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Predicting the influence of high breeding index dairy sires on farm productivity

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ABSTRACT

A computer model was developed to calculate the effect of a sires genetic merit on the yields of fat, protein and milk produced by his daughters, and on their liveweight, feed requirements and achievable stocking rates. Herd statistics, costs and prices were based on average figures for 1992. The effect of a 1 unit increase in sire Breeding Indexes (BI's) for fat, protein and milk and a 1 kg increase in average daughter liveweight on marginal farm profit per hectare were +\$0.48, +\$0.98, -\$0.36 and -\$0.49 respectively in the year of the daughters first lactation. That is, in terms of effects on gross margin per hectare, an increase of 1 unit in protein BI (sire) was equivalent to either +2 fat BI (sire), -3 milk BI (sire) or -2 kg in average daughter liveweight. The net effect of a 1 kg increase in average cow liveweight across a whole herd was calculated as being a reduction of approximately \$1.30 in marginal profit per hectare.

Trends in future yields of milk components were predicted from an on-farm (per cow) and an industry (supply) perspective. These trends were assumed to be solely due to genetic improvement and were based on estimated rates of genetic gain in both New Zealand (NZ) and the United States of America (USA). Based on these estimates, milk supply to the industry could increase between 30-50% in the next 30 years. This would require annual processing capacity increases in the order of 1.2-1.5% per year. Over the last 16 years, increases in milk supply due to greater yields per cow (genetics + management) have only been averaging around 0.6% per year. Careful planning may be required by the dairy industry in order to cope with future supply increases.

Keywords: stocking rate; genetic; profit; dairying; trends.

INTRODUCTION

The impact that genetic improvement can have on the performance of the average dairy herd has been of increasing interest in recent years. In a commercial dairy farming context, these genetic changes are brought about through the use of superior sires identified with the industry-wide objective of increasing dairy farmers net profit.

The economic worth of a sire is determined by his influence on the efficiency with which additional milk yield per cow is produced. The resulting balance between the average yield and size of a cow, and the feed needed to maintain the simultaneous requirements of lactation, pregnancy and growth will decide what gains in production per hectare, if any, are achieved. A computer simulation of a dairy farm was developed to estimate the effects of using high Breeding Index (BI) sires on both productive and economic characteristics of the "average" New Zealand dairy herd.

The influence of genetic improvement and current selection objectives on future yields of milk components is also investigated. Changes in the quantity of milk components supplied as well as the possible contribution of overseas genetics are discussed in relation to the New Zealand dairy industry, using the Jersey breed as an example.

BASIS OF THE MODEL

A farm model to predict changes in milk component yields, cow liveweight, stocking rate and profitability was developed using a computer spreadsheet. The basic assumptions were:

\$Profit/Cow = \$Output/Cow - \$Input/Cow

\$Profit/HA = \$Profit/Cow x Stocking Rate

Outputs per cow were defined as milk, cull cows and calves, while inputs included per cow estimates of labour, health, AB, herd testing, shed, electricity and supplement costs. Milk component prices used were \$2.99, \$4.99 and -\$0.04 per kg fat, protein and milk respectively.

Stocking rate in the context of this study was calculated as:

$$\text{Stocking rate} = \frac{\text{Feed grown per hectare}}{\text{Feed required per cow}}$$

This prevented the genetic merit of animals from being "masked" by the influence of stocking rate on cow feeding levels as may occur in the practical situation.

The feed (energy) requirements per cow were calculated based on average production and liveweight, using literature estimates for maintenance, lactation, pregnancy and growth (Holmes and Wilson *et al.*, 1984; ARC, 1980, Tyrell and Reid, 1965). Feed grown per annum was fixed at 14,000 kg pasture DM per hectare. A herd with assumed productive and genetic characteristics was used as a base against which the influence of genetic improvement could be compared.

METHODOLOGY

A selected group of 14 high BI Jersey sires were evaluated using the model. Knowledge of their proofs for yield traits as well as daughter T.O.P. liveweight information made it possible to estimate the effects of unit changes in sire BI and daughter size on milk composition and liveweight of average herd cows, stocking rate, marginal profit per cow and marginal profit per hectare.

