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TECHNICAL ASPECTS OF THE NATIONAL SHEEP RECORDING SCHEME (SHEEPLAN)

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SUMMARY

Following on from the first national flock recording service which was operated from 1968 to 1975, a modified and expanded service (Sheeplan) was introduced in 1976. The aim was a more flexible but fully integrated scheme which would allow members to decide and to vary their level of performance recording through a choice of character inputs and output listings. Like its predecessor, the records collected by the breeder are processed to assist the identification of genetically superior animals from within his flock.

The traits recorded are: number of lambs born (or reared) for each ewe, lamb weaning weights, hogget liveweights taken in the autumn, winter and/or spring, and hogget fleece weight. Breeding values are calculated using selection index techniques for each of these characters the breeder records and for various combinations of them. These are revised and presented annually for the selection of two-tooth replacement ewes and rams and for the culling of ewes already in the flock. Breeding values are also presented to summarize the performance of the progeny of each sire used in the flock.

Processing procedures are designed to simplify the task of accurate record collection and to permit a revision of economic, environmental and genetic parameters appropriate to each of several main categories of breeding enterprise. Output listings are designed to facilitate the effective use of breeding values in selection decisions. This is promoted by a team of servicing staff which is closely involved in the organization, operation and evaluation of the scheme.

INTRODUCTION

Performance recording generally implies the measurement of important traits using objective techniques. It can be carried out for a wide variety of reasons. As an aid to flock management it may involve financial analysis for the allocation of resources, or the assessment of personnel and of management techniques. For these purposes records of flock performance may be all that is required. Commonly sheep recording implies rather more than simple management records and national or regional schemes of most countries are primarily concerned with genetic improvement of stock (Owen, 1971).

The first national sheep scheme to operate in New Zealand was initiated in 1968 and was aimed at the genetic improvement of the national flock. Its technical background has been described by Clarke (1967, 1968), Owen (1971) and in summary form by Wallace (1974) and Rae (1976). It aimed at a within-flock genetic ranking of animals for an index combining lamb (weight of lamb weaned) and wool production (hogget fleece weight) in the case of dual-purpose breeds, and for lamb growth (weaning weight) in the case of meat breeds producing sires for crossbred lamb production.

The National Flock Recording Scheme (NFRS) operated for 8 years under the control of the Ministry of Agriculture and Fisheries. Few major changes were introduced over this period. Comment and criticism from breeders, the experience of field servicing provided by officers of the Advisory Services Division and of data processing by the Biometrics Division, along with further information from research, gave rise to a number of suggestions for its improvement. Broadly, these indicated that the NFRS was not sufficiently flexible to cope with the variety of needs of different breeds and breeders. Some regarded it as too simple, others as too complex. In addition, the demands of many breeders for a wider range of traits, especially liveweights at various ages, were to some extent supported by research findings. There was also a strong demand from breeders for sire summaries of progeny performance and for a number of features to suit the special circumstances of integrated, large-scale breeding enterprises.

The steps which were taken to initiate a re-examination of the scheme have been detailed by Wallace (1974) and Dalton and Callow (1975). For the present purpose it is sufficient to indicate that technical recommendations were made to establish and promote a modified and expanded recording service which was soundly based on past experience with NFRS and current local research knowledge, including that available from the NFRS data. As a consequence, many individual breeders, breeding organizations, and research, university and advisory personnel contributed to a revised national scheme called Sheeplan which was initiated in 1976 under the control of the Ministry of Agriculture and Fisheries (Dalton and Callow, 1976). Like its predecessor, this scheme had as its prime objective the genetic improvement of commercial sheep flocks.

Plans for genetic improvement on a national scale have several ingredients:

(1) The measurement or assessment of traits of economic importance on individual animals.

(2) The processing and presentation of the records in a way which will assist in identifying genetically superior animals.

(3) The effective dissemination of genetic merit throughout the commercial population.

