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Selection efficiency in ram breeding flocks

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ABSTRACT

A sheep selection efficiency analysis developed to supplement recording on Sheeplan was applied to performance records in 8 group-breeding scheme central flocks. Average flock size was 756 ewes, and 170 rams were selected from 4 birth-years for central flock use. Selection efficiencies for the Sheeplan two-tooth index were 64%, 74%, 70% and 68% for rams born in 1977/80 and the corresponding efficiencies for two-tooth ewes were 29%, 27%, 42% and 44% respectively.

The selection of two-tooth ram and ewe replacements is expected to result in annual rates of improvement of 0.67% in lambing rate, 0.16 kg in weaning weight, 0.34 kg in hogget live weight and 0.029 kg in hogget fleece weight. Other traits breeders emphasised included structural soundness, wool quality and hogget lambing performance. Opportunities for increasing rates of progress in sire breeding programmes are discussed.

Keywords Sheep; selection efficiency; Sheeplan; selection index; breeding objectives; group breeding schemes

INTRODUCTION

The recording of performance data is the foundation for selecting rams and ewes of high breeding merit to become the parents of future generations. Levels of selection efficiency measuring the extent to which breeders use performance records to select flock replacements can be determined by comparing the expected gains resulting from the breeders' decisions with the maximum rates of progress to be expected if selecting the highest ranking animals for any given selection criterion.

Selection efficiencies for clean fleece weight were reported for Merino studs in Australia (Anon, 1979) and realised rates of genetic progress in flocks participating in a Norwegian co-operative sheep breeding scheme were presented by Steine (1982). Dodd *et al.* (1982) found high selection efficiencies were achieved in ram selection, but low levels of efficiency were found in the selection of two-tooth ewes among central flocks of group-breeding schemes.

In 1982 the procedure described below was developed to assist Sheeplan users examine past selection practices and levels of selection efficiency and further develop their breeding programmes.

SOURCE OF DATA AND ANALYSIS PROCEDURE

Flocks chosen for analysis were those group-breeding scheme central flocks identified in the 1980 survey (Dodd *et al.*, 1982) as mating 5 or more rams each year of which no fewer than 50% were bred within the central flock. Through mating-years 1978 to 1982 only 8.5% (27 out of 318 ram mating-years) of ram requirements were met by rams bred outside the central flocks (Table 1).

TABLE 1 Number of rams used and ewes joined (totals for 8 central flocks, 1978/82).

	Mating year				
	1978	1979	1980	1981	1982
Ewes joined	6696	6016	5888	5592	n.a.
Central flock bred rams	47	57	59	61	67
Outside rams	11	6	3	4	3

Table 2 describes the flock selection practices by year-of-birth (tag-year) for the 8 flocks: Romney (2), Perendale (3), Coopworth (2) and Corriedale (1). Of the ram lambs weaned 7780 (65%) were present on selection lists and 170 (1.4%) were later selected and used. Table 2 also shows 7203 ewes (69% of ewe lambs weaned) were present on the two-tooth selection lists and 4873 (47%) were retained as breeding stock.

Central-flock managers were asked to list the 5 traits given the most emphasis in selection decisions in order of priority. The assessments of the groups' breeding objectives are summarised in Table 3.

TABLE 2 Number of rams and ewes present at weaning, on two-tooth selection lists and selected as flock replacements (totals of 8 central flocks by tag-year).

	Tag-year			
	1977	1978	1979	1980
No. ram lambs weaned	2625	2919	3031	3387
No. rams on two-tooth selection list	1674	1988	2071	2037
No. rams selected	42	43	48	37
No. ewe lambs weaned	1800[2]	2568[1]	3021	3029[1]
No. ewes on two-tooth selection list	1239[2]	1807[1]	2061	2096[1]
No. ewes selected	944[2]	1236[1]	1373	1284[1]

[1] 7 flocks only.
[2] 6 flocks only.

TABLE 3 Breeding objectives of 8 group breeding schemes (central flock managers' assessments).

Trait	No. groups ranking the trait	Average[1] ranking	Aggregate[2] score
Fertility	8	1.5	90
Fleece weight	8	2.9	62
Structural soundness	6	2.5	53
Easy care	5	3.0	38
Weaning weight	4	3.3	27
Growth rate/hogget weight	4	4.3	17
Hogget lambing	1	5.0	3
Fleece quality	1	5.0	3
Appearance	1	5.0	3

[1] (1st to 5th)
[2] Aggregate score = (% groups ranking the trait × (6 — ave. ranking))/5.

Expected genetic selection differentials achieved through the breeders' decisions were calculated for the Sheeplan two-tooth selection index and each of its 4 components: number of lambs born or reared (NLB), weaning weight (WW), hogget live weight (HLW) and hogget fleece weight (HFW).

Consider the formula for genetic change when selecting for a single character:

$$\triangle G/yr = h^2 S/GI \tag{1}$$

where

$\triangle G/yr$ is the expected annual rate of genetic gain in the trait being selected.
h^2 is the heritability estimate.
S is the selection differential achieved
and GI is the generation interval.

When selection differentials are measured in terms of breeding value the formula simplifies to:

$$\triangle G/yr = S^1/GI \tag{2}$$

where S^1 is the expected genetic selection differential, or average superiority in breeding value of selected animals.

