MINISTRY OF AGRICULTURE, FISHERIES AND FOOD

Research and Development

Final Project Report

(Not to be used for LINK projects)

Project title	Effects of best management practices and supplementing ewes with Vitamin E on reducing lamb mortality
MAFF project code	**LS1507**
Contractor organisation and location	ADAS Consulting Limited ADAS Redesdale, Rochester, Otterburn Newcastle on Tyne NE19 1SB
Total MAFF project costs	£ 136993
Project start date	01/01/97
Project end date	31/12/99

Executive summary (maximum 2 sides A4)

Despite the considerable amount of R&D which has been done to identify those practices which are likely to reduce lamb mortality, an estimated 4 million lambs still die each year, with a potential value of £120 M. In addition to the significant financial losses, there are implications for the welfare of sheep.

The causes of lamb mortality are numerous, but known, and there are many interrelated factors which influence it. The reduction of lamb mortality requires, therefore an holistic approach to management whereby information available from many disciplines including veterinary, nutrition, genetics and grassland agronomy is combined to produce guidelines of best management practices. It has clearly been shown that, where the available information is implemented effectively, such as is the case on ADAS Research Centres, then lamb mortality rates can be reduced considerably below levels currently reported for commercial production. There is a clear need, therefore, for technology transfer to ensure that all the existing knowledge is effectively demonstrated to, and is practised by, commercial producers.

A major issue to be addressed is the high number of lambs on hill and upland farms which die from hypothermia and starvation. There is growing evidence that Vitamin E is currently fed at levels below those required by sheep and an indication that supplementing ewes with Vitamin E in pregnancy improves lamb vigour and reduces neonatal lamb losses. This research has been done mainly in highly controlled indoor experiments or under climatic conditions and farming systems not wholly appropriate to the UK. The aim of the reported work was to reduce the numbers of lamb deaths, particularly those caused by hypothermia and starvation, on hill and upland farms. This was achieved by defining Best Management Practices specific to hill and upland systems, and by quantifying the impact of Vitamin E supplementation on the vigour and survival of lambs.

Generic best management practices, including veterinary strategies, specific to hill and upland systems were derived from collating research information, using practical experience derived from well-managed sheep on ADAS Research Centres and by drawing on the expertise of members of the Project Steering Group. These were further refined to take account of physical and financial constraints operating on each of four commercial hill farms to produce site-specific management practices. Best Management Practices have been implemented successfully on three demonstration farm, one in each of Northumberland, Devon and Wales since November 1997. A fourth demonstration farm established in Cumbria withdrew from the project in 1998 but has been successfully replaced by another farm in Cumbria, with the new farm coming on line for the 1999 lambing season. Demonstration farm results show that total lamb losses (dead at birth and died subsequently) ranged from 5% - 11%, with neonatal mortality (born alive but subsequently died) ranging from 3% to 6%. On each demonstration farm, total lamb losses and lamb mortality were lower in 1999 than in the 1998 baseline year indicating the effectiveness of Best Management Practices as a mean of reducing lamb losses. The demonstration farms have provided the focus for a comprehensive successfully implemented technology transfer programme.

In two experiments when pregnant twin-bearing ewes were supplemented with additional Vitamin E in-feed, Vitamin E supplementation at rates greater than 100 mg dl-alpha tocopheryl acetate per ewe per day significantly raised ewe plasma and colostrum Vitamin E levels, compared with untreated control ewes, and this was associated with significantly higher plasma Vitamin E levels in their lambs (3.7, 3.9, 3.3, 4.9, 6.3 and 6.9 μmols/l, $P<0.05$, for 0, 50, 75, 100, 150 and 300 additional mg vitamin E per day). Vitamin E supplementation improved significantly the times taken to achieve a number of clearly definable measures of lamb vigour and also significantly increased lamb growth rates. As expected, given the overall low level of lamb mortality on ADAS Research Centres, Vitamin E supplementation was not associated with a reduction in lamb mortality in either of these experiments.

When slow-release, rumen-boluses were used as a means of supplementing ewes with Vitamin E in late pregnancy the results obtained were more marginal and less consistent. Nevertheless, the results suggest that, in some instances, Vitamin E rumen-boluses given to ewes in late pregnancy can increase significantly lamb plasma Vitamin E levels (5.0, 5.1 and 6.6 μmols/l, $P<0.05$, for control ewes and ewes receiving either a single 5 g rumen bolus six weeks pre-lambing or two 2.5 g boluses, one at six weeks pre-lambing and the second at three weeks pre-lambing, respectively) and lamb vigour at birth.

Vitamin E supplementation had no beneficial effects on ewe live weights and condition scores, but there was some limited evidence to suggest that it impacted advantageously on ewe activity immediately after giving birth.

The sustained technology transfer campaign has done much to increase producer awareness of the factors which predispose high levels of lamb mortality. If successfully implemented by commercial producers the information provided will result in a reduction in lamb deaths on hill and upland farms. The technology transfer campaign has also generated much interest from veterinary surgeons and consultants advising sheep producers on sheep husbandry and management. This will also help reduce lamb mortality longer-term.

The results from the Vitamin E experiments have shown clearly that lamb vigour and growth are enhanced when ewes are supplemented in-feed with Vitamin E during late pregnancy. The results obtained for Vitamin E boluses have been less consistent but, again, there is evidence to suggest that lambs born to ewes receiving Vitamin E boluses are also more vigorous at birth. Under conditions providing higher levels of environmental stress, and where lamb mortality rates are higher than those experienced on ADAS Research Centres, it is likely that improvements in lamb vigour immediately after birth will be translated into a reduction in lamb deaths. Therefore the results of this work will potentially improve the underlying efficiency of hill sheep production by reducing lamb deaths, thereby increasing the competitiveness and financial viability of hill and upland farms.

This in-turn should help ensure the continuation of livestock farming in less favoured areas. A reduction in lamb mortality will also improve animal welfare.

Scientific report (maximum 20 sides A4)

THE EFFECTS OF IMPLEMENTING BEST MANAGEMENT PRACTICES AND SUPPLEMENTING EWES WITH VITAMIN E IN PREGNANCY ON REDUCING LAMB MORTALITY ON HILL AND UPLAND FARMS

Summary

Despite the considerable amount of R&D which has been done to identify those practices which are likely to reduce lamb mortality, an estimated 4 million lambs still die each year. The aim of this project was to reduce the numbers of lamb deaths, particularly those caused by hypothermia and starvation, on hill and upland farms by implementing and demonstrating Best Management Practices on commercial hill farms, and by experimental work to quantify the impact of Vitamin E supplementation of ewes during late pregnancy on the vigour and survival of lambs. Best Management Practices have been implemented successfully on three demonstration farm, one in each of Northumberland, Devon and Wales since November 1997. The results show that total lamb looses (dead at birth and died subsequently) ranged from 5% - 11%, with neonatal mortality (born alive but subsequently died) ranging from 3% to 6%. On each demonstration farm total lamb losses and lamb mortality were lower in 1999 than in the 1998 baseline year indicating the effectiveness of Best Management Practices as a mean of reducing lamb losses. The demonstration farms have provided the focus for a comprehensive successfully implemented technology transfer programme. When pregnant twin-bearing ewes were supplemented with additional Vitamin E in-feed, Vitamin E supplementation at rates of greater than 100 mg dl-alpha tocopheryl acetate per day significantly raised ewe plasma and colostrum Vitamin E levels, compared with untreated control ewes, and this was associated with significantly higher plasma Vitamin E levels in their lambs. Vitamin E supplementation improved significantly the times taken to achieve a number of clearly definable measures of lamb vigour and also . significantly increased lamb growth rates. When slow-release, rumen-boluses were used as a means of supplementing ewes with Vitamin E in late pregnancy, the results obtained were more marginal and less consistent. Nevertheless, the results suggest that in some instances Vitamin E rumen-boluses given to ewes in late pregnancy can increase significantly lamb plasma Vitamin E levels and lamb vigour at birth. Vitamin E supplementation had no beneficial effects on ewe live weights and condition scores but there was some evidence to suggest that it impacted advantageously on ewe activity immediately after giving birth. As expected, given the overall low level of lamb mortality on ADAS Research Centres, Vitamin E supplementation was not associated with a reduction in lamb mortality in these experiments.

