectives

Objective 1. To develop a resource kit that contains topic notes, over-head projection transparencies, videos, and computer simulations.

PROGRESS: Achieved. Professional editing of notes is currently being outsourced. Two videos to be completed before commercial release. One hundred (100) beta-test versions of the GENAB kit have been released to agricultural colleges, universities and Agricultural schools

Objective 2. To develop a beef version of the 'SheepBreeder" computer-aided learning package for use by advisory officers, beef breeders, colleges and universities, and Agricultural High Schools.

PROGRESS: First version is complete. One hundred (100) beta-test versions of the GENAB kit have been released to agricultural colleges, universities and Agricultural schools. Extra topics to be included with future releases.

Objective 3. To use the kits' resources to conduct training workshops for Agricultural teaching/lecturing staff, extension staff and primary producers.

PROGRESS: Extensive training has been completed including:

- Twelve (12) in-service Teacher training workshops involving over 200 agricultural college and Ag High School teachers, in the area from Cairns to Katoomba.
- Seven (7) producer workshops with 120 producers attending
- Two (2) DPI staff training workshops (10 BGIP staff 5 other DPI staff)
- One (1) Australian Cattle Vet's workshop (25 vets)
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The kit now forms the basis of the Inter-School Genetic Challenge which was first conducted as a lead up to BEEF 97. This activity highlighted several software problems. Many of the computer programs used in GENAB are pre-Windows (ie DOS based) and cause memory/sharing violations. The problems are being addressed with users preferring a WEB based interface. A project proposal has been developed to address this software re-write.

Detailed communication achievements

The following conference papers/conference workshops were developed to communicate the concept of the GENAB kit in its early stages of development.

- **Thompson, R.J.**, Althaus, C.J., and Martin, J.G. (1993) Teaching tomorrow's animal breeders today. *Proc. 2nd Exten. Conf.* QDPI, 2-4 Feb 1993, Rockhampton. p 225
- **Thompson, R.J.,** Althaus, C.J., and Martin, J.G. (1993) GENAB - GENetics and Animal Breeding, A Resource Kit For Teaching tomorrow's animal breeders, today. *Proc. 1st . Conf Qld Agricultural Teachers Association.* Cairns, 22nd - 25th June.
- **Thompson, R.J. (1994)** GENAB - GENetics and Animal Breeding, A Resource Kit For Teaching tomorrow's animal breeders, today. *Proc. 5th World Congress on Genetics Applied to Livestock Production Guelph Canada.* 8th-12th August.

Media articles

- Queensland Country Life April. 24th, 1997 page 89 Beef 97 feature " Inter-School Genetic Challenge a Winner"

T.V. features

- Cross Country story November 1997

Other Comments

Under the initial project proposal, it was intended to produce a Beefbreeder 'clone' of the Sheepbreeder Program. The software used for creating Sheepbreeder was 'Author'. 'Author' is an extremely antiquated, coded software, and the major shift towards MS-Windows compatible WYSIWYG/GUI software products resulted in a re-think of the software of choice. The commencement of the development of the Beefbreeder CAL was postponed to investigate alternative software for use on the Beefbreeder version. Based on Mrs Wheeler's advice, a Windows based CAL software (Toolbook) was purchased. This decision will increase the 'life expectancy' of the BeefBreeder CAL and allow it to be easily modified or upgraded in the future.

As this kit is primarily a compilation of resources held by a variety of copyright holders, critical to the projects success has been the negotiations for the release of copyright from various authors as outlined below.

Resource	*Name*	*Organisation*
Notes and tutorials	Mr J (Charlie) Martin	Atherton State High School
Notes and tutorials	Mr Rod Thompson	Q.D.P.I.
GENUP programs	Prof Brian Kinghorn	Dept of Animal Science, U.N.E.
BGEN program	Dr Bruce Tier	Animal Genetics and Breeding Unit, U.N.E.
Video Segments on Breedplan	Mr Arthur Richards	Agricultural Business Research Unit, U.N.E.
Video Production of Breedplan	Mr Alec Linning	Channel Ten, Townsville
Text & examples used in Sheepbreeder to develop a Beefbreeder package	Dr Mary Rose	Q.D.P.I.
Brahman Biology Video	Mr John Croaker	Australian Brahman Breeders Association
Visual aids/graphics	Mr Rod Thompson	Q.D.P.I.
Trangie Selection Trial Video	Dr Peter Parnell	NSW Agriculture
Brahman GROUP BREEDPLAN Sire Summary	Mr John Croaker	Australian Brahman Breeders Association
Beef Cattle Breeds	Mr J.J. Daly	Q.D.P.I.
"Tropical Beef Breeds and Performance Assessment"	Mrs Judith Wright	MRC / Belmont Red Association
High & Low EBV PDS - Cross Country Video	Mr Shane Blakley	MRC

Beef 97 Inter-School Genetic Challenge

- Commenced in 1997
- Over 200 students in 16 Qld Agricultural High Schools competed in the inaugural Inter-School Genetic Challenge.

- Students used the GENAB Kit resources to prepare a written report that documented their understanding of genetics and animal breeding in general, and the use of these principles in the beef industry through BREEDPLAN and crossbreeding.
- 3 travelling studentship prizes were awarded with sponsorship from the DPI, Commonwealth Bank, BREEDPLAN at the Agricultural Business Research Institute and McCafferties Coaches (see attached press clipping)
- Students travelled to BEEF 97 in Rockhampton and attended activities such as bus tours, field days, seminars, and show ring events

Review of Project Funding

The initial project proposal (and contract) was from the MRC to fund the printing and production of the first 100 copies of the GENAB kit. In the interests of the development of the kit, it was decided to print alpha and test versions internally at a much lower quality (and cost) than professional outsourced printing. This has allowed cost savings to both the DPI and MRC and has allowed the core of MRC funds to be devoted to the production of the commercial release of the GENAB kit. Hence approximate ½ of the original funds requested from MRC has not yet been spent. It is expected that these funds will be committed by the June 1999.

Evaluation

Feedback from users of the kit has highlighted the need for the following improvements

Videos

- development of new videos covering the topics of cross-breeding systems, Bull structural soundness, genetic improvement., cell division (mitosis and meiosis), reproduction

BEEFBREEDER C.A.L. Tutorial -

- File size is 8 MB - needs technical skills to break the tutorial down into smaller components, (each topic as a separate file) and that file is only loaded into RAM when called

Long Term (for future versions)

- Need to develop new sections to cover other areas of genetic improvement
- Need to incorporate motion (animation and video clips where ever possible)

BGEN

- The BGEN program originally developed by the Mr Bruce Tier from U.N.E. Armidale continues to be an effective teaching tool and is an important part to the kit.
- Teachers using the program have highlighted many computer bugs in the BGEN program, which cause it to crash
- As this is old software, its needs updating so that modern computer memory management does not cause it to crash (ie to run out of Windows 95).
- Prof Terry Stewart from Purdue University, USA has cooperated with the development of the BGEN program. This upgraded version is being tested currently. One major problem with the program BGEN has been rectified and the version improved with free assistance of colleagues in the University of Prude, Illinosis, saving thousands of dollars which would have been needed to employ a specialist programmer. A re-release has been made to test the new version.
- Tier (UNE Armidale),Wade (U of Qld) and Thompson (DPI) are proposing to develop a World Wide Web based version of the BGEN program . The development of A WEB based BGEN will make

this concept of the Inter-school Genetics Challenge and producer workshop training more accessible and easier to manage for instructors. The feedback findings from the GENAB project will be forwarded to Teir/Wade and used to enhance the WEB version.

Across Project Linkage

GENAB is closely associated with other MRC, PIRD / PDS, DPI and CRC (Meat Quality) projects. The GENAB kit has been able to expand and develop it's resource base because of these associated projects (ie incorporating the video on the High and Low PDS at Birralee and the *Belmont Red Association's PIRD* funded manual entitled, "Tropical Beef Breeds and Performance Assessment". As a recommendation of former MRC coordinator Tony Gleeson, members of the PIRD project and DAQ-99 collaborated and the resulting Performance Testing Manual was incorporated into GENAB kit May 1997.

General Feedback - Layout

Evaluation reports from teachers, shows a need to continue in the black and white loose leaf format where the kit is used as the master copy. This allows sheets on various topics to be easily removed and photocopied. Extensive discussions with DPI Publishing Services has been undertaken on how to best accommodate this request.

Detailed Plans for the Coming Year

As outlined in the contract with the MRC, DAQ-99 was funded to establish the base resource kit and field test its applicability/usefulness. Funds generated from the kit's sale are to be used for furthering the development of the kit. The GENAB kit has now been widely adopted by secondary and tertiary institutions across Queensland. As a mailing list of users is maintained, the kit will continue to be upgraded as new resources (videos, notes) and software version upgrades become available.

Until now, it has been uneconomical to commercially print the GENAB kit as regular modifications have been required. As such, field testing kits have been produced 'in-house' at the DPI, saving the DAQ-99 funds for the final release version. These funds have not been committed as yet but are expected to be required fro printing/production in June 1999.

Videos editing is yet to be completed for the Bull Soundness video and Cross breeding Video. It is expected that these resources will be completed by June 1998, in time for the commercial release of the completed kit.

The project to convert the BGEN program to operate off the WEB is subject to funding.

Discussion / Comments

Q1. *When is the kit to be finished?*

A1. The kit was completed as per project milestones and is now being used in 100 Ag colleges/schools/Universities. Commercial release is expected June 1999.

Q2. *What funding has been given to the project?*

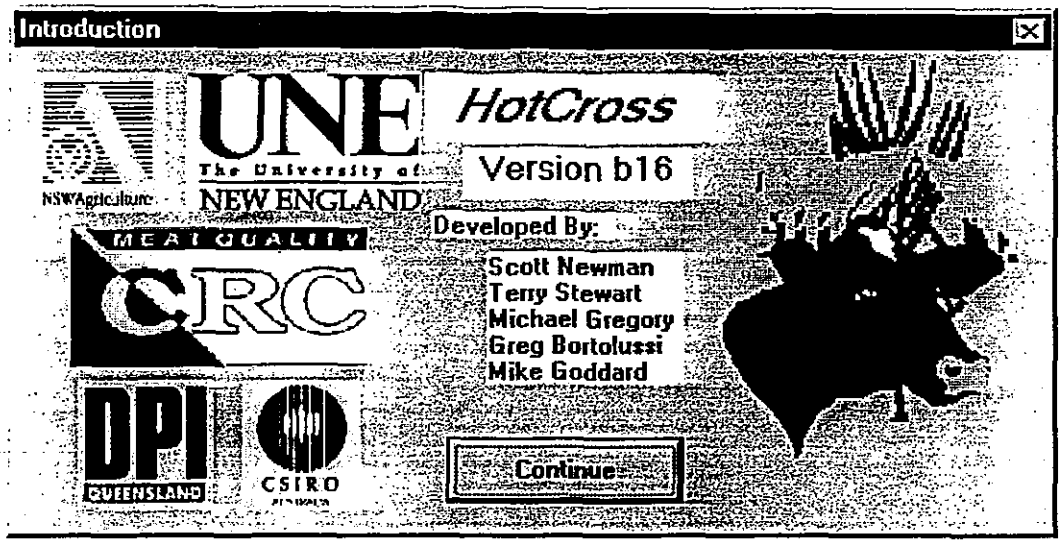
A2. $35,000 was requested from MLA. They committed $16,000 and the project has generated $7,000 from sales. The net to MLA has been $9,000.

