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A comparison of New Zealand and overseas Holstein Friesian heifers

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ABSTRACT

The performance of overseas (OS) and New Zealand (NZ) Holstein Friesian (HF) dairy heifers was compared when fed an all-pasture diet (Grass) or a total mixed ration (TMR) throughout lactation. The four treatments were NZ Grass (n=14); OS Grass (n=9); NZ TMR (n=15); and OS TMR (n=10). Compared with NZ HF, OS HF had a higher live weight and produced more milk, but milksolids yield, efficiency of milksolids production, and persistency of lactation were not different. Compared with HF fed Grass, HF fed TMR produced more milk and milksolids, were more efficient, had a greater persistency of lactation, and ended lactation with a greater body weight. The OS HF genotype was unable to maintain acceptable body condition and live weight on an all-grass diet. This raises serious questions regarding the sustainability and suitability of these genetics for seasonal all-pasture dairying systems.

Keywords: Holstein Friesian; genotype; diet; interaction.

INTRODUCTION

Widespread importation of North American and Dutch Holstein Friesian (HF) genetics into the New Zealand national herd during the last ten years raises important questions regarding the relative performance of these genetics within the New Zealand pasture-based dairy system.

The recent changes to the genetic composition of the national herd have been significant. North American genes accounted for 74% of the genes in Holstein Friesian sires born in 1995 now being used to inseminate the national herd (Dr Bevan Harris, *pers. comm.*). In 1998, 38% of the genes in HF heifers born in the national herd were North American, and 95% of HF heifers in New Zealand had some overseas (OS) genetics (Harris and Winkelman, 2000). Use of OS HF genetics in New Zealand has been high because these genetics are associated with high breeding values for production traits. Until recently most OS HF genetics represented in the national herd were bred from bloodlines selected and proven under intensive, high input feeding systems. Because of the large differences between high input feeding systems and New Zealand's pastoral dairying systems, there is continuing debate regarding the successful management of the high yielding HF of OS ancestry in a seasonal grazing system (Harris *et al.*, 1999).

A comparison of proofs of Canadian sires tested in New Zealand with their original home proofs concluded that proofs made in Canada were not reliable predictors of progeny performances in New Zealand conditions (Peterson, 1988). This re-ranking of sires suggested the existence of a genotype x environment interaction. However, analysis of the performance of high genetic merit heifers of North American origin in commercial herds in Ireland (Cromie *et al.*, 1997), and in high and low input feeding systems at Hillsborough, Ireland (Ferris *et al.*, 1999), and Moorepark, Ireland (Dillon and Buckley, 1998) found no such genotype x environment interaction. These studies clearly indicated that heifers of high genetic merit and North American genetics produced more than medium genetic merit heifers of Irish ancestry in low input grass

systems, albeit at lower levels of production than in high input systems. The grass-based low input system in the Moorepark comparison, however, still included 500 kg DM/cow/year of concentrate and 400 kg N/ha at a stocking rate of 2.54 cows/ha.

Whether a genotype x environment interaction exists in grazing systems receiving no supplementary feed was determined in the present experiment. This paper reports on the first year of a three-year study comparing North American and Dutch HF genetics with New Zealand genetics, either grazing generous amounts of pasture with no supplements or fed a total mixed ration based on maize silage, grass silage and concentrate.

MATERIALS AND METHODS

Design

Genotype, diet, and genotype x diet interactions were investigated during the first year of a three-year experiment that compared HF genetics of New Zealand (NZ) or OS origin. Primiparous OS and NZ heifers either grazed pasture (Grass) or were fed a total mixed ration (TMR) at the Dairying Research Corporation No. 1 Dairy during the 1998/1999 season. The four treatments in this 2 x 2 factorial experiment were NZ Grass (n=14); OS Grass (n=9); NZ TMR (n=15); and OS TMR (n=10). Within genotype, heifers were paired and randomly allocated to treatment groups. Treatments were balanced for Breeding Worth (BW) (61.5 ± 1.3 , Mean \pm SEM) and, within genotype, treatments were balanced for sire and live weight (513 ± 13.4 , OS HF; 425 ± 7.9 NZ HF).

