MINISTRY OF AGRICULTURE, FISHERIES AND FOOD

CSG 15

Research and Development

Final Project Report

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Project title	A comparison of management systems for wintering hill ewes removed from hill grazings over the winter months.
MAFF project code	**LS1505**
Contractor organisation and location	ADAS Consulting Limited ADAS Redesdale, Rochester Newcastle on Tyne NE19 1SB
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Executive summary (maximum 2 sides A4)

Several extensification schemes have been introduced aimed at rehabilitating degraded heather moorland. Although these differ slightly in their prescriptions, all require a reduction in the number of ewes grazing on areas of semi-natural rough grazing during the winter months. There are three basic options which can be adopted to accommodate those sheep removed; (1) home-winter on areas of improved grassland initially and then house, (2) house for the entire winter, and (3) away-winter. Because of extensification schemes there will be an increase in both the numbers of ewes which are away-wintered and the numbers which are housed for prolonged periods. Both practices potentially create new problems. This experiment compared the physical and financial performances and welfare of ewes being wintered under these three management options, and was done under contrasting conditions provided by sites at ADAS Pwllpeiran and ADAS Redesdale. To take account of seasonal variation in climatic conditions and grass supply the experiment was done over three seasons 1996/97, 1997/98 and 1998/99.

Away-wintered ewes were transported (mean of both sites) 115, 45 and 30 miles in 1996/97, 1997/98 and 1998/99 respectively and used a combination of professional hauliers and the farms own transport to move sheep. In these respects ewes on the away-wintered treatment were transported over distances similar to those reported commercially and used similar means of transport. The results obtained can therefore be considered as being representative of commercial practice.

Animal health was good on all treatments. The numbers of ewe deaths over the winter period were low and similar for all treatments (1%, 2% and 1% for the home-wintered, housed and away-wintered treatments respectively) . Transporting ewes back to their farms of origin late in pregnancy had no major effects on animal welfare as measured by the average number of ewes which aborted (1%, 1% and 2% for the home wintered, housed and away-wintered treatments respectively). The numbers of productive ewes, per 100 ewes mated, was acceptable and similar for all treatments (92, 92 and 93 for home-wintered, housed and away-wintered treatments respectively). Mating ewes either in an away-wintered or indoor situation caused no additional problems as indicated by mean lambing percentages (based on lambs born alive and dead) of 133%, 129% and 143% for the home-wintered, housed and away-wintered treatments

respectively. The significantly ($P<0.05$) higher lambing percentage for away-wintered ewes probably reflected a good grass supply on the receiving farms which enhanced ovulation rate and embryo implantation. Lamb losses were low (overall mean 4.4%) and similar for all treatments resulting in weaning percentages of 121%, 118% and 128% for home-wintered, housed and away-wintered treatments respectively.

All ewes gained live weight over the winter with housed ewes gaining significantly more weight that those on the home-wintered treatment which in turn gained significantly more weight than those on the away-wintered treatment (weight gain was 2.2 kg, 3.1 kg and 1.2 kg, ($P<0.05$) for home-wintered, housed and away-wintered ewes respectively). After lambing all ewes lost similar amount of live weight, but ewes were of an acceptable and similar live weight at lamb weaning (49.8 kg, 50.7 kg and 49.7 kg, $P>0.05$, for home-wintered, housed and away-wintered treatments respectively). Changes in condition scores were less marked than for live weights and were similar for ewes on all treatments throughout.

Lamb birth weights on all treatments were acceptable reflecting satisfactory levels of ewe feeding in mid- and late pregnancy. However, lambs born to ewes on the housed treatment were significantly heavier at birth than lamb born to ewes on the other treatments. This reflected ewes on this treatment being of high live weight and good body condition score at lambing, as a results of being well nourished throughout the winter period. Other than for birth weights, treatment difference in lamb live weights and liveweight gains up to weaning were marginal and not significant. Lambs on all treatments achieved growth rates which were acceptable for hill farming conditions and lambs from all treatments were of similar and acceptable weaning weight (28.1 kg, 28.3 kg and 28.3 kg for home, housed and away-wintered treatments respectively)

The relative costs per ewe of the wintering systems were £9.47, £19.18 and £20.53 for the home-wintered, housed and away-wintered treatments respectively. Housing ewes throughout the winter incurred considerable additional cost compared with home-wintering but with no increase in productivity to offset this (118 *vs* 121 lambs weaned per 100 ewes mated on the housed and home-wintered treatments respectively). Although away-wintered ewes produced more lambs per 100 ewes mated compared with home-wintered ewes (128 *vs* 121), which were slightly heavier at weaning (28.3 kg *vs* 28.1 kg), these increases in productivity, estimated to be worth an additional £1.96/ewe, were not sufficient to compensate for the additional wintering cost. All three wintering systems produced high levels of animal performance with similar good levels of animal health and welfare. However, these levels of performance were not achieved at equal cost and this fact needs to be recognised by policy makers when establishing levels of payment in support of agri-environmental schemes.

