BREEDING DAIRY CATTLE FOR ECONOMIC EFFICIENCY: A NEW ZEALAND PASTURE-BASED SYSTEM

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INTRODUCTION

Dickerson (1970) stated that the performance criteria used for evaluating the efficiency of milk production could be improved upon. He argued that including estimated energy intake in the selection objective would dampen the enthusiasm for the larger cow *per se* and thereby reducing costs associated with cow maintenance. Almost 30 years later, a large number of traits are evaluated in dairy cattle populations including: milk production, survival, linear conformation traits and to a lesser extent fertility, health and liveweight traits. Most countries provide indices based on gross milk income as well as separate indices including conformation traits (Leitch 1994). The majority of the indices do not include the feed costs associated with increased production of the individual milk components from genetic improvement. Furthermore, exclusion of other major components of net income such as feed requirements for maintenance can favor higher producing larger cattle over comparatively lower producing, smaller cattle (Visscher et al. 1994) rather than cattle which maybe more economically efficient. In a pasture based system the objective is maximise the net income per hectare or more explicitly maximise the net income per unit of feed consumed, thus the first definition of efficiency is applicable.

Two main methods have been developed to allow selection on the breeding objective. The most common method is the use of a selection index that combines individual trait breeding values with economic weights to provide a single measure on which to select animals. The second method measures the breeding objective (e.g. net income per cow) directly and provides genetic evaluations for this measure (Lin and Allaire 1977; Visscher and Goddard 1995). The advantage of the second method is that it includes a number factors such as lactation length, health status and survival into a single measure. However, the procedure requires net income to be computed on individual cows which involves estimation of feed costs and variable farm costs which are then allocated to individual cows. Such a procedure requires a number of assumptions to be made which may account for the low to moderate heritability estimates being reported. The low to moderate heritability estimates limit the usefulness of this approach. This report will focus on the application of selection index procedures to breed for economic efficiency in a New Zealand pasture based system.

METHODS

An inter-temporal economic model has been developed that values the genetic change from using a sire or cow as the parents of future offspring was used. To model the passage of genes over time and the productive changes in future offspring while accounting for overlapping generations the gene-flow method (Hill 1974) was used. The economic model was used to compute the discounted net income per unit of feed consumed. The net income in a given year was the sum of milk, salvage beef, calf sale revenues less the variable cash costs. The metabolisable energy requirements were calculated for milk production, maintenance, pregnancy, liveweight loss and gain, and the rearing of replacements and used to compute the stocking rate. The stocking rate is the number of milking cows per hectare of productive land. The variable costs were a function of stocking rate and scale of the enterprise. As the stocking rate increased the variable costs increased. The total milk production per unit of feed consumed was a function of the average animal production, genetic improvement and stocking rate. Industry growth in future milk production was included to compute the interaction between milk supply and the future farm gate prices for the milk components. The economic values were computed as the partial derivative of the discounted net income with respect the an individual trait breeding value.

The unit of feed was constrained to 4.5 tonnes of dry matter. This value corresponds to the annual intake of the average cow in New Zealand. Changing this constraint would change the absolute magnitude of the economic values but not the relativity between economic values. Genetic improvement in dairy cattle populations has an average generation interval of 6-7 years. Selection decisions are essentially investment decisions; investment decisions are not normally based on point estimates but on time trends. The economic values should exhibit long term price trends rather than short term price fluctuations. To avoid problems with short-term fluctuations in input parameters the economic values were computed separately from three years of data. An average of the three sets of economic values, each adjusted by the consumer price index to the present year's dollars, were used to compute the selection index. In the future the economic values will be updated for the current years information and rolling year average of the economic values used to compute the selection index.

RESULTS AND DISCUSSION

The inter-temporal model has been used to compute economic values for efficiency. These values have been applied nationally to the New Zealand dairy cattle population. Economic values of milk fat, milk protein, milk volume, liveweight and survival were calculated and used in a selection index termed the Breed Worth (**BW**). The input parameters are in Table 1 and the resulting economic values are in Table 2. In New Zealand there is a penalty for milk volume to account for cartage and processing costs. The economic value for milk volume also includes the economic value of lactose which has an average return of $0.00/kg over the three years.

