EFFECTS OF PRODUCTION LEVEL ON THE EXPRESSION OF BREED AND HETEROSIS FOR LACTATION YIELDS OF MILK, FAT AND PROTEIN IN COWS MILKED ONCE- AND TWICE-DAILY

F. Lembeye[1], N. Lopez-Villalobos[1], J.L. Burke[1] and S.R. Davis[2]

[1]Institute of Veterinary, Animal and Biomedical science, Massey University, Palmerston North, New Zealand
[2]Livestock Improvement Corporation, Hamilton, New Zealand

SUMMARY

The objective of this study was to estimate breed and heterosis effects between Holstein-Friesian (F) and Jersey (J) cows at different herd production levels in herds milked once-a-day (OAD) or twice-a-day (TAD) in New Zealand. Three groups of herd production levels based on milksolids (MS, fat + protein) production per cow were considered: low, medium and high. The average MS production per cow was: 203.6; 269.2 and 339.9 kg of MS in herds milked OAD; and 272.7; 353.8 and 434.1 kg of MS in herds milked TAD. Data consisted of 322,327 lactation records from 35,192 F; 31,118 J and 88,606 crossbred (F×J) cows that calved in spring between 2008 and 2012. Breed effects, defined as F-J, increased as production level of the herd increased in both systems. Heterosis effects, expressed as a percentage of the mean of the parental breeds, ranged between 3.3 and 8.4% in OAD and 4.4 and 7.4% in TAD systems. The highest expressions of heterosis were found at medium (6.3-8.4%) and high (6.1-7.4%) production level in cows milked OAD and TAD, respectively. In conclusion, production level affects the expression of breed and heterosis in both milking systems. Breed and heterosis effects increased as production levels increased.

INTRODUCTION

Pasture-based dairy farming in New Zealand has predominantly been with cows milked twice-a-day (TAD). However, since the late 1990s, milking once-a-day (OAD) has been adopted by some farmers for herd management and lifestyle benefits (Davis, 2005).

Crossbreeding in New Zealand has brought favourable heterosis for production, fertility and survival traits, which results in increased farm profitability (Lopez-Villalobos *et al.* 2000). In an extensive review, Barlow (1981) concluded that heterosis was better expressed when the environmental conditions are sub-optimal, but in New Zealand, Bryant *et al.* (2007) found low or no heterosis on restricted environments in TAD systems.

Because there is evidence of different breed performances and expression of heterosis in different environments in cows milked TAD (Bryant *et al.* 2007; Penasa *et al.* 2010; Kargo *et al.* 2012), the objective of this study was to estimate breed and heterosis effects at different production levels (as an indication of dry matter intake) in cows milked OAD and compare the results with cows milked TAD under New Zealand conditions.

MATERIALS AND METHODS

Data. Lactation yields of milk (MY), fat (FY) and protein (PY) were provided by Livestock Improvement Corporation for the period 2008-2012. Initial data was restricted as follows. Lactation records were sorted based on a code to determine if the cow was milked OAD or TAD at a specific lactation record. In the present study, OAD herds were considered as those herds in which 100% of the cows were milked OAD during the entire lactation. Twice-a-day herds were selected in a radius of 20 km from OAD herds using map coordinates. In some cases, in a given single map co-ordinate, OAD herd was surrounded by several TAD herds, in that case all TAD herds were selected using the GPS Visualizer (Schneider, 2012). Only herds with more than 50 cows recorded per season were used in the analysis. Only records from spring calving cows in their first five lactations with lactation lengths greater than 150 days and less than 305 days were considered. Also, only records from Holstein-Friesian (F), Jersey (J) and their crosses (F×J) were kept, discarding cows whose parents provided no information about their breed composition.

After all the restrictions were imposed, the dataset contained 322,327 lactation records from 154,916 cows (35,192 F; 88,606 F×J and 31,118 J); 127,885 lactations were from 298 herds milked OAD and 194,442 lactations were from 350 herds milked TAD.

Three groups (clusters) per milking frequency were constructed based on herd production levels (low, medium or high) for milksolids (MS, fat + protein) per cow using the FASTCLUS procedure of SAS version 9.3 (SAS Institute Inc., Cary, NC., USA, 2012). Low, medium and high production levels were considered those herds which respectively yielded: 203.6; 269.2 and 339.9 kg of MS in herds milked OAD; and 272.7; 353.8 and 434.1 kg of MS in herds milked TAD. Number of herds per each cluster was: 110, 141 and 47 for low, medium and high production levels in the OAD population; and 168, 150 and 32 in the TAD population.

Statistical Analysis. A univariate linear model was used to obtain breed and heterosis effects for MY, PY and PY using the MIXED procedure (SAS 2012). The model included the random effect of herd-season, the fixed effects of milking frequency, lactation number, production level, interaction between milking frequency and lactation number, interaction between milking frequency and production level, linear regression of MY, FY or PY on mean calving date deviation from median calving date of the herd for a given season, linear regressions of MY, FY or PY on proportion of F within each combination between production levels and milking frequencies, linear regressions of MY, FY or PY on coefficient of heterosis within each combination of production level and milking frequencies and the random residual error. The solutions for fixed effects and estimates of the regression coefficients for proportion of F and heterosis coefficients were used to predict the performance of F, J and F_1 F×J cows at different production levels.

RESULTS AND DISCUSSION

Table 1 presents predicted production level of pure F, J and crossbred F_1 (F×J), with breed and heterosis effects for MY, FY and PY in each combination of milking frequency and production level.

