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Assessing the value of breeding technologies to dairy farmers

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ABSTRACT

The adoption of technologies for breeding dairy cattle requires estimating the financial return to dairy farmers in conjunction with assessing the financial implications to the breeding company. This paper describes a procedure currently used by the Livestock Improvement Corporation.

The net on-farm income generated as a result of the new technology is calculated. This is discounted to a Net Present Value allowing for the cost of the technology. A positive NPV indicates the adoption of the technology is of benefit to the dairy farmer.

The breeding company also should assess the funding implications of any change. Typically this is expressed in terms of the increase/decrease in price of products and services.

Keywords: Breeding scheme; new technology; investment; net present value; dairy cattle.

INTRODUCTION

The mission statement of the New Zealand Dairy Board (NZDB) and Livestock Improvement Corporation (LIC) is: *To maximise the sustainable net income of New Zealand Dairy Farmers by enhancing New Zealand's competitive position as a low-cost efficient producer of milk.* The objective of LIC's breeding scheme is to meet this mission statement. It achieves this through increasing the on-farm economic worth of each crop of daughters sired by bulls produced from the scheme.

From the LIC perspective, breeding technologies which assist the LIC in meeting the above mission are of major importance.

Breeding dairy cattle is a long term investment. Table 1 shows when decisions are made by breeding companies and when the resulting progeny start lactating in dairy farmers herds. It takes 10 years from the time the decision is made to mate a bull and a cow to generate a young bull until a daughter has completed her first lactation in a dairy farmer's herd. Further, these daughters themselves produce offspring which lactate in subsequent years.

The traits which LIC currently considers in the evaluation of its breeding scheme are; protein yield, milkfat yield, milk volume, and liveweight.

METHOD

At the outset it should be noted that there are four reproductive pathways to be considered in dairy cattle breeding. They are:

- dams to breed cows
- dams to breed bulls
- sires to breed cows
- sires to breed bulls

TABLE 1: The timing of events in a dairy cattle breeding scheme.

Year	Event	Bull Age
1	Sire and dam of young bull mated	
2	Bull born	
3	Bull's unproven inseminations	1 year old
4	Bull's daughters born	2 year old
5	Bull's daughters mated	3 year old
6	Bull's daughters lactate	
	Bull proven	
	Top bulls selected	4 year old
7	Bull used widely in AI	5 year old
8	Bull's second crop of daughters born	6 year old
9	Bull's second crop of daughters mated	7 year old
10	Bull's second crop of daughters lactate	8 year old

The methodology used for evaluating breeding schemes can be described by the following five steps:

1. Calculate the change in genetic merit expected in each reproductive pathway,
2. Calculate the change in on-farm product flows expected from the changes in genetic merit,
3. Calculate the change in on-farm revenues and costs associated with the product flows, excluding semen and/or technology costs, and discount to a Present Value,
4. Calculate the change in costs associated with semen production and/or technology costs and discount to a Present Value,
5. Calculate the Net Present Value of the change - this being (3) - (4).

These five steps are described in detail below:

1. Calculate the change in genetic merit in each reproductive pathway

This requires initially defining the key parameters. These are: selection intensities, accuracy of selection, and generation intervals for each of the four reproductive pathways, as well as heritabilities, repeatabilities, correlations between traits, and economic value of the traits in question.

The genetic merit of the selected animals in each of the four reproductive pathways is then calculated.

Two approaches are used to estimate the genetic merit:

(a) Simulation models (i.e., monte carlo simulation), where the breeding scheme and associated cow population is replicated many times,

(b) Selection index procedures (Van Vleck et. al., 1987), which are based on probability theory and do not involve replication.

Simulation allows the variability in genetic response to be estimated. It also can be used to model situations not possible using selection index procedures (e.g., including major genes in a breeding programme, and monitoring inbreeding). The disadvantage of simulation is that it requires access to substantially more computing power than selection index procedures.

Selection index procedures model the population based on normal probability theory. The selection index procedures combine genetic and phenotypic parameters and economic parameters to form an index which weights the traits according to their genetic contribution to future income. The change in genetic merit in each trait can then be calculated.

2. Calculate the change in on-farm product flows expected from the changes in genetic merit

The estimates of the change in genetic merit on the four reproductive pathways are then used to calculate farm production flows in the various traits using Hill's gene flow approach (Hill, 1974). The gene flow method takes into account the age of the animals in each of the reproductive pathways, as well as the relative levels of production of each age group. The product flows are calculated on an annual basis over an appropriate planning horizon.

The product flows can either be from a "one-off" approach (i.e., the results of one set of selection decisions and the resulting product flow) or continuous (i.e., the results of a number of sets of selection decisions and the resulting product flow).

3. Calculate the change in on-farm revenues and costs

The on-farm revenue is estimated using forecasted milk component returns provided by the NZDB. The on-farm costs, excluding breeding costs, are also estimated using forecasted costs. Net income, excluding breeding costs, is calculated for each year as on-farm revenue less on-farm costs. The net income is then discounted to today's dollars to give a Present Value (Income).

4. Calculate the change in costs associated with semen production and/or technology

The costs associated with operating the breeding scheme are estimated by year. These costs are also then discounted back to today's dollars to give a Present Value (semen costs).

5. Calculate the Net Present Value of the change

The Net Present Value (NPV) is calculated as the Present Value (Income) less Present Value (semen costs). It is this financial measure which relates directly to the NZDB/LIC mission statement.

