Experiences with dairy cattle crossbreeding in New Zealand

W.A. Montgomerie. Livestock Improvement Corporation, Animal Evaluation Unit, Hamilton, New Zealand

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Abstract

More than one third of the replacement cattle reared for the New Zealand dairy industry are crossbred, and the trend towards breeding crossbred replacements is increasing. Holstein-Friesian and Jersey are the most heavily represented parent breeds, followed by Ayrshire.

Experimental data demonstrates that efficiency in converting pasture to saleable farm output is similar for the two main parent breeds. National data reveals positive heterosis effects for milk yield traits, and for survival traits. Farmer recognition of these facts explains the popularity of crossbreeding.

Where herds typically comprise more than one breed, and crosses of the breeds, the national genetic evaluation system must develop methods to account for heterosis effects. Provision of profit indexes for cows where herds contain cows of markedly different body size requires the evaluation system to account for feed demands associated with body maintenance.

The New Zealand profitability index calculated as part of the national genetic evaluation system shows that the average Holstein-Friesian x Jersey crossbred cow is more efficient than the average cow of either parent breed. Rotational crossing is used to maintain the efficiency advantage in generations after the first cross.

Introduction

Three main strategies have been used for genetic improvement of the livestock used in animal production systems: (i) selecting between breeds or strains; (ii) selecting within breeds or strains; (iii) crossbreeding – mating parents of two or more breeds or strains together (24). Apart from the widespread upgrading to North American Holstein in the last third of the twentieth century, dairy industries in temperate climates have practised low rates of crossbreeding compared to common practices in other livestock production systems.

Crossbreeding for reasons other than upgrading from one breed to another has been actively practised by New Zealand dairy farmers since 1985, which was the year when the previously rising trend in Holstein-Friesian usage of AI bull semen levelled off (14). Crossbreeding with Ayrshire bull semen also takes place, but at a low level compared to the other two breeds.

Crossbreeding between Holstein-Friesian strains has occurred since 1980 as AI companies introduced North American genes into their breeding schemes. Between 1980 and 1999 the overseas Holstein ancestry in birth-year groups of New Zealand Holstein-Friesian cows increased from 2% to 38% (9). However, farmers did not
pursue a deliberate program of crossbreeding between the local strain and the overseas strain within the Holstein-Friesian breed. In contrast, crossbreeding between Holstein-Friesian and Jersey breeds has been chosen by farmers as a deliberate program. This form of crossbreeding is the primary subject of this review.

**Breeding replacements for the national herd**

In the southern hemisphere dairy season of 2000/2001 the New Zealand national herd comprised 3.5 million cows, and had expanded by 1 million cows in the previous ten years. Crossbred cows comprise a large and increasing proportion of dairy replacements reared. Breed composition of the replacements reared in 2001 and in 1991 is shown in Table 1. Animals with at least ancestry of a single breed were considered straightbred.

<table>
<thead>
<tr>
<th>Table 1. Breeds of dairy replacements reared</th>
</tr>
</thead>
<tbody>
<tr>
<td>Holstein-Friesian</td>
</tr>
<tr>
<td>%</td>
</tr>
<tr>
<td>---</td>
</tr>
<tr>
<td>2001</td>
</tr>
<tr>
<td>1991</td>
</tr>
</tbody>
</table>

In 2000, 44% of the Holstein-Friesian bull semen, 63% of the Jersey bull semen, and 72% of the Ayrshire bull semen was used for artificial insemination of cows other than the bull’s own breed (14).

**Industry background**

The New Zealand dairy industry processes over 90% of its milk into products for export to the global market. Low cost systems for conversion of pasture to milk provide the basis for the industry to survive, given large distances from major markets and restricted access to higher value markets.

Facing costs in storing, transporting and evaporating water in milk, the dairy company payment systems reward farmers who supply milk with high concentrations of milksolids (combined milkfat and protein). In this context, the milk of Holstein-Friesian cows is not ideal as the base product for the dairy product value chain. The Jersey breed has the most concentrated milk, but this milk is characterised by particularly high concentrations of the less valuable milkfat components. Consequently, neither of the major breeds has an obviously preferred type of milk for the industry. Similarly, it is not obvious whether the larger Holstein-Friesian cows with high yields and high feed requirements for body maintenance contribute more effectively to the farmer’s profit than the smaller Jersey cows with lower yields but also with low feed requirements for body maintenance.