Introduction

Despite the considerable amount of R&D which has been done to identify those practices which are likely to reduce lamb mortality, an estimated 4 million lambs still die each year, with a potential value of £120 M (ADAS, 1990). In addition to the significant financial losses, there are implications for the welfare of sheep.

The causes of lamb mortality are numerous, but known, and there are many interrelated factors which influence it. The reduction of lamb mortality requires therefore, an holistic approach to management whereby information available from many disciplines including, veterinary, nutrition, genetics and grassland agronomy is combined to produce guidelines of best management practices. It has clearly been shown that, where the available information is implemented effectively, such as is the case on ADAS Research Centres, then lamb mortality rates can be reduced considerably below levels currently reported for commercial production (Merrell, 1996a). There is a clear need, therefore, for technology transfer to ensure that all the existing knowledge is effectively demonstrated to, and is practised by, commercial producers.

A major issue to be addressed is the high number of lambs on hill and upland farms which die from hypothermia and starvation (Wiener *et al.*, 1983; Nitter, 1987; Merrell, 1996b). There is growing evidence that

Vitamin E is currently fed at levels below those required by sheep (Stubbings, 1996), and an indication that supplementing ewes in pregnancy with Vitamin E improves lamb vigour and reduces neonatal lamb losses (Thomas *et al.*, 1995; Williamson *et al.*, 1995). This research has been done mainly in highly controlled indoor experiments or under climatic conditions and farming systems not wholly appropriate to the UK. Therefore, a three year project was done which aimed to reduce the numbers of lamb deaths, particularly those caused by hypothermia and starvation, on hill and upland farms. This was achieved by implementing and demonstrating Best Management Practices on four commercial farms, in association with a comprehensive technology transfer campaign, and by experimental work to quantify the impact of Vitamin E supplementation of ewes during late pregnancy on the vigour and survival of lambs.

Objectives

The overall aim of this work was to reduce the numbers of lamb deaths, particularly those caused by hypothermia and starvation, on hill and upland farms. This was to be achieved by defining Best Management Practices specific to hill and upland systems, and by quantifying the impact of Vitamin E supplementation on the vigour and survival of lambs. The original specific scientific and technical objectives were to:-

1. define Best Management Practices specific to hill and upland farms;

2. implement Best Management Practices on the demonstration farms, quantify benefits on lamb survival, and use these farms as a focus for a technology transfer campaign;

3. quantify the effects of supplementing pregnant ewes with Vitamin E in feed on ewe and lamb performance, plasma and colostrum Vitamin E levels and the viability and survival of lambs;

4. develop a practical means of administering Vitamin E to extensively managed hill sheep;

5. demonstrate the beneficial effects of Vitamin E supplementation in reducing lamb mortality on commercial hill farms once a suitable Vitamin E administration system for hill sheep has been developed.

Because of unavoidable outbreaks of disease on two of the demonstration farms, and inconclusive results obtained for the prototype slow release Vitamin E bolus, the original project objectives could not be achieved fully within the original timescale. The project was extended by MAFF for an additional 12 months and as a consequence of this a number of changes to the original scientific objectives were agreed with Dr Garwes these are summarised below:-

1. Replace the original North West demonstration farm.

2. Further refine a prototype slow release Vitamin E rumen bolus to more consistently release a supply of Vitamin E and evaluate under controlled conditions at ADAS Pwllpeiran and at ADAS Redesdale in 1999.

3. Postpone the evaluation of a Vitamin E rumen bolus system on reducing lamb mortality on a commercial hill farm until Spring 2000.

Material and methods

The project had two discrete but associated components. These are firstly the setting up of demonstration farms to implement Best Management Practices and to act as a focus for a comprehensive technology transfer campaign to effectively disseminate existing information, relevant to reducing lamb mortality, to hill and upland sheep producers, and secondly a research component designed better to quantify the effect of Vitamin E supplementation on lamb survival and animal performance.

Best Management Practices

Although at the outset a number of publications (SAC, 1983; ADAS, 1990; MAFF, 1995) defining Best Management Practices already existed these were in the main too general to be fully effective. Therefore, the initial stage of this project was to define generic Best Management Practices which were specific to hill and upland sheep systems. This was done by identifying from the information currently available and by using practical experience derived from well-managed ADAS Research Centres, specialising in hill and upland sheep production, those aspects of management which reduce lamb losses considerably. Once developed, Generic Best Management Practices, including veterinary strategies, specific to hill and upland systems were further refined to take account of physical and financial constraints operating on each of four commercial hill farms which were to be used as project demonstration farms. Four site-specific Best Management Practice documents were ultimately produced for use in this project.

Demonstration farms

Best Management Practices were implemented under the supervision of experienced ADAS Consultants, supported by veterinary expertise provided by staff from Intervet UK Limited, Hoechst Roussel Vet and Veterinary Laboratories Agency, on four commercial hill farms, with known levels of lamb mortality. These farms, one in each of Northumberland, Devon and Wales implemented best practices from November 1997. A fourth demonstration farm established in Cumbria withdrew from the project in 1998 but was successfully replaced with another farm in Cumbria, with the new farm coming on line for lambing in 1999.

Chillingham Home Farm, Northumberland - covers 147 ha of which 122 ha are hill grazing and 25 ha are mowable permanent pasture. The farm carries 300 Cheviot ewes with all ages bred-pure except three crop ewes which are mated to Suffolk sires. In addition to the upland flock the farm carries 600 lowland Mules and 50 beef cattle. Ewes are usually flushed on inbye pastures for two weeks prior to mating and are transferred back to hill grazing from early January to one week pre-lambing in late-March. Ewes are usually fed hay and self-help feed-blocks plus compound feed from about eight weeks pre-lambing. As part of Best Practice, ewes were pregnancy scanned and twin-bearing ewes were managed preferentially for the first time in 1998. Other changes to management included a re-evaluation of the veterinary programme and the introduction of condition scoring as a guide to management.

Slade Farm, Devon - covers 140 ha permanent pasture rising in altitude from 170 m to 280 m. It carries 550 breeding ewes of which 100 are Scottish Blackface ewes mated to Blueface Leicester sires, 200 are Exmoor Horn (40 bred-pure and 160 mated to Blueface Leicester sires) and 250 are North Country Mules mated to either Suffolk or Charollais terminal sires. In addition, the farm carries 65 dairy cows plus 70 followers. Ewes are flushed and tupping is from 22 October each year. Scottish Blackface ewes are out-wintered but lambed indoors, and the Exmoor Horn and Mule ewes were housed from mid-January onwards each year. Changes to management as a consequence of Best Practice included a critical look at feeding management, the vaccination of ewes against abortion and a more rigorous culling policy of draft aged animals.

