Economic modelling of the comparative performance of Jersey x Holstein-Friesian crossbred cows in Victorian Holstein-Friesian herds

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ABSTRACT

An economic model was developed to compare two different farm systems using the production results and reproductive performance figures derived from an observational study of 14 seasonally calving dairy herds in Victoria. The farm systems modelled were a crossbred herd comprising Jersey x Holstein-Friesian and Holstein-Friesian x (Jersey x Holstein–Friesian) breed types and a herd of Holstein-Friesian cows with farm operating profit as the outcome. A direct comparison of the two farming systems demonstrated a clear advantage in operating profit that averaged A$21,194 for the 267 cows in the crossbred herd compared to the 252 cows in the Holstein-Friesian herd. The difference in profit was due to the higher potential stocking rate of the crossbred herd (2.27 vs 2.15 cows/ha) because of their lower live weight (1 crossbred cow = 0.93 Holstein-Friesian cow) and superior reproductive performance (84% vs 77% pregnancy rate after 14 weeks) resulting in longer survival and reduced investment in replacement rearing costs.

Keywords: dairy cows; crossbreeding; fertility; production; operating profit.

INTRODUCTION

Crossbreeding takes advantage of both additive and non-additive genetic effects (Ahlborn-Breier & Hohenboken, 1991) with the greatest influence on traits relating to fertility, survival, health and production (Hansen, 2003). New Zealand national data are in agreement revealing positive heterosis effects for milk yield traits and survival traits (Montgomerie, 2002).

The survival and fertility of Jersey (J) cows, strains of Holstein-Friesian (HF) cows and their crosses (JFH) were investigated under the seasonal dairy farming system of New Zealand (Harris *et al*., 2000). That study found crossbreeding increased production and had a favourable effect on fertility traits and survival. Fertility was also found to be superior in JHF crossbred cows compared to J and HF cows in a study that benchmarked the reproductive performance of dairy cows in New Zealand (Xu & Burton, 2003).

There have been very few studies in Australia comparing the performance of JHF crossbred cows to HF cows. A recent study of 332,000 Australian production recorded cows found a low level of heterosis for milk volume, protein and fertility based on non-return rate but a usefully large level of heterosis for fat and survival (Carrick, 2003).

The aim of this study was to develop an economic model comparing two different farm systems using the production and reproductive performance figures derived from an observational study of selected seasonally calving dairy herds containing at least 15% JHF crossbred cows. The farm systems model compared the farm operating profit for a herd of JHF crossbred cows and a herd of HF cows.

MATERIAL AND METHODS

Data

The selection of the 14 study herds was based on the premise that nominating herds situated throughout the major dairying regions of Victoria would best represent the performance of crossbreds. The herds were required to have been production recorded, had a seasonal or split calving pattern with two or three calving periods in a year, were pasture-based with or without supplementary feeding regimens, contained at least 15% of first cross J x HF and/or backcross HF x (J x HF) cows in the herd and had a herd size greater than 140 cows. Non-pregnant and undiagnosed cows were followed through until they were confirmed to be non-pregnant so that an accurate conception date could be assigned to every pregnant cow.

Data collection occurred over a complete lactation during the 2003/04 season with all lactations commencing with a calving on or between specified dates recorded for each study herd. Cows that were carried over into this lactation, or calved outside the specified calving period, were subsequently excluded from the study.

The collection and storage of the reproduction and production data from each farm, prior to statistical analysis, was managed by means of the commercial herd management program, Dairy Data for Windows© (Warrnambool Animal Production Services, Warrnambool, Victoria). Only first cross J x HF, back cross HF x (J x HF) and straight bred HF cows were included in the statistical analyses.

Statistical analyses

Reproductive indices were calculated for 21-day submission rate, first service conception rate, pregnancy rates at 6, 14 and 21 weeks following mating start date (MSD), not-in-calf rate at 21 weeks and calving-to-MSD interval. Milk and component yields based on herd test day milk, fat and protein production were used to predict 305-day production.

Independent variables for the analysis of reproduction and production were the fixed effects of breed (straightbred and crossbred), herd, age category (2, 3 and ≥4 years-old) and calving to MSD duration in days. The age categories used in the calculations were defined as:

Age category 2 = Calving age < 30 months.
Age category 3 = Calving age 30 to < 42 months.
Age category 4 plus = Calving age ≥ 42 months.

The reproduction data from the 14 herds were analysed using a logistic regression model to produce back transformed least squares means of reproductive parameters and odds ratios. The production data from the 14 herds were analysed using a general linear model to produce least squares means of production parameters.

The GLIMMIX procedure of SAS (2006) was used for analysis. Values of $P <0.05$ were considered statistically significant.

