AUSTRALIAN NUFFIELD FARMING
SCHOLARS ASSOCIATION

SCHOLARSHIP REPORT

By

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Introduction

Winning the inaugural Women In Agriculture Nuffield Scholarship was a surprise and an honour. I was up against a very bright and professional group of women and being selected ahead of them spurred me on to try even harder during my scholarship.

My tour encompassed 8 weeks in England, Europe, Northern Ireland, Scotland and Wales, 6 weeks in USA, 2 glorious weeks in Zimbabwe and 3 weeks in SE Asia.

None of this would have happened without the support of the principal sponsors - The Sydney Meyer Fund and QANTAS and I extend to those organisations my warmest thanks for the opportunity afforded me. My travel consultant, Peter Lucas from QANTAS William St, Melbourne should be given a certificate of merit for surviving with goodwill and cheer my seemingly endless itinerary alterations.

While the Scholarship approximates a 50% bursary, I did manage to gain extra funding from local Alice Springs businesses and I would like to thank the Connellan Trust, the Centralian Beef Breeders Association; George Sabadin, Mobil; Westfarmers Dalgety; Viv Oldfield, Gorey and Cole; George Brown and Catri, Codan; M.J. Nancarrow; Jan Milne; Barry Spears; Southern Cross; Ian Cawood, Conservation Commission N.T.; Department of Primary Industry and Fisheries, especially Lynne and Jane; and Ray Smith, Lands and Housing for their unquestioning generosity of spirit. Without you all, it would have been so much harder for me.

Maggie Wilson, my host farmer in the UK and Carol Millar my host in Zimbabwe will remain life long friends as will my many hosts in the USA. Thank you to Heytesbury Beef, especially Alan Richardson, for the opportunity to sail with cattle to SE Asia and for your help and advice with my Indonesian and Philippine itinerary, Brian Gill from the Department of Primary Industry and Fisheries in Alice Springs who encouraged me to apply, Andrew Phillips from DPI&F and Dennis Manhood, Wesfarmers Dalgety for your references and support. To my fellow scholars - I'm glad it was with you my friends. Finally to my family - thanks for your love, your support and the time off work - you won't regret it.

The Crux of the Matter

In Northern Ireland I had a very brief and sober opportunity to look at their Agriculture Department's Stock Identification software.

DANI has a system where each animal is given a number at birth which it retains until death. Disease status, vaccinations and medications, sex, age and geographical location are recorded against this I.D.
DANI are in the process of upgrading this software so that information could be available for labelling at the supermarket i.e. Heifer, fed on organic pastures, 0-30 months age, disease status '0'.

This would allow health conscious consumers to choose at the supermarket shelf. I see this type of information tied in with electronic I.D.. and supermarket type scanners for data entry and retrieval. Together with Cattle Care accreditation this would be a way of marketing our pesticide free, residue free, grass fed beef - a 'total' branded product.

Scotland was cold and windy but I managed to get out of the weather and into an abattoir where they were using advanced post slaughter technology. All the cattle had to be mouthed for age as at that stage, no cattle over 30 months were permitted to enter the food chain due to the BSE scare. They were killing an order for Sainsburys' Traditional line and the carcasses were graded, electrically stimulated, tender stretched (hung from the pelvis) electrically stimulated again, aged on the hook at 0 C - 2 C for several days, then processed, vacuum packed and aged further, for a total of 35 days before being offered for sale. Sainsburys guaranteed tenderness.

Tenderness

Tenderness is still somewhat of an unknown. We know how to measure it in cooked meat, but as of yet we are unable to consistently measure tenderness in uncooked or raw meat. Tendertec has been proven unreliable in US studies. However, if the right post slaughter techniques are used, toughness can be minimised.

According to M Koohmaraie of USDA's Meat Animal Research Centre, (MARC) Nebraska, current evidence that the biochemical factors regulating the toughening and tenderisation processes of meat suggest that:-
Proteolysis (change occurring to proteins during digestion) of key myofibrillar (muscle fibres) and associated proteins is the cause of meat tenderisation ..... the function of these proteins is to maintain the structural integrity of myofibrils. Degradation of these proteins would, therefore cause weakening of the myofibrils and thus tenderisation. Koohmaraie, 1996.

Koohmaraie believes that current data indicates that the proteases (enzymes that digest proteins) responsible for these changes are the calpains, specifically u-calpains. Calpastatin is a protein which is an inhibitor, occurring at the ratio of 2:1 for calpastatin:u-calpain which he says is consistent with post mortem proteolysis and tenderisation in cattle. As the rate of Calpastatin decreases, meat begins to break down and so become more tender. The calpains (m-calpain; a high calcium requiring enzyme and u-calpain; a low calcium requiring enzyme) have an absolute dependency on calcium for activity. Koohmaraie, 1995.

Calcium Chloride

He has developed a process of adding food grade calcium chloride ($CaCl_2$) to post slaughter meat to aid in tenderisation - as there is more calcium for the calpains to utilise, so the tenderisation process continues beyond where it would normally stop. This does not make the meat mushy and can be added to meat up to 14 days post mortem. Koohmaraie says it is effective on all classes of meat regardless of species, breed or sex class and achieves close to maximum tenderness in 24 hours although Morgan et al (1991) reported that taste panelists characterised $CaCl_2$ injected meat as being more metallic, bitter and livery in taste.

He has also developed a mechanised means of testing carcasses for tenderness by removing a slice of loin, cooking it and shear force testing it. The process can handle 400 head per hour and the carcasses designated 'tough' can be treated accordingly. He says that this process together with one which tests for 24 hour calpastatin activity is more than 85% accurate for sorting into tenderness groups compared with 60% accuracy for current US grading method. Koohmaraie (1995)

Research is being undertaken in the USA at Texas A&M, College Station by Dr Rondah Millar and associates for a means of post slaughter identification of tenderness, i.e. before meat is cryvac'd. She is extremely optimistic that their research will enable carcasses to be identified on the kill chain for their tenderness levels. Carcasses can then be drafted accordingly. She believes that there is a genetic link within breeds for tenderness, but says that the heritability estimate for 24 hour calpastatin activity is very low so genetic improvements would be slow and expensive.

