

Maternal Productivity in Beef Cattle

The impact on the female herd of genetic selection for a
divergence in fatness or feed efficiency

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DECLARATION

I declare that this is my own account of my research and contains as its main content work which has not been submitted for a degree at any tertiary education institution.

.....

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ABSTRACT

Beef cows, particularly as part of seed stock and cow/calf enterprises, are farmed extensively in temperate environments in southern Australia. The fundamental premise of a productive beef enterprise is a calving interval of 365 days. However, production system efficiency can also be determined by comparing inputs, namely megajoules of energy in the form of food, to outputs, namely the number of kilograms of beef sold each year. This thesis examined two heritable and economically desirable traits and the impact that selection to improve these traits had on beef herd productivity – defined in this thesis as *Maternal Productivity*. Selection for reduced fatness, achieved by selecting animals on the basis of low Rib Fat EBVs, can increase profitability because of consumer demand for lean meat and because sellers of cattle for slaughter are penalised if the carcasses have too much fat on them. Selection for an improvement in feed-efficiency through the trait *Net Feed Intake* (NFI) can improve profitability because it allows an increase in stocking rates or a reduction in the number of megajoules supplied to the herd for the same level of production.

There are concerns about the continued selection for these traits, particularly when energy supply is restricted such as in times of drought. There is evidence from other intensive production industries that single trait selection can compromise other desirable and necessary traits and that reduced body fatness reduces fertility in the long term. The impact of selection for fatness or feed-efficiency on *Maternal Productivity* was reported in this thesis.

Two hundred Angus heifers, selected for a divergence in either fatness (Fat vs. Lean) or feed-efficiency (high-NFI vs. low-NFI), were subjected over two breeding cycles to either a high- or a low-nutritional treatment on an extensive grazing system in the south-west of Western Australia.

Lean animals were phenotypically leaner than Fat animals at all stages of the breeding cycle and had higher predicted carcass yields than Fat animals, confirming the assumed economic benefit for selection for leanness. This result also confirmed that using Estimated Breeding Values to select for a divergence in fatness works. Low-NFI animals were phenotypically leaner than high-NFI animals at all stages of the breeding cycle and had higher predicted carcass yields than high-NFI animals. This result showed that differences in fatness between high- and low-NFI cattle previously identified in finished, grain-fed animals, persisted in the female grazing herd over two parities. There were no differences between experimental Genotypes in estimations of post-partum anoestrus interval based on fortnightly measures of blood progesterone post-calving. There were no differences between experimental Genotypes in the production measures of days-to-calving or birth, growth and weaning weights but on the low-nutrition treatment days-to-calving increased, and growth and weaning weights were lower than on the high-nutrition treatment. Although not statistically significant, there was a strong trend indicating that low-NFI animals consumed fewer megajoules of energy per kilogram of beef weaned. Nutritional treatment did not affect one particular Genotype more than the other but in all Genotypes, animals on low-nutrition consumed fewer megajoules of energy for each kilogram of calf liveweight (beef) weaned. This result suggests that selection for increased feed-efficiency will enable producers to increase stocking rates and that restricted nutrition will not decrease productivity.

Blood parameters were measured before and after calving to determine whether the Genotypes were associated with different physiological responses to nutritional restriction. No single blood parameter could be used as a marker to distinguish one Genotype from another. Beta-hydroxybutyrate and leptin were most closely associated with body condition and energy balance and differed between Genotypes when there was a difference in adiposity.

Mutations in the bovine leptin gene were examined to determine whether associations with fatness and feed-efficiency, previously reported in North American cattle, were evident in Australian cattle. The mutations were found to exist in the experimental cattle but with differing distributions and associations to those previously reported. An association between one polymorphism (E2JW) and feed-efficiency was noted but shown to be inappropriate for use as a tool in marker-assisted selection. Other associations with circulating leptin concentrations were reported.

The studies reported in this thesis showed that after two breeding cycles, *Bos taurus* cattle selected for reduced fatness or increased feed-efficiency were not compromised in terms of Maternal Productivity when nutrition is restricted. Producers can be re-assured that continued selection for these desirable traits will not impact in a negative way on the female herd. However, it must be noted that the experiment will continue for another three generations and consequently the results might change.