In practice, given that animal performance was acceptable on all treatments, the preferred system is likely to be the one which incurs least cost, and home-wintering would be the first choice of most hill farmers. However, farmer choice will be influenced by the proportion of improved grassland available. On farms with less than 5% improved grassland it will be necessary to away-winter at least a proportion of their ewes to prevent grassland productivity and animal performance being adversely affected. On farms with more than 5% improved grassland there is a greater potential to increase overall grassland productivity, and therefore the possibility of wintering ewes at home is most likely. The fact that there are a number of workable options for wintering ewes, each providing acceptable levels of animal performance and welfare, should provide additional confidence to producer to embrace agri-environmental schemes in the future.

This experiment was not set up as a whole systems study, and it is not possible therefore to quantify the effects of winter management treatments on the farm as a whole. However, it is likely that there would be a number of ‘knock-on’ effects. For example, both housing and away-wintering ewes are practices which are likely to result in increased grass availability in the spring. This in turn should reduce ewe feed costs during lactation, encourage good milk yields and hence enhance lamb growth rates, and potentially reduce lamb mortality across the farm. These benefits could not be quantified within the reported experiment, but would impact advantageously on any cost/benefit analysis of wintering systems. It is recommended that further research is done to quantify fully the extent of these likely ‘knock-on’ benefits.

Scientific report (maximum 20 sides A4)

A COMPARISON OF MANAGEMENT SYSTEMS FOR WINTERING HILL EWES REMOVED FROM AREAS OF SEMI NATURAL ROUGH GRAZING DURING THE WINTER MONTHS

Summary

Extensification schemes often require a reduction in the number of ewes grazing on areas of semi-natural rough grazing during the winter months. There are three basic options which can be adopted to accommodate those sheep removed; (1) home-winter on areas of improved grassland initially and then house, (2) house for the entire winter, and (3) away-winter. This experiment compared these three options. Away-wintered ewes were transported on average 63 miles (range 30 to 200). Animal health was good on all treatments and the numbers of ewe death were low and similar for all treatments. Transporting ewes back to their farms of origin late in pregnancy had no adverse effects on animal welfare. On average there were 92 productive ewes, per 100 ewes mated, which was similar for all treatments. Mating ewes either in an away-wintered or indoors situation caused no additional problems as indicated by mean lambing percentages of 133%, 129% and 143% for the home-wintered, housed and away-wintered treatments respectively. Lamb losses were low (overall mean 4.4%) and similar for all treatments resulting in weaning percentages of 121%, 118% and 128%. All ewes gained live weight over the winter with housed ewes (+3.1 kg) gaining significantly more weight that those on the home-wintered (+2.2 kg) treatment which in turn gained significantly more weight than those on the away-wintered treatments (+1.2 kg). After lambing all ewes lost weight, but by weaning ewes were of similar and acceptable weights. Lambs born to ewes on the housed treatment were significantly heavier at birth than lamb born to ewes on the other treatments but thereafter differences in lamb live weights and liveweight gains up to weaning were marginal and not significant. The relative costs per ewe of the wintering systems were £9.47, £19.18 and £20.53 for the home-wintered, housed and away-wintered treatments respectively. Although away-wintered ewes reared slightly more lambs than home-wintered ewes this additional productivity was not sufficient to compensate for the additional wintering cost. All three wintering systems produced high levels of animal performance with similar good levels of animal health and welfare. However, these levels of performance were not achieved at equal cost and this fact needs to be recognised by policy makers when establishing levels of payment in support of agri-environmental schemes.

Introduction

Agricultural policy until the mid 1980s encouraged a large increase in the numbers of sheep maintained in hill and upland areas. This has resulted in a deterioration in the cover and quality of semi-natural rough grazing (SNRG), particularly those areas where heather (*Calluna vulgaris*) is a dominant or co-dominant species (Felton and Marsden, 1990). Recognising the ecological importance of heather, several voluntary extensification schemes have been introduced in recent years, such as the Environmentally Sensitive Area Scheme (ESAs) and Countryside Stewardship Scheme, aimed at reversing this trend. Although these schemes differ slightly in their prescriptions, all require a reduction in the numbers of sheep grazing on areas of semi-natural vegetation over the winter months.

There are three basic options which can be adopted to accommodate those sheep removed; (1) home winter on areas of improved grassland initially and then house, (2) house for the entire winter, and (3) away winter. The requirement to remove, in addition to all ewe hoggs, up to 25% of breeding ewes from SNRG during the winter is likely to increase both the numbers of breeding ewes which are away-wintered and the numbers which are housed for prolonged periods. Both practices will potentially create new problems.