Electrical Stimulation

Electrical Stimulation (ES) with high voltage (300 + volts) is a means of tenderising tougher meat. Benjamin Franklin remarked in 1749 that 'killing turkeys electrically with the pleasant side effect that it made them uncommonly tender, was the first practical application that had been found for electricity.'

The ideal application for ES is probably with meat intended to be consumed within 14 days as by this time non electrically stimulated (NES) meat has begun to catch up in tenderness levels and by 30 days is practically identical for tenderness with ES meat.

ES doesn't just tenderise meat. Trials in Texas (Miller, M. et al 1996) showed that grading of beef from Select to Choice rose from 19.7%(NES) to 51.7% with medium to high voltage ES, on high grade Bos indicus carcasses. Packers have found however, that with a 48 hour chill prior to grading, non ES meat is comparable to ES meat for grade.

Health and safety measures needed to operate medium high voltage ES has seen most packers discontinue use, because there is no economic advantage to use high level ES - they are not paid for tenderness.

If an animal is inherently tender, ES is of little benefit. 'The tough animals are the ones that really benefit from ES. It's a way to pull up the tail end and eliminate those tough cattle that are causing problems. Millar, R., Beef, April:96

Variation in tenderness - breed

There are many reports that conclude that as the portion of Bos indicus increases, so does mean shear and variation in shear. (Warner Bratzler shear force test) Koohmaraie 1995.

He also says in the same paper 'Genetics makes a large contribution to total variation in toughness. However genetic analysis indicate that environmental factors make a much larger contribution to tenderness. He says that cattle with more than 50% Bos indicus (Brahman, Nellore, Sahiwal) are usually significantly less tender than meat from cattle with less than 50% Bos indicus.

'Jersey, Pinzgauer, South Devon and Piedmontese cattle tend to produce meat that is more tender than meat from other breeds,' but he says 'On average, most breeds are fairly similar in meat tenderness' and that there is 'more within breed variation than across breed.' Koohmaraie 1995.

Let us stop a minute and look at within breed variation. With all the advertising about Certified Angus Beef and more recently, Hereford Prime branded beef, these cattle would be expected to be tender.
In one trial conducted by MARC, in their germplasm project, WB shear force values were as follows. (Adapted from Koohmaraie 1995)

days aging	**Angus**	**Hereford**
7	**2.57 kg to 9.3kg (5.65 lb to 20.46 lb)**	**2.37kg to 11.91 kg (5.21 lb to 26.2 lb)**
14	**2.48 kg to 9.04 kg (5.46 lb to 19.89 lb)**	**2.41 kg to 8.3 kg (5.3 lb to 18.26 lb)**

'Stereo typing of all Bos indicus cattle as tough is as off base as saying that all black cattle will qualify for Certified Angus Beef ..... There are certainly Bos indicus cattle that will eat as well as any other breed.' Miller, M. Beef, April 96

The 1989 National Beef Tenderness Survey (USA) found the average age of meat at retail level was 17 days, but the range was 3 days to 90 days, with the majority falling between 10 and 30 days. (Morgan et al 1991)

A recent study conducted by Texas A&M University at three packers to compare different voltage in ES on slaughter cattle showed that the group of Bos indicus cattle slaughtered at Sam Kane plant (below) were more tender *before* ES than Bos taurus cattle slaughtered at Excel plant. After 30 days aging, there was very little difference.

WBS	EXCEL (Bt)				SAM KANE (Bi)				SUNLAND (Bi)			
Categories	7d	14d	21d	28d	7d	14d	21d	28d	7d	14d	21d	28d
NES												
<3.6 kg	44	93	97	100	75	92	87	92	43	92	92	92
3.6 - 4.5	48	5	3	0	20	6	13	8	25	3	5	5
>4.5 kg	8	2	0	0	5	2	0	0	32	5	3	3
ES	LOW VOLTS				MED/HIGH V				LOW VOLTS			
<3.6kg	53	96	100	100	73	88	95	95	64	87	87	95
3.6 - 4.5	33	2	0	0	24	12	5	5	26	8	11	3
>4.5kg	14	2	0	0	3	0	0	0	10	5	2	2

WBS values segregated into three levels (%) by location, aging time and electrical stimulation. Millar, M., 1996.

Consumers at home or in restuarants were 98% satisfied with steaks which had WBS values of less than 9.02 lbs. (4.1 kg) Huffman et al (1996; J. Anim. Sci. 74:91)

Trait	**BRM**	**TXB**	**AXB**	**SIMX**
WBS LB	8.93	8.22	7.58	7.22
KG	4.06	3.73	3.42	3.28

Warner Bratzler Shear force from Brahman (BRM), Tuli X Brahman (TXB), Angus X Brahman (AXB) and Simmental crossbred (Simmental X F1 Brahman X Hereford (SIMX)) steers after 126 days on feed.

With the absence of colour of hide and size of hump, the taste panelists rated steaks from steers fed for 126 days and with 25% to 100% Brahman as acceptable for home or restaurant use. Rouquette, FM et al 1996 (table above).

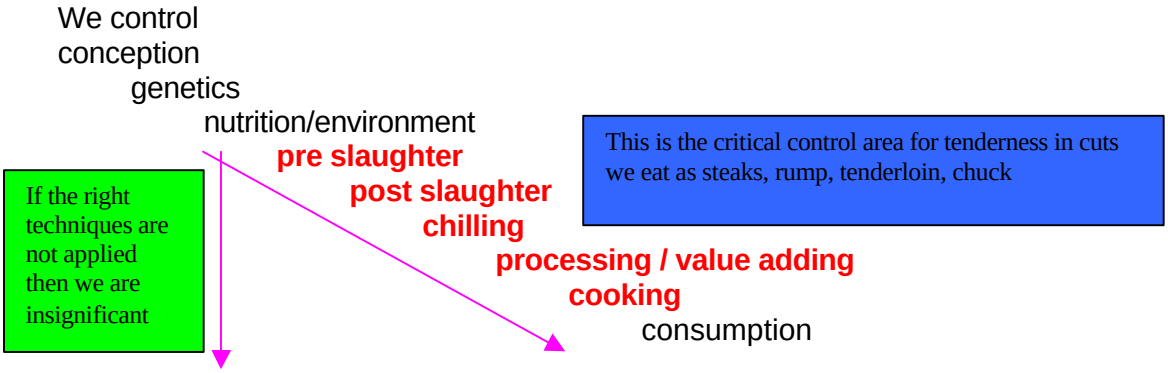
Flavour and Juiciness
Flavour and juiciness combined with cooking method contribute to the overall palatability of a steak.

