final report

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Prediction of Carcass Attributes in Beef Cattle

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Abstract

Failure to achieve market specifications is costly to individual beef producers, processors and the beef industry generally. The most common specifications are for weight and fat thickness.

Not achieving specifications arises from complex factors, which are mostly in control of producers.

Factors such as breed and sex of cattle, Frame Size, current fatness, weight, implant status and projected future weight gain have a large impact on final weight and fat thickness.

This project developed a tool (BeefSpecs) for producers to use that uses their language and skills to predict fat thickness at any weight / weight gain combination. More than 500 producers were exposed to the ideas used in BeefSpecs during development. With research data, BeefSpecs predicts fat thickness within the error of measurement. With industry data, there are some discordant results, which we anticipate can be improved with additional training in live animal assessment skills in beef producers.

BeefSpecs is available at:-
http://www.mla.com.au/TopicHeiracrchy/IndustryPrograms/SouthernBeef/Morebeeffrompastures/BeefSpecs+calculator.htm

Executive Summary

Failure to meet market specifications for carcass weight and fatness costs producers and the beef industry a significant amount each year. It has been estimated that from 16 to 29% of feedlot cattle fail to meet specifications for these attributes, and up to 70% don't achieve the more demanding specifications for marbling. No-one really knows what the statistics of compliance to specifications and cost of non-compliance are for grass finished cattle, except that anecdotal evidence suggests that they are at least as great as for feedlot finished cattle. It is recommended that quantitative information on compliance of grass finished cattle be obtained and cost of non-compliance determined for this sector.

Although breeding to better achieve market specifications is an action that can be taken, and is part of current breeding objectives, much of the failure to reach specifications is a consequence of management practices on-farm.

Tools to help producers understand the impact of their management (growth, implant, sex) on different cattle types (as described by FrameSize and current fatness, and breed) have been developed in this project. These are primarily designed to teach producers the relationships between the things that they have control of (feed supply, growth rate, time, implants), and the way the animals they have respond in terms of fat thickness.

"BeefSpecs", a calculator that uses practical inputs from producers and combines them with an underpinning model of beef cattle growth and composition was developed during this project. BeefSpecs is available on the MLA website http://www.mla.com.au/TopicHeiracrchy/IndustryPrograms/SouthernBeef/Morebeeffrompastures/BeefSpecs+calculator.htm

"BeefSpecs" was developed with input from more than 500 producers, and has been tested with research data and data obtained on-farm. With research data, BeefSpecs provides answers within the error of measurement of fat thickness. When used with on-farm data, on average BeefSpecs provided an estimate of fat thickness within error of that observed, but there were systematic errors with different farms (and types of cattle). Use of markedly different underpinning models (computational procedures) generally produced similar results to BeefSpecs.

A constraint to effective use of "BeefSpecs" is the animal assessment skills of producers. It is recommended that further training in practical animal assessment skills be provided to give producers the skills and confidence required to implement management changes to better meet specifications.

Each Section indicated in the contents page <u>makes up</u> the main sections of the final report (**e.g. 1 Background, 2 Project Objectives etc.**). These are the areas the final report should be focused on.

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1 Background

1.1 Introduction

Australian, Japanese and US consumer demands are primarily concerned with the leanness and fat cover of meat and it has been demonstrated that 'overfat' meat is a difficult product to sell (Egan et al., 2001). Within Australia beef producers have not in general been effective at meeting the requirements of target markets. A recent study, involving 20,000 animals, demonstrated that between 16 and 70% of cattle undertaking either short (100 DOF) or long (> 220 DOF) feeding programs were unable to meet market specifications, depending on what markets and which specifications were being examined (Slack-smith et al., 2009). Of these, 28% failed to meet specifications for carcass weight, 16% for fat thickness and 70% for marbling.

Retail meat yield and distribution of fat are important industrial determinants of value of beef cattle. They are determined by the breed and sex and effect of nutrition on slaughter animals. The challenge is to predict growth and composition of beef cattle from practical inputs at the farm, or the feedlot, and to translate these into industrially relevant measures at the processing plant (to set the value of the animal). This information can then be used in conjunction with knowledge of costs of production to develop more cost effective beef cattle production systems.

Optimal allocation of animals to markets is achieved through sorting and is facilitated by improved information sharing (between vendor and subsequent processor). Information about an animal's propensity to meet specifications such weight and fatness (determinants of yield and quality), other characteristics of the production system (such as HGP status and environmental credentials) are factors that directly influence price paid and thus returns to the producer. Of these, the most difficult for a producer to predict is the effect of weight, sex, frame size, maturity type, breed, implant status (a combination of genetic and environmental effects) and production system attributes which impact on growth rate on potential carcass weight and fat cover and distribution.

The initial purpose of this project was to develop a simple tool that could be used by industry practitioners to learn how to manage those factors that they could control to better achieve market specification with their cattle. Subsequently, "BeefSpecs", was developed to do this. It was considered that this tool met the objectives outlined in Step 1 of Module 8 "Meeting Market Specifications" of More Beef from Pastures.

It has been noted in the context of precision agriculture, availability of tools that assist producers learn how their actions affect value of their product are an important means of taking action to improve their capacity to achieve specifications.

Development of a product designed to inform producers of the effect of their actions on capacity of their cattle to achieve market specifications puts this project in the translation of science to industry practice space. Accordingly, this project employed a product development and testing process that involved end users to both test the product during development and to increase awareness of the issues being addressed.

2 Objectives of the Project

The objective of the project was to develop a model of composition of beef cattle that enables prediction of total fat and lean meat yield into market recognisable terms, and provides a process to incorporate genetic variation in growth and carcass composition parameters. The specific objectives were:-

1. By June 2006, provide description of components of existing models and their data requirements and report on most appropriate model and data structure to achieve objectives.
2. By June 2007, develop a prototype model to predict growth and composition of individual animals
3. by June 2008, refine the prototype model to include genetic and environmental parameters
4. June 2009, deliver a working model of beef cattle composition to industry through More Beef from Pastures and the CRC

3 Results and Discussion

3.1 Development of "BeefSpecs"

Detailed results and discussions have been provided in milestone reports 2 and 4. Only a brief presentation of the content those reports will be made here, to illustrate relevant aspects of progress made. More details will be provided of components which are not covered in past milestone reports. This work was conducted as part of Sub-Program 1.3 "Phenotype Prediction" of the CRC for Beef Genetic Technologies.

4.1.1 Selection of base Model.

A number of calculation systems that permit estimation of growth and body composition of ruminant animals from realistic production system inputs have been developed and reported. Three are potentially useful, insofar as they have been developed using rigorous criteria for data incorporation in an internationally accepted system for integration of energy metabolism and growth.

1. The SCA equation set described in detail by Freer et al (1997) and used within Australia in the GrazFeed and GrassGro computer programs. This uses a compilation of undescribed data obtained from the international literature to estimate parameters and best reflects the pinnacle of thinking that underpins the Metabolisable Energy system. Although some fundamentals of mechanism are implied in the model structure, they are essentially empirically derived based on relationships between variables obtained by regression analysis. This makes the SCA model somewhat difficult to modify without access to the full data set, and as we will see the structure is not easily amenable to modification for prediction of body composition.
2. Those equations developed at the USDA Meat Animal Research Center (MARC), Clay Center, Nebraska by Charles Williams and his colleagues, Tom Jenkins, Gary Bennet and John Keele and described in a series of papers published in J. Anim. Sci. in the period 1992-2003 (Keele et al, 1992; Williams et al, 1992; Williams and Jenkins 2003a,b,c; Williams, 2005). The data set used to build and estimate parameters for this model includes much of the MARC (Meat Animal Research Center) data generated by USDA over the past 30 years. This model uses new ideas about relationships between animal weight and weight gain and body composition set within an energy balance system similar to the US Net Energy system.
3. The equation set described and evaluated by Oltjen et al (1986a,b). Data to build this model originally included the dataset developed at the University of California by Bill Garrett during the period 1960-1970. This data was originally used to develop the California (now the US NRC) Net Energy System. This model uses a simplified description of growth based on the ideas originally developed by Baldwin and Black (1979), coupled with the principles of energy balance described in the US Net Energy system.

The models differ in their requirements for description of the animals and feed resources that are used as input (start up) parameters. Table 1, lists the required inputs to drive the simulation.

