

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.

**FEED INTAKE CAPACITY AND REPRODUCTIVE
PERFORMANCE IN HOLSTEIN-FRIESIAN COWS
DIFFERING GENETICALLY FOR BODY WEIGHT**



ALFREDO CAICEDO CALDAS

2000

**FEED INTAKE CAPACITY AND REPRODUCTIVE
PERFORMANCE IN HOLSTEIN-FRIESIAN COWS
DIFFERING GENETICALLY FOR BODY WEIGHT**

A thesis presented in partial fulfilment of the requirements for the degree of
Master of Applied Science in Animal Science

Institute of Veterinary, Animal and Biomedical Sciences

Massey University

Palmerston North, New Zealand

Alfredo Caicedo Caldas

2000

This thesis is entirely dedicated to my mother Mercedes. To you, I owe more than words can say. Thank you for your endless love.

ABSTRACT

The work outlined in this study was intended to evaluate some differences between cows from two genetic lines of Holstein-Friesian (HF) cows, which have been selected for either heavy or light live weight, but are of similar high genetic merit for milk production. The two aspects studied in this thesis were, feed intake capacity and their reproductive performance because these characteristics can have important effects on efficiency of the cow, and they may be affected by selection for live weight.

In both 1998 and 1999, 16 and 24 pregnant non-lactating high genetic merit Holstein-Friesian cows, which differed genetically in size and weight, were selected from the high (H) and low (L) breeding value for live weight (LW) herd at DCRU Massey University, with eight and 12 animals for each line in 1998 and 1999 respectively. These were fed to appetite on hay (7.52 MJ ME/kg DM in 1998) and on pasture (11.1 MJ MD/kg DM in 1999) in order to measure the maximum voluntary feed intake capacity. The difference between the strains in DMI per cow per day was highly significant ($P < 0.01$) in both years. The heavy cows ate 12.52 kg DM of hay and 13.10 kg DM of pasture in 1998 and 1999 respectively, while the light cows consumed 11.11 kg DM of hay and 11.63 kg DM of pasture in 1998 and 1999 respectively. The regression coefficients generated show that for each 100 kg increase in LW, daily dry matter intake per cow increased by 1.43 and 1.81 respectively in 1998, and 1999, a positive correlation between DMI/cow/day and live weight. Overall least squares means values for DMI/cow/day in 1998 and 1999 were 11.81 and 12.36 which indicates that cows in the first year ate 4.4% less hay DM/cow/day than cows on pasture in the second year. Similarly, the overall least squares means values for DMI/cow/day for H and L cows were 12.81 and 11.37, which indicates that H cows ate 11.2% more DM than L cows. The relation between metabolizable energy intake (MEI)/cow per day and LW was also significant ($P < 0.01$) and ($P < 0.05$) for both years 1998 and 1999 respectively. Least squares means for MEI by line as a treatment and after adjustment by parity number were 94.5 and 144.7 MJ ME/cow per day for the H cows, and 83.9 and 128.4 MJ ME/cow per day for the L cows, in experiment one and two respectively. Regression analysis of the data after conversion into \log_{10} , showed that DMI increased in proportion to $LW^{0.66}$ and $LW^{0.65}$ in 1998 and 1998 respectively. These results indicate that lighter cows are not disadvantaged relative to the heavier cows in their capacity to eat feed in excess of their maintenance requirement, which are generally assumed to increase in proportion to $LW^{0.75}$.

The reproductive performance of Holstein-Friesian cows differing genetically for live weight at Massey University was evaluated for the 1998-1999 period. The aim of the study was to evaluate and compare the reproductive performance of the heavy (H) and light (L) cows two year old, three