Feed requirements for body maintenance absorb a high proportion of the total farm feed supply and differ between cows of larger and smaller body size. For this reason, milksolids yield per kilogram of metabolic liveweight is a useful measure for a first

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1 Typical farmgate prices through the second half of the 1990s have been close to NZ$5.91 per kilogram of protein, NZ$2.72 per kg of milkfat, with a volume deduction of $NZ0.041 per litre supplied. $NZ is worth approximately 0.47 Euro. A typical litre of milk has contained 3.6% protein and 4.8% milkfat (weight by volume). Typical farmgate prices per litre have been close to NZ$0.30 (or approximately 0.14 Euros per litre).
look at cow efficiency. On this measure, Jersey and crossbred cows out-performed the other breeds in recent seasons. Average performance measures, by breed, in the 2000/2001 season is reported for milk-recorded cows in Table 2 (14).

**Table 2. Average cow performance by breed 2000/2001 season**

<table>
<thead>
<tr>
<th>Breed</th>
<th>Holstein-Friesian</th>
<th>Jersey</th>
<th>Crossbreed</th>
<th>Ayrshire</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of cows</td>
<td>1,351,127</td>
<td>408,773</td>
<td>607,449</td>
<td>29,929</td>
</tr>
<tr>
<td>Milk Volume (l)</td>
<td>3,912</td>
<td>2,813</td>
<td>3,519</td>
<td>3,553</td>
</tr>
<tr>
<td>Milksolids (kg)</td>
<td>306</td>
<td>275</td>
<td>304</td>
<td>280</td>
</tr>
<tr>
<td>Liveweight (kg)</td>
<td>489</td>
<td>381</td>
<td>443</td>
<td>451</td>
</tr>
<tr>
<td>Milksolids per kilogram metabolic liveweight* (kg)</td>
<td>2.94</td>
<td>3.19</td>
<td>3.15</td>
<td>2.87</td>
</tr>
<tr>
<td>Milkfat (%)</td>
<td>4.4</td>
<td>5.7</td>
<td>5.0</td>
<td>4.4</td>
</tr>
<tr>
<td>Milk protein (%)</td>
<td>3.5</td>
<td>4.1</td>
<td>3.7</td>
<td>3.6</td>
</tr>
</tbody>
</table>

* defined as liveweight$^{0.75}$

Net income per hectare of available grazing land is a familiar benchmarking measure for New Zealand farmers. Income per cow has not been an important benchmark. As a measure it fails to account for the large variation between achievable stocking rates for herds with substantially different liveweight and milk yield characteristics.

A recent study based on New Zealand data reported that net income per hectare is higher for crossbred cows than for either of the parent breeds (18). The study accounted for

- energy requirements for maintenance, growth, lactation and pregnancy of cows, and for growth of replacements;
- revenues from milk components and beef;
- farm working expenses;
- production, liveweight and survival characteristics of the parent breeds, and of crosses generated from systematic rotational crossing.

**Table 3. Net income per hectare of parent breeds and crosses**

<table>
<thead>
<tr>
<th>Breed</th>
<th>Holstein-Friesian</th>
<th>F$_1$ (H-F x J)</th>
<th>Rotational cross (H-F x J)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Net income ($ per hectare)</td>
<td>1,487</td>
<td>1,590</td>
<td>1,693</td>
</tr>
</tbody>
</table>
The history of the national herd

The New Zealand national herd was pre-dominantly Jersey in the 1950s. During the next thirty years profitability of Holstein-Friesian bulls for manufacturing beef production, and concerns about future markets for butter, prompted an increasing usage of Holstein-Friesian bull semen. In this period many farmers gained experience of working with crossbred cows. Large amounts of data on the performance of crossbred cows became available for research.

Scientific studies

In the late 1980s farmers acknowledged the merits of the first cross cows, but information was not readily available about three issues important for adoption of a crossbreeding program:

- similarity of profitability potential for the candidate parent breeds;
- the size of the heterosis effects for the traits important for farm profitability;
- the degree to which these effects are retained beyond the first cross.

Animal production scientists addressed these questions. They investigated farm performance for farms stocked with the alternative candidate breeds, and they undertook studies to estimate heterosis effects for important traits.

