Supporting the
land-based industries
for over a century

SAC

Prepared For

QMS

Demonstrating the benefits of using maternal EBVs in selecting beef sires

By

Kirsty Moore, Raphael Mrode, Mike Coffey, Basil Lowman,
Gavin Hill and Tim Roughsedge

Draft version 8
October 2010

Executive Summary

Significant genetic improvements have been made for terminal beef traits in the UK. In contrast, there has been no planned selection in maternal traits in the UK beef industry. Recent availability of estimated breeding values (EBVs) for maternal traits provides an opportunity to address this. A desktop study indicated that selection based on these maternal EBVs can result in substantial genetic progress leading to increased profitability of UK beef enterprises. However there is anecdotal evidence that in practise the maternal trait EBVs have so far been underutilised. The aim of this report was to demonstrate the value of maternal EBVs for selecting bulls to breed replacement cows that calve successfully at 2 years of age and calve easier, have shorter calving intervals, have increased longevity in the herd and improved milking abilities.

A number of analyses using the EBVs from an official EGENES genetic evaluation along with the available phenotypic data were undertaken to demonstrate the value of maternal trait EBVs. High and low EBV sire subsets were selected from sires that had maternal trait EBVs with accuracies greater than 50% and with daughters having phenotypic performance records adjusted for contemporary group average. It was clearly shown that the high accuracy maternal trait EBVs are predictive of phenotypic performance for maternal traits. Examining the age structure of the selected sires showed that the sires were generally between 15-20 years of age, highlighting the difficulty in identifying high accuracy young bulls for maternal traits. This is due to the late life and/or sex-limited expression of maternal traits resulting in very little phenotypic data being available for genetic evaluation until the sire is approximately 5 years of age.

Further analysis looking specifically at younger bulls indicated that genetic progress can still be made in maternal traits by selecting young bulls based on their maternal trait EBVs - despite the difficulties in achieving high accuracy. A bespoke maternal trait genetic evaluation was run for 1999 (using the same models and parameters) and compared to the 2009 run. There were strong positive correlations between the EBVs of males aged 0-5 years in 1999 and the 2009 EBVs of the same animals when they were aged 10-15 years old. In addition, the EBV rankings were the same for the older high accuracy sires from the 2009 evaluation and when the same sires were aged 0-5 years in the 1999 evaluation.

Selecting young males based on 1999 EBVs and analysing their progeny phenotypes in 2009 was investigated but inconclusive due to insufficient phenotypic records being available. However, it seems reasonable based on the strong correlations and consistent rankings over time to conclude that selecting maternal trait EBVs on younger males (although not highly accurate) will result in genetic progress for the maternal traits. Although genetic progress can be made by selecting younger less accurate males, it is likely that greater improvement in maternal trait genetic response can be achieved via alternative selection approaches. Further investigation is required into possible workable breeding program designs for selection using maternal traits for the UK beef industry, e.g. progeny testing a subset of males and utilising AI.

In conclusion maternal trait EBVs can be used to select sires that produce daughters that calve successfully at 2 years of age and calve easier, have shorter calving

intervals, have increased longevity in the herd and improved milking abilities. However, high accuracy maternal EBVs are difficult to achieve for young males. Despite these challenges, genetic progress can be made by the more traditional selection method of selecting young males based on EBVs. Further significant improvements to the rate of genetic gain could be made by adopting alternative selection strategies.

Table of Contents

1.0 Introduction

Growth and carcass trait EBVs have been produced since the 1990's for the UK beef industry and significant genetic progress has been made for these terminal traits with UK beef animals reaching heavier weights earlier and with improved carcase characteristics (muscle and fat depth). However, at the same time there has been no effective genetic progress made in the UK for maternal traits – with some maternal traits reported to be actually deteriorating (i.e. the calving interval between the 1^{st} and 2^{nd} calves for cows appears to have increased slightly in the last 10 years, Figure 2.1). Maternal trait EBVs have only been available to the UK beef industry since the mid to late 2000's. Initially the only published EBV representative of maternal traits was a 200 day milk EBV based on the dam contribution to weaning weights of progeny. In 2003 a project to develop maternal EBVs was undertaken by SAC, Signet and Roslin. This project looked at the trait definitions, model development and genetic parameters of the maternal traits (Roughsedge et al., 2005). In 2007 EGENES started providing genetic evaluations and for the first time incorporated maternal EBVs into the suite of EBVs offered as part of the Signet Beefbreeder genetic evaluations. However, to date there is anecdotal evidence of hesitancy in their use in the UK beef industry. The aim of this work was to demonstrate the value of maternal EBVs for selecting replacement cows that calve successfully at 2 years of age and calve easier, have shorter calving intervals, increased longevity in the herd and improved milking abilities.

1.1 The importance of maternal traits

A recent study undertaken in SAC as part of the Defra project "Determining strategies for delivering environmentally sustainable production in the UK ruminant industry through genetic improvement", estimated that 10 years of using the maternal index for selection of sires to produce replacement heifers would result in approximately £60million increase in returns over a 20 year period if the genetic improvement was used across the whole UK industry. This is more than double the impact that can be achieved by terminal sire genetic improvement.

1.2 Available maternal trait EBVs for UK beef breeders

There are 2 providers of genetic evaluations for UK beef breeds. Both the Signet Beefbreeder and ABRI BREEDPLAN genetic evaluations provide EBVs for maternal traits. Descriptions of the maternal trait EBVs available to the UK beef industry are provided in Table1.1. Although there are some differences, the maternal trait EBVs offered by both providers of genetic evaluations are similar. Both providers offer maternal trait EBVs with both direct and maternal components. The direct component of an EBV describes the value of an animals own genes for the trait of interest. Half of the direct genetic effects are inherited and expressed by offspring. The maternal component of an EBV describes the value of their mother's genes for the trait of interest. Half of the maternal genetic effects are inherited by offspring, but maternal genetic effects are only expressed in females. For example, the weaning weight of a suckled beef calf is affected not only by the genes for growth which the calf inherits from both of its parents (the direct genetic effect), and the environment it is reared in, but also by its mother's genes for maternal characteristics such as uterine capacity and milk production (the maternal genetic effect), and the environmental influences on her performance for these traits. Both males and females carry genes for milk production and other aspects of maternal performance, but only females get the chance to express them. However, with sufficient data, BLUP can predict both direct and maternal breeding values for males and females, from the relationships between animals with performance records (e.g. cows with calf weaning weights) and those without (e.g. bulls).

1.3 The availability of maternal trait phenotypes

Unlike growth and carcase traits, maternal traits are only expressed by females and are generally measured later in life. Maternal trait EBVs of sires are therefore dependent on the phenotypic performance of their daughters and in some cases their grand progeny. Because of this, accurate maternal trait EBV are difficult to achieve for young sires which do not have progeny. It can be see in Figure 1.1 that phenotypic information for growth and carcase traits are available at approximately 400 days of age. However, it is not until a sire is 6-7 years of age that the majority of maternal trait phenotypes start to become available. This coupled with heritabilities (h^2 range from 0.05 to 0.29) that are generally lower than for carcase traits (h^2 range from 0.23 to 0.40) makes accurate maternal traits EBVs for young sires unachievable with current pedigree and phenotypic record approaches. However despite these challenges, it is still possible to achieve response to selection for maternal traits.