year & older and all age groups. Differences between genetic lines were evaluated for calving intervals: three week calving rate, calving to first service (CFS), planned start of mating to first service (PSMFS), calving to conception (CC), planned start of mating to conception (PSMC), first service to conception (FSC) and calving interval (CI) and percentage of induced cows. In addition, 21 days submission rate (SR), conception rate to first service (CRFS), percentage of cows treated with CIDRs and empty rate were also evaluated. Light cows showed a more concentrated calving pattern than the H cows, and a higher percentage of L cows calved in the first 3 weeks than H cows (72% and 62% respectively). Cows in the H line had a higher proportion of induced calvings. There were no significant differences between H and L cows in CFS, CC, PSMC, FSC and CI. However, the difference in PSMFS between the strains was significant ($P < 0.01$): H cows had shorter intervals than L cows (8 days and 13 days respectively). Submission rate at 21 days was significantly higher ($P < 0.001$) for H cows than L cows (96% and 85% respectively), and H cows had lower CRFS than L cows (50% and 74% respectively; $P < 0.05$). Similarly H cows tended to have a higher proportion of empty rates and CIDRs than the L cows. The combination of lower conception rate at the first insemination and the later calving extended the conception and calving pattern for the H cows and at the same time increased the probability of an induced calving. These results indicate that light cows had higher CRFS, achieved a more concentrated calving pattern and fewer needed to be induced to calve than heavier cows.

ACKNOWLEDGEMENTS

My deepest and sincere thanks to my supervisor Professor Colin Holmes, for the unconditional support and dedication throughout the process of the course; ending with the completion of the thesis. Thank you Colin for the limitless advice and guidance, your immeasurable patience and flexibility also is very much appreciated.

To Nicolás López, I express my heart felt, thanks for all the statistical assistance. My gratitude to the DCRU staff, especially to Martin Chesterfield for your friendship and advise since the very first time.

My thankfulness to my special friends and classmates Ramon and Vicente, we shared all the good times and supported each other during the difficulties.

My special gratitude to my kiwi friend Stephen for encouraging me to keep going with the course, your sincere friendship and support has been invaluable. To my brothers and sisters, thanks for your love and for giving me confidence during the studies.

Finally, my gratefulness is also given to the Ministry of Foreign Affairs and Trade of New Zealand for granting me with the scholarship.

TABLE OF CONTENTS

ABSTRACT	V
ACKNOWLEDGEMENTS	VII
TABLE OF CONTENTS	9
CHAPTER I	15
GENERAL REVIEW	15
I. GENERAL REVIEW	17
REFERENCES	57
CHAPTER II	69
FEED INTAKE CAPACITY IN HOLSTEIN-FRIESIAN COWS DIFFERING GENETICALLY FOR BODY WEIGHT FED TO APPETITE ON HAY OR GRAZED PASTURE	69
ABSTRACT	71
INTRODUCTION	73
OBJECTIVE	76
MATERIALS AND METHODS	77
RESULTS	87
DISCUSSION	97
CONCLUSIONS	104
REFERENCES	105
CHAPTER III	113
REPRODUCTIVE PERFORMANCE IN COWS DIFFERING GENETICALLY FOR BODY WEIGHT	113
ABSTRACT	115
INTRODUCTION	117
OBJECTIVE	121
MATERIALS AND METHODS	123
RESULTS	127
DISCUSSION	135
CONCLUSIONS	146
REFERENCES	147

