DAIRY COW EVALUATION SYSTEMS IN NEW ZEALAND

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INTRODUCTION

The New Zealand Dairy Board is responsible for calculating both sire and cow evaluations for dairy cattle in New Zealand. For cow evaluation, two indexes are produced. A breeding index which is a prediction of genetic merit; and a production index which is a prediction of productive merit. These indexes are expressed on a percentage scale with a base of 100, which was the average breeding index of cows in 1960 (Shannon 1970; NZ Dairy Board 1970; Wickham and Stichbury 1980). The current systems have been in place since the early 1970's. They have recently been reviewed and a modified system will probably be introduced for the 1990/91 season.

In this paper we review the current system; discuss its limitations; discuss the proposed modified system; and review work on the development of an economic culling index.

CURRENT SYSTEMS

The essential features of the current system are (Bishop 1987):

Production Index

1. It considers only one trait - milkfat.
2. Production indexes are estimated from a within herd comparison, with test day records being pre-corrected for stage of lactation, and age.
3. For each test day the pre-corrected records are averaged to obtain a herd mean.
4. Each cow's performance is then expressed as a percentage of the herd mean for that test day.
5. These percentages are averaged across test days within season, and regressed to 100, using an adjustment based upon the number of test day records and the within season repeatability of milkfat.
6. The indexes so obtained are adjusted for the genetic level of the herd by equating the average index with the herd Breeding Index.
7. A lifetime production index is calculated by averaging the within lactation production indexes.

Breeding Index

1. Again it considers only milkfat.
2. Initially an ancestry breeding index is calculated as the average of the breeding indexes of the sire and dam.
3. The ancestry index is updated as more information becomes available. Of importance here is the cow's own production information expressed as the cow's Lifetime Production Index.
   This updating procedure can be represented as:

$$BI\ (Cow) = BI\ (Ancestry) + \beta \left[\begin{array}{l} \text{Lifetime} \\ \text{Production} - BI\ (Ancestry) \\ \text{Index} \end{array} \right]$$

   where β is an appropriate regression coefficient.
4. Associated with the Breeding Index is a reliability or R^2, which estimates the proportion of the genetic variance explained by the Breeding Index estimate.

   The reliability of the ancestry Breeding Index is initially set as $\frac{1}{4}$ [Reliability of Sire + Reliability of Dam]. As more information becomes available the reliability estimate is updated in a similar way to the Breeding Index estimate.

This updating procedure can be represented as:

Reliability (Cow) = Reliability (Ancestry) + β [1 - Reliability (Ancestry)]

where β is the regression coefficient described earlier in (3).

LIMITATIONS OF THE CURRENT SYSTEM

We have been aware for some time that the current system has a number of limitations. The major ones being (Wickham 1987):

1. The production index is a historical record of a cow's production after adjusting for age, stage of lactation, herd environment, herd genetic level and the amount of information. Such an index does not however predict the future production of a cow.
2. In mixed breed herds, breed influences and measures of genetic and phenotypic merit become confounded because no corrections are made for breed.
3. The system relies on fixed age and stage of lactation factors. These are considered to be unsatisfactory in some situations.
4. Difficulties are encountered with unidentified animals. For such animals the Ancestry Breeding Index is simply set at 100, the average Breeding Index of the population in 1960.
5. The New Zealand Dairy Industry has moved to a payment system which incorporates payment for milkfat, milk protein and milk volume. The current system considers only milkfat.

MODIFIED SYSTEM

As a consequence of the above limitations a major review of the current system has been undertaken. This work has been done largely by B.L. Harris, S.C. Bishop and P. Shannon (Harris et al. 1989). A number of modifications have been made to the procedures for calculating Production and Breeding Indexes.