A prolonged period of housing will significantly increase requirements for winter forage which may not be available on hill farms, and the risk is that ewes may be slightly undernourished over several months. This

potentially could adversely affect long-term ewe productivity (Gunn, 1977; Merrell, 1998) and, as a consequence of low lamb birth weights (Robinson and Forbes, 1968; Robinson 1982; Waterhouse and McClelland, 1987), could increase levels of lamb mortality. Whereas ewe lambs from hill farms have been away-wintered for many years and the effects of this practice on sheep physical performance and financial parameters are well documented (Roberts *et al*., 1949; Bradford *et al*., 1961; Purser and Roberts, 1964) little is known about the effects of away-wintering on mature breeding ewes. Mature ewes which are away-wintered will have to be transported back to their farms of origin late in pregnancy with implications for animal welfare and reproductive performance. Alternatively, because of better winter nutrition, conception rates may be increased, and many hill farms are not geared to manage flocks producing a high proportion of twins. These issues had been stressed by producers implementing ESA management prescriptions and MAFF initially commissioned a survey, done by ADAS, to quantify the extent of these problem. While this survey provided valuable information concerning groups of ewes away-wintered, the logistics of away-wintering and its cost (Pickard and Fergus, 1996), it provided no comparative information with similar groups of animals wintered at home.

The aim of this project was to compare animal health and welfare, sheep physical performance and financial performance of ewes which were either away-wintered or managed on their farm of origin so that cost-effective systems of winter management could be developed which maintained acceptable levels of animal performance and welfare.

Objective

The overall objective was to quantify the impact of three systems of winter management on ewe animal health and welfare, sheep physical performance and financial performance of ewes removed from areas of semi natural rough grazing during the winter months. Specifically to quantify the effects of winter management on:-

1. changes in ewe live weights and condition scores from October to March;

2. ewe live weights and condition scores post-treatment by weighing and condition scoring ewes at approximately 50 and 150 days post-treatment;

3. ewe reproductive performance;

4. animal health and welfare;

5. lamb survival and growth performance to weaning;

6. the relative costs of the different management systems.

Materials and methods

Site descriptions

The experiments started in October 1996 and were done in each of three winters (1996/97, 1997/98 and 1998/99) under contrasting climatic and management conditions provided by sites at ADAS Pwllpeiran and ADAS Redesdale. ADAS Pwllpeiran is located twelve miles inland from Cardigan Bay and is representative of a high altitude (range 305 m to 625 m), high rainfall (mean annual rainfall 1905 mm) hill farm. By contrast, ADAS Redesdale is representative of a low altitude (range 240 m to 350 m), low rainfall (mean annual rainfall 875 mm) progressively managed hill farm located in the Rede Valley in North West Northumberland.

Treatments

Each year 300 pure-bred, regular aged Hardy Speckleface ewes and 300 regular aged Scottish Blackface ewes, mated to Blueface Leicester rams, were used for the experiment at ADAS Pwllpeiran and ADAS Redesdale respectively. At each site ewes were allocated to three treatment groups of 100 ewes balanced for ewe age, live weight and condition score. The following winter management treatments were imposed from 1 October to 28 February each winter:-

1) Home wintering, initially on areas of improved grassland and then when necessary housed from late December/early January.
2) Home wintering with ewes housed throughout
3) Away-wintered.

Sheep management

The experiment was run as a field trial under normal farm management and, apart from the period when the ewes were on differential winter management treatments, the management of ewes and their lambs was the same for all groups, and was typical of hill farming systems in Wales and Northumberland.

Management of ewes on home wintered treatment

The 100 Hardy Speckleface ewes were out-wintered on areas of semi-improved pastures. From early January each year ewes were fed *ad libitum* baled silage and self-help feed-blocks. Ewes were pregnancy scanned on average on 1 February when twin-bearing ewes were housed but single-bearing ewes remained at pasture. After scanning, single-bearing ewes continued to be supplemented with silage and feed-blocks but twin-bearing ewes were fed *ad libitum* baled silage plus increasing amounts of compound feed to a maximum of 0.5 kg/hd/day at the point of lambing.

The 100 Scottish Blackface ewes on this treatment initially grazed two adjacent hill reseeds as a single group, before being divided in to two equal mating groups on 20 November each year. Each group of ewes was mated to Blueface Leicester rams which remained with the flock until housing, on average on 8 January each year. From housing until 28 February the ewes were fed *ad libitum* baled silage plus on average 250g/hd/day of sugar beet pulp nuts.

Management of ewes on the housed throughout treatment

The housed Hardy Speckleface ewes were housed in two pens each of 50 ewes on 1 October each year and were fed a diet of *ad libitum* baled silage plus, while the ram were in with the ewes, self-help feed-blocks. The rams were taken out on average on 8 January from which time until pregnancy scanning the ewes were fed *ad libitum*

baled silage alone. After pregnancy scanning, single-bearing ewes were fed *ad libitum* baled silage and feed-blocks and twin-bearing ewes were fed the same baled silage plus increasing amounts of compound feed to a maximum of 0.5 kg/hd/day at the point of lambing.

The Scottish Blackface ewes were housed in two pens each of 50 ewes on 1 October each year and were fed a diet of *ad libitum* baled silage alone up to on average 20 November when the Blueface Leicester rams (one per pen) were introduced. From 20 November until 28 February ewes were supplemented with 250g/hd/day of either a proprietary sheep nut (1996/97) or sugar beet pulp nuts (1997/98 and 1998/99). The rams were removed in early January each year.