Table 1. Description of parameters required to initialise models, and to describe variation in nutritional and genetic aspects of animal performance

Parameter	SCA	Williams et al	Oltjen et al
Feed Quality	M/D, crude protein, protein degradability	M/D, or in an earlier model could be dispensed with.	M/D converted to Nem and Neg
Feed Intake	Calculated internally from pasture mass height and type or provided as input	Provided as input, or in an earlier model could be dispensed with altogether	Provided as input
Animal Descriptor	Standard reference weight, body weight, sex, breed, past highest weight, (can accommodate condition or fat	Breed (5 traits used to described breed :- potential for birth weight, potential for mature weight, potential for support	Frame size, body weight, condition score, sex, implant status (calculates maximum DNA size from these parameters)

	score)	maintenance, potential for weight maintenance, potential for lean gain). Requires estimate of rate of growth to weaning. An earlier model used breed, weight, liveweight gain as inputs.	

Note. M/D = Metabolisable Energy / kg dry matter;

The structure of each equation system is described in the appropriate references.

Initial evaluation demonstrated that the Davis Growth Model was the most accurate, was flexible and required fewer parameters. See Milestone report 2 for results of evaluation of the Davis Growth Model and the Clay Centre Model using data from Trangie Angus Selection lines (Perry and Arthur, 2001).

Subsequent to this initial work, Malcolm McPhee returned from his PhD studies at the University of California, Davis with an amended version to the Davis Growth Model that explicitly described the different fat pools. The construct Malcolm developed was based on the ideas discussed in Sainz and Hastings (2000). This became the primary model used within this project (until recently).

The Angus breed was chosen as a baseline breed for initial exploration of suitability of the alternate models because it is the base breed for multibreed EBV estimates of growth traits (and it is anticipated that it will remain so as other traits become available into the future, Johnston et al, 2003).

4.1.2 From Model Selection to Development and Testing of a producer tool.

a) Development of a simple calculator "BeefSpecs"

A number of constraints prevented direct application of the Davis Growth Model (DGM) by producers.

The most important was that although the DGM is driven directly from knowledge of food intake and quality, it is rare for producers to have any idea of these inputs. However, the DGM does use many input that producers are familiar with. These include, liveweight, framescore, condition score, sex and implant status. It was considered that producers could anticipate liveweight gain of their cattle in different situations within their production system (based on experience).

Following extensive discussion within the Beef CRC group guiding this work, it was decided to use the DGM to generate an array of output data derived from research inputs (and with representation over a wide range of parameter values) to construct a response surface of values from simulation. This response surface was then used as input into the development of simple equations that underpinned a calculator for use by producers.

The calculator interface was constructed to take the minimal practical inputs and provide a simple single output of fat thickness and estimated carcass weight. It was released on MLAs website as a new tool for use with More Beef From Pastures in November 2008.

The current BeefSpecs calculator is shown below (from "Using BeefSpecs to help meet market specifications" – tips & tools Animal Production, Meat & Livestock Australian Limited June 2009 ISBN 9781741913316) .

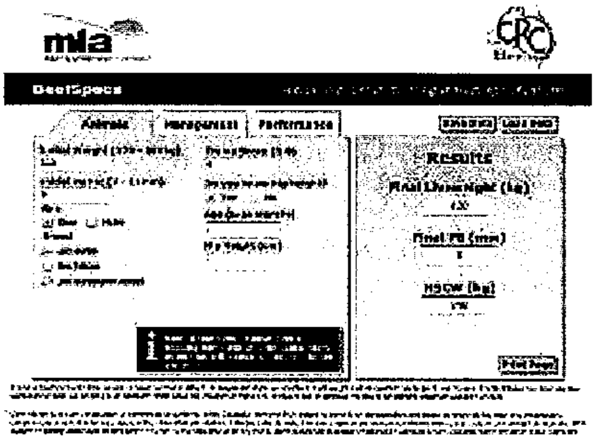

Figure 2: The on-screen display of the 'Animals' tab in BeefSpecs, which is used to input information about the current status and specifications of your cattle

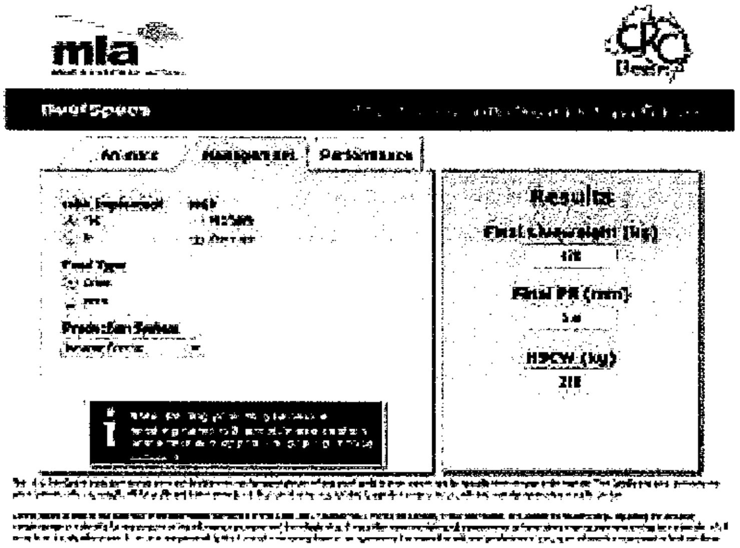

Figure 4: The on-screen display of the 'Management' tab in BeefSpecs, which is used to input information about how your cattle have been managed

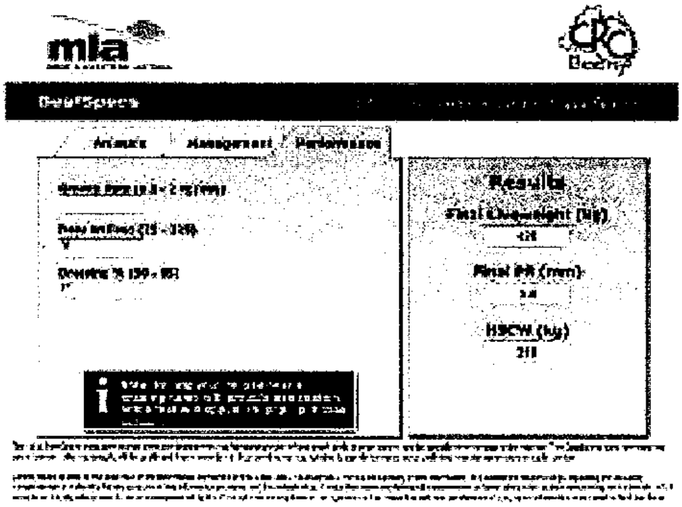

Figure 5: The on-screen display of the 'Performance' tab in BeefSpecs, which is used to input information about the performance of your cattle

To enable the calculator to use those inputs which producers were familiar with it was necessary to develop a mechanism to convert fat content of the body to fat thickness. Relationships between rib fat thickness and empty body fat (McPhee *et al*, 2008), and rib fat and P8 fat thickness (Walmsely *et al*, 2009, in press) were developed to enable linkage between the DGM and practical measures.

Because the data used to calibrate the DGM was derived from feedlot finished cattle (Garrett, 1980), and it has been reported that at the same growth rate grass finished cattle deposit less fat than feedlot finished cattle (Tudor, 1992), an adjustment in rate of fat deposition was made for grass compared with grain finished cattle. Using the data reported in Tudor (1992) it was calculated that at the same growth rate (0.8 kg/d) grass finished cattle deposited fat at a rate equivalent to 0.01mm/d rib fat less than grain finished cattle. This was implemented in the calculator as a simple linear adjustment.

During early stages of development of the calculator it was apparent that the original DGM construct was overestimating fat thickness (particularly at low rates of liveweight gain). It was already known that the DGM overestimated fatness on grass finished cattle due to being originally parameterised on data from feedlot finished cattle (see above) but it was apparent that the grass v grain adjustment above was limited in application in cattle in extensive production systems. Accordingly an environmental adjustment to maintenance requirements was developed that took account of the work involved in walking in different size paddocks, and on lower quality feeds. This was developed as a simple multiplier on maintenance requirements. With no adjustment for feedlot or strip grazing, and 1.3, 1.5 and 1.7 x multiplier used for easy, moderate or hard grazing. The functions used to calculate these adjustments were those described by SCA (1990).

Parameters that were required for a version of BeefSpecs that took account of tropical as well as temperate breed types (and their crosses) were developed by fitting data from the Beef CRC 1 straight breeding project (McPhee *et al*, 2009). This resulted in new parameter values for maintenance and protein metabolism for the DGM and coupled with the breed (temperate vs tropical) specific relationships between rib and P8 fat thickness developed by (Walmsely et al, 2009) enabled the implementation of a general version of BeefSpecs by the end of Q2 2009.