The economic values represent the discounted net income per 4.5t of dry matter and as, they are the direct revenue less the direct feed costs less the indirect cost of using dry matter for this trait rather than other traits (e.g., an opportunity cost). In an econometric sense the economic values are shadow prices (Dillon and Anderson 1990).

An important component of the BW index is the inclusion of liveweight. The economic value of liveweight, when standardized for the individual trait genetic standard deviations, was (in absolute relativity terms) 0.31, 1.79, and 0.72 of the protein, milk fat and milk volume economic values, respectively. The relativity with the production traits was a slightly lower than the values report by (Visscher et al. 1994). Liveweight is important when comparing animals within breed because it enables the distinction between animals with the same breeding values for production but different breeding values for liveweight. Thus, the animal with the lower breeding value for liveweight is a more efficient converter of feed into income. Inclusion of liveweight in the BW is not intended to reduce the body size of cattle in New Zealand, but reduce the rate of increase or keep the liveweight constant at the current level.

Liveweight is essential when comparing the economic efficiency across breeds. Consider New Zealand where there is a breed composition of the national herd which is approximately 57% Holstein, 18% Jersey, 2% Ayrshire and 20% Holstein-Jersey crosses with 85% of herds having more than 1 breed class. Across breed genetic evaluations are available for the 5 traits (Harris, Clark et al. 1996). Table 3 contains the average breeding values for major breed classes. If a selection index based only on net milk income (setting the economic value for liveweight to zero) was used, the breed difference between Holstein and Jersey would be \$33/year/4.5t in favour of the Holstein. This result reflects the net income advantage per cow but fails to account for the fact that the stocking rate of the average Jersey farm is 30% higher than the average Holstein farm (Ahlborn and Bryant 1992). The objective of pasture based farming is to maximise the net income per hectare rather than per cow. Including liveweight accounts for the direct costs associated maintenance and the opportunity costs associated with lower stocking rates. When liveweight is included, the BW difference (see table 3) between the average Jersey and Holstein cows is \$6/year/4.5t in favour of the Jersey cow. This difference is in line with net income per hectare values reported by (Ahlborn and Bryant 1992).

At this time New Zealand farmers can select cows and sires as parents of the next generation based on their future profitability across breed using the Breeding Worth index. The advantages of using this index compared to previous selection indices used in New Zealand; the Total BI and the Production BI (Leitch 1994); are the stabilization of short term price and cost fluctuations, a consistent economic model for all traits, inclusion of liveweight and survival for cow selection, and expression per unit feed input to allow selection of economic efficiency. Further work is required to account for heterosis in the future offspring when selecting sires across breed.

Table 1: Input parameters used to compute the economic values (NZ$).

		1994/95	1995/96	1996/97
Milk Fat Price	$/kg	2.59	3.21	2.72
Milk Protein Price	$/kg	5.62	6.17	5.91
Milk Volume Cost	$/l	0.041	0.041	0.041
Cull Cow Price	$/kg cwt[2]	1.79	1.34	1.29
Variable Costs per Cow[1]	$/cow	214.30	221.30	222.59
Discount Rate	%	6.72	7.16	8.32
Consumer Price Index		1022	1056	1081

[1]Partial Derivative of the cost function with respect to cow number

[2]Carcass Weight

Table 2: Economic values (NZ$).

		1994/95	1995/96	1996/97	Average[1]
Milk Fat	$/kg	0.545	0.665	0.366	0.541
Milk Protein	$/kg	4.130	4.136	3.521	4.042
Milk Volume	$/l	-0.054	-0.053	-0.044	-0.052
Liveweight	$/kg	-0.402	-0.517	-0.379	-0.445
Survival	$/%	0.705	1.394	1.104	1.093

[1]1994/95 and 1995/96 adjusted by consumer price index then averaged

Table 3: Average breeding values for the major breed classes[1]

	Holstein	Jersey	Ayrshire	HF-J Cross
Fat	17.77	7.73	2.37	14.94
Protein	16.45	-1.06	8.17	10.12
Milk Volume	597.99	-240.72	317.00	273.98
Liveweight	42.2	-45.81	1.51	5.42
Survival	0.61	0.13	-0.57	0.62
BW Index	26.9	32.9	16.5	33.0

[1]Relative to a 1985 genetic base

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