RESPONSES TO 27 YEARS OF SELECTION FOR YEARLING FLEECE WEIGHT

H.T. BLAIR[1], NEW ZEALAND

SUMMARY

After 9.6 generations of selection, yearling ewe greasy fleece weight has increased by about 1kg (2 phenotypic standard deviations). Further evidence that the traditional method of assessing cumulative selection pressure is biased upwards is presented. In comparison to the 4.8kg of cumulative selection pressure applied, a 1kg response corresponds to a realized heritability of about 0.2, which is somewhat less than the commonly assumed value of 0.3. Reasons for this discrepancy are discussed. No evidence of a decline in response to selection could be found. Increased liveweight contributed significantly towards the extra wool produced. Selected flock breeding ewes had improved annual fleece producion of 1kg, despite producing a greater number of lambs. Physiological studies indicate selection flock sheep have lower levels of blood plasma urea, possibly induced through an increased rate of urea clearance in the urine. Comparisons of dry matter digestibility in the control and selected flocks produced conflicting results.

INTRODUCTION

The weight of wool produced per animal is an important factor in determining the income of sheep farmers in New Zealand. Typically, on farms producing a combination of meat and wool, earnings from the sale of wool contribute 33-66% of the farm's gross income (Anon., 1984).

Because of the importance of wool weight per animal to New Zealand farmers, it is desirable to know the rate at which this trait can be altered via selection and to what degree other traits show correlated changes. To this end, a selection experiment was initiated at Massey University in 1956 using New Zealand Romney sheep.

It is the purpose of this paper to evaluate the direct response to selection for yearling greasy fleece weight and to examine changes in some correlated traits.

MATERIALS AND METHODS

A full description of the flocks and data collection has been given by Blair _et al_ (1984).

In 1956, 2 flocks of about 80 mixed-age ewes (1½ to 4½ years-old) were established by random allocation from an interbreeding base flock. One flock was maintained as a randomly breeding control whilst in the other flock, 1½ year-old replacements were chosen on the basis of high yearling greasy fleece weight. Each year, 4 new rams were used in each flock, the flocks having been closed in 1958. Lambs were born in August/September, weaned in November, shorn in December and shorn again in the following October. Shearing all animals as lambs served to provide a constant period of about 10 months to produce the yearling fleece.

Statistical analyses were undertaken using the generalised linear models package REG (Gilmour,1985).

[1]Department of Animal Science, Massey University, Palmerston North, New Zealand

RESULTS AND DISCUSSION

Generation Interval

Because of the relatively consistent age structure of the 2 flocks, the average age of parents varied little from year to year. The average generation interval over the 29 years examined was 2.8 years in both flocks, therefore, 10.4 generations have elapsed since the experiment was initiated. However, selection has only been applied in 27 years, or 9.6 generations.

Selection Pressure

James (unpubl) has recently reported that the approach of Pattie (1965) for calculating cumulative selection differentials (CSD) is biased upwards. The reason for this upwards bias is that the better parents in any generation will tend to leave above-average offspring, as a consequence, they will make a greater numerical contribution to ensuing generations than their poorer performing contemporaries. If the CSD is calculated using the approach of Pattie (1965), the contribution of the above-average ancestors to the CSD will be greater than the true selection intensity operating at that time, thereby causing the CSD to be overestimated. James (unpubl) proposes an alternative approach to overcome this problem.

Excluding the first 2 years, where there was no cumulative selection pressure, the technique of Pattie (1965) overestimates the CSD by between 1% and 35%, with the average being 22%. Using the technique of James (unpubl), about 4.8kg of selection pressure has accumulated on yearling greasy fleece weight. On all but 3 occasions, steady increases in the CSD were recorded; about 0.18kg per year. A large proportion of this selection intensity was provided by sire selection. On average each year, 4 rams were chosen from 26 (i=1.476) and 20 ewes from 35 (i=0.672), over the 27 years that selection has been imposed. Assuming that the phenotypic standard deviation is the same for each sex, about 69% of the selection intensity has been derived from ram selection. However, the actual ram contribution was 76%, implying that the phenotypic standard deviation of ram greasy fleece weight is about 44% higher than that of the ewes.