It was mentioned that National training funding could be available for this sort of resource.

Q3. *How has it been used for producer training?*

A3. It has been used in producer workshops as an extension tool and there has been strong cooperation with Hotcross in training workshops. There is a need for a web interface.

HotCross: A Decision Aid for Tropical and Sub-Tropical Crossbreeding.



A major limitation to implementing crossbred mating programs in tropical areas has been the lack of quantitative information on the impact of environmental stresses on specific breeds and their crosses. HotCross was developed to predict differences in performance of various genotypes for major performance traits (reproduction, growth and carcass attributes) under northern Australian tropical environmental conditions by accounting for the impacts of environmental stresses. The major descriptors of environmental stress used by the software are ambient temperature (heat), ticks, worms and nutritional adequacy.

HotCross is used to predict differences between genotypes in production traits for the environment in which production occurs. What makes HotCross unique is the fact that predicted performance of genotypes is adjusted for four environmental stresses: heat, ticks, worms, and nutrition. The option also exists for individual users to input their own environmental stress levels (if known), or use the default data from the region of northern Australia where the cattle are produced.

The user inputs the following basic information:

Current Environment: identifies the region where the animal is located (eg. Brigalow, Speargrass, etc.), and the nutritional status of the region (eg. improved, unimproved, crops, feedlot). This is done for each growth phase.

Current Genotype: identifies the current breed of the cow herd. This becomes the base of comparison for further prediction. The base genotype traits are used to derive the stress levels. Once the base genotype has been identified, the user can then move on to predicting and comparing various crossing systems.

In addition to the user-supplied information on the current environment, performance and breeds being used, and what breeds (crosses) are to be predicted, default stress information is supplied by three databases:

1. The Vegetation/Pasture community database was compiled from the classifications used by Bortolussi *et al.* (1998) in their survey of the northern Australian herd to determine productivity (growth, reproduction and mortality) of the herds grazing different regional pasture communities.

2. The environmental stress database contains information on the previously mentioned stresses in each region.
3. The genetics database includes information on average performance, breed, and crossbreeding parameters. This database is composed of a large amount of information obtained from both tropical and temperate crossbreeding studies around the world. At present, over 750 literature citations have been evaluated for their use in the database. However, only a small number of breeds and studies have been available for use in this first version due to the quality of published information.

These three databases drive HotCross, which is written in Visual Basic and programmed for a Windows® environment.

How does the software work?

We have divided an animal's life cycle into three phases for this program - Breeding (pre-weaning), Growing, and Finishing. This was done because an animal might be with his/her dam to weaning on one property, grown out on and finished at other properties (or a feedlot) for varying periods of its life.

The performance of alternative breeds or crosses is predicted using two predictive models. First the performance in an environment which doesn't experience stresses typical of the tropics or sub-tropics (poor nutrition, heat, ticks, and worms) is predicted using a classic genetic model. This model contains direct and maternal breed effects and direct and maternal heterosis, estimates of which, based on published reports, and is held in a database developed as part of this project. Secondly, the decrease in performance caused by stress is predicted based on the stress levels specified by the environment (region and nutrition) and the genotype.

Equations to predict the decrease in growth rate caused by ticks, worms and heat are then used to predict decrease in growth rate. To utilise these equations, genotype differences in tick count, faecal egg count, and rectal temperature are used. The effect of temperature is a two step process of first predicting rectal temperature as a function of ambient temperature and genotype and then predicting the reduction in performance associated with elevated rectal temperature. Nutritional stress is currently described as the percentage reduction in performance due to nutrient limitations for each phase of production.

HotCross Options

- HotCross allows any breeding program using any number of the available breeds in the database to be developed on-screen. Boxes representing breeds are presented on-screen similar to pedigrees.
- Performance of breeds and crosses can be compared either in tabular form (as a deviation from the base genotype – the user can set the base to any breed or cross), or graphically.
- Individual sire information can be utilised with those breeds that generate a GROUP BREEDPLAN genetic evaluation.
- A revenue equation provides information on the average value of an animal (estimated saleable meat yield)
- Breeding plans can be saved for future work or printed
- HotCross now has an on-line help manual that can always be accessed by pressing the F1 key

Availability

A pre-release version of HotCross is available at no cost by contacting the individuals below. Later this year a fully commercialised version will be available at a small fee. The developers of HotCross are also offering to configure and deliver full-day workshops on breed utilisation, which include copies of HotCross as part of the tuition. More information can be had by contacting:

Scott Newman (Scott.Newman@tag.csiro.au)
Greg Bortolussi (Greg.Bortolussi@tag.csiro.au)

Meat Quality CRC
CSIRO Tropical Agriculture
Box 5545
Rockhampton Mail Centre Qld 4702

Phone: (07) 4923 8100
Facsimile: (07) 4923 8222

Discussion / Comments

Q1. *What data has the Hotcross model drawn on?*

A1. It is largely based on literature searches and the new CRC data. Greg Bortolusi's North Australia Survey data has also been incorporated. It was acknowledged that reproduction data is incomplete. F2 data is also problematic with the only reliable source being CS183.

Q2. *How does it rate environmental stress?*

A2. Stress predictions were based on literature figures.

Collation of Performance Data on Beef Cattle Production in Northern Australia

MLA Project No.: NAP3.313

Project Duration: Jan 1998 to Jul 1999

Principal investigators: Peter Hasker (Qld)
ARI, Brisbane
Phone: 07 3362 9490
Fax: 07 3362 9609
Email: haskerp@dpi.qld.gov.au

Neil MacDonald (NT)
Katherine
Phone: 08 8973 9746
Fax: 08 8973 9777
Email: neilmacdonald@nt.gov.au

Greg Bortolussi (CSIRO)
TBC, Rockhampton
Phone: 07 4923 8131
Fax: 07 4936 1034
Mobile: 041 9714 0912
Email: greg.bortolussi@tag.csiro.au

Objectives

To enhance management and decision making in the beef industry in northern Australia (and hence productivity) by the collation of beef cattle performance data (reproduction, growth, mortality) expected from average (and better) good practice for a range of agri-ecological zones across northern Australia (Qld, N.T. W.A.) and by December 1998 compile key productivity and related data in three ways:

- collation (similar to "The collation of basic biological data on beef cattle production in northern Australia" by RG Holroyd and PK O'Rourke, 1988") to provide researchers with an index to authoritative reference material (scientific publications)
- collation of text, tables and graphics, suitable for advisers (mainly data recorded in Queensland)
- summary of a descriptive nature in a style suitable for producers (case studies from Northern Territory)

Summary

The project consists of two main parts:

1. The collection, collation and summarising of growth and reproductive performance data recorded (1) in trials and observations at research stations and PDS sites in Queensland and the Northern Territory and reported in scientific journals, various reports and other printed communications during the decade 1987-97 and (2) in a survey of northern Australian commercial properties by CSIRO.
2. The publication of the summaries targeting (1) researchers, and similar to "The collation of basic biological data on beef cattle production in northern Australia"; (2) extension people (advisers, consultants, etc), and consisting of text, tables and graphics in a user friendly format: and (3) producers, and consisting of case studies from Northern Territory presented in an easy to read style. The extension and producer publications may be combined into a single publication.

Results

Most collection, collation and summarising of data have been completed.

Scientific publication

Collation and summarising of references from literature search done at the end of 1997 completed except for addition of PDS data (if this is considered worthwhile) and changes to data to ensure uniformity with values in the other publication.

The summaries are at present on an Excel spreadsheet. They differ from its predecessor in that no index for quality is included, results other than for control treatments are included and codes have been included to give detail on nutrition (Appendix 1). The format and hardcopy planned is much like its predecessor, tabular and spiral bound.

Producer publication (Northern Territory)

Statistical analysis of the main data sets (Kidman Springs Droughtmaster and Brahman breeders, Mt Sanford breeders) has been completed. These data, particularly that for the Droughtmasters, are comprehensive and of high quality. To increase its credibility, these are "government cattle", commercial property data will be included. It is hoped that data will be available from at least five sources (2 PDS and 3 commercial herds). Before releasing their data , commercial companies approached want to see the form of the publication. A basic "style" outline has been written.

Extension publication

This would include data Queensland, the Northern Territory (whether or not Northern Territory data is in a separate publication) and regional summaries of data collected in the CSIRO survey of beef cattle enterprises. It will also include data from the Pilbera and Kimberley regions of Western Australia if available.

Queensland data: Most of the collection, collation and summarising of data is completed (Table 1). Completion was scheduled for July 1998 and, with no additional references, should occur by December 1998. Remaining work consists of a number of trials conducted at Brigalow Research Station and Brian Pastures Research Station, PDS and other work conducted in the brigalow and southern speargrass regions, and trials of an across-region nature. Factors causing delays included recalculation of data, approaching authors for more details and clearing up ambiguities, etc, and extraction and interpretation of essential data and messages (many reports are over 10 pages).

CSIRO survey of commercial beef enterprises: Survey work is finished. Database reconstruction (and debugging) so it can handle the volume of data collected and interrogation of the data for report generation has held up progress by at least 2 months. The original database specialist resigned and the replacement has been tied up with learning how the previous worker structured the program language. Work includes removing the use of soil type in the reporting. The original database had everything linked to a soil type-vegetation-pasture x breed field that generated a considerable amount of often meaningless data.

Table 1 An indication of the number of Research Station and PDS trials summarised and completion status of each region

Region	Research Station	PDS	Completion status (%)
Northern speargrass	56	22	90
Mitchell grass	Na	9	100
Mulga	Na	3	100
Spinifex	Na	5	100
Aristida/Bothriochloa	Na	5	100
Southern speargrass	1	25	70
Blue grass browntop	Na	3	100
Brigalow	7	13	70
Qld blue	Na	2	100
High rain	5	14	100
Translocation*			0
Across state**			0

* Trials comparing growth performance between regions/sites

** Trials concerning principles applicable across regions (eg P supplementation)

DPI Publishing Services agreed to produce the publication and were supplied with a sample to produce a mockup. This was received at the end of October. Formatting difficulties stemming from the nature of the summaries and the incursion of higher priority work caused delays and, because of the nature of the summaries, it was desktopped text only, and not designed. It does not appear suitable for its intended purpose that was for selected distribution to gain feedback and assess interest in advertising.

