

Copyright is owned by the Author of the thesis. Permission is given for a copy to be downloaded by an individual for the purpose of research and private study only. The thesis may not be reproduced elsewhere without the permission of the Author.

**USE OF GENETIC INFORMATION  
ABOUT THE HERD  
IN THE DESIGN AND  
MANAGEMENT OF DAIRY  
FARM SYSTEMS**

**A thesis presented in partial fulfilment  
of the requirements for the degree of  
Master of Science majoring in Animal Science  
at  
Massey University  
Palmerston North  
New Zealand**

**Jeremy Ralph Bryant**

**2003**

## ABSTRACT

The aim of this thesis was to find ways of using the genetic information available about the cows to assist in improving the management of the herd and replacements. In particular models were developed which used Estimated Breeding Values to determine the feed demand of the cow and target liveweights for replacement heifers. The relationships between estimated breeding values (EBV) and cow performance at a range of feeding levels, and the effect of genetic merit on the partitioning of feed to milk or liveweight gain throughout the lactation, were also investigated.

At low levels of feeding, the absolute differences in milk yield between cows corresponded to the absolute differences in breeding values between cows. However, at high levels of feeding the difference in milk yields between genetic groups are greater than the difference in breeding values. This constitutes a form of genotype x environment interaction, which has important practical and economic implications for dairy farms, and for the expected value of genetic improvements.

High genetic merit (HGM) cows partitioned a significantly higher proportion of metabolisable energy intake into milk than low genetic merit (LGM) cows in early (0.68 vs 0.62), peak (0.59 vs 0.57), mid (0.58 vs 0.56) and late lactation (0.53 vs 0.51) (HGM vs LGM respectively). In early lactation, HGM cows utilised more body reserves for milk production (-0.06 vs -0.004, for HGM and LGM, respectively). In addition, HGM and LGM cows appeared to compensate for low intakes in early lactation by reducing the level of MEI partitioned to milk, which probably prevented excessive weight losses. These results with grazing cows confirm published data with cows fed on other rations.

Results from a grazing experiment, with 5 separate farmlets at 5 different stocking rates, were used to provide genetic information and performance per cow of a "calibration" herd corresponding to maximum profitability per farm (max EFS). The genetic and performance information for the calibration herd was then used to predict the performance of other cows or herds based on the difference in EBV for liveweight and milksolids. From these predicted values for liveweight and milksolids the "Genetic Feed Demand" (GFD) of the herd was calculated at max EFS. The GFD can then be used to adapt and improve the Comparative Stocking Rate (CSR) equation by replacing kg liveweight/ha with total GFD. Optimum values for the new CSR of 0.7 to 0.8 are proposed. This simple adjustment using genetic values provides a better estimate of the

feed demand of the herd. From this an appropriate number of cows for the specified feed supply can be determined

Another model was developed to use the liveweight EBV to formulate a set of liveweight targets for individual heifers of any breeds at different ages throughout the first two years of their life. Feeding regimes for the heifers were also proposed. A heifer herd management report was outlined that could be used by farmers and graziers to focus special attention on those individual heifers which were significantly lighter or heavier than their target weights for age.

In conclusion, greater use should be made of genetic information of individual cows and herds when designing and managing dairy farm systems. Genetic values can be used in a number of ways to ensure cows or heifers are fed more appropriately so they achieve levels of performance, which are closer to their pre-determined genetic potential. Genetic information should also be included in tools that are used to model the management of dairy farm systems, as this will improve the accuracy of prediction.

## ACKNOWLEDGEMENTS

I would like to acknowledge the efforts and input of many people who made the completion of this thesis possible. Special thanks to my supervisors Professor Colin Holmes, Dr Nicolas Lopez-Villalobos and Dr Ian Brookes.

Colin Holmes spent untold hours reading and promptly returning drafts, and I hope to give him a break from reading drafts for a while. He always made himself available, and provided many ideas that enriched this thesis. His detailed knowledge of dairy systems proved extremely valuable.

Thanks also to Dr Nicolas Lopez-Villalobos who had many ideas that he challenged me to develop, he was always willing to help, and reined me in when I got ahead of myself. His comprehensive knowledge of genetic evaluation, statistical analysis, and modelling was particularly valuable. To Dr Ian Brookes, thanks for helpful comments and information relating to the calculation of feed requirements.

I would also like to acknowledge the efforts of Kevin Macdonald at Dexcel, and Graeme Pitman at the Stratford Demonstration Farm, who provided information, which has been included in this thesis. The funding provided by the L.A. Alexander Trust, the J.E. Prestige Trust, AGMARDT, Dexcel and the Large Herds' Association, allowed me to continue my studies and without their contributions I would have given up long ago.

Thanks also to fellow post-graduates and friends who provided time-outs, especially Rao Dukkipati for his interesting discussions relating to the merits of the Indian and New Zealand cricket teams.

To my parents, Ralph and Raewyn, thanks for providing a loving and grounded upbringing, and for the financial support you have provided me throughout my studies. Thanks also to my sisters, especially Andrea who was always there when I needed a break.

I would like to give special thanks to my best friend and wife Michelle, for providing love, encouragement, and financial support throughout my studies, and also for her help in the proof reading of this thesis.