The technical background relating to the second of these objectives is the subject of this paper. The approach adopted represents the collaborative efforts of all members of the Sheeplan Technical Group and is described in greater detail in the Sheeplan Advisers Manual, the first edition of which (Clarke and Rae, 1976) was distributed to field staff early this year. Only the broad principles will be covered here.

THE FLEXIBILITY AND INTEGRATION OF SHEEPLAN OPTIONS

An important feature of Sheeplan in comparison with NFRS is its flexibility in terms of the choice of recording options. The breeder is able to choose the characters he wishes to record and the output lists he requires. Both determine the processing details that are involved but not the broad processing approach which is basically the same regardless of the options taken. This common underlying feature permits breeders to adjust to their specific requirements and to progress from a simple to a more complex recording programme. The processing approach has also been designed to allow future additions and amendments to the scheme and the genetic parameters on which it is based, and to facilitate data analysis.

Sheeplan is based on four measures of productivity (Fig. 1): (1) Number of lambs born (NLB) or reared (NLR); (2) lamb weaning weight (WWT); (3) hogget liveweights taken in the autumn (ALW), winter (WLW) and/or spring (SLW); and (4) hogget fleeceweight (HFW).

In addition, quality number, or fibre diameter and fleece grade assessments, along with remarks on faults, condition or other aspects of the fleece or the animal, can be recorded and listed along with the other performance data.

Number of lambs born is the only character which is mandatory for all users. The other characters are optional with the exception of hogget fleece weight, which is not processed for

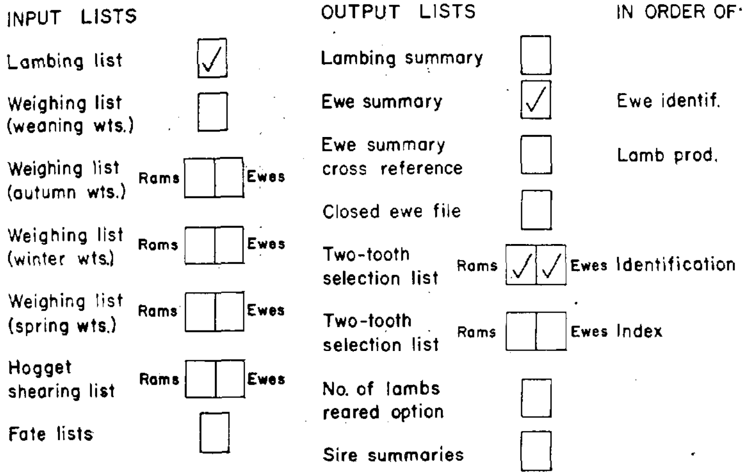

FIG. 1: *Input and output options as indicated on the enrolment form.*

those breeds which tend to be restricted to a role of producing sires for crossbred lamb production (meat breeds).

A further mandatory requirement of Sheeplan is that full records of parentage be kept. This is to permit NLB information on the dam to be used for genetic assesssment of the progeny, especially ram progeny. The keeping of records on the sire of each lamb is also encouraged to allow the processing and analysis of half-sister and sire-progeny information.

Because of the basic requirement to record NLB, the completion and processing of the lambing list is the prime unifying feature of all Sheeplan character options. The lambing list introduces progeny to the recording system and thereby facilitates the collection of subsequent hogget and ewe information using computer-prepared lists for recording purposes; it establishes pedigree information in the computer files and thereby allows pedigree relationships to be utilized to predict breeding values.

The use of computer-prepared lists of the animals, which are expected to be updated with further information, provides the breeder with a current inventory of his flock. This allows him to check the accuracy of performance, pedigree or disposal data recently entered, on the same list on which he is recording new information. It may often also assist validation of the new information and avoid unnecessary transcription of data. The use of lists in standard format also facilitates fast and accurate data input to the computer system.

From the point of view of genetic improvement from selection, the important common feature of most output listings is the calculation of breeding values for the characters recorded and for various combinations of them. Prime emphasis is given to the calculation of breeding values for the young ewes and rams which are candidates for entry into the flock. These are presented in the two-tooth selection lists which are prepared separately for ewes and rams. Breeding values for NLB are calculated for all sheep in or available for inclusion in the breeding flock and both selection lists and ewe summary lists are distributed to all Sheeplan users (Fig. 1). On the ewe summary list, estimated breeding values for NLB are revised annually with current information from the lambing list to give an up-to-date assessment of ewe performance for culling purposes.

