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Factors Affecting Rankings of Dairy Bulls across New Zealand Dairy Farm Systems

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ABSTRACT: In this study we found that indices and bull rankings for economic indices were most sensitive to scaling effects that increase the expression of genetic differences due to the spread in breeding values for milk production traits under intensive feeding systems. In contrast, the economic index was very robust to changes in many other assumptions, including accounting for regional differences in seasonal feed cost. A simple theoretical basis for adjusting economic values to account for scale differences in expression of breeding values spread is presented under the assumption of a genetic correlation of one between milk production in low versus high input systems. Further research is required to determine if the true genetic correlation is sufficiently less than one, such that separate breeding values need to be estimated to correctly rank bulls for high versus low input systems.

Keywords: dairy, pastoral systems, breeding objectives, economics, genetics.

Introduction

In New Zealand, the National Breeding Objective (NBO) for the dairy industry is expressed as a genetic selection index called Breeding Worth (BW; Harris et al. 1996). It assesses sire and cow genetic merit and sets the direction for the cow of the future through economic weightings calculated for changes in performance traits. The calculation of economic values (EVs) is based on average commercial farm inputs and industry statistics that affect the relationships between genetic traits and profitability on dairy farms (Amer et al. 2013). In New Zealand, the significant increase in the number of farms adopting high input supplementary feeding systems (intensive systems) might lead to development of specific economic values in the breeding objectives. Strain comparison studies in New Zealand and Ireland, and a field data analysis in Australia indicate that expression of genetic differences for milk production traits can be substantially magnified in intensive versus extensive (milk production based predominantly on pasture feeding) production systems. This paper quantifies the impact of a range of key variables and assumptions on sire rankings and breed differences for economic indices estimated specific to dairy farm systems of different feed input intensity.

Materials and Methods

Parameters and assumptions considered. The calculation of different indexes was undertaken using a model which predicts the economic implications resulting from a unit change in trait performance (Amer et al. 2013). The parameters considered for sensitivity analysis were milk price, feed cost, value component ratio (VCR, which is the value of the payment for fat relative to the payment for protein), live weight, cull cow and bobby calf prices, heifer rearing cost and overall profitability. The effect of those changes was assessed by increasing their values by 25% in the breeding objective model.

The effects of increasing the spread of realized genetic differences in expressions of milk production traits under intensive farming systems were also investigated through application of genetic regressions.

Assessment of scaling effects. There is reasonable evidence that differences between high and low milk yield genotypes for milk production traits are much greater for high input systems than for low input systems. For example, Figure 1 presents average results of strain differences for milk solids production in low, medium and high input supplementary feeding systems from a large number of strain comparison trials undertaken in New Zealand and Ireland. Significant increases in index effects on realized milk yield differences in daughters has also recently been shown in a substantial field trial in Australia (Morton et al. 2013). A range of genetic regressions for milk traits (i.e. 1.0, 1.2 and 1.4 genetic regression) were therefore modelled to estimate the magnitude of the scaling effects on indexes specifically formulated for intensive systems. We propose that a high input index can be formulated as follows:

$$INDEX_{Intensive} = \sum_{i=1}^{nmilk} \beta^{i}_{Intensive.National} \times EV^{i}_{National} \times BV^{i}_{National} + \sum_{i=nmilk+1}^{ntraits} BV^{i}_{National} \times EV^{i}_{National}$$

where, $\beta^{i}_{Intensive.National}$ is the genetic regression of high input system farm genetic performance on the national breeding value of each of *nmilk* milk production traits, while $EV^{i}_{National}$ and $BV^{i}_{National}$ are the national economic values and industry breeding values for *ntraits* traits that are included in BW. From this, it is clear that the genetic regression coefficients can be directly embedded in the economic value calculation, i.e.

$$EV^{i}_{Intensive} = \beta^{i}_{Intensive.National} \times EV^{i}_{National},$$

thus avoiding the need to publish system specific sets of breeding values if sire re-ranking does not occur and only scaling effects are exhibited for individual traits.

Regional feed cost differences. The NBO model makes substantial use of economic weights derived for the DairyNZ Forage Value Index (FVI). For the purpose of valuing feed, milking platform feed costs were based on the models described by Chapman et al. 2012 (Figure 2). In New Zealand, because of the predominance of contract

Figure 1. Representation of scaling effects of spreading breeding values for milk solids production in different feeding systems for high and low yield genotypes.