Management of ewes on away-wintered treatment

The distances which the 100 Hardy Speckleface ewes were transported in each year are summarised in Table 1. On the receiving farms, ewes were rotationally grazed and were moved regularly around a series of ryegrass/white clover swards at the discretion of the farmer. No supplements were fed to Hardy Speckleface ewes on this treatment in any of the years. On their return to ADAS Pwllpeiran twin-bearing ewes were housed and were fed *ad libitum* baled silage plus increasing amounts of compound feed to a maximum of 0.5 kg/hd/day at the point of lambing, and single-bearing ewes were supplemented with silage and feed-blocks at pasture. Ewes were mated by two Blueface Leicester rams released on average on 15 November each year.

On the receiving farm Scottish Blackface ewes were either set stocked (1996/97) or rotationally grazed (1997/98 and 1998/99) with ewes moved at the discretion of the farmer around a series of ryegrass/white clover swards. In both 1997/98 and 1998/99 ewes always had a good supply of grass available when ADAS staff visited, and, because of this ewes were not supplemented in 1997 and 1998. In 1996/97 grass supply on the receiving farm was limited and ewes were supplemented with 250g/hd/day of sugar beet pulp nuts from 5 November to 28 February. In addition, from 18 December 1996 to 28 February 1997, ewes were also fed a restricted ration of 0.7 kg/hd/day of hay. Ewes were mated by two Blueface Leicester rams released on average on 20 November each year.

Table 1. Distances over which away-wintered ewes were transported (miles)

	1996/97	1997/98	1998/99	Mean
ADAS Pwllpeiran	200	30	30	87
ADAS Redesdale	30	60	30	39
Mean	115	45	30	63

Management of treatment groups at mating time.

At each site a total of six rams were used each year, a team of two rams per treatment giving a ewe to ram mating ratio of 50:1 initially. To try and ensure that any differences in ram fertility did not impact on ewe reproductive performance the ram teams were rotated around the treatment groups on a seven day basis during the first oestrous cycle (21 days after the start of mating). After the first oestrus cycle had been completed one ram from each treatment group was removed leaving a single ram to cover the small number of ewes expected to return to service. Rams were not rotated during the second oestrous cycle.

Management common to all groups

The Hardy Speckleface ewes lambed from mid- March onwards each year with a mean lambing date of 6 April. Ewes rearing single lambs were returned to SNRG as soon as weather conditions allowed. After lambing, twin-rearing ewes were supplemented at grass until there was sufficient herbage available to meet their nutritional requirements. Ewes rearing twin lambs remained on improved pastures throughout the summer until weaning.

Because of the later lambing date at ADAS Redesdale (mean date 20 April) ewes were further from the start of lambing when the differential winter management period ended on 28 February than were the Hardy Speckleface ewes at ADAS Pwllpeiran. This impacted on ewe management at ADAS Redesdale, particularly the management of ewes after the end of the differential management period.

From 1 March to lambing single-bearing ewes from all treatments were amalgamated onto sheltered pastures and were supplemented with *ad libitum* baled silage and self-help feed-blocks. Ewes rearing single lambs were returned to SNRG as soon as practicable after lambing.

On their return to Redesdale twin-bearing ewes on the away-wintered treatment were housed, joining those twin-bearing ewes already housed on the home-wintered and housed treatments. From housing to lambing twin-bearing ewes were fed a basal ration of *ad-libitum* baled silage, supplemented with a total of 26 kg per ewe of compound feed over the last six weeks of pregnancy. After lambing, twin-rearing ewes continued to be supplemented with compound feed until sufficient grass was available to meet their nutritional requirements. Supplementary feeding post-lambing ceased on average on 20 May. After lambing, twin-bearing ewes were initially turned out to sheltered, improved pastures before being transferred back to SNRG on average on 7 June.

At both sites lambs were weaned in August at which point the experiment finished each year.

Assessments

Ewes were weighed and body condition scored at the start (October) and at the end (February) of the treatment period. To quantify any treatment 'knock-on' effects on ewe performance they were also weighed and condition scored in mid-June and mid-August each year.

Lambs were weighed within twenty four hours of birth, and then at routine intervals up to weaning in August.

The amounts of straw, compound feed, hay and silage used were recorded and comprehensive records of sheep health, husbandry and management and financial records were maintained throughout.

Statistical analysis

Ewe and lamb live weights were analysed by analysis of variance as an unbalanced design and ewe condition scores and litter size were analysed by Chi-squared. A preliminary analysis showed significant differences between years and between sites for most measured parameters, but that there were no significant year x treatment or site x treatment interactions. Treatment data are therefore reported meaned across years and sites. There was a significant treatment difference in lamb rearing status, and lamb live weight and liveweight gain data were therefore corrected using rearing status as a covarate.

Results and discussion

This report summarises work done between October 1996 and December 1999. During this period all scientific objectives were achieved and all project 'milestones' were delivered in full, to agreed deadlines.

In this experiment ewes were transported on average 115, 45 and 30 miles in 1996/97, 1997/98 and 1998/99 respectively with distances ranging from 30 miles to 200 miles. Ewes were transported by a combination of professional hauliers and by the host farm's own transport (landrover and horse box). In these respects ewes on the away-wintered treatment were transported over distances similar to those reported commercially and using similar means of transport (Pickard and Fergus, 1996). The results obtained can therefore be considered as being representative of commercial practice.