Maternal Effects

Since rams and ewes were run in separate groups post-weaning, they were analysed separately. The selection flock and the control flock were also analysed separately.

For the control ewes and rams and the selected line ewes, there was a disadvantage of about 0.1kg in being born and reared as a twin. For the selected line rams, this disadvantage increased to 0.2kg. The effects of being reared by a 3, 4 or 5 year-old dam were similar, whilst yearlings reared by 2 year-old dams generally grew 0.10 to 0.15kg less wool than their contemporaries reared by mature dams. The selected group yearling ewes were an exception to this as there was no significant effect of dam age on yearling fleece production. This could be explained by the younger dams having the benefit of more selection than their older counterparts, but the effect was not apparent in the rams.

Because of the significant depression in wool growth caused by being born (reared) as a twin and/or being reared by an immature dam, farmers selecting for improved wool weights should make allowances for these effects to maximise genetic gains. This finding is not in agreement with that of McGuirk (1983) who suggested the effects of dam age and birth/rearing rank would probably be small if the animals had been shorn as lambs. The inconsistent results suggest that, where possible, adjustments should be made on a within flock basis if genetic gains are to be maximised.

Inbreeding

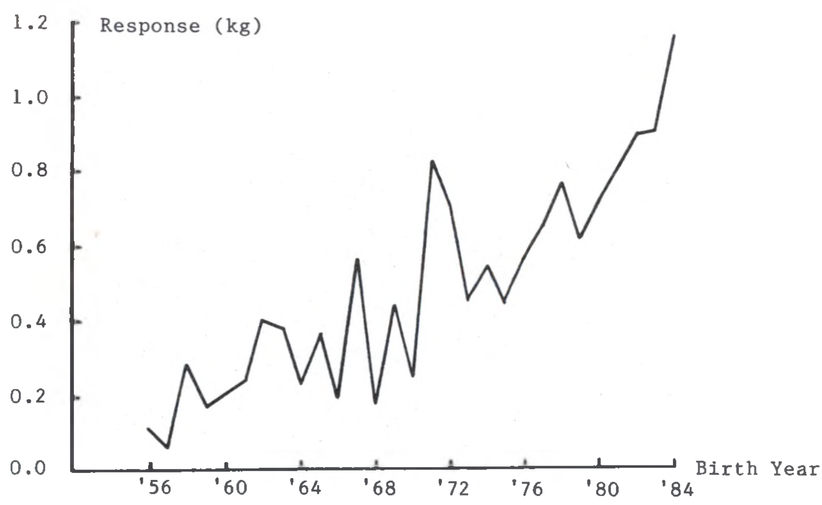
In randomly-bred flocks where 4 new rams and 20 new ewes are used each year, the yearly increase in the inbreeding coefficient would be approximately 0.5%, assuming the generation interval is 2.8 years. With selection, it might be expected that the above rate would increase, the increase being greater for traits of higher heritability. However, Blair (1981) showed that for the first 21 years, the annual increase in inbreeding was 0.5% in both flocks (no attempt had been made to avoid the mating of close relatives at any stage). If it is assumed that inbreeding is still accumulating at ½% per year, both flocks should, on average, be 14½% inbred.

Blair (1981) found that for a 10% increase in inbreeding, yearling fleece weight was depressed by about 0.1kg in ewes and about 0.3kg in rams. However, no adjustment for inbreeding has been made. Both flocks are equally affected, and consequently any response estimated as a difference between the 2 flocks should not be biased by the effects of inbreeding. This argument would be erroneous if either, the flocks had different levels of inbreeding or, there was a genotype by inbreeding interaction; neither of these has been found, to date.

Direct Response

Figure 1 shows the selected flock adjusted year means minus control flock adjusted year means of yearling ewe greasy fleece weight. Over the years 1982-1984 (approximately 1 generation), the selected flock ewes exceeded the control flock ewes by an average of 0.98kg. This represents an annual response of 1.2% per year over the 27 years that selection has occurred, compared with the pooled control flock mean of 3.00kg. The yearling rams have shown a similar rate of increase in fleece weight.