Converting outputs from the DGM into simple equations that run within the BeefSpecs calculator has presented some challenges. Originally the concept was to put the entire array of outputs from the DGM under the producer interface and use look up functions to interpolate between adjacent data points to provide calculator outputs. This quickly became unworkable and an interim solution of fitting the full array of simulated data with a regression model (either using DGM initialisation calculations followed by regression terms for rate of change, or latterly using terms derived from the regression models only to compute outputs) was developed. This suited the product development environment where MLA maintained control of the look and feel of the web / downloadable app interface, but unfortunately resulted in some constraints to accuracy of prediction. Failure to fit the surface of the array developed by repeated runs of the simulation model has introduced, at the edges, some additional calculation errors. This has recently come to light and several new methods are being evaluated to enable direct computation under the BeefSpecs calculator to avoid potential errors around the edges of the simulation space. These will be discussed below.

Although the computational errors identified diminish the fidelity of the BeefSpecs calculator in a limited set of situations, the concept of using a simple tool to assist producers understand what they can do to affect fatness and its relationship to weight and weight gain remains extremely valuable. The primary objective for the development of BeefSpecs was to provide a simple means of integrating all those factors which affect fatness in beef cattle, into an easy to use interface that producers can understand. The purpose was to enable producers to learn how the things they do to manage cattle and the environment in which they run cattle, influence an animals' capacity to achieve specifications. Although absolute accuracy of prediction is important, it is the understanding developed through producers exploring the behaviour of the system that generates the intended learning outcome. It is only by understanding the effects of the things that they can control that will enable producers to change their management to better achieve specifications.

b) **Producer involvement during development and testing of BeefSpecs**

Producers have been actively involved during the development of BeefSpecs. This was considered an important part of the product development process. Engagement with producers took the form of presentation of the ideas underpinning BeefSpecs at field days, and then offering an invitation for interested producers to become involved as a monitoring site. This involved them working with extension staff to select a mob of cattle, being involved in measurement of weight, hip height (to estimate frame score) and having their cattle scanned using ultrasound equipment to measure fat depth at the P8 site. This had the advantage of ensuring that selected producers became proficient in estimation of frame score and fat thickness, and were aware of the benefits of weighing cattle and calculating growth rates to understand their production systems. Overall more than 20 Field Days have been held to date in NSW, 5 in Vic, one in each of Queensland and Western Australia. More than 750 producers have been involved with these field days and presentations, and over 24 properties have been or currently are involved in evaluation and testing the use of BeefSpecs to inform management decisions about meeting specification and at least 400 cattle have been or are currently being assessed for evaluation.

This process has provided practical data to determine the utility of BeefSpecs in the field. Although it was understood that producer data was not up to the data quality standards of research derived data, it provided an opportunity to assess the magnitude of likely errors under practical conditions.

It became apparent during this process, that many producers (and more disturbingly some Extension Officers) did not have a sufficient level of skills in live animal assessment (particularly of frame score and fat thickness) to make appropriate inputs to BeefSpecs. This has since become the focus of further producer training within NSW DPI and More Beef from Pastures.

It has also become apparent that the data structures used to predict the performance of cattle using the principles of BeefSpecs are subject to considerable measurement error. A consequence of this is use of BeefSpecs as a tool to predict performance of individual animals is not recommended. However, the utility of BeefSpecs as a teaching and learning aid to assist producers understand the consequences of their actions on achieving specifications remains.

c) Evaluation of BeefSpecs using producer data

Evaluation of BeefSpecs with producer data continues. Below is a summary of the producer data sets where data collection is complete compared with predicted values derived from BeefSpecs. These evaluations highlighted some computational issues with the method used to translate the research model into BeefSpecs that have since been addressed.

Table 2: Summary of initial data used as inputs to the 'BeefSpecs' fat calculator for the current evaluation datasets. Note iBW = initial body weight (kg), FS = Frame Size (9 point scale), iP8 = initial P8 fat from scanning or estimated from fat score (mm), DOF = days on feed, ADG = average daily gain (kg/d)

	iBW	FS	iP8	DOF	ADG
Glen Innes	80	80	80	80	80
N	332	7	10	203	1.19
Maximum	206	3	3	203	0.64
Minimum	269.68	5.4	5.53	203	0.94
Mean, mm	27.85	0.77	1.78	0	0.10
SD					
Gordon	18	18	18	18	18
N	318	5	3	158	1.2
Maximum	238	3	2	158	0.9
Minimum	284.33	3.39	2.5	158	1.07
Mean, mm	22.38	0.61	0.51	0	0.09
SD					
Jorgensen					
N	31	31	31	31	31
Maximum	462	6	10	150	1.41
Minimum	372	3	4	150	0.77
Mean, mm	424.23	4.68	6.65	150	1.10
SD	24.68	0.87	1.43	0	0.15
Mitchell					
N	16	16	16	16	16
Maximum	410	6	6	64	1.5
Minimum	326	4	3	64	0.63
Mean, mm	360.38	4.69	3.69	64	1.15
SD	23.88	0.70	0.87	0	0.22
Moorehead					
N	49	49	49	49	49
Maximum	435	7	5	158	1.69
Minimum	320	4	1	158	0.86
Mean, mm	387.73	6.14	2.69	158	1.14
SD	23.63	0.68	0.77	0	0.17
Orange					
N	79	79	79	79	79
Maximum	544	7	11	100	2.02
Minimum	304	3	2	100	0.44
Mean, mm	428.32	4.97	3.54	100	1.54

SD	50.91	0.93	1.80	0	0.29
Yulgilbar					
N	64	64	64	64	64
Maximum	442	7	9	108	2.22
Minimum	354	3	3	91	1.33
Mean, mm	386.81	5.45	4.36	99.5	1.82
SD	19.46	0.85	1.30	8.57	0.25

Table 3: Output from the 'BeefSpecs' fat calculator – assessment of the differences between observed and predicted P8 fat depths for the current evaluation datasets. Note, names of evaluations in Table 1. GI – Glen Innes

Item	GI	Gordon	Jorgensen	Mitchell
N	80	18	31	16
Mean observed, mm	9.68	6.06	10.90	7.44
Mean predicted, mm	11.84	10.09	13.68	6.29
Mean bias, mm	-2.16	-4.03	-2.78	1.15
P[1]	<0.01	<0.01	<0.01	0.10
MSEP[2]	7.60	19.31	15.39	7.93
Root-MSEP, mm	2.76	4.39	3.92	2.82
Bias, %	61.54	84.29	50.10	16.70
Slope, %	0.06	0.89	8.91	53.03
Random, %	38.40	14.81	40.99	30.27

[1] Paired t-test of mean bias

[2] MSEP = mean square prediction error, Bias = MSEP decomposed into error due to overall bias of prediction; Slope = MSEP decomposed into error due to deviation of the regression slope from unity, Random = MSEP decomposed into error due to the random variation.

Table 4: Output from the 'BeefSpecs' fat calculator – assessment of the differences between observed and predicted P8 fat depths for the current validation datasets.

Item	Moorehead	Orange	Yulgilbar
n	49	79	64
Mean observed, mm	6.49	16.96	13.75
Mean predicted, mm	15.45	13.90	15.90
Mean bias, mm	-8.96	3.06	-2.15
P[1]	<0.01	<0.01	0.001
MSEP[2]	129.90	37.20	29.44
Root-MSEP, mm	11.40	6.10	5.43
Bias, %	61.81	25.15	15.75
Slope, %	31.78	6.17	32.52

Random, %	6.40	68.68	51.73

[1] Paired t-test of mean bias

[2] MSEP = mean square prediction error, Bias = MSEP decomposed into error due to overall bias of prediction; Slope = MSEP decomposed into error due to deviation of the regression slope from unity, Random = MSEP decomposed into error due to the random variation.

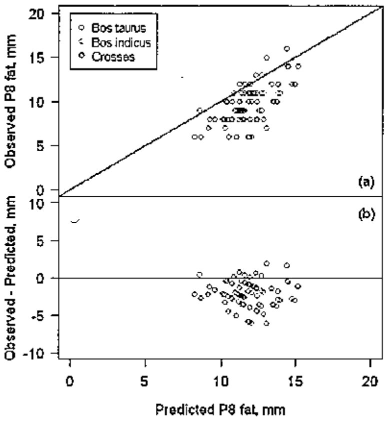

Figure #: Plot of (a) observed vs predicted and (b) the residual (observed – predicted) for P8 fat depth in Glen Innes animals.

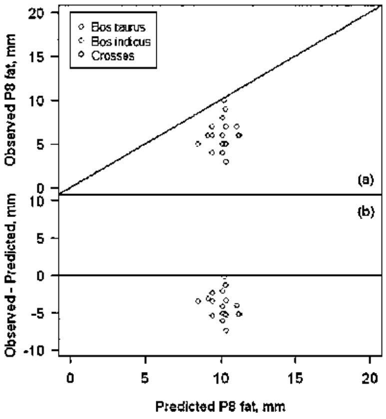

Figure #: Plot of (a) observed vs predicted and (b) the residual (observed – predicted) for P8 fat depth in Gordon animals.