LIST OF TABLES

Table 1-1. Intervals from calving to first ovulation and first detected oestrus in Jersey (J) and Friesian (F) cows of different ages and grazed at two stocking rates (H vs L) (Macmillan, 1997).	23
Table 1-2. Intervals from calving to first ovulation and oestrus, and numbers of ovarian follicle waves to first ovulation in Friesian (F) and Jersey (J) heifers with high (H) and low (L) post-calving live weight (Macmillan, 1997).	23
Table 1-3. Effects of calving pattern with the same PS date (Trials 1 to 3) or same calving pattern with varied PS date (trial 4) in groups of monozygous twins on production differences (Macmillan, 1984).	26
Table 1-4. Reproductive performance for induced and normally calved contemporaries (Hayes 1996; cited by Hayes 1998).	29
Table 1-5. Calving and mating performance during 1995 from records on the LIC national and DairyMAN database (Extracted from: Hayes, 1997; Burke, 1999).	31
Table 1-6. The effect of condition score at calving on per cow performance (Extracted from Holmes and Wilson, 1987; Deane, 1993).	36
Table 1-7. Minimum drying off condition score for individual cows (Macdonald <i>et al.</i> , 1997).	37
Table 1-8. Guideline plan, which reflects best practice management (Burke, 1999).	38
Table 1-9. Estimated values for substitution rate, for cows at different relative levels of feeding (Extracted from Grainger <i>et al.</i> , 1989).	43
Table 1-10. Effects of pasture allowance (kg DM/cow/day) on levels of substitution (kg DM reduction in pasture intake/kg DM of supplement eaten) for grazing cows (Stockdale <i>et al.</i> , 1997).	44
Table 1-11. Effects of pasture mass (t DM/ha) on levels of substitution (kg DM reduction in pasture intake/kg DM of supplement eaten) for grazing cows (Stockdale <i>et al.</i> , 1997).	45
Table 1-12. Comparative performance of NZ HF and OS HF grazing pasture at low stocking rate (2.2 cows/ha) or fed TMR <i>ad-libitum</i> during 1998/1999 and 1999/2000 periods. (Extracted from Penno <i>et al.</i> , 2000; Kolver, 2000)	54
Table 2-1. Least squares means and s.e.d ¹ for breeding worth (BW), breeding value (BV), Age, body condition score (BCS), live weight (LW) and days in pregnancy (DIPG) for the cows used in experiments one and two.	78
Table 2-2. <i>In vitro</i> mean values for the digestibility of the hay and pasture used in experiment one and two respectively.	87
Table 2-3. Characteristics of the pasture used for herbage in experiment two.	88

Table 2-4. Least squares means and s.e.d ¹ for BCS, LW, metabolic LW (LW ^{0.75}), liveweight change (LWC), DMI, and DMI per kg ^{0.75} adjusted by lactation number for each genetic line recorded during experiments one and two in 1998 and 1999 respectively.	90
Table 2-5. Increase in DMI (kg DM) of dairy cows for each increase of 100 kg of LW (estimated values from the regression coefficient for LW from the equations presented by the authors	99
Table 2-6. Comparisons of least squares means for LW, BCS, DMI of genetically heavy or light Holstein-Friesian cows in different trials.	100
Table 2-7. Relations reported between feed intake and live weight for cattle grazing on pasture or fed with hay trials	103
Table 3-1. Reproductive management calendar for DCRU during the period of 1998/1999.	125
Table 3-2. Least squares means (s.e.d.) ¹ for initial live weight (ILW), final live weight (FLW), liveweight gain (LWG), initial body condition score (IBCS) and final body condition score (FBCS) for the heavy (H) and light (L) genetic lines of cows.	127
Table 3-3. Number and percentage of cows in 1998/1999 calving period of the heavy (H) and light (L) genetic lines of cows, two years old, three years & older, and total age groups.	128
Table 3-4. Calving performance in 1998/1999 period of the Heavy (H) and Light (L) genetic lines of cows, two years old, three years & older, and total age groups.	129
Table 3-5. Calving intervals in 1998/1999 period of the Heavy (H) and Light (L) genetic lines of cows, two years old, three years & older and the total age groups.	132
Table 3-6. Number and percentage of cows mated in the 1998/1999 breeding period of the heavy (H) and light (L) genetic lines of cows, two years old, three years & older, and total age groups.	133
Table 3-7. Mating performance in 1998/1999 period of the Heavy (H) and Light (L) genetic lines of cows, two years old, three years & older and the total age groups.	134
Table 3-8. Experimental evidence of reproductive performance for Holstein-Friesian cows differing genetically for live weight.	135
Table 3-9. Comparison of the calving intervals in different studies for Holstein-Friesian cows differing genetically for live weight	137
Table 3-10. Comparative performance of Holstein-Friesian cows bred for heavy (H) and light (L) live weights at Massey University (from Garcia Muñiz <i>et al.</i> , 1998; Holmes, <i>et al.</i> , 1999)	143
Table 3-11. Evidence of reproductive performance in different countries	144
Table 3-12. Reproductive performance of 2 and 3 year old cows during the 1999/2000 lactation. (Extracted from Verkerk <i>et al.</i> , 2000 ^b)	145