Breed effects, defined as F-J, increased as production levels of the herd increased in both OAD and TAD systems. The superiority of F cows at high production levels showed more than double the level observed for yield of milk, fat and protein at low and medium production level in both systems. The smaller breed effect at low and medium production level compared to high production level suggest that J cows might have an advantage over F cows in those environments, in particular in OAD systems. The nutritional status of cows in grazing conditions varies considerably across the seasons in New Zealand; hence F cows cannot express their potential when they are exposed to restrictive periods (Ahlborn-Breier and Hohenboken, 1991).

Differences in productive performance among breeds relate to the environment in which the breeds are evaluated (Bryant *et al.* 2007; Penasa *et al.* 2010; Kargo *et al.* 2012). Those studies reported that in general, more productive cows (with large proportion of North American genes) increased their superiority for MY in higher input systems. In more intensive systems, the nutritional requirements of high productive cows are likely better achieved (Penasa *et al*. 2010) allowing high producing cows (as F cows) to express their genetic merit for milk, fat and protein production.

Table 1. Breed performance and standard errors of production traits for Holstein-Friesian (F), Jersey (J) and first cross (F_1) F×J cows, and estimates of breed and heterosis effects at different production level

Production level[1]	MF[2]	F	F_1 F×J	J	Breed effect	Heterosis effect	
					F-J (kg)	kg†	%‡
			Milk yield (kg/cow)				
L	1	2572±26	2479±24	2101±25	471[a]±18	143[a]±15	6.1
	2	3526±18	3319±17	2760±19	767[b]±12	176[a]±10	5.6
M	1	3305±21	3193±20	2703±20	602[a]±12	189[a]±10	6.3
	2	4520±17	4198±17	3523±18	997[b]±11	177[a]±8	4.4
H	1	4221±29	3901±28	3331±29	890[a]±15	125[a]±13	3.3
	2	5595±26	5141±27	4096±29	1499[b]±15	295[b]±13	6.1
			Fat yield (kg/cow)				
L	1	121.4±1.3	132.7±1.1	118.6±1.2	2.8[a]±0.9	9.3[a]±0.7	7.7
	2	157.7±0.8	178.9±0.8	151.7±0.9	6.0[b]±0.6	11.4[a]±0.5	7.3
M	1	157.2±1.0	178.9±0.9	155.9±0.9	1.3[a]±0.6	11.1[a]±0.5	7.1
	2	202.0±0.8	231.4±0.8	195.9±0.9	6.1[b]±0.5	13.5[b]±0.4	6.8
H	1	195.8±1.4	209.4±1.3	191.3±1.4	4.5[a]±0.7	10.0[a]±0.6	5.2
	2	245.5±1.2	267.4±1.3	233.4±1.4	12.2[b]±0.7	17.8[b]±0.6	7.4
			Protein yield (kg/cow)				
L	1	97.7±1.0	99.3±0.9	87.6±1.0	10.1[a]±0.6	6.7[a]±0.5	6.7
	2	127.6±0.7	127.1±0.7	111.0±0.7	16.7[b]±0.4	7.8[a]±0.3	6.6
M	1	126.2±0.8	128.7±0.7	114.4±0.8	11.8[a]±0.4	8.4[a]±0.4	8.4
	2	164.1±0.6	162.4±0.6	142.8±0.7	21.3[b]±0.4	9.0[a]±0.3	5.9
H	1	160.1±1.1	157.5±1.1	141.2±1.1	18.9[a]±0.5	6.9[a]±0.5	6.9
	2	203.9±1.0	199.6±1.0	171.3±1.1	32.6[b]±0.5	12.0[b]±0.5	6.4

[1] L= low milksolids (fat + protein) yield, M = medium milksolids yield, H = high milksolids yield.

[2] MF = milking frequency, 1 = milking once-daily and 2 = milking twice-daily.

† Expressed as F_1 F×J – (F + J)/2.

‡ Expressed as a percentage of heterosis effects relative to the phenotypic average of the parental breeds under milking frequency and production levels, as appropriate.

[a,b] Within traits and production level, breed and heterosis effects with different superscripts were significantly different between milking frequencies (P<0.05).

Heterosis effects for production traits, expressed in absolute values, tended to be greater in TAD, but in relative values, heterosis effects were similar in both, OAD and TAD systems (3.3-8.4% in OAD and 4.4-7.4% in TAD systems).

The expression of heterosis for production traits was influenced by production levels. In TAD systems the absolute values of heterosis effects for milk, fat and protein increased as production level increased but in relative values, heterosis at low and high production levels tended to be similar. The lowest heterosis effects expressed in relative values were observed at medium production levels. In OAD systems, the absolute and relative heterosis effects for the production traits were greater at medium compared to low and high production levels.

Despite lower relative heterosis effects at low production level these effects are similar to the heterosis effects for production traits in New Zealand by Ahlborn-Breier and Hohenboken (1991) and Harris (1996).

The results obtained in this study are similar to the studies of Bryant *et al*. (2007) and Kargo *et al*. (2012), who found greater heterosis in the medium and high producing environments, contradicting Barlow (1981) who affirmed that heterosis effects tended to be greater in less supportive environments.

CONCLUSION

Expression of breed and heterosis effects differed across milking frequencies and production levels. The productive performance of F cows relative to J cows increased as production levels of MS increased in both, OAD and TAD systems. Production levels of the herds are also a factor which affects the expression of heterosis in both milking frequencies.

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