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GROUP BREEDING SCHEMES IN SHEEP IMPROVEMENT IN NEW ZEALAND

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SUMMARY

Group breeding schemes involve the screening of high-producing animals from contributing flocks into a central (nucleus) flock. The nucleus flock is used for further evaluation of the ewes and to supply rams to contributing (and often other) flocks. Most of the schemes which have developed since 1967 have the major objective of improving reproductive rate in Romney, Perendale and Coopworth sheep.

Maximum rates of genetic gain are achieved when 5 to 10% of the group population are in the nucleus and 40 to 50% of the female replacements are from contributing flocks. With this structure 10 to 15% faster genetic gains will result from an "open" nucleus scheme, compared with a closed flock, when a trait is measured in both sexes. For a trait measured only in ewes an "open nucleus" scheme gives a 15 to 25% faster genetic gain.

The success of group breeding schemes in New Zealand has been partly due to their concentration on simple criteria of productivity for screening ewes. The effect of limiting the inbreeding in the nucleus flock appears unimportant in most circumstances.

INTRODUCTION

In most breeds of livestock, a hierarchical or pyramid population structure has developed in order to spread genetic improvement through the breed. In its simplest form, this may consist of a two-tier structure — a nucleus supplying males for use in the commercial flocks of the breed. More often, however, an additional tier has developed, a group of multiplying flocks which use sires from the nucleus and, in turn, sell sires to the commercial flocks. Thus a typical pyramid structure is established. After several generations, the rate of genetic gain per year is the same in all three tiers, but the multiplying flocks lag about two generations behind the nucleus and the commercial flocks about two generations behind the multiplying flocks. Usually, the top two tiers (the nucleus and the multiplying flocks) consist of animals registered with a breed society. Most breed societies will only register the progeny of registered parents; consequently, the nucleus is closed. The gene flow is downwards from the nucleus

through the multiplier to the commercial flocks. Thus any genetic changes which may take place in the commercial flocks cannot be incorporated into the nucleus.

In recent years, a modification of this structure referred to as group breeding schemes has developed in New Zealand. The essential feature of these schemes is that the sire-breeding nucleus is not closed and gene flow can occur from the base of the pyramid up to the nucleus.

The first group breeding scheme, the New Zealand Romney Development Group, was established in 1967. This was followed by a further two private schemes and the scheme established by the Department of Lands and Survey at Waihora in 1968 (Hight *et al.*, 1975). By 1975, 25 sheep schemes involving 322 breeders (Parker, 1975) were operating. Of these, eight were Romney, seven Coopworth, six Perendale and one each of the Border Leicester, Corriedale, Poll Dorset and South Dorset Down breed. Several more groups have been formed in the last two years.

A common element in the working of these group breeding schemes is the identification of high-producing ewes from different flocks (screening). These ewes are brought together to form a central flock which in turn acts as the main source of sires for the contributing flocks. The 25 schemes covered by Parker (1975) are reported to be screening a total of 646 000 ewes and 65 000 of these were being recorded through the National Flock Recording Scheme.

TYPES OF GROUP BREEDING SCHEMES

A distinction between group breeding schemes can be made on the basis of the type of population which is being screened. Some groups are screening from commercial flocks only, others from registered flocks only, and still others from both registered and commercial flocks. The distinction between the first two needs to be made because the genetic consequences may be different. In screening from commercial sheep, advantage is taken of the opportunity to have high-producing sheep from the whole population contributing to ram production and to genetic change. The structure usually consists of one central flock, and its associated contributing flocks — *i.e.*, it is an open nucleus scheme with a two-tier structure which allows the genetic gain to be passed on to the commercial population with minimum time lag. Where screening is from registered sheep only, the central flock functions in very much the same way as does a nucleus flock in the typical pyramid structure found among registered

flocks. Thus, apart from the fact that there is no contribution from the commercial population, the structure involved is three-tiered. Consequently, the time lag to the commercial flock is doubled compared with the two-tiered system.

