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**A STUDY OF THE INTERACTIONS BETWEEN HOLSTEIN-
FRIESIAN GENOTYPES AND FEEDING SYSTEMS, WITH
EMPHASIS ON SYSTEM PERFORMANCE AND COW GRAZING
ABILITY**

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Dedicated to Sonia, Martín and Dominique

ABSTRACT

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Imported genetic material of the Holstein-Friesian breed from overseas (OS), mainly from North America, has been used in New Zealand (NZ) since the late 1960's. This has diluted the genetic base of the former NZ Friesian genotype selected under intensive seasonal pasture-based systems. As a result, increased concerns have been raised about the negative influence of these overseas genes on the modern NZ Holstein-Friesian, as it is apparent that the OS Holstein-Friesian has a lower capacity to perform on grazed pasture. The objective of the present thesis was to investigate differences in production performance between three Holstein-Friesian genotypes farmed at different feed allowances (FA) on pasture-based systems; in addition, to investigate differences in the grazing process between strains under contrasting managements and sward conditions, and so to identify animal and pasture factors that affect the herbage intake (DMI_H) and performance of the grazing cow. An accurate procedure was also established to estimate DMI_H for cows fed forage and maize supplements, grazing in groups. Two modern high breeding worth (BW) Holstein-Friesian strains from NZ (NZ90) or overseas (OS90) origin and a low BW 1970's NZ Friesian genotype (NZ70) were farmed in two field experiments: (1) a long-term 'system' study that compared the yield performance of these genotypes in a range of systems with different feed allowance (FA) per cow, and a (2) a short-term 'component' study that compared the grazing capacity of the strains under contrasting sward conditions but at a common daily herbage allowance. The differences in productive performance between genotypes increased as the study progressed in the system study, with the largest observed in the last season. The mean milk solids (MS) yield per cow and per hectare were higher in NZ90 (395 kg cow⁻¹ and 1,236 kg ha⁻¹) than in the NZ70 (336 kg cow⁻¹ and 1,093 kg ha⁻¹) and the OS90 (377 kg cow⁻¹ and 1,154 kg ha⁻¹). The higher production of NZ90 cows was supported by their higher mean daily MS yield than the NZ70 (1.45 vs. 1.21 kg MS cow⁻¹day⁻¹) and more days in milk than OS90 cows (271 vs. 257 DIM). The lower lactation length of the OS90 strain occurred due to its lower body condition score (BCS) in late lactation, which determined an early dry-off for these cows. The lowest BCS of OS90 at the nadir (irrespective of FA), during lactation and at dry-off indicate these cows mobilised greater amount of body reserves and partitioned most of the energy ingested to yield. Genotype by FA interactions for milk and lactose yields, protein content in the milk and BCS were observed in the second and third seasons of the 'system' study. Milk yield increased as FA increased to a greater extent in OS90 than in the two NZ strains, whereas the content of solids in milk, particularly protein, increased to a greater extent for NZ90 than in both OS90 and NZ70. During lactation DMI_H was higher for NZ90, intermediate in OS90 and lower in NZ70 (14.5, 13.9 and 12.6 kg DM cow⁻¹day⁻¹ respectively for NZ90, OS90 and NZ70, as measured with n-alkanes), and declined as lactation progressed, with a smaller difference for the total intake achieved (15.5, 15.2 and 13.1 kg DM cow⁻¹day⁻¹ respectively) due to the increased supplement consumption. These results indicate that the OS90 needs more feed with a higher proportion of supplement in the diet to improve productive