Llandre, Pumsaint - covers 85 ha hill grazing rising in altitude from 185 m to 305 m. The farm carries 600 Beulah Speckled Face ewes of which 300 are pure-bred and 300 are mated to Blueface Leicester sires. In addition to the sheep enterprise the farm carries 38 dairy cows plus 27 followers. Ewes are typically flushed at grass for three weeks prior to the start of mating on 13 October and are housed in December and fed silage initially but changing to hay from 20 February. Ewes are supplemented with compound feed from 1 February. Changes brought about as a consequence of the experiment included a critical review of the existing veterinary programme and changes to nutrition and management based on ewe body condition scoring.

Terrace Farm, Cumbria - was the replacement Cumbria demonstration farm coming on-line in 1999, and covers 254 ha, rising in altitude from 70 m to 430 m, of which 78 ha are inbye ground and mowing fields, 40 ha are improved rough grazing and 136 ha are enclosed hill grazing. The farm carries 550 Swaledale ewes of which 170 are bred pure and 350 are mated to Blueface Leicester sires. The farm is sufficiently harsh that ewes are normally drafted after four crops. In addition to the sheep there is a 70 cow suckler herd. Ewes mated to Blueface Leicester sires are tupped from early October and the pure-bred ewes are tupped from early-November. Ewes are pregnancy scanned and up to 150 twin-bearing ewes can be housed. Changes brought about as a consequence of Best Practice included making better use of scanning information with respect to feeding twin-bearing ewes more accurately, a review of the veterinary programme, and a potential change from the usual practice of finishing a high number of lambs to one of selling a proportion as stores, thereby reducing pressure on grassland in the autumn.

<u>Technology transfer campaign</u>

Although at the outset several publications already existed aimed at providing information to farmers on ways to reduce lamb mortality, there was considerable experience to suggest that providing producers with advisory/technical publications in isolation would have only limited impact on technology transfer, and that what was needed was a steady release of information over an extended period continually to reinforce the desired messages at relevant times in the sheep production cycle.

With the collaboration of the National Sheep Association, the Sheep Veterinary Society, Intervet UK Limited, Hoechst Rousell Vet, Roche Products Limited and Animax Limited a steady release of information relevant to reducing lamb mortality was made available to hill and upland farmers commencing in November 1997. A range of media were used to ensure that maximum cover was obtained from the technology transfer programme. These included a series of study workshops held on the demonstration farms, regular articles in Sheep Farmer and other trade publications, promotion at national and regional sheep events and the presentation of results at relevant scientific conferences.

<u>The effects of Vitamin E supplementation on sheep performance and lamb mortality</u>

A series of separate but related experiments were done to study the effects on lamb vigour and survival and on sheep performance of supplementing hill ewes with Vitamin E during late pregnancy.

Experiment 1

Two hundred and seventy twin-bearing ewes at each of two hill farms (ADAS Pwllpeiran and ADAS Redesdale) were used for the experiment in 1997. At Pwllpeiran ewes were Hardy Speckled Faces, the majority of which were bred pure, but a small number (20%) were mated to Suffolk rams. At Redesdale the ewes were Scottish Blackfaces mated in approximately equal proportions, to Blueface Leicester and Scottish Blackface rams. At both sites the ewes were housed for the last eight weeks of pregnancy and were fed a basal ration of well fermented *ad libitum* baled silage (DM 273 g/kg, CP 154 g/kgDM, ME 10.3 MJ/kgDM; Vitamin E 47 mg (dl-alpha tocopheryl acetate)/kgDM) at Pwllpeiran, and restricted hay (DM 939 g/kg; CP 117 g/kgDM; ME 9.0 MJ/kgDM; Vitamin E 30 mg/kgDM) at Redesdale. In addition, at each site, half the ewes were supplemented with a standard proprietary sheep nut (Control) and half were fed a Vitamin E enriched version of the nuts (Supplemented). The nuts had a chemical analysis of; DM 880 g/kg; CP 197 g/kgDM; ME 12.7 MJ/kgDM. The Vitamin E levels were 46 and 891 mg dl-alpha tocopheryl acetate per kgDM (mg/kgDM) for standard and enriched formulations respectively. Control and supplemented diets were formulated to provide a total of 50 and 200 mg (dl-alpha tocopheryl acetate)/hd/day respectively. Vitamin E supplementation started at housing and ceased at lambing but, after lambing, ewe continued to receive the standard sheep nuts at a rate of 450 g/hd/day until sufficient grass was available to meet their nutritional requirements.

Experiment 2

Experiment 2 was done in 1998 at ADAS Redesdale alone and involved 120 twin-bearing Scottish Blackface ewes mated to Blueface Leicester sires. The ewes were housed for the last eight weeks of pregnancy and were fed a moderate quality basal diet of *ad libitum* baled silage (DM 422 g/kg, CP 129 g/kgDM, ME 8.9 MJ/kgDM; Vitamin E 19 mg/kgDM) plus compound feed at a rate of 400g/hd/day initially rising to 800 g/hd/day at the start of lambing. The ewes were divided into 12 groups of ten ewes each balanced for ewe age, live weight, condition score and expected lambing date. Two groups of ewes were randomly allocated to each of six treatments; a control diet providing no additional Vitamin E, and a series of test diets formulated to provide an additional 50, 75, 100, 150 and 300 mg/hd/day of Vitamin E. The differential Vitamin E rates were achieved by feeding in varying proportions a standard proprietary sheep nut (DM 870 g/kg; CP 218 g/kgDM; ME 12.6 MJ/kgDM, Vitamin E 52 mg/kgDM) and a Vitamin E enriched sheep nut (DM 870 g/kg; CP 220 g/kgDM; ME 12.7 MJ/kgDM, Vitamin E 752 mg/kgDM). Vitamin E supplementation ceased at lambing but ewe continued to receive after lambing the standard sheep nuts at a rate of 500g/hd/day until sufficient grass was available to meet the ewes nutrition requirements.

Experiment 3

Providing Vitamin E in-feed is not practicable for the majority of extensively managed hill ewes. This issue was addressed, and the effectiveness of using Vitamin E rumen boluses was assessed. In 1998, a rumen bolus study was done at ADAS Pwllpeiran using 135 twin-bearing Welsh Mountain ewes. Treatment groups of 45 ewes balanced for ewe age, live weight, condition score and expected lambing date were randomly allocated to each of three treatments. Specially developed (Animax Products Limited) slow-release, rumen boluses of two functional designs (uncoated *vs* coated with a protective wax designed to mediate release rate) and formulated to provide 5 g Vitamin E over approximately 70 days were compared with an unsupplemented control. The boluses were administered at the time of pregnancy scanning, six weeks before lambing. To reduce the risk of boluses being regurgitated, ewe feeding was withheld immediately prior to bolus administration. Each bolus was identified by a unique number allowing any boluses which were regurgitated immediately (up to 2 hours) after treatment to be re-administered to the appropriate ewes. Ewes were housed following treatment and fed a basal diet of *ad libitum* baled silage (DM 258 g/kg, CP 150 g/kgDM, ME 10.0 MJ/kgDM; Vitamin E 27 mg/kgDM) plus a compound feed (DM 870 g/kg; CP 185 g/kgDM; ME 12.3 MJ/kgDM, Vitamin E 35 mg/kgDM) to a maximum rate of 500 g/hd/day at the point of lambing.