THE BASIS FOR SCREENING

In the schemes operating in the breeding-ewe breeds such as the Romney, Coopworth and Perendale, the trait upon which initial screening is mostly based is number of lambs reared by the ewe. The standard set for this trait varies from scheme to scheme. A common requirement is that the ewe should rear twins after an unassisted lambing as a two-tooth. In more intensively recorded groups, ewes are required to have lambed as hoggets and have produced twins in their two subsequent lambings. Further selection is done among the available sheep for freedom from structural faults, for fleece weight and quality, and for any other requirements laid down by the group members. In most schemes, the selection and management in the central flock are designed to discriminate against ewes which require assistance at lambing.

THE GENETIC CONSEQUENCES OF GROUP BREEDING SCHEMES

The various genetic consequences of the open-nucleus schemes have been discussed by Rae and Hight (1969), Hight and Rae (1970), Jackson and Turner (1972), Rae (1974), Clarke (1975) and James (1976).

RATE OF GENETIC GAIN

The essential effect of opening the nucleus is that individuals of high genetic merit in the base flocks will contribute to the genetic gains made in the nucleus. Thus, the genetic gain per generation in the nucleus when it reaches equilibrium will be related to:

- (1) The genetic superiority of the rams selected as sires for the nucleus.
- (2) The genetic superiority of the ewes born in the nucleus which enter the nucleus.
- (3) The genetic superiority of the ewes entering the nucleus which are born in the contributing flocks.

Although these screened ewes can be very highly selected, their expected genetic superiority over the average of the con-

tributing flocks has to be reduced by the genetic difference between the nucleus and the contributing flocks. The rate of genetic gain will depend on the proportion of the total ewe replacements which come from the contributing flocks.

The studies of Jackson and Turner (1972), Rae (1974) and James (1976) have shown that maximum rates of gain are achieved when 5 to 10% of the total population is in the nucleus, when 40 to 50% of the nucleus female replacements come from the contributing flocks, and when all nucleus-born ewes not needed for replacements in the nucleus are used in the contributing flocks. The rate of gain is not very sensitive to variations in these parameters. With a trait such as fleece weight measurable in both sexes, the open nucleus gave genetic gains which were 10 to 15% greater than would be obtained in a closed-nucleus system. Using a trait which can be measured only in the ewe (such as number of lambs born or weight of lamb weaned per ewe), the advantage of opening the nucleus appears to be greater, the increase in rate of gain over the closed nucleus being usually in the range of 15 to 25%. This occurs because the accuracy of selection of the ewes on their own records is substantially greater than that of selecting the rams on the records of their dams. Hight *et al.* (1975) presented evidence of genetic gain in the Department of Lands and Survey scheme at Waihora.

RATE OF INBREEDING

The screening of ewes into the nucleus reduces the average relationship between sires and dams in the nucleus below what would be expected in a closed nucleus of the same size. Thus the rate of inbreeding is lowered. James (1976) has shown that the variable with the greatest effect on reducing inbreeding is the proportion of nucleus replacement ewes which come from the contributing flocks. Most of the increase in the effective size of the nucleus is achieved by the time 50% of the replacement ewes are from the contributing flocks. At this stage the open nucleus would have about twice the effective size (and thus half the rate of inbreeding) of a closed nucleus of the same size. The size of the nucleus rather than the size of the scheme as a whole is the major determinant of rate of inbreeding. In most flocks inbreeding is not a major problem and the inbreeding effect will be only a minor consideration in planning the group breeding scheme. However, selection and mating methods can sometimes increase inbreeding greatly so that this effect could be of greater importance.

GENETIC VARIATION BETWEEN FLOCKS

The model used in the analyses reported above assumes that the base population is homogeneous rather than being subdivided into separate contributing flocks. If there is real genetic variation between flocks in the trait under selection, then screening from these different flocks to establish a nucleus will tend to increase the heritability of the trait in the nucleus. In the absence of information about between-flock genetic variation, the importance of this effect cannot be evaluated.