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PUBLICATIONS

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2. Laurence, M., Barnes, A., Taylor, E. Pethick, D., Jones, F., Speijers, J., Accioly, J. 2008. *Maternal traits in beef cattle are not compromised by selection for yield or feed efficiency*. Proceedings of the Beef CRC Post-graduate Conference, Gold Coast.
3. Laurence, M., Barnes, A., Taylor, E., Costa, N., Accioly, J. 2007. *Genetic impacts on the MP of beef cattle in variable temperate environments*. Proceedings of the Beef CRC Post-graduate Conference, Bribie Island.
4. Laurence, M., Barnes, A., Taylor, E., Pethick, D., Accioly, J. 2006. *The effect of nutrition on MP in cattle selected for NFI and Fatness*. Proceedings of the Beef CRC Post-graduate Conference, Coffs Harbour.

LIST OF ABBREVIATIONS

A	author
ADG	average daily gain
AGBU	Animal Genetic and Breeding Unit
AS	accredited scanner
ATP	adenosine tri-phosphate
BCS	body condition score
BHB	beta-hydroxybutyrate
BLUP	best linear unbiased predictor
BSE	breeding soundness examination
BW	liveweight
CI	confidence interval
CL	corpus luteum
CP	crude protein
CRC	Co-operative Research Centre
DAFWA	Department of Agriculture and Food Western Australia
DEXA	dual-energy x-ray absorptiometry
DIR	direct
DM	dry matter
DMD	dry matter digestibility
DTC	days to calving
DTRS	Daughters
E	Environment
EBV	estimated breeding value
EMA	eye muscle area
FCR	feed conversion ratio
FOO	food on offer
FSH	follicle-stimulating hormone
G	gram
GF	gross efficiency
GH	growth hormone
GnRH	gonadotrophin-releasing hormone
h^2	heritability

HWE	Hardy-Weinberg Equilibrium
IGF-1	insulin-like growth factor 1
IMF	intra-muscular fat
kg	kilogram
L	litre
LH	luteinising hormone
LHRH	luteinising hormone-releasing hormone
LMM	linear mixed model
MAS	marker-assisted selection
ME	metabolisable energy
MJ	megajoule
MLA	Meat and Livestock Australia
mm	millimetres
MP	maternal productivity
NEFA	non-esterified fatty acid
NLIS	national livestock identification system
NIDDK	National Institute of Diabetes and Digestive and Kidney Diseases
NFI	net feed intake
NO	nitrous oxide
NPY	neuropeptide-Y
P8	P8 fatness measured at the position 8 rump site
PBBA	Performance Beef Breeders Association
PEG	Partial Efficiency of Growth
PGF2 α	prostaglandin F2 α
PGR	pasture growth rate
P	phenotype
P8	depth of fat measured at the position 8 rump site
PPAI	post-partum anoestrus interval
QTL	qualitative trait loci
RBV	retail beef yield
RFI	residual feed intake
RPRD	boneless retail product and lean trim adjusted to 20% fat from one carcass side
RTUS	real time ultrasound scanning
SF6	sulfa-hexafluoride
SNP	single nucleotide polymorphism
SE	standard error
US	ultrasound
VFA	volatile fatty acid
VRC	Vasse Research Centre
YG1	superior yield class

TABLE OF CONTENTS

Declaration	2
Abstract	3
Acknowledgements	6
Publications	9
List of abbreviations.....	10
Table of contents	12
List of figures	19
List of tables.....	22
Introduction	24
CHAPTER 1. Review of literature.....	27
1.1 Reproduction in female cattle	27
1.1.1 The oestrous cycle.....	28
1.2 Genetic improvement of cattle.....	34
1.2.1 Animal Breeding	34
1.2.2 Breedplan	35
1.3 Experimental traits	39
1.3.1 Net Feed Intake	39
1.3.2 Fatness.....	51
1.4 Blood parameters	57
1.4.1 Leptin	57
1.4.2 Mutations in leptin gene.....	65