Drafts of a preface, and sections of an introductory nature have been written and comment given by DPI Publishing Services. An outline draft of background details has been forwarded to the MLA for checking and inclusion of statistics.

Production of extension publication

The draft Table of Contents is given in Appendix 2. Summaries of sites within a region follow each region summary. Seven levels of headings were identified (Appendix 3). At the start of an appropriate level, the contents of the section at that level were listed, mostly in the form of questions (Appendix 4). The general format of a site summary is:

Site details - name, location, climate, vegetation and soil (text)
Numeric data (tables or graphs, occasionally text)
Background detail (text)
Main points (dot point form)

Summaries for research stations and PDS sites only differ in that numerous trials are reported for a research station whereas generally only a single trial is reported for a PDS site.

Decisions were made initially about what management detail should be included and whether to present growth data as liveweight, liveweight gain (kg) or ADG (kg/head/day). Liveweight was adopted for first choice followed by liveweight gain and ADG for the reason that beef producers generally view it this way. See Appendix 4 for examples of summaries.

Problems encountered by DPI Publishing Services when producing a mockup

The draft of sample summaries given to DPI Publishing Services had the tables and graphs embedded in the text; they prefer these to be in separate files. The structure and lack of uniformity in the amount of data at each site presented problems. The editor suggests a better balance between text and non-text was needed; eg, reducing or rearranging the number of footnotes (management detail), tables and graphs.

The 7 levels of headings presented major difficulties. Three are preferred, 4 are acceptable and at the very outside 5. The editor recommends restructuring to reduce the number to 4.

The large amount of text in footnote form often appearing under tables or graphs presented a problem with flow. The editor suggests changing these footnotes to text material as text material would remain uninterrupted.

The large number of tables and graphs caused some bullet points to be 'lost' between tables. Also the text did not clearly flow on from the headings. The editor cannot see an easy way around this without a significant restructuring of the text or a reduction in the number of tables and graphs; eg, by making less use of bullet presentation and where possible reverting to paragraphs of text. The various options considered would have been difficult to maintain and would have substantially increased book length.

The editor also suggested moving rainfall data to appendices and separating site summaries from region summaries by having them in two distinct sections.

Communication achievements

None

Plans for coming year

At the completion of collection, collation and summarising (December 1998), the following work is planned:

1. Have authors of references summarised check them for omissions and misinterpretation.
2. Incorporate Northern Territory site summaries and CSIRO region summaries.
3. Invite selected industry members to a workshop to review summaries for technical soundness, etc.
4. Send summaries (and instructions for preparation for the workshop) to workshop participants 2 months prior to workshop. The intention is to send out the summaries early in the New Year.
5. Hold a 2-day workshop in April at an appropriate location to review the technical content andc structure, etc of site summaries, provide agreed values for region summaries, and suggestions for improving the overall structure and format of the publications.
6. Formulate a marketing strategy (inc promotion and distribution).
7. Revise summaries according to workshop outcomes.
8. Submit draft for a technical edit and incorporate changes.
9. Submit draft to DPI Publishing Services for a general edit and incorporate changes.
10. Submit draft to DPI Publishing Services for producing a test page layout.
11. Review test layout.
12. DPI Publishing Services to incorporate changes and produce draft.

13. Review draft and if approved request nominated number of copies be printed.
14. Print and distribute.

Other comments

Where to combine the "producer" publication and the "extension" publication will be determined by the final format of the latter.

Matt Bolam (Western Australia), although interested in the project, was unable to commit himself. When the project is at an appropriate stage (possibly when all Queensland and Northern Territory work is summarised), the intention is to approach him about supplying data, either in summarised or unsummarised form.

DPI Publishing Services may be viewing this publication in a rather narrow way and hence the problem of ensuring the publication is easily navigated (data is easily accessed) can be achieved in other less traditional ways. For example, magazines and catalogues are not uniform throughout although certain essential uniformity is maintained. Such approaches may be worth considering

Suggestions regarding content and for improving individual site summaries and structure in general are sought from this workshop.

Appendix 1 Example of Holroyd style layout

Sources and indices of basic biological data for liveweight, growth and mortality in north Australia

Key	Author	Site	Breed	Years	Index	Stock rate	Class	Wt (kg) Nov	Wt (kg) May	Wt (kg) Start
	1. Queensland - high rainfall									
1.1	Crompton et al 1989	Isis Junction	Brahman cross	1974-1980			Calves			
1.2	Evans and Hacker 1992	Beerwah R.S.		1971-1974	M3 T6 P2	4/ha	Steers		156-177	
1.3	Evans and Hacker 1992	Beerwah R.S.	Hereford	1974-1977	M3 P2	6/ha	Steers			
1.4	Jones 1989	Samford		1971-1974	M3 P2	5/ha	Steers			
1.5	Teitzel and Wilson 1991	Utchee Ck R.S.		1978-1979	M2 T6 X7 P4	2.7/ha	Yearling steers			

Sources and indices of basic biological data for liveweight, growth and mortality in north Australia (cont.)

Key	ADG (g) Dry	ADG (g) Wet	ADG (g) Annual	ADG (g) Period	Period	Deaths
1.1						
1.2	194-419	358-550	397-482			
1.3	-190	552-675	241-730			
1.5	354-600	655-451	520			

Sources and indices of basic biological data for breeder fertility, mortality and liveweight in north Australia

Key	Reference	Site	Breed	Years	Index	Mating period	Stock rate	Class	Preg % wet	Preg % dry
	2. Queensland - northern speargrass									
2.1	Burns et al 1990	Swans Lagoon	Brahman (50 %)		T8 S			FCC		70
2.1	Burns et al 1990	Swans Lagoon	Brahman (75%)		T8 S			SCC		47
2.2	Davis et al 1993	Lansdown	D'master	1988-1992	T8 S	Jan-Apr		heifers, cows		
2.2	Davis et al 1993	Lansdown	D'master	1988-1992	T8 S	Jan-Apr		heifers, cows		
2.3	Dixon et al 1996	Swans Lagoon	Brahman X	1994/1995	M1 T1 X1	Dec-Apr		SCC		50
2.3	Dixon et al 1996	Swans Lagoon	Brahman X	1994/1995	M1 T1 X1	Dec-Apr		FCC		68

Sources and indices of basic biological data for breeder fertility, mortality and liveweight in north Australia (cont.)

	Preg % All	Calve (%)	Brand (%)	Wean (%)	Loss to branding	Loss to weaning	Cow Deaths	Wt (kg) mid-dry	Wt (kg) end-dry	Wt (kg) end-wet
2.1										
2.1										
2.2		64-92		66-76						
2.2		54-93		38-91						
2.3										334
2.3										364

Appendix 2 Draft Table of Contents

Appendix 3 Region and site headings (Draft)

(1) **PERFORMANCE DATA**

(2) **Region Summary**

(3) Reproductive performance
(4) Pregnancy and weaning rates
(5) Native pasture without supplementation
(5) Improving pregnancy rates
(4) Losses from breeder herd
(3) Growth performance
(5) Native pasture without supplementation
(5) Improving growth rates
(5) Effect of early weaning on liveweight
(3) Commercial property survey

(3) **Site summaries**

(4) **Reproductive performance**

(5) Pregnancy rates of *Bos indicus* cross females grazing native pasture
(6) Maiden heifers
(7) Does SOM liveweight affect pregnancy rate?
(7) Does age at weaning affect pregnancy rates?
(7) Does date of birth affect age at puberty and conception at first mating?
(7) Does post-wean supplement affect age at puberty and conception at first mating?
(6) Yearling mating
(6) Lactating cows
(5) How to improve pregnancy rates
(6) Does time of weaning and supplementation affect pregnancy rate of cows?
(7) Does spike feeding affect next conception?
(6) Creep feeding of calves
(5) Losses from the breeder herd
(5) Calf losses from pregnancy testing to weaning
(5) Scrotal circumference

(5) **Growth performance**

(5) Native pastures with no supplementation
(6) Liveweight changes and liveweights
(6) Does spaying affect growth of heifers?
(5) Does age at weaning affect liveweight performance?
(6) Early weaning
(6) Post weaning growth of radical weaned steers
(7) Calves of same age weaned at different times
(7) Calves of different ages weaned at the same time
(5) Improving growth rates
(6) Supplementation
(6) Sown pastures
(5) Deaths in grower herd

Appendix 4a Some research station summaries

(5) How to improve pregnancy rates

(6) Does time of weaning and supplementation affect pregnancy rate of cows?

In this section

Does time of weaning and supplementation affect pregnancy rates?
Does pre-calving dry season and post-calving wet season supplementation affect pregnanct rates?
Does supplementation for short periods in mid to late pregnancy affect next conception?

Table n Liveweights (kg) and pregnancy rate (%) of first calf cows supplemented during the wet season (Jan-Mar)%%13%%

	LWt 8 Mar 94	LWt 20 May 94	Preg. Rate
No supplement	334	354	72
Supplement	358	378	69

Jun 93 liveweight 374 kg and CS 7.5. By Jan 94 liveweight 309 and CS 5.0. Mated Jan-Apr 1994. Supplement CSM-grain-Megalac-P-mineral premix fed Jan-Mar 94 at rate of 21 kg/week/cow-calf unit.

- Supplementation increased liveweight gain of cows
- Calves from supplemented groups were heavier (130 kg and 136 kg) at the end of supplementation.
- Supplements had no effect on proportion of cows cycling or pregnant.

Table n Liveweights (kg) and pregnancy rate (%) of first and second calf cows supplemented during the dry season and late wet season (Jan-Mar)%%12%%

Supplementation	LWt Jan 95	LWt May 95	PR May 95
First calf cows (FCC)*			
Nil	285	364	68
Dry season	298	367	76
Wet season	292	374	74
Wet+dry season	329	402	86
Second calf cows (SCC)**			
Nil	251	334	50
Dry season	291	362	64
Wet season	279	367	50
Wet+dry season	311	387	92

*Jun 94 liveweight 408 kg and CS 7.2. ** Jun 94 liveweight 350 kg and CS 5.2.
Mated Dec 1994 to Apr 1995. Dry season supplement 32% CSM-27% urea-18% salt-14% calcium phosphate-9% ammonium sulphate fed Jul-Nov 94. Wet season supplement 33% CSM-15% urea-30% salt-21% calcium phosphate-1% sulphur fed Mar-May 95. Intake of dry season supplement averaged 175 g/hd/day and wet season supplement 116 g/hd/d.