A study conducted over 210 households in Dallas and San Antonio on British type beef, Continental European X British and Brahman X British cattle lot fed in the Ranch to Rail project found that there were - no significant breed type effect on overall Like, Juiciness or Flavour.

WBS force for the three types of cattle were (lbs) Cont X British 6.51, Brahman X British 7.27 and British 7.17. Hale et al 1996

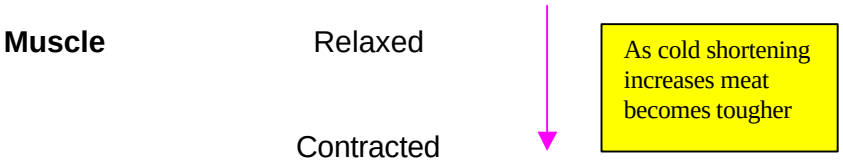
A key implication of the report was that 'while the findings in the Warner Bratzler Shear force measurement evaluations were comparable to those reported in the literature, these trends did not hold up when consumers evaluated steaks in their homes ..... cattle used in this .... project were from mainstream production systems and should have performed without major problem from a palatability stand-point. This should not be interpreted to say that all breeding and management systems will produce beef that will guarantee 100% customer satisfaction. Producing and managing cattle should be a system where the end product - beef - is the focus of every decision made.' Hale et al 1996.

Some Australian Answers - Helen Hernshaw Snr Research Scientist
Achieving consistent tenderness



From pre slaughter to consumption, we have no control and conception, genetics and nutrition/environment can be totally overridden. 'Any cuts' tenderness depends on the cooking - is it appropriate for that piece of meat?

Tenderloin is always tender, regardless of age - it doesn't cold shorten. Other muscles are affected by age at slaughter therefore we need to kill younger.
At or before 2 years of age, most muscles are tender or average tender stage.



In a stress experiment, the control cattle were tender and those stressed had high PH and were extremely tough.

Young age at slaughter - less than 30 months

	Muscle (myofibrils)	connective tissue	peak force(WBS)
Type			
Weaner	3.0	1.6	3.8
Yearling	3.2	1.8	4.1
Steer	3.8	1.9	4.9

Muscle plus connective tissue equals peak force. Myofibrils are very sensitive to pre and post slaughter stress.
Avoid cold shortening, this is critical for age at slaughter.

	toughness	
	Achilles	Pelvic hung
age		
9 mths	10.2	3.5
16 mths	9.5	4.5
27 mths	5.9	4.6
42 mths	5.0	4.3

Because the younger carcasses were lighter and leaner than the older, heavier carcasses, they cold shortened with the fast chill.

Cold shortening can be avoided by any or all of the following methods. Tenderstretch, Slow Chill (though there is a microbiological count problem here) or Electrically Stimulate at high voltage.

Breed is less important in tenderness than controlling cold shortening as there is more across breed variation in tenderness than within.

Gene Markers

Qld CSIRO researchers have found 5 gene markers for tenderness. This may mean that in addition to EBV's in bull selection, we may also select for tenderness although it is more likely to aid in not selecting bulls for breeding that have few or none of the markers. A means of discarding tough bulls rather than selecting tender. These researchers have found that there is more within breed variation for tenderness than there is across breed.

Productivity

Producers in the Alice Springs District are still concerned about injecting Bos indicus for two reasons - management and being stuck with an unsaleable animal if the Northern market falls through.

Managing a Brahman herd is a little different to managing a Bos indicus herd. If calves are weaned, educated, and cows are culled for non performance and bulls selected for growth, low birth weights and temperament as well as fertility tested then the Brahman herd should be a very productive one, given their longevity and ability to use low quality forage.

Best Beef Breed - is there one?

Just as different biological types utilise energy differently, so is there a range of performance across and within different beef cattle breeds. A lot of research in the USA is undertaken at MARC (the United States Department of Agricultures' Meat Animal Research Centre in Nebraska) who maintain a herd of 7,300 breeding cows and who have been evaluating breeds for more than 30 years. The research for all traits are for F1 crosses that benefit from the effect of heterosis averaged over both Hereford and Angus dams. Evidence to date shows that *no one breed excels in **all** traits that are important to beef production.*

Breeds with heavier weights at birth and weaning tend to have more calving difficulty (dystocia) than those with lower growth potential. Calf survival tended to be lower in breeds requiring more assistance at birth. Heifers sired by bulls of large mature sizes (Charolais, Chianina) tended to be older at puberty than heifers sired by bulls of smaller mature size (Hereford, Angus). However, higher milk yielders tend to reach puberty earlier than their same mature size moderate or low yielders. (Braunvieh, Gelbvieh, Holstien, Simmental and Salers vs Charolais and Chianina).

Fertility

One of the largest challenges in a cattle herd in Central Australia is fertility. In the past, herds were mustered once per year and calves branded, bullocks, steers and dry cows taken off. There were few paddocks if even a boundary fence and bulls were run with the cows all year. Branding rates of between 50 and 60% were the order of the day.

With today's more intensive management (although considered extremely extensive by others - one comment by a Zimbabwe farmer on being told that we didn't calve our cows or dip for ticks was 'Well what do you *do* all day then?') there are more fences, more waters and most people would brand and wean their cattle twice per year. This in itself would lift conception and weaning rates, but there are also biological types who perform better than others on limited feed intakes.

Biological Type for Production Environment
Studies in the USA on different feed levels showed that at less than 4000 kg Dry Matter Intake (DMI) per year, Red Poll and Angus cattle were the most productive of the nine breeds in the study, whereas Gelbvieh, Charolais, Braunvieh, Simmental and Pinzgauer cattle were more efficient at DMI of more than 6000 kg per year.