1.4.3	Growth hormone	69
1.4.4	Insulin-like growth factor-1	72
1.4.5	Non-esterified fatty acids and beta-hydroxybutyrate.....	74
1.4.6	Glucose.....	76
1.4.7	Acetate.....	77
1.5	General aims.....	79
CHAPTER 2. General material and methods.....		81
2.1	Animals	81
2.1.1	Western Australian Industry Animals.....	82
2.2	Individual feed test.....	83
2.3	Allocation of animals to the experiment	86
2.3.1	2007.....	86
2.3.2	2008.....	87
2.4	Joining.....	90
2.4.1	2006.....	90
2.4.2	2007.....	92
2.4.3	2008.....	92
2.5	Liveweight measurement	93
2.6	Collection of blood samples.....	93
2.7	Pregnancy diagnosis.....	94
2.8	Live animal ultrasound techniques.....	94
2.9	Calving.....	96
2.9.1	Birth weight recording	96
2.9.2	Obstetrical problems	97
2.9.3	Post-calving collection of blood samples.....	98
2.10	Statistical analyses	99

2.10.1	Genotype definition.....	100
2.10.2	Interpretation of bar charts	101
2.10.3	Fixed and random terms.....	102
2.11	Animal health.....	104
2.11.1	Routine vaccination of all heifers and cows	104
2.11.2	Routine vaccination of bulls.....	104
2.11.3	Anti-parasitic treatment.....	105
2.11.4	Trace Elements.....	105
2.12	Nutritional treatments.....	105
2.12.1	Grazing green pasture	107
2.12.2	Grazing dry pasture	109
2.12.3	Supplementary feeding.....	109
2.13	Blood parameter assays - hormones.....	110
2.13.1	Progesterone.....	110
2.13.2	Growth hormone	111
2.13.3	Insulin.....	112
2.13.4	Insulin-like growth factor-1	115
2.13.5	Leptin	117
2.14	Blood parameter assays - metabolites	117
2.14.1	Beta-hydroxybutyrate.....	117
2.14.2	Non-esterified Fatty Acids	117
2.14.3	Glucose.....	117
2.14.4	Acetate.....	118
CHAPTER 3. Measuring and assessing fatness, and predicting beef carcass retail product in cows selected for a divergence in fatness or feed efficiency.....		119
3.1	Introduction.....	119

3.2	Aims	121
3.3	Hypotheses	122
3.4	Materials and methods	122
3.4.1	Statistical analysis	124
3.5	Results	128
3.5.1	Comparison of scan results obtained by the author and an accredited scanner.....	128
3.5.2	3 rd trimester P8 fatness	130
3.5.3	P8 fatness during the breeding season 2008	132
3.5.4	Change in P8 fatness during the breeding season	134
3.5.5	Predicted carcass yield and liveweight change over the breeding cycle...	137
3.6	Discussion	139
CHAPTER 4. Estimation of the length of the post-partum anoestrus interval in beef cows on an extensive grazing system.....144		
4.1	Introduction	144
4.2	Aim.....	145
4.3	Hypothesis.....	146
4.4	Materials and methods	146
4.4.1	Animals	146
4.4.2	Data collection	146
4.4.3	Estimation of post-partum anoestrus interval	147
4.4.4	Statistical Analysis	149
4.5	Results	149
4.6	Discussion	152
CHAPTER 5. Production measures and herd efficiency in a beef production system using cows selected for a divergence in fatness or feed efficiency.....156		

5.1	Introduction	156
5.1.1	Production parameters.....	157
5.1.2	Efficiency parameters.....	159
5.2	Aims	161
5.3	Hypotheses	162
5.4	Materials and methods	162
5.4.1	Animals	162
5.4.2	Data collection	163
5.4.3	Estimation of group feed intake on growing pasture	164
5.4.4	Statistical Analysis	171
5.5	Results	173
5.5.1	Days-to-calving.....	174
5.5.2	Birth weight.....	176
5.5.3	Growth rate.....	178
5.5.4	Weaning weight	180
5.5.5	DM disappearance, MJ ME disappearance and MJ ME disappearance per kg weaned – 2008 only	182
5.6	Discussion	185
5.6.1	Measuring DM intake on growing pasture.....	186
5.6.2	Production parameters.....	186
5.6.3	Efficiency parameters.....	192
5.7	Conclusions	200
CHAPTER 6. Biochemical, endocrine and physiological responses to restricted nutrition in cows selected for a divergence in fatness or feed efficiency		201
6.1	Introduction	201
6.2	Aims	204