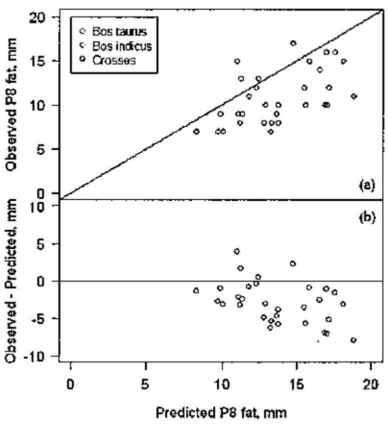

Figure #: Plot of (a) observed vs predicted and (b) the residual (observed – predicted) for P8 fat depth in Jorgensen animals.

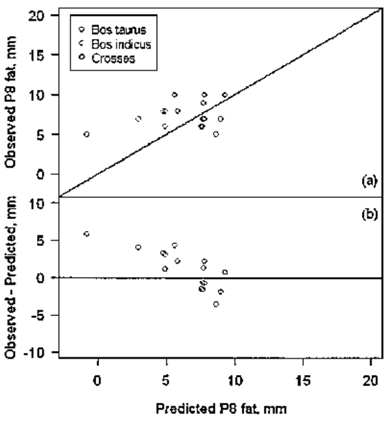

Figure #: Plot of (a) observed vs predicted and (b) the residual (observed – predicted) for P8 fat depth in Mitchell animals.

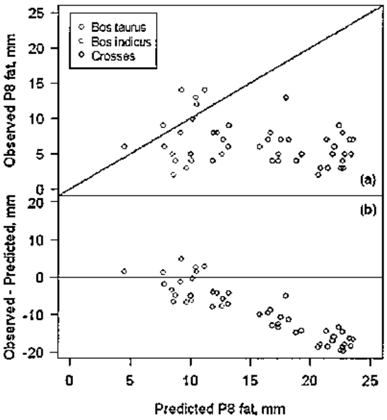

Figure #: Plot of (a) observed vs predicted and (b) the residual (observed – predicted) for P8 fat depth in Moorehead animals.

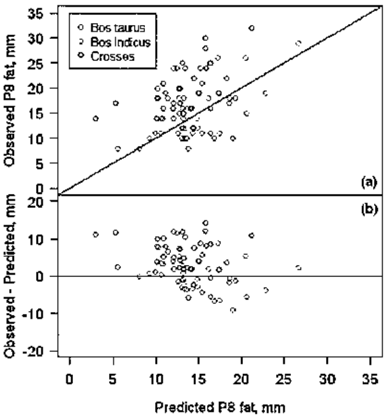

Figure #: Plot of (a) observed vs predicted and (b) the residual (observed – predicted) for P8 fat depth in Orange animals.

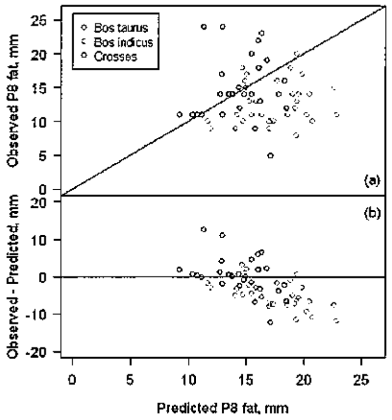

Figure #: Plot of (a) observed vs predicted and (b) the residual (observed – predicted) for P8 fat depth in Yulgilbar animals.

In addition to the above, an evaluation of BeefSpecs was conducted at Werribee Water (on the site of Melbourne's Sewerage works). Data from that report have been forwarded to MLA by Dougal Purcell on 22/07/2009. That report highlighted a weakness in prediction of fat thickness at ADG less than 0.6kg/d.

Subsequent to that report a number of issues in BeefSpecs were explored in detail. It was found that at certain parts of the simulation space used to generate the simple calculation in BeefSpecs were not well predicted by the regression coefficients. David Meyer (DPI QLD) demonstrated that error of prediction of the base simulation data used to generate the regression coefficients was 4 mm P8 fat at some parts of the simulation space.

To try and overcome errors in prediction that may be due to the interface between the Davis Growth Model and the prediction provided by BeefSpecs we have explored ways to compute fat thickness directly from producer inputs. That is, without the need to use a secondary method of prediction as currently implemented in BeefSpecs. Two new methods were devised that used
a) reconfiguration of the equations in NRC 1996 that enable calculation of retained energy for liveweight and weight gain, and
b) recoding of the model of Keele et al, 1992 with the breed specific parameters as estimated in Williams et al 1995, and the implementation to deal with cattle at all stages of maturity as described by Williams and Jenkins (1998).

Of these, the second (recoded Williams / MARC Model) performed better over the entire data range than the NRC based calculator.

A comparison of this model with BeefSpecs is shown below. This model does not require back calculation of the feed intake form daily gain to run and can be implemented without recursion in visual basic.

Note the full table (below) is shown in landscape format on Page 38. If someone can move it to here that would be wonderful.

Table n. Comparison of predicted outputs of BeefSpecs calculator and the revised Williams / MARC model against reported final fat thickness. Inputs shown are as used for the BeefSpecs calculator. Imp. = implant status, Wt = initial full body weight (kg), iP8 = initial P8 fat thickness (mm), ADG = input average daily gain = realised SDG over stated period, Days = days between initial measurement and final output. Outputs shown are Final P8 fat thickness (mm), and predicted final P8 fat thickness (mm), the mean bias between observed and predicted (mm) and the percentage of the bias that is due to random effects for BeefSpecs and the Williams / MARC model respectively.

Data Set	Inputs									
	Feeding System	Breed	Imp.	Wt	iP8	ADG	Days	Final P8 (mm)	BeefSpecs	
									Pred (mm)	Bias (mm)
FLOT 210	Feedlot	Angus + Shorthorn	No	434	6.4	1.48	169	23.2	21.2	2
Werribee	Pasture (1.3)	Angus, Angus x Hereford	No	333	3.4	0.76	127	5.6	6.1	-0.5
Glen Innes	Pasture (1.3)	Angus	No	270	5.5	0.94	203	9.7	11.8	-2.2
Gordon	Pasture (1.3)	Hereford	No	284	2.5	1.07	158	6.1	10.1	-4.0
Jorgensen	Supplemented on Pasture (1.3)	Brangus	Yes	424	6.65	1.1	150	10.9	13.7	-2.8
Mitchell	Pasture (1.3)	Angus	No	360	3.7	1.15	64	7.4	6.3	1.1
Moorehead	Pasture (1.3)	Simental and Simental Cross	No	388	2.7	1.14	158	6.5	15.5	-9.0
Orange	Feedlot	Mixed	Yes	428	3.5	1.54	100	17.0	13.9	3.0
Willowtree	Pasture (1.5)	Santa x Hereford	No	454	4.4	0.61	176	8.8	7.6	1.2
Yugilbar	Supplemented on Pasture (1.3)	Santa , Santa x Angus	Yes	387	4.4	1.82	99	13.8	15.9	-2.1

Of particular interest is the comparisons in data sets where BeefSpecs did not work well. One particular example that has been drawn to our attention by Dougal Purcell, is where the Werribee steers were growing at less than 0.6 kg/d as shown below.

Table n+1. Comparison of BeefSpecs and Williams / MARC model outputs using Werribee data. Animals and feed system are described in Table n above. The discrepancy in BeefSpecs is highlighted. DGM is the full Davis Growth Model (Feed Quality inputs adjusted to match observed growth rate).

	Inputs				fP8	BeefSpecs			Williams / MARC		
Period	iWt	iP8	ADG	d		pP8	Bias	% random	pP8	Bias	% random
Jan-Mar	333	3.4	0.94	64	4.9	4.2	0.7	34.2	5.3	-0.5	72.2
Mar–May	393	4.9	0.59	63	5.6	2.4	3.2	8.9	6.2	-0.6	64.8
Jan-May	333	3.4	0.76	127	5.6	6.1	-0.5	56.0	6.3	-0.7	53.1
						DGM					
Mar-May	393	4.9	0.59	63	5.6	5.7	-0.1				

As shown in Table n+1 above, this discrepancy between observed and predicted is not seen using the Williams / MARC model. In a separate evaluation using the full Davis Growth Model, where feed quality was adjusted to provide the observed growth rate of 0.59 kg/d, estimated final P8 fat thickness was 5.7mm (i.e. 0.1mm higher than the observed values). This suggests that in this case the discrepancy in BeefSpecs is a function of the regression mesh used by BeefSpecs to speed the calculations and not the underlying simulation model.