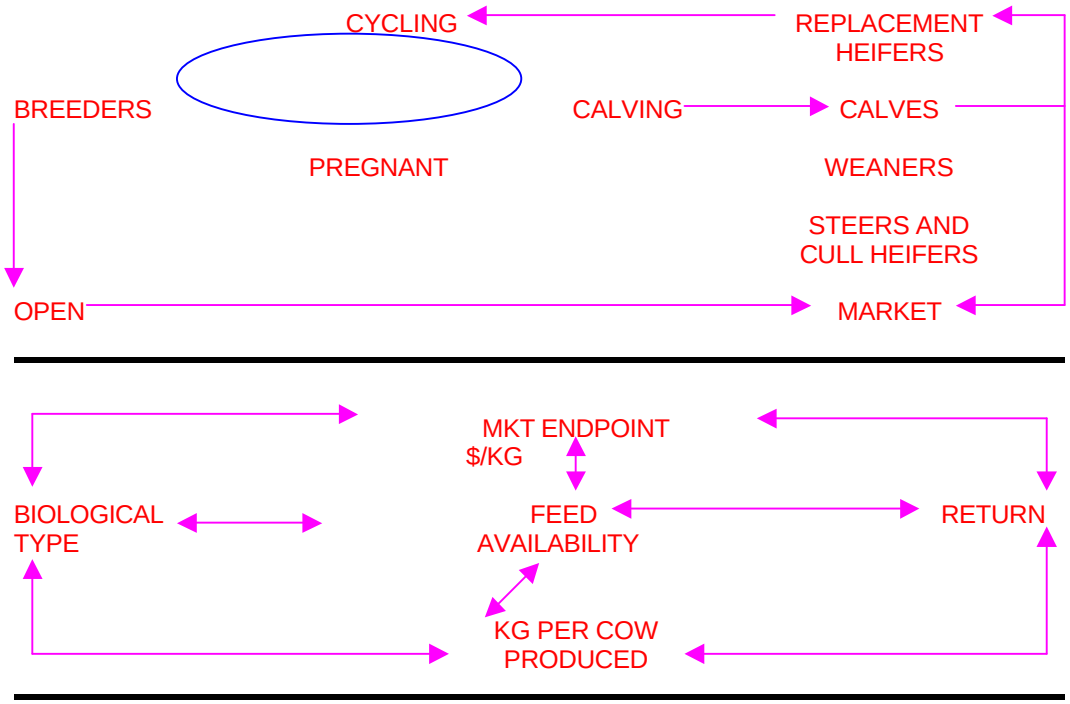
Breeds with greater potential for mature size tended to have reduced reproductive rates at lower DMI but higher rates of calving at DMI of more than 6000 kg per year, relative to moderate mature sized breeds. Jenkins and Ferrel, 1994.

Large size moderate milk yield cows required longer to return to estrus than did large size, high milk yield with the shortest returns seen in moderate sized, moderate or high milk yield. Even with a 90 day breeding season, a pattern of calving every other year became evident among breeds with greater mature size and lactation potential at low DMI. Jenkins and Ferrel, 1994.

Jenkins also suggests that testing breeds or breed crosses at energy intake levels sufficiently high for reproduction to be unrestricted for that breed would reduce the opportunity to detect between breed variation for biological efficiency.
Finally :- The merit of a particular breed resource requires evaluation in the production environment in which it is expected to produce. Use of breeds or breed crosses with high genetic potential in the cow herd with limited feed resources will have a negative effect on production efficiency primarily through reproduction.

Another study by Jenkins and Williams 1994 looked at the economic performance of different biological types with variable levels of feed availability. The genotype/environment interaction is where the expression of genetic potential is dependent on the environment. (a cow can't get fat without grass) The cow herd

consumes the largest portion of feed in the production of a kilogram of edible product.



All points are interrelated, but the most limiting resource is feed availability.

Breeds characterised as having greater potential for growth and lactation tend to be challenged more in a restrictive feed environment leading to more reproductive failures by that breed. With fewer calves weaned, the feed consumption of the cow is spread across fewer kilograms of calf weaned. The increase in potential for growth in calves raised **does not** offset the loss in kilograms through the sale gate due to lowered calving rate.

DRY MATTER INTAKE	COW WEIGHT		CALVING RATE		BIRTH WEIGHT		WEAN WT/ COW EXPOSED		EFFICIENCY (g/KG DMI)	
	MM	LH	MM	LH	MM	LH	MM	LH	MM	LH
3750	490	558	96.1	79.6	36	43	170	121	45.3	32.3
5000	564	612	99.2	97.6	39	46	210	196	42.0	39.2
6500	652	678	94.6	96.1	43	50	189	263	29.1	40.5

MM - Mature standard reference weight 529 kg, lactation 10.2 kg/day
LH - Mature standard reference weight 650 kg, lactation 11.2 kg/day

With increasing feed availability, the moderate genetic potentials for growth and lactation that had an enhanced efficiency at lower feed levels have a negative effect when ample feed sources are available. Jenkins and Williams 1994.

In another study (Jenkins et al 1991) cows were measured for the conversion of feed energy to calf weight during the pre weaning interval. The cows were from

Hereford and Angus dams crossed with Brahman, Sahiwal, Pinzgauer, Hereford or Angus sires and rearing a Charolais calf. The calf gain relative to cow weight was higher for Brahman and Sahiwal cross than for Pinzgauer and Hereford or Angus cross cows.

The total efficiency of the calves in weight was 11% higher for Bos indicus cross Bos taurus cows (BiXBt) than for Bos taurus cross Bos taurus cows (BtXBt), where the BiXBt cows' calves gained 35 grams of weight per megacalorie of food consumed vs 32g/Mcal for BtXBt. However the cows were of older average age and therefore the BiXBt cows had an advantage over the fatter BtXBt cows. The BiXBt cows possibly also had a heterosis advantage over the BtXBt cows.

Jenkins 1991 also looked at the conversion of food energy consumed to calf weight during the pre weaning period.

The cows were from Angus and Hereford dams and sired by Angus, Hereford, Brown Swiss, Chianina, Gelbvieh, Maine Anjou and Red Poll bulls and rearing calves by Simmental sires.

Calves from Red Poll, Angus and Maine Anjou produced more calf weight per unit of energy (g/Mcal) consumed by the cow and calf than Chianina and Gelbvieh who were the least efficient, with Brown Swiss intermediate.

