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RESEARCH ON CURRENT SIRE PROVING PROCEDURES

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SUMMARY

The structure of the present artificial breeding (A.B.) organization in New Zealand is described, and on the basis of a simulation study is shown to be near optimum in terms of genetic gain. The results of a study investigating the efficiency of young sire selection on pedigree are presented. It is concluded that young sire selection should be based on sampling bulls from the youngest available A.B. dams. Differences in genetic merit between groups of herds are investigated. It is concluded that short-term additional genetic gains would result from sampling young bulls from herds which had been using A.B. heavily for several years. The evaluation of natural proofs is discussed, as well as the significance of natural mating sires to a large A.B. organization.

THE BASIC STRUCTURE of the artificial breeding organization and the sire proving scheme has been described by Searle (1962). Since that time advances in semen dilution (Shannon, 1968) have led to wider annual use of proven bulls. Genetic implications of this increased coverage have been discussed by Stichbury (1968). With growth of artificial breeding to just over 1 million cows at present, the essential nature of the organization can be described as in Fig. 1.

The "engine" of the system consists of the 50 proven bulls which are used to upgrade the genetic merit of the cow population by mating them to the 950,000 cows in standard service herds throughout the country. The "fuel" necessary to keep the engine performing efficiently is the 170-odd young bulls which are progeny tested each year in sire proving herds. These young bulls are selected on ancestry, usually have an A.B. proven bull as their sire, and an H.C. or V.H.C. pedigree cow with 2 to 5 records as the dam.

Although only 25% of A.B. users also herd test, all sire proving herds do (under financial inducement), with the result that, for every 100 inseminations by young bulls, approximately 17 tested daughters are reared. Consequently, 300 inseminations per young bull are sufficient to ensure approximately 50 tested daughters reared for progeny test purposes.

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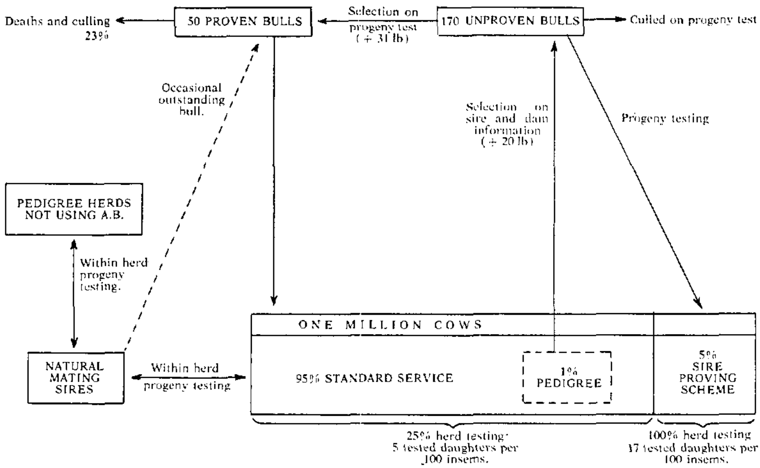

FIG. 1: *Present sire proving organization.*

Following a simulation study of the expected genetic gains to be made from such a breeding programme, Searle (*loc cit.*) (1962) concluded that it was desirable to obtain the greatest possible use of proven bulls, progeny test as many young bulls each year as is practicable, and utilize proven bulls on 90% of the cow population. Since that study, the A.B. population has increased from 0.7 to 1.0 million cows, and coverage per proven bull has increased from 4,000 to 30,000 inseminations per year.

A new simulation has been carried out under the present conditions, in which 20 plans involving sampling 50 to 200 young sires each year and mating proven bulls between 70% and 98% of the population are compared on the criteria of effective gain in genetic merit over the whole scheme. The results of the simulation indicate that mating proven bulls to 95% of the population and sampling 150 to 200 young bulls per year, as is done at present, gives a near optimum plan in terms of genetic gain under static conditions. The estimated mean additive genetic superiority of all A.B. daughters over the daughters of unproven bulls used in A.B. is 31 lb of fat for this plan. As the unproven bull's daughters averaged + 20 lb in 1966-7 as a result of selection on pedigree, it is apparent that a proven bull team averaging approximately + 50 lb in genetic merit can be expected. The present average rating of the proven bull team (weighted by usage) is + 46 lb and is thus approaching this figure.