Heifer selection

Eight sires were represented in the OS treatments and seven sires were represented in the NZ treatments. The OS genotype had 100% OS ancestry; 10 of the 20 OS heifers originated from the United States and 10 of the 20 OS heifers originated from the Netherlands. Holland Genetics Ltd. imported the OS genetics into New Zealand in 1996 as embryos for the Livestock Improvement Corporation (LIC) as part of the LIC Sire Proving Scheme. As such, the

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OS genetics used in the present experiment represent OS genetics that have been used in NZ. After birth, OS calves were sold to commercial farmers and were subsequently purchased by the DRC prior to their first parturition. The NZ genetics used in the present experiment were selected from the DRC herds based on BW and proportion of NZ ancestry. Heifers were selected with less than 12.5% OS genes and that had a BW comparable to the OS genetics.

Although small numbers of heifers per treatment were used, the respective genotypes were fairly represented. The OS HF represented sires that were widely used in the New Zealand national herd. At the initiation of the experiment, half of the OS sires had been proven in New Zealand, and half of the OS sires had relatives that had been proven in New Zealand. Of these sires, all now have New Zealand proofs. In addition, the brothers of the heifers used in this experiment were part of the Livestock Improvement Corporation's sire proving scheme.

Feeding and management of TMR heifers

Heifers fed TMR were confined to one of three loafing paddocks (0.25 ha/paddock) and a concrete and sand free-draining feedpad which was sheltered from the wind (288 m²; 11.5 m² per cow). NZ and OS HF were maintained in separate herds throughout lactation. The feedpad was used during July, August and September and the loafing paddocks for the rest of lactation. The TMR was fed between 0800 and 1000 h and between 1500 and 1700 h each day in four 5m long mobile fibreglass troughs. NZ HF and OS HF received the same TMR and were fed to achieve a 10% refusal rate (ad libitum intake). The feeds were weighed and manually mixed in feed troughs at each feeding. At the start of lactation, heifers were introduced to TMR over a two-week period. Delays in construction of the feed pad meant that 60% of cows in each of the NZ and OS TMR groups grazed pasture for an average of four weeks before transition to TMR.

TABLE 1. Proportion of maize silage, grass silage, and concentrate in the total mixed ration during the 1998/1999 lactation.

	Maize silage (%)	Grass silage (%)	Concentrate (%)
August – October 1998	25	25	50
October – December 1998	55	0	45
December – March 1999	30	30	40
March – April 1999	35	35	30

The criteria used to formulate the TMR were to maintain a ration supplying nutrients and to use feed ingredients that were typical of the diets fed in North America or Europe in systems within which the OS genetics were selected. The TMR was not a least-cost ration, but a standard control. Heifers were fed according to NRC (1989) dairy cow feed requirements for high production. Rations were formulated using the Spartan ration formulation programme (van de Haar *et al.*, 1992) and the Cornell Net Carbohydrate and Protein System model (Fox *et al.*, 1992). The TMR consisted of forage and concentrates in the proportions described in Table 1. The pelleted concentrate (10 mm in length) was formulated to balance nutrients supplied by the forages. For much of the lactation, the concentrate comprised 42.8% ground maize grain, 22.5% soybean meal,

8.6% barley grain, 6.4% molasses, 4.8% corn gluten meal, 4.3% fishmeal, 4.3% soyoil, 2.1% calcium di-phosphate, 1.5% limeflour, 1.1% rumen-protected fat, 0.7% salt, 0.5% urea, 0.3% magnesium oxide, and 0.05% ruminant trace mineral and vitamin pre-mix (% concentrate DM).

