ECONOMIC HETEROSIS AND BREED COMPLEMENTARITY FOR DAIRY CATTLE IN NEW ZEALAND

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INTRODUCTION

Crossbred cows are a significant proportion of the New Zealand dairy herd and are gaining popularity in the U.S. (McAllister, 2001). Crossbreeding can result in increased farm profit in some economic circumstances (Lopez-Villalobos *et al.,* 2000; Van Raden, 2001) where payment systems reward milk solids and penalise volume of milk. Crossbreeding can benefit traits such as reproduction, health and survival, which sometimes have large influences on farm profit. Accumulated effects of heterosis for individual traits can result in significant economic heterosis (Touchberry, 1992 ; McAllister *et al.,* 1994). Economic heterosis can be defined as the difference in farm profit between the crossbreed herds and the average of the straightbreed herds. Economic heterosis can also arise from breed complementarity in the absence of heterosis for individual traits (Moav, 1973). The objective of this paper was to investigate economic effects of breed complementarity and heterosis for individual traits in a pastoral system of milk production.

MATERIAL AND METHODS

A pastoral farm model developed by Lopez-Villalobos *et al.* (2000) was used to evaluate the effect of payment systems on the relative farm profitability (NZ$/ha) of straightbred and crossbred herds involving the Holstein-Friesian and Jersey breeds. Body weight and milk productivity were calculated from additive breed, heterosis and age effects. Heterosis effects were assumed at 1.7, 13.6, 3.9, 4.5 and 4.0% for cow live weight, longevity and lactation yields of milk, fat and protein, respectively. Effects of heterosis and breed complementarity were evaluated under three scenarios : scenario I ignored heterosis; scenario II assumed heterosis only for production traits; and scenario III assumed heterosis for production traits and longevity.

Metabolisable energy requirements were derived for maintenance, growth, lactation and pregnancy of cows, and for growth of replacements. Average dry matter (DM) required per cow (including proportional replacements) was calculated assuming an energy density of 10.5 MJ of metabolisable energy/kg DM. Stocking rate, defined as number of cows per hectare, was calculated by assuming 12000 kg DM was eaten annu ally per hectare, regardless of breed.

Farm profit was gross income from milk and beef minus production costs. Milk revenue was assessed at a low value market (NZ$0.294/l) and a high value market (NZ$0.369). In each market payment solely on milk yield was compared to a payment based on index A+B–C that rewards yields of fat and protein and penalises milk yield. Payment values were chosen such that milk with an average composition had the same value under either payment system (milk yield or A+B–C).

Income from beef was calculated from male and surplus female calves (NZ$5.1/kg carcass weight), culled rising 2-yr-old (NZ$3.7/kg carcass weight) and older cows (NZ$3.1/kg carcass weight). Farm production costs were from Dexcel (2000). Direct expenses per cow were NZ$342 and included: labour, animal health, breeding and herd-testing, farm dairy expenses, electricity and freight. Direct expenses and overheads per hectare were $1,324 and included: pasture renovation, fertiliser, weed and pest control, repairs and maintenance, vehicle expenses, administration, standing charges and depreciation. Additional costs (concentrates, labour, animal health and breeding) for rising 1-yr and 2-yr olds were NZ$66 and NZ$57 per animal, respectively.

RESULTS AND DISCUSSION

Herd averages for productive and reproductive traits are in Table 1. For live weight, milk and protein yields per cow, the Holstein-Friesian herd ranked highest, and the Jersey herd ranked lowest. Heterosis effects for production traits (scenario II) caused the crossbred herds to rank higher than the Holstein Friesian for fat yield per cow.

Table 1. Productive performance of straightbred and crossbred dairy herds[A] under different scenarios for heterosis[B]

			Scenario I		Scenario II		Scenario III	
	F	J	F_1 FxJ	Rt FxJ	F_1 FxJ	Rt FxJ	F_1 FxJ	Rt FxJ
Live weight, kg	447	353	400	400	407	405	410	406
Production per cow								
Milk, *l*/year	3,770	2,768	3,269	3,269	3,396	3,354	3,427	3,370
Fat, kg/year	165	160	162	162	169	167	171	168
Protein, kg/year	131	112	122	122	126	125	127	125
DM requirements, kg/year	5,006	4,209	4,607	4,607	4,728	4,688	4,568	4,591
Stocking rate, cows/ha	2.40	2.86	2.61	2.61	2.54	2.56	2.63	2.61
Production per hectare								
Milk, *l*/year	9,036	7,890	8,514	8,514	8,620	8,586	9,002	8,808
Fat, kg/year	395	455	422	422	430	428	449	439
Protein, kg/year	313	321	316	316	321	319	334	327
Replacement rate, %	22.0	22.0	22.0	22.0	22.0	22.0	17.8	19.6
Average herd age, years	4.48	4.48	4.48	4.48	4.48	4.48	5.09	4.89

[A] F=Holstein-Friesian, J = Jersey, F_1 FxJ = first cross, and Rt FxJ = rotational cross.