Experiment 4

In 1999 a second Vitamin E rumen-bolus experiment was done at both ADAS Pwllpeiran and ADAS Redesdale. This evaluated a refined version of the best performing boluses from the previous experiment. The experiment was done using 210 hill ewes, of which at least 50% were single-bearing, at both sites. At each site, treatment groups of 70 ewes balanced for ewe age, live weight, condition score, predicted litter size and expected lambing date were randomly allocated to each of three treatments. Unsupplemented control ewes were compared with ewes supplemented with 5g of Vitamin E contained within a rumen-bolus system, given as either a single 5g dose six week pre-lambing, or as a split dose, with 2.5g boluses being administered at six and three weeks pre-lambing. After treatment, single-bearing ewes remained on hill grazing and were supplemented with *ad libitum* baled silage (DM 260 g/kg, CP 143 g/kgDM, ME 9.6 MJ/kgDM; Vitamin E 29.9 mg/kgDM) plus self-help feed-blocks (DM 825 g/kg; CP 223 g/kgDM; NCGD 658 g/kgDM, Vitamin E 51 mg/kgDM). They were confined to paddocks or housed for a short period at lambing time to facilitate the collection of blood and colostrum samples. After treatment, twin-bearing ewes were housed and fed a basal diet of *ad libitum* baled silage (mean chemical analysis as fed to single-bearing ewes) plus proprietary sheep nuts (DM 865 g/kg; CP 210 g/kgDM; ME 11.8 MJ/kgDM, Vitamin E 39.9 mg/kgDM).

<u>Flock management</u>

The Vitamin E experiments were run as field trials under normal farm management typical of Cambrian Mountains (ADAS Pwllpeiran) and Northumberland (ADAS Redesdale) farming conditions. Lamb performance was assessed adopting a parallel group design. Apart from differential treatments within site, the management of ewes and lambs was the same, but did differ slightly between sites reflecting regional farming practice.

ADAS Pwllpeiran

Ewes were mated on the hill during October and November each year and were pregnancy scanned at the end of January. At that time, twin-bearing ewes were housed and fed *ad libitum* grass silage supplemented with a proprietary compound feed. Single-bearing ewes were wintered on semi-improved pastures and were supplemented with *ad libitum* baled silage plus self-help feed-blocks from early January each year. They were transferred to improved pastures immediately prior to lambing to facilitate management. The ewes lambed from mid-March and those rearing single lambs were returned to hill grazing as soon as weather conditions allowed, but twin-rearing ewes remain on improved pastures throughout.

ADAS Redesdale

Ewes were mated on improved hill-reseeds during November and December. They were supplemented with restricted hay and self-help feed-blocks from early January, at rates which reflected ewe body condition, the amounts of herbage available on the hill and the prevailing weather conditions. Following pregnancy diagnosis, single-bearing ewes remained on hill grazing but twin-bearing ewes were housed and fed a basal ration of either restricted hay or *ad-libitum* baled silage, supplemented with compound feed over the last seven weeks of pregnancy. Single-bearing ewes were removed from hill grazing immediately prior to lambing and were lambed outside on an area of semi-improved pasture. Mean lambing date was 20 April and ewes rearing single lambs were returned to hill grazing in early May. After lambing, twin-bearing ewes were initially turned out to sheltered, improved hill pastures before being transferred to hill grazing on average on 7 June.

At both sites lambs were weaned in August at which point the experiments terminated each year.

Assessments

Ewe measurements

For each Vitamin E experiment and at both sites ewes were weighed and condition scored at the start of the Vitamin E supplementation period, at the start of lambing, and at on average 30 days and 115 days (Weaning) after lambing. In addition, for each experiment, a core number of ewes per treatment, identified at the outset and balanced for age, live weight, condition score and expected lambing date, were sequentially blood sampled by jugular venepuncture pre-treatment, at the time of the second bolus application (Experiment 4 only) and at the point of lambing. The numbers of core ewes per treatment were 20, 6, 10 and 12 for Experiments 1, 2, 3 and 4 respectively, equating to 15%, 30%, 22% and 17% of the populations. Blood samples were analysed to determine Vitamin E (μmol/l, by a liquid chromatography technique), and selenium (as measured by GSPHx) levels. In addition, a 5 ml sample of colostrum taken from each core ewe was analysed to determine Vitamin E levels.

In 1999 only, an objective assessment of ewe behaviour was made in the period immediately after lambing by recording the time taken to perform a number of identifiable behaviours including time taken to vocalise and stand following parturition.

Lamb measurements

At both sites, and for all experiments, lambs born to core ewes were blood sampled by jugular venepuncture at between 24 hours and 36 hours after lambing. Blood samples were analysed to determine Vitamin E and selenium (GSPHx) levels.

For each experiment at Redesdale an objective assessment of lamb vigour was made in the period immediately after lambing by recording the time taken to perform a number of identifiable behaviours including time taken to attempt to stand, stand, attempted to suck and suck.

At both sites, lambs were weighed at birth and at approximately 30 days and 120 days (Weaning) of age.

Miscellaneous records

At both sites, the numbers of stillbirths and the dates and causes of all lamb deaths were recorded throughout each experiment as were all veterinary treatments, both prophylactic and disease specific. Causes of death were confirmed by post-mortem examination for all lambs other than stillbirths.

Statistical analysis

Blood plasma determinations, colostrum Vitamin E levels, ewe and lamb live weights and measures of lamb vigour were analysed by analysis of variance. Ewe condition scores and lamb mortality data were analysed by Chi-squared. For the in-feed experiments done using twin-bearing ewes (Experiments 1 and 2), data analysis was restricted to those ewes which successfully reared twin lambs, and lamb data were restricted to lambs which were twin born and reared.

Results

This report summarises work done between 1 January 1997 and 31 December 1999 during which time all revised scientific objectives and project 'milestones' were achieved in full, to agreed deadlines.

Best Management Practices and technology transfer

Performance of demonstration farm

Best Management Practices were implemented on three of the demonstration farm for two seasons, but for one season only on the fourth farm in Cumbria. Lamb mortality data collected during the first project year, November 1997 to November 1998, were used to calculate baseline levels of mortality for each demonstration farm. The impact of implementing Best Management Practices on lamb survival in the first year was encouraging, given the difficult weather condition experienced at lambing time in 1998. However, the results obtained for this first year were confounded by an outbreak of Sheep Pulmonary Adenomatosis (SPA) on the South West demonstration farm. This, while not disrupting the project totally, did mean that the first year's baseline data for the South West farm were somewhat atypical and subsequent results must be interpreted carefully against this background.

Flock productivity data for the three demonstration farm up and running for the 1998/99 season are summarised in Table 1.

Table 1. Flock output and lamb deaths on three demonstration farms in 1999

	Chillingham (Northumberland)	Llandre (Wales)	Slade (Devon)
Ewe to tup	323	641	656
Ewes lambing	323	632	643
Lambs scanned	450	1103	1115
Lambs born[φ]	432	1074	1094
Stillbirths	25	24	54
Lamb deaths[ξ]	14	37	61
Lambs reared	393	1013	979
Total losses (%)[ϕ]	9.0 (10.7)	5.6 (9.7)	10.5 (13.5)
Lamb mortality (%)	3.4 (8.1)	3.5 (7.7)	5.8 (10.1)

[φ] Numbers of lambs born alive and dead
[ξ] Born alive but subsequently died
[ϕ] Total lamb losses including still births and those born alive which subsequently died
( ) 1998 figure given in brackets

Overall, levels of lamb mortality for the demonstration farms in 1999 was 4.5% and total lamb losses were 8.3% (Table 1). These levels of lamb mortality were considerably lower than those reported for commercial hill farms (MLC 1996, 1997, 1998, 1999) and from survey data collected for hill farms in the early 1970s (Slee, 1979). Encouragingly, these results were in-line with those reported for hill flocks managed on ADAS Research Centres (Merrell, 1996).

Comparison across the demonstration farms should be avoided as they represent very different types of hill and upland farms, with different levels of resources and harshness of environment. In order to demonstrate that implementing Best Management Practices are impacting beneficially on flock productivity and reducing lamb losses it is necessary to compare results across seasons within a farm. It is acknowledged that this approach is not ideal, as the benefit of best practice are confounded with season but, providing the results are interpreted carefully, it should be possible to quantify the impact of implementing Best Management Practices on reducing lamb losses.