Grazing management

The aim was to generously feed NZ Grass and OS Grass on pasture throughout lactation, i.e., an allowance of >60 kg DM/heifer/d was offered. This experiment did not test NZ and OS HF in a confined pasture system. Rather, heifers were offered the optimal paddocks at No. 1 Dairy (total area 60 ha) for grazing and were followed by a non-treatment herd of cows to maintain pasture quality. Post-grazing residuals were used to determine pasture allocation; post-grazing residuals of >1800 kg DM/ha were targeted during spring and autumn and >2200 kg DM/ha during summer. During the dry summer grass silage was offered to both herds at a rate of 2 kg DM/heifer/day to maintain pasture residual targets. Both NZ Grass and OS Grass herds grazed the same paddock but were separated by a wire.

The decision to dry off was based on condition score and daily milk production. Both grazing herds were dried off at the same time. Differences in lactation length between NZ Grass and OS Grass reflect differences in calving date. Both of the TMR herds were dried off one week after the grazing herds because milking facilities were not available. Based on condition score and daily milk production, the TMR herds could have milked on for longer had milk facilities been available.

Measurements

Milk yield was recorded daily and milk composition determined weekly from a 30-ml subsample. Live weight was recorded weekly and body condition score every second week. Daily intake was determined on a herd basis by rising plate meter (Grass) and by daily weighing of feed offered and refused (TMR). Calculation of pasture DM intake from rising plate meter assessments was difficult at the high allowances used in this experiment as pre- and post-grazing herbage masses were often similar. Estimates of DM intake during lactation were subsequently made based on milk production and live weight. A representative 500-g sample of the feeds used in the TMR, refused TMR, and pre-grazed pasture was collected on one day each week. Samples were oven-dried at 100 °C for determination of DM, and at 60 °C for subsequent near-infrared analysis (Ulyatt *et al.*, 1995) of nutrient composition.

Statistical analysis

Data were analysed using the general analysis of variance procedure of Genstat (Version 3.2) according to completely randomised design. The analysis tested for genotype, diet, and genotype x diet interaction. All means presented are least squares. Significant effects were declared at $P < 0.05$ and trends at $P < 0.10$.

RESULTS

The chemical components of the pasture were consistent with high quality herbage (Table 2). Nutrient levels of the

TMR met or exceeded minimum levels recommended by NRC (1989) for high producing dairy cows. The TMR contained less CP, NDF, ADF, and more NSC than pasture during the season. Both diets had a similar mean ME content.

TABLE 2. Mean annual nutrient composition of the grass diet and total mixed ration (TMR).

(% DM)	Grass	TMR
ME (MJME/kg DM)	11.7	11.8
Crude protein (%DM)	24.8	18.1
Neutral detergent fibre (%DM)	42.6	30.6
Acid detergent fibre (%DM)	21.8	19.4
Nonstructural carbohydrate (%DM)	10.8	28.1
Fat (%DM)	4.5	5.6
Ash (%DM)	10.6	12.3

OS HF had fewer days in milk, higher live weight, produced more milk with a lower milkfat content, and ended the lactation with a lower body condition score compared to NZ HF (Table 3). The OS HF tended ($P=0.08$) to be less efficient than NZ HF when efficiency was expressed as kg MS/kg LW^{0.75}. The two genotypes did not differ significantly in yield of milksolids, milk protein content, or persistency of lactation.

Compared to HF fed Grass, HF fed TMR produced more milk and milksolids, had a lower milkfat content, were more efficient producers of milksolids, and had a more persistent lactation (Table 3). HF fed TMR also gained more live weight during lactation than HF fed Grass, and ended lactation with a greater live weight and body condition score. Feeding TMR tended to increase days in milk ($P=0.06$). Diet did not influence milk protein content or live weight pre- or post-calving.

A genotype x diet interaction was observed for liveweight gain during lactation (Table 3). OS TMR gained more live weight from immediately post-calving to the end of the season than NZ TMR ($P<0.05$), but OS Grass gained less live weight than NZ Grass ($P<0.05$). As a result a genotype x diet interaction trend ($P=0.09$) was observed for live weight at the end of the season.