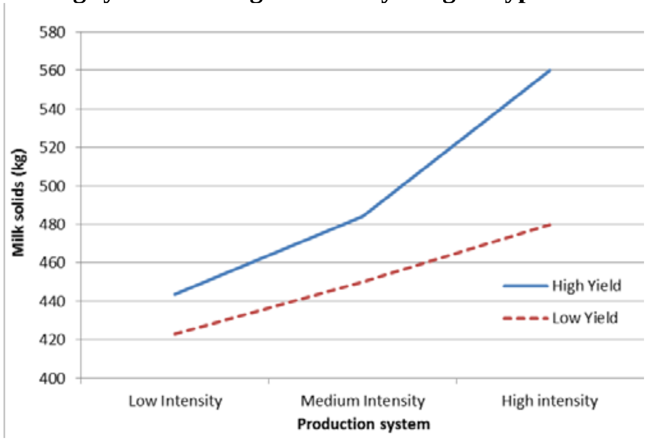
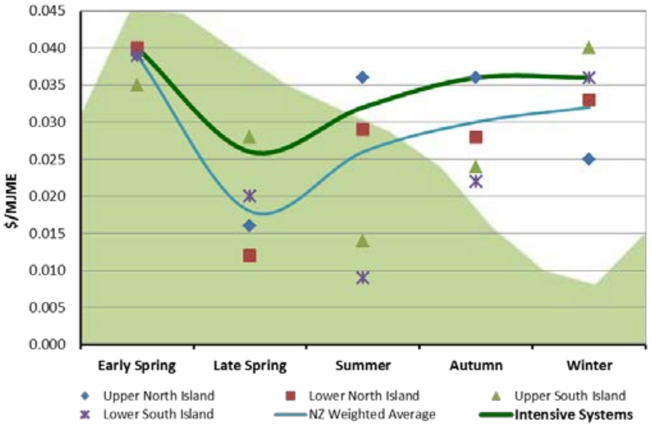


Figure 2. Feed costs per Mega Joule of metabolisable energy (MJME) in different regions and seasons of the year, national weighted average and intensive systems feed costs and pasture growth.



grazing arrangements, sheep and beef farm feed costs are used to calculate replacement heifer costs, as well as wintering costs. These values consider average prices for grass, silage/baleage making, cropping, and opportunity costs of feed for finishing stock. These weights are used to reflect the opportunity cost of feed and in particular to account for differences in the cost of feed at different times of the year and in different regions across the country.

Regional differences in feed costs are accounted for in the model by taking a weighted average to generate a single national index for the whole country. For instance, in the South Island (SI), a substantial proportion of dry cows are managed off the milking platform during winter, as this releases extra feed in autumn and early spring that can be more profitably used for milking cows. Feed costs in the North Island (NI) are lower during winter and late spring when compared to South Island, which has lower costs during summer and autumn. We used region specific feed prices in the economic model to determine if this would result in meaningful changes in ranking of bulls.

Table 1. Economic weights of traits for the base index BW 2013 and intensive system scenario indexes.

Trait	Unit	BW 2013	Intensive Systems[1]		
			High Reg	Mod Reg	No Reg
Milk Fat	$/kg	1.79	2.72	2.33	1.94
Milk Protein	$/kg	8.63	12.22	10.47	8.73
Milk Volume	$/L	-0.09	-0.12	-0.10	-0.09
Live weight	$/kg	-1.52	-1.73	-1.73	-1.73
Survival[2]	$/day	0.15	0.21	0.21	0.21
Somatic cell score	$/SCS	-38.57	-46.25	-46.25	-46.25
Fertility[3]	$/%	7.35	5.46	5.46	5.46

[1] Considering 1.4, 1.2 and 1 genetic regression for milk production traits (High Reg, Mod Reg and No Reg, respectively).

[2] Expressed as $ per % per day in the average herd age.

[3] Expressed as $ per % calving in the first 42 days of planned start calving.

Metrics for comparing indexes. Overall economic index values for AI sires were tested for sensitivity to changes in factors which impact EVs. Outcomes are presented as correlations between the current BW index used in 2013 (base index) and alternative indexes where economic values reflect changed inputs and assumptions (Table 1). Additional metrics included the number of bulls that remain ranking in the top 30 and top 100 by breed following a change in the index. Changes in average breed differences for the economic index, expected rates of genetic progress in the index and its component traits are also presented.

Results and Discussion

Results for index sensitivity to changes in cost and price assumptions, including regional feed cost differences were extremely modest. For example, correlations between indexes exceeded 0.98, and changes in breed overall averages, and representation in the top 30 and 100 bull sets were also modest. In contrast, changing the scale of breeding values via genetic regressions to account for greater expression of genetic potential for milk production traits under intensive feeding systems had a much more substantial impact on animal rankings. Table 2 summarizes the results in terms of bull and breed rankings compared to, and correlations with, the base index, when the three regression levels were used. The high regression index resulted in a relatively lower correlation, as well as the highest impact on bull re-rankings and the largest breed differences in favor of Holstein-Friesians.