A comparison of meteorological data collected from stations in close proximity to each demonstration farm indicated that the 1998 and 1999 lambing seasons were not dissimilar in terms of severity of weather conditions. Data collected for the demonstration farms in 1999 after Best Management Practices had been implemented for just one year, suggest that both total lamb losses and lamb mortality were reduced on each of the demonstration farms compared with 1998.

Lamb deaths were attributable to numerous causes, with 29 different causes identified for Slade farm alone, and no one causes was dominant on any of the farms. As expected, abortion, stillbirths and deaths due to hypothermia and starvation were among the most frequently cited causes of lamb loss.

Technology transfer campaign

Between the project launch in November 1997 and 31 December 1999 a comprehensive and highly successful technology transfer campaign, focused around the four demonstration farms, was carried out. In total 35 promotional events were held to promotes aspects of Best Management Practices, including eight Best Practice Workshops held on the demonstration farms. More than 20 management/technical and scientific publication were produced and the work featured regularly in trade and technical media. Full details of the technology transfer programme are given at the end of this report.

Effect of supplementing pregnant ewe with Vitamin E on sheep performance

For the in-feed experiments (Experiments 1 and 2) the diets as fed provided per head per day 45 mg and 197 mg for control and Vitamin E enriched diets respectively in Experiment 1, and 38, 83, 106, 127, 173 and 309 mg for control, additional 50 mg, 75 mg 100 mg, 150 mg and 300 mg treatments respectively in Experiment 2. The diets as fed therefore adhered quite closely to the planned differential Vitamin E levels between treatments in both Experiment 1 and Experiment 2.

The Vitamin E boluses, dispite being relatively large (20 m diameter and 50 mm in length) caused no major problem to administer. Where boluses were not swallowed immediately, they were usually destroyed by chewing before being discharged, and a total of 12 boluses or 2% were lost in this manner. Once properly swallowed, no boluses were regurgitated within the first two hour after administration and none were found in bedding or on pasture subsequently. It is assumed therefore that boluses were successfully retained by the ewes.

Ewe plasma and colostrum Vitamin E levels.

Selenium status as measured by GSPHx levels were adequate throughout and for all experiments and results were therefore not confounded by low selenium levels.

At the start of the experiments the mean ewe plasma Vitamin E levels of all treatments were 3.1, 2.4, 2.1 and 4.4 µmol/l for Experiments 1, 2, 3, and 4 respectively. Therefore plasma Vitamin E levels were at the lower limit of the normal range (> 2.3 µmol/l) with the exception of ewes on Experiment 3 which were Vitamin E deficient at the outset.
Despite ewes being in the main clinically normal, supplementing ewes with additional Vitamin E at levels of 100 mg and above either maintained or significantly raised ewe plasma Vitamin E levels over the last six weeks of pregnancy, when provided in-feed (Experiments 1 and 2).

For example, in Experiment 1, plasma Vitamin E levels of control ewes at ADAS Pwllpeiran declined significantly (3.54 μmol/l reducing to 2.40 μmol/l, P<0.05) over the last six weeks of pregnancy, whereas those of supplemented ewes, increased slightly (3.33 μmol/l rising to 3.47 μmol/l, P> 0.05). In contrast, at ADAS Redesdale, ewe plasma Vitamin E levels of both control and supplemented ewes increased significantly (P< 0.05) in late pregnancy, but with the increase most marked in supplemented ewes (2.88 μmol/l rising to 5.72 μmol/l and 2.84 μmol/l rising to 7.42 μmol/l for control and Vitamin E supplemented ewes respectively). The difference in the response of control ewes is difficult to explain, but may have reflected the different forages fed. It is possible that rumen retention time was shorter on the well fermented silage based diet fed at ADAS Pwllpeiran , and this may have adversely affected Vitamin E absorption from the rumen. Vitamin E supplemented ewes had significantly (P<0.05) higher plasma Vitamin E levels at lambing.

Data from in-feed Experiment 2 indicated that there is a threshold level of Vitamin E supplementation below which ewe plasma Vitamin E levels will not be beneficially influenced (Table 2). Plasma Vitamin E levels of ewes provided with less than an additional 100 mg/hd/day mainly declined over the last six weeks of pregnancy whereas those provided with 100 mg/hd/day or more had plasma Vitamin E levels which increased significantly (P<0.05) over this period. There was a linear increase in plasma Vitamin E levels in response to supplementation up to an additional 300 mg/hd/day.

In both in-feed Experiments 1 and 2, ewes supplemented with more than an additional 100 mg/hd/day had significantly high plasma Vitamin E levels at the point of lambing and this was associated with significantly higher Vitamin E levels in their colostrum. This was in good agreement with the finding of Njeuru *et al*, (1994). This in turn impacted on Vitamin E levels in lamb plasma and lambs born to supplemented ewes had significantly higher levels than those born to control ewes, or to ewes supplemented at levels below 100 mg/hd/day (Table 2). These finding were in good agreement with results reported by Pherson *at al*. (1990) and Kott *et al*, (1998) but were achieved by supplementing ewes with a lower level of Vitamin E, for a longer duration. This result suggests that duration of supplementation may be of greater importance than rate of supplementation *per se*.

Table 2. Effect of supplementing pregnant ewes with Vitamin E on ewe plasma and colostrum Vitamin E levels and on lamb plasma Vitamin E levels (μmol/l)

	Rate of additional Vitamin E (mg/day)						
	0	50	75	100	150	300	sed
Ewe plasma							
At start	2.45	2.50	1.86	2.38	3.05	2.70	0.531 NS
At lambing	2.11^{a}	2.08^{a}	1.99^{a}	2.99^{b}	3.27^{b}	5.97^{c}	0.565 ***
Change	-0.34^{a}	-0.42^{a}	0.13^{ab}	0.61^{b}	0.22^{ab}	3.27^{c}	0.686 ***
Ewe colostrum							
	11.3^{a}	11.8^{ab}	8.1^{a}	17.3^{b}	16.0^{ab}	41.3^{c}	2.857 **
Lamb plasma							
	3.66^{a}	3.89^{a}	3.33^{a}	4.87^{ab}	6.28^{bc}	6.9^{c}	1.020 **

NS = not significant, ** P<0.01, ***P<0.001
Within rows, means followed by a different letter, were significantly different (at least P < 0.05)

The responses in ewe plasma and colostrum Vitamin E levels, and in lamb plasma Vitamin E levels, to Vitamin E boluses (Experiments 3 and 4) were less marked and less consistent than when additional Vitamin E was provided in-feed (Table 3). The rumen boluses were formulated to release 5 g (dl-alpha tocopheryl acetate) over an estimated 50 to 55 days release period. Assuming a relatively constant leaching of Vitamin E from the boluses, they should have provided approximately 95 mg to 100 mg per day, a level similar to that provided by the mid-way treatments in the in-feed Experiment 2. The fact that responses to supplementation were different for in-feed and bolus experiments, for what in theory were similar daily dose rate of Vitamin E cannot be easily explained. The different responses may have reflected differences in the supply of Vitamin E with the bolus system not providing a consistent release to the point of lambing, differences in absorption from the rumen, or possibly a combination of the two. It is not possible from these experiments to separate these possible causes.