Having established a desirable structure for proven bull usage and young sire sampling, attention is focused on the efficiency of pedigree selection in obtaining high genetic merit young bulls for progeny testing. This is the subject of the next two studies to be described.

SELECTION OF YOUNG SIRES

Selection of young sires for progeny testing is based on classical selection index procedures (Henderson, 1963) utilizing sire and dam information, and in some cases that of grandparents and maternal half-sisters. In recent years, the majority of the male parents of these young bulls have been A.B. proven sires. As the long-term success of the improvement programme depends on the superiority of the young sires sampled, it is appropriate to investigate the extent to which the accuracy of selection of young sires approaches that which is theoretically possible according to selection index criteria. The present study was initiated to compare the effectiveness of sire and dam information, with that which might be expected on theoretical grounds.

The data consisted of the ratings for fat production of 223 young sires of the Jersey breed, sampled between 1961 and 1963, together with the ratings of their respective sires and dams. Only those young sires whose male parent had an A.B. proof were included in the sample.

Utilizing values of heritability of fat yield equal to 0.25 and repeatability equal to 0.50, the expected value of a son's rating on m daughters, given his sire's rating on n daughters is:

$$\text{Expected son's rating} = \tfrac{1}{2} \left(\frac{m}{m + 15}\right) \left(\frac{n}{n + 15}\right) \bar{y}_s$$

Where $\bar{y}_s$ is the average herdmate deviation of the sire's daughters. The expected value of son's rating on m daughters given his dam's rating on p records is

$$\text{Expected son's rating} = \tfrac{1}{8} \left(\frac{m}{m + 15}\right) \left(\frac{p}{p + 1}\right) \bar{y}_d$$

Where $\bar{y}_d$ is the average herdmate deviation for the dam's records.

The results of regressing the observed son's rating on that expected from (a) sire information and (b) dam information as given above are shown in Table 1.

TABLE 1: THEORETICAL AND OBSERVED REGRESSION COEFFICIENTS FOR THE REGRESSION OF ACTUAL SON'S RATING ON EXPECTED SON'S RATING

	Expected Regression	*Observed Regression*	*S.E.*	*t*
Expected son's rating based on:				
Sire information	1.0	0.96	0.20	4.7
Dam information	1.0	0.50	0.46	1.1

Considering sire information first, it can be seen that the regression of observed on expected son's rating is estimated as 0.96 giving an efficiency of 96%. This result would indicate that the prediction of a young bull's future rating on the basis of his sire's A.B. rating proceeds on average in accordance with genetic theory. The observed heritability of the rating is 0.96 $m/(m + 15)$, which with 50 daughters per young sire gives 0.74 as compared with the theoretical heritability of 0.77.

In contrast to the sire information, the results in Table 1 show that the dam ratings give little indication of approaching their expected usefulness in predicting young sire ratings. A further regression was carried out of son's average contemporary comparison on dam's average contemporary comparison, which gave a regression coefficient of 0.015 ± 0.046, indicating (with 4 to 5 records per dam as in this sample) a heritability for fat yield of about 0.04. Taken as a group, there is evidence that the dams were above average for the population. Using only sire information, the expected average rating of the sons as a group was + 8.4. The observed average was + 11.3, suggesting a small contribution of + 2.9 from the dams. The apparent low utility of the dam information in this study, in contrast with that elsewhere (O'Connor, 1968), points to the need for further investigation. Since dams of selected young sires must be pedigree cows classified H.C. or V.H.C., some rearing and other managemental influences may exist which cannot be allowed for in the usual contemporary comparison method.

GENETIC DIFFERENCES BETWEEN HERDS

It is generally agreed that, under artificial breeding, genetic differences between herds will tend to disappear. While this will be true among a group of herds making heavy and continuous use of A.B., it may not be true of differences between groups of herds which differ in their reliance on A.B. over a period of time. Thus if an A.B. scheme is associated with an effective selection policy, those herds which have made use of the scheme for many years can be expected to show some genetic superiority over those herds using A.B. infrequently; and even greater superiority over those herds not using A.B. at all. The purpose of this study is to see if such genetic differences can be identified, and consequently evaluate the advantages which might be obtained by carrying out young sire selection from a genetically superior group of herds.