Table 2 presents the scaling effects on index and individual trait responses to selection. The high regression index gives the highest economic value for milk traits and so predicted responses to selection on this index are higher by 20-30% for milk solids traits, and these extra gains come at the expense of improvements in fertility and survival. The overall predicted value of selection is increased by 25% to 40% with the high regression index. This reflects the greater opportunity for superior milk producing genotypes to be expressed as higher milk production in intensive feeding systems.

Table 2. Correlations, changes in ranking of bulls and in the average difference in economic index between breeds after modifications of relevant factors.

Change Relative to BW 2013[1]	Cor-rela-tion	Bulls remaining[2]		Change in economic index ($/5 t DM) difference		
		Top 100 across breeds	Top 30	HF vs. Cross	HF vs. J	Other
High Reg	0.952	68	22	25.26	56.40	45.83
Mod Reg	0.968	78	24	10.53	22.96	14.95
No Reg	0.976	83	25	-4.04	-10.18	-15.73

[1] In comparison to scenarios considering 1.4, 1.2 and 1 genetic regression for milk production traits (High Reg, Mod Reg and No Reg, respectively).

[2] Number of bulls that remain ranking in the top 100 across breeds and average number of bulls remaining in the top 30 rank of each breed.

Conclusions

Changes to breed averages for indexes were generally found to be more sensitive than within breed rankings. However, changes in some economic values can also have a significant impact on the number of bulls that remain ranking in the top 100 for all breeds and in the top 30 of each breed.

Changes in economic values applied to existing breeding values have a modest impact on the rankings of bulls within breeds and minimal impact on relative breed differences. When the amount of spread in milk production trait breeding values is scaled up to reflect greater genetic differences in high input systems, larger changes in breed and sire rankings occur. This scaling can be accommodated in practice by including the scaling factor in the definition of the economic values for milk production traits as a genetic regression coefficient. Further research is required to determine the extent to which genetic regressions from industry data are sufficiently robust to correctly rank bulls for high versus low input systems or to test whether bulls re-rank when assessed in a high versus low input system.

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Table 3. Response to selection expressed in units change in traits, and economic impact[2] for breeds by scenario index, considering the equivalent to 10 years of genetic progress.

Trait	Trait Unit	Holstein-Friesian[1]				Crossbred[1]				Jersey[1]			
		Base	High Reg	Mod Reg	No Reg	Base	High Reg	Mod Reg	No Reg	Base	High Reg	Mod Reg	No Reg
Milk Fat	kg	7.53	9.2	8.51	7.54	10.97	13.38	12.49	11.07	11.8	13.09	12.54	11.67
Milk Protein	kg	5.25	7.25	6.66	5.82	9.03	11.23	10.46	9.27	9.13	10.26	9.85	9.22
Milk Volume	L	28.74	98.79	79.82	55.03	187.49	265.12	237.06	195.46	182.52	222.17	210.96	193.9
Live weight	kg	-7.64	-5.00	-6.83	-9.05	-1.88	1.72	-0.57	-3.68	2.24	3.28	2.16	0.63
Fertility	%	2.68	0.96	1.24	1.57	1.33	-0.23	0.03	0.37	1.31	0.29	0.4	0.55
Somatic cell score	Score	0	0.01	0.00	0.00	-0.14	-0.09	-0.12	-0.15	-0.07	-0.05	-0.07	-0.08
Survival	Days	27.89	39.22	44.78	51.31	-11.32	-4.24	0.88	7.87	2.99	10.22	17.25	26.66
Economic impact by EV reference[2]						$/10 years of genetic progress							
Base		100.00	95.04	96.63	97.49	100	95.35	96.99	97.78	100	96.92	97.67	97.78
High Milk Reg		120.06	126.33	125.8	123.64	133.84	140.37	139.72	136.75	132.91	137.12	136.73	134.94
Mod Milk Reg		108.42	111.73	112.19	111.45	116.94	120.01	120.57	119.53	115.43	117.85	118.18	117.56
No Milk Reg		96.83	97.2	98.65	99.31	100.13	99.76	101.52	102.4	98.04	98.67	99.74	100.27

[1] Considering 1.4, 1.2 and 1 genetic regression for milk production traits (High Reg, Mod Reg and No Reg, respectively).

[2] For these values we use predicted trait responses to selection based on the column header index, but estimate economic impact based on the economic values described in the row header index.