In this experiment away-wintered ewes were sent to a total of four receiving farms only. It must be accepted that there is likely to exists some variation in sheep performance between receiving farms, attributable to seasonal and management differences. Indeed, this has been clearly demonstrated from ewe hogg wintering experiments (Roberts *et al*., 1949; Bradford *et al*., 1961; Purser and Roberts, 1964). However, these same experiment also showed that difference in animal performance between home and away-wintered treatments were consistently greater than differences recorded between receiving farms. While accepting that the number of receiving farms in this study was small, it is likely that difference between treatments will be sufficiently large to mediate any variations between receiving farms.

Animal Health and welfare

The health and welfare of ewes on the experiment was generally good with few treatment differences. The numbers of ewes which died over the winter period were low (mean 1%) compared with those recorded on commercial hill farms (Merrell, 1996; MLC 1998 and 1999) and were similar for all treatments (Table 2). Ewe deaths on the home-wintered treatment were slightly lower than that normally recorded at the two ADAS Research Centres (1% *vs* 2-3%). This probably reflected the fact, that in this experiment, ewes were removed from exposed SNRG to more sheltered grazing for the entire winter period. Normal commercial practice on hill farms is for single-bearing ewes to remain on SNRG for the entire winter and twin-bearing ewes are normally housed only for the last eight weeks of pregnancy. Surprisingly, ewe deaths were highest on the housed treatment which might have been expected to provide a more sheltered environment thereby promoting ewe survival (Alliston and Lucas, 1979). Housing ewes for a prolonged period caused no specific health problems at either site. Good ventilation and frequent foot-bathing prevented outbreaks of pneumonia and lameness the two most likely problems associated with prolonged housing.

Transporting ewes late in pregnancy is perceived by many commercial producers to be contrary to good animal welfare. As assessed by the number of ewes which aborted on each treatment there is little to suggest from this experiment that transporting ewes from their wintering farm back to their farm of origin compromised animal welfare. Although the numbers of ewes which aborted on the away-wintered treatment were higher than for ewes on either the home-wintered and housed throughout treatments, they were still low compared with commercial flocks (Slee, 1979; Stubbings and Greig, 1994).

Interestingly the numbers of ewes which aborted on the away-wintered treatment tended to be slightly higher at ADAS Redesdale, where ewes were transported over less distance, and were further from the start of lambing when transported, than were ewes on this treatment at ADAS Pwllpeiran (3%, 4% and 2% *vs* 0%, 2% and 1% in 19966/97, 1997/98 and 1998/99 respectively) This result may suggests that distance *per se* is not the main issue when transporting sheep in late pregnancy, and that the stage of pregnancy may impact more on sheep welfare. Ewes transported within about one month of lambing as at ADAS Pwllpeiran may be better able to tolerate this disturbance than ewes six weeks from lambing as at ADAS Redesdale.

Table 2. Effects of winter management on flock productivity per 100 ewes mated (Mean 1997 - 1999)

	Home	Housed	Away	sed
Ewe deaths	1	2	1	---
Barren ewes	6	5	4	---
Ewes aborted	1	1	2	---
Productive ewes	92	92	93	---
Lambs born	133	129	143	---
Stillbirths	6	6	9	---
Born alive	127	123	134	---
Lamb deaths	6	5	6	---
Lambs reared	121	118	128	---
Mean litter size$^{\Psi}$	1.45^{a}	1.40^{a}	1.54^{b}	0.034 *

$^{\Psi}$ lambs born alive and dead per ewe carrying to term
Within rows mean followed by a different superscript differ significantly ($P<0.05$)

Flock productivity

The numbers of productive ewes were similar on all treatment and acceptable for a hill farming system (Merrell, 1996; MLC 1997, 1998, 1999). The numbers of barren ewes were similar to those reported commercially (MLC, 1998) but considerably higher than those reported for hill sheep by Smith *et al*., (1995). Treatment differences in the numbers of barren ewes were not large and it is interesting to note that, for the housed treatment, the numbers of barren ewes were in-line with the other two treatments. It is perceived by many commercial producers that mating ewes indoors, as was the case for the housed treatment, adversely affects reproductive performance primarily as a consequence of a high barren rate. Clearly this was not the case in this experiment.

For hill farming systems the relatively high numbers of lambs born on all treatments reflects the fact that ewes were mated on a high plane of nutrition before and during mating which is known to increase ewe reproductive performance (Gunn et al., 1984; Merrell, 1990a). This was most marked for ewes on the away-wintered treatment reflecting good grass supplies on the receiving farms. The results also demonstrate the adequacy of the plane of nutrition achieved on the home-winter and housed treatments.