Whole farm analysis model

Various published models have enabled different farming systems to be compared in terms of biophysical and economic performance. Two studies that have utilised economic models to analyse the performance of crossbreds were Lopez-Villalobos and Garrick (2002), and Malcolm and Grainger (2004). The former investigated relative farm profitability of crossbred and straightbred herds using a pastoral farm model to investigate economic effects of breed complementarity and heterosis for individual traits. Malcolm and Grainger (2004) developed a model that looked at the implications of changing an HF dairy system to that of a JHF crossbred herd running 230 HF cows as compared to 242 JHF crossbred cows as the JHF cows were assumed to weigh 90% of the live weight of the HF cows (Auldist & Grainger, 2004).

The comparison of the two farm systems using study data required a number of changes to the values that had been incorporated in the original model of Malcolm and Grainger (2004). They included production and reproduction results from 2,373 HF and 974 JHF crossbred cows from the 14 study herds, the age distribution of the breed types in those herds and the current monetary value of HF cows. The total numbers in each herd were adjusted to accommodate the different age structure of the study herds and to reflect the average liveweight difference between the HF and the two crossbred breed types equivalent to one crossbred equalling 0.93 of a HF cow (Auldist *et al*., 2007). This ensured that the total energy supplied to meet actual milk and non-milk energy requirements of the cows was the same for both herds. The HF herd in the model comprised 252 cows whereas the crossbred herd was 267 cows.

RESULTS

Reproductive performance

The reproductive performance of the JHFcrossbred cows was superior to the HF cows involving first service conception rate ($P = 0.002$), pregnancy rate 6 weeks after MSD ($P <0.001$), pregnancy rate 14 weeks after MSD ($P <0.001$) and a lower not-in-calf rate ($P <0.001$) (Table 1). The 21 day submission rates of 83.7% and 80.9%, ($P = 0.07$) were not statistically different.

TABLE 1: Back transformed least squares means and odds ratios for selected parameters of reproductive performance ratios for conception rate to first insemination (CR_1), 21 day submission rate (SR21day), proportion of cows pregnant in the first 6 (6Wk ICR) and 14 weeks of breeding (14Wk ICR) and not pregnant at 21 weeks (NIC) from 14 study herds for 2,179 Holstein-Friesian (HF) cows and 894 first cross or backcross crossbred (JHF) cows adjusted for herd and age group.

Reproduction variable	Breed type	%	Odds ratio	95% confidence interval	Probability value
CR_1	HF	47.0	1.0	1.15 – 1.60	0.002
	JHF	54.7	1.36		
SR21day	HF	80.9	1.0	0.98 – 1.50	0.07
	JHF	83.7	1.21		
6Wk ICR	HF	56.8	1.0	1.22 – 1.69	<0.001
	JHF	65.3	1.44		
14Wk ICR	HF	77.0	1.0	1.26 – 1.86	<0.001
	JHF	83.7	1.53		
NIC (21 weeks)	HF	19.3	1.0	0.54 – 0.81	<0.001
	JHF	13.7	0.66		

Milk yield and composition

The JHF crossbreds produced 487 litres of milk less than the HF cows ($P <0.001$) but had higher percentages of fat and protein ($P <0.001$). They yielded 4.1 kg more fat ($P = 0.053$) and 6 kg less protein ($P <0.001$) (Table 2).

Whole farm economic model

The superior reproductive performance of the crossbred cows was built into the farm model to allow differences in longevity and heifer rearing costs to be accounted for in the final operating profit. A higher conception rate, 6 and 14 week pregnancy rate and lower not-in-calf rate at the completion of the breeding period implied the crossbreds would survive longer in the herd and that fewer replacement heifers would need to be reared each year. This meant allocating a different culling

TABLE 2: Least squares means and difference (JHF – HF) of the milk, fat, protein and fat plus protein yields, and fat and protein percentage for 305 days from 14 study herds for 2,373 Holstein-Friesian (HF) cows and 974 first cross or backcross crossbred (JHF) cows adjusted for herd, age group and calving to mating start date interval. SE = Standard error.

Production variable	Breed type	Mean	SE	95% confidence interval	Probability value
Milk yield (L)	HF	5855	35.39	5786 - 5925	
	JHF	5368	51.22	5267 - 5468	
	Difference	-487	56.12	-597 to -377	<0.001
Fat yield (kg)	HF	228.0	1.35	225.4 - 230.6	
	JHF	232.1	1.95	228.3 - 235.9	
	Difference	4.1	2.13	-0.1 to 8.3	0.053
Protein yield (kg)	HF	191.5	1.15	189.3 - 193.8	
	JHF	185.5	1.66	182.3 - 188.8	
	Difference	-6.0	1.82	-9.6 to -2.4	0.001
Fat plus protein yield (kg)	HF	419.5	2.43	414.8 – 424.3	
	JHF	417.6	3.52	410.7 – 424.5	
	Difference	-1.9	3.85	-9.5 to 5.7	0.62
Fat (%)	HF	3.92	0.012	3.90 - 3.95	
	JHF	4.33	0.018	4.30 - 4.37	
	Difference	0.41	0.020	0.37 to 0.45	<0.001
Protein (%)	HF	3.28	0.005	3.27 to 3.29	
	JHF	3.46	0.008	3.44 to 3.47	
	Difference	0.18	0.009	0.16 to 0.20	<0.001

rate to each herd based on their not-in-calf rate leading to differences in livestock trading activities.

