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SOME ASPECTS OF CURRENT EFFORTS TO IMPROVE DAIRY CATTLE GENETICALLY WITH SPECIAL REFERENCE TO SOUTH AFRICA

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During the past two decades the dairy industries of most western countries have been characterised by radical changes, including greater dependence on fully integrated national dairy improvement programmes. The underlying techniques involved in these programmes based on, designed and developed according to the broad principles of Population Genetics, have acquired a high level of sophistication with the current access to and increased used of electronic computors.

For their success these improvement schemes require and rely very heavily on efficient milk recording services and well developed artificial insemination (A.I.) organisations with adequate facilities for effective young sire testing programmes. In order to ensure maximum genetic improvement these requirements should be brought to the highest pitch of efficiency and full use made of the important advantage of A.I. which lies in the fact that it can provide access to a common pool of highly selected and tested sires.

These developments, in clear and distinctive contrast to the pre-A.I. era with its single herd (and often single sire) efforts and traditional hierarchical breed set-up in which chance rather than planned breeding has often been responsible for favourable results, have led to a dramatic departure from the formal and classic approach to animal selection and breeding which, until recently, dominated and characterised the views and dictums of the stud industry.

There is no doubt that the requirements and preferences of the commercial producer have been forcibly put across to the stud breeder through the A.I. industry. The breeder has been forced to revise and adjust his efforts in order to meet the objectives of modern breeding programmes where genetic improvement is aimed at raising the average population level rather than the individual herd or animal. Unless he conforms to the new demands he will inevitably be replaced by larger and more effective organisations with better facilities for the successful improvement of the national dairy herd.

Current status of national dairy cattle improvement schemes

At the recently held 1st World Congress on Genetics Applied to Livestock Production (Madrid, 7–11 Oct. 1974), the current status of applied breeding programmes and possible rates of genetic improvement were discussed by leading authorities during the course of several sessions. The formal papers presented at the Congress have already been published and the proceedings of the congress will shortly be available. No attempt will, therefore, be made here to review this aspect. Suffice it to say, that the papers and discussions of Plenary session VIa and Round Table session B have a direct bearing on the position regarding dairy cattle. However, the following general comments are germane to the objects of this paper –

1. The primary objective of any dairy cattle improvement scheme is to provide a means of ensuring effective identification, evaluation and utilization of superior germ plasm.
2. Developments which led to the present state of dairy cattle improvement schemes are briefly the following (*vide* Skjervold, 1974):
   (a) The original theoretical contributions (e.g. Rendel and Robertson, 1950; Robertson, 1954) providing the basis for techniques required to estimate the respective optimum genetic gains with alternative breeding schemes.
   (b) The construction of suitable models and analyses of the assumptions required for optimum breed structures and different population situations (Specht & McGilliard, 1965; Van Vleck & Henderson, 1961; Skjervold, 1963 & 1966; Skjervold & Langholtz, 1964; Smith, 1969).
   (c) The inclusion of costing techniques in model calculation studies with the object of arriving at the most economical improvement scheme for a given population (Soller *et al.*, 1966; Lindhé, 1968; Hinks 1971; Hill, 1971 & 1974).
3. Breeding plans built into national schemes receive their genetic slant from the requirements set by the industry.
4. Within a closed population i.e. in the absence of any significant bull or semen importation, the rate of genetic improvement is related to the effective size of the breeding population.

The percentage of stud cows in milk recording and A.I. is, therefore, of cardinal importance in any effort to effect maximum rates of improvement.

This point is effectively demonstrated by the following figures calculated by Skjervold (1966) for optimum breeding structure situations with A.I. breeding:

	Size of milk recorded population (cows)		
	2 000	20 000	400 000
Annual Improvement (%)	1,7	2,5	3,4
Relative contributions (%) of –			
Sires ——→ sons	43	50	62
Dams ——→ sons	33	23	18
Sires ——→ daughters	18	21	15
Dams ——→ daughters	6	6	5

It is possible with the aid of current knowledge to construct optimum improvement programmes for practically any situation in practice. Such schemes are in fact underway and even well established (Skjervold, 1974) and their full impact will soon become evident.

Problems of national dairy cattle improvement schemes

Apart from the obviously practical and overriding (dominating) problems arising from limited milk recording and A.I. there are also technical problems preventing optimum genetic progress through organised improvement schemes. Several of these are often overlooked and, therefore, not accounted for in practice. A few are referred to here in order to indicate their nature and possible implications.

Any meaningful effort directed towards the genetic evaluation or improvement of a population depends on information concerning the vital statistics of the population, which determine selection intensity, generation interval and the functional relationships i.e. the genetic and phenotypic parameters which characterise the population. Information concerning the latter i.e. estimates of these parameters are obtained with the aid of standard and accepted statistical techniques which enable the separation of the observed variance into genetic and covariance components. Since these parameters are primarily functions of variance and covariance ratios their values are subject to changes which arise from time to time as a result of the operation of various factors such as selection, management, nutrition, etc. In the absence of suitable data on a population it is often necessary to operate on assumptions and extrapolations derived from other sources.