If requested, breeding values are also processed to summarize the performance of the progeny of the individual rams (sire summaries) used in the flock each year. Breeding values for the traits recorded are processed and presented sequentially as the information becomes available.

Quickly returning processed data in the form of breeding values for all animals in a breeder's flock encourages the use of this information for selection and culling decisions.

ESTIMATION AND LISTING OF BREEDING VALUES

The Breeding Value Concept

Breeding values constitute the technical basis underlying the processing and presentation of records to assist in making effective selection decisions. Selection for genetic improvement is concerned with how well the offspring of an animal will (on average) perform in the flock. The breeding value allows a prediction of the likely performance of an individual's progeny for the character concerned.

The breeding value is a statistical abstraction which has been found useful in practice for the prediction of selection responses on a population or flock basis (Rae, 1958a). For this purpose, the statistical model involved separates the total phenotypic performance into a component due to breeding value and a residual component which may be thought of as the environmental effect on performance (see Fig. 2 for a model appropriate to HWF). The heritability of a trait is then defined as the fraction of the total variation attributable to variation in breeding values. It is an important genetic parameter for the prediction of breeding

$$HFW = BV(HFW) + EN(HFW)$$

$$\begin{tikzcd}
 & & BV(HFW) \arrow[dl] \arrow[dr] & \\
BV(HFW) \arrow[r] & HFW & UE(HFW) \arrow[l] \arrow[r] & HFW' \\
EN(HFW) \arrow[ur] & & RE(HFW) \arrow[ul] &
\end{tikzcd}$$

$$h^2 = \text{heritability} = \frac{\text{Variance } BV(HFW)}{\text{Variance } BV(HFW) + \text{Variance } EN(HFW)}$$

FIG. 2: *Breeding value concepts.*

value from measurements of performance (phenotype), for assessing the accuracy of these predictions and for predicting flock response to selection.

ADJUSTING RECORDS FOR NON-GENETIC EFFECTS

The environmental contribution to phenotypic variation is usually extremely complex but in some cases it includes effects such as birth-rearing rank, sex, and age of dam which can be identified. Allowing for these effects by adjusting the data for recognizable environmental influences (RE of Fig. 2) has the effect of reducing the total environmental variance (EN) to that resulting from the more complex unrecognizable sources (UE) and increasing the effective heritability of the character.

The advantage to be gained by adjusting for known environmental sources of variation depends on their magnitude and the accuracy with which they can be discounted. Sheeplan uses two methods of adjustment. Overall additive correction factors adjust for the effects of birth-rearing rank, age of lamb and mature age of dam on liveweights, these coming from analyses of large amounts of research data and data from NFRS and other commercial ram breeding flocks. Within-flock deviations from appropriate group means are used to eliminate the effects of sex and hogget lambing on progeny liveweights and for the effects of age and year on the lamb production of ewes. The latter method is equivalent to assessing additive correction factors from within each flock each year and is considered to be a better method than the use of standard correction factors for environmental effects which are typically more variable from flock to flock and year to year. Records adjusted by either method are designated by primes throughout the remainder of this paper — see Fig. 2 for the hogget fleece weight example (HFW′).

Direct and Indirect Prediction of Breeding Values

A second important technical aspect in the prediction of breeding values under Sheeplan is that all available relevant information is used to predict the breeding value of animals for each trait. This involves both direct and indirect pathways of genetic determination and is illustrated for the case of two characters, weaning weight (WWT) and hogget fleece weight (HFW), by the right side of Fig. 3. Using the direct path, breeding value for WWT (BV(WWT)) is estimated from adjusted weaning weight (WWT′). BV(WWT) can also be estimated from HFW′ using the indirect path. The accuracy of this method depends upon the strength of the genetic correlation between WWT′ and HFW′ and the heritability of HFW′ ($h^2_{HFW'}$). Even though indirect prediction will usually not be as accurate as the direct method, a combination of the two methods is often worth while. The combined method is equivalent to a multiple regression approach to breeding value prediction. It is applicable to predictions from different traits on the same animal and to predictions from the same trait on different but related animals (*e.g.*, the ewe and her dam).