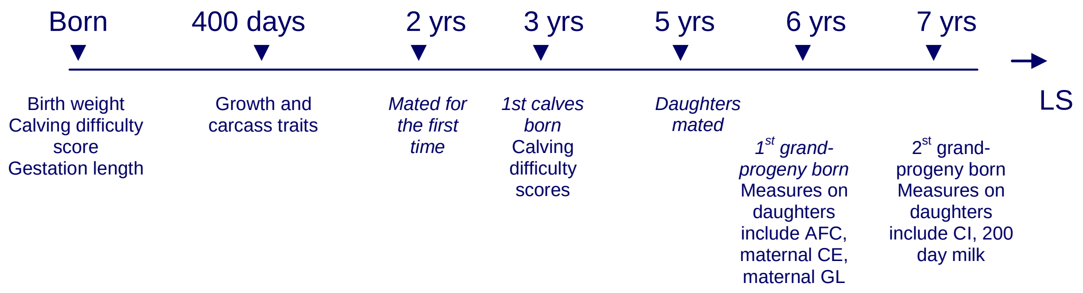

Figure 1.1: The life span of a sire showing the earliest possible ages for phenotype collection for use in genetic evaluation

Table 1.1: Available maternal trait EBVs for the UK beef industry

EBV	Units	EBV Description	Phenotype measured
Beefbreeder (source: pers com EGENES)			
200 Day Milk	Kg	An animal's maternal effect on the 200 day weight of its calf	Calf's 200 day weight
Age at first calf	Proportion	Proportion of cows that calve as a 3 year old when given the opportunity to mate as 2 years old	Days difference between the cow's and its first calf's date of birth
Calving Interval	Days	Time to recover from calving, be rejoined and calve again	Days difference between a cows 1st and 2nd calves
Gestation length	Days	Number of days from the date of conception to the calf birth date	Difference between date of conception via AI and calf birth date
Calving Ease Direct	% unassisted calvings	% of animals calves that will be born unassisted from 2 year old heifers	1-5 calving difficulty score
Calving Ease Maternal	% unassisted calvings	% of cows that calve unassisted at 2 years of age	1-5 calving difficulty score
Life span	Parities	Number of parities over the cows lifespan	1-9 score based on the number of current parities and current age of the cow
BREEDPLAN (source: http://breedplan.une.edu.au)			
200 Day Milk	Kg	Cow's maternal effect on the 200 day weight of its calf	Calf's 200 day weight
Mature cow weight	Kg	Cow live weight at 5 years of age	Cow's live weight when calf is 200 days of age
Days to calving	Days	Time from the start of the joining period until subsequent calving	Difference between calf birth date and recorded bull in date. Cows that don't calve are penalised.
Gestation length	Days	Number of days from the date of conception to the calf birth date	Difference between calf birth date and date of conception via AI or hand mating
Calving Ease Direct	% unassisted calvings	% of an animal's calves that will be born unassisted from 2 year old heifers	1-6 calving difficulty score
Calving Ease Daughters	% unassisted calvings	% of cows that calve unassisted at 2 years of age	1-6 calving difficulty score

1.4 EBV Accuracy

It is important to quantify how well we expect EBVs to predict the true breeding value (the underlying breeding value of an animal that cannot be observed). The degree to which the EBV predicts the true breeding value changes with the accuracy, i.e. higher accuracy indicates the EBV is closer to the animals' true breeding value. To establish how close EBVs are to the true breeding value when the accuracy changes the 95% confidence intervals for EBVs were computed using the formula; 95% CI = $\pm$ 1.96 × sqrt(PEV) where $PEV=(1-r^2_{A\hat{A}})\sigma^2_A$ (Cameron, 1997), PEV is the prediction error variance. The additive variance assumed was that used in the UK evaluations while the accuracy value varied. The general message is that the higher the accuracy the better guide is the EBV. For example an animal with a AFC EBV of 0.0 and acc of 30% can expect that the true breeding value ranges between -0.39 and 0.39 (EBV ± 95% confidence interval)

Table 1.2: 95% confidence intervals of EBVs to predict the true breeding value based on different EBV accuracies[*1]

		ACC (%)								
Trait[*2]	**σ^2_A**	**10**	**20**	**30**	**40**	**50**	**60**	**70**	**80**	**90**
BWT	2.12	2.8	2.8	2.7	2.6	2.5	2.3	2.0	1.7	1.2
WT200	268.32	32	31	31	29	28	26	23	19	14
WT200-m	55.24	14	14	14	13	13	12	10	9	6
WT400	635.88	49	48	47	45	43	40	35	30	22
MSC	0.36	1.2	1.2	1.1	1.1	1.0	0.9	0.8	0.7	0.5
FD *10	1854.47	84	83	81	77	73	68	60	51	37
MD *10	654.79	50	49	48	46	43	40	36	30	22
LS	0.67	1.6	1.6	1.5	1.5	1.4	1.3	1.1	1.0	0.7
CE	0.12	0.68	0.67	0.65	0.62	0.59	0.55	0.49	0.41	0.30
CE - m	0.05	0.42	0.42	0.41	0.39	0.37	0.34	0.30	0.25	0.18
GL	6.97	5.2	5.1	4.9	4.7	4.5	4.1	3.7	3.1	2.3
CI	213.08	28	28	27	26	25	23	20	17	12
AFC	0.04	0.41	0.40	0.39	0.38	0.36	0.33	0.29	0.25	0.18

[*1]- For example an animal with a AFC EBV of 0.0 and acc of 30% can expect that the true breeding value ranges between -0.39 and 0.39 (EBV ± 95% confidence interval)

[*2]- BWT=birth weight, WT200=200 day weight, WT200-m=maternal 200 day weight, WT400=400 day weight, MSC=muscle score, FD=ultrasound scanned fat depth, MD=ultrasound scanned muscle depth, LS=life span, CE=calving ease, CE-m=maternal calving ease, GL=gestation length, CI=calving interval between 1st and 2nd calves, AFC=age at first calving

1.5 Project objectives

This project had 3 main objectives:

1. Report on analysed maternal EBV data of breeds using EGENES evaluations service and review equivalent EBV availability in ABRI evaluation system.
2. Deliver farmer workshops providing clear messages about maternal EBVs to industry
3. Develop information sheet for delivery of key information on EBVs.

2.0 Analysis of maternal trait EBVs

Specific details of particular analyses will be detailed in the following sections. In brief, Limousin performance recording data and the March 2009 genetic evaluation were used to examine the relationship between the EBVs of sires and the corresponding performance of daughters. To look at EBVs as predictors of phenotypic performance over a 10 year period, a simulated 1999 genetic evaluation was undertaken based on data that would have been assumed available at the time. This run included only data and animals available prior to 1st March 1999. The same extraction procedures (e.g. contemporary grouping rules), genetic parameters and models were used to allow the runs to be comparable. In this report, the 2 evaluations will be referred to as the 1999 and 2009 genetic evaluation.