Table 3 Effects of administering Vitamin E boluses to ewes on ewe plasma and colostrum Vitamin E levels and on lamb plasma Vitamin E levels (µmol/l)

	Experiment 3				Experiment 4			
	Control	5g coated	5g uncoated	sed	Control	5g	2.5g + 2.5g	sed
Ewe Plasma								
Start	2.33	1.98	1.90	0.635 NS	4.66	4.35	4.36	0.602 NS
Lambing	1.61	1.52	1.36	0.513 NS	3.67	4.54	4.51	0.593 NS
Change	-0.72	-0.46	-0.54	0.438 NS	-0.99[a]	+0.19[b]	+0.15[b]	0.562 *
Colostrum								
	9.7	8.9	10.5	1.820 NS	8.76	7.49	10.08	1.677 NS
Lamb Plasma								
	2.43	2.72	2.02	0.521 NS	5.00[a]	5.07[a]	6.55[b]	0.785 *

NS = not significant, * P<0.05
For each experiment within rows, means followed by a different letter, were significantly different (P < 0.05)

Administering Vitamin E rumen boluses to ewes either prevented as great a decline in plasma Vitamin E levels over the last six weeks of pregnancy (Experiment 3), or resulted in a slight increase in plasma Vitamin E levels at this time (Experiment 4), but differences in the main were marginal and not significant. Data for Experiment 4 showed that providing 5g of Vitamin E as two separate 2.5 g doses, administered at six and three weeks pre-lambing, produced higher responses in colostrum Vitamin E levels than a single 5 g dose given six weeks pre-lambing (Table 3). This results would suggest that Vitamin E was probably leaching too quickly from the 5 g single application bolus and hence was providing an insufficient supply of Vitamin E at the point of lambing. A good supply of Vitamin E in the period immediately prior to lambing is essential if it is to be concentrated effectively in colostrum. The levels of Vitamin E in colostrum are of paramount importance to lambs, as this represents the most important route by which lambs acquire a supply of Vitamin E. It is known that Vitamin E does not readily passed across the placenta in a number of species (Pherson *et al*, 1990 ; Mahon, 1991; Njeuru *et al*, 1994; Shenker *et al*, 1998).

Lambs born to ewes administered 5g Vitamin E coated-boluses tended to have slightly higher plasma Vitamin E levels than those born to control ewes but differences were not significant (Experiment 3, Table 3). Differences between 5g-coated and 5 g-uncoated treatments probably reflected the fact that Vitamin E leached too quickly from the uncoated boluses and was not available at the time of lambing. The results from Experiment 4 show that lambs born to ewes receiving two, 2.5 g rumen boluses at six and three-weeks pre-lambing had significantly higher plasma Vitamin E levels than unsupplemented control ewes and those receiving a single 5 g dose six weeks pre-lambing.

Lamb plasma ZST levels

There is some evidence from the literature (Stephens *et al*, 1979; Tenggery *et al*, 1983). that Vitamin E supplementation of ewes increases levels of IgG and other immunoglobulins in lambs blood. There was little evidence to support this from any of the four reported experiments For example, in Experiments 3 and 4, lamb plasma immunoglobulin levels, as measured indirectly by ZST levels, were not enhanced significantly by Vitamin E supplementation of ewes (Table 4).

Table 4. Effects of administering Vitamin E boluses to ewes on lamb plasma ZST levels

Experiment 3				Experiment 4			
Control	5g coated	5g uncoated	sed	Control	5g	2.5g + 2.5g	sed
24.4	23.2	23.1	1.986 NS	32.3	33.1	32.1	2.950 NS

NS = not significant

Ewe live weights and condition scores

Supplementing ewes with Vitamin E in late pregnancy had no significant effect on ewe live weight or condition score in any of the reported experiment, even when Vitamin E was provided at relatively high levels as in in-feed Experiment 2 (Table 5)

Table 5. Effect of supplementing pregnant ewes with Vitamin E on ewe live weight and condition score (Experiment 2)

	Rate of additional Vitamin E (mg/hd/day)						
	0	50	75	100	150	300	sed
Ewe live weights (kg)							
February	59.65	59.24	59.38	59.67	59.16	60.3	1.578 NS
April	64.53	63.47	64.19	64.83	64.16	65.76	2.039 NS
June	57.05	55.24	54.99	55.45	56.67	56.94	1.891 NS
August	55.44	54.54	54.12	54.15	56.14	55.36	1.774 NS
Ewe condition scores$^{\Psi}$							
February	2.78	2.79	2.79	2.78	2.75	2.79	0.0817 NS
April	2.54	2.49	2.59	2.56	2.53	2.62	0.0858 NS
June	2.51	2.4	2.44	2.49	2.43	2.47	0.0856 NS
August	2.54	2.49	2.54	2.5	2.56	2.43	0.0950 NS

$^{\Psi}$ score 0 to 5, where 0 = very thin and 5 = very fat.
NS = not significant

Lamb live weights and daily liveweight gains

For both in-feed experiments lambs born to Vitamin E supplemented ewes tended to be heavier and grow more quickly than those born to unsupplemented ewes or to those supplemented at levels less than 100 gm/hd/day. For example, in Experiment 1, lambs born to ewes supplemented with an additional 150 mg/hd/day Vitamin E were significantly heavier at 30 days of age than those born to control ewes (12.3 kg *vs* 11.7 kg, $P<0.05$), but were of similar weight at 120 days of age (29.3 kg *vs* 28.6 kg, $P>0.05$). In Experiment 2, lambs born to ewes supplement with 100 and 150 mg/hd/day Vitamin E achieved significantly higher growth from birth to 30 days of age and from birth to 120 days of age than did lambs born to unsupplemented control ewes (Table 6). These results are in good agreement with those reported by Williamson *et al.* (1995).

Table 6. Effects of supplementing pregnant ewes with Vitamin E on lamb growth performance

	Rate of additional Vitamin E (mg/hd/day)						
	0	50	75	100	150	300	sed
Live weights (kg)							
Birth	4.0	3.8	4.0	4.1	4.0	3.9	0.1501 NS
30 days	10.0	10.6	10.2	10.7	10.4	10.5	0.515 NS
120 days	27.4	28.9	28.3	28.4	29.2	27.7	0.930 NS
*Liveweight gain (g/day)**							
Birth - 30 d	240^{a}	260^{ab}	258^{ab}	264^{b}	263^{b}	259^{ab}	10.81 *
Birth - 120 d	186^{a}	201^{bc}	196^{b}	198^{bc}	202^{c}	190^{ab}	4.736 *

NS = not significant, * $P<0.05$
Within rows, means followed by a different letter, were significantly different ($P < 0.05$)

For the bolus experiments (Experiments 3 and 4) differences in responses in lamb live weights and liveweight gains to Vitamin E supplementation of ewes were marginal, inconsistent and not significant (Table 7)

Table 7. Effects of administering Vitamin E boluses to ewes on lamb live weights and daily liveweight gains

	Experiment 3				Experiment 4			
	Control	5g coated	5g uncoated	sed	Control	5g	2.5g + 2.5g	sed
Live weight (kg)								
Birth	2.8	2.7	2.8	0.084 NS	3.9	3.8	3.8	0.097 NS
30 days	10.3	10.2	10.4	0.341 NS	12.4	12.2	12.4	0.309 NS
120 days	21.3	22.2	21.8	0.651 NS	28.0	28.2	28.5	0.491 NS
Liveweight gain (g/day)								
Birth - 30	251	253	251	6.951 NS	253	257	254	7.404 NS
Birth - 120	154	162	161	4.896 NS	195	197	197	3.770 NS

NS = not significant

Effects on lamb vigour and survival

There were no significant differences between treatments in the measurements of lamb vigour in Experiment 1, but lambs born to Vitamin E supplemented ewes tended to be more vigorous immediately following birth than those born to unsupplemented control ewes (Table 8). Experiment 1, was done using twin born lambs which were housed at the time of birth, being turned out to pastures at approximately 36 hours of age. In addition the experiment was done in the spring of 1997, when weather conditions at lambing time were among the most favourable on record. It has been suggested that lamb vigour and survival are most important when lambs experience high levels of environmental stress (Williamson *et al.*, 1995) and it is likely that differences in lamb behaviour would have been more marked had the spring of 1997 be more severe.

