
THE PROCEEDINGS OF THE
NEW ZEALAND SOCIETY
OF
ANIMAL PRODUCTION
VOLUME 62 2002

Replacement policies for dairy cows

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ABSTRACT

A simulation model of dairy herds was built to examine the economic consequences of alternative culling policies. Only culling cows on the basis of their first lactation was examined because previous studies had shown that it is not worthwhile acquiring more information before making the culling decision. The simulation model shows that the culling decision is sensitive to the ratio of cull salvage value to replacement cost. At a ratio of 0.7, a third of first lactation cows should be culled. Used optimally to make replacement decisions, herd testing is worthwhile particularly if the less expensive alternate month test is used.

Keywords Dairy cows; replacement policies; culling; modelling; herd testing.

INTRODUCTION

In 1940 the New Zealand Dairy Board appointed the first 6 consulting officers under the government-subsidised Herd Improvement Plan. One of their primary objectives was to advise farmers on how best to use herd testing records — how to select bulls, heifer replacements, and how to use herd test records to cull cows. While research on bull and heifer selection provided consulting officers with the basis for sound advice (though the development of AB removed the bull selection decision from the farmer), very little research has been done on the best way to use herd testing records for culling dairy cows.

Twelve years ago the author reported the use of stochastic dynamic programming to make optimal culling decisions (McArthur, 1973). This recursive optimisation procedure makes it possible to decide whether to keep or cull a cow with a specific level of previous production performance and a given age. The procedure is a backward optimising method which takes into consideration the value of immediate production in the current year and also the expected value of following the optimal replacement subsequently (Wagner, 1969).

Recent research with an improved version of this dynamic programming model using a repeatability of 0.6 (Castle and Searle, 1957) indicates that it is usually optimal to cull cows on the basis of their first lactation. This rule holds for a wide range of economic circumstances. In other words, a second chance is seldom worthwhile. The details of this model will be published elsewhere.

In this paper, the results of a simulation model of a dairy herd are presented. For this model there is only one decision variable — the proportion of heifers to cull after they have completed their first lactation. This model has been used to:

1) search for the optimum level of culling for production, and
2) find the associated economic value of making the best use of herd testing information.

THE SIMULATION MODEL

The output variables of the simulation were:

1) the production of milkfat/cow (M) over a 30-year time horizon,
2) the steady state proportion of 2-year-olds (P_2).
3) the steady state proportion of cows sold as culls (P_s).

The numeraire used for valuing the price of inputs and outputs was 1 kg of milkfat.

The opportunity cost of rearing a 2-year-old is approximately equal to the annual production of a mature cow — typically about 150 kg of milkfat. Given the ratio of the salvage value of a cull cow to this opportunity cost (F), then the gross margin in any one year is:

$$GM = M - 150(P_2 - F \times P_s) - H \qquad (1)$$

where H is the herd testing cost/cow.

The value of this series of gross margins was expressed as a present value using a 10% interest rate. The equivalent annual return is the annual equivalent of this present value. This 'EAR' was the criterion used to assess the value of a culling plan.

The model required these inputs:

(1) Death rates and failure rates (involuntary culling rates) by age. An equation was fitted to death rate data published by the New Zealand Dairy Board (1957). D_t is the death rate % in the t^{th} lactation.

$$D_t = 10.37 - 2.19t + 0.36t^2 \qquad (2)$$

The equation for failure rate % was:

$$F_t = 2.84 - 0.32t + 0.057t^2 \qquad (3)$$

Given that there is no culling for production and that the maximum number of lactations is 11, the proportion of replacement 2-year-olds is 16% for a herd in a stable state.

(2) Repeatability, heritability and phenotypic standard deviation. The estimates published by Castle and Searle (1957) of 0.6, 0.3, and 30 kg of milkfat were used in the case of monthly herd testing.

(3) The genetic gap between AB bulls and the herd, as well as the annual rate of genetic gain of AB bulls. Estimates of 30 kg of milkfat and 1.5 kg were used respectively.

(4) The standard age correction factors used by the New Zealand Dairy Board. A Jersey 2-year-old has an expected level of production of 0.77 of the mature level.

The most important calculations within the model involved estimating the effect of the culling level on production of milkfat in each year. The short term effect of more culling for production of 2-year-olds at the end of their first lactation is:

a) to increase the proportion of 2-year-olds in the herd and so lower production/cow because immature cows produce less.
b) to lift the performance of the remaining cows by the selection differential multiplied by the repeatability. The usual assumption of normally distributed production records was made in order to find the selection differential induced by culling 2-year-olds.

