THE ACROSS-BREED EVALUATION OF DAIRY CATTLE IN NEW ZEALAND

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SUMMARY

New Zealand dairy cattle are genetically evaluated using an across-breed animal model fitted to production records every three weeks. The traits evaluated and included in economic indices are milk volume, fat and protein yields, lactating cow liveweight and survival. Some additional traits (e.g., animal and udder conformation) are evaluated but not included in any economic index. This evaluation system, which replaced the previous systems as from June 1996, incorporates three major research findings. First, a new methodology to predict total lactation yields from individual test-day information. This accounts for any number of herd tests over any testing frequency and allows for variable information among herdmates and for the effects of culling. Second, a mixed model routine to calculate breeding values using a single trait repeatability model equation, allowing for heterogeneous subclass variation and including fixed breed and group effects. Third, an economic model to derive relative economic values parameterised to a fixed feed supply. Economic indexes describe animal profitability per unit of feed and account for the variation in body size and individual productivity that is a feature of across-breed evaluation. A programme of industry consultation was integral to these developments over some five years, in tandem with an educational campaign targeted at all 14,500 farmers plus other industry players.

Keywords: Animal model, genetic evaluation, herd test, economic model

INTRODUCTION

Increases in dairy farm profitability result from the use of superior sires and culling of the least profitable cows. Identification of superior individuals requires definition of the characteristics which influence profit and the determination of their relative (future) importance. Collection and analysis of relevant pedigree and performance data in order to estimate genetic merit for the traits that influence profitability introduces practical and theoretical challenges. A system of dairy cattle evaluation was developed in New Zealand in the 1960's and remained largely unchanged, except for fine-tuning during the mid 1980's. Major developments in database capability and statistical techniques have since taken place. These developments provided new opportunities to improve the system in several respects. Dairy farmers indicated that a single major change was preferable to several somewhat smaller changes to the system. Accordingly, a major review of sire and cow evaluation was undertaken, culminating with replacement of the system in June 1996. This paper describes some of the main elements of the changes.

ESTIMATION OF LACTATION YIELDS FROM TEST DAY RECORDS

Test day production records are combined to predict 270-day yields for use in genetic evaluation. The procedure is undertaken separately for milk volume, fat and protein yields. The procedure adjusts for test-day environment, standardises lactation length, and takes account of culling. Test day records are weighted according to the number of tests in the lactation, the stage of lactation on the day of test, and the intervals between tests. Any combination of tests can be used, allowing for inclusion of records in progress or incomplete lactations. A detailed account is in Johnson (1996).

The procedures that were historically used to combine test-day records for bull evaluation involved approximating the area under the lactation curve and did not adjust for lactation length. Cow evaluations were based on a procedure that adjusted yields to a fixed point of the lactation curve and analysed the average of these estimates. The use of an animal model (rather than separate sire and cow evaluations) requires a consistent handling of test day yields.

Variance components were estimated between nine 30-day intervals of the lactation curve, treating each interval as a separate trait. These results were used to obtain an expression to calculate the phenotypic co-variance between any pair of test-day records. Accordingly, an individual variance-covariance matrix can be calculated for every cow-lactation. Analysis of test-day records, within herd-year-season-age contemporary groups, is undertaken after each test day. A linear model is fitted to account for days in milk. Residuals from this model are accumulated across all test-days from one lactation of a cow and a linear combination of these residuals is used to predict a 270-day lactation yield deviation from contemporary average. The methodology is best linear prediction using the covariance structure appropriate to the individual cow. The predicted lactation yield is then expanded to standardise genetic variance, and a lactation weight is calculated accounting for the expansion and prediction error, to use within the animal model.

ANIMAL MODEL EVALUATIONS OF YIELDS, LIVEWEIGHTS & SURVIVAL

The model equation used to evaluate predicted lactation yields (milk volume, fat and protein) ignores genetic and phenotypic relationships between the traits, and assumes yields are a repeatable trait with the same genes involved in production at all ages. Fixed effects are included for: herd-year-season-age contemporary group; period of calving (relative to the mean of the contemporary group); induced lactation within age (in years); heterosis; age at calving class (in months, nested within breed); and genetic group. Random effects include: animal genetic, permanent environmental; and residuals. The liveweight model (fitted to weights measured during lactation) includes the effect of stage of lactation nested within age, in place of induction and period of calving effects. More details of these model equations (including type and survival) are in Harris et al (1996). Survival analysis is based on single trait analysis of 0, 1 observations representing the survival of a cow from one lactation to the next. Survival breeding values (BV)are calculated from lactation 1 to 2, 2 to 3, 3 to 4 and 4 to 5, then these are pooled into a single survival BV by weighting each survival based on changes in age structure. Breeding values and producing values (PV, which includes heterosis and permanent environmental effects) are reported in units of measurement (litres milk, kg fat & protein, percent for survival), relative to an across-breed base defined by those (30,000) 1985-born cows that were assessed for type traits. This is a major change from the percentage scale used in the past, with a (Holstein-Friesian and Jersey) 1960-born within-breed base of 100.

The animal evaluation for yield traits is undertaken every three weeks, with computations carried out on a different computer from that used for maintaining the database. An interim (within-herd update) calculation is run every night, to process herds as test-day records are entered into the database. The continuous evaluation has enabled progeny test bulls to be widely-used on the basis of partial lactation evaluations, one year earlier than has historically been the case.