DM intake measured on a herd basis indicated OS TMR had a higher intake than NZ TMR, but that OS Grass and

NZ Grass had similar DM intakes (Table 3).

DISCUSSION

This study made the unique comparison of two HF genotypes of the same initial Breeding Worth. As such, differences observed in the first lactation can be attributed largely to genotype differences rather than genetic merit *per se*.

First lactation results have important implications for the production and survival of OS HF in all-grass dairying systems. Although OS HF produced more milk on both diets, the lower milkfat content of OS HF milk meant that milksolids production was comparable between genotypes. This was consistent with the comparison of Canadian sires and New Zealand sires in the CANZ study (Peterson, 1988) which reported similar levels of milksolids production between the two genotypes within the respective countries environment. Dillion and Buckley (1998) also reported that high genetic merit HF cows of North American origin grazing pasture and receiving 0.9 to 1.5 t DM/cow/year of concentrates, produced more milk (945 kg/cow/year) with a lower milkfat content (0.31 percentage units) than medium genetic merit cows containing less North American genetics. Unlike the present study, Dillion and Buckley (1998) reported a reduced milk protein content (0.09 percentage units) and increased milksolids production (48 kg/cow/d). The differences in milk components between genotype in the present study reflect the different selection criteria traditionally used in New Zealand and North America and Europe. Despite OS HF having a lower milksolids content than NZ HF (7.2 vs. 8.0%), OS HF produced more protein for a given level of milksolids, i.e., the protein:fat ratio was higher for OS HF (0.94 vs. 0.80). For the grazing herds in the present study, this meant that OS Grass produced milk with a value of \$4.08/cow/d compared with NZ Grass that produced milk with a value of \$3.89/cow/d.

The milksolids production of OS Grass, however, came at the expense of live weight. OS Grass heifers only gained 22 kg LW (5% of post-calving LW) from after calving to the end of their first lactation in comparison with NZ Grass heifers that gained 55 kg (14% of post-calving LW). Genetic merit comparisons at Moorepark (Dillion and Buckley,

TABLE 3. Mean annual milk production, lactation persistency, efficiency of milksolids production, live weight and body condition score, and mean annual DM intake of New Zealand (NZ) and overseas (OS) heifers grazing pasture (Grass) or fed total mixed ration (TMR) during the 1998/1999 lactation.

Genotype (G) Diet (D)	NZ		OS		SED	Genotype	P	
	Grass	TMR	Grass	TMR			Diet	G x D
Annual milk production								
Days in milk	261	268	242	261	8.7	0.047	0.055	0.347
Milk yield (kg/cow)	3317	5036	3597	5898	266.4	0.004	<0.001	0.128
Milksolids (kg/cow)	281	380	271	401	20.9	0.651	<0.001	0.293
Milkfat (%)	4.93	4.04	4.16	3.36	0.171	<0.001	<0.001	0.701
Milk protein (%)	3.54	3.48	3.44	3.46	0.07476	0.283	0.596	0.393
Decline in milksolids (%/month)	9.8	3.8	9.4	3.1	0.7804	0.308	<0.001	0.785
Efficiency (kg MS/LW ^{0.75})	3.12	4.0	2.74	3.82	0.2204	0.081	<0.001	0.535
Live weight and body condition								
Pre-calving (kg/cow)	439	440	541	519	19.6	<0.001	0.571	0.396
Post-calving (kg/cow)	379	378	441	436	20.2	<0.001	0.834	0.860
Season end (kg/cow)	434	501	464	575	18.1	<0.001	<0.001	0.091
Gain during lactation (kg/cow)	54.9	123.1	22.1	139.3	17.3	0.571	<0.001	0.050
Season end condition score	4.6	6.2	3.9	5.5	0.3	0.002	<0.001	0.970
DM intake (kg/cow)	3254	4661	3126	4799				

1998) also reported greater live weight loss in early lactation and lower liveweight gain in the second half of lactation for high genetic merit HF of North American origin. However production differences between high and medium genetic merit was confounded in the study of Dillon and Buckley (1998) because the high and low genetic merit heifers were two different genotypes. The novel aspect of the present study is that we can attribute differences in liveweight gain to differences in genotype, and not Breeding Worth (or genetic merit). Unlike the Moorepark comparison, the present study detected a genotype x diet interaction for liveweight gain during lactation, i.e., on TMR, OS HF gained more live weight than NZ HF, and on Grass, OS HF gained less live weight than NZ HF.