Farm studies

Massey University animal production scientists and New Zealand Dairy Board farm advisors analysed data from commercial farms. They concluded that Jersey herds produced more milkfat per hectare, similar or more milk protein per hectare, and less volume per hectare compared to Holstein-Friesian herds (10). This study provided a quantitative basis for analysing breed choice, with a strong indication that simply replacing the previous national Jersey herd with a national Holstein-Friesian herd would not be optimal for farmer incomes.

Experiments at the Ruakura Agricultural Research Centre involved a 2 x 2 factorial arrangement in which dairy production of Holstein-Friesian and Jersey cows was determined at high and low stocking rates. The experiments were replicated across three dairy seasons, commencing with the 1990/91 season. When each breed was stocked at the breed’s optimal rate for maximum net performance per hectare, the researchers reported that the Holstein-Friesians produced higher yields per-cow, while the Jerseys produced higher yields of milksolids per hectare. At optimal stocking rates for net income, the net income for Jersey was 5% higher than for Holstein-Friesians (3, 11). In general, the Jersey farmlets and the Holstein-Friesian farmlets produced very similar amounts of milk protein per hectare, while the Holstein-Friesian farmlets produced noticeably more volume and lactose per hectare and the Jersey farmlets produced noticeably more milkfat per hectare.²

² Given New Zealand’s very small fluid milk market, breed choice is sensitive to the relative value of lactose and milkfat as base inputs into manufacture of dairy products. To date, milk processors have not assigned any value to lactose. The ratio of the farmgate value of a kilogram of milkfat to a kilogram of protein has been declining from 1:1 in the mid 1980s, but still exceeds 0.4:1. The ratio is forecast to continue to decline. Uncertainty about future values of milkfat and lactose contribute to the desire of many farmers to maintain a herd that is intermediate between the extreme types.
Reports from the Netherlands showed that the biological efficiency for milk production (energy in milk divided by net energy in feed) for a group of Jersey cows exceeded that of a group of cows of large dairy breeds when the cows were fed high roughage diets (22). Similar findings were reported for New Zealand strains of Jersey and Holstein-Friesian (13, 19).

**Heterosis estimation**

Analysis of over 15 million lactation records from 1986 to 1995 revealed significant heterosis effects for important profit-related traits (6), and confirmed estimates for yield traits obtained in previous smaller studies (1, 23). An Australian study in 1989 had reported similar results (20). Expressed in percentage terms, the average first cross heterosis effects estimated from the New Zealand national data 1986-1995 are shown in Table 4.

<table>
<thead>
<tr>
<th></th>
<th>Holstein-Friesian x Jersey</th>
<th>Holstein-Friesian x Ayrshire</th>
<th>Jersey x Ayrshire</th>
</tr>
</thead>
<tbody>
<tr>
<td>Milkfat yield</td>
<td>4.3</td>
<td>1.8</td>
<td>5.0</td>
</tr>
<tr>
<td>Protein yield</td>
<td>4.2</td>
<td>1.9</td>
<td>4.7</td>
</tr>
<tr>
<td>Volume yield</td>
<td>4.1</td>
<td>1.8</td>
<td>4.8</td>
</tr>
<tr>
<td>Liveweight</td>
<td>1.7</td>
<td>0.8</td>
<td>3.1</td>
</tr>
<tr>
<td>Survival (first to second lactation)</td>
<td>4.7</td>
<td>2.6</td>
<td>4.7</td>
</tr>
</tbody>
</table>

National genetic evaluation has shown positive heterosis effects for cow fertility. In the case of the Holstein-Friesian x Jersey the first cross effect is about the same magnitude as the use of the elite 1% of sires for the trait. Subsequent analyses of total longevity have estimated the Holstein-Friesian x Jersey first cross effect at +222 days (11). This magnitude is equivalent to the use of the elite 8% of sires for the trait. A study reported in 2000 estimated heterosis effects for New Zealand Holstein-Friesian x Jersey and for Overseas Holstein-Friesian x Jersey (8). Estimates for cow fertility and survival traits (P < 0.001) are reported in Table 5.