The procedure used here is the "marker bull" approach. Ideally this procedure depends on having one bull sire a large number of daughters in each of the two groups of herds to be compared. His rating based on the herdmate comparison is then obtained for each group separately. As the bull's genetic merit is constant, a *lower* rating on one group indicates that the herdmates are genetically *superior* to the herdmates in the other group. The difference between the ratings estimates the amount of this superiority.

Three groups of herds were used in the study:

Group I. — 69 herds which were known to have been using A.B. continuously for at least ten years, and which were thought to be a genetically superior group on the basis of the number and ratings of A.B. sires used in those herds. This group was called the High Group.

Group II. — 95 grade herds known to have only one or two crops of A.B. daughters. This group was called the Low Group.

Group III. — 70 herds known to have at least 50% of pedigree cows in each herd. This group was called the Pedigree Group.

As no one bull used in A.B. had a large number of daughters in each of any two groups, the ideal approach was modified by seeking bulls with at least five daughters in each of the groups to be compared. In this way the difference in ratings for the two sets of daughters of a single bull was replaced by the weighted within-sire difference for a large number of bulls.

The data consisted of age corrected fat yield records for the 1967-8 season. The herdmate averages were estimated from *all* of a daughter's herdmates excluding paternal half-sibs, and were adjusted for the number of such herdmates.

No adjustment was made for the between herd heritability of 0.20, since this would assist in eliminating the genetic differences that were to be identified. Only Jersey bulls were used.

In the first analysis the High Group was compared with the Low Group. The results are shown in Table 2.

TABLE 2: COMPARISON OF DATA FROM HIGH AND LOW GROUP HERDS

High Group, 69 herds; Low Group, 95 herds
No. of sires with at least five daughters in each group = 57
Average no. daughters per sire HG = 26, LG = 17

	Average Rating based on all Herdmates	*Average Herd Production (lb butterfat)*
High Group	+ 5	352
Low Group	+ 22	320
Difference	— 17	32
Actual high group production (lb)		352
Estimated high group superiority (lb)		34
Expected low group production (lb)		318
Actual low group production (lb)		320
Environmental advantages of low group (lb)		+2

The weighted average within-sire difference in rating was 17 lb of fat in favour of those daughters in the Low Group, indicating that the dams in the High Group were genetically superior by 34 lb to those in the Low Group. The accompanying budget in Table 2 indicates that there was little evidence of environmental differences between the two groups of herds.

The second analysis compared the High Group with the Pedigree Group, and the results are shown in Table 3.

Dams in the High Group are estimated as being genetically superior by 26 lb to those in this particular sample of pedigree herds. The higher actual production of the Pedigree Group is accounted for by a 36 lb environmental advantage of this group.

It can be concluded that herds using high rating A.B. sires heavily over a number of years are genetically superior to some other groups of grade and pedigree herds.

TABLE 3: COMPARISON OF DATA FROM HIGH AND PEDIGREE GROUP HERDS

High Group, 69 herds; Pedigree Group, 70 herds
No. of sires with at least 5 daughters in each group = 71
Average no. daughters per sire: HG = 28, PG = 13

	Average Rating based on all Herdmates	*Average Herd Production (lb butterfat)*
High Group	+ 3	356
Pedigree Group	+ 16	366
Difference	— 13	— 10
Actual high group production (lb)		356
Estimated high group superiority (lb)		26
Expected production of pedigree group (lb)		330
Actual production of pedigree group (lb)		366
Environmental advantage of pedigree group (lb)		+ 36

There would be distinct short-term genetic advantages in selecting young sires from such herds — that is, having increased the merit of the proven bull team by such a policy, future gains would proceed at the normal rate.

