STUDIES OF HOLSTEIN-FRIESIAN CATTLE BRED FOR HEAVY OR LIGHT MATURE LIVE WEIGHT

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Studies of Holstein-Friesian Cattle Bred for Heavy or Light Mature Live Weight

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Dedication

I dedicate this Thesis to my wife Marcela and my children José Alberto (5), Ana Victoria (4) and Eduardo (1). For all their love and support, and for putting up with my busy schedule during the first three years of my PhD and with my absence during the last 10 months.

To my mother, Victoria Muñiz, for encouraging me to further my education since the very first day I attended primary school.

Abstract

The new Animal Evaluation Model predicts that heavier live weight (LW) of the lactating cow reduces the profitability of the pasture-based dairying farm in New Zealand, because its effects on increased maintenance requirements are not fully compensated by the extra income generated from selling heavier culled cattle and surplus progeny. The work outlined in this thesis was intended to validate the expected effects of selection for differences in LW on actual LW from birth to maturity and on herbage intake and feed conversion efficiency (FCE) of growing cattle and lactating cows. It also investigated the existence of any associated effects on calving difficulty, calf mortality, onset of puberty and reproductive performance of the two lines of Holstein-Friesian (HF) cattle bred for heavy or light mature LW. These two lines have been developed at the Dairy Cattle Research Unit, Massey University, New Zealand, since 1989. The high genetic merit HF cows from the base herd have been mated to high genetic merit HF sires with either high or low breeding value (BV) for LW but with similar breeding worth (BW) in order to generate the heavy (H) and the light (L) mature LW selection lines. During the period 1994 to 1997, a series of experiments with growing heifers and lactating cows from the H and L lines, and analysis of data collected from the cows were undertaken to compare the two genetic lines.

The BV's for live weight of the sires were 86 kg for the H and 31 kg for the L cows and the actual H animals were heavier at birth (41 *vs.* 35 kg) and at maturity (510 *vs.* 460 kg). In addition the BV's for milk (1037 *vs.* 737 *l*), milkfat (33.0 *vs.* 27.5 kg) and milk protein (31 kg *vs.* 22 kg) of H sires were also higher and the H cows produced significantly more milk (4708 *vs.* 4323 *l*/lactation), more milkfat (207 *vs.* 198 kg/lactation) and more milk protein (157 *vs.* 150 kg/lactation) than the L cows. However, the L sires had slightly higher breeding worth ($ 46 *vs.* $ 37) than the H sires and theoretically calculated and experimentally measured feed intakes and the resultant feed conversion efficiencies, confirmed that the L cows had slightly higher values for FCE than the H cows in three short-term grazing experiments and when FCE was calculated over multiple lactations. Therefore the basic assumptions in the Animal Evaluation Model seem to be correct.

Sires of H cows had a higher proportion of USA Holstein genes in their pedigrees than the L sires. Consequently cows from the H line had a higher (≈27%) proportion of USA Holstein genes compared to cows from the L line (≈7%), whose sires were mainly of New Zealand ancestry. New Zealand bulls are progeny tested under grazing conditions and a very tight seasonal system of reproduction, whereas North American bulls are progeny tested under dairying systems of all year round milk production and feedlot feeding.

There were significant differences in the pattern of grazing behaviour of H and L cows. The L cows displayed a more 'aggressive' pattern of grazing behaviour than H cows given by significantly longer grazing times (520 *vs.* 499 min/d), faster rates of biting (58 *vs.* 52 bites/min), higher number of total bites per day (31053 *vs.* 25046 bites/d), lower rumination times (471 *vs.* 572 min/d), and the selection of herbage of higher digestibility (72.0% *vs.* 69.3%). These results may reflect not only a difference in mature LW between the H and L cows, but may also reflect a strain of Holstein (i.e. NZ *vs.* USA Holstein) difference due to the sires' ancestry referred to above.

There were no differences between H and L cows in the incidence of calving difficulty. However, offspring of bulls with high BV for rump width (i.e. wider pelvises) were more likely to face a difficult calving, and so were daughters of bulls with low BV for rump angle (i.e. less sloping pelvises). There were no differences between H and L cows for calf mortality. However, induced calves were more likely to die or undertake an emergency slaughter, and the H cows had significantly higher induction rates than the L cows (10.5 *vs.* 4.2%).

The H heifers grew faster, ate more feed (4.3 *vs.* 3.8 kg/hd/d) and were heavier (241 *vs.* 221 kg) and older (325 *vs.* 300 d) at puberty than L heifers, and there were no differences between H and L heifers in pregnancy rate, age at first calving and first lactation yield of milk and milk components.

There were only small differences in the reproductive performance of H and L cows after adjusting by differences in induction, calving date and percentage of USA Holstein genes in the cows. The L cows had slightly shorter intervals from first service to conception (13 *vs.* 17 d) and from the start of mating to conception (24 *vs.* 29 d), and slightly higher first service conception rate (65 *vs.* 54%), which translated in a more concentrated calving pattern and lower induction rate (4.2 *vs.* 10.5%) for the L cows.