6.3	Hypotheses	204
6.4	Materials and methods	205
6.4.1	Animals	205
6.4.2	Data collection	205
6.4.3	Statistical Analysis	206
6.5	Results	210
6.5.1	Pre-calving blood parameter analysis	210
6.5.2	Post-calving blood parameter analysis	224
6.6	Discussion	239
6.7	Conclusions	255
CHAPTER 7. Chapter Single Nucleotide Polymorphisms in the bovine leptin gene and their association with carcass and efficiency traits, and pre and post-calving endocrine profiles, in cows selected for a divergence in fatness or feed efficiency ..257		
7.1	Introduction	257
7.2	Aims	259
7.3	Hypotheses	259
7.4	Materials and methods	260
7.4.1	Animals	260
7.4.2	Collection of blood samples	260
7.4.3	DNA extraction and SNP analysis	261
7.4.4	Statistical Analysis	262
7.5	Results	264
7.6	Discussion	278
7.6.1	The frequency distribution of SNP alleles in an Australian experimental population of cattle.....	279

7.6.2	The association between the SNP identified in VRC experimental cattle and carcass and efficiency traits.	283
7.6.3	The association between SNP and pre- and post-calving blood parameters...	286
7.7	Conclusions.....	288
CHAPTER 8.	General conclusions and future directions.....	290
CHAPTER 9.	Appendices.....	297
9.1	Timeline of important periods during the experiment at Vasse Research Centre	297
9.2	Edna HiSpEx™ Blood Kit.....	299
9.3	NFI animals – Angus ID, sire ID and date of birth.....	302
9.4	Industry animals EBVs	304
9.5	NFI animals EBVs	307
9.6	Significance (P-values) for fixed terms in all LMMs	310
CHAPTER 10.	Bibliography.....	321

LIST OF FIGURES

Figure 1-1: A schematic representation of follicle development (Webb <i>et al.</i> , 2004).....	30
Figure 1-2: Waves of follicle development and physiological terms associated with this process (Ireland <i>et al.</i> , 2000).....	33
Figure 2-1: Shed used for individual NFI feed test. Vasse Research Centre, Busselton WA.	84
Figure 2-2: Individual pens used for NFI feed test.....	84
Figure 2-3: Ring halter used for the collection of jugular blood samples	94
Figure 2-4: The author taking US subcutaneous fat measurements from a live animal using a linear transducer probe with an ultrasound machine	96
Figure 2-5: Measuring calf birth weight using vehicle-mounted sling and scales	97
Figure 3-1: Scatter plot of log _e P8 data (A vs. AS) with a one-to-one (i.e. x=y) red dashed line drawn on the same graph. Regression line (solid line) formula included.....	129
Figure 3-2: Main effect of i) Genotype and ii) nutrition on 3 rd trimester US measures of P8 (mm) in 2007 and 2008. Within line and year, means with different letters differ significantly (P < 0.05). Error bars represent 68% confidence intervals.....	131
Figure 3-3: Trellis plot of individual cow P8 measures (mm fat), within replicate groups, during the breeding season in 2008.....	133
Figure 3-4: Mean P8 fat (mm fat) for categories Genotype (Fat, Lean, high-NFI, low-NFI), nutrition (high-nut, low-nut), cohort (1 st cohort, 2 nd cohort), lactating status (yes, no) in 2008. Within category, * denotes means differ significantly (P < 0.05). Error bars represent 67% confidence intervals.	134
Figure 3-5 Mean rates of fat accretion (mm P8 fat/day) post-calving in 2007 and 2008 for each i) Genotype and each ii) nutritional treatment. Within line and year, means with different letters differ significantly (P<0.005). Error bars represent standard errors.	136
Figure 3-6: nutrition effect on i) Liveweight change over breeding season 2008 and ii) Predicted carcass yield (kg). * denotes means differ significantly (P <0.001). Error bars represent standard errors.	138
Figure 3-7: Genotype (Fat vs. Lean, high-NFI vs. low-NFI) means for predicted carcass yield (kg). Within line, * denotes means differ significantly (P <0.001). Error bars represent standard errors.	139
Figure 4-1: Trellis plots of progesterone concentrations (ng/ml - y-axis) vs. days-post-calving, by replicate group.	150
Figure 5-1: Bike-mounted Ellinbank automatic pasture reader (Victoria Department of Primary Industries)	165
Figure 5-2: Splines used to predict MJ ME on similar groups of paddocks (Farm A – replicate groups H1,H2,H3,H4 and Farm B – replicate groups M1,M2,M3 and M4). Blue dots = actual MJ ME measure and green x = predicted values for dates corresponding to DM measures. Y-axis ME (MJ ME).....	169
Figure 5-3: Main effects of (i) Genotype (corrected for calf sex and multiple birth) and (ii) nutrition (corrected for dam birth date, calf sex and multiple births) on DTC (days) in 2007 and 2008. Within	