LIST OF FIGURES

Figure 1-1. Pasture growth and feed requirements throughout the year. Thomson <i>et al.</i> , (1995).	19
Figure 1-2. The calving pattern for all cows in herds using DairyMAN (Hayes, 1998).	22
Figure 1-3. Mean daily milk yield (liters) for cows induced to calve (Δ) and cows that calved normally (\square) (Hayes, 1998).	30
Figure 1-4. Submission rates for New Zealand dairy herds (97/98 season) LIC (Hayes, 1998).	32
Figure 1-5. Demonstration of substitution rate for grazing cows at different levels of pasture intake (Grainger <i>et al.</i> , 1989).	42
Figure 1-6. Relationship between level of substitution and pre-grazing herbage mass for cows offered 20 kg DM/c/d white clover and 3.4-5.0 kg DM/c/d of maize silage (Stockdale <i>et al.</i> , 1997).	46
Figure 1-7. Effect of condition score at calving on dry matter intake during early lactation (Garnsworthy, 1988).	47
Figure 1-8. Immediate short term responses to supplementary feeds by cows eating 7kg DM of cut pasture /day. Stockdale <i>et al.</i> , (1997).	49
Figure 2-1. The relation between dry matter intake (DMI; kg/cow/day) and live weight (LW) for the genetically heavy and light cows in 1998 fed <i>ad-libitum</i> on hay	90
Figure 2-2. The relation between dry matter intake (DMI; kg/cow/day) and live weight (LW) for the genetically heavy and light cows in 1999 fed <i>ad-libitum</i> on pasture	91
Figure 2-3. The relation between dry matter intake (DMI; kg/cow/day) and live weight (LW) for the genetically heavy and light cows in 1998, and 1999	91
Figure 2-4. The relation between \log_{10} dry matter intake (DMI) and live weight (LW) for the genetically heavy and light cows in 1998 fed <i>ad-libitum</i> on hay	92
Figure 2-5. The relation between \log_{10} dry matter intake (DMI) and live \log_{10} weight (LW) for the genetically heavy and light cows in 1999 fed <i>ad-libitum</i> on pasture	93
Figure 2-6. The relation between \log_{10} dry matter intake (DMI) and \log_{10} live weight (LW) for the genetically heavy and light cows in 1998, and 1999	93
Figure 2-7. The relation between dry matter intake per $\text{kg}^{0.75}$ ($\text{kg DMI}/\text{kg}^{0.75}$) and live weight (LW; kg) for the genetically heavy and light cows in 1998 fed <i>ad-libitum</i> on hay	94
Figure 2-8. The relation between dry matter intake per $\text{kg}^{0.75}$ ($\text{kg DMI}/\text{kg}^{0.75}$) and live weight (LW; kg) for the genetically heavy and light cows in 1999 fed <i>ad-libitum</i> on pasture	94
Figure 2-9. The relation between dry matter intake per $\text{kg}^{0.75}$ ($\text{kg DMI}/\text{kg}^{0.75}$) and live weight (LW; kg) for the genetically heavy and light cows in 1998, and 1999	95

Figure 3-0. Relevant fertility traits for seasonal dairy systems. Grosshans et al., (1997).	120
Figure 3-1. Calving rate in 1998 of the Heavy (H) and Light (L) genetic lines of Holstein cows, tow years old	129
Figure 3-2. Calving rate in 1998 of the Heavy (H) and Light (L) genetic lines of Holstein cows, three years and older	130
Figure 3-3. Calving rate in 1998 of the Heavy (H) and Light (L) genetic lines of Holstein cows (all age groups)	131
Figure 3-4. Percentage of cows induced in 1998 calving period of the Heavy (H) and Light (L) genetic lines of Holstein cows, two years old, three years & older and the total (all age groups)	131