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A. ANIMAL NUTRITION AND PRODUCTIONREPRODUCTION (01001)1. Repeatability of ovulation rate during the breeding season
J.M. Doney, A. Whitelaw and R.G. Gunn

The first phase of this project was carried out and reported in the Annual Report 1973, p.1. Ewe liveweight and body condition was maintained as constant as possible throughout the breeding season. Ovulation rate was assessed by laparoscopy and observations were terminated before the end of oestrus activity for some ewes because of difficulties associated with excess fat. The results are shown in Table 1 as mean body condition and mean ovulation rate for the first 6 oestrus cycles.

Table 1. Mean body condition and ovulation rate at constant body condition (1973/4)

Cycle		1	2	3	4	5	6
High body condition	C.S.	2.79	2.71	2.75	2.85	2.75	2.69
	O.R.	2.0	2.0	2.0	2.4	2.0	1.8
Low body condition	C.S.	1.79	1.71	1.67	1.67	1.71	1.88
	O.R.	1.0	1.3	1.0	1.2	1.2	1.5

The experiment was repeated in 1974/5 but the two groups were crossed over after 4 complete cycles. Two groups of 6 ewes each were established in body condition 2.75 ± 0.25 or 1.75 ± 0.25 before the onset of the first seasonal oestrus cycle. These were maintained by control of feed level. After 4 cycles the rations were changed with the objective of increasing or decreasing body condition as rapidly as possible. The ewes for this second phase were assembled from more than one farm source and some were over-age draft ewes which had been involved in nutritional experiments during the previous year. Some difficulty was experienced in achieving the initial desired body condition, especially in the low group; the onset of first oestrus was much later than expected and was spread over a wide period; change of body condition after 4 cycles proved to be very slow despite extreme differences in rations. The results shown in Table 2 were not as clear as in the first phase. However, taken together, they do suggest that in this breed the ovulation rate throughout the seasonal oestrus may remain relatively constant if body condition is constant. A change in body condition may increase or decrease the ovulation rate as the breeding season progresses. It is therefore possible that some of the patterns of change in ovulation rate during the breeding season that have been reported for different breeds may be associated with progressive changes in nutrition and body condition.

Table 2. Mean body condition and ovulation rate when condition was maintained constant for 4 cycles followed by cross-over (1974/5)

Cycle		1	2	3	4	5	6	7	8
High-Low body condition	C.S.	2.71	2.71	2.79	2.83	2.58	2.54	2.42	2.40
	O.R.	1.3	2.0	1.7	1.7	1.7	1.5	1.7	1.0
Low-High body condition	C.S.	1.88	1.79	1.80	1.90	1.90	2.05	2.19	2.25
	O.R.	1.5	1.3	1.2	1.2	1.0	1.6	1.4	1.5

2. The effect of environmental stress of early embryo loss
J.M. Doney, R.G. Gunn and W.F. Smith

The first phase of this experiment was reported in the Annual Report 1972, p.1. Post-mating environmental stress was created by transfer of ewes from a sheephouse, in which they had been treated for 2-3 months, to outdoor pens where they were subjected to additional "wetting stress". This resulted in an increase in embryonic loss by 29 ± 3 days post-mating, as measured by the number of viable embryos found on slaughter relative to the number of established corpora lutea. Similar effects were found in a small group of ewes treated with ACTH after mating. However, these results did not reach statistical significance.

The experiment was modified and repeated. A control group and an ACTH treatment group were treated as in the first experiment but environmental stress, provided in the same periods (days 1-10 or 11-20 post-mating) was changed. The treatment in this experiment took the form of 'management stress' in which ewes were subjected to a variety of procedures, ranging from road transport to handling and foot and udder examination, each day. The results from the two experiments are compared in Table 1 and it can be seen that post-mating stress did increase the rate of embryo loss irrespective of the form of the applied stress. A similar increase in mortality was associated with a daily injection of ACTH which might suggest that the level of embryonic loss is related to some aspect of pituitary-adrenal response.

Table 1. Number of corpora lutea represented by an embryo at slaughter (viable) or not represented by an embryo (non-viable). The potential lambing per cent at a constant 200% ovulation rate is shown.