<table>
<thead>
<tr>
<th></th>
<th>New Zealand Holstein-Friesian x Jersey</th>
<th>Overseas Holstein-Friesian x Jersey</th>
</tr>
</thead>
<tbody>
<tr>
<td>Days to first mating (days)</td>
<td>-1.2</td>
<td>-1.5</td>
</tr>
<tr>
<td>Successful AI calf (%)</td>
<td>6.8</td>
<td>10.1</td>
</tr>
<tr>
<td>Survival first to second lactation (%)</td>
<td>3.4</td>
<td>8.8</td>
</tr>
<tr>
<td>Survival first to fifth lactation (%)</td>
<td>9.6</td>
<td>18.3</td>
</tr>
</tbody>
</table>

*In New Zealand successfully bearing an AI calf indicates high fertility due to the nature of the seasonal mating and calving systems.*

Within breed, this study reported heterosis effects between the New Zealand Holstein-Friesian strain and the North American Holstein strain for yield traits similar to those reported in some European studies (16). The estimated heterosis effects (P < 0.05) between these strains for some fitness traits were 3.3%, 2.7%, and 6.3% for Successful AI calf, Survival first to second lactation, and Survival first to fifth lactation respectively. There were significant (P < 0.05) differences between strain means for some traits. The North American strain means were higher for protein and
volume yield and liveweight, lower for proportions of cows in calf to AI and lower for survival rates from both to first to second and from first to fifth lactations (9).

**Retaining Heterosis**

During the 1980s many farmers appreciated the merits of the F₁ cows, but were sceptical about the merits of backcross cows. Analysis of 1980s data indicated that backcrosses and other advanced generations of Holstein-Friesian Jersey crosses retained productive benefits as expected if the heterosis is controlled primarily by dominance effects (2). Consequently, the scientific community was in a position to advocate rotational crossing strategies at farmer conferences (1, 15).

National data for milk-recorded cows in the 2000/2001 season, reported in Table 6, shows that the average performance of backcross cows continues to give farmers confidence in systematic rotational crossing. The average milksolids yields of the first reciprocal crosses and of the ¾ Holstein-Friesian backcross cows exceeded the average milksolids yield of the Holstein-Friesian cows.

**Table 6. Average cow performance by breed or cross 2000/2001 season**

<table>
<thead>
<tr>
<th>Breeds/Backcross</th>
<th>First Reciprocal Crosses</th>
<th>¾ Holstein-Friesian Backcross</th>
<th>¾ Jersey Backcross</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of cows</td>
<td>1,351,127</td>
<td>212,707</td>
<td>151,460</td>
</tr>
<tr>
<td>Milksolids (kg per cow)</td>
<td>306</td>
<td>275</td>
<td>309</td>
</tr>
<tr>
<td></td>
<td></td>
<td>312</td>
<td>295</td>
</tr>
</tbody>
</table>

*Group averages based on age composition of the Holstein-Friesian cows

**Information Transfer**

Publication of the results of the studies was not confined to academic journals. Information transfer from researchers to farmers was achieved by reporting studies at farmer conferences, by the network of farm advisors, and by the example of successful farmers operating with mixed breed herds. Massey University scientists have engaged in a vigorous extension program to communicate scientific discoveries and to encourage the informed use of genetic knowledge for the improvement of dairy cattle. *Milk Production from Pasture* (Holmes et al 1984, revised edition 1988, completely revised edition 2002) has served as a fundamental source of information for farmers and advisers for nearly twenty years.

**National genetic evaluation system**

Since 1996 the national genetic evaluation system has been conducted with a common base for all breeds and crosses.

Across breed genetic evaluation has required the inclusion of some particular features in the animal models (5, 6). Heterosis coefficients are calculated for all animals based on five breed classes (Holstein-Friesian, Jersey, Ayrshire, Non-Ayrshire Red Breeds, Other (beef) Breeds), and heterosis is included as a fixed effect in the animal models. Genetic groups for unidentified parents are defined according to breed (eight classes), country of origin, date of birth and sex. To account for different rates of maturity of the breeds, age at calving nested within breed is fitted as a fixed effect. The genetic base for the system is a group of 30,000 cows born in 1985 of all breeds and crosses.
The group comprises all cows born in that year that have records for all traits used in the evaluation system.

Breeding Values are estimated as the sum of the additive animal genetic effect and the genetic group effect. Production Values for the production and liveweight traits are estimated as the sum of the breeding value, non-additive genetic, permanent environment and average heterosis effects.