The greatest discrepancy between observed and predicted is in the Yugilbar dataset. Closer inspection of the data suggests that if the quoted weight increase (ADG) is correct, this could in part be because of compensatory gain. The average growth rate from birth to the start of the measurement period is 0.6 kg/d (over 530+ d), and the reported growth rate in the measurement period is 1.8 kg/d (for 99d). Using the underlying Davis Growth Model indicates that to grow at that rate would require a feed with an Energy Density of >12MJ ME / kgDM and result in P8 fat thickness of >19mm. This also over predicts the observed result, but raises doubt about the accuracy of the reported growth rate.

These observations indicate that in general where good quality data have been collected under research conditions (FLOT210, Werribee and Glen Innes) the models work with accuracy within the error structure of the measurements and are without systematic bias. However, not all measurements made in the field are made under the same rigorous conditions as research measurements. Without recognition of the potential for such errors may lead to less precision in prediction (i.e. more error, much of it biased)

Measurement in the field and limits to accuracy of estimation of fatness traits

Errors induced by computational shortcuts are only one source of error in prediction of fat thickness. There are a number of data quality issues that constrain the utility of the BeefSpecs tool in producers hands. These relate to accuracy in assessment / measurement of fat thickness.

The standards for accreditation of fat scanning are repeatability and accuracy within +/- 1.5mm. Given that many assessments are made by un-accreditted scanners it would be expected that an error of at least 1.5mm could be anticipated.

To get a feel for errors in ultrasound scanning and other practical inputs such as Frame Size and muscle score, data from a joint Beef CRC 1/ MLA study (MLA project FLOT210) was investigated. This study has repeated measures of ultrasound scanning (rib, P8 fat thickness, eye muscle area and predicted intramuscular fat content of the eye muscle), hip height and muscle score on 195 feedlot fed cattle fed for 70d and 170 fed to 184d. In addition a full suite of carcass fatness measurements were also recorded.

Table

Relationship between sequential measurement of P8 fat in Feedlot finished cattle

	d0 -d35	d35-d74	D74-d109	D109-d144	D144-d179	D179-d184 (carcass)
Slope	1.24	1.5	1.33	1.18	1.11	1.02
R^2	0.65	0.63	0.59	0.71	0.53	0.61
Change in Slope mm/d	0.035	0.038	0.038	0.034	0.031	

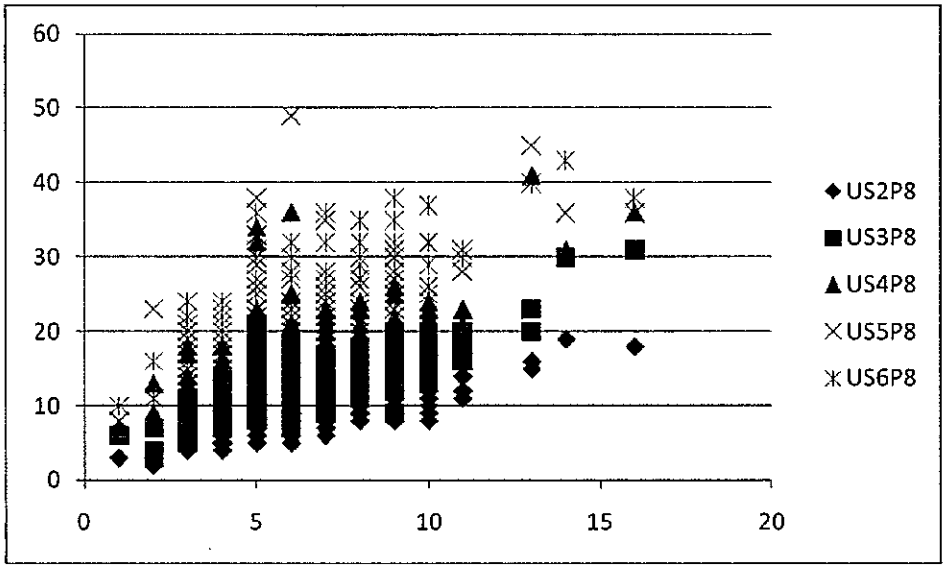

Figure relationship between P8 fat measured on entry to the feedlot with P8 fat measured at approx 35 d intervals until slaughter at d 184. X axis is P8 fat measured by Ultrasound at feedlot entry (d0) and Y axis is mm P8 fat measured by the same ultrasound operator at the days shown in Table...(data from FLOT210).

In some cases in the producer evaluation, no exit fat measurement was made and P8 fat measurement was assessed on the slaughter floor. Although the relationship between final ultrasound fat thickness and P8 fat measured on the carcass is almost 1:1 in It is likely that a random selection of carcasses will have suffered damage at the p8 site and that the assessment made will reflect this. If the research data in FLOT 210 is anything to go by, the best one could expect is that the relationship between P8 fat thickness measured by ultrasound and P8 fat thickness measured on the carcass accounts for 60% of the variation (a correlation coefficient of approx 0.78). It could not be expected that the relationship between Ultrasound and Industry data would be better than this.

Other industry inputs are assumed constant. For example, the assumption underpinning the DGM and the Williams / MARC models is that weight of protein (or fat free weight) at maturity can be estimated. The DGM uses Frame Size to estimate maximum protein (DNA) mass, the MARC model uses a breed mean estimate derived from the different cycles of the long running Germ Plasm Evaluation Project. To achieve consistency between the approaches, we have added an estimation of FFM at maturity from Frame Size to the MARC model. Unfortunately, Frame Size (estimated from hip height and age) is not the industry indicator of Maximum DNA and Protein Max we thought it was. Inspection of the Hip Height data in FLOT 210 steers (Figure n, below) shows that repeated estimates of Frame Size creep over time in cattle on feedlot diets by up to 2 units. Perhaps this is because the initial estimate was in cattle that had grown from birth to feedlot entry at a rate of 0.65 kg/d (range 0.55-0.75 kg/d) and in the feedlot the initial rate of growth was >1.5kg/d. In short, hip height and age were not a good indication of potential mature size, because the animals did not have the chance to express their growth potential on pasture.

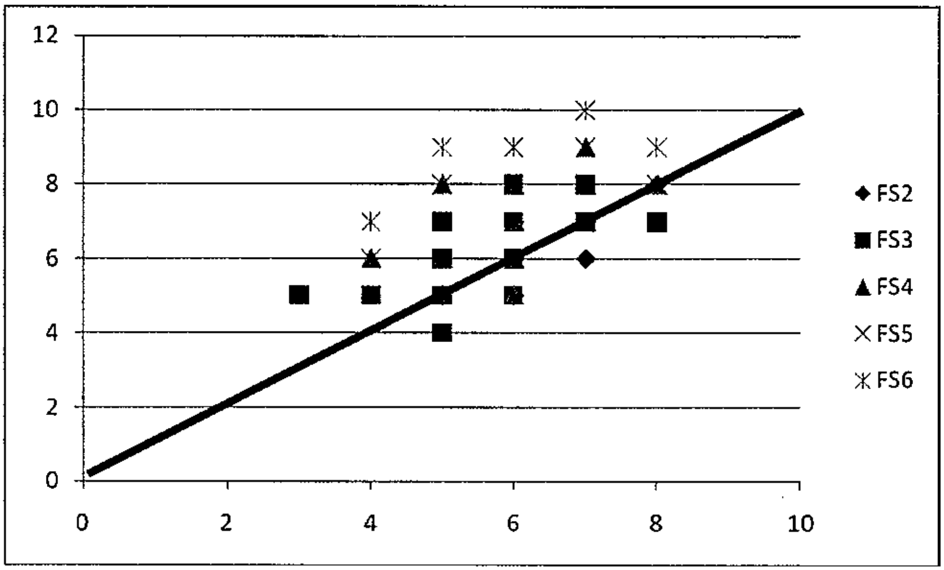

Figure Relationship between Frame Size measured at Feedlot Entry (x axis) (FS1) with repeated sequential estimates of Frame Size (FS 2- 6). If frame size (using hip height and age) was a stable measure of growth potential it would be anticipated that subsequent estimates of frame size would lie on the line of equality with the X axis (blue line). Instead, it can be seen that later estimates of Frame Score (FS5 and FS6) lie consistently above the line.

An implication of the above observations is that the ability to estimate parameters about individual animals required by different models to predict fatness using simple industry measures is not as good as expected.

Further work to explore the relationship between frame score / size estimated from hip height and age has since been carried out using the feedlot south data from Beef CRC1. There was no significant relationship between post weaning growth rate and change in frame size. There was however, a significant relationship between pre weaning growth rate and subsequent change in frame size. Slower growth pre weaning was associated with a subsequent increase in rate of change of frame score, i.e. animals which grew slower before weaning, had greater rates of change in frame size between weaning and finish than those that grew more quickly to weaning. The amount and quality of data available to test hypotheses about causes of change in Frame Size is generally small and not adequate in structure to permit a clear resolution of cause and effect.