RESULTS AND DISCUSSION

Table 1 presents a summary of the effect a one unit change in sire BI and daughter liveweight can have on the productive and economic characteristics of the base herd as predicted by the model.

The calculated changes in yields, liveweight, stocking rate, marginal profit per cow and per hectare due to a particular sire are only for the case where his daughters are completing their first lactation i.e., all replacements in a given year are his daughters.

TABLE 1: Summary of sire effects on the base herd.

	+1 Fat BI	+1 Protein BI	+1 Milk BI	+1 kg Daughter Liveweight
Fat (kg/cow)	+0.13	-	-	-
Protein (kg/cow)	-	+0.10	-	-
Milk (ltr/cow)	-	-	+2.47	-
LWT (kg/cow)	-	-	-	+0.25
No. cows per ha	-0.0005	-0.0002	-0.0002	-0.001
Marginal $/cow	+0.36	+0.44	-0.08	+0.13
Marginal $/ha	+0.48	+0.98	-0.36	-0.49

Thus for any two sires, a difference of 1 unit in milk component BI's would generate differences of +0.13 kg, +0.10 kg and +2.47 ltr in average cow yields of fat, protein and milk if they were used over the same herd.

An increase of 1 kg in average daughter liveweight had a greater depressing effect on achievable stocking rate than a similar unit increase in sire BI's for fat, protein and milk. For example, consider a comparison between two sires with equal genetic merit for yield but a 20 kg difference in average daughter liveweight, for use over a 200 cow herd. For the sire with heavier progeny to generate the same increases in average yield per cow, total cow numbers must be dropped by four to ensure animals are still fed to requirement. This indicates the importance of body maintenance requirements in determining the efficiency of per hectare production.

A unit change in protein BI would have the largest influence on differences in marginal profitability between sires. This reflects the greater value of this milk component relative to fat. The negative value of milk volume is shown by the decreasing marginal profit achieved with greater sire milk BI. Although increasing daughter liveweight can generate additional profit per cow, its effect on profit per hectare is negative to the extent that a 1 kg increase in daughter liveweight can effectively cancel out any additional profit generated by a 1 unit increase in sire fat BI.

From Table 1 it can be seen that in terms of generating marginal profit per hectare, an increase of 1 unit in sire protein BI is equivalent to +2 units of fat BI, -3 units of milk BI or -2 kg of average daughter liveweight. The practical implications of this result can be shown by way of an example. (See Table 2).

Therefore:

Sire 1($/ha) - Sire 2($/ha) = [(147-135) x 0.48] + [(122-121) x 0.98] + [(114-119) x -0.36] + [(326-311) x -0.49] = $1.19/ha

This result indicates how sires differing greatly in payment BI may still be very similar in terms of marginal profit per hectare.

TABLE 2: For two sires with the following characteristics:

Trait	Sire 1	Sire 2
Fat BI	147	135
Protein BI	122	121
Milk BI	114	119
Daughter LWT	326	311
Payment BI	131	124
Total BI	131	128

For the purposes of predicting the net effect on a system, the Total BI is a better reflection of a sires overall economic worth.

The net effect of a 1 kg increase in average cow liveweight across a whole herd was calculated as being a reduction of approximately $1.30 in marginal profit per hectare. For two herds differing by 50 kg in average cow liveweight this is equivalent to a $65 difference in marginal profit per hectare.

Implications of genetic improvement for the New Zealand dairy industry

Trends in future yields of milk components were predicted, both from an on-farm (per cow) and an industry (supply) perspective. These trends were assumed to be solely due to genetic selection and were based on estimates of genetic gain being achieved under New Zealand's current national herd improvement scheme. While these estimates may be adequate for predicting future changes under a closed population, the importation of international genes into the national herd may markedly influence the actual rate of genetic improvement. Therefore to provide an indication of the potential extremes to which milk yields could change, a similar exercise was carried out assuming past rates of genetic gain measured in the USA Jersey cattle population (Wiggans, pers. comm.) (see Table 3).

TABLE 3: Estimated annual rates of genetic gain in NZ and USA Jersey cattle (Clark, 1992).