2.1 Summary of the 2009 genetic evaluation phenotype and EBV information

The 2009 evaluation produced EBVs for 393,777 animals. These EBVs were based on between 36,141 (calving interval) and 187,326 (birth weight) phenotypic records. Summaries of the phenotypes and EBVs from the 2009 genetic evaluation are recorded in Appendix A. From the 2009 genetic evaluation, 24,688 sires were identified and a summary of their EBVs are shown in Table 2.1. Generally, the higher the heritability of a trait the higher the accuracy of the EBV will be. The growth and carcase traits had the more accurate EBVs with average accuracies ranging from 0.40 to 0.53. The average accuracy of maternal trait EBVs was lower spanning from 0.37 to 0.47.

Table 2.1: A summary of the March 2009 EBVs produced for Limousin cattle that were used as sires at any time (n=24,688)

		EBV				Acc ranges (0-99)		
Trait*	**Units**	**Avg**	**Std**	**Min**	**Max**	**Avg**	**Std**	**h**
BWT	Kg	0.6	0.9	-3.3	6.4	53	28	0.50
WT200	Kg	9.2	10.2	-40	66	52	28	0.57
WT400	Kg	16	17	-59	135	51	28	0.63
MSC	Score	0.2	0.4	-1.4	2.1	46	26	0.52
FD	mm	-0.01	0.2	-0.9	1.4	40	23	0.54
MD	mm	1.1	1.7	-7.3	8.7	49	27	0.51
WT200-m	Kg	-0.3	2.5	-16	12	38	22	0.26
LS	Parities	0.1	0.3	-1.7	1.6	37	21	0.33
CE	% easy calving	-0.9	2.1	-23	4	47	26	0.35
CE - m	% easy calving	0.6	0.6	-3.8	3.1	38	21	0.22
GL	Days	-0.08	1.6	-7.1	7.3	48	27	0.54
CI	Days	0.7	3.9	-19.5	24.8	34	20	0.30
AFC	Proportion	-0.01	0.1	-0.33	0.33	41	23	0.45

***-BWT=birth weight, WT200=200 day weight, WT200-m=maternal 200 day weight, WT400=400 day weight, MSC=muscle score, FD=ultrasound scanned fat depth, MD=ultrasound scanned muscle depth, LS=life span, CE=calving ease, CE-m=maternal calving ease, GL=gestation length, CI=calving interval between 1st and 2nd calves, AFC=age at first calving**

Figure 2.1 shows the genetic trends over time for the growth, carcase and maternal traits. This figure shows that genetic progress has been made for the growth and carcase traits. However, it can also be seen for the maternal traits that the genetic trend has generally been unfavourable (i.e. increasing calving interval) due to unfavourable correlated responses with terminal sire traits. Unless maternal traits are considered as breeding objectives they will continue to decline further.

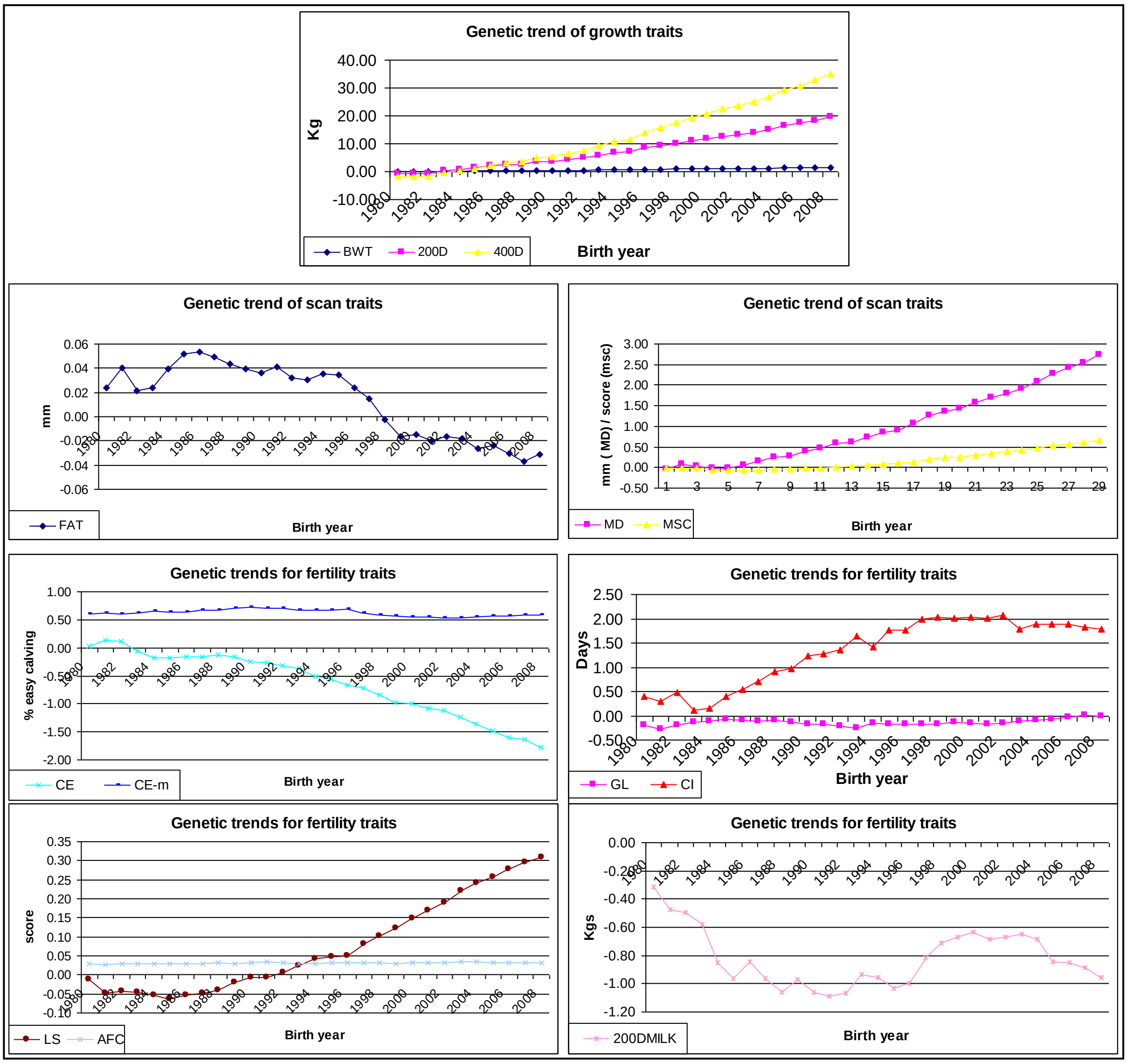

Figure 2.1: Genetic trends of growth, carcase and maternal traits for Limousin cattle
***-BWT=birth weight, 200D=200 day weight, 400D=400 day weight, MSC=muscle score, FAT=ultrasound scanned fat depth, MD=ultrasound scanned muscle depth, LS=life span, CE=calving ease, CE-m=maternal calving ease, GL=gestation length, CI=calving interval between 1st and 2nd calves, AFC=age at first calving, 200DMILK=maternal 200 day weight**

2.2 Correlations between the phenotypic information and 2009 EBVs

For all animals with phenotype information the relationship between their own and their sires EBVs were examined. Table 2.2 shows correlations between different sets of EBVs and phenotypes.