Prediction of phenotype in individual animals

The BeefSpecs calculator cannot predict future fat thickness of individual animals with the same accuracy as prediction of means of specific groups of animals. There are number of reasons for this. The first relate to the nature of the data used to generate the relationships upon which the original models (DGM, Clay Center, SCA (1990), NRC (1996)) were based. The relationships used to predict performance are obtained from data on groups of animals. In many cases the data have been pooled across a large number of studies to generate sets of "metadata". It is the relationships between the group or experiment means that inform the behaviour of the various models. Accordingly use of mean data to predict the performance (or phenotype) of an individual introduces additional errors in that without reference to the group in which the comparison is made. In many ways this is the similar to the contemporary group problem dealt with in genetic evaluation. However, in the case of prediction of phenotype (i.e. both genetic and environmental effects at the same time), an environmental effect cannot be removed from the analysis by forming contemporary groups (as is done to obtain estimates of genetic variation) because it is the combination of environmental effect and genotype that is being predicted.

In addition to this fundamental difference in genetic v phenotype prediction, the concatenation of errors in measurement / estimation of initial conditions and ongoing performance, produce levels of uncertainty of individual animals far in excess of those of the means of the groups running in the same environment.

4.1.3 Potential for inclusion of Genetic Parameters into simple calculators such as BeefSpecs

In February 2008 Prof R.D. Sainz (University of California, Davis) visited Armidale to assist with development of a procedure to include genetic parameters (EBVs for weight, carcass and fatness traits) into the Davis Growth Model. A report on the work undertaken by Prof Sainz is shown in Appendix 1.

It should be noted that the nature of EBV's as implemented in the Australian Cattle industry makes them breed specific. Although estimated breeding values using a common baseline for some traits have been developed (MultiBreed EBVs) for a limited number of breeds (Johnston et al, 200x), these are not yet implemented by the Australian beef industry. This was a constraint identified early within the project and was why we initially chose to use Angus as the baseline breed for development of the phenotypic prediction tools (Angus is the baseline breed for the current estimates of Multibreed EBVs).

Although it is technically feasible to include EBVs within the framework of the Davis Growth Model (and the Clay Center and SCA models) there are number of practical constraints to their implementation within industry focussed phenotype prediction tools.

1. The breed specific nature of current EBVs requires that the phenotype prediction tools be breed specific. However in commercial industry there are few producers who are constrained to a single breed, and who know the parents of the progeny. Although some commercial producer might have some idea of the EBVs of the sires used, they rarely know the EBVs of the dams. This suggests that there is a longer term education process required to increase awareness of the need to retain and use knowledge if breeding values within the commercial sector of the beef industry. Implementation of across-breed breeding values will assist with this learning process.
2. Phenotypic models can use simple on farm measurements of cattle as proxies for internal parameters that drive growth and composition. Of these parameters, frame size, and fatness at a particular weight (maturity type) capture a substantial proportion of the variance in the realised traits, including genetic variance. Although it could be argued that EBVs (initially mid parent values, but perhaps sometime in the future Genomic derived breeding values) are potentially available at a younger age than simple phenotypic measures such as weight, frame size and fatness, they contribute to only a part of the variance in actual performance. However as noted above, in commercial industry few producers have such data.

Current experience suggests that upgrading the skills of commercial producers to better assess live animal characteristics (Weight, Frame Size, Fat thickness / Fat score), and to measure liveweight gain within their production system will yield greater improvement in achieving specifications than inclusion of EBVs in the phenotypic prediction models. Nonetheless, ongoing work is required to determine how to better include breeding values into commercial phenotype prediction models. Unfortunately observations made during the work reported here suggests that if this is to be taken seriously, then significant changes need to be implemented in application of breeding value technology across the commercial sector of the Australian industry. The first step to enable this would be implementation of a system of across-breed values for commercially important traits.

4 Success in Achieving Objectives

4.1 The following have been achieved

4.1.1 Development of BeefSpecs

The project has achieved it objective of providing a tool that can be used to better manage cattle to target specifications as required in More Beef from Pastures and generally by the producer community. BeefSpecs and the Tip and Tool describing BeefSpecs and how to use it are available on MLA's website (see links below).

BeefSpecs

http://www.mla.com.au/NR/rdonlyres/75DFF295-A92F-46A3-AE03-5E73FEB6C2B/0/BeefSpecs.swf

Tip and Tool
http://www.mla.com.au/NR/rdonlyres/19BB4821-960C-4C2E-9ADA-AD17BF3E1D54/0/LPI846BeefSpecsTipsandTools.pdf

4.1.2 A framework for continued development of phenotype prediction tools

The project has laid the foundations for continued development of phenotype prediction tools. By basing the core model for phenotype prediction on well documented models of animal growth and development, it is relatively simple to incorporate genetic information into that framework in the future. This project has indicated how this can be accomplished, but further work is required to complete it. External constraints to completion include continued use of within rather than across breed, estimated breeding values by the beef industry and the limited data currently available on size of effect, and frequency of major genes affecting relevant phenotypes.

5 Impact on Meat and Livestock Industry – now & in five years time

5.1 Impact on Meat and Livestock Industry – now & in five years time

As the industry continues to press for reduced cost of production while maintaining income, better achieving specifications will continue as an important goal. Without formal modelling of the outcomes possible from use of, say, the BeefSpecs tool it is difficult to accurately estimate the value of its use within the beef industry. However, as Slack-Smith (2009) has pointed out, the current rate of failure to achieve specifications within the feedlot industry of from 16-28% for weight and external fatness traits and up to 70% for marbling provides a significant opportunity to reduce wastage and improve profitability by improved management practices. It is hard to see how the industry will remain profitable while such wastage occurs. In such an environment, any tools that provide producers and feed lot managers with the confidence to improve their management to achieve specifications will ultimately impact on reduced wastage. The time to implementation will largely depend on circumstances of individual business units.

6 Conclusions and Recommendations

6.1.1 Estimate value of phenotype prediction - It has been often asked what is the value of better predicting the impact of management (e.g. choice of breed and genotypes within breed, nutrient supply and enterprise level decisions – pasture management, type of enterprise) on the capacity of animals to achieve specifications and thereby enterprise profitability. There is limited objective data available in the public domain, and almost nothing on grass fed cattle. Where it does exist in feedlot operations, Slack-Smith (2009) has shown that approx 16% of animals fail to meet the most basic of specifications (weight) and 28% fatness criteria (approx 70% of cattle fail to meet the more demanding marbling specification). Slack Smith (2009) estimated that the costs of failing to achieve specifications in the 40,000 feedlot cattle he studied was more than $1.6m or $40/head. Anecdotal evidence is that the variation in grass fed cattle is greater than in feedlot cattle, but there is no hard recorded evidence. It would be a useful exercise to survey selected segments of the grass fed industry to determine the incidence and cost of not achieving specifications.

Recommendation:- A pilot project be established to ascertain the parameters that need to be measured to estimate the cost of failing to meet specifications in the beef industry. If this pilot project shows that the measurements are feasible then proceed to establishing a routine monitoring process to allow estimation of impact of different production parameters on profitability of beef enterprises and on processors.

6.1.2 Methods to predict phenotype – data requirements. This project highlighted the general lack of quantitative animal assessment skills in producers. Furthermore, it demonstrated that even in research environments, data that could be used for calibration of simple fatness models across different breeds is rarely available.

Recommendations:-
1. More attention should be paid by extension agencies on teaching producers the basic skills of animal assessment (frame size, maturity type, fat scoring / measurement).
2. Data on distribution between different parts of the body in different breeds of cattle be collected under research environments as a matter of urgency. It is noted that a small scale project to do this is Angus and Brahman cattle is currently being done within the CRC for Beef Genetic Technologies. It is important that this information also be collected within breeds where selection has occurred for different levels of fatness (e.g. where a breed, such as Angus, is developing populations of cattle divergent for fatness and retail yield).

6.1.3 Implications for industry. An efficient beef industry requires that waste be eliminated throughout the chain. There is sufficient evidence to suggest that failure to achieve specifications is one source of waste in both the production and processing sectors. Through this project a tool is now available to assist producers better achieve specifications (and change management practices where required to improve compliance). The tool "BeefSpecs" works within the errors of measurement of fatness. Although the tools only use information that producers can reasonably be expected to measure on farm, many producers need help to better get that information. As noted above, the total cost to the industry of failing to meet specifications also needs to be determined.

Recommendations:- Implement the recommendations above.