- Dry season supplement reduced LWt loss of FCC (from 120 kg to 95 kg) and SCC (from 85 kg to 49 kg).
- Wet season supplementation tended to increase LWt gain from 19 kg to 29 kg.
- Dry season supplementation increased pregnancy rate.
- Wet season supplement tended to increase pregnancy rate.
- Combined dry and wet season supplementsation gave best increase in LWt and PR.

Appendix 4a Some PDS summaries

Improving growth rates

Supplementation

Thalanga[%%130%%] (20.27° S, 145.80° E)
Yellow earth (2-3 ppm bicarbonate extractable P)
Silverleaf iron bark with occasional dense understory of various wattles

Table n Annual liveweight gain (kg) of Brahman cross steers of various ages 1984-1991

Native pasture (202 ha)	Stylo (151 ha)	Stylo + 30% area fertilised with P (156 ha)	Stylo + 100% area fertilised with P (168 ha)
87 (31-160)	100 (na)	Same as native pasture	115 (40-205)

Verano and Seca sown into native pasture in December 1983. Superphosphate applied at 125 kg/ha at planting (1983) and 1987. Stocking rate varied annually depending on pasture availability after growing season. Due to higher stocking rate, fertilised stylo produced an average of about 30 (5-52) kg liveweight/ha/year compared to 16 (0-29) for other treatments.

- Fertilised stylo supported higher stocking rates and liveweight gain.

Pajingo (20.78° S, 146.17° E)

Red yellow earth low in P, blackwood/gidgea and open ironbark country, black speargrass and some buffel

Table n Liveweight (kg) response of No. 0 Brahman cross steers to dry season supplementation with CSM

	Liveweight			Liveweight change
	11.9.92	14.12.92	30.3.93	11.9.92 – 30.3.93
Nil supplement	401	368	464	63
Supplement	400	407	501	101

Half the supplemented steers were implanted with Compudose 200 prior to start of feeding. Supplemented steers given 1 kg/hd/d CSM from 12 Sep - 15 Dec 92. Following supplementation half the supplemented and unsupplemented steers were implanted with Compudose 200 and both groups run together in a paddock that had got some rain. Steers were slaughtered on 1 Apr 93. Unsupplemented and supplemented steer carcase weights were 235 kg and 255 kg respectively and 76% of all (supplemented?) steers had 6 teeth or fewer.

- Supplemented steers maintained a liveweight advantage of 40 kg until slaughtered.
- Supplementation in dry season can increase the percentage of steers with carcases of 280-300 kg and 6 teeth or less.

Molongle[%%122%%] (20.00° S, 147.00° E)

Speargrass invaded by indian couch.

Table n Effect of supplementation (Sep-Dec 92) on liveweight (kg) of Brahman cross steers

	Liveweight 20/8/92	Liveweight 10/12/92	Liveweight 27/5/93
Nil supplement	359	342	451
Supplement	358	363	455

Animals were weaners (<250 kg), yearlings (250-350 kg), older steers (>350 kg) - overall 358 (196-536) kg. Supplemented steers fed CSM at 0.5 (weaners), 0.75 (yearlings), 1.0 (older) kg/h/day respectively for 90 days from 11 Sep 92 when they were also implanted with Compudose 400. Unsupplemented steers were implanted with Compudose 200 at break in the season (4 Feb 93) of their anticipated final season. Both groups ran together except when the supplemented group was given supplement. Steers of suitable weight and saleability were slaughtered in Jun 93. The remainder were carried for a further year but because of drought few were ready for slaughter in May 94.

- Supplemented steers were 23 kg heavier than unsupplemented at end of feeding in Dec 92 but unsupplemented steers had compensated for most of this difference by Jun 93.
- Big range in individual performance of both supplemented and unsupplemented steers slaughtered in June 93.
- Greater percentage of higher priced carcases from supplemented steers.

Discussion / Comments – Technology Transfer & Adoption Session

Q1. *Have you thought about using Future Profit as a forum to deliver genetics?*

A1. Rod Thompson answered. Yes, would be a good idea, but lot of competition between various groups, competing against each other for some clientele. Should have a module to be used across all groups. Within training programs there is a need to develop better training in basic disciplines and skills.

Shane Blakeley indicated that a directory of training projects is under development and that directory will illustrate where fit within the property management mix possible linkages between projects. Rod Thompson also mentioned the use of a newsletter to give a list of courses (modules available). Neil Donaldson stressed the need for people working in this area to understand what Storelink is doing.

Tom Stockwell said there was a need to be some rationalization of what to do because of scarcity of funds. He thinks we are in danger of hitting people too hard – wanting to offer them something all of the time.

Q2. *Is the Breedplan Technical Officer position expected to do too much and is it spread too thinly?*

A2. Shane Blakeley acknowledged that while there was a lot involved in the project, it was essential that the position worked towards creating demand among commercial cattle breeders for Breedplan data ie. EBVs and for seed stock with those figures and then managing that demand over time.

Geoffry Fordyce highlighted the fact that while we think of ourselves as being involved in RD & E, we do a lot of R & E but not the D. "Need commercial systems application".

Shane Blakeley said he would like to see a format in place where people want to come back and buy more.

Q3. Should we draw out what Geoffry Fordyce said? Maybe somewhere we could demonstrate the whole production situation, maintaining a whole system approach. Show where you fit areas into management.

A3. Steve Banney said that Beefplan was along these lines.

Geoffry Fordyce saw it as a bigger issue than on one place. There is a need to put our thinking into a more structured approach, a systems point of view. For example, use of cottonseed is very easy but the use of cross breeding is more difficult. There is a need for a closer association between research and extension staff. He did not agree that Beef plan is the only way to do it.

Peter Lonergan explained that Beefplan is operating across a range of sites across Northern Australia with producers looking at a range of technologies which are working and which are understandable. His question is how can the information be put across more simply on a whole property basis.

Geoffry raised the conundrum of who should drive these activities. If driven by people where the technology is coming from it misses the commercial context. If driven by producers, there is potential to miss out on a lot of information. In this case, the "Systems approach" applies to researches and producers involved in RD & E.

It was mentioned that the pastoral companies are able to appear well able to adopt new technology but that there is a less sophisticated market beyond those companies. This drew a strong caution from many participants that there are a large number of progressive individual producers.

Noel Haugh said that the companies had a strong strategic plan and within that plan had developed cattle husbandry manuals to present information in a structured and practical way. Others counted that there is too much information available and that some filter is needed to enable people to get a grip on that information and the basic options for Northern Australia.

Rod Howard said that he saw Beefplan as a means of enabling smaller producers to have system that is available to them similar to those developed by the large pastoral companies. John Sullivan, a Beefplan group member said that that was exactly what their group was doing but that there had a problem in getting sufficient numbers to get the project off the ground.

Tom Stockwell concluded the discussion by saying that he believed that there were too many researches and not enough producers present to best discuss the issues but that forums such as these were powerful tools and he would like to see all players involved having ownership from the start.

Session 7:
Workshops

Workshop Sessions

Issues: from Wed & Thurs, as identified on Thurs & Fri am.

A Reproduction & Genetics – new directions

- Yearling mating – males
- Bull power development
- Growth pathway management and meat quality
- Linking reproduction and genetics
- Breed herd and grazing management

B Data collection, analysis and application – scientific and technical.

- Data analysis and available expertise
- Standardization - branding rates
  - other issues
- Scientific reform and extension timing ("best bet" approaches)
- Industry assessment of the Willis Spaying technique
- Long term funding / expertise for genetics research
- Facilitation of publication of existing results
- Cost-benefit of projects – research and extension
- Accreditation – opportunities for networking.

C Effective information delivery

- Information delivery software use of DSS
- Development and delivery of information and training packages – reproductive disease packages (vaccines)
- Workshops / education materials and delivery
- Commercial systems application of outcomes
- Appropriate extension methods (groups and 1:1)
- Focus / linkages across the north
- Adoption of genetics technologies – produce perceptions of relevance – recognizing a hierarchy and targeting systematically
- Economic analysis of genetics - available software

Workshop Groups

Keeping in mind the requirement to service producers needs (ie. With relevant, practical and cost-effective outcomes) and to move towards whole property management.

Define what needs to be done to make best use of the information we have available.

Identify gaps and explore whether these can profitably be addressed.

Identify what actions need to be taken, by whom, and on what timelines. (Be realistic and think about cross-linkages beyond animal nutrition and genetics / reproduction)

Report back with an oral presentation (less than 2- minutes) and written notes for inclusion in peer review report.

Group A	Group B	Group C
Heather Burrow	Greg Bell	Richard Apps
John Bertram	Vivian Doogan	Steve Janney
Ross Brunckhorst	John Frisch	Brian Burns
Dennis Boothby	Peter Hasker	Ian Braithwaite
Rob Dixon	Noel Haug	Greg Bortolussi
Geoffry Fordyce	Dick Holroyd	Michael d'Occhio
Vince Edmonston	Lee Fitzpatrick	Geoff Kingston
Alastair Henderson	John Lapworth	Gehan Jayawardhana
Rod Howard	Scott Newman	Peter Loneragan
Tristan Jubb	Peter Ridley	Tom Stockwell
Michael McGowan	David Taylor	John Sullivan
Steve Petty	Mick Tierney	Mick Sullivan
Lee Taylor	Mike Goddard	Jim Turnour
Maurie Josey		Rod Thompson
		David Skerman

Workshop A : Genetics and Reproduction R&D issues

Bullpower Project

The project team had previously identified three areas of future research, namely:

1. Effect of relocation on bull fertility;
2. Herd dispersion effects on bull ratios; and
3. The impact of bull behaviour, including dominance, on calf output.

These areas were considered separately.

Effect of relocation on bull fertility

The group suggests that:

In any scientific study of bull fertility, all bulls should be included, regardless of whether they pass or fail the BSE test (Bullpower project team report that ~17% of young bulls consistently fail the AACV tests, but at Belmont, where bulls are simply culled on testicular abnormalities and are joined in single-sire mating situations, <5% of bulls fail totally or have calf outputs well below breed average. This discrepancy can only be sorted out by joining all bulls tested, regardless of whether they pass or fail the fertility test.)

Any sperm morphology problem in relocated bulls needs to be quantified and management strategies to overcome the problems identified.

Researchers need to keep in mind that there may be a breed effect causing or related to the problem, and this effect should be tested if possible.

The study needs to be conducted across breeds and across environments.

A suggestion was made that epidemiologists could be consulted in the design of the project.

The outcomes of the project should be focused on the bulls themselves, rather than mating outcomes (i.e. mating outcomes and effects of various bull fertility measurements can be extrapolated from the current Bullpower project.)