FIGURE 1 : Estimated Response in Yearling Ewe Greasy Fleece Weight



In 2 other experiments involving selection for high yearling greasy fleece weight in New Zealand Romney, annual responses have been slightly higher (3% and 2%) than that reported here (see Blair et al, 1985). However, these responses are based on only 2½ and 4½ generations of selection. McGuirk (1983) has reviewed several experiments involving selection for clean fleece weight in Merino sheep and, in general, responses appear to be similar to those mentioned above.

Realized Heritability

Four estimates of the realized heritability of yearling greasy fleece weight are shown in table 1. These values have been obtained by regressing (through the origin) response on CSD, estimated by the 2 techniques discussed earlier, for both sexes. As expected, realized heritiability estimates based on CSD calculated using the approach of James (unpubl) are about 25% higher than those using the technique of Pattie (1965). There is no suggestion that the sexes have responded differently.

TABLE 1 : Realized Heritabilities for Yearling Greasy Fleece Weight

TYPE OF CSD	REALIZED HERITABILITY (SE=0.03)	
	Ram	Ewe
Pattie	0.16	0.15
James	0.20	0.19

Thus, the data in this experiment suggest that the heritability of yearling greasy fleece weight is about 0.2. This is somewhat less than the commonly assumed value of 0.3 (Blair et al, 1985). A likely reason for this difference is that when heritabilities are estimated via covariances between relatives, it is common to adjust for non-genetic effects. In this trial, selection was based on unadjusted values. It is also possible that a small amount of positive genetic drift has occurred in the control flock. The CSD has been significantly positive for the last 11 years, the average of the last 3 years being 0.32kg. Furthermore, Blair and Pollak (1984), using best linear unbiased prediction techniques, suggested that some positive drift had occurred up until 1976.

After 9½ generations of selection, the phenotypic variance of greasy fleece weight has increased in the selected flock compared with the control flock ($0.41kg^2$ v $0.30kg^2$ for the rams and $0.29kg^2$ v $0.22kg^2$ for the ewes: calculated using the last 6 years data). However,the coefficients of variation are 14% for the control and selected flock rams and 15% for the ewes in both flocks, implying that the increase in variability is due to an increase in selected flock performance.

It appears likely that the genetic variance has not, as yet, been markedly changed by selection and there is no evidence of any plateauing of response.

Correlated Responses

In the last 3 years analysed, selected flock rams and ewes were 2.0kg and 2.9kg, respectively, heavier than their control flock peers. However, the increase in wool weight cannot be solely explained by greater size in selection flock animals and adjusting for liveweight in the ewes, for example, only accounts for 0.17kg (17%) of the response (using b=0.06 kg/kg).

Data from the 1984 and 1985 shearings of adult breeding ewes indicates that the selected flock ewes produce 0.98kg more wool than the control flock ewes, after accounting for age. Whilst this is the same as the response found in the yearling ewes, the breeding ewe response is based on 12 months growth but the yearling ewe response on only 10 months growth. It is possible that the true response is slightly greater than 0.98kg since the selected flock is currently producing about 0.25 more lambs weaned per ewe exposed to the ram compared with control flock ewes. Corbett (1979) reviewed numerous reports which showed that the combined effects of pregnancy and lactation could reduce the annual amount of wool produced by 10-14%, compared with ewes not producing lambs. It is also likely that ewes producing twins will produce less wool than ewes rearing only one lamb. The strong correlated response in fleece weight at later ages justifies the use of yearling production as an indicator of lifetime wool production

Physiological Changes

More recently,interest has centred on identification of physiological changes that may have accompanied the response in wool production.

Initial comparisons of dry matter digestibility between the 2 flocks have yielded variable results, with one study showing control animals to have superior digestibility (62.8% v 60.1%), and the other study showing no difference (McClelland et al, 1986). Further work has been initiated in this area in an attempt to clarify the situation.