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8 Appendices

8.1 Incorporating EBV into the DGM

A report on initial investigation into methods to incorporate EBVs for weight and fatness traits into the Davis Growth Model. The work in this report was conducted during February 2008 whilst Prof R D Sainz (University of California, Davis) was visiting the CRC for Beef Genetic Technologies in Armidale.

Incorporation of EBV into DGM predictions
R. D. Sainz
February 2008

Objective:
To utilize genetic information to improve the predictions of the Davis Growth Model (DGM).

Methodology:

1. Complete (2008) Estimated Breeding Values (EBVs) for 300 Angus sires with at least 25 progeny were obtained from the website of the Angus Society of Australia (http://www.angusaustralia.com.au/).

2. For each sire, the phenotype was estimated as:

Phenotype = Mean 2008 phenotype – mean 2006 EBV + (Sire EBV + Dam EBV)/2

- Dam EBVs were estimated from mean 2001 EBVs
- Mean 2006 EBVs were estimated from the January 2008 Angus Group Breedplan Analysis mean phenotypes

- Total body fat was estimated based on meta-analysis data:

$$\text{TBF, kg} = -31.4 + 0.361\ \text{HCW, kg} + 2.46\ \text{Rib fat, mm} + 2.83\ \text{IMF, \%}$$
$$R^2 = 84.2\%,\ s_{y.x} = 8.89$$

- P8fat (and not ribfat) was used, because of the high correlation between EBVs for P8 fat and ribfat:

$$\text{EBV (P8fat)} = 0.2934 + 1.356 * \text{EBV(ribfat)}$$
$$R^2 = 0.976,\ s_{y.x} = 0.245$$

- IMF was also used, because of the low correlation between EBVs for P8 fat and IMF:

$$\text{EBV (IMF)} = 0.9258 + 0.2304 * \text{EBV(P8fat)}$$
$$R^2 = 0.191,\ s_{y.x} = 0.739$$

3. The DGM was then fitted to each estimated phenotype:
    a. Frame size: against slaughter weight and estimated total fat
    b. Kmaint: against slaughter weight and estimated total fat (meaningless)
    c. Dsmax: against P8 fat and IMF
    d. Dmmax: against P8 fat and IMF

Results:

Fitting each sire resulted in reasonable fits for 213 sires, but the DGM was unable to match the phenotypes for 67 sires. At this initial stage, those 67 sires were excluded from further analysis. When frame size was fitted to final slaughter weight and total body fat (both at 600 days of age), the DGM was able to predict slaughter weight with high accuracy and precision (Figure 1). Further analysis revealed that frame size could be estimated directly from the EBVs for carcass weight and 12th rib fat (Figure 2). It should be noted that the maintenance energy coefficient (Kmaint) was also fitted to those data in order to be able to run the model; however, those values are considered meaningless because the actual intakes are unknown. Stepwise regression of estimated frame size on EBV predictors resulted in inclusion of IMF and 200d weight EBVs, however these predictors added very little precision to the estimate, therefore only carcass weight and 12th rib fat were retained. Predictions of total body fat were poorer than predictions of slaughter weight (Figure 3), with a coefficient of determination between the DGM predictions and estimated TBF of 0.64. Subsequent fitting of maximum DNA in subcutaneous (Dsmax) and intramuscular (Dmmax) fat depots, holding frame size and Kmaint at their individual fitted values, was not able to account for variability in P8 fat (Figure 4) and IMF (Figure 5), with R^2 values of 0.114 and 0.046, respectively. Moreover, examination of the observed and predicted values for TBF, P8 fat and IMF show that there are some unusual patterns in the data that are as yet unexplained.

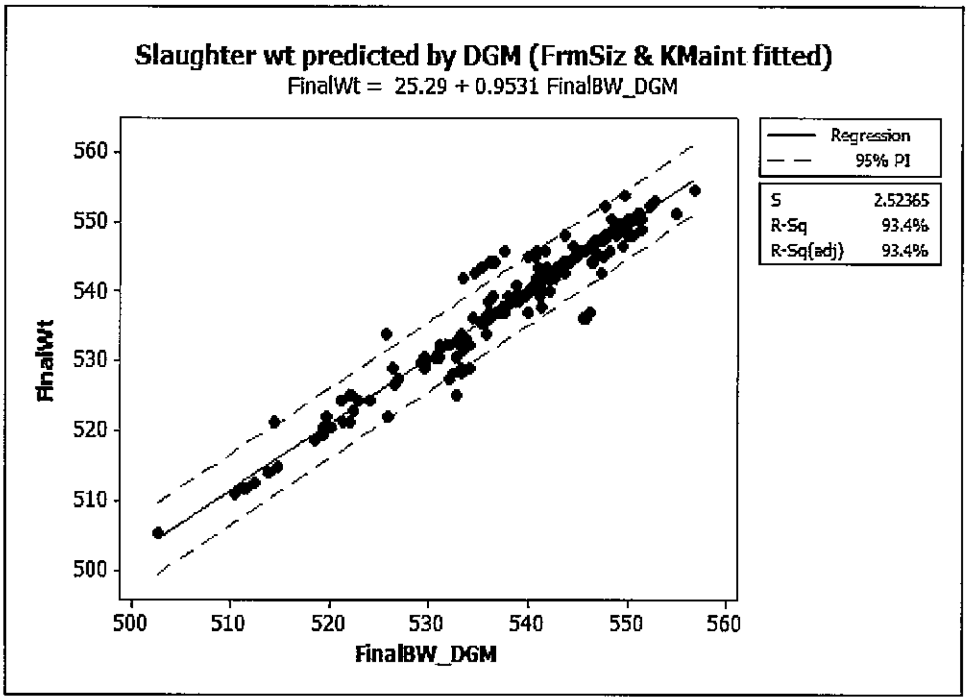

Figure 1.

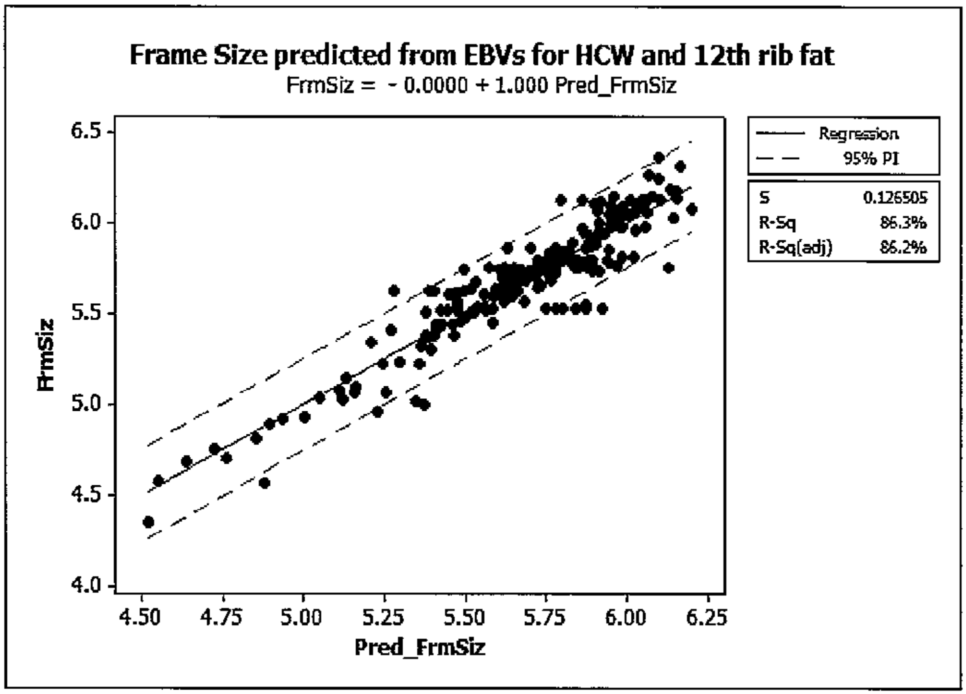

Figure 2.