line and year, means with different letters differ significantly ($P < 0.05$). Error bars represent standard errors.	175
Figure 5-4: Main effects of Genotype (i) and nutrition (ii) on birth weight (kg) in 2007 and 2008. Error bars represent standard errors.	177
Figure 5-5: Effect of calf sex on birth weight (kg) in 2007 and 2008. Means with different letters differ significantly ($P < 0.05$). Error bars represent standard errors.	178
Figure 5-6: Main effect of Genotype (i) and nutrition (ii) on growth rate of calves (kg/day) in 2007 and 2008. Within line and year, means with different letters differ significantly ($P < 0.05$). Error bars represent standard errors.	179
Figure 5-7: Effect of calf sex on growth rate (kg/day) of calves in 2007 and 2008. Within year, means with different letters differ significantly ($P < 0.05$). Error bars represent standard errors.	180
Figure 5-8: Main effects of Genotype (i) and nutrition (ii) on weaning weight (kg) of calves in 2007 and 2008. Within line and year, means with different letters differ significantly ($P < 0.05$). Error bars represent standard errors.	181
Figure 5-9: Nutrition means and SE (error bars) for i) DM disappearance (kg DM/head/day), ii) MJ ME disappearance (MJ ME/head/day) and iii) MJ ME disappearance/kg weaned. * denotes means are significantly different ($P < 0.05$).	184
Figure 6-1: Interaction between the effect of Genotype and nutrition on pre-calving BHB (mmol/l) in a) 2007 and b) 2008. High-nutrition (H), low-nutrition (L). Error bars represent 68% confidence intervals.	212
Figure 6-2: Main effect of nutrition on pre-calving glucose concentrations (mmol/l) in 2007 and 2008. Within year, means with different letters differ significantly ($P < 0.05$). Error bars represent 68% confidence intervals.	214
Figure 6-3: Main effect of nutrition on pre-calving acetate concentrations (mmol/l) in 2007 and 2008. Within year, means with different letters differ significantly ($P < 0.05$). Error bars represent 68% confidence intervals.	215
Figure 6-4: Average pre-calving NEFA (mmol/l) for each Genotype and nutritional treatment in 2007. High-nutrition (H), low-nutrition (L). Error bars represent 68% Confidence Intervals.	216
Figure 6-5: Average pre-calving leptin concentrations (ng/ml) for each (i) Genotype and (ii) nutrition treatment in 2007 and 2008. Within line and year, means with different letters differ significantly ($P < 0.05$). Error bars represent 68% Confidence Intervals.	218
Figure 6-6: Average pre-calving IGF-1 concentrations (ng/ml) for each (i) Genotype and (ii) nutrition treatment in 2007 and 2008. Within line and year, means with different letters differ significantly ($P < 0.05$). Error bars represent 68% Confidence Intervals.	220
Figure 6-7: Average pre-calving insulin ($\mu\text{mol/l}$) in 2007 for each Genotype on high-nutrition (H) and low-nutrition (L). Error bars represent 68% Confidence Intervals.	222
Figure 6-8: Main effects of Genotype (i) and nutrition (ii) on pre-calving GH concentrations (ng/ml) in 2007 and 2008. Within line and year, means with different letters differ significantly ($P < 0.05$). Error bars represent 68% confidence intervals.	223