It is suggested that the current Bullpower team further develop this project.

Herd dispersion effects on bull mating ratios

Need for further work on herd dispersion effects because the current Bullpower team do not want to put producers at risk by making recommendations on bull percentages without solid data to support their recommendations.

Other groups such as the CSIRO Rangelands group at Alice Springs may have some useful data to contribute to this project, as they are also working in this area.

The issue relating to the effect of behaviour, including dominance, on calf output should be included in this project at an appropriate level.

Some industry herds are already reducing their bull percentages and hence it would be useful to piggy-back this project in these herds. This will provide opportunities for collaborative projects across environments.

Rather than costly, replicated, designed experiments, the project could operate more as a data collection exercise in herds that are using reduced bull percentages to get a better feel for mating loads and outcomes.

It is suggested that the current Bullpower team together with industry collaborators and possibly the CSIRO group at Alice Springs further develop this project.

Longevity and wastage of bulls in commercial herds

There was some discussion on whether wastage of bulls was a genuine problem, or whether it resulted because bull mating loads were simply too high. The group recommends:

The small project currently underway to investigate this issue be expanded to quantify whether or not bull wastage is a genuine industry problem. This could be done in conjunction with the study on herd dispersion effects to be developed by the Bullpower project team.

Use of yearling bulls

Can we currently identify genetically and reproductively superior yearling bulls?

Is there an effect on longevity of using yearling bulls (suggestion we could get more rather than less years of service per bull by using yearlings.)

How best do we identify yearling bulls, and what traits are they selected on?

There is an issue of what information breeders miss out on by pushing bulls along to achieve joining weights by 12-15 months of age (e.g. measures of adaptive traits).

Do we have good enough knowledge of the relationships between traits such as adaptation and early life performance measurements, so that in the absence of phenotypic information on the bulls themselves, we can use correlated responses (answer likely to be "no").

Issue of rate of turnover of bulls in commercial herds needs to be considered - where is the cutoff point in $$returns to the producer of costs of bull turnover relative to rate of genetic progress that can be achieved by using younger, more highly selected bulls (i.e. to parallel rather than drop behind the genetic progress that is being made concurrently in seedstock herds.)

Are fertility issues different in younger bulls (i.e. can the same tests be used to predict fertile younger bulls?)

It is recommended that the Bullpower project team progress this issue further.

Grazing Herd Management Systems

The issue relates to the concept of evaluating grazing management systems in a range of environments to try and understand the biology and dynamics of the system so better recommendations can be made to producers and others.

Gross measures can be used to put the systems approach on an economic basis.

There is an opportunity in CRC Mk II project to impose treatments in collaborating herds to better evaluate grazing management systems. This work is being coordinated through QDPI.

Definitive, accurate recommendations for northern Australia using a systems approach are not currently available.

What data are needed and by whom should this be collected? Need to look at the whole system and what works and what does not work in that system, including the biology and economics of grazing management systems. This needs to be supplemented by key component research.

First principles have been taught by Rural Consulting Services (RCS) and this makes people think critically. They recognise and use a standardised language across participants, and participants are encouraged to conduct on-property trials to test out these principles and best practice for individual properties. RCS should therefore be considered and possibly included in any systems-based projects.

Essential that grass mechanics and animal mechanics start working closely together!

The group strongly recommends that NAP3 should convene a workshop within the next 12 months to identify who is working in this area and what they are doing. Participants should include CSIRO (Tropical Agriculture and Rangelands research group), QDPI, NT DPI&F, WA Agriculture, CRC, RCS, industry and consultants.

Comment from Shane Blakeley - NAP3 is currently planning such a workshop with QDPI for February 1999, and suggestions had been made that WA Agriculture either be included in that workshop or that they hold a separate workshop. The February 1999 workshop is likely to proceed anyway, but options for an expanded workshop could be investigated.

Growth Pathway Management and Effects on Meat Quality

Three issues were identified:

Timing of calving (later-born calves never achieve same growth rates as calves born earlier in the season. Hence the issue is not only quantity of weaner, but also quality of weaner.) This was perceived as an application of knowledge issue rather than an R&D issue, and should best be pursued through a systems development approach.

Identification of critical control points and appropriate, cost-effective nutritional / management intervention strategies to ensure meat quality. This issue is being pursued through the CRC and is outside the scope of the current genetics and reproduction review.

Problems with use of ossification in MSA.

The latter two issues were considered high priority by the group, but it was recognised they are being addressed by other groups and R&D priorities should be addressed by them.

Linking Reproduction and Genetics

Issue : Use of reproductive technologies to enhance use of genetically superior animals, to provide genetic linkages for evaluation purposes and to allow easier use of crossbreeding (e.g. use of non-adapted bulls to produce adapted F_1 progeny).

Recommendation : Work should focus on AI program development rather than ET, JIVET, cloning etc. in the context of northern Australia. The group supports ongoing R&D by neutral researchers (i.e. companies selling the products should not be those responsible for the R&D) into AI program development and ovulation (not oestrous) synchronisation.

***Issue** : Reversible suppression of oestrous*

Recommendation : There is a need to identify whether the existing GnRH agonist will be commercialised before proceeding with further R&D in this area.

Issue : Identification of genetically superior animals

(Use of gene marker profiles and direct markers - needs to be substantially cheaper for widespread use)

Recommendation : Further R&D is needed in this area for markers and alternative selection criteria, and for traits in addition to carcase and meat quality (resistance to environmental stressors, feed efficiency etc.)

Discussion / Comments

Q. *Why are you recommending that funding for R&D come only from neutral parties?*

A. The issue is not with funding, but rather who does the R&D. The group considers it essential that neutral parties conduct the R&D and be free to publicly release both positive and negative results. There was a perception that if R&D is conducted by people with a vested interest, that party could choose to suppress negative results.

Q. *It seems the group decided that most issues raised are worth pursuing. But what are the priority issues?*

A. The group made no attempt to prioritise issues, and obviously this would be dependent on complete project details. Some of the issues (e.g. grazing herd management systems) may not be R&D issues. In that example, what we have suggested is that we look at the whole area to try and have a look at what's being done, by whom and whether there are genuine R&D issues in the area.

Q. *Is the whole area of bull dispersal effects just another example of academic wankery?*

A. The group recommends use of existing herds that have changed their management practices to reduce bull percentages, rather than designing new projects (i.e. collate existing data to see if better recommendations can be made.)

Workshop B: Data Collection, Analysis and Application

Data Analysis and Publication of Results

Expertise is available but is not always adequately funded. This discrepancy arises on two fronts; it may not be costed into the project and/or it is not recognised or is under-emphasised by funding bodies.

There should be a greater emphasis on collation and publication in the contract with the funding body (eg. John Frish's work). It would be desirable that one project roll over into another with researchers being able to work on publication of results from the first project concurrent with early work in the second.

General recommendations were:

- MLA to alter contract design
- Research providers to assess data that has not been progressed to analysis and publication
- Nap 3 peer review – encouraged
- Build into project biometrics resource.

Standardisation of Terminolgy

The group agreed that there was a need to develop an agreed terminology across disciplines.

A list of descriptive items should be included in all project reports, eg. Vegetation etc.

Accreditation of the Willis Spay Technique

The general feeling was that industry has made its own positive assessment of the technology and that a formal accreditation system may be difficult to devise and implement.

Long Term Funding/Expertise for Genetic Research

General recommendations include:

- Funding bodies support needed with checks / milestones during projects.
- MLA provide guidelines (pre-requisites for long-term projects
- Support post-grad training.

Project Cost Benefit Analysis

The group understands that research and extension projects do give consideration to cost benefit assessment of their work. No formal action is necessary on this issue.

Networking Opportunities

The group believes the peer review process is worthwhile.

It is recommended though that future reviews have the capacity to report back on the progress of recommendations and that the workshop sessions be more structured.

Discussion / Comments

Terminology

Peter Loneragan said that standardisation of terminology has come up at previous peer reviews. Peter Hasker pleaded for the consistent use of standard terminology throughout the industry, not just in specific reports.

Willis Spay

Geoff Fordyce maintained that there are welfare issues involved in QA for Willis Spaying. There is a need for accreditation to satisfy these welfare requirements. Some person or group would need to oversee the accreditation.

Tristan Jubb said that, at present, there is no accreditation other than in some parts of Western Australia. Lee Taylor stressed the possible loss of markets if international equivalence in animal welfare issues cannot be demonstrated.

Analysis and Publication

QDPI sees biometricians as having a vital role in all stages of projects. Some other organisations do not have the same emphasis. In Western Australia trials must involve biometricians. The vital continuing role of biometricians was endorsed.

Regarding publication, Dick Holroyd maintained that research providers have a responsibility in this area. There must be time for the writing up of results. There is often an "empty paddock" syndrome on research stations which puts the emphasis on continual experimental work at the expense of writing previous work up.

Peter Loneragan indicated that some contracts now include clauses regarding publications.

Studentships

MLA is allocating $306,000 to studentships this year for 7 students, with 2 or 3 in genetics.

QDPI is re-initiating scholarships, mainly post-graduate.

Long Term Research

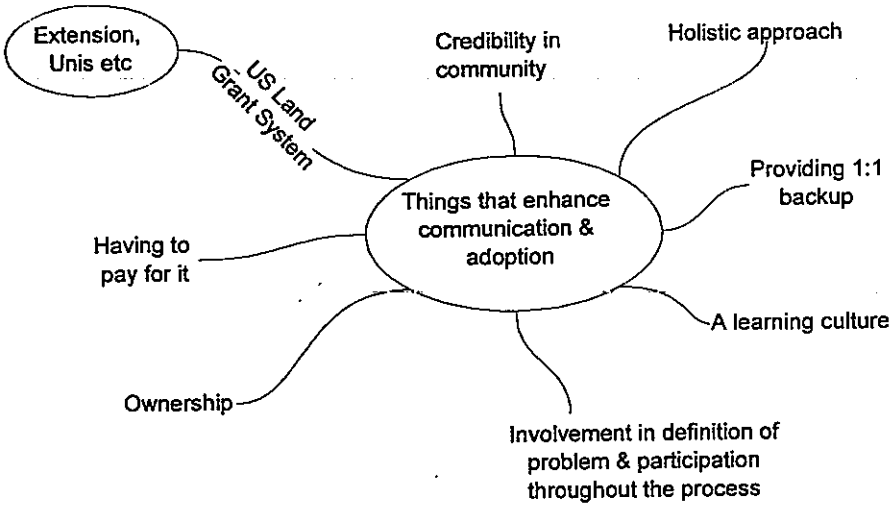
David Skerman commitment to long term work is a real issue in a number of areas including disease, genetics, improved pasture species and resource management.