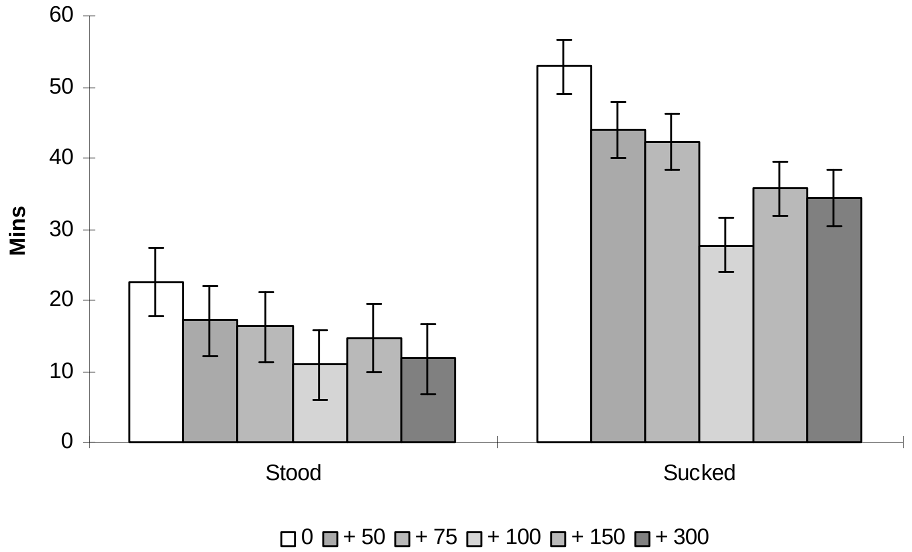
Table 8. Effect of supplementing ewes with and additional 150 mg/hd/day Vitamin E on lamb vigour (Experiment 1)

Mean time (minutes) from birth to:-	Control	Supplemented	sed
Attempting to stand	12.9	11.4	1.945 NS
Standing	15.8	15.9	1.002 NS
Attempting to suck	28.8	25.8	2.268 NS
Sucking	38.7	35.7	2.526 NS

NS = not significant

Experiment 2 was done in the spring of 1998 under more severe weather conditions than those experienced in 1997. Lambs born to ewes supplemented with Vitamin E in late pregnancy performed a number of key behavioural tasks, including time to stand and time to suck significantly sooner than those born to unsupplemeneted control ewes (Figure 1). The difference was most marked for lambs born to ewes supplemented at 100 mg/hd/day Vitamin E which, compared with those born to unsupplemented control ewes, sucked successfully 25 minutes sooner. This benefit has major implications for reducing lamb deaths caused by hypothermia and starvation.

Figure 1. Effects of Vitamin E supplementation on lamb vigour (Experiment 2)



A similar, but less marked, response in lamb behaviour was also a feature of one of the rumen-bolus experiments (Experiment 4), where lambs born to ewes administered two, 2.5 g boluses performed most key behavioural tasks significantly (P<0.05) sooner than lambs born to unsupplemented control ewes (Table 9).

A significant increase in lamb vigour in response to Vitamin E supplementation, as seen in most of these experiments, is in good agreement with the results reported by other authors (Thomas *et al.*, 1995; Williamson *et al.*, 1995).

Table 9. Effects of administering Vitamin E boluses to ewes during late pregnancy on lamb vigour (Experiment 4)

Mean time (minutes) from birth to:-	Control	5g	2.5g + 2.5g	sed
Attempting to stand	16.2[b]	15.6[b]	11.9[a]	2.020 *
Standing	19.7[b]	17.6[b]	14.8[a]	2.255 *
Attempting to suck	19.0	17.9	15.4	2.016 NS
Sucking	44.8[b]	42.3[b]	37.3[a]	3.068 *

NS = not significant, * P<0.05
Within rows, means followed by a different letter, were significantly different (P < 0.05)

It is generally recognised that little Vitamin E crosses the placenta and it is therefore difficult to explain why lambs born to supplemented ewes are more vigorous, even before they have received Vitamin E enriched colostrum, than lambs born to unsupplemented ewes. This result may in-part reflect the behaviour of ewes immediately after lambing. For experiment 4 the effect of treatments on the behaviour of the ewes immediately after lambing showed that their was a tendency for supplemented ewes to be more active that unsupplemented ewes (Table 10). Most differences were marginal and not significant but ewes which received two, 2.5g Vitamin E boluses stood following lambing significantly sooner than unsupplemented ewes. Care must be taken when interpreting this result as it was based on one years study only and involved relatively few animals. However, this result would suggest that Vitamin E supplemented ewes may be more active themselves following lambing and thereby able to take a more pro-active role in influencing the behaviour of their lambs.

Table 10. Effects of Vitamin E supplementation on ewe behaviour after lambing (Experiment 4)

Mean time (minutes) from lambing to:-	Control	5g	2.5g + 2.5g	sed
Vocalise	1	0.8	1	0.189 NS
Commence licking	0.9	0.8	0.7	1.002 NS
Stand	9[a]	5[a]	4[b]	2.216 *

NS = not significant, * P<0.05
Within rows, means followed by a different letter, were significantly different (P < 0.05)

Lamb loses on ADAS Research Centres are very low, typically 6% (Merrell, 1996), compared with the estimated mortality of 15% that has been regarded as typical for hill farms (McHutcheon *et al*, 1981). Therefore, as expected, treatment differences in lamb vigour did not impact beneficially on lamb survival in any of these reported experiments. For example in Experiment 1 supplementing ewes with Vitamin E had no beneficial effects on reducing the number of stillbirths or in reducing neonatal mortality (Table 11). The fact that it would be difficult to demonstrate improvements in lamb survival, against a background of very low lamb losses, was recognised from the outset. This issue is being addressed during spring 2000 when the Vitamin E rumen-boluses, evaluated in Experiment 4, are being administered to ewes on a commercial hill farms with appreciably higher levels of lamb mortality than those experienced on ADAS Research Centres. It is expected that a relationship between increased lamb vigour, a feature of the reported experiments, and reduced lamb losses will be established under these more exacting conditions.

Table 11. Effect of supplementing ewes with Vitamin E on the numbers of stillbirths and neonatal mortalities (Experiment 1)

	Control	Supplemented
Numbers of stillbirths	20	24
Numbers of lambs born alive	506	494
Numbers of neonatal mortalities	15	17
% Mortality	2.9	3.4

General comments

The sustained technology transfer campaign has done much to increase producer awareness of the factors which predispose high levels of lamb mortality. The information provided by the technology transfer campaign, if successfully implemented by commercial producers, will result in a reduction in lamb deaths on hill and upland farms and this will directly benefit commercial sheep producers. The technology transfer campaign has also generated much interest from veterinary surgeons and consultants advising sheep producers on sheep husbandry and management. This will also help reduce lamb mortality longer-term.