Funding issues are also considered. Of particular importance is the extent to which the new technology increases the price of semen and how this impacts on the breeding companies financial viability.

RESULTS

The methodology has been used to evaluate a number of new technologies. Examples are set out below:

1. The number of bulls progeny tested annually by LIC has been increased by 50%, from 95 Holstein-Friesians to 145, and 55 Jerseys to 80.
2. A recommendation was made that the Ayrshire Breed Society and LIC should jointly progeny test 14 bulls per annum with 60 daughters in each bull's proof. The Ayrshire investigation also looked at a *young bull scheme*. In this scheme, instead of a farmer mating proven bulls to his cows, most cows would be mated to young unproven bulls. Proven bulls would be used mainly to generate the next crop of young bulls. The traditional progeny test approach was shown to have a higher NPV than the young bull scheme.
3. The structure of the progeny testing scheme operated by LIC was also investigated. The current system of specialised progeny testing herds was shown to have a larger on farm NPV than one where all herds were involved in proving sires.
4. For liveweight genetic evaluations the benefit of actually weighing daughters of unproven bulls, relative to TOP scores was examined. It was shown to be beneficial in terms of on-farm NPV to weigh the daughters.
5. Other work has examined how much farmers can afford to pay for the technology, given expected performance characteristics. Currently research in conjunction with AgResearch is investigating the potential value of reproductive technologies to the dairy industry. These include the use of sexed semen, and *In Vitro Production* of embryo's. Both these technologies result in less cows being required to breed bulls and cows. This increases the selection pressure on these two reproductive pathways thereby increasing genetic gain. The results are currently confidential to LIC and AgResearch.
6. Preliminary investigations into including selection for milk proteins in the breeding scheme has also been undertaken.
7. The approach has been used to identify performance characteristics that new technologies need to meet in order for them to be beneficial to the dairy industry. For example, Physiological Indicator Traits (PITs). These are traits measured early in an animals life that are linked with either their future performance, or daughters performance. Examples include measuring

blood metabolites (e.g., urea). The performance characteristics (e.g., heritabilities and genetic correlations with production traits) required to make greater genetic gains in the resulting proven sires and hence the NZ dairy cattle population have been defined.

CONCLUSION

A method for evaluating the benefits of new technologies to Livestock Improvement's breeding scheme has been outlined. The method focuses on the NZDB/LIC mission statement. Several applications of the approach have been outlined.

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Associations between milk protein genetic variants and production traits in New Zealand dairy cattle

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ABSTRACT

Records on 7574 first lactation cows were used to investigate the associations between milk protein genetic variants and 305-day milk, fat, and protein yields. Friesians, Jerseys and Ayrshires and their crosses were represented in the data. Milk samples were typed for 3 casein (CN) proteins α_{s1}-CN (B,C), β-CN (A^1, A^2), κ-CN (A,B) and 1 whey protein β-lactoglobulin (LG) (A,B). The model used to describe the data included the additive genetic effect of animal and the four protein phenotypes.

The interaction between breed and α_{s1}-CN phenotype and between breed and β-CN phenotype was significant ($P<0.05$) for milk, fat and protein yields while the interaction between breed and κ-CN phenotype was significant ($P<0.05$) only for protein yield. The interactions associated with the α_{s1}-CN and κ-CN phenotypes were scale effects while the interactions associated with β-CN resulted from reranking of protein phenotype across the breeds. Friesian and Jersey α_{s1}-CN BB cows had higher (2.8% and 0.8%, respectively) milk production and lower (0.3% and 1.2%, respectively) protein production than BC animals while the differences between the phenotypes for fat production were small. The β-CN A^2 allele was associated with increased production in the Friesians with A^2A^2 cows producing approximately 2% more milk, fat and protein than A^1A^1 cows. The opposite effect was found in Jerseys where A^2A^2 cows produced 3-4% less milk, fat, and protein than A^1A^1 cows. The B allele of κ-CN was associated with a 0.6 to 3.5% increase in production. The β-LG BB phenotypes produced approximately 1.3% less milk and protein and 1.2% more fat than the AA phenotypes. The dominance effect was not significant ($P<0.05$) for any of the protein phenotypes.

Keywords: milk protein polymorphism; production traits.

INTRODUCTION

Genetic polymorphism exists in 3 casein (CN) proteins (α_{s1}-CN, β-CN and κ-CN) and 1 whey protein (β-lactoglobulin (LG)) of milk produced by the common breeds of Western cattle (for a review see Ng-Kwai-Hang and Grosclaude; 1992). The polymorphs, referred to as genetic variants, differ in their amino acid composition through either deletions or substitutions. Associations have been found between the genetic variant composition of the milk and its manufacturing properties. For example, Hill *et al.* (1995) found that β-LG BB milk had higher casein content, lower whey protein content, significantly higher curd firming rate and greater cheese yield than β-LG AA milk. Other research found associations between genetic variants and yield traits. Bovenhuis *et al.* (1992) and Aleandri *et al.* (1990) found β-LG BB cows had lower milk and protein but higher fat production than β-LG AA cows. However, agreement between the two studies with respect to the associations of the casein proteins with production traits were less consistent with certain variants associated with increased production in one study but decreased production in the other study.

Given the potential manufacturing benefits of milk of a specific genetic variant composition as well as the associations between genetic variants with production traits, the value of genetic variants as selection criteria should be assessed. The economic value of milk of a specific genetic