Figure 6-9: Main effect of lactation on post-calving BHB concentrations (mmol/l) in 2007 and 2008. Means with different letters differ significantly ($P < 0.05$). Error bars represent 68% confidence intervals.	225
Figure 6-10: Effect of nutrition on post-calving glucose concentrations in 2007 and 2008. Within year means with different letters differ significantly ($P < 0.05$). Error bars represent 68% confidence intervals.	228
Figure 6-11: Main effects of Genotype (i) and lactation (ii) on post-calving acetate concentrations (mmol/L) in 2007 and 2008. Within line and year, means with different letters differ significantly ($P < 0.05$). Error bars represent 68% confidence intervals.	230
Figure 6-12: Effect of lactation on mean NEFA concentrations (mmol/L) post-calving in 2008. Means with different letters differ significantly ($P < 0.005$). Error bars represent 68% confidence intervals.	231
Figure 6-13: Effect of nutrition on circulating leptin concentrations (ng/ml) in 2007 and 2008. Means with different letters differ significantly ($P < 0.005$). Error bars represent 68% confidence intervals.	233
Figure 6-14: Effect of lactation on mean leptin concentrations (ng/ml) post-calving in 2008. * indicates means differ significantly ($P < 0.005$). Error bars represent 68% confidence intervals.	233
Figure 6-15: Effect of lactation on circulating IGF-1 concentrations post-calving in 2007 and 2008. Means with different letters differ significantly ($P < 0.005$). Error bars represent 68% confidence intervals.	234
Figure 6-16: Main effect of nutrition on post-calving GH concentrations (ng/ml) in 2007 and 2008. Means with different letters differ significantly ($P < 0.005$). Error bars represent 68% confidence intervals.	236
Figure 7-1: SNP genotype count prediction and standard error associated with the E2FB SNP in VRC experimental animals. Error bars represent standard errors.	267
Figure 7-2: Mean NFI for AA, AT and TT genotypes of the E2JW SNP in the VRC experimental animals. Error bars represent standard errors.	270
Figure 7-3: Mean ultrasound measured P8 fat (mm) depth for AA, AT and TT genotypes of the E2JW SNP in the VRC experimental animals. Error bars represent standard errors.	270
Figure 7-4: Mean NFI EBV categorised by E2JWE SNP Genotype (AA, AT or TT) in the expanded data set. Error bars represent standard errors.	271
Figure 7-5: Number of animals of each genotype (AA, AT or TT) within category (high-, average- or low-NFI EBV).	273
Figure 7-6: Mean pre- and post-calving leptin concentrations in VRC experimental animals with CC, TC or TT alleles of the UASMS1 SNP. All means differ significantly. Error bars represent standard errors.	276
Figure 7-7: Mean pre- and post-calving leptin concentrations in VRC experimental animals with CC, TC or TT alleles of the E2FB SNP. All means differ significantly. Error bars represent standard errors.	277