An important feature of the system is the partitioning and storage of the three components that account for every animal evaluation (Garrick et al, 1993). That is, the parent average merit, the individual performance deviation and the merits of progeny (adjusted for mates) are stored each run, along with the weighting factors that relate to these three components. This facilitates explanation of apparently unexpected changes in evaluation of any individual animal between evaluations.

ECONOMIC MODEL FOR ASSESSING RELATIVE PROFITABILITY

The advent of across-breed evaluation leads to considerable disparity in BV and PV between breeds of markedly different size, such as Holstein-Friesians and Jerseys. However, these breeds also differ in individual feed intakes, and farmers account for this by managing smaller breeds at higher stocking rates than is the case with larger breeds, such that comparable quantities of dry matter are harvested. In recognition of this fact, economic indexes are calculated to reflect profit per unit feed consumption. These indexes are known as Breeding Worth (BW) and Production Worth (PW) and are expressed in terms of profit per 4,500 kg Dry Matter. This roughly equates to the annual feed consumption of the base cows and their replacements. Breeding Worth is a linear function of BVs for milk volume, fat and protein yields, liveweight and survival, whereas PW is an analogous function of corresponding PVs. The economic weights incorporated in the BW and PW calculations are different, reflecting discounting factors for different time horizons (next generation vs remaining lifetime) in addition to different future price expectations. The economic weights essentially account for the marginal income for milk or beef traits, discounted for the cost of the marginal feed. The approach is similar to Visscher et al. (1994). Some alternative (derivative-free) approaches to these calculations are in Garrick (1996). The economic model assumes higher energy requirements for fat relative to protein production and accounts for maintenance requirements as a function of metabolic liveweight. Some farmers and breeding organisations have had difficulty accepting the negative economic weights associated with milk volume and liveweight. In retrospect, it may have been useful to have explained the concept in terms of milk traits, beef traits and feed income, rather than including the feed income components implicitly in the calculation of economic values for yield and liveweight traits.

IMPACT OF ACROSS-BREED EVALUATION

Many dairy farmers milk herds of mixed breed cows. In the past, these would have been compared to different historic bases, such that the indexes were not comparable. The new system allows all breeds and breedcrosses to be fairly evaluated. Not surprisingly, many crossbred cows have high PW, thereby encouraging further crossbreeding. The reduction in returns for manufacturing beef has also reduced some indirect benefits from the use of Holstein-Friesian semen. An analysis of on-farm returns based on additive breed effects and heterosis estimates that have been obtained from the model, indicates clear benefits for first-cross Holstein-Friesian × Jersey cows (Lopez-Villalobos et al 1996) and potential for profitable use of rotational crossbreeding systems. Semen sales this year have indicated an increased preference for Jersey semen in comparison to previous years. Major shifts back to the Jersey breed will have other implications. It is likely that milk colour will change, and that the number of potential bull mothers (three generations artificial breeding to the same sire breed) will be eroded. The effects of substantial increases in crossbreeding on genetic gains and on industry returns are the subject of current study.

INDUSTRY CONSULTATION & PROTOTYPE TESTING

A major component of the review of the evaluation system has been the regular consultation with industry (at all levels) and this collective input has guided a number of changes to the developments in comparison to those originally proposed. A prototype system was developed, and tested in parallel over three seasons. In the latter two seasons the number of trial farmers was increased, until finally, all farmers received output from both the existing and the proposed system, in February 1996. Nevertheless, there remains a small minority dissatisfied with the negative economic values for milk volume and liveweight. Throughout the process, there have been audits of the system by international experts. Reports on their findings are available to interested parties.

EDUCATION AND ON-GOING SUPPORT

A major education programme was central to the widespread release of the new system. In the first instance, this centred on some 200 trial farmers that were involved in the parallel testing phase. These farmers had been nominated by Breed Associations, AB companies and other means. A number of changes to the system and the presentation of results took place as a result of those experiences. In the second instance, explanatory information was sent out to all farmers, along with the new system rankings of their own cows, prior to the termination of the old system. This information was followed up by some 150 meetings, held all around the country. All these meetings included some members of the system development team. A toll-free system for telephone support was also established coupled with the improved ability of the evaluation system to detail responses to individual queries.

DISCUSSION

Major changes to the calculation, reporting and interpretation of dairy breeding information have taken place from June 1996. Furthermore, recognition that the system must continue to develop and meet new needs has been integral to these developments. New genetic evaluations of biological traits will occur whenever research results indicate such traits can be, from an industry viewpoint, profitably added to the system. Current research is being undertaken on fertility traits, somatic cell counts and milk composition. The economic model is timetabled for annual update, with facility for inclusion of new traits. It is likely that the new system will now evolve with continuous small improvements, rather than quantum change.

REFERENCES

Garrick, D.J. (1996) *Proc. Massey University Dairyfarmers' Conf.* **48:**129.

Garrick, D.J., Harris, B.L., Shannon, P., and Sosa, C. (1993) *Proc.N.Z.Soc.Anim.Prod.* **53:**91.

Harris, B.L., Clark, J.M., and Jackson, R.G. (1996) *Proc.N.Z.Soc.Anim.Prod.* **56:**12.
Johnson, D.L. (1996) *Proc.N.Z.Soc.Anim.Prod.* **56:**15
Lopez-Villalobos, N., and Garrick, D.J. (1996) *Proc.N.Z.Soc.Anim.Prod.* **56:**216
Visscher, P.M., Bowman, P.J., and Goddard, M.E. (1994) *Livestock Production Sci.* **20:**123