performance on pasture-based systems; the NZ90 would perform better when cow nutrition is mainly supported by grazing pasture, although further increments in performance could be expected from strategic supplementation, but requiring more feed than NZ70. The DMI_H per unit of live weight (DMI_H/LW) was highest in NZ90 strain in both the 'system' and in the short sward of the 'component' study (31.5 and 31.1 g DM kg^{-1} DM in NZ90 vs. 28.9 and 28.6 g DM kg^{-1} DM for OS90 in 'system' and 'component' studies respectively). The higher intake of NZ90 on pasture was sustained by a higher capacity to graze short swards than NZ70 and OS90, and to deal with the herbage of higher bulk density and lower quality present at the base of taller swards. The NZ90 can maintain DMI_H in swards with different structures, indicating higher flexibility to perform under different managements and sward conditions. The size of the jaw is smaller in NZ90 than OS90 (88.4 vs. 92.4 mm) with effects on bite area and bite size, and this flexibility to adapt the size of the bite to swards of different structure may improve bite penetration under constraining sward conditions. The reduced ability of the OS90 to adjust ingestive behaviour to different swards would limit the capacity of this strain to perform on pasture. The fact that OS90 cows increased DMI_H and DMI_H/LW substantially in a leafy and taller sward (up to 21.6 kg cow^{-1} and 40.8 g DM kg^{-1} LW vs. 19.2 kg cow^{-1} and 41.0 g DM kg^{-1} LW in NZ90 during early lactation) suggests that yield performance can be improved in these cows even on pasture, by fine-tuning pasture management.

Keywords: Pasture-based dairy systems, Holstein-Friesian, genotype environment interactions, grazing ability, grazing behaviour, pasture management.

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By the time I arrived at Hamilton in late March 2002 the 'Strain Trial' had already started at the old Dexcel No 2 dairy. Although I was involved in the trial since my arrival, it took me time to settle. Soon after arrival John Milburn was appointed farm manager and this made my time at the 'No 2' a lot easier. John is not only an excellent manager, he became a good friend and I really enjoyed sharing time with him and the rest of the staff at the farm. Hopefully they also found enjoyable having me around, requiring their frequent help.

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After the 'Strain Trial' was finished, I moved to AgResearch, Ruakura, where I was responsible for a 'component' trial at the No 1 dairy during the spring of 2004. As usual, Kevin Macdonald's help and support were invaluable; in addition, the support provided by Barbara Dow for the statistical data analysis from the two field experiments was acknowledged and appreciated.

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LIST OF TERMINOLOGY AND ABBREVIATIONS