In the study, daily metabolizable energy (ME) uptake required to maintain a weight equilibrium increased among breed crosses with greater mature size and milk production potentials - except for Maine Anjou. The authors suggest this exception could have been due to the Maine Anjous' extremely docile temperament - especially in comparison to the Chianina. The Chianina also ate like a high milk yielder, even though they are moderate in this area.

Variation in efficiency seemed more dependent on the ME consumption of the dam than that of the progeny. To maintain body weight during the test period, the two higher - milking breed crosses required approximately 15% more ME (Gelbvieh and Brown Swiss). This, combined with a smaller percentage increase in calf gain resulted in less desirable efficiency ratios relative to the Angus and Hereford, which in turn were less than the Red Poll. Cross bred cow groups with smaller size and either moderate or high milk production out performed cross bred cows groups with high genetic potential for mature weight. The latter group would not have realised a similar benefit from additional growth potential from a large third breed to produce the progeny.

F1 (first cross) cows that produced the heaviest calves required more ME to maintain body weight during the lactation test period. In this study moderate mature weights and moderate levels of milk yield were more efficient. When these cows are crossed with terminal sire breeds for greater genetic potential for growth, the calf will probably be efficient for ME usage during the preweaning period.

While 'moderate' cow weights in the studies were probably higher than local weights for the same cows in the Alice Springs district, the message is still the same and heavily reinforced during the past seven dry years - grass is the most finite and limiting factor in beef production. Water can always be piped, but grass can not be

grown with out rain. In an average run of ten seasons, we will have only three above average years. Three years will be dry and may be droughted and four will be average.

It seems to me to be inefficient to choose biological types for breeders that can only perform to their biological capacity three years in ten.

Reproductive merit is five times more important economically than is growth performance and at least ten times more important than product quality for the average US cow calf producer. (Lunstra 1993) I don't have any figures for Australia, but I imagine them to be fairly similar.

Bos Indicus

Like tenderness, fertility in Bos indicus cattle has been subject to much speculation and fears regarding delayed puberty, low fertility, longer gestations and post partum (after birth) return to estrus (heat) intervals, higher neonatal (new born) death rates and depressed winter cycling are among what is probably not an exhaustive list.

To lump all Bos indicus cattle together for one average response to a given trait is like saying all Thoroughbred horses can win the Melbourne Cup. Within Thoroughbred horses there are stayers and sprinters, fair weather runners and mud pluggers, and there are some that are only fit for fertilizer.

There is also variability for traits both across and within Bos indicus breeds. For instance, Sahiwal bulls reach puberty later than Brahman (Crouse et al 1993) and the meat from Sahiwal cattle is not as tender as Brahman (Lunstra 1993). The sex weight difference is greater in Indu Brazil cross calves, with bulls weighing 6.8 kg heavier than it is in Red Brahman cross calves, where bulls weighed 4.4 kg heavier than heifers, or in Angus Hereford cross, where the difference is 2.2 kg at birth. Paschal et al 1991.

Indu Brazils are more prone to large or bottle teats which lead to nursing disorders and an increase in neonatal deaths. ibid 1991. Boran cross cattle weaned more weight per cow exposed than did Tuli or Brahman cross cattle - MARC data 1993. Within breed, progeny of current (1980's) Brahman bulls are heavier and tend to reach puberty earlier than the progeny of original Brahman bulls (1960's). MARC data 1993.

Puberty

Bos indicus (Brahman, Nellore and Sahiwal) were older than any other breed at puberty and appear to have been subjected to selection pressures that set them apart from Bos taurus breeds for age at puberty. Although age at puberty significantly differed among breeds at MARC, conception rate among yearling heifers did not differ consistently between breed groups - Bos indicus heifers conception rates as yearlings were very high in spite of their older age at puberty.

Heifers developed more slowly on diets with lower energy density have been shown to exhibit puberty at significantly older ages and have lower conception rates when

exposed to breeding as yearlings than heifers developed more rapidly. Females with Bos indicus sires had progeny with relatively light birth weight and excelled in calving ease.

Delayed puberty occurs when the average age of one group is significantly older than the average age of another group at puberty. Chenoweth (1994) notes that the age of puberty in Bos indicus cattle can range from 15.6 to 40 months of age, with the latter extreme no doubt coming from environmental stresses that would also severely delay any breeds' onset of puberty. The MARC figures on puberty for Brahman cross heifers are 13.5 to 14 months with 'current sired' heifers 6 days earlier than 'original sired' heifers.

Fordyce (1990) reported on two problems of fertility in Brahman cows in Northern Australia.

1. low fertility (50-60%) and a high annual death rate (10%) which was related to poor nutrition and out of season calvings with an average 7 month post partum interval.

2. low pregnancy rates in maiden heifers.
He related 1. and 2. as a failure to cycle early enough.

For 1. he suggested spike feeding supplement to pregnant cows about 2 months before the main calving season for 6-8 weeks. This could result in a 20% above normal return to estrus by 6 months after calving. Feed given after calving is mostly converted to milk, rather than energy.

For 2. He said that of the nutritional effects on pregnancy in maiden heifers, weight was probably the most important. Very few 200kg heifers but 80% of 275 kg heifers will conceive. The percentage of heifers pregnant at a given weight can vary from year to year depending on their growth as weaners.

PREGNANCY RATE IN 2 Y.O. BRAHMAN HEIFERS

		GROWTH AFTER WEANING	
		-0.1 kg/day	+0.1 kg/day
weigh	200 kg	21%	66%
at	250 kg	52%	80%
mating	300 kg	82%	90%

Fordyce says that there is some evidence that a critical development phase occurs in heifers somewhere between 3 and 12 months and this may have an influence in life time fertility. The point then is that replacement heifers must not loose weight after weaning. This may mean supplementary feeding after weaning, retaining only those heifers that have gained weight after weaning or leaving replacement heifers on their mothers.

Schlink et al reported that weaning calves down to 48 - 92 kg instead of 180 kg in a North Australian cattle herd had improved live cow weights overall and pregnancy rates increased by 48% at weaning. Pregnancy rates had climbed from 61% to 90%

and Post Partum Interval was reduced by one month. However the weaned calves need to replace the protein formerly gained from milk and so need a protein supplement to enable normal growth.

In MARC conditions which would be moderate to high energy levels, Bos indicus cross heifers reach puberty about six weeks after Bos taurus cross heifers, though in the Centre it might be a better rule of thumb to use 275 kg as a puberty measure.