	Annual Genetic Gain (%Yield/yr)	
Trait	NZ	USA
Fat	1.3%	1.4%
Protein	1.4%	1.1%
Milk	1.2%	1.6%
Liveweight	0.04%	- *

* No information was available for estimating correlated responses in USA cow liveweight.

(i) Milk Composition per cow

Projected trends in future milk composition per cow were established by assuming:

- Average genetic merit of Jersey cattle in NZ and the USA are currently equal.
- The estimated annual rates of genetic gain as shown in Table 2.

Two scenarios were assumed:

- New Zealand Jersey population with NZ rates of genetic gain.
- New Zealand Jersey population with USA rates of genetic gain.

Yields of fat (153 kg), protein (110 kg) and milk (2700 ltr) per Jersey cow were based on 1990/91 average figures (Dairy Statistics, 1990/91). Table 4 gives a summary of the predicted changes to average Jersey cow milk yield and composition under both scenarios for the next 30 years.

Assuming USA rates of genetic gain, the predicted yield increase for the average New Zealand Jersey cow after 30 years would be slightly greater for fat (+64 kg vs +61 kg), and much greater for milk yield (+1260 ltr vs 990 ltr) per cow but less for protein yield per cow (+35 kg vs +45 kg) than with solely NZ rates of gain. A significant result of the changes to milk component yields generated by USA genetics are the decrease in milk solids concentration and the protein : fat ratio per cow. These changes amount to a total difference after 30 years of approximately 0.3 and 0.6 of a percent for fat and protein percent respectively, relative to the values under NZ rate of genetic gain. Whereas protein : fat ratio will change very little in the future under current NZ breeding objectives, USA trends would generate a 7% decrease in protein : fat ratio over 30 years relative to current values.

TABLE 4: The effect of NZ or USA rates of genetic gain on average milk and solids yield per Jersey cow

		NZ (USA)	
Year	Fat (kg)	Protein (kg)	Milk (ltr)
1992	153	110	2700
2022	214 (217)	155 (145)	3690 (3960)
Total change	+61 (+64)	+45 (+35)	+990 (+1260)
% change	+40 (+42)	+41 (+32)	+37 (+47)

Results in Table 4 assume that past differences in selection emphasis between the two countries do not alter in the future. The large domestic milk market in the USA has resulted in greater importance being placed on genetic gains in total milk yield rather than yields of milk solids as in New Zealand.

(ii) Supply of milk components for processing

Genetic changes to per cow milk composition are determined, at the individual herd level, by the breeding and culling decisions of the farmer. A simple estimate of annual changes on an industry scale would therefore involve the average change in yields of fat, protein and milk per industry cow per year multiplied by the number of cows in the national herd. Based on 1990/91 figures (Dairy Statistics, 1990/91), average yields per industry cow per year can be calculated from breed averages and the proportions of each breed which make up the national herd. These weighted averages were 154 kg, 117 kg and 3213 ltr for fat, protein and milk per cow per year. Assuming the rates of genetic gain shown in Table 3 are similar across all breeds, current annual processing volumes can be extrapolated to predict the genetic influence on future supply of milk components within the New Zealand dairy industry.

Table 5 presents a summary of predicted changes in annual supply of milk components under both genetic gain scenarios. Predictions assume that all herds are involved in the national improvement scheme and share in the genetic gains made within the industry. Cow numbers are fixed at 1990/91 levels (2,225,045 factory supply cows) to remove the influence of changing cow numbers on supply trends.

TABLE 5: The effect of NZ or USA rates of genetic gain on total yields of milk components in factory supply milk.

		NZ (USA)	
Year	Fat (kg) (million kg)	Protein (kg) (million kg)	Milk (ltr) (million ltr)
1992	343	260	7149
2022	476 (486)	370 (342)	9723 (10473)
Total change	+133 (+143)	+110 (+82)	+2574 (+3324)
% change	+39 (+42)	+42 (+32)	+36 (+46)

Changes to future milk composition per cow under NZ rates of genetic gain could see the supply of milk components to the dairy industry increasing by 134 million kg (39%), 109 kg (42%) and 2574 ltr (36%) for yields of fat, protein and milk respectively over the next 30 years. The concentration of milk solids will increase slightly.