Mean litter size (lambs born alive and dead) was significantly ($P<0.05$) higher on the away-wintered treatment (1.54 lambs/ewe) than on either the home wintered or housed treatments, which did not differ significantly (1.45 lambs/ewes *vs* 1.40 lambs/ewe respectively). All three winter management systems resulted in high numbers of twin lambs compared with those produced by ewes mated on SNRG (Davies, 1987), with an average of 43 ewes per 100 ewes mated producing twin lambs. This could potentially cause major management problems on hill farms where resources may preclude the preferential management of twin-bearing ewes during late pregnancy. This could adversely affect lamb birth weights and increase lamb mortality considerably. Both ADAS Pwllpeiran and ADAS Redesdale are sufficiently well resourced to accommodate and manage high numbers of twin-bearing ewes and this was reflected in this experiment by good lamb birth weights (Table 4) and low levels of lamb mortality (Table 2).

The proportion of stillbirths was higher on the away-wintered treatment (6.3%) than on the home and housed treatments (4.5% and 4.6% respectively) possibly indicating some adverse effects of transporting ewes late in pregnancy.

Lamb mortality overall was 4.4%, about half that reported for MLC Flcokplan recorded hill flocks (MLC, 1996, 1997, 1998), but was similar to that achieved long-term in ADAS managed flocks (Merrell, 1996). Winter management treatment had little effect on lamb mortality which was 4.7%, 3.9% and 4.4% for the home, housed and away-wintered treatments respectively, despite ewes on the away-wintered treatment rearing considerably more, potentially vulnerable, twin lambs (Purser and Young, 1983; Merrell, 1996).

Throughout and at both sites, flock output (numbers of lambs weaned), was acceptable for hill farming systems (MLC, 1999). This reflected good, overall standards of husbandry and management at ADAS Pwllpeiran and ADAS Redesdale. On average lambs weaned per 100 ewes mated were 121, 118 and 128 for the home-wintered, housed and away-wintered treatments respectively. The superior performance of ewes on the away-wintered treatment reflected almost entirely the greater number of lambs conceived, compared with the other two treatments, as lamb losses were similar for all treatments.

Ewe live weights and condition scores

On average ewes were of high live weight (mean 50.7 kg, se $\pm$ 0.41) and good condition score (mean 3.05, se $\pm$ 0.018) at the start of the winter period. Thereafter over the winter all ewes gained in live weight, with those on the housed treatment gaining significantly more weight than those on the home-wintered treatment, which in turn gained significantly more weight than those on the away-wintered treatments (+ 3.1 kg > + 2.2 kg > 1.2 kg sed 0.331, $P>0.05$). By comparison ewe remaining on the open hill over the winter would be expected to lose on average 6.5 kg between November and March (Merrell, 1998).

At the end of the winter period ewes on the home-wintered and housed treatment were of similar live weight and were significantly heavier than those on the away-wintered treatment (Table 3). The fact that ewes on the away-wintered treatment were lighter at the end of the wintering period probably reflected a dwindling supply of available herbage on the receiving farms as the season progressed, adversely affecting level of nutrition of away-wintered ewes. Surface sward height on the receiving farms was on average 8 cm in November but had fallen to < 3 cm at the end of February. However, this possible period of under-nutrition must have been for a relatively short period as mean litter size was significantly higher in ewes on this treatment (Table 1), reflecting a good plane of nutrition immediately before and during the mating period (Gunn et al., 1984; Merrell, 1990a) and lamb birth weights were good, reflecting adequate nutrition to promote good placental development over the first 90 days of pregnancy (Waterhouse and McClelland, 1987; Waterhouse *et al.*, 1992).

It is interesting to note that ewes on the away-wintered treatment were not heavier than ewes wintered at home at the end of the wintering period. This is contrary to the results obtained for ewe hoggs where most studies have shown a significant weight advantage to ewe hoggs away-wintered (Roberts *et al*., 1949; Bradford *et al*., 1961; Purser and Roberts, 1964). The lack of response in live weight of ewes on the away-wintered treatment is not readily explainable.

After lambing, ewes on all treatments lost a similar amount of live weight up to weaning (- 3.0 kg *vs* -3.2 kg *vs* -2.1 kg, for home, housed and away-wintered respectively, sed 0.586 $P>0.05$) and were of a similar and commercially acceptable weight at weaning in August (Table 3).

Treatment differences in condition scores were generally less marked than for live weights and were also less consistent. In general, changes in condition scores followed a similar pattern to live weights and were acceptable for all treatments and at all stages in the production cycle.

Table 3. Effects of winter management on ewe live weights (kg) and condition scores[Ψ] (mean 1997 - 1999)

	Home	Housed	Away	sed
Live weights				
October	50.6	50.8	50.6	0.591 NS
February	52.8[a]	53.9[a]	51.8[b]	0.613 *
June	51.2	51.6	51.3	0.526 NS
August	49.8	50.7	49.7	0.528 NS
Condition scores				
October	3.05	3.06	30.3	0.024 NS
February	2.94	2.99	2.97	0.026 NS
June	2.82	2.83	2.86	0.028 NS
August	2.78	2.79	2.77	0.026 NS

[Ψ] score 0 to 5, where 0 = very thin and 5 = very fat.
Within rows mean followed by a different superscript differ significantly ($P<0.05$)

Lamb live weights and liveweight gains

An initial analysis showed that there was a significant difference in lamb rearing status between treatments, with ewes on the away-wintered treatment rearing significantly more potentially slower growing twin lambs. Lamb live weight and liveweight gain data were therefore corrected using rearing status as a covarate.