Post Partum Interval

Another trait associated with Bos indicus cattle is delayed return to estrus or longer post partum interval (PPI). While in Colorado, I had occasion to spend a few days on the Lassater Ranch, just outside of Colorado Springs.

Their Beefmaster (Brahman X (ShorthornXHereford)) cattle are joined as yearlings to their siblings. If the heifer fails to rear a calf to weaning that year and every year there after, she is culled from the herd, even if the calf loss was due to lightening strike or death from coyotes. I also drafted cows and calves on horseback and never took my horse out of a walk. Brahman cross cattle can breed to a yearly interval and I might add that Lassater has a 45 day breeding season, in March/April, which is still pretty cold.

Post partum interval in Bos indicus cattle can be influenced by environment, nutrition, sire of calf and age of dam. Brahman cows who calved out to Angus, Brahman and Tuli bulls (Browning et al 1994) had different gestation lengths and different PPI.

Sire	Gest. Length	PPI	Birth Weight
Angus	284	91	31
Tuli	288	95	29
Brahmn	293	80	31

Browning 1994 found the PPI interval to be - Angus X Brahman 95, Tuli X Brahman 97 and Brahman 83 days. The author found that while 97% of multiparous cows (more than one pregnancy) were pregnant by the end of the breeding season, only 43% of first calf heifers were pregnant. In one year of the study the cows were supplemented and their PPI was longer than in the unsupplemented year (96 vs 81 days) and muliparous cows had a shorter PPI than primiparous (first calf) cows (77 vs 106).

Energy availability can also affect PPI. Nugent et al 1993 studied the relationship between nutritional environment and biological type in mature beef cows. They found that the level at which energy begins to limit performance may not be constant for all biological types. At the lowest level of energy availability the biological types with the greater genetic potential for mature weight exhibited extended PPI. Where there was also higher genetic potential for milk, the effect of low energy avaiability was greatly reduced.

Browning et al 1994 reported that the sucking calf is a significant contributor to post partum anestrus (no estrus) in cows. Crossbred calves may have placed more lactation and or sucking stress on their mothers than straightbred Brahman calves. Cross bred calves have greater sucking activity and higher milk consumption compared to purebred calves. Bos indicus cows show lower reproductive performance to high suckling stimulation and lactational demands. Therefore PPI may have been delayed by increased milk demands of the cross bred calves.

Neonatal Death

Neonatal death in the first 72 hours of life has been associated with Bos indicus cattle, but it is largely due to calving in wet, cold conditions or nutritional stress producing small calves - the latter would produce neonatal deaths in any breed.

Bos indicus calves have less Brown Adipose Tissue (BAT) than other genotypes. Calves warm themselves by shivering to produce heat and by a heat producing organic action (thermogenisis) in BAT. Brahman calves have less capacity for non shivering thermogenisis in the new born calf. Carstens et al.

Franke et al noted that birthweights of weak Brahman calves were 9.3 kg less than the birthweight of normal Brahman calves, (Weak calf syndrome) and Koger et al 1980 said that after breed, birthweight was the most important factor of calf survival, with intermediate birthweight being associated with higher survival rates than either low or heavy birthweights. Kim et al 1988 reported on Dummy Calf Syndrome where calves who take a long time to get up (regardless of birthweight) often cannot suckle. 27.3% of calves from 9,923 born on one ranch in Louisiana had the problem and 8% showed no interest and desire to suckle and died even with assistance. Poor udder/teat conformation and poor mothering ability contributed significantly to loss. The syndrome occurs in all beef cattle, but mainly in Brahman and Chianinas.

Josey et al (1987) reported mortality rates of 3, 3, 8 and 21% for calves with 0, 25, 50 and 75% Bos indicus inheritance respectively, demonstrating that Bos indicus calves are less cold tolerant than Bos taurus calves.

Browning et al 1996 looked at neonatal death in Bos indicus cattle. Rates of weakness (30%) and 72 hour mortality (13.2%) were higher for purebred Brahman calves than for Angus Brahman or Tuli Brahman.

Sire Breed Of Calf (Brahman Cows)

TRAIT	ANGUS	BRAHMAN	TULI
Low Vigour rate	1/38(2.6%)	10/38(26.3%)	2/38(5.3%)
Survival	38/38(100%)	33/38(86.8%)	37/38(97.4%)

The calves were spring born at Overton, Tx; but no data for temperature on day of birth was given.

Vann et al 1995 studied the influence of calf genotype on colostral immunoglobins (ig) in Bos taurus and Bos indicus cows and their pure and crossbred calves. They found that dams of crossbred calves had higher concentrations of ig than did dams

of pure bred calves. Absorption of ig was similar between all calves. The authors suggest that the increased vitality of cross bred calves may be due to increased concentrations of ig in colostrum.

Calves absorbed ig more efficiently at 6 hours (70%) than at 12 hours (54%).

To reduce neonatal deaths in Bos indicus cattle, calving season should be changed to the warmer months of the year; cull cows for poor udders and poor production and cull sire for high incidence of Dummy Calf Syndrome (although this may be a little hard to do outside of single sire matings.)

Maternal Calving Ease

Sanders 1996 studied the maternal performance of F1 (first cross) females sired by Brahman bulls vs alternative subtropically adapted sire breeds. He found maternal calving ease to be outstanding and similar for Brahman, Gir, Sahiwal, Indu Brazil and Nellore F1's; with similar calving percentages, although Nellore X's may have weaned more calves. Nellore had the best udders and Indu Brazil the least desirable udders which led to the worst nursing performance. The rest were intermediate. Weaning weight was highest for calves from Brahman F1 cows.

Senepol, Tuli and Boran F1's reached puberty sooner than the Brahman F1 but maternal calving ease was higher for the Brahman F1. Calf crop percentage may be higher as 2 and 3 year olds for Senepol, Tuli and Boran F1's (although Senepols had high levels of dystocia) than for Brahman F1, though weaning weights for Brahman F1 were higher.

Africander X Bos taurus have lower reproductive rates than Brahman X Bos taurus F1's. He listed limitations with Brahman X Bos taurus F1 cows as age at puberty, udder problems and disposition, whereas advantages were high productivity, maternal calving ease, high reproductive rates, maternal effects on weaning weights and longevity. He noted the Nellore may be competitive or even superior to the Brahman F1 in cow productivity (more calves weaned).

