MEASUREMENT IN DAIRY CATTLE IMPROVEMENT

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INTRODUCTION

Many studies have been made with the aim of improving the estimation of milk production and its component traits, or to get acceptable estimates with less cost and/or effort. "Acceptable" raises the question of acceptable to whom? A higher degree of accuracy, and over more traits, is generally required by a sire-evaluating co-ordinator in a herd improvement organization, than is needed to allow a farmer to periodically use opportunity culling within his own herd.

Complications in the problem include factors such as:

a) uneven periods between samplings, and between milkings within days,

b) variations among milking systems, and methods of obtaining milk volumes and samples,

c) diurnal temperature variations.

ITEMS TO BE MEASURED

These may include:

a) identities of production units (animals) and of their close relatives,

b) production characters such as milk and protein yields, and

c) data of potential use in improving or monitoring health or reproduction or production. Examples are oestrus, conception and mating dates, karyotypes (to aid screening for economically important chromosome defects), digestive enzymes (suggested correlation with bloat susceptibility), scrotal circumferences (correlated with fertility), certain protein types (possible correlations with fertility and production), liveweight (correlated with production and fertility), disease status (to allow possible corrections for production drop due to disease stress), information on relatives (for use in selection indexes, etc.), and type traits (correlations with production, and/or use in public relations exercises with breed organizations).

SAMPLING METHODS AND FREQUENCIES OF OBSERVATIONS

To obtain a level of accuracy sufficient to usefully distinguish between cows for production merit, different numbers and frequencies of observations are likely to be optimal for milk yield and its component traits.

Traditional once-monthly sampling, a.m. plus p.m. within a 20 hour period, has proved accurate enough to allow substantial genetic progress. Labour cost constraints have for several years made systems of less frequent sampling appear attractive, and a considerable literature has already accumulated on comparisons between suggested alternatives. The major alternatives have been alternate month a.m-p.m. testing, starting with either a.m. or p.m. test, and bimonthly or trimonthly a.m. plus p.m. tests. Trimonthly tests are probably not accurate enough even for farmer use (for opportunity culling), and numerous studies (e.g. Schaeffer and Rennie, 1976; Munro, 1976) have shown that alternate a.m.-p.m. is more accurate than bimonthly recording. All a.m., or all p.m., tests are less accurate than alternating a.m.-p.m. tests (Dickinson and McDaniel, 1970; Schaeffer and Rennie, 1976). Munro (1976) found that bimonthly recording starting in the second month of lactation, gave mean estimates closer to the mean of standard monthly estimates than any other method, including bimonthly starting in the first month of lactation. But combination of the means of the two bimonthly methods, as would be the case in practice, gave less accurate estimates than use of alternate a.m.-p.m. Her study was also somewhat biased against the alternate a.m.-p.m. method, as monthly estimates were obtained by simply doubling the single (a.m. or p.m.) recording. A more accurate estimate is obtained by using different correction factors for a.m. and p.m. recordings, and by taking account of the interval between milkings (Everett and Wadell, 1970; Schaeffer and Rennie, 1976). Irvine and McKnight (1977) have also shown that, since the a.m. and p.m. milkings differ in the relative levels of milk components, a more accurate sample is given by weighting the samples proportionally to the milk yield of that milking. Such weighted estimates, compared to those calculated from equal sized night and morning samples gave lower (more accurate) estimates for fat percentage and total solids percentage, but similar values for protein percentage. Schaeffer and Rennie (1976) found morning recordings predicted daily milk yield better than did evening recordings. They also found that estimates should be corrected for the effect of milking interval and, less importantly, month of lactation, but that lactation number was relatively unimportant.

SAMPLING SUPERVISION

Recording costs can also be reduced by eliminating or reducing supervision of the testing process. That is, farm labour can be used to replace the "outside" labour cost of contractors (private or governmental), which is beneficial if farm labour is utilized, or contractors are unduly expensive (perhaps due to a substantial travel cost component).

Most dairy breed societies do not accept unsupervised recordings, so there is a need to develop a cheap tamper-proof testing system that also minimizes use of labour both on farm and at the central testing laboratory. The well known firm of Foss Electric have developed an automated tamper-proof system, if it is assumed that cow identification is correct. This loophole should soon be solved by AGBU-initiated research aimed at developing a permanently implanted small cheap identity marker, electronically readable, for each cow. The Foss system uses a removable magnetic device, which dishonest operators could swap around. Another major defect of the Foss system is its expense, but mass usage of future automatic systems would surely allow overall cost savings.