To compare cows and bulls for breeding replacements the Breeding Worth index has been developed. The Breeding Worth is the sum of Breeding Values for milkfat, protein, volume, liveweight, cow fertility and longevity each weighted by an economic weight. The Breeding Worth economic weights are derived from a farm model that includes income streams from production, cull cows and surplus calf sales; and cost streams associated with farm operating expenses, and with the feed required for production and for the growth and maintenance of cows and replacements. The economic weights are expressed as the additional profit per 4.5 tonnes of dry matter (average quality pasture) for a unit change in Breeding Value (4, 7, 28). The Breeding Worth index is confined to additive genetic effects. The average additive genetic merit of crossbred cows is higher than would be predicted from the averages of the parent breeds. Breeders of crossbred cows (i) have a larger pool of proven sires from which to select and apply more intense selection on the bull to breed cow pathway, and (ii) are less inclined to apply secondary selection based on traits of little or no economic importance.

To compare cows for contributions to net farm profitability, an index called Production Worth was developed. The Production Worth index is the sum of Production Values for milkfat, protein, volume and liveweight each weighted by an economic weight.

For cow ranking purposes the Production Worth index is superior to summary measures such as milksolids per kilogram of metabolic liveweight. It more fully accounts for income streams including values of different milk components, accounts for all feed demands, and accounts for the additional costs that arise if a larger number of smaller cows are needed to harvest the available farm feed.

The true efficiency advantage of the crossbred cows is under-estimated in the Production Worth index because Production Values are not available for cow fertility and longevity. Even so, the Holstein-Friesian x Jersey crossbred group has had the highest average index of any of the breed groups for every year for which the Production Worth has been available (14).

**Body size and across breed evaluation**

The case study approach is useful for illustrating the importance of body size and liveweight when assessing the relative contributions to profitability of cows within a herd. The cows aged 4 to 9 years in the herd of Mr and Mrs Alvin Reid were all crossbred (Holstein-Friesian x Jersey) or straightbred Holstein-Friesian in the 1998/1999 season (21). The liveweights of the cows ranged from 370 to 620 kilograms. The calculated requirements for annual body maintenance of the heaviest
cow in the group exceeded that of the lightest cow in the group by over \( \frac{3}{4} \) of a tonne of dry matter (around 15% of the average annual feed intake of the group).

The liveweight and milksolids performance of the cows is illustrated in Figure 1. Herdmates with yields of close to 450 kilograms of milksolids had liveweights covering the whole range of mature liveweights in the herd. Given the wide variation in feed demand for body maintenance for these cows, the contributions they were making to Mr and Mrs Reid’s profitability can clearly not be assessed solely on the basis of their milksolids yields. Effective across breed evaluation requires accounting for the costs of body maintenance. In practice, New Zealand dairy farmers with mixed breed herds make use of measures like the Production Worth index, or an approximation like milksolids per kilogram of liveweight, to rank the usefulness of the cows in their herds.

![Figure 1. Liveweight and milksolids yield for the mature cows in a single mixed breed herd demonstrating the wide variation in body size for cows with similar yields](image)

For the future

Progeny testing crossbred sires

Around 15% of bulls born in 2001 and selected by AI companies to be progeny tested are themselves crossbred (pre-dominantly with close to half Holstein-Friesian, half Jersey ancestry, but including some with Ayshire ancestry). Scientifically the primary motivation is to maintain high selection intensities on the cow to breed bulls pathway. Implications for international evaluation if progeny testing of crossbred bulls becomes widespread are yet to be investigated. Interbull’s current MACE procedures are conducted within breed, as separate evaluations for the international Ayrshire, Brown Swiss, Guernsey, Holstein-Friesian, Jersey and Simmental populations. A bull with, for example, a Jersey sire and a Holstein-Friesian dam does not obviously fit into this international evaluation system.

\( F_2 \) experiment

An \( F_2 \) experiment involves about 900 \( F_2 \) female progeny of interbred Holstein-Friesian x Jersey \( F_1 \) parents (26). The objectives of the experiment are to identify the
underlying genetic difference between Holstein-Friesian and Jersey breeds in New Zealand, and to identify quantitative trait loci (QTL) for traits of interest including milk characteristics, health traits and reproduction traits. Choice of the two breeds was decided on the basis of the phenotypic differences between the two breeds for a number of milk characteristic traits and the availability of a large pool of genetically elite $F_1$ cows to be contracted as dams of the experimental daughters. The $F_2$ design was preferred to the backcross design to reduce the number of experimental cows required to achieve the desired statistical power. Approximately half of the heifers have recently calved for the first lactation, and half will calve in August 2003. It is anticipated that this project will advance our understanding of the genetic basis for superior performance of crossbred cows.