Selection Index

In sheep, productivity is usually made up of more than one trait. Thus, for dual-purpose breeds, the improvement objective will generally comprise not only the number of lambs produced and their growth rate, but also the weight and merit of the fleece. It is convenient to define the objective as an aggregate economic measure of overall merit which depends upon the relative economic values established for each of the component traits (Morris and Clarke, 1977). This is illustrated, for the case of the previous example, by the left-hand side of Fig. 3.

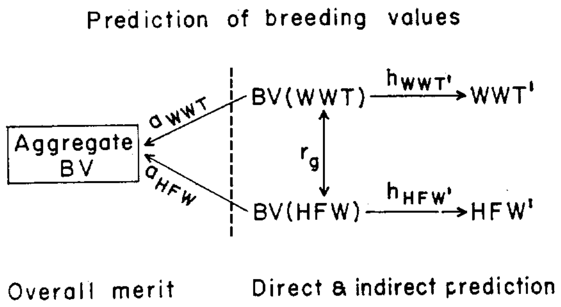

FIG. 3: *Prediction of breeding values.*

Once an aggregate breeding objective has been defined, it is possible to use the selection index method (Hazel, 1943) to balance the good features of an animal's performance against the bad.

The method used by Sheeplan for the prediction of breeding values for traits of the rising two-tooth ewes and rams of the dual-purpose breeds follows that given by Henderson (1963). This method is identical with, but more convenient than, the method of Hazel (1943) since it first uses methods of direct and indirect prediction to give breeding value estimates for each of the component traits and then combines these according to the economic values specified to estimate the breeding value for overall economic merit. This facilitates the processing of records using different sets of relative economic values for each breed or breed category and in the long term could permit the individual breeders to choose their own set of relative economic values for the traits they are recording.

Relative Economic Values

At the present stage of Sheeplan, economic values have been estimated for six of the numerically more important dual-purpose breeds. Other dual-purpose breeds are at the present stage included in one of these categories. Values in current use for the Romney are shown in Table 1. They are based mainly on gross

TABLE 1: PARAMETERS USED TO ESTIMATE DUAL-PURPOSE BREEDING VALUES

Trait	*REV (cents)*	*Standard Deviation*	*Heritability*	*Correlations*[a] *NLB*	*WWT*	*SLW*	*HFW*
NLB	554	0.65	0.10	—	0.12	0.20	—0.05
WWT (kg)	24	3.0	0.20	0.12	—	0.70	0.20
SLW (kg)	0	4.5	0.35	0.15	0.50	—	0.30
HFW (kg)	92	0.45	0.30	0.00	0.30	0.40	—

[a] Genetic correlations above the diagonal and phenotypic correlations below.

Repeatability of NLB taken as 0.15.

rather than net returns, having been estimated from data from a variety of sources giving prices for wool, store and fat lambs over the five-year period 1970-1 to 1974-5. For the present, hogget liveweights are regarded as having zero relative economic value on the grounds that the greater return from the larger animal when it is slaughtered is likely to be compensated by a higher maintenance cost throughout its life. It is intended to maintain a regular review of these values and to incorporate the results from work of the sort described by Morris and Clarke (1977).

Two-tooth Selection Lists for Dual-purpose Breeds

For dual-purpose breeds, breeding values are presented for NLB (or NLR) and also for WWT, latest liveweight (ALW, WLW or SLW) and HFW if these options have been selected by the breeder. For NLB the primary information is the average number of lambs produced at birth per lambing of the dam of the individual. The index of aggregate economic value is also presented.