The long term effect of more culling for production is through its effect on the quality of replacements reared. Higher culling and greater replacement rate imply a lower selection intensity in that larger numbers of calves have to be reared. Selection may be reduced to the point that heifers' calves may have to be kept. On the other hand, heavy culling increases the breeding value of the remaining cows mothering the next generation.

Because culling affects the age distribution of the herd, it was necessary to simulate the breeding value of each age group in the herd in each year. This matrix provided the basis for finding the average milkfat/cow (M) in equation (1).

MODEL RESULTS

Common sense suggests that if culls fetch almost as much as the value of fresh 2-year-old replacements, high replacement rates should be optimal. On the other hand if replacement is expensive because cull prices are low relative to the price of a replacement, low replacement rates should be best.

The model results supported common sense. Figure 1 shows the relationship between optimal culling rates of 2-year-olds against the ratio of salvage price for culls to the opportunity cost of 2-year-old replacements. When the salvage value of a culled cow was 0.7 of the price of a replacement heifer, equivalent annual return was at a maximum if a third of the replacement heifers were culled on the basis of their first lactation performance. Culling a third of the heifers requires 22% replacements each year for a stable state herd. This is a little higher than the industry norm of 18 to 19%.

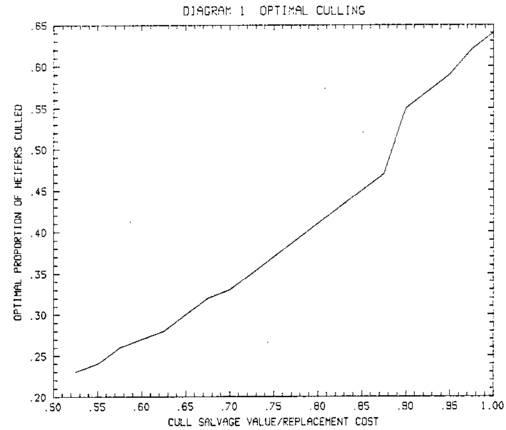

FIG. 1 Effect of the ratio of cull salvage value to replacement cost on the optimal culling rate of heifers.

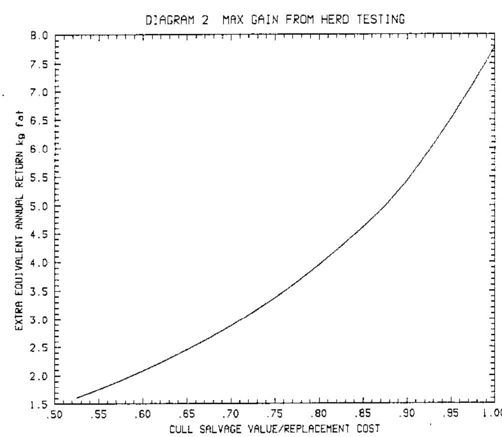

FIG. 2 Additional annual return from herd testing and the optimal replacement policy at a range of ratios of cull salvage value to replacement cost.

The additional equivalent annual return from herd testing associated with the optimal replacement rate was found by comparing the return with no culling for production with the return using the best replacement policy. Figure 2 shows the extra equivalent annual return (which is the gain from herd testing) plotted against the ratio of cull salvage value to replacement cost. Livestock Improvement Associations will be pleased to note that the gain was positive throughout.

Further gains from herd testing can be achieved by using alternate monthly testing rather than the monthly test. Castle and Searle (1957) published a 0.55 repeatability for alternate month records compared with 0.6 for monthly records. This would imply a smaller heritability of 0.27 instead of 0.3, and a slightly larger phenotypic standard deviation of 31.3 kg instead of 30. For a 120 cow herd, the cost/cow of alternate monthly testing is 2.05 kg of milkfat rather than 3.15 kg for monthly testing.

The extra equivalent annual return from adopting alternate monthly testing increases by almost this cost reduction because the extra information from more accurate testing results in only small increases in production both short and long run.

The dairy industry could further reduce the cost of herd testing for culling purposes by offering a service which tested heifers only. This would seem a very rational option for farmers to adopt because optimal culling policies are confined to removing cows after they have completed their first lactations.

Finally there is a need to update the estimates of the parameters used in models of replacement. It could be that these parameters have shifted in the last quarter of a century!

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