LIST OF TABLES

Table 2-1: The allocation of 200 animals to the experiment	89
Table 2-2: Experimental trait EBVs – midparent (mid-p) and at time of allocation (allocation). Rib fat EBV units mm fat, NFI EBV units kg/head/day. Standard errors in parenthesis.	89
Table 2-3: Stocking rate (cow/calf units per hectare) in each experimental year (2007 and 2008). Numbers of units per paddock is the average of the two replicate groups (7.5 in 2007, 12.5 in 2008).....	108
Table 3-1: Prediction equation for weight and percentage of retail product (yield) developed from live animal measurements adapted from Greiner <i>et al.</i> (2003a).	124
Table 4-1: Analysis of days to first ovulation.	151
Table 5-1: Effect and level of significance (P-value) of covariates (calving date, height, dam-birth-date and 3rd trimester P8) on production parameters in 2007 and 2008.	176
Table 5-2: Level of significance (P-values) for efficiency parameters; DM disappearance (kg DM/head/day), ME MJ disappearance (MJ ME/head/day) and MJ ME disappearance per kg weaned.....	182
Table 5-3: Genotype means (\pm SE) for DM disappearance (kg DM disappearance/head/day), MJ ME disappearance (MJ ME disappearance/head/day) and MJ ME disappearance/kg weaned.....	185
Table 6-1: Significance level (P-value) and effect of covariates (height, calving date and 3rd trimester P8) on pre-calving blood parameters in 2007 and 2008.	213
Table 6-2: Effect (unit change/day) and level of significance (P-value) of days-post-calving on post- calving blood parameters in 2007 and 2008.	226
Table 6-3: Effect (unit change/day) and level of significance (P-Value) of height, calving date and 3 rd trimester P8 on post-calving blood parameters in 2007 and 2008	226
Table 6-4: Effects of days-post-calving for each Genotype and nutrition in 2007 and 2008 and their significance (P-value). Only significant interactions are displayed	227
Table 6-5: Correlations and the level of significance (below, P-values) between measured parameters, post-calving in 2008. *** = <0.001, ** = P <0.05, * = P<0.01.....	237
Table 6-6: Correlations and the level of significance (below, P-values) of rates of change between measured parameters, post-calving in 2008. *** = <0.001, ** = P <0.05, * = P<0.01.	238
Table 7-1: Percentage of leptin SNP Genotype (CC, CT or TT) for SNP (UASMS1, UASMS2, E2FB) and (AA, AT or TT) for E2JW SNP, total number of animals typed and allele %. Animals are categorised by experimental genotypes: Industry (Fat or Lean) and NFI (high-NFI or low-NFI). 265	265
Table 7-2: Significance table (P-values) for distribution of SNP by comparing VRC experimental line and genotype.	266
Table 7-3: Pearson Chi-squared test results for SNP in VRC experimental cattle compared to results in Kononoff <i>et al.</i> (2005) and Nkrumah <i>et al.</i> (2005).....	267
Table 7-4: Significance level (P-values), additive effect (add) and dominance effect (dom) trait associations between date of birth (dob) covariate and SNP, carcass and efficiency traits in VRC experimental animals.	269

Table 7-5: Count and mean NFI EBV for the AA, AT and TT genotypes of the E2JW SNP in the data set including extra Trangie Research Station sourced animals.	271
Table 7-6: Number of animals (AA, AT or TT) and percentage of total within category (low-NFI, average-NFI or high-NFI).....	272
Table 7-7: Significance of associations (P-values) between UASMS1, UASMS2, E2FB and E2JW SNP, additive (Add) and dominance (Dom) effects for each SNP and pre- and post-calving ultrasound measures of EMA, IMF and P8 fat depth.	274
Table 7-8: Associations between UASMS1, UASMS2, E2FB and E2JW SNP and pre- and post-calving concentrations of leptin, IGF-1, insulin and GH.....	275
Table 7-9: The frequency of the CC, CT and TT genotypes in E2FB SNP of the bovine leptin gene in cattle at VRC experimental cattle and in Kononoff <i>et al.</i> , 2005.	280
Table 7-10: The frequency of SNP genotypes in UASMS1, UASMS2, and UASMS3 SNP of the bovine leptin gene in VRC experimental cattle and in a Nkrumah <i>et al.</i> (2005).....	282
Table 9-1: Significance (P-values) for P8 fatness during the breeding season in 2008	310
Table 9-2: Significance (P-values) for 3rd trimester P8 fatness analysis in 2007 and 2008; and analysis of the change in fatness during the breeding season in 2007 and 2008	310
Table 9-3: Significance levels (P-values) analysis of liveweight change in 2008 and predicted yield (yield)	311
Table 9-4: Significance level (P-values) for analysis of number of days to first ovulation post-calving (days-post-calving) in 2008	311
Table 9-5: Significance (P-values) of terms in analysis of calf production (birth weight, growth rate, weaning weight, DTC) in 2007	312
Table 9-6: Significance (P-values) of terms in analysis of calf production (birth weight, growth rate, weaning weight, DTC, calf P8 at weaning) in 2008	312
Table 9-7: Level of significance (P-values) for efficiency parameters; DM disappearance (kg DM/head/day), ME MJ disappearance (MJ ME/head/day) and MJ ME disappearance per kg weaned	313
Table 9-8: Significance level (P-values) for analysis of pre-calving blood parameters in 2007	314
Table 9-9: Significance level (P-values) for analysis of pre-calving blood parameters in 2008	314
Table 9-10: Significance level (P-values) for analysis of post-calving blood parameters in 2007.....	315
Table 9-11: Significance level (P-values) for analysis of post-calving blood parameters in 2008.....	316
Table 9-12: Significance levels (P-values) for analysis of rate of change of blood parameter compared to changing fatness in 2008	317
Table 9-13 (above): Significance level (P-value) for associations between SNPs (UASMS1, UASMS2, E2FB, and E2JW) with pre- and post-calving (predicted for day 14 post-calving) leptin, EMA, IMF and post-calving P8 (P8).....	319

