SELECTION FOR SUSTAINABLE UK HILL SHEEP PRODUCTION

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INTRODUCTION

The hill areas of the UK are populated by hardy hill sheep breeds such as the Scottish Blackface, Welsh Mountain and Swaledale. These breeds are adapted to live under harsh climatic conditions with poor quality grazing. However, they make a major contribution to the UK stratified sheep industry as they are crossed with a longwool breed such as the Blue-faced Leicester to produce the crossbred ewes that are the main ewe genotype used for lamb carcass production. Therefore, hill breeds serve a multi-purpose role to supply lambs for meat production as well as ewe lambs for breeding. Over 50% of lamb carcasses fail to meet target fat and conformation specifications at slaughter, with hill and crossing breeds especially implicated in this problem (Roper, 1999). Breeding for carcass quality in these breeds offers a permanent and cost-effective solution. However, breeding objectives for these breeds should not compromise their adaptive characteristics.

This paper demonstrates, both theoretically and experimentally, the use of indexes developed to improve sustainable, economic performance for UK hill breeds. In this study, the term 'sustainable' refers to increased performance without detrimental correlated decreases in animal welfare, as judged by lamb and ewe mortality. Initial realised responses to selection in experimental flocks of Scottish Blackface sheep are quantified and alternatives to the advocated index explored.

MATERIALS AND METHODS

Selection indexes. Ten breeding goal traits are evaluated for their inclusion in selection indexes and combine both maternal and lamb traits. Maternal traits include mature weight, longevity (age at culling), number of lambs reared, number of lambs lost from birth to weaning, maternal weaning weight and fleece weight. Lamb traits include direct weaning weight, carcass fat class, carcass conformation and carcass weight. Measurements of ultrasonic fat and muscle depth at weaning are used as predictors of carcass merit. Details of the importance of each breeding goal and index trait are given by Conington *et al*. (2001). Two selection indexes were derived to suit the extremes of hill production systems: i) intensive, where all surplus lambs not required for breeding are finished for slaughter and ii) extensive, where all surplus lambs are sold to other farmers for finishing. Whole-farm modelling was used to estimate the economic value of breeding goal traits for the different production systems. The development of these indexes, genetic parameters and economic values used are described by Conington *et al*. (2001). These indexes are currently being evaluated in an experiment on two SAC hill farms.

Evaluation of alternative index. Evaluations of alternative indices were undertaken using selection index theory to calculate expected genetic progress in each goal trait. The consequences of alternative indexes using measurements of fat and muscle on ewes rather than on lambs, and of excluding fleece weight in the breeding goal are discussed by Conington *et al*. (2001). Economically, lamb survival is the most important trait on hill sheep farms, and here we consider the inclusion of lamb survival as a trait of the lamb, in an attempt to accelerate responses to selection in this trait. Genetic parameters were based on those presented by Bishop and MacKenzie (2001). So that we can predict selection responses using BLUP, the selection index calculations assumed the same data structure as that seen in across-flock evaluations of industry sire referencing schemes. For lamb traits, these are measurements on the lamb itself, on the dam of the lamb and on 60 paternal half-sibs of the lamb. For lamb survival, measurements on 60 paternal half sibs were assumed. For maternal traits, these are assumed to be measurements on a ewe, on the dam of the ewe and on 15 female paternal half-sibs of the ewe. For each of the maternal traits, each female has an average of two recordings, in separate parities. The exception is longevity, which has only one measurement or prediction per animal. Lamb survival information is assumed to be available only for half sibs, as the observation on the candidate for selection and on its dam is uninformative, i.e. these animals have survived, by definition.

Experimental farms. The two SAC hill farms used to test the indexes are described in detail by Conington *et al*. (1995), and they differ considerably in topography, rainfall and hill pasture quality. The 'intensive' index is being tested at farm 1, which is situated in the drier, lower, eastern part of Scotland. The 'extensive' index is being tested on farm 2, which has a harsher, wetter climate and steep mountain terrain. Farm 1 has a 680-ewe Scottish Blackface flock and farm 2 has a 540 ewe flock of the same breed. On both farms, single-born lambs graze the poor quality hill pasture whereas twin-born lambs graze re-seeded perennial ryegrass-based swards.

Experimental selection lines. Three selection lines per farm were created in 1998 with the first lambs born in each line in 1999. The three lines were selection (S), control (C) and industry (I). Selection commenced in 1998, using multi-trait BLUP EBVs to calculate the indexes. Five top-performing animals were selected to start the S lines in each of the two experimental farms. A maximum of 2 half sibs and one full sib were used in this line for any one year. In addition, 5 average-performing ram lambs were selected to be sires of the first batch of control line lambs. To constrain inbreeding, no half or full sibs were used. The I line used 4 mature rams bought from industry breeders that do not participate in objective breed improvement programmes. The purpose of this line was to facilitate technology interaction and to compare the impact of traditional *vs.* index selection. For both farms, all three lines were managed together as one flock, except at mating time. Ewes already on the farms rotated across the three lines until they left the flock at the end of their normal lifespan.