The results of this thesis indicate that selecting for heavier mature live weight produced the expected results of heavier animals with higher yields of milk and milk components, higher feed requirements and higher herbage intakes and slightly lower feed conversion efficiency than lighter mature live weight cows. However, there were also differences in grazing behaviour in which the L cows displayed a more competitive pattern of grazing behaviour than the H cows. The results of this thesis suggest that for the New Zealand seasonal system of milk production based almost completely on grazed pasture, lighter mature LW HF cows may have an advantage over heavier mature LW cows. Under the conditions of this experiments L cows were slightly more efficient, younger at puberty, had a more concentrated calving pattern, and were less prone to be induced to calve than heavier mature live weight HF cows.

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A project of this magnitude could not have been completed without the help, input, participation, enthusiasm and foresight of many people. Back in 1987 Associate Professor Colin Holmes from Massey University and Dr. Brian Wickham and Gisele Ahlborn-Brier from the Livestock Improvement Corporation laid the foundations of the present project.

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During two years Yvette Cottam helped me with the collection of blood samples and field data while the heifers were grazing away. The weekly trips we made to collect the data were a delightful experience. During the winter months we were able to taste most of the local chocolate brands available, while in summer we always made sure to call into a Fielding Pub for a bowl of hot 'Nachos' and a cold beer.

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A large number of international students gave their time to participate in the running of the experiments and collection of field data. In no particular order, I will always be grateful to Stuart Crosthwaite (Australia), Lisa Watson (New Zealand), Michelle Jones (Canada), Jan (Holland), Brian Read (U.K), Carolina Realini, Daniel Laborde and Bettina (Uruguay), Pablo Londoño (Colombia), and from México, Nicolás López, David Pacheco, Aurelio Guevara, Mauricio Padilla and Alberto Torres.

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During the last 10 months while I have been without my family, Joyce and Arthur Worboys have become my foster family while in New Zealand. I will certainly miss Arthur's cup of tea and bunch of 'fancy' cookies that kept me going and helped me work until late every single night I spent in their house. Joyce always kept an interest and an open mind about my project, and was willing to listen to my ideas and findings as I was progressing in the analysis of the data and writing of this thesis. As it turns out, at the completion of this thesis she was familiar with my research and did not hesitate in doing the English proofreading of the manuscript. I am particularly grateful for that. However, any mistakes in the present thesis are my sole responsibility. Without any doubt, the completion of this thesis would not have been possible without Joyce and Arthur's help, and I will always be grateful for their support.

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List of Abbreviations and Symbols

Abbreviations

A	mature live weight
a.m.	*ante meridiem*
AI	artificial insemination
ANOVA	analysis of variance
b	constant of integration
BR	biting rate
BS	bite size
BV	breeding value
BW	breeding worth
C_{32}	dotriacontane
C_{36}	hexatriacontane
CFH	calving to first heat
CFS	calving to first service
CI	calving interval
CIDR	controlled internal drug release device
Cr	chromium
CR1st	conception rate to the first service
CR21	21-days first service conception rate
Cr_2O_3	chromium sesquioxide
CRC	controlled release capsule
CS	body condition score
CSH	compressed sward height
d	day
DM	dry matter
DMD	dry matter digestibility
DMI	dry matter intake
DO	days open
DOMD	digestible organic matter in the dry matter (D-value)
DTC	days to calving
FCM	4% fat corrected milk
FO	faecal output
FREQ	frequency
FSCO	first service to conception interval
GL	gestation length
GLM	Generalised Linear Models
GT	grazing time
h	hours
ha	hectare
hd	head
HFRO	Hill Farming Research Organization (Scotland)
HIR28	four-weeks herd in calf rate
HIR49	seven-weeks herd in calf rate
IAB	incisor arcade breadth
k	maturation rate parameter
ln	natural logarithm
$\log_e$	natural logarithm
LW	live weight
$LW^{0.75}$	metabolic weight
LWG	live-weight gain
ME	metabolisable energy
min.	minute
MJ	megajoule
MJME	megajoules of metabolisable energy

MS	mean square
MSY	milksolids yield
N	nitrogen content
n	number of observations
NLIN	non-linear
NM	natural mating
NZ	New Zealand
OM	organic matter
OMD	organic matter digestibility
P	probability
p.m.	*post meridiem*
P_4	progesterone
$PGF_{2\alpha}$	prostaglandin $F_{2\alpha}$
PHREG	proportional hazards regression
PROC	procedure
PSC	planned start of calving
PSM	planned start of mating
SAS	Statistical Analysis System
sec	second
SMCO	start of mating to conception
SMFS	start of mating to first service
SR28	four-weeks submission rate
SR49	seven-weeks submission rate
SSH	sward surface height
t	time (days)
USA	United States of America
vs.	*versus*

Weights, volumes and measures

°C	degrees centigrade
g	gram
kg	kilogram
km	kilometer
l	liter
m	meter
m^2	square meter
mg	milligram
ml	milliliter
ng	nanogram

Statistical terms

*	significant at $P < 0.05$
**	significant at $P < 0.01$
***	significant at $P < 0.001$
†	significant at $P < 0.1$
μ	overall mean
χ^2	chi-square
b	partial regression coefficient
CDF	cumulative distribution function
CI	confidence interval
CV	coefficient of variation
d.f	degrees of freedom
HR	hazard ratio
n	number
NS	not significant
OR	odds ratio
R^2	coefficient of determination
RSD	residual standard deviation
s.e.d	standard error of the difference
SD	standard deviation
SE	standard error of the mean