CLASSES OF MEASURING DEVICE

The complexity of equipment required ranges from none, for visual observations, to very high, for automated devices like Milko Scans. Operator-read devices are intermediate; some as simple as eartags, some relatively complex, such as sonic probes. Subjective evaluations can be improved in accuracy by use of multiple observations and/or operators, especially the latter. Simple statistical calculations can allow deletion of aberrant or unduly variable observers from panels of observers.

Complex equipment may improve accuracy of measurement, but requires reliable staff with high levels of mechanical skills. As the automated equipment becomes cheaper, the economic desirability of centralized testing may decrease as the relative importance of problems of transport looms larger. Eventually the only item requiring transport may be electronic data travelling via telephone line, with all measurement occurring at the farm level.

MEASURING DEVICES

Milk meters have replaced bucket weighings in the majority of schemes, with the Tru-test meter most favoured. The Waikato meter has a small market share. The Victorian Department of Agriculture provides a meter testing reference centre whose findings are widely accepted. The pre-use testing of new meters is universal, and some states have established within-use testing. This latter program has developed slowly because of the widely held view that meter faults likely to cause significant measurement inaccuracy are readily detectable on visual examination. The need for independent and objective examination will increase as unsupervised schemes expand and less supervision is applied to meter usage.

Three separate sampling arrangements can be identified, and separate metering nozzles are available for each. Infra-red equipment has replaced the Babcock or Gerber for butterfat testing. The amido black dye-binding technique is widely used for protein testing (Radcliffe, 1968), to generally replace SNF testing. The difficulties in this latter technique have tended to restrict its wider use. It was based on specific gravity, and was slow, labour-intensive, and much affected by factors such as temperature at test time, and cooling and heating history of the samples. Automatic equipment of the SCAN type capable of analysis for butterfat, protein and lactose in integrated consecutive tests on the one sample are in use in one state and under consideration in others. The sample size required for this equipment varies between 8 ml for the SCAN and 2 ml for the Milko Tester. Centralized testing is widely used. All samples are processed through one laboratory in Tasmania, Queensland and Western Australia. Victoria has eight such units, while New South Wales utilizes dairy association (factory) equipment. Recorder type meters and composite sampling farmer type meters generally take a 2½% sample. Two separate schemes of in-lab rather than on-farm measuring are available and separate metering nozzles delivering 0.5 and 0.75% respectively are available. These systems derive individual cow productions by in-lab measurement. A problem with this scheme is that production information does not remain on the farm on observation day. Where geographic limitations allow, this information is returned to farmers one to four days after test. Cumulative and other processed information is returned 14 to 21 days later.

Centralized testing allows increased accuracy due to economics of scale permitting use of more or less completely automated procedures for milk component (and cell count) testing, and thus elimination of a lot of repetitive work where monotony was likely to lead to carelessness (in, for example, fully cleaning sensors between samples). Development of completely foolproof methods of off-farm sample identification would eliminate another (probably minor) potential source of error. Transcription errors between measuring device and computerized record can be minimized by eliminating the human component, and linking, e.g. the Scan and the computer.

Deterioration of samples between farm and central testing laboratory will become a more important source of error as within-laboratory errors are (hopefully) reduced by better equipment and planning, and may justify more consideration in the future, particularly in the hotter and/or more isolated regions.

Completely automated recording of milk volume would avoid transcription errors onto sheets at the farm level, and also keypunch errors at the central laboratory level. The latter are a potentially important source of error in systems where cost constraints have led to data being entered (into computer readable form) but not routinely verified.

CARRYOVER EFFECTS

1. Nutritional

Most present dairy sire (and cow) evaluation systems ignore carryover effects from one lactation to later lactations. They are demonstrably important in some countries where cows are better fed than is usually the case in Australia, so may be even more important in Australia.

Milk production of a given cow can be much affected by her body condition (liveweight), as dairy cows convert body tissues into milk, particularly cows of high genetic merit for milk yield. This conversion is particularly important in early lactation, when the cow's appetite is relatively low, but production is building up to peak lactation, which sets the maximum yield for the entire lactation. Since the dry period between lactations may not allow a cow, particularly a very heavy milker, to fully replenish her body reserves, it is quite possible for there to be major carryover effects from one lactation to the next (Broster, 1971).

2. Foetal Genetic

Another possible source of bias is the so-called "direct sire effects", i.e. the effect of a sire on the cow he is mated to, not his genetic inheritance to his daughters. This was first established by a Scandinavian study (Skjervold and Fimland, 1975) of 120,000 first lactations. These authors suggested the direct sire or "mate" effect might be associated with genetic differences in the hormone-secreting activity of the foetus-placental unit. Hormones such as oestrogen and progesterone are known to affect mammary growth.