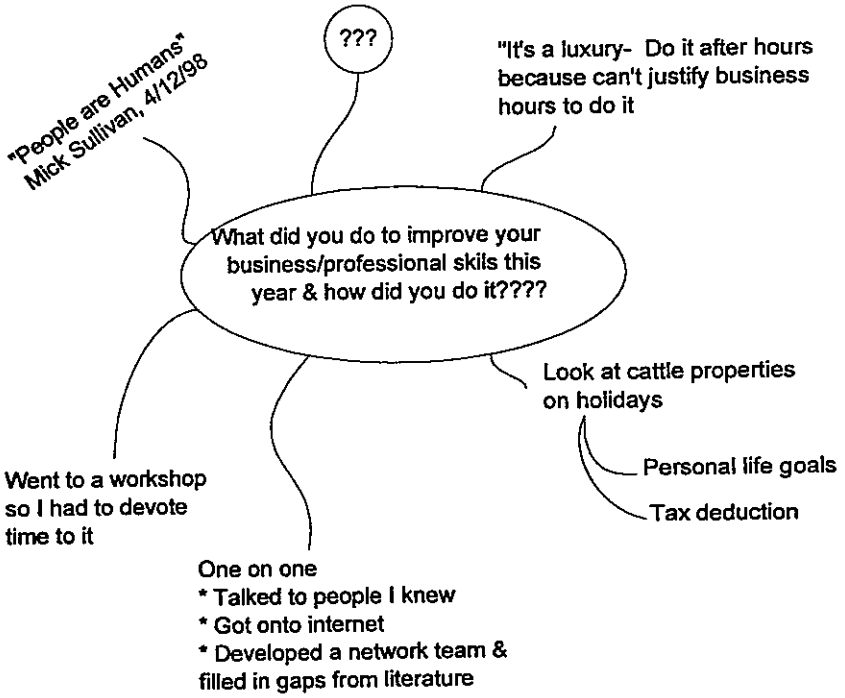
Each funding Board has a short-term life and this poses problems with long term commitments. There is a responsibility on researchers to provide information and confidence to funders.

Workshop C: Effective Information Delivery

TASK 1

- Understand the client's **needs**
- **Segment** and target the audience
- Translate the **relevant** information for each segment
- **Accessibility** and collation of the information
- Industry **ownership** of issues and information
- Utilise **existing** interest and social groups





Recommendations

A. Use of full range of expertise available in terms of:

- *Communication*
- *Marketing*
- *Information and Media Technology*

Actions

1. Pick a project or two and do a better job of it.
   - Involve people outside the normal sphere
   - Use it as a learning and training exercise

2. Develop a business plan for an alternative to current extensive grazing management / intensive management schools – develop a manual.

   MLA I.D. a group of people with relevant skills to produce the manual within 12 months.

   As only 10-20% of the market is being adequately serviced at present there is no likelihood of competition between government/corporate/private providers and the project could involve all three groups.

B. Integration of Products at Uni/TAFE/District Level

Actions

1. Its all in a name – Future Profit – not PMP
   Market research, focus groups etc.

2. Fire up and expand/empower the regional beef research committees to better represent and integrate the issues, problems, needs of particular regions – enhance participation of "grass roots" producers.

C. Understanding of Regional/Client:

- *Cultures*
- *Attitudes*
- *Needs and Objectives*

Actions

1. More effective use of regional beef committees

2. NABRC can enhance the linkages across the North Australia

3. At the regional level the producer groups and the associated government and private organisations need to want it to happen – it's everybody's job.

Session 8:
External Reviewers Comments

Comments by External Reviewers

Mike Goddard

Bull Fertility

The Bullpower project is impressive for its scale and comprehensive nature. Some of the important findings are negative ones such as the lack of predictive value of heparin binding proteins and serving capacity tests.

The results warrant further statistical analysis. All of the results should be combined in one analysis to determine which effects are significant across groups. After all, the purpose of the analysis is to develop a predictive model which can be applied to bulls in the future. I suspect the significance tests should be more conservative. At present table 3 shows variables with a significant positive effect in some groups and a significant negative effect in other groups. This may be because the significance test does not take account of the variation between bulls which is not explained by the model. An F test as in an anova might be better. It might also be worthwhile to analyse the differences in pregnancy rate between groups as well as within groups of bulls. The effect of variables which differ between groups might then be assessed.

The conclusions regarding mating ratios are suggestive rather than definitive.

The proportion of a group of calves sired by one bull is not the same parameter as the calving rate achieved by a group of similar bulls. For instance, high dominance rank increases the number of calves sired by a bull but a group of highly dominant bulls would not necessarily have a high calving rate. It would help the interpretation of the results of the project to have a model which predicted the pregnancy rate of a herd and the success of individual bulls based on the characteristics of the individual bulls. Key parameters would be the number of bulls mating a cow and the probability of conception to each bull. This model would require some knowledge of mating behaviour. Geoff Fordyce, who is better able to judge than I am, says that this would require a lengthy study and is not justified. However it might still be worthwhile to spend a very short time on planning the model to see what the key parameters are and hence assess how costly it would be to acquire the necessary information.

Future field experiments need to be considered very carefully based on their capacity to generate clear-cut answers, their demonstration value, cost and what industry is doing anyway.

Breeder fertility

Many years of thorough research has defined the major factors affecting calving rate under traditional northern management. Controlling cow body condition by early weaning and supplementation are important components. Industry has adopted some of this technology and benefited from it. However branding rates at research stations, such as Swans Lagoon, are still much higher than the industry average. Part of this may be because some supplementation is marginally profitable and hence poorly adopted.

The environment across the northern cattle zone varies widely. Mating yearling heifers is not very successful in most places but can be done successfully in places with better nutrition such as Douglas Daly. The question is 'under what other conditions could it be desirable?' Perhaps F1 heifers or even composite breeds in better country or stud herds. The high dystocia rate would need to be controlled (eg by a better growth from birth till the first trimester of pregnancy) before recommending this. The reduction in generation time would be beneficial in a stud herd and provide an opportunity to select for easier calving.

The view that mating yearling heifers is not practical is partially in conflict with Geoff Fordyce's point that it happens anyway due to lack of control of bulls and heifers. His concept of a separate group for females 0.5 to 3.5 years of age is interesting. It could offer a number of synergistic benefits that foster its

adoption and so is worth further consideration. However, like other management changes, it will be difficult to research given the need for replication.

Reproductive Disease

I found this topic puzzling, as I think did others present. There are clearly some properties where disease is reducing reproductive rate significantly. In many cases this is due to diseases that we have known how to control for some years (eg vibrio), so it does not appear to represent a research or even an extension opportunity. However we (I?) do not know what is the average level of reproductive loss caused by disease. Perhaps people closer to the field than I could make a reasonable guesstimate. I suspect that investment in R&D is only worthwhile if there are very specific targets and new outcomes which we can see being adopted.

Control of Cyclicity

The Willis spay technique has been a successful technology transfer project.

Commercial availability of the GnRH agonist is eagerly awaited but the cost will have to be somewhat competitive with spaying to be adopted.

Genetics

AI has a logical place in the stud sector. It would be heavily used if bull buyers paid a rational premium for genetic superiority. Therefore we should concentrate on getting market signals transmitted up the chain to bull breeders and AI usage will occur naturally.

The crossbreeding results of John Frisch are very encouraging. There are some simple conclusions which could be utilized by industry. The impediments to adoption appear to be:

- concern that the results from central Queensland do not apply in harsher environments. It is true that the superiority of the brahman increases in harsher conditions but limited experimental evidence shows that F1's perform well in all environments.
- The live cattle trade wants brahmans. If this is true you could still use a Boran cross.
- Cross breeding complicates management. True in general but very simple crossing systems are available. Eg put a few Belmont Red bulls in with the brahman bulls and cows. The producer could pick the F1 calves by eye and compare their performance with that of the brahmans.
- You can't buy big numbers of bulls for crossbreeding. If there was a demand breeders would produce them.
- What do you do after the F1? There are many options. If the F1 is better than brahman, a backcross to brahman will also be better.
- Isn't it better to concentrate on selection within a breed or property management than crossbreeding? Do all 3 – the effects are probably additive.

The number of objections put forward suggests that breed choice is partly a 'religious' decision and hard to change. What should be our extension strategy in this environment?

The impending retirement of John Frisch threatens the complete analysis and reporting of the results. A plan needs to be put in place, probably using staff who will remain on the payroll, to extract the full value from this series of experiments.

The CRC crossbreeding and straightbreeding experiments are steadily producing sound results which, together with other projects, will provide the factual basis for decisions for years to come. The comparison of eating quality across and within breed is important, especially when combined with a knowledge of the management techniques needed to achieve eating quality from a particular genotype. Another important part is the integration of crossbreeding and selection. For instance, some hereford sires produce calves as big as some charolais sires and in future we will know how to use EBVs to compare cattle from different breeds.

The Northern Territory project is surprising in many respects. (That over-fatness was a problem in NT cattle was novel to me.) The project is quite complex and I am not close enough to it to make sound judgements but will just raise a few questions. Do feedlots in SE Asia complain about our cattle being over-fat? Is it likely that we will supply heifers and bulls to this market? How are the bulls being used described (eg by EBVs) so that the results can be generalised to future sources of bulls? Can the use of indicator steers really overcome the need for normal replication of experimental units (ie paddocks)? Is the efficiency measure used in the presentation of results equivalent to profit? Novel approaches are most welcome but perhaps this project would benefit from a friendly but critical review.

The CRC molecular genetics project is exciting research (to me at least). I have a personal interest in this work and my opinion may be biased but I will give it anyway. Chromosome regions containing genes affecting meat yield and quality have been identified. However, the results are not readily usable as yet because the marker alleles that are associated with improved meat yield and quality vary from sire to sire. Consequently, a large progeny test with genotyping of all progeny must be done for every sire in which the markers are to be used. This is too costly in most cases. Further research is needed to develop markers that can be used in any family without progeny testing and I am proposing that this is part of CRC II. Otherwise the excellent work done to date will be of limited value.

Technology Transfer

Adoption of sound selection methods has been poor in northern Australia. However I think progress is being made. The appointment of Richard Apps is a good idea which I strongly support. It is important that he is perceived as working for the northern breed societies and in the interests of their members. Therefore his role should be sharply distinguished from that of DPI and CSIRO scientists although of course they should cooperate. He needs to operate at a one to one level. I was a little concerned at the number of tasks he was expected to do.

The BGIP project of DPI undertakes a range of extension activities. These need to be continually reviewed, updated and new opportunities taken advantage of. As far as I could judge this is happening.