Operating profit and return to total capital were superior for the JHF crossbred herd as depicted in Table 3. The actual difference in operating profit was A$21,194 and there was a 1.21% improvement in return to capital over that of the HF herd.

DISCUSSION

The reproductive performance for the JHF crossbred cows was superior to that of the HF cows in the 14 herds. The differences in reproductive performance were similar to those recorded for the breed types in other studies conducted in New Zealand, Ireland and the USA (Harris & Winkelman, 2000; Buckley *et al*., 2004; Heins *et al*., 2006). The superior and significantly different first service conception rate, 6 and 14 week pregnancy rate and the lower not-in-calf rate mean crossbred herds can achieve a more compact calving pattern with fewer replacements and lower rearing costs all leading to a longer productive life.

TABLE 3: Case study farm running either a 252 cow Holstein-Friesian (HF) herd or a 267 cow crossbred (JHF) herd showing operating profit (A$) after deducting costs from an estimated income.

Economic variables	HF	JHF
Gross income		
Milk receipts	$398,669	$418,797
Stock trading profit/loss	$37,279	$30,225
Less total variable costs	$251,357	$240,629
Total gross margin	$184,592	$208,394
Less overhead costs	$80,732	$83,341
Less operators allowance	$60,000	$60,000
Operating profit (Before interest & tax)	$43,859	$65,053
Profit $/cow	$174	$244
Return to capital	2.51%	3.72%

The small difference in 21 day submission rate of 2.8% in favour of the crossbreds (Table 1) is consistent with the reported fertility of the HF cow. Although ovarian activity may commence sooner after calving in these animals, it does not necessarily lead to overt oestrus with ovulation until the greater negative energy balance in the larger HF is reduced (Macmillan *et al*., 1996). The results of the DairyNZ strain trial (MacDonald *et al*., 2008) support this finding demonstrating that North American HF cows commence oestrous activity earlier than the modern New Zealand HF but experience a lower in-calf rate. On the other hand J cows appeared to initiate oestrous cyclicity sooner than HF cows (Grosshans *et al*., 1997).

The higher yields of milk and protein by the HF cows compared to the greater amounts of fat and significantly higher concentrations of fat and protein in the milk produced by the crossbreds (Table 2) are in agreement with recent studies that have assessed the differences in production between HF and JHF crossbred cows (Madgwick & Goddard, 1989; Harris *et al*., 2001; Carrick *et al*., 2003). Any production advantages for HF cows appear to be of limited value due to their larger size, higher energy requirements and less efficient feed utilization (Malcolm & Grainger, 2004).

Farm operating profit, calculated through whole farm analysis and based on the actual production and reproductive performance of the enrolled 14 mixed breed herds confirmed the superior profitability of the crossbred herd compared to the HF herd. The model demonstrated a substantial difference in operating profit between the two systems and a substantial improvement of nearly 50% in return to capital for the crossbred herd compared to the HF herd. This difference mainly involved milk income and reproductive performance.

The HF cows attracted higher replacement values and higher cull values due to their heavier weight to create a higher livestock trading income of A$7,054 plus an additional A$2,608 that equated to reduced labour costs from carrying 15 fewer cows.

Although the HF herd had a better return to income from livestock trading and spent less on labour due to stocking a lower number of animals, the milk receipts and consequences of superior reproductive performance in the crossbred herd, outweighed these benefits.

The higher stocking rate in the JHF crossbred herd brought about by the lower maintenance requirements of the lighter crossbred cows meant there were an extra 15 cows each producing milk solids at a level just below that of the HF cows. This translated into a difference in milk receipts of A$20,128 in favour of the JHF crossbreds. This advantage was further enhanced by a reduced number of JHF yearling heifers that required feeding and agistment, a total benefit of A$10,728. A superior conception rate, 6 and 14 week pregnancy rate and not-in-calf rate were responsible for the differences.

Reproductive performance and calving pattern influence the rate of genetic progress, herd wastage, feed demand, lactational length and milkfat production (Macmillan *et al*., 1990). The benefit that can flow from an improvement in the reproductive performance of a herd is the development of a tighter calving pattern (Grosshans *et al*., 1997) and the quantity of milk produced per cow per day, directly affecting the profitability and longevity of dairy cows (Hageman *et al*., 1991). A tighter calving pattern may in turn allow managers to maintain a seasonal calving pattern. This can confer significant economic benefits on the system by minimising the cost of milk production (Macmillan *et al*., 1990).

A self-replacing crossbred herd of JHF cows can deliver clear benefits in operating profit to commercial dairy farmers under low input, pasture-based conditions when compared to a HF herd receiving the same energy inputs. This can be managed through the production of changed proportions and quantities of milk solids from reduced energy supplies while decreasing herd replacement costs in direct contrast to the energy requirements and herd costs of a HF herd.

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