DISCUSSION

If the results presented here indicating a low utility of dam information adequately reflect the real situation, then some aspects of young sire selection will need reviewing. The average age of cows chosen as dams of young sires is approximately equal to one generation interval under A.B. sire selection. If the time spent in waiting for the necessary 4 to 5 records is largely wasted owing to the low value of the information received, then it may be better to select young bulls from first-calving A.B. sired heifers. In the present population where heifers are traditionally naturally-bred and the offspring not kept as replacements, such a procedure would involve some form of selected mating.

A possible procedure could be based on inseminating A.B. heifers (which could be selected on pedigree) with semen from high rating proven sires and making arrangements for bull calves to be kept. By inseminating more heifers than are required ("overmating" in the sheep industry sense), a preliminary culling could be made on the young bull calves at 1 year of age following the completion of the 2-year-old dam's lactation. The selected bull calves would then enter the sire proving scheme for progeny testing.

A preliminary step along these lines is being considered by the Herd Improvement Department in the present (1968-9) season. Based on insemination details from the 1968 spring mating season, it is hoped to give a genetic assessment of all calves born to A.B. For herds that are not testing, the future calf will be evaluated on the basis of his sire's rating. In tested herds, the dam's cumulative production will be used also, and where appropriate the A.B. maternal grandsire's rating. Thus, all farmers using A.B. will be in a position to practise genetic selection at the calf stage with the maximum available information, and the resulting estimates will also be available for young sire sampling.

The results pertaining to genetic differences between groups of herds should be interpreted cautiously. Herds using A.B. heavily for several years are, in the majority, grade herds. Furthermore, although there appear to be immediate gains associated with sampling from such herds, these gains must be considered as resulting from a "one-shot" process. This fact has been noted by Lush (1967) who points out that, having caught up once, it is not possible to catch up again.

With increasing emphasis on sire information, and dependence on the A.B. system to generate its own further gains, the possibility of undesirable inbreeding levels arising must be considered. It is in this context that the group of herd sires used in natural mating achieves some measure of importance. Although one can be sure that there are

TABLE 4: AVERAGE (WEIGHTED BY USE) RATINGS OF A.B. BULLS SELECTED ON NATURAL PROOF 1959-1963*

Year	*No. Bulls*	*Av. Natural Proof Rating*	*Av. Proof Rating*
1959	93	+ 30	+ 24
1960	96	+ 28	+ 22
1961	102	+ 28	+ 21
1962	94	+ 31	+ 25
1963	82	+ 31	+ 23

*Data from *N.Z. Dairy Board Annual Report 1966-67.*

better bulls in use outside the A.B. organization than inside it, in general it is not known which ones they are. Ratings obtained under natural mating conditions on bulls selected for use in A.B. are unreliable and also tend to overestimate the rating as obtained later in A.B. Data presented in Table 4 illustrate this point.

In an attempt to obtain a less biased natural proof in future, the factor weighting the sire's average herdmate deviation has been adjusted to allow for the distribution of daughters among herds. A similar adjustment is at present used by the United States Department of Agriculture in their sire summary procedure (Plowman, 1968). If the sire has n daughters, with n_i in the ith herd, the factor is ($h^2 = 0.25$):

$$w = \frac{n}{n + 15 + \sum_i (n_i^2 - n_i)k/n}$$

where k is the ratio of herd by sire interaction variance to that of between-sire variance. For herdmate deviation records, k has been estimated as 1.0 based on all lactations in the 1967-8 season. If there is 1 daughter per herd, which is the ideal case under A.B., w reduces to the conventional $n/(n + 15)$. However, if all the daughters are in one herd, w reduces to $n/(2n + 14)$ and the average herdmate deviation receives much less weight. Under this system the difference between A.B. and natural mating proofs is abolished. The reliablity of a rating can be highlighted by reference to w which is also the heritability of the rating. Ratings obtained under A.B. conditions will have w in excess of 0.77, while single-herd proofs will be in the range of 0.20 to 0.30, with a theoretical maximum of 0.50. Thus, provided a sire code is entered with a daughter's record, all natural and A.B. ratings are obtained at the same time, and without distinction. The ratings and reliabilities obtained are available both to the farmer, if required, and to the Dairy Board for information to supplement the proven bull team if at any stage it is felt desirable.

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