Table 2.2: Correlations between EBVs and Own phenotypes (for the female sex limited traits only females were included)

Trait*	h^2	N	r(Own EBV, Own Phen)	r(Sire EBV, Own Phen)
BWT	0.23	187326	0.40	0.16
WT200	0.33	117172	0.58	0.30
WT400	0.40	71022	0.44	0.25
FD	0.29	27490	0.43	0.15
MD	0.26	25610	0.43	0.21
MSC	0.27	30913	0.28	0.11
LS	0.11	55680	0.37	0.08
CE	0.12	99537	0.42	0.10
GL	0.29	79934	0.58	0.23
CI	0.09	36141	0.41	0.11
AFC (score)	0.20	60933	0.25	0.02
AFC (days)	-	60933	0.36	0.06
Trait*	**h^2**	**N**	**r(Dam EBV, Own Phen)**	**r(Mat GrandSire EBV, Own Phen)**
WT200-M	0.07	117152	0.19	0.10
CE -M	0.05	99537	0.26	0.11

***-BWT=birth weight, WT200=200 day weight, WT200-m=maternal 200 day weight, WT400=400 day weight, MSC=muscle score, FD=ultrasound scanned fat depth, MD=ultrasound scanned muscle depth, LS=life span, CE=calving ease, CE-m=maternal calving ease, GL=gestation length, CI=calving interval between 1st and 2nd calves, AFC=age at first calving**

The correlations for the maternal traits were comparable to correlations found for the carcass and growth traits. As expected, traits with lower heritabilities had lower correlations between the EBV and the phenotypes. These correlations were lower when the sire's EBV was used, more so when the trait was sex-limited. This illustrates one of the challenges posed by female fertility traits being sex-limited and lowly heritable. The EBV is reliant on progeny phenotypes and the relationship coefficient between the sire and progeny is 0.5 (i.e. the progeny inherits half their sires genes).

2.3 The use of 2009 EBVs to identify high accuracy maternal traits sires

For each maternal trait, high accuracy sires from different regions of the EBV distributions were identified. Although not high accuracy by the standards of growth or carcase traits, maternal trait EBVs with accuracies greater than 50% were generally considered as high. Table 2.3 shows clear and defined differences in the average EBVs between best, average and worst sire subsets (all with high accuracy EBVs).

Table 2.3: Summary of EBVs for each the selected subset of highly accurate (>50%) sires representing the best, average and worst sires

			EBV				ACC	
Trait*	**Sire subset**	**N**	**Avg**	**Std**	**Min**	**Max**	**Avg**	**Std**
AFC	Best	200	-0.16	0.03	-0.33	-0.13	68	12
AFC	Average	200	0.03	0.00	0.03	0.03	68	10
AFC	Worst	200	0.23	0.03	0.19	0.33	67	11
CI	Best	200	-9.8	2.5	-19.5	-7.0	61	10
CI	Average	200	1.8	0.2	1.5	2.1	56	7
CI	Worst	200	13.4	2.2	10.9	23.5	63	10
LS	Best	200	0.92	0.1	0.8	1.6	65	12
LS	Average	200	0.10	0	0.1	0.1	66	8
LS	Worst	200	-0.80	0.2	-1.7	-0.6	67	11
WT200-m	Best	200	5.9	1	5	12	66	10
WT200-m	Average	200	-1.0	0	-1	-1	71	8
WT200-m	Worst	200	-8.4	2	-16	-7	68	11
CE	Best	200	2.7	0.3	2.3	4.0	69	12
CE	Average	200	-0.8	0	-0.8	-0.8	70	10
CE	Worst	200	-7.8	1.8	-23	-6.1	73	12
CE-m	Best	200	2.0	0.2	1.8	3.1	65	11
CE-m	Average	200	0.5	0	0.5	0.5	63	8
CE-m	Worst	200	-1.3	0.4	-3.8	-0.9	64	10
GL	Best	200	-4.4	0.7	-7.1	-3.7	76	10
GL	Average	200	-0.2	0	-0.2	-0.2	74	6
GL	Worst	200	3.9	0.7	3.1	7.3	76	12

***- AFC=age at first calving, CI=calving interval between 1st and 2nd calves, LS=life span, WT200-m=maternal 200 day weight, CE=calving ease, CE-m=maternal calving ease, GL=gestation length**

2.4 Evaluating the phenotypic performance of the high accuracy sire subsets

To investigate the high accuracy sires subsets for each trait, all contemporary groups containing progeny from the subset sires were selected. Within these contemporary groups the individual phenotypes were deviated from the contemporary group mean and the deviations of progeny by identified sires compared. This provides some means of correcting the phenotype fixed effects.

To do this the contemporary groups (CG) were as defined in the genetic evaluation. Details of the starting CG definitions are below, However CGs are collapsed such that animals with dates within 92 days (184 if needed) were in the same group and there were at least 5 animals per CG. This ensures that meaningful group sizes are achieved.

- AFC CG = Herd and date of birth for the heifer
- CI CG = Herd and year of birth for the heifer's first calf + 6 month season
- LS CG = Herd and year of birth for the heifers's first calf + 6 month season
- WT200-m = Herd and date of birth for the calf + user defined management group
- CE CG = Herd and date of birth for the calf

- GL CG = Herd and date of birth for the cow

Table 2.4 shows that in all cases the progeny deviated-phenotypes reflected the sire subset. The differences may even be greater given that this comparison only made a simple correction for fixed effects.

Table 2.4: The mean deviated-phenotypes for progeny of high accuracy sires identified as being Best, Average and Worst for maternal traits

	Best sires			Average sires			Worst sires		
Trait*	**N**	**Mean**	**Std**	**N**	**Mean**	**Std**	**N**	**Mean**	**Std**
AFC	1973	-21	101	1604	0	95	2349	17	110
CI	2938	-7	41	1151	0	39	3260	9	48
LS	3974	0.4	2.3	3969	0.03	2	3825	-0.54	2.7
WT200-m	6389	5.3	31	9358	-0.9	32	9491	-5.1	32
CE	1222	-0.11	0.5	1883	-0.03	0.6	5342	0.1	0.7
CE-m	7637	-0.07	0.5	3533	-0.01	0.6	5480	0.12	0.7
GL	5025	-1.4	4.4	788	-0.1	4.4	6412	1.4	4.7

***- AFC=age at first calving, CI=calving interval between 1st and 2nd calves, LS=life span, WT200-m=maternal 200 day weight, CE=calving ease, CE-m=maternal calving ease, GL=gestation length**

This analysis clearly shows that high accuracy EBVs correlate with the phenotypic performance of their daughters and grand progeny. However, the average age of the high accuracy sires used was 15-20 years depending on the trait. Sires of this age would not be considered as selection candidates.