Large calves may also elicit higher milk production in their dams in the subsequent lactation, as oestrogen levels in late pregnancy are highly correlated with calf birth weights (Terqui *et al*, 1975). Crossfostering experiments in mice show higher milk production from dams with larger litters at birth (Skjervold, 1977; Nagai, 1978).

In a recent British study (Taylor *et al*, 1978), cows were mated either to high contemporary comparison (CC) bulls for their first pregnancy and to low CC bulls for their second pregnancy, or vice versa. The high CC bulls tended to depress their mates' milk yield in the subsequent lactation, and the low bulls tended to increase it. The high bulls appeared to depress their mates' milk yield by at least 10% of the amount by which their daughters' yield was expected to increase.

This series of experiments is not absolutely conclusive due to the scale of the study; 16 proven bulls were used, 4 "high" and 4 "low" in each breed (Friesian and Jersey), and only 175 lactations were available for analysis. Skjervold and Fimland (1975), in their analysis, found no significant correlation of "mate effect" with breeding value, although their data clearly show the reality of "mate effects". Adkinson *et al* (1977) also found a direct sire effect, while the genetic correlation between the direct sire effect and breeding value was effectively zero. The magnitude of the "sire of foetus" effect, as a percentage of total variation in milk yield, was 2% for Skjervold and Fimland (1975) and 8% and 12% respectively for the Holstein and Jersey data for Adkinson *et al* (1977).

Taylor *et al* (1978) suggested their relatively large estimate of negative correlation between bull breeding value and the milk yield of their mates might be specific to their system of *ad libitum* feeding of a "complete" but (for dairy production) sub-optimal diet. Their other suggestion, that other researchers should seek to analyse data bearing on this subject, merits support.

Van Vleck (1978) points out that sire evaluation by methods which ignore mate effects lose little efficiency unless the genetic correlation between breeding values and foetal genetic values is negative or zero. The loss is greater if foetal genetic effects last for more than just the subsequent lactation.

VISUAL AND TACTILE OBSERVATIONS

Some subjective visual judgements, such as condition-scoring (Frood and Croxton, 1978), are accurate enough to usefully predict major deviations from expected milk yield. But note this is a procedure where some effort has gone into standardizing of the method of taking observations.

DATA CORRECTION FOR EFFECT OF FEEDING LEVELS

Tong *et al* (1976a, b) have studied the effect of feeding level upon milk yield and its component traits. It is difficult to separate cause and effect in the relationship between feed intake and milk production, but the question is of importance. If the relationship is wholly causal (i.e. high producing cow fed more to sustain that higher production), feed intake can be ignored in estimating genetic parameters of milk production. If the relationship is wholly one of effect (i.e., cow produces more only due to being fed more), feed intake should be corrected for like any other source of environmental variation. The real life situation will of course lie somewhere between these two extremes.

As also well attested by numerous experimental results, higher feed energy concentrations raised yields, but had little effect on milk composition, for the field data of Tong *et al* (1976a, b). Correcting records for net energy intake levels reduced total variation for milk, fat and protein yield by more than 60%, but did not alter the variances of fat percentage and protein percentage (Tong *et al* 1976a). Very little of the yield trait reduction in variance could have been due to correcting for body weight rather than feed intake differences, for this data set. After correction, repeatibilities of the yield traits were substantially reduced, to levels similar to accepted heritability values, suggesting that permanent environmental effects may be largely of nutritional origin. There is a danger, if the causal hypothesis of the preceding paragraph is true, that correction for feed intake will result in a partial correction of milk production for milk production (Tong *et al*, 1976b).

The correction of the records substantially reduced estimates of both phenotypic and genetic correlations among the yield traits (Tong *et al*, 1976b). If the reduction in genetic correlations is due to reduction of the effect of an environmental (feeding level) variable, then the higher (normal) generally accepted genetic correlations between yield traits are partly illusory, due to feeding bias.

This field seems ripe for further analyses of field data, perhaps in conjunction with specifically planned experiments.

In Canada, cow breeding value estimates based on herdmate deviations were excellent indicators of future production (b = 0.98 ± 0.15) when cows were transferred from low to high producing herds, but markedly less so (b = 0.44 ± 0.17) when the transfer was from a high herd to a low one (Burnside *et al*, 1976). Preferential feeding and so on is intuitively more likely to be prevalent in high-producing herds.