Abbreviations

ADF	acid detergent fibre	H _R	height reduction
AFRC	Agricultural and Food Research Council	<i>i...ii</i>	content of C ₃₁ & C ₃₃ odd natural <i>alkanes</i>
am	ante meridian	IA	artificial insemination
B	bite	IR	intake rate
BCS	body condition score	<i>j</i>	content of C ₃₂ dosed <i>n-alkane</i>
B _D	bulk density	J _Z	jaw size
BR	bite rate	k ₁	efficiency of energy utilisation for milk
BV	breeding value	k _m	efficiency of energy utilisation for maintenance
BW	breeding worth	LC	milk lactose concentration
BZ	bite size	LIC	Livestock Improvement Corporation
C _{27...C₃₅}	odd natural <i>alkanes</i> , different carbon chain	L ₀	lowest feed allowance (equal to FA1)
C ³	winter grasses, C ³ photosynthetic pathway	LW	liveweight
C ₃₂	dosed of pellets with C ₃₂ - <i>alkanes</i>	LW ^{0.75}	metabolic LW
C ⁴	summer grasses, C ⁴ photosynthetic pathway	LW _E	empty LW
CIDR [®]	controlled internal drug-releasing device	M	measurement period
C ₀	concentrate feed	M _E	dietary metabolisable energy
CP	crude protein	ME	metabolisable energy
Cr ₂ O ₃	chromic oxide	MJ ME	megajoule of ME
CRC	controlled release capsule	MJ	megajoule
CSR	comparative stocking rate	MS	milk solids
DH	herbage in-vitro digestibility	NDF	neutral detergent fibre
DHA	daily herbage allowance	NE _m	net energy maintenance
DHA/LW	daily herbage allowance per LW unit	NIRS	Near Infrared Reflectance Spectroscopy
DIM	days in milk	NPO	nominal pasture offered
DM	dry matter	NSO	nominal supplement offered
DMD	dry matter digestibility	NTF ₀	nominal total feed offered
DMI	daily dry matter intake	NZ	New Zealand
DMI _H	daily herbage DMI	NZ70	NZ Holstein-Friesian dairy cow of the 1970's
DMI _{LW}	daily herbage DMI per LW unit	NZ90	NZ Holstein-Friesian dairy cow of the 1990's
DMI _{MZ}	daily maize silage or maize grain DMI	OF	oesophageal fistulated animals
DMI _{PS}	daily pasture silage DMI	OM	organic matter
DMI _S	daily supplement DMI	OMD	organic matter digestibility
DMI _T	daily total DMI	OS	overseas
DMI _T /LW	daily total dry matter intake per LW unit	OS90	OS Holstein-Friesian dairy cow of the 1990's
DMI _V	daily dry matter intake visual	P	parity
D _{0j}	dosed n-alkane <i>j</i>	PADI	<i>Paspalum dilatatum</i> poir.
DS	supplement in-vitro digestibility	PC	milk protein concentration
DTA	daily total allowance	P _E	experimental period
E	eating supplement	pm	post meridian
e	error term	P ₀	pasture offered
E _{NBAL}	energy balance	PR _{E,XP}	pre-experimental period
E _{NM}	energy required for maintenance	PU	pasture utilisation
E _{NO}	energy in milk	q _m	dietary ME/G _E
E _T	eating time	R	ruminating
F	faeces	ratio	Relation C ₃₁ /C ₃₃ in H or F
FA	feed allowance	Rel H/F	ratio C ₃₁ /C ₃₃ in H to the same ratio in F
FA1...4	feed allowance level from 1 (lowest) to 4 (highest)	R _{i...ii...j}	Recovery of <i>i...ii...j-alkanes</i> in faeces
FC	milk fat concentration	RPM	Rising Plate Meter
Fi...ii...j	<i>i...ii...j-alkanes</i> concentration in faeces	RT	ruminating time
FO	faecal output	SAS	Statistical Analysis System [®]
FO _H	herbage faecal output	SC	sward condition
FO _S	supplement faecal output	SC	sward condition
FO _T	total faecal output	S _F	proportion of supplement in faeces
G	grazing	SH	sward surface height
GE	genotype of Holstein-Friesian	SHORT	short sward
G _E	gross energy	SH _{POST}	post-grazing sward surface height
GLU	concentration of glucose in blood samples	SH _{PRE}	pre-grazing sward surface height
G _T	grazing time	Si...j	content of n-alkane in the supplement
G _T /R _T	grazing to ruminating ratio	SR	stocking rate
H	herbage	TALL	tall sward
HAR	herbage accumulation rate	TMR	total mixed ration
HERD	cows allocated to experimental mobs	TS ₀	total supplement offered
H _F	proportion of herbage in faeces	v.s.	versus
H _I	highest feed allowance (equal to FA4)	Y	age of the cow (in years)
Hi...ii...j	<i>i...ii...j-alkanes</i> concentration in herbage	δ ¹³ C	ratio of the natural ¹² C and ¹³ C isotopes in the herbage or feed
HM	herbage mass	δ ¹³ C _F	ratio ¹² C and ¹³ C in faeces
HM _{POST}	post-grazing herbage mass	δ ¹³ C _S	ratio ¹² C and ¹³ C in supplement
HM _{PRE}	pre-grazing herbage mass		

LIST OF SYMBOLS

Weights, volumes, measures and statistical terms

P	probability
*	significant at $P < 0.05$
**	significant at $P < 0.01$
***	significant at $P < 0.001$
°C	degree centigrade
CORR	correlation
g	gram
kg	kilogram
km	kilometre
L	litre
m	meter
m ²	square meter
mg	milligram
n	number of observations
ha	hectare
MJ	megajoule
mm	millimetre
t	tonne
h	hour
min	minute
MIXED	mixed
PROC	procedure
r	coefficient of correlation
r^2	coefficient of determination
REG	regression
RMSE	root mean square error
SD	standard deviation
SE	standard error of the mean
SED indicated)	standard error of the difference (maximum indicated)
CV	coefficient of variation