The number of lambs born is calculated for all ewes joined and present in the flock at lambing time. Where the breeder has chosen to take the lambs reared option, NLR is calculated instead and is based on those lambs produced by the ewe which are alive and being reared by the ewe at the time the lambing list is completed. This option gives breeders the opportunity, through the appropriate use of fostering remarks and lamb fate codes on the lambing and weaning lists, of excluding fostered lambs and lambs which die from the assessments of lamb production made on the ewes in his flock.

The genetic and phenotypic parameters used for the calculation of breeding values in the Romney breed are presented in Table 1 and derived from several analyses of large amounts of New Zealand research data (Baker *et al.*, 1974; Ch'ang and Rae 1961, 1970, 1972; Rae, 1958a, b; and unpublished data of R. L. Baker, J. N. Clarke and A. L. Rae). These parameters give rise to tables of weighting factors for breeding value prediction which are built into the data processing procedures. Provision is made to handle separate sets of parameters for different breed groups although at the present stage separate sets are available for only the broad categories of dual-purpose and meat breeds. As new information comes to hand it will be used to update and expand the sets of parameters in use.

The features of the selection index for aggregate merit derived from the dual-purpose parameters presented in Table 1 are summarized in Table 2.

The "value of each trait" shown in the first column of Table 2 indicates the percentage reduction in the rate of improvement in

TABLE 2: FEATURES OF THE SELECTION INDEX FOR DUAL-PURPOSE BREEDS

Trait	*Value of Each Trait (%)*	*Rate of Response*[b]	*REV (cents)*	*Contribution to Economic Response (cents)*
NLB[a]	24	0.05 lambs	554	28 (65%)
WWT	2	0.5 kg	24	12 (28%)
SLW	13	1.2 kg	0	0
HFW	0	0.03 kg	92	3 (7%)
				43

[a] Based on three lambings.
[b] Response per generation from one standard deviation of selection.

aggregate breeding value which would result if that trait were excluded from the index but not from the aggregate breeding objective; *i.e.,* selection is still aimed at improving the same overall objective. Thus the two traits which bear the major role are NLB and SLW, despite the fact that SLW does not contribute to the aggregate breeding value (because it has been given a zero economic value). This results from the contribution of indirect prediction because of the high heritability of SLW and the positive genetic correlations between SLW and NLB′ and SLW and WWT. For the same reasons both WWT and HFW tend to play a minor role. Nevertheless, these characters still show a positive response to selection using the index. This is shown by the column headed "rate of response" in Table 2. These figures indicate the rate of genetic improvement in each trait per generation which can be expected from a selection differential of one standard deviation on the index (in this case, 43 cents). Thus, if the animals chosen for breeding average 43 cents above the average of the flock before selection, the expected rate of genetic progress would be 0.05 lambs born plus 0.5 kg in WWT, 1.2 kg in SLW, and 0.03 kg in HFW for each generation of selection. For a typical breeding flock these figures need to be divided by a factor of approximately 3-4 to convert them to expected annual rates of genetic gain. The last columns of Table 2 indicate the contribution which the responses in the individual traits make to the overall response in aggregate breeding value. Because of its high economic value, improved NLB makes the greatest contribution to overall progress in economic terms.

In addition to selection lists in order of tag number, breeders may request an additional list, presented in descending order of index values, to assist his decisions or those of his clients.

Two-tooth Selection Lists for Meat Breeds

For the meat breeds, the selection lists supply breeding values for NLB, WWT and ALW. The breeding values for WWT and ALW are the most important criteria. These are relevant for early and heavy-weight lamb production, respectively. Breeding values for NLB are presented to cater for those breeders of sires for crossbred lamb production who wish to give emphasis to this component of the costs of their ram-breeding enterprise. Breeding values for NLB are predicted on the basis of dam information for this character with no indirect prediction through other characters. In addition, because of the variation in emphasis which individual breeders wish to place on breeding value for NLB, no attempt is made to include NLB into an index along with the breeding values for WWT or ALW. Breeding values for WWT and ALW are each predicted from any one, or from any combination of up to four liveweights for which the breeder decides to enrol. The parameters on which the predictions are made are presented in Table 3 and derive from unpublished analyses of Southdown data (Rae, pers. comm.). The appropriate weighing factors are built into the processing procedures to cater for the particular combinations of liveweights the breeder has chosen to record.