For the case where USA rates of genetic gain are assumed, the larger predicted increases in overall milk volume and the associated decreases in milk concentration have important implications for the future development of the processing industry. Compared with NZ rates of gain, supply increases generated by USA genetics may provide an extra 143 million kg of fat, 82 million kg of protein and 3324 million ltr of milk after 30 years of genetic improvement.

The issue of increasing milk volumes in relation to dairy industry efficiency has been discussed frequently in the past (Cooper, 1979; Bay, 1983; Bryant et al., 1988; Paul, 1985). The problem lies not so much with volume *per se* as with the pattern in which milk is supplied to factories during the year. A factory which receives a higher than average milkflow before or after the spring flush has a higher level of sustained throughput so allowing costs per kg of processed milk solids to be reduced (Paul, 1985).

At NZ rates of genetic gain the total milk supplied to dairy companies will increase by approximately 2574 million ltr (36%) over the next 30 years of genetic improvement (see Table 4). This will require an expansion of 86 million ltr (1.2%) in total industry processing capacity per year. For the case where USA rates of gain are assumed, milk volume will increase by 3325 million ltr (46%) over the next 30 years, requiring capacity increases in the order of 111 million ltr (1.5%) per year. To put these figures into perspective, annual increases in processed milk volume in the New Zealand dairy industry over the last 16 years have averaged 119 million ltr per year (1.7%) (Dairy Statistics, 1990/91). However over the same time period cow numbers increased by 24,946 (1.1%) cows per year. Actual volume increases due to greater production per cow (i.e., genetics plus management) has therefore only averaged 0.6% per year.

CONCLUSIONS

The influence of the 14 selected sires on farm production and profitability revealed several important relationships between sire merit and changes to average performance per cow and per hectare. In general, increasing sire BI (fat, protein, milk) was associated with:

- greater yields of protein, fat and milk per cow in the herd
- lower achievable stocking rates

- greater marginal profit per cow
- greater marginal profit per hectare

Increasing cow liveweight was associated with:
- lower achievable stocking rates
- greater marginal profit per cow
- lower marginal profit per hectare

In general, it was found that in terms of a sires effect on marginal profit per hectare, an increase of 1 unit in sire protein BI was equivalent to +2 fat BI (sire), -3 milk BI (sire) or -2 kg in average daughter liveweight. From these results the economic influence of a 1 kg increase in liveweight over all cows in the herd was estimated as a reduction of $1.30 in marginal profit per hectare.

Based on the estimated rates of genetic improvement in the NZ and USA Jersey populations, milk supply to the industry could increase between 30-50% in the next 30 years due to genetic improvement. This would require annual processing capacity increases in the order of 1.2-1.5% per year. Past increases (1974-1990) in processing capacity have averaged about 1.7% per year within the industry, however over the same time period cow numbers have also increased at the rate of 1.1% per year. Increases in milk supply due to greater yields per cow (genetics + management) have therefore only been averaging around 0.6% per year. This indicates that careful planning will be required to insure future industry processing structure can cope with the expected increases in milk volume as a result of genetic improvement.

REFERENCES

Agricultural Research Council (ARC), 1980. The nutrient requirements of ruminant livestock. Commonwealth Agricultural Research Bureaux.

Bay, D., 1983. Payments to dairyfarmers. *Dairyfarming Annual.*

Bryant, A.M.; Paul, K.J.; Scott, D.C., 1988. The new milk payment system. *Ruakura Farmers Conference.*

Clark, J.M., 1992. Effects of high protein Jersey sires from New Zealand and North America on dairyfarm profitability. M.Ag.Sci. Thesis, Massey University, Palmerston North.

Cooper, A.E., 1979. Should we expand our dairy production? Ruakura Farmers Conference.

Dairy Statistics, 1990/91, Livestock Improvement Corporation Ltd.

Holmes, C.W.; Wilson, G.F.; Mackenzie, D.D.S.; Flux, D.S.; Brookes, I.M.; Davey, A.W.F., 1984. Milk Production from Pasture. Butterworths Agricultural Books.

Paul, K.J., 1985. A new direction for the payment for milk. *Ruakura Farmers Conference.*

Tyrell, H.F.; Reid, J.T., 1965. Prediction of the energy value of cows milk. *Journal of Dairy Science,* **48:** 1215.