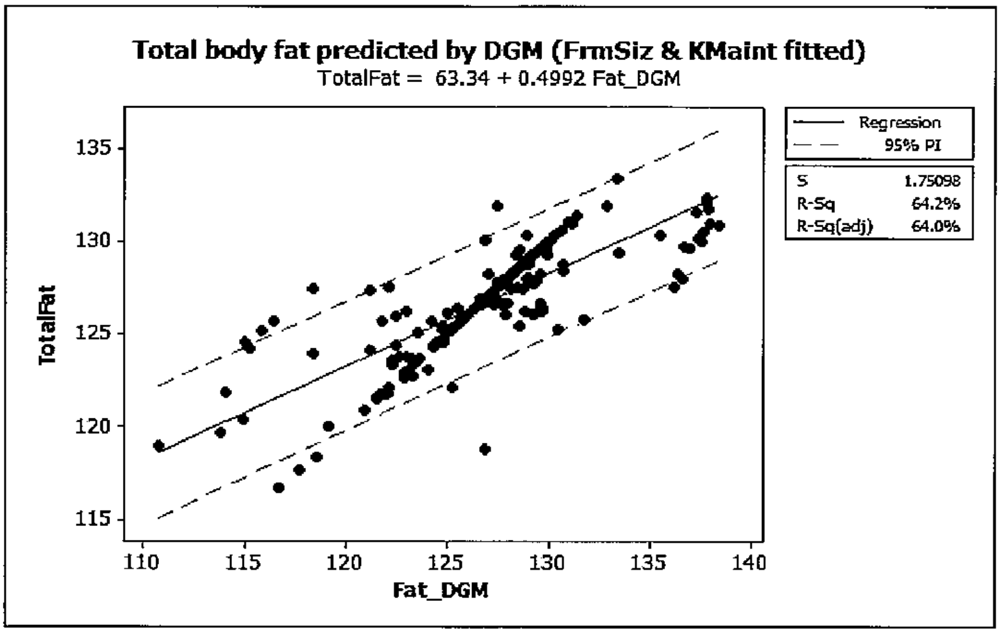

Figure 3

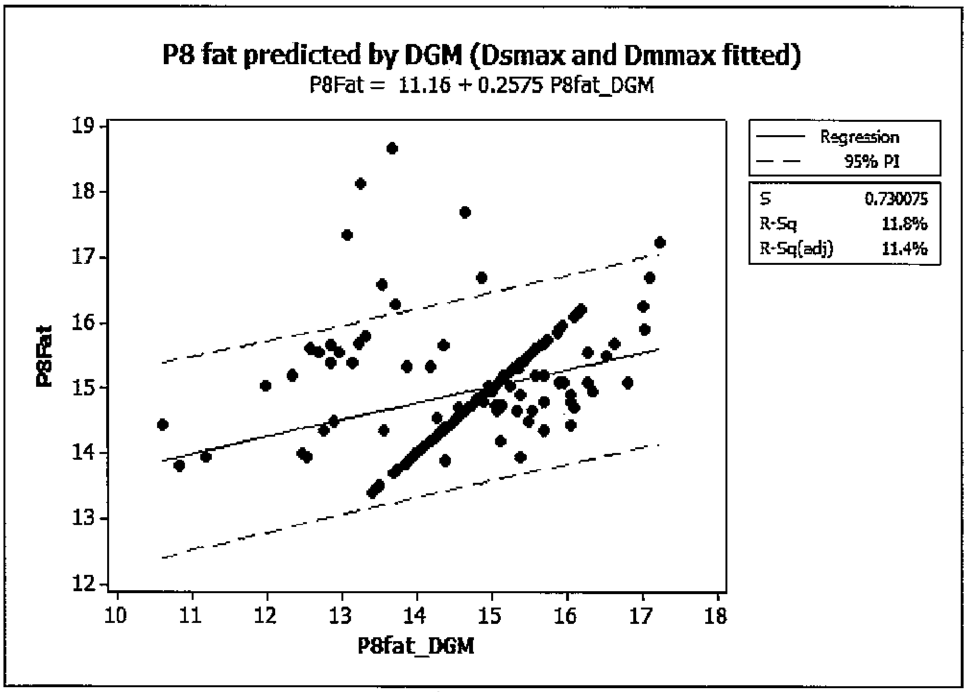

Figure 4

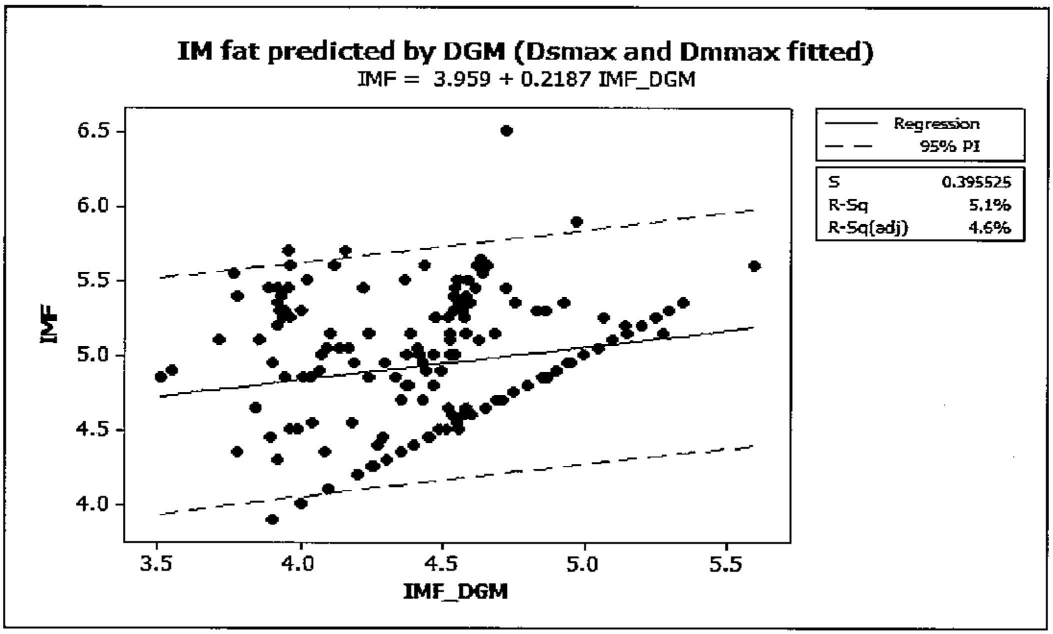
IM fat predicted by DGM (Dsmax and Dmmax fitted)
IMF = 3.959 + 0.2187 IMF_DGM
6.5
6.0
5.5
5.0
4.5
4.0
IMF
3.5
4.0
4.5
5.0
5.5
IMF_DGM
Regression
95% PI
S 0.395525
R-Sq 5.1%
R-Sq(adj) 4.6%

Figure 5

8.2 Appendix 2

Publications arising from this project

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Table n. Comparison of predicted outputs of BeefSpecs calculator and the revised Williams / MARC model against reported final fat thickness. Inputs shown are as used for the BeefSpecs calculator. Imp. = implant status, Wt = initial full body weight (kg), iP8 = initial P8 fat thickness (mm), ADG = input average daily gain = realised SDG over stated period, Days = days between initial measurement and final output. Outputs shown are Final P8 fat thickness (mm), and predicted final P8 fat thickness (mm), the mean bias between observed and predicted (mm) and the percentage of the bias that is due to random effects for BeefSpecs and the Williams / MARC model respectively.

Data Set	Inputs							Outputs						
	Feeding System	Breed	Imp.	Wt	iP8	ADG	Days	Final P8 (mm)	BeefSpecs			CW/MARC model		
									Pred (mm)	Bias (mm)	%bias random	Pred (mm)	Bias (mm)	% bias random
FLOT 210	Feedlot	Angus + Shorthorn	No	434	6.4	1.48	169	23.2	21.2	2	85.8	21.7	1.5	88.5
Werribee	Pasture (1.3)	Angus, Angus x Hereford	No	333	3.4	0.76	127	5.6	6.1	-0.5	56.0	6.3	-0.7	53.1
Glen Innes	Pasture (1.3)	Angus	No	270	5.5	0.94	203	9.7	11.8	-2.2	38.4	9.9	-0.2	93.7
Gordon	Pasture (1.3)	Hereford	No	284	2.5	1.07	158	6.1	10.1	-4.0	14.8	8.9	-2.9	22.5
Jorgensen	Supplemented on Pasture	Brangus	Yes	424	6.65	1.1	150	10.9	13.7	-2.8	41.0	15.9	-5.0	21.2

	(1.3)													
Mitchell	Pasture (1.3)	Angus	No	360	3.7	1.15	64	7.4	6.3	1.1	30.3	6.8	-0.6	76.2
Moorehead	Pasture (1.3)	Simental and Simental Cross	No	388	2.7	1.14	158	6.5	15.5	-9.0	6.4	11.5	-5.0	22.3
Orange	Feedlot	Mixed	Yes	428	3.5	1.54	100	17.0	13.9	3.0	68.7	14.0	3.0	70.3
Willowtree	Pasture (1.5)	Santa x Hereford	No	454	4.4	0.61	176	8.8	7.6	1.2	80.4	10.5	-1.7	75.1
Yugilbar	Supplemented on Pasture (1.3)	Santa , Santa x Angus	Yes	387	4.4	1.82	99	13.8	15.9	-2.1	51.7	16.7	-2.9	38.4

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