

## SELECTION FOR PROLIFICACY IN ROMNEY SHEEP I. DIRECT RESPONSE TO SELECTION

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### Summary

A selection experiment with Romney Marsh sheep was used to evaluate direct responses to selection. Two flocks were maintained; a) the selection line formed in 1979 by the Romney Group Breeders to select for high prolificacy, defined as the number of live lambs born per ewe joined per year and b) a control line, established in 1982, where flock replacements were chosen at random. Predicted responses per year of birth female group and per year respectively were 0.033 and 0.027 live lambs. The rate of predicted response per year was within the theoretical expected range from 0.01 to 0.03 of the mean. The rates of realized response in prolificacy per year of birth female group and per year respectively were 0.026 and 0.021. These estimates of realized responses represented between 0.01 and 0.02 of the control line mean per year.

(Key Words : Sheep, Selection, Prolificacy, Direct Response)

### Introduction

Reproductive performance in sheep plays a major role in determining the biological and economic efficiency of meat production (Hanrahan, 1987). Genetic improvement of reproductive performance may be achieved by within population selection or by immigration of genes from a superior population. A number of successful selection programmes for changes in reproductive performance have been reported and reviewed by Dalton and Baker (1980), Land, Atkins and Roberts (1983), Bradford (1985), Atkins, McGuirk and Thompson (1986), Burfening and Hanford (1986) and Anderson and Curran (1990). All of them have been confined to within breed selection and most of these involved the accumulation of foundation animals by screening a recorded population.

Bradford (1985) reviewed several experiments and concluded that an increase of 1-2% or better per year in lambs born per ewe lambing can be achieved by selection for multiple births. The results of the reported selection experiments are in reasonably good agreement with each other.

The aim of this study was to evaluate the predicted

and realized direct responses to selection in the Romney Group Breeders selected flock. A preliminary analysis of response from the same flock have been reported by Anderson and Curran (1990).

### Materials and Methods

#### Sheep and management

The data used in this study were obtained over a period of 10 years (1980 to 1989 inclusive) from a selection flock of Romney sheep maintained at Wye College, Kent, England. In 1979, the flock was established by the Romney Group Breeders (RGB), a farmer cooperative formed by 12 members of the Romney Sheep Breeders Society. The objective of the RGB was to develop a line of prolific Romney sheep to use as a source of high merit breeding stock particularly males for their own flocks. As a result, prolificacy, defined as the number of live lambs born per ewe joined per year (LLB/EJ) was chosen as the selection criterion.

A contemporary control flock was established in 1982 and maintained in the same environment with the target of monitoring genetic progress achieved in the RGB selected flock. Details of the formation of the selected and control flock were described by Anderson and Curran (1990).

The animal management procedures in both the selected and control flocks were similar; the two flocks

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managed as a single flock at all times except for (a) mating and (b) lambing. In the autumn, all ewes were flushed on well-grown fresh pasture and supplemented with 0.25 kg/ewe/day of a concentrate feed (210 g CP and 12.7 MJ, ME/kg DM) starting from 3 weeks prior to putting the entire rams in the flock and continued until the pedigree mating was completed during the first 25-30 days of November in each year. Ram lambs were used in both flocks and for one breeding season only, when they were approximately 8-9 months of age. The ewes were winter housed and shorn in early January each year. Upon lambing in the pens, they were moved to small individual pens of approximately 1 m<sup>2</sup>. All lambs were individually ear-tagged using the Meat and Livestock Commission (M. L.C.) metal tags and their birth weights were recorded within 24 hours of birth. Prolificacy, defined as the number of live lambs born per ewe joined per year (LLB/EJ) of individual ewes were recorded. Ewes and lambs were turned out to pasture within 2-3 days of lambing.

#### Selection procedure

After each lambing, the breeding values of individual ewes were predicted using their prolificacy records applying the formula (Dalton, 1984) shown below:

Ewe's Breeding Value =

$$\frac{kh^2}{1 + (k - 1)t} \times \begin{array}{l} \text{Average deviation of} \\ \text{the ewe's records} \\ \text{from her contemporaries} \end{array}$$

where, k = number of records, h<sup>2</sup> = heritability (assumed to be 0.10), t = repeatability (assumed to be 0.15).

The above prediction formula was applied within three age groups of ewes, i.e. 2, 3 or above 3 years. The animals of each age group which were born in the same lambing season were considered to be contemporary.