Computer based decision support systems such as Hotcross are a puzzle to me. There is obviously a need for them but it is hard to get them well used. However, even if Hotcross is only used as a research tool I believe it would be useful because there is no other available mechanism to predict the performance of the multitude of possible crosses in the multitude of environments. A high priority at this stage is to make sure it is giving the right answers. It is not feasible to experimentally validate its predictions except in a very few selected cases. Therefore most of the validation should be done by someone other than the developers, checking a large number of its predictions against published findings and common sense.

General Comments

R, D & E for the northern cattle industry faces many difficulties which the participants in NAP3 understand better than I. Cattle production derives what profitability it has from large herds run under extensive conditions on cheap land with minimal inputs. This limits the new technology which is profitable and, combined with the old age and low education of producers, inhibits adoption of what is profitable. However, before becoming too pessimistic, it is important to be realistic about what we are

seeking. The dairy industry does not suffer from these difficulties nearly as much as beef, but it only achieves a 2% per year increase in efficiency of production (ie value of outputs divided by value of inputs). Other industries perform similarly. So it is unrealistic to expect more than 2% per year. There will be no or very few breakthroughs that save the industry. We are looking for small marginal gains that a proportion of producers will implement.

Pastoral companies represent a significant fraction of the cattle and they are adopting new technology. They have professional management and are more willing to take on debt to invest in new technology, but most importantly their size means they can afford company specific technical advice.

Given the risk of adoption, I believe other producers need personal consultant type advise. The ? project of MLA seems like a good move in this direction but we should be on the lookout for other approaches. There is also a need to segment the market and develop marketing strategies for different segments. Strategies for the pastoral companies might be different to those for small producers. Also there are big differences in production systems between NT and southern Queensland. It is perhaps a mistake to think generically about plans for the northern cattle industry.

In planning new work (NAP4 ?) we need to consider the mix of research, demonstration and extension that is best. Is demonstration of technology within a producer's own region effective in promoting adoption? Does he define his region so narrowly that it is impossible to do demonstrations in each region? Which research projects are providing new information we didn't know before and which contain an element of local demonstration and/or integration of technologies? These questions seem to be more important in the northern beef industry than elsewhere and re-enforce the importance of planning research, demonstration and extension as a package.

In 2-5 years time, we will have a powerful set of tools available for genetic improvement. These will largely be traditional methods but will cover a wide range of traits and integrate crossbreeding and within breed selection. Hopefully there will also be DNA based tests commercially available. Although the basic science is old, this suite of tools will be perceived by industry as, and is, new technology. The challenge is for the northern industry to gain benefit from it. How will this be done and what new opportunities for R, D and E does it present?

The small size of the gains that are realistically possible must not discourage us. If no gains in efficiency of production are made the beef industry will fall behind other sectors of the economy and be unable to deliver a satisfactory standard of living to producers. Therefore the industry needs to invest in R&D even if the benefits seem unspectacular. The scientists located on regional research stations represent an important resource for the industry that needs supporting. However they are somewhat isolated and may become bogged down in day to day issues. Opportunities for them to undertake study leave in new surrounding, or for visiting scientists to spend time at research stations should be encouraged.

Maurice Josey

Bull Power Project

This was an extremely extensive project which was initially designed with two major aims as listed in paper 1. Release of findings has occurred in a managed manner but however appears to have been undertaken before final analysis of the project was completed. This is often necessitated by producer interest in the project but can be potentially dangerous given that any recommendations made in isolation may not always be later sustained after detailed analysis of all the results. This particularly applies when the number of individual parameters being measured is large.

The final analysis presented (Table 3, paper 5 and more completely at the meeting) indicates that many traits are poor indicators of a bulls fertility and even all the traits measured collectively may at times be poor predictors as indicated by the results especially from site 11. Percentage normal sperm appears to be the most common single predictor but the 70% normal sperm threshold level may need further assessment or be only used as a guideline.

Physical traits as recommended by the AACV were used as guidelines. It appears thes are useful guidelines and whilst recommended to be used they were in themselves not shown to be useful predictors of fertility. This was most likely due to initial culling of bulls by property owners. It must be assumed that this is the reason rather than the guidelines may be faulty for the breeds involved. The demonstration that particular serving capacity assessment methods will allow sexual behaviour of bulls in the breeds involved to be assessed is an advance. Their lack of use in predicting subsequent fertility and their cost would mean that more emphasis needs to be placed on other assessment.

The results reported indicating a reduction in the percentage of bulls was possible to achieve satisfactory branding percentages supports anecdotal evidence. However the research was limited and effects of paddock properties, dispercion of cattle and dominance needs further work whether by further collection of data from property records past or future and/or trials. Dominance and behaviour studies

The working life of bulls is an important contributor to costs. Whilst a longer working life could be considered to slow down genetic improvement it would result in fewer replacement bulls needed and thus a higher standard (genetic) of bulls being purchased. Factors affecting the working life of bulls needs investigation and was a recommendation of one of the working groups.

The demonstration of the accuracy of DNA finger printing has the potential for use in genetic improvement in multisire herds by allowing sire identification. This needs to be promoted. This cost may be a contributing factor.

Yearling Mating Programs, Heifer and Breeder Management

This is a topic covering a time frame of many years in a production cycle from birth of the calf, its survival to subsequent reproduction as a heifer and as a mature cow. Environmental factors especially nutrition are the greatest factors involved. The papers presented were from different environments. The paper by Gehan Jayarardhan highlighted two problems namely one of experimental design and subsequent analysis of results especially where small numbers of animals are involved and the unforseen appearance of dystocia. The matching of required inputs especially of young reproductive animals to desired outputs especially regarding nutrition requirements as supplied by pasture may require a change in traditional time of the year for mating . The papers from Queensland presented by g G. Fordyce indicate the complexity of nutritional management in a tropical pasture environment. There is a necessity to have long term management and planning especially matching inputs to perceived outputs. The use of supplements appears essential to achieve what are now considered realistic production targets however the long term production of both pasture and animals needs ongoing research and cost analysis. This would include the extension of this work into other northern pasture environments. Life time production

of animals is important not just short term responses. Short term responses are often easier to measure and often necessitated by financial management constraints.

The supplementation paper by Dixon outlines many of the requirements and results of supplementation especially with urea. A considerable amount of knowledge has been in place for many years. Again its relativity to cow lifetime productivity and/or per productivity over greater than 5 year spans must be investigated especially where sustainability of pastures is important.

Disease Papers

These papers were largely a position statement. Their importance in a production enterprise is often poorly appreciated and they mainly become a focus of concern in an outbreak type situation. Most cattle producers became focussed on disease with the BTEC eradication campaign but since then it appears that the importance of disease or its relevance to production has largely been ignored. The importance of Trichmoniasis may be needed to be reinvestigated and the vaccine availability reassessed.

Control of Cyclicity

The Wills Dropped Ovary Technique is a highly satisfactory speying technique. Its use needs to be promoted for its obvious advantages and its use to become more widespread. The GnRH agonist bioimplants are a successful treatment and the only doubt may be in any longterm effects. Their commercialisation is really all that needs to be undertaken.

Crossbreeding

The paper by John Frisch outlined the importance and potential of crossbreeding in Northern Australia. The matching up and use of the 4 major cattle populations available in the world has been clearly researched and demonstrated. This work could be considered to be prematurely terminated. This brings into focus the problems of long term research especially genetic projects where normal timetables for funding are inappropriate. The data that has not as yet been analysed and presented needs to be finalised.

The CRC projects are largely for imformation. The projects are ongoing and large amounts of data has still to be analysed. The Northern crossbreeding project only utilises one dam breed ie. Brahman. This I believe is a defect but I understand this may be rectified in proposed further research.

The project outlined by Peter Ridley has as its object the improvement of suitability of the cattle being offered for live export. The analysis of genotypes and the study of growth patterns are involved. This study is focussed on the perceived long term market requirements and it is assumed that these have been adequately researched and not just perceived. It is also assumed that graziers will be paid a price incentive for a more suitable animal in future years. The project appears to require the use of a considerable number of suppositions based on formula estimations. The final use of this research is difficult to assess due to these considerations.

The molecular genetic project produces promising results if they can be translated to commercial seedstock cattle breeding. This applies particularly to Northern Australia multisire herds with respect to carcass traits but naturally has full industry ramifications. A commercialisation trial is underway and this may clarify the situation.

Technology Transfer

The appointment of a BREEDPLAN Technical Officer by several Tropical cattle breed societies should be a positive step. The duties envisaged are almost too wide and may require rationalisation. The other

aspect of this project is the perceived duplication of services with other agencies eg QDPI. This matter needs to be carefully watched as any provision of services should not be an unnecessary duplication.

The Beef Genetic Improvement Project by QDPI addresses most of the extension activities for genetic improvement available to producers. It has been apparently successful but may have an appearance of stalling in certain areas especially the use of Breedplan. The important consideration is whether the uptake of Breedplan has lead to an improvement in the genetic merit of bulls marketed and/or a more discerning buyer. These changes are essential if projects such as this are successful. The appointment of the Breedplan Technical Officer could be perceived as an adjunct to this project and it hoped that the beef industry adopts improved genetic programs.

The transfer of basic genetic knowledge to producers and potential producers and others involved in the industry has always been a matter for discussion. The provision of packages such as GENAB and Hotcross rely on the premise that the increased use of computers will mean these packages have a major impact on knowledge transfer and improve decision making. The enthusiasm of the people involved is high and only time will assess the situation.

Collation of all existing information has always been a problem especially where a lot of this information is not published in scientific journals and/or is not readily available in an matter easily resourced and understood by potential users. Failed experiments and or "unscientific" projects all have a message. How this material is finally collated and released has been a long term project by Peter Hasker. I certainly cannot offer solutions but share the investigators concerns.

Workshop Evaluation

Evaluation comments provided by participants in NAP3 Reproduction & Genetics Peer Review workshop, Brisbane, 2-4 December 1998

These comments should be read in conjunction with a spreadsheet analysis of the scores given by participants at the conclusion of the workshop, using a simple evaluation survey sheet.