Discussion

Synthetic breed

Some farmers speak about crossbreeding in terms of creation of a synthetic breed, arising partly from their desire to work with cattle with intermediate performance between extreme parent breeds. An essential feature of such a scheme is to impose selection on the extremely varied offspring of the crossbred parents in such a way that variation in performance and appearance is reduced, and a recognisable breed type emerges. No objective plan for such a synthetic breed has been developed for New Zealand dairy cattle. However, two coinciding factors might lead to the future emergence of a synthetic breed. The first is the adoption of nearly uniform selection practices by the great majority of farmers whose business is to supply milk as a base commodity for export manufacturing companies. The second is the future availability of progeny-tested crossbred sires.

Viability of alternative parent breeds

Concerns are often raised about the viability of alternative breeds in the face of the overwhelming international resources applied to improving the Holstein-Friesian breed. Numerically smaller breeds are at a disadvantage in matching the rates of genetic gain in economically important traits achievable in the very large international Holstein-Friesian population. If the smaller breeds cannot match the rates of genetic gain in the Holstein-Friesian population then their future place in crossbreeding schemes is endangered. The current New Zealand experience is that the numerically disadvantaged Jersey breed has almost matched the rates of additive genetic gain of the Holstein-Friesian in terms of the Breeding Worth, but off a higher base. Various conjectures have been advanced. It is possible that selection for economically important traits amongst Jerseys has been relatively less impeded by selection for economically unimportant traits, compared to other breeds. Modelling by Massey University scientists indicates that the breed’s future place in breeding schemes is not under threat from slow rates of genetic gain within breed (17). Maintaining a viable Ayrshire population for those preferring three-way rotational crossing is less assured.

Avoiding inbreeding

Avoidance of inbreeding partially motivates crossbreeding in New Zealand. Rotational crossing based on the breed of the recorded sire of the cow to be mated, or on the milkfat percentage of the cow, is an easy plan for managers of large herds who desire simple cow mating programs.
Complementarity of breeds
It is possible for breed complementarity to generate economic advantage in crossbred animals even in the absence of heterosis for individual traits. Under current milk component prices in New Zealand, breed complementarity is not a primary factor influencing adoption of crossbreeding (18). However, a type of breed complementarity contributes importantly to the popularity of crossbreeding. Holstein-Friesian or crossbred cows give birth to calves that have Jersey sires much more easily than they give birth to calves that have Holstein-Friesian sires. With farmers managing very large numbers of calving cows in very concentrated time periods, this factor determines a large number of mating decisions.

Crossbreeding for high input systems
Crossbreeding has been more popular in countries with lower input management systems, relying on grazed pasture and large numbers of cows per person employed in the enterprise. Typically this has been attributed to the relatively minor difference between breeds in terms of milksolids per hectare compared to the larger difference between breeds in per cow yields (24). However, a more important distinction might relate to the purpose for which the milk is being produced: milk for fluid consumption, or milk for manufacture into other dairy products such as cheese. For example, a recent study in the USA has indicated that, with cheese yield pricing and with all traits considered, profit from crosses of Jersey and Holstein and crosses of Brown Swiss and Holstein exceeded that of Holsteins for matings at breed bases (but not for elite animals). For the fluid milk market no cross would approach the economic merit of the Holstein cows (27). International Dairy Federation statistics show that there is wide variation between countries in the proportion of cows’ milk utilised in the fluid market. The average proportion for fifteen EU countries is around 25%, and for USA the proportion is around 35% (12). The high proportion of bovine milk produced in temperate climates for manufacture of dairy products rather than for fluid consumption indicates continuing opportunities for production systems with crossbred dairy cows.

Conclusion
Widespread adoption of crossbreeding has been a feature of the recent history of the New Zealand dairy industry. Unless there are major changes in the industry’s markets this trend is likely to continue, particularly with the increasing awareness of the importance of reproduction and survival traits.

Positive interaction between scientists and farmers has driven adoption of the practice. Scientists have provided quantitative bases for farmers’ choice of breeds and crosses. Farmers have multiplied the numbers of cows with both recorded performance and with recorded mixed breed ancestry. Scientific analyses of these large data sets, and farmer perception of the performance of cows with mixed breed parentage, have combined to challenge seriously the idea that breeding objectives should be aimed at an “ideal cow” with specific breed attributes. New Zealand’s animal production scientists have helped farmers identify the cows that contribute efficiently to their systems, and farmers have quickly learned to like the attributes of these cows.
References