The observation of a genotype x diet interaction in the current study, was probably a result of using diets that had a greater difference in nutrient supply than the diets compared in the study of Dillon and Buckley (1998). Veerkamp *et al.* (1994) discussed the possibility that high genetic merit dairy cows may not be able to maintain their genetic advantage under a low input system as the increase in gross energetic efficiency of high genetic merit dairy cows is not due to better utilisation of feed, but rather to a higher degree of body tissue catabolism and to simple dilution of maintenance. If there was a limit to the rate of tissue mobilisation or the amount of mobilisable tissue, a genotype x environment interaction may occur. However, because tissue reserves are substantial, Veerkamp *et al.*, (1994) suggested that the use of these reserves in one lactation might buffer high merit animals against nutritional adversity and so diminish interactions in the short term, these only becoming evident in subsequent years. Evidence from the present study would support this notion. Although no genotype x diet interaction was detected for milk or milksolids production, based on the end of season body condition scores, OS Grass clearly supported a significant proportion of milk production at the expense of body reserves. Without significant supplementation during the dry period, a genotype x diet interaction might be expected to occur in the following season. The cost of achieving calving condition score targets (>5) for OS Grass was 200 kg maize silage DM/cow and 60 kg concentrate DM/cow in addition to generous pasture feeding during the 60 days prior to calving. Dillon and Buckley (1998) also reported the need for significant winter feeding to prepare for the following season, despite a feeding system during lactation that supplied more than 0.9 t DM/cow in supplements during lactation. These results indicate that despite generous pasture allowances throughout lactation, OS HF were unable to consume sufficient additional feed to support adequate liveweight gain. This result is clearly a function of qualitative differences between pasture and TMR and/or the inability of the OS HF to harvest sufficient pasture DM in relation to a greater body mass. The inability of OS HF to gain live weight on an all-pasture diet may partly explain the findings of Harris and Winkelman (2000) who reported that only 33% of NZ HF with a high proportion of OS genetics survived to the fifth lactation in Sire Proving herds, compared to 60% of HF with a low proportion of OS genetics.

Prior to the start of the present study we hypothesised

that the lactation curve of OS HF would exhibit greater persistency than NZ HF, based on the nature of the New Zealand seasonal grazing system, which requires a dairy cow to produce more than two-thirds of her production in the first 150 days of lactation. Results from the first year of lactation indicate that the decline in milksolids production of NZ TMR was the same as OS TMR (average 3.5% per month). Provided nutrient supply is adequate, it appears that the NZ HF heifer has a similar capability to produce milksolids as an OS HF heifer. It must be noted, however, that differences in persistency may have been revealed had lactation length been longer than the 265 days attained in this experiment. This result may also have been affected by the proportion of heifers in each of the TMR herds that grazed pasture after calving prior to commencement of TMR feeding. For these animals peak production may have been compromised and persistency affected.

CONCLUSION

As heifers, OS HF genetics produced similar levels of milksolids as NZ HF of similar breeding worth. The inability of OS genetics to maintain adequate condition score throughout lactation presents serious questions regarding the sustainability and suitability of these genetics for seasonal all-pasture dairying systems. The dilemma for dairy farmers and the industry is whether to modify the production system to match the cows potential, or alternatively to breed cows to suit the production system. Given that 50% of the national herd will consist of OS HF genetics in 2002 (Dr Bevan Harris, *pers. comm.*), these are significant considerations. Further comparison of OS and NZ HF will be required to improve the prediction of survivability in pastoral dairying systems.

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