Administration

Need more structured discussion

Insert objectives of workshop in front of the proceedings

Need more on defining objectives and outcomes of the workshop

Lack of clearly defined objectives. No defined rationale for why some projects were included and some excluded

Papers arriving the day before gives little opportunity to get a feel for topics prior to presentations

A longer lead-up time

A longer lead-time would be better for individuals to fit into schedules

I received very short notice of the workshop. Travelled and have accommodated at my own cost

The need to meet travel costs from non-MLA funds creates difficulties for some of us

Fit of funding would have helped

Some inequality of MLA support, which was a concern

Lecture room atmosphere not good. I prefer a seminar room rather than a lecture theatre, and particular a hot one

Air conditioning would have been nice

List of participants and their organisations/locations would be useful. Name tags useful - need to provide them. Need more on desired outcomes of reviews

Workshop format

Very good, need more of the same. More structured program and discussions. No differentiation of time on topics

Should be more discrimination of presentation time, depending on the individual papers

More planning required for Friday (Issues of common interest) workshop sessions. Directions unclear, only presented verbally. Venues did not allow efficient workshopping or participation, no workshop aids. Need more planning of structure for group discussions

Look to better plan the final day for more focussed discussion, collation of key points throughout presentations. QA could be improved

More critical review from an R&D perspective would have been useful (ie. Mike's comments very good and would have been good to get additional comments from another scientist)

Very little really critical review of projects. Limited expertise of some reviewers

External experts should have included two in each category; one 'expert' admitted a lack of current understanding

An outsider reviewer with commercial information and expertise would have challenged the group more than the selected reviewers

I didn't see the reviewers to be effective enough in summarising issues

Need more information specialists present. Producers need more involvement

Producers only from pastoral companies, not representative of the industry

I think we could have used more producers

Software demonstrations need more time - suggest running as 'hands-on' workshop or tutorial on software

Presenters needed to be more conscious of time and use fewer OHPs

Left enough time for comments, which was good

Overall assessment

Workshop much better (than annual written report)

Producers - Where were they? Not enough to make a difference and should probably be at a different 'function' anyway

Research & producer comments - None given by either during verbal presentations

Other comments

Very good workshop. Require more structured discussion such as this for all major topics to provide update and opportunity for discussion and peer review eg. supplementation, pasture etc - annual interface: infrastructure developments, reproduction, pasture management

Overall it was a very useful workshop

Good initiative which should be continued, pleased to participate

Main benefit was opportunity of "extending" project results to a new group of people and allowing further development of current and planned projects

Generally very useful to become aware of work being done by other groups - good for networking

Good way to get input from a variety of angles and expertise. The resulting debates are interesting and useful if only to show the complexity. The benefits of adding to the network are extensive

Generally this has been an excellent forum to review, discuss and chat about R, D, E and I issues, better than any conference or intra-organisational. Thanks for the opportunity of being involved

Worthwhile - very enlightening for a participant without background. Good networking opportunity

Very beneficial in allowing communication between institutions, regions, producers and the funding body

The peer review is worth continuing even though it did not score well here. It was the nature of the project

Annual reports are a waste of time and money. Genuine peer review of projects is desirable. If MLA expects participation, they should pay

These peer reviews are a good idea, but should not replace milestone/annual reporting system

Concern that much of the valuable information will not be put into a form that producers can relate to and apply in their businesses

There was a tendency to provide solutions rather than identifying problems for solutions to be found in association with industry and scientific rigour. This group is poorly equipped to decide on extension process

It would be nice to have one page fact sheets produced for each project

Need to have biometrician on panel to look at rigour of analysis methods etc. and address this in presentations and stress that people make comments and don't leave things unsaid

Not enough attention to benefits and costs of projects

If we are talking about economics with genetics and reproduction, then let's see the economics at all levels

Not enough criticism in relation to strategic direction of MRC/MLA and how projects address this strategy

A look at organisations' priorities would help

Some more explanation of the goals of the last day would have led to more focus in the day

Discussion groups could be better facilitated. Mine used very poor process that excluded contributors comments. The workshop program was too full

Still not sure what the outcomes were supposed to be. Finding out about others work was very good

Too big and broad to get a sufficiently detailed level to get good peer review. Objective very unclear

Group work seemed not to be as productive as it might have been - more agreement of objectives prior to group work would have been useful

Participants need to look forward, not backwards

Need to get presenters to focus on what work found, and its implications, rather than on history of the work. A lot of presenters used different data to that in papers, which negates the pre-reading by participants

Introduce each other, uses name tags. Lay down the laws on how critical to be in review

Reprod.Genetics
Peer Review evaluation

	Prep	Papers	Venue	Travel	Accom	Format	Length	Outside exp	Theme disc	Participants	Chairing	Usefulness	Res. Comment	Prod. Comment	W/shop or report
	3	1	4	3	5	3	1	3	4	4	3	1	5	5	0
	3	4	4	0	3	4	4	4	4	4	3	4	4		0
	4	3	5	5	5	5	4	3	4	4	4	4	3	3	1
	4	5	5	5	5	4	5	4	4	4	4	2	0	0	1.2
	3	4	5			5	4	4	5	5	4			5	
	3	3	4	3	3	4	2	3	4	4	4	4	4	3	1
	3	2	5	3	4	4	4	5	4	5	4	4	4	4	1
	3	4	1			4	5	5	5	4	4	4	4	4	0.5
	5	5	4			4	4	3	3	3	4	3	3	3	1
	5	5	5	5	5		5	3	4	3	5	5	3	4	0
	4	4	3			3	4	4	4	4	4	4	4	2	0
	4	5	5	5	5	4	3	4	4	3	4	4	4	4	0.5
	5	5	4	4	2	4	4	5	5	4	4	4	4	4	1.5
	4	2	4			4	4	2	4	1	5	4	5	1	0.5
	4	5	5	3		4	5	5	5	5	5	3	3	3	0
	4	3	4	3	4	3	4	3	3	3	4	4	4	3	3.5
	4	2	4			4	4		4	5	5		5		0
	4	4	4	5	5	4	4	4	4	4	4	4	4	4	1
	3	5	4	3	4	3	4	4	3	4	4	4	4		0
	5	5	5		4	4	5	3	4	4	4	4	4	4	1.5
	3	1	4			2	4	4	3	1	4	2	4		0.5
	5	5	3			3	4	3	4	4	3	3	3	3	1
	4	4	3	1	1	3	3	4	2	4	2	1	1	2	1
	5	5	5	5	3	4	4	4	4	2	3	4	4	1	0.5
	5	5	3	3	4	4	4	3	4	2	3	3	3	2	1
	5	4	5	5	5	4	3	4	5	3	4	4	4	4	0
	3	4	4	2	2	3	4	3	3	2	2	2	3	3	2
	1	3	5	1	4	2	1	2	3	1	3	0	1	1	2.5
	4	4	5	4	4	3	2	5	5	5	5	3	3	4	3
	2	4	4	4	4	3	1	4	4	4	2	4	3	3	4.5
	3	5	4	5	4	3	4	2	4	3	4	3	3	2	1.5
N=31/40															
Mean	3.77	3.87	4.16	3.5	3.86	3.6	3.65	3.63	3.94	3.48	3.77	3.28	3.43	3	1.06
Range	1 - 5	1 - 5	1 - 5	1 - 5	1 - 5	2 - 5	- 5	2 - 5	2 - 5	1 - 5	2 - 5	0 - 5	0 - 5	0 - 5	0 - 4.5*

* 0=W/shop
5=Report

Mike Goddard
University of Melbourne
Institute of Land and Food Resources
PARKVILLE 3052

Tristan Jubb
Dept of Natural Resources and Environment
Box 2500
BENDIGO MAIL CENTRE 3554

Alistair Henderson
Taylor Byrne
GPO Box 1776
BRISBANE 4001

Geoff Kingston
NAPCO
GPO Box 319
BRISBANE 4001

John Armstrong
Stanbroke Pastoral Company
GPO Box 155
BRISBANE 4001

Noel Haug
Australian Agricultural Company
GPO Box 587
BRISBANE 4001

Michael McGowan
University of Queensland
School of Veterinary Science & Animal Production
PO Box 125
KENMORE 4069

Neil Donaldson
Droughtmaster Stud Breeders' Society Ltd
PO Box 978
KENMORE 4069

Dennis Boothby
QDPI
Beef Breeding Services
Grindle Rd
WACOL 4076

Jim Walkley
QBII
Animal Research Institute
Locked Bag 4
MOOROOKA 4105

Mick Tierney
QBII
Animal Research Institute
Locked Bag 4
MOOROOKA 4105

Peter Hasker
QBII
Animal Research Institute
Locked Bag 4
MOOROOKA 4105

Vivian Doogan
QDPI
Animal Research Institute
Locked Bag 4
MOOROOKA 4105

John Sullivan
Western Downs BeefPlan
PO Box 243
COOPARROO 4151

Maurie Josey
8 Maylen Ct
HIGHFIELDS 4352

John Bertram
QBII
Locked Bag 2
GOONDIWINDI 4390

Peter Knights
SQBRC
PO Box 308
ROMA 4455

Rod Howard
Roma Veterinary Clinic
PO Box 426
ROMA 4455

Russ Tyler
QBII
PO Box 48
GAYNDAH 4625

Richard Apps
Tropical Cattle Technology Services
PO Box 809
ROCKHAMPTON 4700

Brian Burns
QBII
Tropical Beef Centre
PO Box 5545
CENTRAL QUEENSLAND MAIL CENTRE 4701

Dick Holroyd
QBII
Tropical Beef Centre
PO Box 5545
CENTRAL QUEENSLAND MAIL CENTRE 4701

Greg Bortolussi
CSIRO
Tropical Beef Centre
PO Box 5545
CENTRAL QUEENSLAND MAIL CENTRE 4701

Heather Burrow
CSIRO
Tropical Beef Centre
PO Box 5545
CENTRAL QUEENSLAND MAIL CENTRE 4701

John Frisch
CSIRO
Tropical Beef Centre
PO Box 5545
CENTRAL QUEENSLAND MAIL CENTRE 4701

Scott Newman
CSIRO
Tropical Beef Centre
PO Box 5545
CENTRAL QUEENSLAND MAIL CENTRE 4701

Michael D'Occhio
Central Queensland University
Faculty of Arts Health & Science
CQ Mail Centre
ROCKHAMPTON 4702

Lee Taylor
QDPI
LMB 1
BILOELA 4715

Geoffry Fordyce
QBII
Swan's Lagoon
MILLAROO 4807

Rob Dixon
QBII
Swan's Lagoon
MILLAROO 4807

Rod Thompson
QBII
PO Box 1085
TOWNSVILLE 4810

Lee Fitzpatrick
James Cook University
Australian Institute of Tropical Veterinary & Animal Science
TOWNSVILLE 4811

Ian Braithwaite
PO Box 2092
MT ISA 4825

Mick Sullivan
QBII
PO Box 1333
MT ISA 4825

Mike Goddard
University of Melbourne
Institute of Land and Food Resources
PARKVILLE 5032

Matt Bolam
Ag WA
PO Box 19
KUNUNURRA 6743

Steve Petty
Heytesbury Pastoral Company
PO Box 7225
Cloisters Square
PERTH 6850

Gehan Jayawardhana
NT DPI&F
GPO Box 990
DARWIN 0801

Peter Ridley
NT DPI&F
GPO Box 990
DARWIN 0801

Tom Stockwell
NT DPI&F
PO Box 1346
KATHERINE 0850