Research has been initiated to examine concentrations of hormones and metabolites in the blood of selected and control flock animals. Preliminary results have shown the selected animals to have lower plasma levels of urea and it appears that this status may be reached through the selected animals having a higher rate of urea clearance via the urine. A similar result has been reported by Sejrsen et al (1984) whereby, bull calves with high estimated breeding values for butterfat yield had lower blood plasma levels of urea compared with those with low estimated breeding values. M.L.Carter (pers. comm.) noted that sheep from a Massey University flock selected for low levels of subcutaneous fat have lower blood plasma levels of urea than those from a high line.

Other work at present in progress includes: the measurement of sulphur levels in wool fibre; an assessment of the contribution of various components of fleece weight to the increased production; a comparison of feed intake levels under field conditions; an examination of the seasonal pattern of wool growth; the effects of intravenous methionine infusion on the concentration of blood metabolites and hormones and the comparison of various amino-acid transferase levels in blood plasma.

CONCLUSIONS

The evidence provided in this report justifies the belief that selection for yearling greasy fleece weight will not only improve production at the yearling stage but also in later life. It is highly probable that by adjusting for dam age and birth/rearing rank, that faster progress than the 1.2% per annum obtained could have been made. This has important implications for industry selection programmes if improved wool weights are to be included in the selection criteria.

Further evidence is provided to show that the technique of Pattie (1965) overestimates the cumulative selection differential. This outcome should be accounted for during the evaluation of all selection experiments, as failure to use the correct technique could result in underestimation of realized heritabilities by up to 20%.

After only a brief period of work involving physiological comparisons, some interesting differences have already been found. The lower plasma level of urea in the selected flock is of particular interest, since the same outcome has now appeared in 3 independent, and quite diverse, experiments. An understanding of how this difference has arisen could provide a new, previously unthought of, indicator of lifetime productivity. Further research must be devoted to this field in the immediate future to uncover other physiological changes.

REFERENCES

ANON. 1984. Sheep and Beef Farm Survey 1982-83. N.Z. Meat and Wool Boards' Economic Service, Publication No. 1908.

BLAIR,H.T. 1981. Response to selection for open face and greasy fleece weight in Romney sheep. Ph.D. Dissertation. Massey Univ., Palmerston North, New Zealand.

BLAIR,H.T.,GARRICK,D.J.,RAE,A.L. AND WICKHAM,G.A. 1984. Selection response in New Zealand Romney sheep 1. Selection for wool-free faces. N.Z. J. Agric. Res. 27,329-336.

__________. 1985. ________ 2. Selection for yearling greasy fleece weight. N.Z. J. Agric. Res. 28,257-264.

BLAIR,H.T. AND POLLAK,E.J. 1984. Estimation of genetic trend in a selected population with and without the use of a control population. J. Anim. Sci. 58,878,886.

CORBETT,J.L. 1979. Variation in wool growth with physiological state. In: Physiological and Environmental limitations to Wool Growth. Eds. J.L.Black and P.J.Reis. Univ. of New England Publishing Unit. Pp 79-98.

GILMOUR,A.R. 1985. REG - A Generalised Linear Models Program. Dept. of Agric. N.S.W., Australia.

JAMES,J.W. (unpubl). Cumulative selection differentials and realized heritabilities with overlapping generations. Submitted to Anim. Prod.

McCLELLAND,L.A.,BLAIR,H.T.,BROOKES,I.A. AND WICKHAM,G.A. 1986. A comparison of fleece-weight selected and control Romney sheep for feed intake, wool growth and feed utilisation. Proc. N.Z. Soc. Anim. Prod. 46,(in press).

McGUIRK,B.J. 1983. Genetic selection for wool production. In: Sheep Production. Ed. W.Havesign. Butterworths, England. Pp 545-566.

PATTIE,W.A. 1965. Selection for weaning weight in Merino sheep 1. Direct response to selection. Aust. J. Exp. Agric. Anim. Husb. 5,353-360.

SEJRSEN,K.,LARSEN,F. AND ANDERSEN,B.B. 1984. Use of plasma hormone and metabolite levels to predict breeding value of young bulls for butterfat production. Anim. Prod. 39,335-344.