The important point is that amongst these parameters heritability estimates are of primary importance since they are prerequisites for the construction of effective improvement programmes where they are used in the assessment of breeding values. The known variation in heritability estimates for individual production traits can be ascribed to various causes (*vide* Maijala & Hanna, 1974). While the variation could be due to real genetic differences between populations it is more likely to be caused by non-genetic sources of variation, different statistical techniques or errors in measurement. In the case of milk yield heritability estimates increase with rising levels of production and decrease with increasing age or advanced (later) lactations (Johansson, 1962; Barker & Robertson 1966). The latter is one of the reasons why first lactations are commonly used in the assessment of breeding value and production potential.

An effective young sire progeny testing programme is not only an integral part of any modern national dairy cattle improvement scheme but has in fact become the heart of the matter. Studies on the methodology of progeny testing as well as experience in several countries have led to the wide acceptance of the contemporary comparison (CC) method as the soundest technique for the evaluation of dairy sires through progeny testing. This method is particularly well suited for use in A.I. populations and is based on the following general requirements and assumptions for an unbiased calculation of the genetic differences between sires (*vide* Everett, 1974):

(a) all production records must be suitably adjusted for age, lactation length and times milked per day;
(b) all records used must be unselected;
(c) all daughters of sires must be distributed at random among herds;
(d) sires to be tested must constitute a random sample of a single population;
(e) herd/year/seasons must be a random sample from a single population;
(f) there must be no genetic trend;
(f) all contemporaries (or mates) within a herd must be a random sample of all possible contemporaries (mates) in the herd; and
(h) differential environment within the herd must be random in respect of sires.

Problems arise where these requirements are not met or where the assumptions are invalid. There is evidence that this situation is fairly common and is often the cause of serious errors in the assessment of breeding values (Johansson, 1962; Shannon, 1974; Everett, 1974; Dickinson, 1974). Research has revealed that daughters of A.I. sires are not always randomly spread among herds (Hofmeyr, 1955; Johansson & Rendel, 1968; Miller *et al.*, 1968 – *vide* Everett 1974). The widespread use of A.I. has led to the development of two different populations in most countries – one bred by A.I. and the other by natural mating, thus invalidating the basic assumption of the CC-method that contemporaries are drawn from one genetically homogeneous population. The presence of genetic trends has been demonstrated in both population groups. In the case of the U.S.A. a genetic trend amounting to 50 kg milk per year was estimated for the A.I. population and 15 kg per year for the natural-mating population (Everett, 1974). These estimates also reflect the effect of A.I. on the rate of genetic improvement in the two populations. Furthermore, they also imply that where estimates of breeding value are based on the assumption that all sires are derived from the same population and are, therefore, assumed to constitute a random sample of a single population, the A.I. sires will be undervalued and the other sires overvalued.

Research has been conducted on methods that will eliminate the above assumptions and provide a means by which a more accurate assessment of genetic merit of all dairy sires will be possible. Two methods have been suggested in the U.S.A. (Dickinson, 1974). The first is referred to as the USDA-DHIA Modified Contemporary Comparison. The most important modification consists of an adjustment of each daughter-herd mate deviation for the genetic merit of the herdmate's sire. The modified contemporary deviations are iterated thereby ensuring that the genetic evaluations become more accurate with repeated summaries. (All available lactation records are used for both daughters and herd mates.) The iterated modified contemporary deviations are regressed to the genetic group to which the sire belongs rather than to the overall breed average. (The genetic grouping procedure is based on a pedigree estimate of transmitting ability for each bull, calculated from his sire's and maternal grandsire's Predicted Differences.) According to Dickinson the adjustment for the genetic level of the herd mates' sires, accomplished by repeated solutions, should eliminate the bias due to genetic trend as well as genetic merit of herd mates.

The method used in Israel shows some resemblance as it provides for half of the genetic value of each sire to be expressed as a cumulative difference (CD) from a foundation population. The contemporary comparison is calculated and the genetic value of each contemporary is estimated by the CD of her sire. The CD of a sire is, accordingly, his CC plus the weighted mean CD of the sires of his daughters' contemporaries (Bar-Anan, 1974).

Other attempts have been made to solve the problem associated with the genetic level of contemporaries. Lentz *et al.* (1968) e.g. proposed a least – squares analysis for contemporary sires within age groups and A.I. (testing) regions which include sires with overlapping progeny groups as connecting links.

A practical solution might be to restrict contemporary comparisons to contemporary young bulls on test in the same herds and by ensuring proper randomisation of semen and adequate numbers of effective contemporaries in such test herds.