Key Message 1: Maternal trait EBVs are predictive of phenotypic performance for maternal traits
When sires had accuracies of 50% and greater they were shown to have maternal trait EBVs that were predictive of their daughters actual performance.

Key Message 2: High accuracy maternal trait EBVs are difficult to obtain for young bulls
The sires that were identified in this study as being very high accuracy were generally between 15-20 years of age and would not be considered as realistic selection candidates.

2.5 Summary of the 1999 genetic evaluation phenotypic and EBV information

At this time point, the genetic evaluation produced EBVs for 200,205 animals. These EBVs were based on between 7,174 (ultrasound muscle depth) and 117,549 (birth weight) phenotypic records. Summaries of the phenotypes and EBVs from the 1999 genetic evaluation are recorded in Appendix B. Across the whole population the 1999 and 2009 EBVs for the same animals at the different time points were very strongly correlated. This was also generally the case for the 14,973 sires that were identified in 1999 (Appendix B) with correlations between the two sets of EBVs ranging from 0.71 to 0.93.

In total there were 33,686 Limousin males identified that were 0-5 years of age in the 1999 evaluation. For these males, the correlations ranged between 0.66 and 0.94 (Table 2.5). The traits with the lower correlations were those that for which records are obtained later in life. For example, the correlation between 1999 and 2009 lifespan EBVs was only 0.60 for males 0-5 years of age. This is not surprising since sires are older than 5 years of age before they have daughters with known (or even predicted) life spans.

Table 2.5: A summary of the March 1999 EBVs produced for Limousin males born 1994-1999 and aged 0-5 years old (n=33,686)

		EBV					Acc ranges (0-99)		
Trait*	**Units**	**Avg**	**Std**	**Min**	**Max**	**$R_{Fullrun}^{\#}$**	**Avg**	**Std**	**h**
BWT	Kg	0.8	0.8	-3.7	6.3	0.94	62	11	0.50
WT200	Kg	9.7	8.9	-39	59	0.90	60	12	0.57
WT400	Kg	18.6	14.9	-56	92	0.89	58	12	0.63
MSC	Score	0.3	0.3	-1.4	1.7	0.88	53	11	0.52
FD	Mm	0.01	0.1	-0.7	1.0	0.80	44	12	0.54
MD	Mm	1.3	1.3	-4.8	7.3	0.89	56	11	0.51
WT200-m	Kg	-0.5	2.1	-10	8	0.68	41	8	0.26
LS	Score	0.09	0.2	-0.8	1.0	0.60	39	8	0.33
CE	% easy calving	-0.7	1.7	-18.1	4.4	0.89	55	10	0.35
CE - m	% easy calving	0.6	0.6	-2.5	4.2	0.77	39	9	0.22
GL	Days	-0.5	1.3	-6.8	6.3	0.94	55	11	0.54
CI	Days	1.2	3.7	-15.6	15.7	0.66	34	8	0.30
AFC	Days	0.01	0.07	-0.30	0.35	0.78	45	9	0.45

***-BWT=birth weight, WT200=200 day weight, WT200-m=maternal 200 day weight, WT400=400 day weight, MSC=muscle score, FD=ultrasound scanned fat depth, MD=ultrasound scanned muscle depth, LS=life span, CE=calving ease, CE-m=maternal calving ease, GL=gestation length, CI=calving interval between 1st and 2nd calves, AFC=age at first calving. # Rfullrun=correlation between the 1999 EBV and the 2009 EBV**

Key Message 3: There are strong positive correlations between the maternal trait EBVs of males aged 0-5 years and their maternal trait EBV as 10-15 year olds
Correlations ranged from 0.60 to 0.94 for maternal traits. In comparison, correlations ranged from 0.80 to 0.94 for growth and carcase traits. This indicates that EBVs estimated for young bulls provide a good guide to the actual genetic potential of these bulls.

2.6 Analysing the 1999 EBVs for the high accuracy sire subsets selected using 2009 EBVS

Of the 2009 sires identified in section 2.3 as being high accuracy, approximately 150 were present in the 1999 genetic evaluation. Table 2.6 shows a summary of the 1999 EBVs for the different sire subsets (best, average and worst EBV). While the standard deviations were larger 10 years prior there were still distinct differences between the sire subsets. The accuracy of these EBVs were still relatively high as there were still sires older than sires that would be considered for breeding.

Table 2.7 looks only at the sires that were aged 0-5 years in 1999 but went onto be selected as a high accuracy sire in 2009. On average there were 50 sires per subset (best, average, worst EBV) that were 0-5 years of age in 1999. Again the standard deviations were larger but more importantly, the average EBVs of the different subsets were still ranked as expected given the known EBVs in 2009 when the bulls were 10-15 years old. The average accuracies of these 0-5 year old sires were lower and varied depending on the trait.

Table 2.6: Summary of 1999 EBVs for each of the selected high accuracy sire subset representing the best, average and worst sires from 2009

				EBV			ACC	
Trait*	**Sire subset**	**N**	**Avg**	**Std**	**Min**	**Max**	**Avg**	**Std**
AFC	Best	156	-0.12	0.07	-0.32	0.16	59	16
AFC	Average	166	0.01	0.05	-0.12	0.22	61	12
AFC	Worst	157	0.16	0.09	-0.06	0.43	59	14
CI	Best	177	-5.9	5.4	-19.9	9.2	51	16
CI	Average	160	1.0	3.2	-7.2	11.6	51	11
CI	Worst	179	7.5	5.2	-10.9	21.3	50	15
LS	Best	136	0.36	0.31	-0.3	1.2	48	17
LS	Average	180	0.13	0.17	-0.3	0.7	58	13
LS	Worst	199	-0.41	0.32	-1.2	0.7	60	14
WT200-m	Best	159	4.2	3	-3	12	57	14
WT200-m	Average	179	-0.4	2	-8	7	59	15
WT200-m	Worst	175	-5.4	3	-13	2	57	17
CE	Best	91	-5.0	3.2	-11.5	0.5	60	22
CE	Average	122	-0.7	0.6	-2.1	1.7	67	12
CE	Worst	197	2.4	0.6	-1.4	3.9	67	13
CE-m	Best	141	-0.8	0.8	-3.8	1.4	54	15
CE-m	Average	176	0.3	0.3	-0.6	1.3	57	11
CE-m	Worst	147	1.6	0.5	0.3	3.5	57	15
GL	Best	176	-4.6	0.9	-7.1	-1.0	73	12
GL	Average	145	-0.5	0.4	-2.0	1.8	72	9
GL	Worst	139	2.5	1.7	-1.5	6.1	66	23

***- AFC=age at first calving, CI=calving interval between 1st and 2nd calves, LS=life span, WT200-m=maternal 200 day weight, CE=calving ease, CE-m=maternal calving ease, GL=gestation length**

There were not enough sires to look further at specific ages. These results show that despite low numbers being compared the rankings of the sire subgroups as a whole remain the same as in 2009. The ranges of the 1999 EBVs were not as distinct as in 2009 and therefore some individuals will not have the same ranking between 1999 and 2009. This is because when aged 0-5 years the accuracies of the EBVs are low and it is difficult to predict the true EBV. For example, sires 1483185 and 1404490 were both born in 1997 (2 year old) and in 1999 both had an AFC EBV of 0.01 with accuracy of 16 and 17%, respectively. With such low accuracy changes are expected and in 2009 sire 1483185 went on to be a highly accurate Best sire while 1404490 went on to be a highly accurate Worst sire for AFC.