Treatment	Experiment	No. viable	No. non-viable	% non-viable	Estimated lambing % at constant 200% OR
Control	1972/3	38	8	17.4	165
	1974/5	39	8	17.0	166
	Total	77	16	17.2	165
Stress day 1-10	1972/3	28	14	33.3	134
	1974/5	40	15	27.3	145
	Total	68	29	29.9	140
Stress day 11-20	1972/3	33	14	29.8	140
	1974/5	38	15	28.3	143
	Total	71	29	29.0	142
ACTH day 1-20	1972/3	13	7	35.0	130
	1974/5	30	19	38.8	122
	Total	43	26	37.7	125

3. The effects of time of mating and body condition on ovulation rate, early embryo mortality and lamb production of Greyface ewes (01001/03008: upland)
R.G. Gunn, J.M. Doney, T.J. Maxwell, J. Eadie, J.D. MacDonald and W.F. Smith

The objectives of this study are detailed in the Annual Report 1973, p.2. Information from the main flock is given here on lamb production in the first experimental year and on the pattern of mating in the second experimental year, while information from a supplementary study on ovulation rate and embryo mortality was obtained this year with ewes mainly in leaner condition.

(a) In the main experiment, the effect of time of mating on lamb production was less pronounced than it might have been. Only half the ewes in the early group were marked by the ram in the first cycle and a number of these were returned to service.

The pattern of lamb production was as follows:-

	Time of successful mating	Condition at mating	No. of ewes	Lambing %	No. barren
Early	8 Oct. - 25 Oct.	3.10	48	208	4
	26 Oct. - 12 Nov.	3.07	62	187	
Late	5 Nov. - 22 Nov.	3.09	100	188	2
	23 Nov. - 10 Dec.	2.88	10	170	

These ewes which lambed to mating between 8th and 25th October produced significantly more lambs than the other mating groups, although there was no difference in body condition (3.10 vs. 3.07). This result suggests that every effort should be made to increase the proportion of ewes in the early group which mate and hold to the ram during the first cycle.

In the second year, teaser rams were run with the ewes from mid-September, in an attempt to stimulate more of the ewes to exhibit oestrus during the first early mating cycle. In each group there are now ewes being stocked at high and low levels (6 and 4 ewes/acre, respectively). With early mating starting on 7th October and late mating on 4th November, mean live weights (LW) (kg) and condition scores (CS) were as follows:-

Mating	Stocking	27 Sept.	7 Oct.	17 Oct.	4 Nov.	14 Nov.	4 Dec.
Early	Low	70.2	71.1	75.0	74.6		
		3.32	3.38	3.34	3.24		
	High	68.0	70.4	71.4	71.9		
		3.41	3.37	3.41	3.25		
Late	Low	64.4		70.0	69.4	69.6	67.1
		3.08		3.12	3.15	3.17	3.11
	High	63.9		66.3	65.9	65.6	62.6
		2.89		2.98	2.98	2.91	2.83

The pattern of mating was as follows:-

	Early				Late			
	Low		High		Low		High	
Marked in 1st 10 days	30/51	59%	49/72	68%	31/44	70%	45/66	68%
" " next 7 "	15/51	29%	17/72	24%	13/44	30%	20/66	30%
" " 1st cycle	45/51	88%	66/72	91%	44/44	100%	65/66	98%
" " 2nd "	5/51	10%	4/72	6%	0/44	0%	0/66	0%
Unmarked	1/51	2%	2/72	3%	0/44	0%	1/66	2%
Returns to service after 1st cycle	1/45	2%	6/66	9%	2/44	5%	2/65	3%

More ewes were marked in the early group during the first cycle this year than in 1973, possibly because of the teaser stimulation. Returns to service were also much lower this year. Lamb production will be reported next year.

(b) In the supplementary experiment this year, 60 draft Greyface ewes were purchased in early August and were brought down in body condition by differential group management in grass paddocks. Grouping into early and late mating and all other aspects of pre- and post-mating management were as last year, except that all ewes were killed at about 4 weeks after mating. Mating this year was timed to take place a week after the start of the main-flock mating for each group.

Some difficulty was experienced in reducing condition and there was therefore a wider spread than had originally been intended.

Overall, the results for the two groups were as follows:-

<u>Group</u>	<u>Start of mating</u>	<u>No. of ewes</u>	<u>LW (kg) & CS at mating</u>		<u>OR</u>	<u>EM</u>	<u>PLR</u>
Early	14 Oct.	30	68.7	2.26	2.07	19	1.67
Late	11 Nov.	30	67.2	2.23	1.90	44	1.07

PLR = Potential Lambing Rate

As in 1973 there was an apparent but non-significant decline in ovulation rate (OR) with time. The significantly higher embryo mortality (EM) in the late group may well relate to a spell of extremely wet and unpleasant weather which occurred during the post-mating period.