Replacement males and females were selected on the basis of a lamb index (for prolificacy), calculated as 0.5 dam's breeding value plus 0.25 sire's dam's breeding value. Ten ram lambs and between 30-40 ewe lambs were selected in each year.

In the control line, 10 ram lambs and 15 ewe lambs were retained each year as flock replacements. They were chosen randomly within the constraint that each and every sire and dam would be replaced respectively by one son and one daughter.

#### Data analysis

The trait considered for analysis was prolificacy (LLB/EJ), i.e. the selection criterion.

#### Predicted response

Selection differentials were calculated using their lamb indices value for year of birth groups from 1983 to 1988. Selection intensities were calculated by dividing the selection differential by the standard deviation of lamb index within sex. Accumulated selection differentials were calculated following James (1986).

Response to selection was predicted for year of birth female replacements from 1983 to 1988 inclusive using the formula (Falconer, 1989) shown below:

$$\text{Response} = i \cdot \sigma_p \cdot h^2$$

where, i is the selection intensity,  $\sigma_p$  is the phenotypic standard deviation and h<sup>2</sup> is the heritability of the trait.

Selection intensity was taken as the mean of the accumulated female selection intensity up to the year of replacement. The phenotypic standard deviation of the trait was calculated from the performance of all ewes in the particular year of birth. Because of variations in the number of records of lambs dams, heritability value for use in the above formula ( $h_F^2$ ) was calculated (Falconer, 1989) as follows:

$$h_F^2 = \frac{nr}{1 + (n - 1)t} h^2$$

where, n = number of record of relatives, t = repeatability (assumed 0.15), r = coefficient of relationship, h<sup>2</sup> = heritability of the trait (0.12, Anderson and Curran, 1986).

#### Realized response

Realized response in prolificacy was estimated using least-squares method. In this method, statistical least-squares procedure (Harvery, 1988) was used to develop environmental correction factors for prolificacy data. Because of the small size of the control flock, the data from both the genetic groups were analysed together to develop the environmental correction factors. The best fitting model was:

$$Y_{ijk} = \mu + L_i + A_j + P_k + e_{ijk}$$

where, Y<sub>ijk</sub> is the prolificacy record,  $\mu$  is the overall mean, L<sub>i</sub> is the effect of ith line, A<sub>j</sub> is the effect of jth age of ewe, P<sub>k</sub> is the effect of kth year of performance and e<sub>ijk</sub> is the random error.

The raw data were then corrected for significant non-genetic fixed effects (age and year). The control line corrected mean performance was deviated from the corresponding selected line and the difference represented the genetic change or response free from environmental fluctuations. Selection response was studied by year and year of birth. Response was also tested by a one-tailed test (SAS, 1985).

### Results

Selection intensities, accumulated selection differentials and predicted response in prolificacy (expressed per 100 ewes) are presented in table 1. They are averages of both sexes.

There was a steady increase in predicted response with a slight decline in the 1988 year of birth group (table 1). This result indicate an expected response of 0.0249 of control mean in prolificacy per year of birth group. Expressed per annum, it represent 0.0199 of control mean prolificacy.

TABLE 1. SELECTION INTENSITIES, ACCUMULATED SELECTION DIFFERENTIALS AND PREDICTED RESPONSE IN PROLIFICACY (LLB /EJ) (EXPRESSED PER 100 EWES)

	Year of birth					
	1983	1984	1985	1986	1987	1988
Selection intensity	6.68	6.43	5.80	7.09	7.38	6.05
Accumulated selection differential	4.20	5.95	7.05	7.70	8.35	8.75
Predicted response	5.00	12.10	13.50	15.40	20.00	19.90

### Realized response to selection

Age of ewe and year of performance were two non-genetic sources that had significant effect on prolificacy. Least-squares means and standard errors for prolificacy are presented in table 2.

Estimates of response calculated by year of birth are presented in table 3. Overall responses expressed per year of birth and per annum respectively were 0.026 (s.e. 0.007) and 0.021 (s.e. 0.005) live lambs.

TABLE 2. LEAST-SQUARES MEANS AND STANDARD ERRORS FOR PROLIFICACY (LLB /EJ)

	Least-squares	
	Mean	Standard error
Overall	1.43	0.05
Line	***	
Selected	1.54	0.05
Control	1.33	0.06
Age of ewe (yrs)	*	
2	1.31	0.04
3	1.43	0.05
4	1.45	0.06
5	1.37	0.07
6	1.40	0.12
6+	1.62	0.23
Year	***	
1983	1.52	0.10
1984	1.52	0.09
1985	1.48	0.08
1986	1.64	0.07
1987	1.38	0.06
1988	1.23	0.07
1989	1.26	0.07

\*  $p < 0.05$ , \*\*\*  $p < 0.001$ .