Paschal et al 1991 compared calving and weaning characteristics of Angus, Grey Brahman, Gir, Indu Brazil, Nellore and Red Brahman sired calves out of Hereford cows and noted the usefulness of Bos indicus X Bos taurus cows in heat tolerance, parasite resistance/tolerance, ability to use low quality forages, longevity, cow productivity and maternal effects on weaning weight.

However, when Brahman bulls are bred to Bos taurus cows, the calves have a higher birth weight and higher calving difficulty levels than would be expected from the size of the Bos indicus sire breed. Bos indicus bulls should not be used with Bos taurus heifers. Average gestation length ranged from 289 (Red Brahman, Gir) to 293 days (Nellore) with Grey Brahman and Indu Brazil intermediate.

Birth weight ranged from 33.0 kg (Gir) to 39.1 kg (Indu Brazil) with the rest intermediate. Indu Brazils had the highest dystocia (29%) and calf mortality (14%) in male calves. Breeds with a large difference between sexes for birthweight can experience higher frequencies of dystocia than would be expected from average birth weight for the breed.

Sex of Calf and Birth Weight

Breed	Bulls	Heifers	Difference
Angus	33.1	30.5	2.6
Grey Brahman	39.8	34.4	5.4
Gir	35.5	30.6	4.9
Indu Brazil	42.5	35.7	6.8
Nellore	40.2	33.2	7.0
Red Brahman	39.6	35.2	4.4

Nellores had 14% dystocia. Other breeds dystocia figures were not given.

	LOW WW/AGE	**HIGH WW/AGE**
Neonatal mortality	**10.5%**	**2.7 %**
Weaning rate	**60%**	**70.4%**

Young cows, (3&4 years old) had a higher percentage of neonatal calf death than 5 + year cows. Selection for growth (weight) in all genotypes in tropical environments will result in improved overall herd productivity owing to increases in both growth of the progeny and higher reproductive rates in the breeder herd. Burrow et al 1991

	Weaning Weight	
Sire	**Average Daily Gain (pre wean) kg**	**Weaning Weight kg**
Angus	.77	198.7
Grey Brahman	.82	212.9
Gir	.76	197.8
Indu Brazil	.77	205.1
Nellore	.79	206.3
Red Brahman	.82	214.4

Paschal et al

Grey Brahman, Nellore and Red Brahman were intermediate to Gir (lightest birth weight and least dystocia) and Indu Brazil (heaviest birth weight and most dystocia) but heavier than Gir and Indu Brazil at weaning. No figures were given for kilograms weaned per cow exposed.

Production

weight of calf weaned/cow/year

	BOTSWANA	**ZIMBABWE**
BREED		
AFRICANDER	108	89
TULI	145	121
BRAHMAN	116	130

BOTSWANA HIGH PERFORMANCE ENVIRONMENT; ZIMBABWE LOW PERFORMANCE ENVIRONMENT. Hetzel 1988

PRODUCTIVITY OF PUREBRED AND CROSSBRED COWS AT MATOPOS RESEARCH STATION ZIMBABWE (1984)

	kg calf/cow/year	kg calf/100 kg cow/year
Brahman X Brahman	**130**	**32.4**
Sussex X Brahman	**138**	**34.6**
Charolais X Brahman	**144**	**32.8**

Hetzel 1988

There was no real advantage for cross breeding in this environment.

Selection of weight for age will result in increased weights at other ages.

Burrow et al 1991 studied cows that had been selected for high weaning weight for age and found that they weaned more calves per number of breeding seasons, had fewer neonatal mortalities and calved earlier than cows selected for low weaning weight for age. He concluded that cows with high growth to weaning have improved lifetime fertility. This could be influenced by heifers continuing to gain weight in the critical pre puberty period.

Performance on different energy intakes
(Helen Hernshaw)

PERFORMANCE ON DIFFERENT FORAGE LEVEL - HIGH, MEDIUM AND LOW

Weaning weights

	High	Medium	Low
Hereford	212	188	110
Brahman X	238	229	169

Cross breeding helps when things are difficult.

Calf weight weaned / young cow joined

	High	Medium	Low
Hereford	176	139	43
Hereford X Brahman	200	172	110

Increased cow weight and bigger and fatter cows to sell (cull cows increased weight therefore more $)

Total KG / Cow joined

BREED	Hereford X Hereford	Brahman X Brah Hford	Brahman X Hereford F1	Hereford X Brah Hford
WEIGHT	105	101	168	144

Hybrid Vigour is very important

- Herefords supplied growth, fertility and fat depth (mm)

- Brahmans supplied milk, forage adaptability, carcass (increased dressing % and yield)

Bull Fertility (an attributed data from John Bertram, Q.D.P.I.)

Bull fertility in Brahman and Brahman cross cattle has also been questioned. Brahman breeders in Argentina are joining bulls at a rate of 2%, with calving in the 90% range and at least one breeder in the Territory joins cows in single sire groups at 50 cows to one bull. These figures are competitive with any other breed. Three or Four percent should be easily adequate for Bi bulls. The average size of testes in mature bulls across all genotypes is 34/35cm. The minimum size at two years old should be 32 cm.

MARC found that all bulls reached puberty at 30 - 32.5 cm scrotal circumference. Including scrotal circumference in selection criteria for bulls, combined with semen testing and service capacity testing can lessen the likelihood of poor or infertile bulls being purchased.

There is a positive relationship between scrotal circumference and age of puberty both in the bull and in his off spring. Allowing some below standard bulls to be selected could increase the age of puberty of his heifers. Culling open cows and annual checks of bull soundness at mustering should vastly improve the management portion of poor fertility. Environmental factors are a little bit harder to control. Some cows perform year in year out unsupplemented. Perhaps by supplementing we are propping up the weak end of the breeding herd that should be culled for non performance.

Serving capacity test

This should not be a means of choosing the most active bulls, but of not selecting the 'low' or 'one' group. Mediums, Highs and Very Highs or 2, 3, and 4's are all acceptable. It is impossible to predict every bull, but you can increase the probability in your favour. The test should be combined with a semen test to increase accuracy. The object is to cull the bottom rung. If the bulls have been tested then experience should not be a problem. Inexperienced bulls need to be yarded at 8 bulls to 5 females for 72 hours to gain sufficient experience before release with the cow herd.