Key Message 4: The rankings of the older high accuracy maternal trait sires were the same when they were 0-5 years of age

Although differences were smaller, the males aged 0-5 years in 1999 ranked the same as when they were the high accuracy sire subsets selected in 2009. This indicates that choosing the best EBV bull when it is young is expected to provide the best option to achieve progress in maternal traits.

Table 2.7: Summary of 1999 EBVs for each of the selected high accuracy sire subsets representing the best, average and worst sires from 2009 where sires are aged 0-5 years in 1999

			EBV				ACC	
Trait*	**Sire subset**	**N**	**Avg**	**Std**	**Min**	**Max**	**Avg**	**Std**
AFC	All 0-5 males	33686	0.01	0.07	-0.30	0.35	45	9
AFC	Best	54	-0.08	0.08	-0.21	0.16	47	14
AFC	Average	59	0.01	0.05	-0.10	0.11	52	9
AFC	Worst	50	0.11	0.10	-0.06	0.32	50	10
CI	All 0-5 males	33686	1.2	3.7	-15.6	15.7	35	8
CI	Best	54	-2.1	5.0	-14.4	8.9	35	10
CI	Average	47	-0.7	3.2	-6.9	6.1	43	9
CI	Worst	71	4.6	4.0	-10.9	12.5	39	9
LS	All 0-5 males	33686	0.09	0.20	-0.8	1.0	39	8
LS	Best	70	0.22	0.19	-0.2	0.7	37	12
LS	Average	56	0.09	0.15	-0.3	0.5	46	11
LS	Worst	36	-0.06	0.24	-0.5	0.7	43	10
WT200-m	All 0-5 males	33686	-0.5	2	-10	8	41	8
WT200-m	Best	48	1.2	2	-3	7	42	11
WT200-m	Average	54	-1.0	2	-5	2	44	12
WT200-m	Worst	42	-2.9	3	-9	2	41	14
CE	All 0-5 males	33686	-0.7	1.7	-18.1	4.4	55	10
CE	Best	18	1.7	1.3	-1.4	3.3	56	17
CE	Average	46	-0.6	0.7	-1.9	1.7	63	12
CE	Worst	50	-3.8	3.2	-9.8	0.5	51	21
CE-m	All 0-5 males	33656	0.6	0.6	-2.5	4.2	39	9
CE-m	Best	28	1.3	0.5	0.5	2.1	42	13
CE-m	Average	51	0.3	0.4	-0.6	1.2	48	10
CE-m	Worst	66	-0.3	0.6	-1.7	1.4	44	8
GL	All 0-5 males	33686	-0.5	1.3	-6.8	6.3	55	11
GL	Best	36	-4.5	1.0	-6.5	-1.1	66	12
GL	Average	42	-0.6	0.5	-1.5	1.2	65	10
GL	Worst	48	1.4	1.8	-1.5	3.8	50	24

***- AFC=age at first calving, CI=calving interval between 1st and 2nd calves, LS=life span, WT200-m=maternal 200 day weight, CE=calving ease, CE-m=maternal calving ease, GL=gestation length**

2.7 Selecting sires using 1999 EBVs and evaluating them based on 2009 evaluations

Given that there were low number of males aged 0-5 that went on to be identified as high accuracy sires in 2009. Selection using 1999 EBVs was considered in a forwards approach. There were 3585 males in 1999 aged 0-5 years that went on to be a sire in 2009. From these males the Best, Average and Worst 2 and 5 year old sires were identified for each trait provided the 1999 accuracy was greater than 40%. It was not possible to select 200 sires for each subset as there were not enough sires identified with the required accuracy. The 1999 and 2009 EBVs were compared for these chosen 2 and 5 year old sires (Table 2.8 and 2.9 for 2 and 5 year old males, respectively).

Table 2.8: Comparison of selected males aged 2 years in 1999 and with a minimum accuracy of 40% and the final 2009 EBVs

			1999				2009			
			EBV		ACC		EBV		ACC	
Trait*	Sire subset	N	Avg	Std	Avg	Std	Avg	Std	Avg	Std
AFC	Best	150	-0.06	0.03	51	5	-0.03	0.06	61	10
AFC	Average	150	0.02	0.02	50	5	0.03	0.05	58	9
AFC	Worst	150	0.10	0.05	53	6	0.09	0.06	59	9
CI	Best	50	-4.19	2.80	46	5	-0.70	4.70	54	6
CI	Average	50	0.75	0.76	46	5	3.49	3.94	54	5
CI	Worst	50	5.41	1.92	44	3	5.06	4.84	53	5
LS	Best	90	0.35	0.10	48	5	0.31	0.36	57	8
LS	Average	90	0.13	0.05	47	5	0.16	0.24	56	6
LS	Worst	90	-0.07	0.09	47	4	-0.08	0.28	56	7
WT200-m	Best	120	2.19	1.25	47	4	1.13	2.00	58	7
WT200-m	Average	120	-0.44	0.58	47	6	-0.42	2.33	56	7
WT200-m	Worst	120	-2.89	1.28	48	5	-2.41	2.79	57	7
CE	Best	190	0.58	0.58	58	6	0.35	0.93	66	10
CE	Average	190	-1.02	0.39	58	6	-0.97	1.04	67	11
CE	Worst	190	-2.94	1.30	60	5	-2.38	1.44	70	11
CE-m	Best	90	1.17	0.40	47	5	0.92	0.61	57	6
CE-m	Average	90	0.39	0.14	47	5	0.37	0.48	57	7
CE-m	Worst	90	-0.30	0.40	47	5	-0.31	0.68	58	6
GL	Best	190	0.67	0.65	59	8	0.98	0.90	67	11
GL	Average	190	-0.67	0.29	60	9	-0.15	0.67	66	10
GL	Worst	190	-2.04	0.73	61	8	-1.46	0.99	67	10

***- AFC=age at first calving, CI=calving interval between 1st and 2nd calves, LS=life span, WT200-m=maternal 200 day weight, CE=calving ease, CE-m=maternal calving ease, GL=gestation length**

These results show that the rankings remain the same for these sire sub groups. For example, the Best sires in 1999 were still the Best sires in 2009 compared to the other selected sire sub groups. The standard deviations were larger in the 2009 evaluation for the selected sires. However, this can be attributed to changes in accuracy and the resulting changes in the EBVs increasing the spread of values.

The difference between the Best and Worst sires was also smaller in 2009 – generally with the average EBV of Best sires being smaller. The explanation for this is the additional 10 years of information available on animals which are presumable genetically better than their predecessors. Despite the assumed genetic improvement of the more recent animals, the distribution of EBVs remains similar because BLUP scales the EBVs according to the assumed genetic parameters which were kept constant for both evaluations. Therefore, the range of EBVs are still similar and because the modern animals are usually genetically better, the sires selected as being ‘Worst’ are still at the tail end of the distribution. This is not the case for the sires selected as being the ‘Best’ in 1999. In the initial evaluation they were at the tail of the distribution, but the inclusion of genetically better animals shifts them towards to centre of the distribution reducing the value of the EBV observed.