## TABLE OF CONTENTS

Abstract	ii
Acknowledgements	iv
List of Tables and Figures	vi
List of Abbreviations and symbols	vii
<b>CHAPTER 1:</b>	
General introduction and objectives	1
<b>CHAPTER 2:</b>	
Evidence of a genotype by feeding level interaction in grazing Holstein-Friesian dairy cattle at different stocking rates	8
<b>CHAPTER 3:</b>	
Effect of genetic merit on the estimated partitioning of energy towards milk production or live weight gain by Jersey cows grazing on pasture	19
<b>CHAPTER 4:</b>	
Utilisation of genetic information to determine the level of performance and the feed demand of the cow which corresponds to the farm's optimum economic performance	30
<b>CHAPTER 5:</b>	
Use of breeding values to improve the management of dairy heifers, by calculation of individual live weight targets of each heifer	45
<b>CHAPTER 6:</b>	
General Discussion	55
<b>APPENDIX</b>	
Calculation of feed requirements	61

## LIST OF TABLES AND FIGURES

### CHAPTER 2:

<b>Table 2.1:</b> Lactation yields for milk, fat, protein and milksolids of Holstein Friesian cows at four different levels of feeding	12
<b>Table 2.2:</b> Regression coefficients of lactation yields for milk, protein, fat and milksolids, on respective estimated breeding values (EBV) at four different levels of feeding	13
<b>FIGURE 2.1:</b> Regression of milksolids yield on milksolids estimated breeding value (EBV), at high (—) and very low (- - -) feeding levels of Holstein-Friesian cows for the 1999/2000 season.	14

### CHAPTER 3:

<b>Table 3.1:</b> Least square means of daily milksolids yields, estimated breeding value for milksolids, lactation yield for milksolids, estimated breeding value for LWT, and live weight of high genetic merit (HGM) and low genetic merit (LGM) Jersey cows.	23
<b>Table 3.2:</b> Metabolisable energy intakes (MEI), and proportion of energy partitioned to lactation ( $EP_l$ ), maintenance ( $EP_m$ ), and live weight change ( $EP_g$ ) of HGM and LGM Jersey cows.	24
<b>Table 3.3:</b> The proportion of energy partitioned to lactation ( $EP_l$ ) at each feeding level of HGM and LGM Jersey cows.	26

### CHAPTER 4:

<b>Table 4.1:</b> Results from an experiment with five separate dairy “farmlets”, with Holstein Friesian cows at 5 different stocking rates, with no heifers grazed-on and with no “imported” supplements fed (Macdonald <i>et al.</i> , 2001)	32
<b>Table 4.2:</b> Description of a number of farmlet and commercial studies where \$EFS/ha has been measured.	34
<b>Table 4.3:</b> Maximum hybrid vigour for straight cross animals	35
<b>Table 4.4:</b> Milksolids yields and Lwt predicted for the Stratford herd based on the differences in EBVs between the calibration herd and those at the Stratford	36
<b>Table 4.5:</b> Predicted milksolids yield based on EBV for milksolids at max EFS (+1 kg EBV = +1 kg MS)	39

## CHAPTER 4 continued

<b>Table 4.6:</b> Predicted Lwt based on EBV for Lwt at max EFS (+1 kg EBV = +1 kg Lwt)	39
<b>Table 4.7:</b> The Genetic Feed Demand for max EFS for a base cow (EBV = 0 kg for all traits, and the increase in GFD caused by an increase of one unit in yield or Lwt)	39
<b>Table 4.8:</b> The average estimated breeding values (EBV) for animals from the four major breed groups born in 1998 and their predicted yields per cow, Lwt and GFD corresponding to the max EFS.	41
<b>Figure 4.1:</b> Prototype worksheet to calculate Genetic Feed Demand and the number of cows for a specified feed supply, to achieve the max EFS <sup>1</sup> .	38

## CHAPTER 5:

<b>Table 5.1:</b> Live weight targets for different breeding value heifers at important management stages.	50
<b>Table 5.2:</b> Feed requirements (kgDM/day) for different breeding value heifers at important management stages.	51
<b>Table 5.3:</b> Proposed management report for heifers, with heifers ranked according to their deviations from their individual target weights.	51

## LIST OF ABBREVIATIONS

### *Abbreviations*

kg	Kilogram
DM	Dry matter
Lwt	Live weight
DIM	Days in milk
MS	Milksolids
ME	Metabolisable energy
MEI	Metabolisable energy intake
MJ	Mega joule
$M_m$	Metabolisable energy requirements for maintenance
$M_l$	Metabolisable energy requirements for lactation
$M_c$	Metabolisable energy requirements for pregnancy
$M_g$	Metabolisable energy requirements for liveweight gain
$M_{g-l}$	Metabolisable energy spared from liveweight lost
$EP_m$	Proportion of energy partitioned to maintenance
$EP_l$	Proportion of energy partitioned to lactation
$EP_g$	Proportion of energy partitioned to liveweight change
HGM	High genetic merit
MGM	Medium genetic merit
LGM	Low genetic merit
HF	Holstein-Friesian
J	Jersey
A	Ayrshire
HF/J	Holstein-Friesian/Jersey cross
J/A	Jersey/Ayrshire cross
HF/A	Holstein-Friesian/Ayrshire cross
EBV	Estimated breeding value
PTA	Predicted transmitting ability
BW	Breeding worth
LwtEBV	Liveweight estimated breeding value
GxE	Genotype by environment interaction
PROC	Procedure
SAS	Statistical Analysis System
GFD	Genetic feed demand
EFS	Economic farm surplus
CSR	Comparative stocking rate
max EFS	Maximum economic farm surplus per farm

### *Statistical terms*

*	Significant at $P < 0.05$
**	Significant at $P < 0.01$
***	Significant at $P < 0.001$
SED	Standard error difference
NS	Not significant