Combining male (m) and female (f) selection, equation (2) becomes:

$$\triangle G/yr = \frac{S^1_m + S^1_f}{GI_m + GI_f} \tag{3}$$

this equation also holding for the general case of index selection.

The measure of selection efficiency chosen was obtained by expressing the genetic selection differentials achieved by the breeder as a percentage of those which would have been achieved had the same number of animals with the highest breeding values been selected.

RESULTS AND DISCUSSION

Selection efficiency percentages averaged over central flocks within tag-year are set out for rams and ewes in Table 4. Over the 4 tag-years the levels of efficiency in ram selection are high being in the range 64 to 74% for the index. The corresponding figures for ewes are lower (27 to 44%) but there is evidence for increased performance selection of animals born in the latter 2 tag-years.

TABLE 4 Efficiency of selection (%) for the Sheeplan index and its component breeding values.

	Rams Tag-year				Ewes Tag-year			
	1977	1978	1979	1980	1977	1978	1979	1980
Sheeplan index	64	74	70	68	29	27	42	44
NLB	45	48	24	39	10	9	28	20
WW	42	53	49	49	29	20	31	27
HLW	47	60	52	54	25	23	37	35
HFW	40	40	59	40	11	16	18	49

Examination of efficiency levels for individual trait selection in Table 4 indicates that in both ram and ewe selection highest efficiency levels were achieved for HLW, a trait included in the index because of its value in indirect selection: HLW is favourably correlated with the other 3 index components (Clarke and Rae, 1976). The increased emphasis placed on HFW in selecting tag-year 1979 rams was associated with a large reduction in the emphasis on NLB. Increased selection for HFW is also evident for tag-year 1980 ewes.

Less selection has taken place for fertility (NLB) than might be expected from the flock managers' assessments of selection priorities although these show several non-index components are given attention in selection decisions (Table 3). Structural soundness ranked high on priorities and investigation of individual flock selection practices showed that the index traits were often compromised in ewe selection (e.g., through an initial culling of ewes with unacceptable feet, teeth or wool fibre quality). Ram selection differentials were also sometimes reduced in an effort to avoid inbreeding by selecting sons of several, rather than few, parental rams.

Rates of Genetic Improvement

Expected rates of genetic progress based on the breeders' decisions are presented in Table 5 with potential rates of progress, assuming that each of the 5 criteria (index and the individual components) were selected for singly. Generation intervals averaged 2.4 years for rams and 3.5 years for ewes. J. N. Clarke (1979, unpublished) showed that the expected genetic gain in each of the traits NLB, WW, HLW and HFW through selection on the index is 84%, 75%, 78% and 25% respectively, of the gain to be expected through single-trait selection when recording the same information. While the breeding groups have exploited only 34% to 49% of the individual trait responses, HFW has been more intensely selected for than had the animals been selected solely on the Sheeplan index.

The most rapid expected rates of improvement in the index in this study were seen in flocks 1, 2 and 3 where selection efficiencies and average ram rankings tend to be high and generation intervals lowest (Table 6). In flock 6 where the use of a large number of rams has reduced selection differentials, a lower ram:ewe ratio or the restricted use of lower-ranked

TABLE 5 Expected and potential rates of genetic improvement in Sheeplan two-tooth traits.

	Sheeplan index[1]	NLB (lambing %)	WW (kg)	HLW (kg)	HFW (kg)
Expected		Δ G/generation			
rams	51	3.3	0.80	1.70	0.151
ewes	8	0.6	0.12	0.30	0.020
		Δ G/year			
Expected (both sexes)	10	0.67	0.16	0.34	0.029
Potential (both sexes)	16	1.95	0.35	0.70	0.071
% efficiency	62	34	45	49	41

[1] In units of the weighted aggregate genotype.

TABLE 6 Factors affecting rates of genetic improvement in group breeding scheme central flocks.

Flock[1]	Rams selected/ rams weaned (%)	Ave. ranking selected rams (1-100 scale)	Selection efficiency Rams %	Selection efficiency Ewes %	Generation[2] interval (yr)	Expected[2] gain/yr index
1 (P)	1.6	9	71	56	2.9	14
2 (C)	1.0	3	87	22	2.5	13
3 (R)	1.4	11	67	50	2.6	12
4 (Ce)	0.8	10	71	19	3.2	10
5 (C)	1.9	9	73	45	3.3	9
6 (P)	4.0	9	85	52	3.0	8
7 (C)	1.4	19	44	43	3.0	7
8 (R)	1.0	14	51	17	3.0	7

[1] P = Perendale; C = Coopworth; R = Romney; Ce = Corriedale.
[2] Rams and ewes combined.

sires would bring about an increased rate of gain. The higher selection efficiencies attained in selecting tag-year 1979 and 1980 ewes (Table 4) occurred when a smaller proportion of two-tooth ewes available entered the flocks (Table 2) and could have resulted from increased selection on performance records following initial culling for unacceptable structural faults.

The analysis shows that opportunities exist among the flocks for increasing selection efficiency based on the Sheeplan index. The relative emphasis on the various productive traits can also be modified to suit individual breeding programmes, based on analyses of past and proposed selection plans.

Additional performance information on older animals on Sheeplan's sire and ewe summaries can also be used in selection decisions. Further components of genetic progress include the post weaning culling of young animals, screening from contributing flocks and the exploitation of genetic differences existing between ram breeding units.

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