Using similar methodology to section 2.4 an attempt was made to compare the 2009 phenotypes of progeny with the 1999/2009 EBVs of the sire subsets. However this proved not to be statistically valid given the small progeny group sizes. The result of the progeny group sizes meant that we were unable to obtain significant results from using industry data. This was also the case when selection strategies also considered narrower accuracy ranges.

Table 2.9: Comparison of selected males aged 5 years in 1999 and with a minimum accuracy of 40% and the final 2009 EBVs

			1999				2009			
			EBV		ACC		EBV		ACC	
Trait*	**Sire subset**	**N**	**Avg**	**Std**	**Avg**	**Std**	**Avg**	**Std**	**Avg**	**Std**
AFC	Best	170	-0.08	0.05	53	6	-0.04	0.06	59	10
AFC	Average	170	0.01	0.02	53	6	0.03	0.05	59	11
AFC	Worst	170	0.10	0.05	54	6	0.09	0.06	60	9
CI	Best	90	-4.33	3.25	46	4	-2.00	5.07	53	6
CI	Average	90	0.90	0.77	46	4	2.16	3.93	53	7
CI	Worst	90	6.25	2.28	46	4	4.87	5.09	53	7
LS	Best	140	0.37	0.13	49	5	0.30	0.26	57	8
LS	Average	140	0.14	0.05	48	5	0.14	0.28	57	9
LS	Worst	140	-0.11	0.13	48	4	-0.13	0.29	55	9
WT200-m	Best	150	2.51	1.35	50	5	1.27	1.92	57	9
WT200-m	Average	150	-0.42	0.56	49	5	-0.73	2.20	56	9
WT200-m	Worst	150	-3.12	1.38	49	5	-2.49	2.52	57	9
CE	Best	190	0.98	0.57	62	9	0.91	0.90	65	10
CE	Average	190	-0.68	0.43	64	10	-0.71	0.85	67	12
CE	Worst	190	-2.98	1.68	67	11	-2.61	1.62	71	12
CE-m	Best	140	1.30	0.66	48	5	1.13	0.47	57	8
CE-m	Average	140	0.47	0.16	49	5	0.57	0.45	57	8
CE-m	Worst	140	-0.25	0.37	49	6	0.02	0.50	57	8
GL	Best	190	0.96	0.75	64	10	1.32	0.87	67	12
GL	Average	190	-0.57	0.30	63	9	-0.17	0.62	67	11
GL	Worst	190	-2.07	0.88	64	9	-1.31	0.90	67	10

***- AFC=age at first calving, CI=calving interval between 1st and 2nd calves, LS=life span, WT200-m=maternal 200 day weight, CE=calving ease, CE-m=maternal calving ease, GL=gestation length**

2.8 Conclusions

This research has shown that the maternal trait EBVs of sires with reasonable accuracies (40%) can predict the maternal trait performance of their daughters. However, this study did highlight the difficulty in producing high accuracy maternal trait EBVs for young sires. The reasons for this is that the traits generally have lower heritabilities and are sex-limited so can only be measured on their daughters. Furthermore, the traits are only measureable post puberty and in some cases only after a heifer has had multiple parities. Several approaches were pursued to compare the daughter phenotypes of younger less accurate sires to their EBVs. However there were not enough daughter records to draw significant and meaningful conclusions. We were able to conclude that the EBV rankings of the high accuracy older sires were the same when current EBVs were compared with EBVs 10 years prior when the sires were younger with less accurate EBVs. Given this it is reasonable to assume that had there been sufficient daughter phenotypes available in the industry data, the results would have shown that the daughter phenotypes were reflective of the young sire's maternal trait EBVs.

This research highlighted the challenges associated with selecting sires for maternal traits. The lower heritabilities, sex limitation and late expression make maternal traits difficult to select for. However, there are significant benefits to overcoming these challenges and genetically improving maternal traits. In order to fully exploit these benefits in improving maternal traits the beef breeding sector needs to implement a new approach to the design of breeding programmes for maternal traits. In conjunction with the beef breeding industry further investigation is required into the different breeding program designs that could be employed to select for maternal traits. Possible breeding program options may include the following components; two tier selection strategies, progeny test schemes, use of AI and use of genomic selection.

Key Message 5: Traditional selection approaches may not be optimal when selecting for maternal traits
Given the low heritiabilities and difficulty (i.e. sex limited and late expression) of performance recording for maternal traits it is not easy to get high accuracy estimates of maternal trait EBVs on young sires. Further investigation into possible **workable** breeding program designs for selecting for maternal traits are required for the UK beef industry.

3.0 Workshop and Technical note

A breed society focused workshop has been planned for 25th November 2010. The program for this workshop includes a view of what the commercial suckled calf producer wants, transfer of information about maternal traits and what they mean, presentation of the results from this project and breakout groups based on possible breeding program options to genetically improve maternal traits. Attached to Appendix C are a provisional agenda for the workshop and the technical notes that were developed as part of this project.

Appendix A: Summary of the 2009 genetic evaluation phenotypic and EBV information

A summary of the available phenotypic information and resulting EBVs are shown in Tables A.1 and A.2, respectively.

Table A.1: A summary of the raw phenotypes of Limousin animals in the genetic evaluation

Trait*	Units	N	Avg	Std	Min	Max
BWT	Kg	187326	37	5	10	80
WT200	Kg	117172	263	44	52	492
WT400	Kg	71022	484	95	35	844
MSC	Score	30913	9	3	2	16
FD	mm*10	27490	284	139	2	1475
MD	mm*10	25610	767	110	60	1170
LS	Score	55680	5	3	1	9
CE	Linear transformed score	99537	0.09	0.64	-0.20	2.60
GL	Days	79934	291	6	260	310
CI	Days	36141	402	59	290	630
AFC	Days	60933	1011	121	548	1278

***-BWT=birth weight, WT200=200 day weight, WT400=400 day weight, MSC=muscle score, FD=ultrasound scanned fat depth, MD=ultrasound scanned muscle depth, LS=life span, CE=calving ease, GL=gestation length, CI=calving interval between 1st and 2nd calves, AFC=age at first calving**

TableA.2: A summary of the March 2009 EBVs produced for Limousin cattle (n=393,777)