TABLE 3: PARAMETERS USED TO ESTIMATE BREEDING VALUES FOR MEAT BREEDS

Trait	*Standard Deviation*	*Heritability*	*Correlations*[a] *WWT*	*ALW*	*WLW*	*SLW*
WWT	3.1	0.10	—	0.70	0.60	0.50
ALW	3.4	0.22	0.62	—	0.67	0.47
WLW	3.8	0.36	0.53	0.78	—	0.85
SLW	4.6	0.45	0.50	0.63	0.81	—

[a] Genetic correlations above diagonal and phenotypic correlations below.

Although using all four liveweights gives the most accurate prediction of both weaning and autumn breeding values, combinations of only two weights achieve between 95 and 99% of this maximum accuracy. If the main objective is improved weaning weight, then any one of the later weights adds substantially to the accuracy, owing in part to the relatively low heritability of weaning weight. For the improvement of autumn weight, this weight alone has a high level of accuracy and adding weaning weight gives almost as much gain in accuracy as can be achieved by any other combination of liveweights.

Ewe Summaries

As in two-tooth selection lists, the ewe summary presents three types of information: pedigree information, individual performance data and progeny data relating to the ewe, and breeding values for the more important traits. Because of its importance in culling decisions, breeding values based on the number of lambs produced by a ewe are given major emphasis for dual-purpose breeds. By contrast, in the meat breeds where major attention attaches to the genes for meat production passed on through the sire to his slaughter lambs, breeding values for WWT are given most emphasis.

While all Sheeplan breeders receive breeding values for NLB in their ewe summary, whenever the weaning weight option is taken, breeders of dual-purpose sheep are also provided with a breeding value which reflects the mothering ability of their ewes. It is based upon an economic weighting of lamb survival to weaning and the average weaning weights of the lambs produced by the ewe each year and is predicted from these same traits. In this case also an overall measure of lamb production, combining both mothering ability (lamb survival and growth) and NLB (fertility and prolificacy), is calculated. Fostering and lamb fate codes indicating the breeder's assessment of whether lamb fosterings or deaths should be used to *incriminate* the ewe are taken into account in calculating breeding values for mothering ability and lamb production.

All dual-purpose breeding values are based on each year's lambing information for both the ewe and her dam. They are updated annually with new information from the lambing and weaning lists. To encourage their use in culling and provide easier identification of high-ranking ewes, a ewe summary cross-reference list may be requested. It provides a list of tag numbers in order of breeding value for lamb production, or breeding value for NLB if the weaning weight option has not been taken.

The meat breed ewes summary also aims to provide an updated summary of the lifetime performance of the ewes in the flock. Information on the ewe herself and on her progeny is used to make predictions of breeding value for weaning weight. Information on the progeny amounts to a progeny-test of the ewe. This is of increasing value for breeding value prediction as the number of progeny increases and individual sires have less effect. Breeding value predictions for weaning weight are complicated by maternal effects on weaning weight; effects which are not passed on by the meat breed sire to his slaughter lambs but which are passed on to the purebred ewe progeny of the rams and ewes in the ram-breeding flock. Thus breeders of sires for crossbred lamb production are not conecrned with maternal effects in so far as the objectives of their clients from commercial export lamb flocks are concerned. Maternal effects are, however, of some relevance to the costs of ram production in their own flocks. As a part compromise to this situation, breeders may enrol on the lambs reared option and thereby receive a breeding value for number of lambs which takes some account of postnatal lamb survival as well as fertility and prolificacy.

A further output related to the ewe summary is the "closed ewe file" (Fig. 1). It is produced annually and includes all ewes which have died or been culled. It contains the same information as the most recent ewe summary for each of these ewes and is to allow the breeder to accumulate a record of the performance history of ewes previously in his flock.