Lamb birth weights on all treatments were acceptable, reflecting adequate levels of feeding in mid-pregnancy (Waterhouse and McClelland, 1997) and late pregnancy (Robinson, 1983 and 1990). However, lambs born to ewes on the housed treatment were significantly heavier at birth than lambs born to ewes on the other treatments (Table 4). This reflected ewes on this treatment being of high live weight and good body condition score at lambing, as a results of being well nourished throughout the winter period. The higher birth weight of lambs on this treatment was associated with a slightly lower level of lamb mortality (Table 4) a relationship which is well documented in other reports (Robinson and Forbes, 1968; Robinson and Scott, 1977; Robinson, 1982).

After lambing, treatment difference in lamb live weights and liveweight gains up to weaning were marginal and not significant. Lambs on all treatments achieved growth rates which were acceptable for hill farming conditions.

Table 4 Effects of winter management on lamb live weights and growth rates to weaning (mean 1997 - 1999)

	Home	Housed	Away	sed
Live weight (kg) $^{\Psi}$				
At birth	3.94^{b}	4.07^{a}	3.96^{b}	0.044 *
At 35 days of age	14.5	14.6	14.6	0.227 NS
At 120 days of age	28.1	28.3	28.3	0.279 NS
Daily liveweight gain (g/day) $^{\Psi}$				
Birth to 35 days	242	244	243	3.996 NS
35 days to 120 days	178	186	185	3.769 NS
Birth to 120 days	199	201	201	1.888 NS

$^{\Psi}$ data corrected using rearing status as a covariate
Within rows mean followed by a different superscript differ significantly ($P<0.05$)

Feed consumption and wintering costs

Feed consumption and wintering costs for the period 1 October to 28 February are summarised in Table 5. As expected the home-wintering system was the least expensive and the away-wintering system the most expensive. The difference in cost between the housed and away-wintered systems was less than expected. This reflected the high cost associated with the purchase of straw on the housed treatment and the relatively low 'Tack' cost on the away-wintering treatment. In the experiment 'Tack' costs averaged £0.55 per ewe per week. Commercially producers can pay more than £1.00 per ewe per week (personal communication Mervyn Edwards, FRCA). These costs also assume that buildings were available to house sheep removed from SNRG during the winter months. Sheep housing is very limited on most hill farms and to erect a sheep shed specifically to accommodate ewes could add a further £6 to £9 per ewe (sheep shed at between £60 and £90 per ewe place, depreciated over 10 years) to the cost of the housed treatment.

The costs summarised above are the relative cost associated with the three management system over the statutory period when ewes must be removed from SNRG, 1 October to 28 February. However, this does not represent the total costs associated with the three management systems. There are various knock-on effects of the treatments such as proportionally more twin-bearing ewes on the away-wintered treatment which incurred additional costs out with of the experimental period, including the period between 28 February and the start of lambing needs to be accounted for. These additional costs were calculated at £4.23, £4.42 and £5.08 per ewe for ewes on the home, housed and away-wintered treatments respectively. This resulted in a total cost for the different winter management systems of £9.47, £19.18 and £20.53 per ewe.

Housing ewes throughout the winter incurred considerable additional cost compared with home-wintering (£19.18 *vs* £9.47) but with no increase in productivity to offset this (118 *vs* 121 lambs weaned per 100 ewes mated for ewes on the housed and home-wintered treatments respectively). Although away-wintered ewes produced more lambs than home-wintered ewes (128 *vs* 121 lambs weaned per 100 ewes mated), and their lambs were slightly heavier at weaning (28.3 kg *vs* 28.1 kg), these increases (worth an estimated additional £1.96 per ewe) were not sufficient to compensate for the additional cost of away wintering. All three wintering systems produced high levels of animal performance, animal health and animal welfare. However, these levels of performance were not achieved at equal cost, and this fact needs to be recognised by policy makers when establishing levels of payment in support of agri-environmental schemes.

Table 5. Effects of winter management system on feed consumption and wintering costs 1 October to 28 February (mean 1997 - 1999)

	Home-wintered	Housed	Away-wintered
Amounts (kg/ewe)			
Hay	1.2	0	6.8
Silage	118	335	0.0
Feed-blocks	4.5	6.94	0.2
Compound (nuts)	0	1.71	1.7
Sugar beet pulp nuts	8.3	13.62	3.1
Straw	7.4	75.3	0.0
Cost (£/ewe)			
Hay	0.11	0.00	0.60
Silage	2.68	7.53	0.00
Feed-blocks	1.13	1.74	0.06
Compound (nuts)	0.00	0.28	0.29
Sugar beet pulp nuts	0.96	1.58	0.42
Straw	0.36	3.63	0.00
Transport	0.00	0.00	2.08
Tack	0.00	0.00	12.00
Total	5.24	14.76	15.45

Hay @ £91/t; silage @ £22.47/t; feed-blocks @ £251/t; compound sheep nuts @ £163/t; sugar beet pulp @ £116/t and straw @ £48.20/t

General discussion

In this experiment the treatments were not established as part of a whole systems study and it is not possible to quantify the effects of winter management of ewes on the whole farm. However, it is likely that within a system, those ewes remaining on SNRG over the winter would benefit from the 25% of ewes being removed, with the possibility of improved animal performance (Merrell *et al.*, 2000) potentially helping to offset some of the additional costs associated with the housed and away-wintered treatments.. The design of this experiment did not allow this to be quantified.