		EBV				Acc ranges (0-99)		
Trait*	Units	Avg	Std	Min	Max	Avg	Std	h
BWT	Kg	0.8	0.9	-4.5	7.9	58	17	0.50
WT200	Kg	9.8	10.4	-50	66	57	18	0.57
WT400	Kg	16.7	17.9	-85	135	55	18	0.63
MSC	Score	0.2	0.4	-1.8	2.2	50	16	0.52
FD	Mm	-0.01	0.2	-1.0	2	43	16	0.54
MD	Mm	1.2	1.7	-7.8	10	53	17	0.51
WT200-m	Kg	-0.6	2.4	-17	30	42	14	0.26
LS	Score	0.1	0.3	-1.7	1.8	41	14	0.33
CE	% easy calving	-1.1	2.0	-24.9	4.4	52	16	0.35
CE - m	% easy calving	0.7	0.6	-4.0	3.2	41	14	0.22
GL	Days	0.03	1.5	-8.4	7.7	52	17	0.54
CI	Days	1.2	4.0	-21.7	30.6	37	14	0.30
AFC	Days	0.02	0.1	-0.38	0.39	45	15	0.45

***-BWT=birth weight, WT200=200 day weight, WT200-m=maternal 200 day weight, WT400=400 day weight, MSC=muscle score, FD=ultrasound scanned fat depth, MD=ultrasound scanned muscle depth, LS=life span, CE=calving ease, CE-m=maternal calving ease, GL=gestation length, CI=calving interval between 1st and 2nd calves, AFC=age at first calving**

Appendix B: Summary of the 1999 genetic evaluation phenotypic and EBV information

Table B.1: A summary of the raw phenotypes of Limousin animals in the genetic evaluation

Trait*	Units	N	Avg	Std	Min	Max
BWT	Kg	117549	37	5	10	80
WT200	Kg	61836	254	41	52	489
WT400	Kg	35312	467	91	35	791
MSC	Score	15328	10	2	2	15
FD	mm*10	9062	243	111	2	938
MD	mm*10	7174	747	97	390	1050
LS	Score	27134	5	3	1	9
CE	Linear transformed score	37081	0.08	0.64	-0.2	2.6
GL	Days	42789	290	6	260	310
CI	Days	17162	398	58	290	630
AFC	Days	30041	995	125	548	1278

***-BWT=birth weight, WT200=200 day weight, WT400=400 day weight, MSC=muscle score, FD=ultrasound scanned fat depth, MD=ultrasound scanned muscle depth, LS=life span, CE=calving ease, GL=gestation length, CI=calving interval between 1st and 2nd calves, AFC=age at first calving**

TableB.2: A summary of the March 1999 EBVs produced for Limousin cattle (n=200,205)

		EBV					Acc ranges (0-99)		
Trait*	Units	Avg	Std	Min	Max	$R_{Fullrun}$	Avg	Std	h
BWT	Kg	0.5	0.8	-3.7	7.5	0.95	59	17	0.50
WT200	Kg	5.6	9.0	-47	59	0.91	58	17	0.57
WT400	Kg	10.3	15	-82	95	0.90	56	17	0.63
MSC	Score	0.1	0.4	-1.8	1.8	0.90	50	15	0.52
FD	Mm	0.005	0.1	-0.8	1.8	0.82	41	14	0.54
MD	Mm	0.6	1.3	-6.1	7.8	0.91	54	16	0.51
WT200-m	Kg	-0.3	2.4	-18	26	0.73	42	13	0.26
LS	Score	0.04	0.2	-1.4	1.4	0.73	40	13	0.33
CE	% easy calving	-0.7	2.7	-30.1	4.4	0.92	52	15	0.35
CE - m	% easy calving	0.6	1.0	-9.2	4.5	0.83	41	13	0.22
GL	Days	-0.3	1.7	-8.9	8.5	0.94	54	17	0.54
CI	Days	0.7	3.7	-19.9	24.3	0.78	36	13	0.30
AFC	Days	0.004	0.08	-0.36	0.43	0.89	45	14	0.45

***-BWT=birth weight, WT200=200 day weight, WT200-m=maternal 200 day weight, WT400=400 day weight, MSC=muscle score, FD=ultrasound scanned fat depth, MD=ultrasound scanned muscle depth, LS=life span, CE=calving ease, CE-m=maternal calving ease, GL=gestation length, CI=calving interval between 1st and 2nd calves, AFC=age at first calving**

Table B.3: A summary of the March 1999 EBVs produced for Limousin cattle that were used as sires at any time (n=14,973)

		EBV					Acc ranges (0-99)		
Trait*	**Units**	**Avg**	**Std**	**Min**	**Max**	**$R_{Fullrun}$**#	**Avg**	**Std**	**h**
BWT	Kg	0.4	0.7	-3.3	6.3	0.92	53	27	0.50
WT200	Kg	1.5	8.4	-39	51	0.85	52	26	0.57
WT400	Kg	9.0	13.9	-54	92	0.84	50	26	0.63
MSC	Score	0.1	0.3	-1.7	1.8	0.85	46	24	0.52
FD	Mm	-0.01	0.1	-0.8	0.9	0.80	38	21	0.54
MD	Mm	0.6	1.1	-5.9	6.8	0.87	49	25	0.51
WT200-m	Kg	0.06	2.4	-13	12	0.76	39	20	0.26
LS	Score	0.01	0.2	-1.2	1.2	0.71	38	19	0.33
CE	% easy calving	-0.4	2.5	-23.5	3.9	0.89	47	24	0.35
CE - m	% easy calving	0.4	1.0	-5.7	4.2	0.81	38	19	0.22
GL	Days	-0.5	1.7	-7.1	7.5	0.92	49	26	0.54
CI	Days	0.4	3.6	-19.9	21.3	0.80	34	18	0.30
AFC	Days	-0.01	0.09	-0.32	0.43	0.93	43	22	0.45

***-BWT=birth weight, WT200=200 day weight, WT200-m=maternal 200 day weight, WT400=400 day weight, MSC=muscle score, FD=ultrasound scanned fat depth, MD=ultrasound scanned muscle depth, LS=life span, CE=calving ease, CE-m=maternal calving ease, GL=gestation length, CI=calving interval between 1st and 2nd calves, AFC=age at first calving. # Rfullrun=correlation between the 1999 EBV and the 2009 EBV**

Appendix C: Agenda for workshop and technical notes

Workshop For Breed Societies On Maternal EBVs

Thursday 25th November 2010.

Venue: Quality Hotel, Edinburgh Airport

10.00	Arrival and coffee	
10.30	Welcome and introduction	Donald Biggar, QMS
10.35	What maternal EBVs are available and what do they mean?	Gavin Hill, SAC
10.50 – 10.55	Questions	
10.55	Do maternal EBVs work? – Results from QMS funded project	Kirsty Moore, SAC
11.15 – 11.20	Questions	
11.20 – 11.35	A breeders perspective	John Elliot, Roxburgh Mains
11.35 – 11.40	Questions	
11.40	How can we improve the genetic gains for maternal traits?	Tim Roughsedge, SAC
12.00 – 12.05	Questions	
12.05 – 12.20	Panel session	
12.20 – 12.30	Introduction to afternoon workshop	
12.30 – 13.30	Lunch	
13.30 – 14.30	Group workshops on aspects to improving the genetic progress of maternal traits for UK beef breeders	
14.30 – 15.00	Groups report back	Ian Pritchard, SAC
15.00 – 15.15	Coffee	
15.15 – 16.00	Groups report back	
16.00 – 16.15	What now?	Geoff Simm, SAC Basil Lowman, SAC

Technical notes