Sire Summaries

The current approach to preparing sire summaries emphasizes breeding values based on adjusted data. The mean of the progeny of each sire is adjusted to take account of variation in numbers of progeny per sire. Retention ratios are calculated for each sire in order to highlight both the absolute and relative levels of culling taking place at various stages among the progeny. Difficulties of interpreting sire summaries as progeny test estimates of breeding value for the rams are being investigated (Rae, 1976). In addition, methods whereby these data may be included as half-sib information for the ranking of young flock replacements are being studied.

DISCUSSION

Sheeplan emphasizes the relative performance of the individual animals within the flock for selection purposes. It gives little attention to recording as an aid to flock management although the lambing summary and the weaning summary are supplied with largely this purpose in mind. These summarize performance figures for the flock as a whole, subdivided according to age of ewe.

One feature of within-flock performance recording is that no genetic comparison is possible between flocks. Thus there are no meaningful performance data to guide the commercial breeder to any one flock in preference to any other. This must come from the reputation the breeders establish for themselves. In the long term this will presumably be on the basis of the stock they produce for sale. In the short term it could be on the basis of the recording objectives they set and the selection differentials they achieve in their own flock or the length of time for which they have been recording, and by the breeding value rankings of the rams they offer. These can be assessed only from a study of the records of individual breeders, although the publication of the enrolment details of individual breeders is useful and is currently undertaken in the form of a list of national performance recorded flocks. In this regard also, servicing staff associated with the recording scheme quickly build up an experience which is very valuable.

Adequate numbers of trained servicing staff closely involved in the organization, operation and evaluation of the scheme are extremely important in ensuring that the potential of the scheme is fully understood and in assisting breeders to make effective use of their records for selection decisions. They also play an important role in promoting the scheme among ram breeders and buyers.

The inclusion of sufficient pedigree information in output listings to meet the registration requirements of breed associations has been considered in the development of Sheeplan. This may be an important factor in future membership. In Sheeplan's first year of operation (1975-6), with little promotion, enrolments totalled 203 415 ewes and 748 flocks, 75% of the flocks representing breeders (unregistered and registered breed association members) transferring from NFRS.

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REFERENCES

Baker, R. L.; Clarke, J. N.; Carter, A. H., 1974. *Proc. N.Z. Soc. Anim. Prod., 34*: 19.
Ch'ang, T. S.; Rae, A. L., 1961. *N.Z. Jl agric. Res., 4*: 578.
————; ———— 1970. *Aust. J. agric. Res., 21*: 115.
————; ———— 1972. *Aust. J. agric. Res., 23*: 149.
Clarke, E. A., 1967. *Proc. N.Z. Soc. Anim. Prod., 27*: 29.
———— 1968. *Proc. 18th Linc. Coll. Fmrs' Conf.*: 25.
Clarke, J. N.; Rae, A. L., 1976. *Sheeplan Advisers Manual,* Ministry of Agriculture and Fisheries, Wellington.
Dalton, D. C.; Callow, C. F., 1975. *Sheepfmg A.*: 187.
————; ———— 1976. *Proc. Ruakura Fmrs' Conf.*: 13.
Hazel, L. N., 1943. *Genetics, 28*: 476.
Henderson, C. R., 1963. In *Statistical Genetics and Plant Breeding,* NAS-NRC 982, 141.
Morris, C. A.; Clarke, J. N., 1977. *Proc. N.Z. Soc. Anim. Prod., 37*: 182.
Owen, J. B., 1971. Performance recording in sheep. *Commonw. Agric. Bur. Tech. Comm. No. 20.*
Rae, A. L., 1958a. *Proc. N.Z. Soc. Anim. Prod., 18*: 5.
———— 1958b. *N.Z. Jl agric. Res., 1*: 104.
———— 1976. In *Sheep Breeding* (Eds. G. J. Tomes, D. E. Robertson and R. J. Lightfoot). Western Australian Institute of Technology, Perth, p. 33.
Wallace, L. R., 1974. *Sheepfmg A.*: 150.