Phenotypic differences in responses to selection were investigated for lamb weaning weight, fat class and muscle depth. No maternal traits were compared as only one ewe age group has been born to selected sires in the project to date. Line means were calculated using restricted maximum likelihood (REML) techniques using GENSTAT, accounting for the effects of age of dam, grazing paddock, birth/rearing type, sex and age at weaning (covariate).

RESULTS AND DISCUSSION

Properties of intensive and extensive indexes. Predicted annual progress in each goal trait for the two farm types is shown in Table 1. In general, greater responses are expected in the intensive farm system for all traits compared to the extensive farm systems. With the exception of conformation score and mature size, all predicted responses are in the desired direction. Improvements in maternal characteristics can be achieved alongside increasing lamb weaning and carcass weights, with little change in subjective lamb carcass quality traits.

Evaluation of alternative index. Table 1 also shows predicted responses to the goal traits as a result of implementing the intensive index when lamb survival as a trait of the lamb is included. Again, responses are dominated by maternal traits. Weaning weight is expected to increase considerably and carcass weight modestly. Other traits show little change. Including lamb survival as a trait of the lamb in the index is predicted to slow the rate of increase in mature size, increase lamb survival and reduce the decline in conformation.

Table 1. Expected annual genetic change in each goal trait following selection as 3 indexes

Trait	'intensive' index	'extensive' index	'intensive' + lamb survival
Mature size(g)	654	608	574
Longevity (days)	6.4	7.1	8.9
Fleece weight (g)	21	26	25
Ave. weaning wt. (g)	135	141	109
No. Lambs reared/ewe	0.023	0.020	0.025
No. Lambs lost/ ewe	0.000	0.000	0.000
Lamb survival (prob. of death)	-	-	-0.0026
Weaning weight (g)	371	341	324
Fat class (ESF[A])	-0.007	N/A[B]	-0.010
Conformation (units)	-0.006	N/A	0.001
Carcass weight (g)	121	N/A	110

[A]ESF=estimated subcutaneous fat proportion. [B]No carcass traits in the breeding objective.

Realised responses to selection. Figure 1 shows the responses in overall index score for the three lines on farm 2. It shows that the S line has persistently higher index scores than the C line. The standard deviation of the index score was 115 index points. The index scores for the three lines on farm 1 showed less divergence by year 3, being 208.7, 180.3 and 233.5 for C, I and S lines respectively in 2001, with a standard deviation of the index of 93.7. As the index comprises both maternal and lamb traits, and only one ewe age group has so far been born within the selection experiment, it is anticipated that greater differences will emerge with time, and the economic benefits of selection using the indexes will be realised.

Phenotypic means for lamb weaning weight are shown in Table 2. S line lambs had higher weaning weights than C or I lambs on both farms. Compared to the C line animals, at today's prices (£0.80/kg live weight), lambs born to the S line show an economic advantage for extra weight alone of approximately 99p/head (farm1) and 81p/head (farm 2) at weaning (at an average age of 17 weeks). On both farms, lambs born to the I line were intermediate between the two other genetic lines. As predicted from the index evaluation procedure, no differences were seen between the lines in fat or muscle depths at weaning, with 0.81, 1.02, 0.92 mm fat, and 19.3, 18.4, 19.3 mm muscle for C, I and S lines respectively. Therefore, higher weaning weights have been achieved in the selection line without correlated increases in fatness.

Table 2. Mean weaning weights (kg) for line and farm for 2001-born lambs

	Control	Industry	Selection (s.e.d. = 0.51)
Farm 1	26.8	27.7	28.0
Farm 2	24.4	24.8	25.5

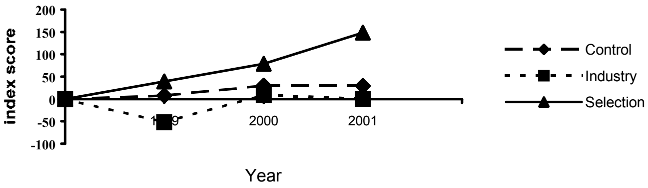

Figure 1. Responses to selection on farm 2

CONCLUSION

We predict that gains in productivity can be made without compromising ewe or lamb survival. The indexes described here are a first step towards improving sustainability and flock performance simultaneously, through genetic selection. By including lamb losses and lamb survival in the breeding goal, the 'wastage' of lambs from birth to weaning will be reduced. Including longevity in the breeding goal will also reduce ewe wastage. Initial responses to selection on farm 2 to these new selection indexes are in line with expectations. Responses in overall index score on farm 1 are lower than anticipated. However, initial results based on phenotypic responses to selection on both farms are promising and indicate that selection for a sustainable increase in productivity should be feasible.

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