TABLE 3. REALIZED RESPONSE IN PROLIFICACY BY YEAR OF BIRTH (EXPRESSED PER 100 EWES)

	Response (LLB /100 EJ)	Significance of response
Overall	21.0(5.30)#	***
Year of birth		
1980	23.6	NS
1981	23.5	*
1982	33.6	**
1983	5.6	NS
1984	13.5	NS
1985	23.1	NS
1986	30.6	NS
1987	20.0	NS

# ( ) = standard error, NS = Not significant, \*  $p < 0.05$ , \*\*  $p < 0.01$ , \*\*\*  $p < 0.001$ .

### Discussion

Variation in the degree of selection intensity among year of births was observed which was due to differences in the number of animals available for selection and differences in the standard deviations which arose mainly

from the varying number of records per dam. A slow but steady increase in accumulated selection differential was noticed in the RGB selected flock as expected in the overlapping generation state. The calculation accounted for the differential contribution in the number of offspring by parents of each year of birth. This sort of steadiness in increase in the accumulated selection differential agrees with those reported in the cannon bone length (Atkins and Thompson, 1986a; James, 1986) and greasy fleece weight (Blair, 1986) selection experiments.

The formula used to predict response for the individual year of birth female replacement groups took account of the previous selection pressure applied to the female ancestors of the group in question, the increased heritability due to the accumulation of reproductive records of the dams and the phenotypic standard deviation of the selected trait. The decrease in predicted response for both traits in 1988 year of birth was due to reduced heritability acting through a decrease in the mean number of dams records which resulted from the culling of all ewes born before 1983 after their 1987 lambing. However, this decline are in agreement with Berny (1980) who reported that expected response decreases with the decreased amount of information used in selection. The predicted responses are in agreement with the expected changes of Bradford (1985), Land et al. (1983) and Smith (1984).

In the best fitted model, there was no confounding of main effects which allowed the adjustment factors to be unbiased (Hazel, 1946). But while calculating response a confounding between year and year of birth was noticed. With only a limited number of categories the phenotypic distribution of prolificacy was non-normal, which violated one of the basic assumptions of the principle of analysis of variance. But there is a quantitative difference between the categories of 0, 1, 2 or 3 lambs which, according to Harvey (1982), justifies the analysis of categorical data by the least-squares method.

From the present analysis, it is evident that positive selection response in prolificacy occurred in the RGB selected flock. Predicted responses per year of birth female group and per year respectively were 0.033 and 0.027 live lambs. The estimated realized response in prolificacy was in the scale of 0.021 (s.e. 0.005) per year and 0.026 (s.e. 0.007) per year of birth. This rate of realized response was between 1 and 2% (of control mean) per year. The positive responses obtained for prolificacy in the present study are consistent with Bhuiyan and Curran (1993), where genetic trends are presented in terms of average predicted breeding value of animals. Similar rate of realized response in reproduction rate is reported by

Hanrahan and Timon (1978) and Hanrahan (1984) in Galway sheep, Clarke (1972) in New Zealand Romney sheep, Turner (1978) in Australian Merino sheep, Burfening and Hanford (1986) in Rambouillet sheep and also Anderson and Curran (1990) in the Romney Marsh sheep.

The review of literature indicate that comparisons using an unselected control population are the best way to remove environmental effects for measuring selection response. But the measurement of selection response using a control group assumes a replication of the same genetic material in successive generations in the control group. The control group used in the present study was of the same genetic background as the selected line was. Since both genetic groups were maintained in the same environment the genotype environment interaction was found to be non-existent (Bhuiyan, 1989).

In the selected flock, realized response increased in the first three year of birth groups (i.e. 1980 to 1982). This was followed by a decline in the subsequent one year of birth group after which there was a gradual increase in response. A similar pattern of response was observed in the earlier generations of Ruakura selection program (Meyer and Clarke, 1982), where New Zealand Romneys are selected on reproduction rate.

In monitoring responses to selection an analytical problem was posed by the scale effect due to the non-normal distribution with prolificacy data (Bhuiyan, 1989). A similar problem was encountered in analysing litter size data in cannon bone length experiment in the Scottish Blackface sheep (Atkins and Thompson, 1986b). The importance of scale effects in the estimates and interpretation of the responses to selection for prolificacy was also not clear in the present study.

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