Age and condition

All bulls in the paddock should be the same age to offset dominant behaviour from older bulls which will prevent young bulls from working. Bulls should be about score 4.5 on a scale of 1 - 9 to be in top working order. If too fat or too thin, performance is diminished.

Selection for weights

In a trial over 20 years where yearling weights were recorded, increases were as follows.

Bulls only selected	52.0 kg
Cows only selected	5.5 kg
Bulls and cows selected	53.0 kg

A bull has influence over more calves than does a cow.

Heterosis
Heterosis is the difference between the cross and the parental breeds weighted by their contribution. Cross breeding systems can use high levels of heterosis. For instance, heterosis can be used to increase weight weaned per cow exposed by 20%.

data from Helen Hernshaw

Weaning Rate and Hybrid Vigour

Breed	Hereford X Hereford	Brahman X Hereford F1	Fresian Brahman X Hereford	1/3 : 2/3 Rotational
Rate %	76	85	67	79

67% of hybrid vigour is retained on a 1/3 : 2/3 rotational cross
Fertility is very important if you are upgrading or compromising hybrid vigour. F1 and Rotational breeding are better options

System	F1	Rot	Pure
Total Kg	181	160	132

In this experiment,
- Hereford were less productive under all circumstances
- Bi X excelled on medium low quality pastures
- Bt only out did Bi on particularly soft environments
- Brahman and other Sanga types were not as productive as Bi F1's

F1 is better on :-
- post weaning growth - production per head
- efficiency - weaning weights and rates
- longevity - calving ease and bloat resistance

The level of heterosis for traits may vary among different breed crosses and the more unrelated the breeds are, the higher will be the level of heterosis expressed. Heterosis in Bos indicus X Bos taurus is 2 or 3 times greater than that in Bos taurus X Bos taurus.

The difficulty is in retaining heterosis past the first cross. Loss of heterozygosity occurs between the F1 and F2 generations. If inbreeding is avoided, further loss of heterozygosity in inter se (same generation to each other) matings does not occur. All the information I have looked at is for Bos taurus X Bos taurus and it cannot be assumed that the retention rate to the F2 and F3 generations will be the same for Bos indicus X Bos taurus.

	Retained Heterozygosity relative to F1 (%)	Estimated increase in weight weaned per cow exposed (%)
2 breed rotation	66.7	15.5
3 " "	85.7	20.0
4 " "	93.3	21.7
2 breed composite	44.8	10.4
3 " "	64.1	15.0
4 " "	69.8	16.3
5 " "	73.5	17.1
6 " "	81.3	18.9
7 " "	82.5	19.8
8 " "	87.5	20.4

Gregory 1995

Heritability of breed (large numbers of individuals from a representative sample) approaches 100%, where heritability of differences within breeds (based on individual observations) for major traits varies from less than 10% to about 50%, depending on the trait.

The estimated heritability versus environment influences are:-

	Heritability	Environment (what it eats)
Fertility	10 - 15%	85 - 90%
Growth	30%	70%
Carcass	30 - 50%	50 - 70%

Genetic Variations in Alternative Mating Systems

MARC DATA: Gregory 1993

Future Directions

Wherever cattle end up, they must be quiet, to minimise bruising and dark cutting. They must be de-horned. Where the consumer is demanding tenderness the cattle should have electrical stimulation post slaughter as a matter of course. They should be tender stretched or hung from the H bone. The meat should be aged at least 14 days before consumption and preferably 30 days. There should be no cold shortening.

Based on what I have learned during my Nuffield Scholarship regarding biological types, environment, productivity, longevity, fertility, temperament and markets I have devised a cross breeding program. It is necessary to increase the infusion of Bos indicus into our herds. The Live Export Market isn't going to go away in the near

term. I am sure that even if the Live Export Market fades away in the late mid term, South East Asian people will still want a lean product without too much fat. Attempting to meet the quality that is demanded in specifications can only help to improve our management practices.

We should all wean, dehorn and cull unproductive cows. I think that my research has settled the twin ogres of tenderness and productivity including fertility for Bos indicus cattle. At the same time I don't think that it would be a good idea to breed high grade brahman cattle for the simple reason that we do not have to. We do not have tick or buffalo flies and very little worm. British breed cattle are productive in this environment and have been for over 100 years. We are the lucky ones, in that we can capitalise on cross breeding and hybrid vigour and obtain the best from both sides.

The best course of action that we in the Southern Alice Springs District can take is to be active fence sitters. We should keep a foot in both camps and not breed our selves out of markets. We need to be dynamic and flexible and able to supply quality cattle to the widest number of markets possible.

There are feeders in the Philippines who take nothing but F1 red cattle. I heard of an order recently for Brafords. The market is already there - we don't have to make it - we just have to cement our place in it. And if we are still penalised by buyers in Southern live auction markets, there is an answer - only sell over hooks. Stand by your product. We can't afford to sit down under a tree and wait for things to happen. If we do that, the train will pass us by. We must flag that train down and get on it and if we combine together as sellers, we might have a whole train to ourselves.

Food Safety

I am prepared to guarantee that the meat from this property is free from pesticides and residues but I have no where to place that information on a label and no-one is willing to pay me extra to raise my beef that way. We are meat producers and beef producers, not pastoralists or cattlemen - it is a business now, no longer a way of life. I've seen organic raised beef sold in Central Market in Adelaide for $20.00 per kg - How much in Japan?

We must have some sort of electronic recording system from branding to the supermarket shelf. We need that feedback through the chain. It is a Catch 22 situation. If market forces are allowed to prevail then consumers must demonstrate that they are willing to pay more for processors to purchase organic beef, but how can the consumer ask for it if they don't know it is there?

To sum up we must spread our risk. The risks we take must be acceptable for the return on our investment. In the last few years the return hasn't been high, but I sincerely believe that we have a future and a productive future. I would like to see the Southern Alice Springs District band together and sell cattle under a strategic alliance as a group. Ultimately I would like to see our product branded. I am proud of the way we raise our cattle and for our environmental sensitivity. I love the beef I eat and everyone else should have the opportunity to eat it too.

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