The essential features of the modified system are:

1. Three traits are considered, milkfat, milk protein and milk volume. These are combined to form a Payment Index. This is analagous to the Payment Breeding Indexes used in New Zealand for sire selection.
2. For both the Production Index and the Breeding Index an initial estimate is made based on the Breeding Indexes of the parents.
   This can be represented as:
   PI (Ancestry) = BI (Ancestry) = $\frac{1}{2}$ [BI Sire + BI Dam]
3. Associated with the ancestry estimate is a Reliability estimate, which estimates the proportion of the genetic or phenotypic variance explained by index estimate.
   The reliabilities are:

   BI Reliability(Ancestry) = $\frac{1}{2}$ [BI Reliability (Sire) + BI Reliability (Dam)]

   PI Reliability(Ancestry) = $\frac{h^2}{R}$ [BI Reliability (Ancestry)]

   where R is the between season repeatability and h^2 is the between season heritability for the trait.

4. The ancestry based indexes are updated as further information becomes available. The cow's own production information is of particular importance in this context. A major change is that the updating procedure will be carried out within contemporary groups. These are defined according to age, breed, and season of calving.

5. A modified pre-correction system has been developed whereby test day records are pre-corrected for stage of lactation.

6. Analysis of production records has suggested a trend toward increasing variability of within herd variance with increasing herd productive level. A transformation procedure whereby the pre-corrected records are adjusted by the contemporary mean yield is used to reduce the heterogeneity between contemporary groups. This procedure adjusts the record to a ratio.
7. The transformed record is further adjusted by the contemporary phenotypic level to account for genetic trend.

The transformed production record is then used to update the initial estimate as follows:

$$BI\ (Cow) = BI\ (Ancestry) + \beta_1 \left[\begin{matrix} \text{Transformed} \\ \text{Record} \end{matrix} - BI\ (Ancestry) \right]$$

$$PI\ (Cow) = PI\ (Ancestry) + \beta_2 \left[\begin{matrix} \text{Transformed} \\ \text{Record} \end{matrix} - PI\ (Ancestry) \right]$$

Where β_1 and β_2 are the appropriate regression coefficients.

The updating is done after each test.

8. A modified procedure has been developed for handling non-identified cows. They will be given an ancestry breeding index equal to the average breeding index of their contemporaries. Where there are no contemporaries the non identified cows will be given a value equal to the breed average.
9. Genetic and phenotypic evaluations are made for the three traits milkfat, milk protein and milk volume. They are then combined to form payment indexes using the appropriate relative economic values.

It should be noted that some investigations have been made into the feasibility of using procedures based on Best Linear Unbiased Prediction (BLUP) techniques.

A number of issues have been raised which are being further investigated. Such issues include: the computer processing time required to solve the equations, amount of information required, procedures for handling poor animal identification, and the variance structure implied by the model. Further work is continuing.

ECONOMIC INDEXES

The New Zealand Dairy Board has for some time been examining the feasibility of developing economic indexes for culling and selection. Exploratory work suggests that economic models for determining asset replacement policies may be of value.

Three broad issues have emerged from this work. (Jackson and Taylor 1984). They are:
1. How many cows should be replaced (culled)?
2. Which cows should be replaced (culled)?
3. When should they be replaced (culled)?

It appears the questions of 'how many' and 'when' can be best answered by whole farm Linear Programming and Simulation models. The 'which' question can be best answered by using Dynamic Programming models.

A recent study (Harris and Jackson 1989) suggests the relationship between the modified production index and an economic culling index is poor. Consequently work in this area is continuing.

SUMMARY

In this paper we review the current system used for cow evaluation in New Zealand. The limitations of the current system are discussed being: the production index is not predictive, in mixed breed herds breed influences and measures of genetic and phenotypic merit are confounded, and only one trait milkfat is considered.

A modified system is described which it is hoped will be introduced in 1990/91. The essential features of this system are: the evaluations are made within contemporary groups, transformations are made to adjust for heterogeneity between contemporary groups and for genetic trend, three traits are considered and a modified updating procedure means the indexes are predictive.

Exploratory work suggests the relationship between the modified production index and an economic culling index is poor. Work in this area is continuing.

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