REASONS FOR THE SUCCESSFUL ESTABLISHMENT OF GROUP BREEDING SCHEMES

There are several elements in the New Zealand sheep industry which have contributed to the successful establishment of group breeding schemes. The first is that number of lambs reared is the most important trait economically in the improvement of the basic breeding-ewe breeds in New Zealand. It is a particularly convenient trait because it is relatively easy to set standards of performance (such as twinning as a two-tooth) which are simple to measure and need to be recorded over only a small proportion of the flock. Because the advantages in rate of genetic gain through opening the nucleus have to be balanced against the extra cost of recording in the contributing flocks, it is crucial that the cost of recording be kept to a minimum.

A second factor has been an interest among breeders and commercial growers in breeding for increased productivity. In fact, the members of group breeding schemes have been the most consistent group in the industry in emphasizing the importance of performance recording and selection on the basis of performance records and in seeking improvements in the recording services to meet their special needs. It is noteworthy that about a third of the total ewes on the National Flock Recording Scheme are from group schemes.

The availability of advice and assistance in the technicalities of setting up group breeding schemes has also been important in their development. This assistance has been supplied by research and university personnel, the Advisory Officers (Animal Husbandry) and Sheep and Beef Officers of the Ministry of Agriculture and Fisheries and, above all, by members of already established groups. The formation of the New Zealand Federation of Livestock Breeding Groups has also been of substantial value.

The reaction of breed societies to group breeding schemes has been mixed. The long-established breed societies have generally been antagonistic to the idea of opening the nucleus (more especially where commercial sheep are involved). In some of the more recently established societies, there has been a willingness to accept the group-breeding approach.

Finally, the financial success of many of the groups, in circumstances where traditional breeders have found it hard to compete, has been a potent factor.

SOME PROBLEMS OF GROUP BREEDING SCHEMES

The first problem is posed by the presence in some groups of substantial differences in the performance of sheep screened (at the same initial level of performance) from different flocks when they are brought together into the central flock. This may be caused simply by inaccurate recording of the performance of the ewes in some flocks, in which case the efficiency of the scheme is reduced. It may be the result of real genetic differences between flocks. In this case, the comparisons between sheep are unbiased and the between-flock genetic variation could contribute to increased selection response. It is also possible that the differences are the result of carry-over effects of the environment on the farm before entry to the central flock. If this is the case, comparisons between sheep in the central flock are biased.

A second source of contention is the level of environment adopted in the central flock. In most cases, the decision has been to run the flock at normal commercial stocking rates and under normal management consistent with the need to obtain the records required. This seems to be a sensible approach but many contributors have been dissatisfied with the phenotype of their sheep in the central flock.

A question which will need to be answered in the near future concerns increasing the standard of performance in lamb production required for acceptance into the central flock. As the level of lamb production improves in the contributing flocks, there is need for new standards of performance to be set for screening ewes out of these flocks. The standards used at present are simple and easily handled in the contributing flocks. More rigorous standards may be more time-consuming and expensive to record.

Some genetic problems still remain. The results of group-breeding schemes raise the question of whether the heritability of reproductive rate is greater at high levels of lamb production than at lower levels. To what extent do particular epistatic combina-

tions of genes contribute to genetic variation at high reproductive rates? Some schemes have drawn their contributors from a wide area covering different environmental conditions whereas others have concentrated on screening stock from a limited area. Is genotype-environment interaction likely to be of importance in this situation?

CONCLUSION

Space does not permit discussion of selection programmes within the central flock (Rae, 1974, 1976; Clarke, 1975), organization problems or the use of co-operative breeding ideas in the meat breeds of sheep. There is little doubt, however, that the group breeding schemes are well established in the basic breeding-ewe breeds such as the Romney, Perendale and Coopworth in New Zealand. It is anticipated that further expansion will occur. But it is not expected that group breeding schemes will take over the whole of the ram-breeding function for these breeds. Indeed, it seems likely that both group breeding schemes and the traditional stud-breeder will co-exist, the competition between the two approaches encouraging efficiency in each of them.

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