The second method was developed co-operatively by the U.S.D.A. and the Cornell group (C.R Henderson and co-workers) and is the Linear Model Method which uses very complex statistical and computing procedures to solve large matrices. This model can accommodate both A.I. and natural services (NS) bulls and also accounts for intraherd correlation among a bull's daughters an important point to consider with NS bulls.

Since systematic improvement in the long term is the ultimate objective of organised improvement schemes it is imperative that all factors affecting the rate of genetic improvement should be considered. It has already become difficult to reduce the number of traits even in a programme where the emphasis is based solely on economically efficient production. It is usually necessary to include apart from the qualitative and quantitative aspects of milk also milkability, ease of calving and body size where the latter assumes additional economic importance.

A critical analysis of many dairy cattle improvement schemes shows a lack of clear definition of breeding objectives. This gives rise to confusion at different levels and within different sectors of the industry and subsequently applied breeding programmes do not show the positive rate of progress that one might expect. The problem is not an easy one to solve particularly in view of the growing importance of the qualitative characteristics of milk and possible future changes in the market requirements and final use of milk. (It might soon even become necessary to pay attention to specific protein components – Barker, 1968). While the ideal objective would seem to be to aim at a maximum yield of protein with minimum milk volume in order to reduce processing problems and costs to the manufacturing market it is doubtful whether this would entirely satisfy the liquid-milk market.

The question is often asked whether testing for protein is necessary in dairy cattle improvement programmes in view of the high genetic correlation between fat and protein in milk. According to Syrstad (1971) the inclusion of measures of both components could result in increasing the rate of progress by approximately 25 per cent – an entirely feasible and practical procedure particularly now that simultaneous testing for fat and protein can be done at relatively low cost.

An important aspect which should be mentioned here is the accuracy of measurements. Milk recording is the accepted method by which production characteristics are measured. There are indications that current methods might have to be changed in future to cope with expansion, labour problems and other requirements. Alternative systems to the usual monthly sampling technique of milk recording have been investigated very comprehensively in many countries (e.g. Cunningham & Vial, 1968; Everett *et al.*, 1968; Munro & Bailey, 1974; Madsen & Christensen, 1974). While the accuracy of most methods falls within acceptable limits of accuracy the cost and convenience differ widely. Local (unpublished) and overseas experience (Roos, 1972) suggests that the merits of owner sampling justify its general application particularly under South African conditions. In Australia (Hammond, 1974) where similar conditions exist there is also support for the method.

Dairy cattle improvement in South Africa

Organised efforts to improve dairy production were started in 1917 when the Friesland Cattle Breeders' Association initiated milk recording in South Africa. The original scheme was taken over by the State in 1923 and re-organised in 1956 on a co-operative basis. The proportion of dairy cattle in South Africa which is included in the official milk recording scheme has always been low. During the year 1st September 1973 to 31st August 1974, 59 988 cows were recorded. During August 1974, according to the estimates of the Department of Agricultural Economics and Marketing, there were 1 093 753 cows, over two years of age, kept mainly for milking purposes on South African farms. The percentage in milk recording thus barely exceeds 5% – a depressingly low figure.

From a genetic improvement point of view the effective breeding population is limited to those cattle from which future breeding animals can be selected. In respect of future sires, therefore, this effective breeding population is confined to registered cattle in milk recorded herds. It is estimated that only 38,8% of the registered Friesland and only 37,5% of the registered Jersey cows in South Africa were milk recorded in 1974. The prospects for improvement in the field of milk recording are good, however. Participation in terms of cows entered for test has increased every year for the last three years. The recent introduction of the techniques of owner sampling and central testing together with the initiation of an annual financial contribution towards the costs of milk recording from the Dairy Industry in 1975 should do much to overcome many of the problems of which the major one is the persistent lack of suitable personnel, which has hindered the development of efficient milk recording services in the past.

Artificial insemination of cattle in the dairy industry in South Africa is still very limited. It is estimated that 164 800 dairy cows were inseminated artificially during 1974. This represents 15% of the population of dairy cows older than two years. Only a very small fraction of the registered dairy cows are artificially inseminated and in most cases use is only made of this technique when semen is imported. During 1974 special permission was granted to the A.I. Co-ops. to import limited amounts of semen for contract mating.

There may be many factors militating against rapid expansion of A.I. among South African dairy herds. However, if semen from superior proven sires were readily available to the South African dairy farmer it is confidently believed that A.I. would increase rapidly.