DISTRICT AND HERD EFFECTS

As Australia has a very wide range of dairying environments, compared to most other countries, there may well be a case for data analysis on a within-district basis, or inclusion of district effects in the statistical model. Rathie (1979), in this Conference, shows major district effects in Queensland milk and fat yield data, and a statistically significant sire x district interaction for fat yield in Jerseys. Correction for district effects is complicated by factors such as the occasional occurrence of several microclimates within a small geographical area, and by variation in soil types and in irrigation and supplementary feeding practices within districts. In theory, knowledge of, for example, irrigation practices on farms would allow further correction for management practices. Such multiple corrections might be avoided if feeding, management and climatic effects were additively manifested in overall herd production level, and one could just correct for herd level (by, for example, using average herd production as a covariate when analysing for milk yield traits). Another decision in such an approach would be which herd average to use, as milk yield, for instance, is known to be more sensitive to most environmental influences than is fat yield.

MODELS WITH AND WITHOUT INTERACTIONS

Statistical models for analysis of dairy records quite often assume zero interactions between main effects of the model. This is clearly invalid if interactions are present and of a non-negligible magnitude. Contemporary comparison (CC) methods assume that effects (e.g. seasons, districts, years) other than genetic ones do not exist within the CC grouping. If daughter numbers are large enough to allow analysis within effects (e.g. within-season), unbiased results should be obtained. If not, bias is likely to ensue, and a method of analysis (e.g. BLUP, least-squares) should be followed that takes account of the several major causes of variation, and possible interactions between them. Queensland data (Rathie, 1979) gives evidence for sire x district and sire x season interactions for milk yield traits. It would be interesting to examine data from, for example, the presumably more uniform Victorian environment. The current Victorian RBV (modified CC) sire assessments are calculated within the two six monthly seasons.

In Canadian Holstein data (Tong *et al*, 1977), sire x herd interaction accounted for 4.1, 1.1, 0.3, 2.6 and 5.6% of the total variation for milk, fat and protein yield and fat and protein percentage, respectively.

METHODS OF DATA ADJUSTMENT FOR FIXED EFFECTS

This subject is covered briefly by Rayner and McCormack (1979) in this Conference.

TRAITS CORRELATED WITH MILK YIELD

There are always farmer voices, from liquid milk areas, asking why all selection is not on milk yield alone. The trend to unsupervised milk recording will doubtless accentuate pressure for milk-only recording. I am a believer in selection for protein, on both technical and social grounds, but that argument falls more in the realm of definition.

Assuming one is only interested in milk volume, and not in its composition, there are still genetic gains (in milk yield) in recording milk yield plus composition, due to the high genetic correlations among yield components (milk, fat, protein, SNF). The correlated traits can be used to increase the accuracy of selection for milk yield. For instance, Schmidt and Van Vleck (1974) tabulate estimated selection responses equivalent to a 1000 lb response in milk yield using records for milk yield only. The estimates are based on their "best bet" estimates of variances and genetic correlations. Response in milk yield using records for milk and protein yields (but with all selection emphasis on milk yield) was 1250 lb (their table 15.10); the response using records for milk yield and fat percentage (with similar provisos) was 1224 lb (their table 15.8).

In practice, the most cost-effective system for herd improvement may well be a monthly (probably alternate a.m.-p.m.) milk yield test, supplemented by composition tests on some of those test days. This raises the question of of which would be the most effective time(s) to sample composition. Some of the composition work already done, mostly in conjunction with analyses of alternative monthly sampling methods, may cover this point, but some cost-benefit studies would still be required.

CHECK-TESTING

This subject is covered by Rayner and McCormack (1979) in this Conference. The biases that can be detected by such methods are relatively unimportant, in the herd improvement context where evaluation is based on many records over many (mostly commercial) herds, compared to the non-detectable biases due to preferential feeding and management.

USE OF LATER LACTATIONS

Wickham and Henderson (1977) found a genetic correlation of significantly less than unity between the first and second lactations, for milk yield in Holsteins. This implies "that the use of age factors to remove lactation effects is open to question since a fixed effect alone cannot explain the difference in yield". That is, ideally one should compare sires within lactations. To combine the resulting evaluations when selecting sires, an index utilizing the relative economic values of each lactation could be constructed.

Recent studies (Wickham and Henderson, 1977; Nicholson *et al*, 1978) of North American Holsteins have shown little selection bias between the first and later lactations. Thus later records could be validly used in sire evaluation. Whether Australian data is also subject to little selection bias is likely but not proven, and the situation may vary between populations and/or areas.

CONCLUSION

Taking the aim of production measurement to be the attempt to get accurate and unbiased estimates, at a reasonable cost, of animal's true breeding values, the industry is making progress with accuracy due to greater automation of procedures. This trend seems certain to continue, due to pressure of labour costs.

Problems of bias remain, and may only be overcome by more stringent control of the genetic design of breeding programs, which is another topic. The major challenge is to develop herd recording and bull proving schemes which are seen to directly benefit individual producers, thus inducing widespread membership of such schemes, so as to enable the operation of effective selection programs. Genetics is largely a numbers game.

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