The results from the Vitamin E experiments have shown clearly that lamb vigour and growth performance are enhanced when ewes are supplemented in-feed with Vitamin E during late pregnancy. The results obtained for Vitamin E boluses have been less consistent but, again there is some evidence to suggest that lambs born to ewes receiving Vitamin E boluses will also be more vigorous at birth. Under conditions providing higher levels of environmental stress, and where lamb mortality rates are higher than those experienced on ADAS Research Centres, it is likely that improvements in lamb vigour immediately after birth will translate into a reduction in lamb deaths. Therefore the results of this work will potentially improve the underlying efficiency of hill sheep production by reducing lamb deaths, thereby increasing the competitiveness and financial viability of hill and upland farms. This in-turn should help ensure the continuation of livestock farming in less favoured areas. A reduction in lamb mortality will also improve animal welfare considerably.

Conclusions

Best Management Practices have been implemented successfully on three demonstration farm since November 1997. The results show that in 1999 total lamb looses (dead at birth and died subsequently) ranged from 5% - 11%, with neonatal mortality (born alive but subsequently died) ranging from 3% to 6%. These were very encouraging results and were considerable lower than the national average. On each demonstration farm total lamb losses and lamb mortality were lower in 1999 than in the 1998 baseline year indicating that implementing Best Management Practices has helped to reduce lamb losses. The demonstration farms have provided the focus for a comprehensive successfully implemented technology transfer programme.

When pregnant twin-bearing ewes were supplemented with additional Vitamin E in-feed, Vitamin E supplementation at rates of greater than 100 mg dl-alpha tocopheryl acetate per day significantly raised ewe plasma and colostrum Vitamin E levels, compared with untreated control ewes, and this was associated with significantly higher plasma Vitamin E levels in their lambs. Vitamin E supplementation improved significantly the times taken to achieve a number of clearly definable measures of lamb vigour and also significantly increased lamb growth rates.

When slow-release, rumen-boluses were used as a means of supplementing ewes with Vitamin E in late pregnancy, the results obtained were more marginal and less consistent. Nevertheless, the results suggest that providing ewes with 5 g of Vitamin E, administered by means of 2.5 g rumen boluses given 6- and 3-weeks pre-lambing, increased significantly lamb plasma Vitamin E levels and lamb vigour at birth.

Vitamin E supplementation had no beneficial effects on ewe live weights and condition scores but there was some evidence to suggest that it impacted advantageously on ewe activity immediately after parturition.

As expected, given the overall low level of lamb mortality on ADAS Research Centres, Vitamin E supplementation was not associated with a reduction in lamb mortality in these experiments.

Recommendations

This project was set-up in 1997 to demonstrate the benefits of implementing best management practice, and of supplementing pregnant ewes with Vitamin E, on reducing lamb mortality on hill and upland farms. Good progress has been made towards achieving these objectives. However, because of unavoidable outbreaks of disease on two of the demonstration farms in the first year, and inconclusive results obtained for the prototype slow release Vitamin E bolus experiment, MAFF and the corporate funders agreed in January 1999 that the project should be extended by 12 months . This will allow further refinements and reformulation to the bolus release system to be assessed under controlled condition on ADAS Research Centres, before being tested ultimately on commercial hill farms, and for data on Best Management Practices to be collected for an additional season, offsetting the somewhat atypical circumstances encountered on two of the demonstration farms during the baseline year.

There is increasing evidence both from research and from commercial experience that supplementing ewes with Vitamin E during pregnancy increases lamb vigour and enhances lamb growth rates. The extent of Vitamin E adequacy in UK flocks is not known and there are many management practices which could potentially produced symptoms consistent with Vitamin E deficiency. There would be considerable merit it doing an epidemiological study to quantify the extent of the problem and to help identify possible predisposing factors which could increase oxidative stress, resulting in Vitamin E deficiency.

More research effort is needed to understand better the underlying mechanisms which control digestion and absorption of Vitamin E and how Vitamin E effects different tissues. More information is needed on dietary Vitamin E allowances required to promote good health, enhance growth performance and influence meat quality traits, as these are likely to differ markedly.

Acknowledgements

Funding for this work from MAFF, Roche Products Limited, Hoechst Rousell Vet, Intervet UK Limited and Animax Products Limited is gratefully acknowledged, as is technical support provided by staff from Roche Products Limited, Animax Products Limited, Hoechst Rousell Vet, Intervet UK Limited, Longbenton, Shrewsbury and Y Buarth VICs, numerous ADAS staff and MSc student from Aberdeen University. A special acknowledgement is extended to the owners and managers of the four demonstration farms and to their local veterinary practitioner. W & J Pye Limited produced the specially formulated compound sheep nuts.

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Technology transfer

Between November 1997 and December 1999 this work was promted as follows:-

<u>Publications</u>

Papers

Merrell, B.G. (1999). The effects on lamb survival rate of supplementing ewes with VitaminE during late pregnancy. In *Proceeding of the Sheep Veterinary Society 1998*, **Vol 22**, 57-61.

Merrell, B.G. (1999). Effects of supplementing ewes with VitaminE in late pregnancy on sheep performance. In *Vitamin E requirements in sheep - an invited workshop to discuss current needs*, Harper Adams University College 29 June 1999, paper 2.

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Media coverage

This work has featured in:-

The Scotsman, 9 December 1997, *Farmers Weekly*, 12 December 1997, *Farmers Guardian*, 12 December 1997, *Farming in the North,* Winter 1997/98, *Farming in the North*, Spring 1998, *Farming News,* February, 1998, *Farming Journal*, February 1998, *Farmers Weekly*, 20 February 1998, Welsh Farming (TV) programme, March

1998, *Farmers Weekly*, 17 April, 1998, *Farmers Weekly*, 12 June 1998, *Farmers Weekly*, 26 June, 1998, *Farmers Weekly*, 3 July, 1998, *Agribusiness*, December 1998, *Farmers Weekly*, 22 January 1999.

Promotional

1. Open day and best practice workshop - Eycott Farm, December 1997
2. Open day and best practice workshop - Slade Farm, February 1998
3. Evening meeting and best practice workshop for Chillingham Farm, February 1998
4. Evening meeting and best practice workshop for Llandre Farm, February 1998
5. Sheep Veterinary Society Meeting, spring 1998
6. Royal Highland Show, June 1998
7. Sheep 1998, July 1998
8. MAFF Sheep Science Prospective meeting, Malvern November 1998
9. MAFF/NSA technology transfer evenings, Devon, November 1998
10. MAFF/NSA technology transfer evenings, Derbyshire, 1998
11. MAFF/NSA technology transfer evenings, Brecon, November 1998
12. MAFF/NSA technology transfer evenings, Yorkshire, November 1998
13. MAFF/NSA technology transfer evenings, St Asaph, November 1998
14. Border Sheep Fair, Penrith, January 1999
15. ADAS Pwllpeiran open day, February 1999
16. MAFF VitaminE workshop, June 1999
17. Open day and best practice workshop - Slade Farm, July 1999
18. Open day and best practice workshop -Terrace Farm, July 1999
19. Open day and best practice workshop - Chillingham Home Farm, July 1999
20. Open day and best practice workshop - Llandre Farm, August 1999
21. MAFF/NSA technology transfer evenings, Malvern, December 1999
22. Overseas visitors including farmers from Australia, South Africa, Germany and Uruguay
23. To parties of farmers and visitors to ADAS Pwllpeiran and ADAS Redesdale (approximately 1200 visitors)
24. Staff and students from Newcastle, Sunderland, Aberdeen, Aberystwyth, and Nottingham Universities and from Newton Rigg, Kirkley Hall and the Scottish Agricultural Colleges;
25. MAFF and WOAD staff including Mr R Cowan, Mr M Roper, Drs Wall and Hennessey and FRCA, SVS staff
26. Mr Martin Newman (EU Sheep Commissioner);
27. Nuffield Scholars

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