Both housing and away-wintering ewes are practices which are likely to result in increased grass availability in the spring (Johnson and Evans, 1987; Johnson and Merrell 1994). This in turn should reduce ewe feed costs during lactation (Merrell, 1990b), encourage good milk yields and hence enhanced lamb growth rates (Young *et al.*, 1980; Milne *et al*., 1981), and potentially reduce lamb mortality across the farm. These benefits could not be quantified within this experiment, but would impact advantageously on any cost/benefit analysis of the wintering systems.

In practice, given that animal performance was acceptable on all treatments, the preferred system will be the one which incurs least cost, and home-wintering would be the first choice of most hill farmers. However, farmer choice will be influenced by the proportion of improved grassland available. On farms with less than 5% improved grassland it will be necessary to away-winter at least a proportion of their ewes to prevent grassland productivity and animal performance being adversely affected. On farms with more than 5% improved grassland there is a greater potential to increase overall grassland productivity, and therefore the possibility of wintering ewes at home is most likely.

Conclusions

The results clearly show that ewes removed from hill grazing between 1 October and 28 February, to encourage heather moorland recovery, could be successfully wintered on all three management systems evaluated. Standards of animal health were high on all treatments and there was no indication that either transporting ewes late in pregnancy or a prolonged period of housing compromised animal welfare. Sheep performance was good throughout and treatment differences were in the main marginal and not significant, with the notable exception that ewes on the away-wintered treatment conceived and reared more lamb than ewes on the home-wintered and housed treatments. Whereas treatment differences in animal performance were generally not large, the costs per ewe of the three winter management treatments differed considerably, with ewes on both the housed and away-wintered treatments incurring twice the cost of those wintered at home. Although away-wintered ewes produced more lambs than home-wintered ewes, this increases in productivity was not sufficient to compensate for the additional cost of away wintering. All three wintering systems produced high levels of animal performance, animal health and animal welfare. However, these levels of performance were not achieved at equal cost and this fact needs to be recognised by policy makers when establishing levels of payment in support of agri-environmental schemes. The impact of the three winter management systems on the farms as a whole could not be quantified from this experiment, but both housing for a prolonged period and away-wintering could be expected to impact advantageously on the whole farm system. This topic should be investigated further to quantify fully the impact of ewe winter management systems on whole farm systems.

Recommendations

At the request of the customer, this experiment was not set up as a full systems study. It is likely that winter management of ewes, particularly housing for a prolonged period and away-wintering, will have considerable advantageous 'knock-on' effects on grass availability and animal performance across the farm as a whole. This could not be quantified from the reported experiment but it is a topic worthy of further investigation given the continued importance of agri-environment schemes to hill farming systems.

An Advisory Booklet giving the practical implications of this work could be produced for MAFF, to distribute to Project Officers and to sheep farmers participating in extensification schemes. Given that support payments in the future are likely to be linked more closely to extensification criteria, particularly in hill and upland areas, a booklet which provides practical guidelines on wintering systems is likely to be received favourably, by producers already concerned about the management implications of removing ewes from areas of semi-natural vegetation over the winter months.

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Technology transfer

The results of this project have been disseminated at a number of scientific and technical events, details of which are summarised below:-

Publications

Merrell, B.G., Wildig, J and Davies, O.D. (2000). Moorland conservation and hill sheep performance. In *Proceedings of the Heather Trust Conference*, Battleby, 1999 (in press).

Davies, O.D. (2000). Effects of winter management on sheep performance and welfare. In *ADAS Research 1998/99* (in press).

Presentations

- Staff and students from Newcastle, Sunderland, Aberdeen, Nottingham and Bangor Universities and from Newton Rigg, Kirkley Hall, WIRS and the Scottish Agricultural Colleges;

- MAFF and WOAD staff including Mr R Cowan, Mr M Roper, Drs Wall and Hennessey.
- Martin Newman (EU Sheep Commissioner);
- Nuffield Scholars.
- NSA organised sheep meeting (Spring 1999)
- MAFF/NSA Technology Transfer Sheepnights at Brecon and Ruthin
- Northumberland NFU organised sheep producers meeting
- Northern Uplands 5B Moorland Regeneration Project - demonstration event.
- Sheep 1998
- Parties of farmers and visitors to ADAS Pwllpeiran and ADAS Redesdale (approximately 1200 people).
- Staff from the Heather Trust, Scottish Natural Heritage, Northumberland National Park and CCW.
- Pwllpeiran's open day, February 1999
- Redesdale's organic and environment open day, August 1999
- The results of this work have formed part of environment training days organised for staff from:-
  English Nature
  National Trust
  Northern Uplands 5B Moorland Regeneration Project, Project Officers
  Farming and Rural Conservation Agency, Project Officers

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