INTRODUCTION

This thesis addresses the selection for desirable and heritable traits in beef cattle and the impact this has on breeding cows. The focus is on *Bos taurus* cattle in southern grazing regions of Australia, and pertains particularly to producers of seed stock and cow/calf enterprises. Breedplan, developed in Australia in the 1970s by the Animal Genetics and Breeding Unit (AGBU) based at the University of New England, uses best linear unbiased prediction (BLUP) technology to generate estimated breeding values (EBVs) for a range of production traits. EBVs have been used by Breedplan since 1985 (Upton, 2005) and the technology has been widely adopted by producers of beef across the country.

There are inherent concerns about the continued selection for some traits. There is evidence in other intensive production industries that single trait selection can compromise other desirable and necessary traits. Single trait selection has been shown to have detrimental results in both the dairy and pig industries (Kerr and Cameron, 1995; O'Dowd *et al.*, 1997; Kadarmideen *et al.*, 2003). In the pig industry, selection for reduction in fatness, improvement of feed efficiency and promotion of lean tissue growth to maximise finishing pig performance and carcass quality had unfavourable consequences for the long term productivity of breeding females (O'Dowd *et al.*, 1997). Similar problems were encountered in the dairy industry as a result of selection for high milk yield (Kadarmideen *et al.*, 2003; Veerkamp *et al.*, 2003).

This thesis investigates the impact of selection for leanness and feed efficiency on maternal productivity (MP). The basis of MP is a calving interval of 365 days and the term encompasses all aspects of production in the breeding herd. It includes the reproductive performance of a cow as well as factors such as breeding longevity,

measured by the age of the cow when they no longer fall pregnant, and cow salvage value. When considering MP, input, particularly feed, is taken into account as well as the main output, being kilograms of live calf (beef) sold. Ultimately production per hectare is a good measure of MP, but there are other efficiency indices which are discussed in the thesis. Specifically, measures and records of conception rates, days to calving, ease of calving, birth weight, calf growth rates, milk production, weaning weight, postpartum anoestrus interval, mature cow weight (600 day weight), breeding longevity, fat storage and retrieval reflected in the change of subcutaneous fat levels at the P8 and rib sites, and cow salvage value all contribute to the understanding of MP in a breeding herd. The best measure of MP is one that includes the inputs and outputs of both dam and progeny and includes the capacity of progeny to meet market requirements (Walmsley and Parnell, 2009).

The economic desirability of the traits considered in this thesis are well recognised. Selecting for leanness in cattle is economically beneficial owing to its relationship to higher-yielding carcasses (Nkrumah *et al.*, 2004a), and net feed intake (NFI) is a trait used to measure feed efficiency in beef cattle. NFI is calculated as the actual amount of feed eaten by an individual animal less the expected amount of feed consumed based on the animal's growth rate and liveweight (Koch *et al.*, 1963). This trait is economically desirable because of the potential to reduce feed costs and increase stocking rates.

One of the main areas of concern in the beef industry regarding the selection for leanness or feed efficiency pertains to MP. The impact of long term selection for either of these two traits on the female herd is largely unknown. Some questions that have been posed by producers include:

- does selection to improve these traits change cows' fertility and production efficiency?

- are fertility and production efficiency in animals selected for a divergence in these traits influenced by level of nutrition?
- might selection to improve these traits mean fewer kg of beef are weaned per MJ of ME input?
- is there an association between circulating blood parameters or particular genetic mutations and feed efficiency or fatness?
- can cows selected for decreased fatness, or better feed efficiency, maintain good production in an energy restricted environment?

The aim of this work was to answer these questions using cattle selected for a divergence in either leanness or feed efficiency, in an extensive grazing experiment, over two breeding cycles.