[B] Scenario I: ignoring heterosis; scenario II: heterosis for production; and scenario III: heterosis for production and longevity.

Heterosis for longevity (scenario III) reduced replacement rate. This lead to increased milk, fat and protein yields per cow as the proportion of mature cows increased. The Jersey herd had the lowest total DM requirements per cow with the highest stocking rate, whereas the Holstein-Friesian herd had the highest total DM requirements and the lowest stocking rate. The Jersey herd had the highest fat production per hectare. When heterosis effects were ignored (scenario

I), productions per ha of milk, fat and protein for the crossbred herds differed by +51 *l*, –3 kg and –1 kg from the average of the straightbred herds.

Economic performances and economic heterosis are in Table 2. The milk payment system affected the ranking of breed groups on the basis on profit per ha. The Holstein-Friesian herd ranked highest when milk revenue was assessed on milk yield but lowest when milk revenue was assessed from milk components. Crossbred herds were more profitable when heterosis effects were considered. VanRaden (2001) found that crossbred cows in the US might be more profitable than Holsteins with a payment system rewarding cheese yield. Heterosis for profit in the low milk value market was higher than in the high market. Payment on milk yield resulted in higher economic heterosis than payment on milk components.

Table 2. Economic performance ($/ha) of straightbred and crossbred dairy herds with low or high milk values, different milk payment systems[A] and scenarios for heterosis

			Scenario I		Scenario II		Scenario III	
	F	J	F_1 FxJ	Rt FxJ	F_1 FxJ	Rt FxJ	F_1 FxJ	Rt FxJ
Production costs	2,218	2,388	2,296	2,296	2,271	2,279	2,288	2,290
Beef income	505	473	490	490	486	487	448	466
Low market value (NZ$0.294/*l* milk)								
Milk yield payment								
Milk income	2,657	2,320	2,503	2,503	2,535	2,524	2,647	2,590
Net income	943	406	698	698	749	733	807	766
Economic heterosis, %			3.5	3.5	11.2	8.7	19.6	13.6
A+B-C Payment								
Milk income	2,551	2,808	2,669	2,669	2,711	2,697	2,823	2,762
Net income	837	893	863	863	926	905	983	938
Economic heterosis, %			-0.2	-0.2	7.0	4.6	13.6	8.4
High market value (NZ$0.369/*l* milk)								
Milk yield payment								
Milk income	3,330	2,908	3,138	3,138	3,177	3,164	3,318	3,246
Net income	1,616	994	1,332	1,332	1,392	1,373	1,477	1,423
Economic heterosis, %			2.1	2.1	6.7	5.2	13.2	9.0
A+B-C Payment								
Milk income	3,201	3,504	3,340	3,340	3,392	3,375	3,533	3,457
Net income	1,487	1,590	1,535	1,535	1,607	1,584	1,693	1,633
Economic heterosis, %			-0.3	-0.3	4.5	2.9	10.0	6.1

[A]At the low market value for milk A+B-C payment was NZ$2.72×kg fat + NZ$5.91×kg protein – NZ$0.041×*l* milk; and at the high market value for milk A+B-C payment was NZ$3.32×kg fat + NZ$7.22×kg protein – NZ$0.041×*l* milk.

Economic heterosis of 3.5 and 2.1% resulted when heterosis effects of individual traits were ignored (scenario I) under the payment on milk yield for the low and high market milk value. This result confirms the findings of Moav (1973) who suggested that profit heterosis can arise from breed complementarity. The effect of heterosis for longevity on herd age structure has an impact on economic heterosis which is as large as the effect of heterosis for production (scenario II vs scenario III). Heterosis for longevity reduced replacement rate and increased the milk, fat and protein yields per cow but increased stocking rate because less feed was required for the growing of the replacements. These results from a pastoral farm confirm that large economic benefits may arise from heterosis for reproduction and survival as calculated by Touchberry (1992).

CONCLUSION

Results from this study confirm that the economic merit of breeds depends on the economic circumstances (payment system for milk) and that accumulated heterotic effects of individual traits and breed complementarity result in economic heterosis that increases farm profit.

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