Progeny testing programmes for the testing of dairy sires in South Africa are, by comparison with overseas developments in this field, in their infancy. In the past, unofficial bull analyses were undertaken by private breeders, breed societies and the Department of Animal Husbandry of the University of Pretoria. These analyses were based mainly on within-herd, daughter-dam comparisons. The first systematic effort bore fruit in 1955 when "official" bull analyses were published by the Division of Animal Husbandry and Dairying of the Department of Agriculture. The method used was based on a daughter-hypothetical herd average comparison and also included a daughter-breed average comparison. This method has since been replaced by the contemporary comparison technique and results of bull analyses are now published at regular intervals.

In the publications on official sire analyses covering first lactations of daughters completed over the period 1969 to 1973 analyses of 222 sires appear. A breakdown by breed shows the following –

Number of dairy bulls analysed 1969–73

	Bulls used in A.I.			Bulls used in natural service		
Reliability	80	60-80	40-60	80	60-80	40-60
Friesland	28	18	9	–	3	63
Jersey	3	7	12	–	1	49
Ayrshire	–	1	1	–	2	15
Guernsey	–	1	–	–	–	9
TOTAL	31	27	22	–	6	136

Despite the limitations of the techniques of analysis and their limited scope at this stage there can be no denying the fact that the publications have had considerable impact on the dairy industry in South Africa. Bulls which have been identified as breeders of superior progeny have become bywords among dairy farmers while others which had built up reputations on show performances and impressive pedigrees have fallen rapidly from grace on publication of their poor progeny tests.

A method for the progeny testing of A.I. dairy sires in South Africa was proposed by Hofmeyr (1958) in 1957 but efforts to introduce it failed mainly because of the lack of success in obtaining the co-operation of the dairy breed societies and A.I. co-operatives. Renewed attempts by the A.I. Board to initiate a progeny testing scheme for the A.I. Industry resulted in a Ministerial committee submitting a report and recommendations on the subject on the 10th October, 1970.* This report included full details on a proposed scheme for the progeny testing of young dairy breed sires. The delay in implementing these recommendations is to be regretted but recent developments relating to the financial requirements of the scheme augur well for its introduction in the very near future. It is noteworthy that a pilot testing scheme for young A.I. sires based on the original proposals submitted in 1957, was launched in 1968 in co-operation with the Transvaal A.I. Co-op. (now Insemina) and a few State herds. Full credit must also be given to the Transvaal and Natal A.I. Co-operative Societies which while declaring their intention to co-operate in every way with the National Progeny Testing Scheme when it eventuates, embarked in the interim on young sire testing programmes based in principle on the scheme suggested by the Committee. These two co-operatives have between them 60 young bulls on test at the present time and the progeny results from the first of these will become available in the current year.

Conclusions

The comparatively restricted size of the effective breeding population within the national herd constitutes a serious obstacle limiting efforts to generate and achieve effective genetic improvement in dairy cattle in South Africa. Technically, this situation can be improved only and simply by increasing milk recording, expanding A.I. services, introducing a young sire progeny testing programme and ensuring the efficient use of proven sires.

It must be accepted that natural mating of dairy cattle will continue for quite some time in this country. Methods can, however, also be applied to increase the efficiency of breeding and selection in this population. Limitations in the current techniques of sire evaluation in single herds cannot all be overcome but methods to reduce errors involved are at present being considered by the Animal and Dairy Science Research Institute (Irene).

One of the inherent problems of the local dairy cattle improvement scheme lies in the fact that attention and efforts in this connection are focussed on the long term prospects while many animal breeders are more concerned with the short term gains. Short term gains are not only small and unimpressive but also require

*Report of the Committee of Investigation regarding the use of Proven Bulls and Financial Assistance to Artificial Insemination Services (as amended).

complicated calculating techniques. This is particularly so in dairy cattle populations where generations overlap and where current selection practices do not immediately improve all animals in the population by the same amount. (Methods to enable the computation of these short term responses have been proposed by Searle 1961, Hinks 1971 and Hill 1974).

The tendency in the past to divorce the development of the dairy cattle industry from that of other livestock industries has unfortunately resulted in it being permitted to develop its present fragmented set-up where the efficiency of its organisation, technical services and its biological and economic efficiency are being questioned and investigated. From a national dairy cattle improvement point of view the present situation has become intolerable. Greater consolidation of efforts, resources and incentives are required to promote and encourage an effective scheme for dairy cattle improvement. Closer integration and co-operation of the breed societies through the South African Stud Book and Livestock Improvement Association,* A.I. Co-operatives and the State could contribute immensely to an increase of the overall effectiveness of their individual efforts to put the industry on a technically sounder basis. It is also of vital importance that the necessary encouragement and incentive to revitalise the industry be provided e.g. through quality payment of milk, etc.

On the strength of the new schemes launched or presently in the process of being launched there is every reason to believe that the serious short-comings of the local dairy industry in failing to generate and promote genetic improvement will soon be matters of the past.

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*New name of the South African Stud Book Association envisaged by the Draft Livestock Improvement Act, 1976.

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