Combining the two years results does show the early group to have had a significantly higher OR than did the late group (2.19 vs. 1.92), while overall, ewes in body condition 2 or below had a significantly lower OR than did ewes in better condition (2+ and above) (1.75 vs. 2.13).

Clearly there are advantages of having Greyface ewes in better condition than CS2 and to start mating early in their breeding season when they have a higher OR potential and they are less prone to suffer from the weather stresses which might occur later on.

4. The effects of level of pre- and post-mating nutrition on ovulation rate and early embryo mortality in South Country Cheviot ewes in moderate condition (CS = 2) at mating.
R.G. Gunn, J.M. Doney and W.F. Smith

In 1973 it was shown that ovulation rate (OR) was significantly higher in ewes well fed and rising to moderately good condition (2.5) than it was in ewes undernourished and falling to this condition. There was also no effect of level of pre-mating nutrition on embryo mortality (EM) after 30 days of post-mating maintenance feeding. EM of single-shed ova also appears low in this breed, particularly in ewes in moderately good (2.5) or better condition.

This experiment was designed to obtain information on the effects of level of pre- and post-mating nutrition on OR and EM in ewes in only moderate condition (2) at mating.

In early September 120 SCC ewes were group-penned in the Sourhope sheep-house and allocated to two groups. Food intake was then adjusted by differential sub-group management to bring the ewes in one group into condition score CS 1.5 and those in the other into CS 2.5 by the first week in November. For 5 weeks prior to a synchronised mating, the CS 2.5 ewes were fed at a restricted level (< 10 g food/kg LW) and the CS 1.5 ewes were fed at an unrestricted level (> 25 g food/kg LW) to bring all ewes into CS 2 by mating.

After mating, half the ewes from each of the original groups continued to be fed as prior to mating, while the other half were transferred to the other level of feeding. All ewes were killed either at return to service or 4 weeks after first mating and the number of corpora lutea and viable embryos were counted.

Condition scores, mean live weights (LW), OR, percentage EM and potential lambing rate (PLR) to first mating (M) are shown in the following table:-

M-5 weeks		Pre-M food level	M		OR	Post-M food level	M + 4 wks LW (kg)	%EM	PLR
CS	LW(kg)		CS	LW (kg)					
2.5	56.7	L	2	49.2	1.23	H	56.8	9	1.10
						L	48.5	20	1.00
1.5	44.7	H	2	51.2	1.35	H	54.3	21	1.00
						L	46.4	38	0.89

Unlike the significant response to nutrition obtained in 1973 with ewes in CS 2.5 at mating, this year there was no effect of pre-mating nutrition on OR in ewes in CS 2. There was, however, significantly more EM in the ewes on a low level of post-mating nutrition but no apparent interaction with the level of pre-mating nutrition. The EM of single-shed ova was again low (13%) and significantly less than that of multiple-shed ova (34%). Since the sub-groups with higher values of EM also had slightly higher OR's, it was not possible to show any significance in the resultant differences in PLR.

5. The effects of different durations of feeding prior to mating on body condition change and ovulation rate in Blackface ewes in moderately poor condition

R.G. Gunn, J.M. Doney and W.F. Smith

Previous studies have shown that ovulation rate (OR) is significantly increased when body condition is raised by about 0.5 of a grade by feeding well for approximately 5 weeks, but the OR is not affected by feeding well for only the last 8 days prior to mating.

Information is therefore required for ewes approaching mating in moderately poor condition (1.5) on the optimum duration of feeding which will produce the least increase in condition necessary for a significant increase in OR. Information is also required on the timing of this optimum duration of feeding during the pre-mating period.

Between September and early November, 162 BF ewes (72 from Glensaugh and 90 from Lephinmore) were brought into condition 1.5 by differential group management in grass paddocks. Oestrus was synchronised and, over the 5 weeks prior to mating, feeding management was designed as follows:-

As far as it is possible to draw conclusions from the between-treatment differences, it would appear that 18 days of a high level of feeding was not sufficient to produce a significant response in OR, while 27 days was sufficient. The failure to maintain LW makes it difficult to draw conclusions on the timing of the feeding period, since group H₃M lost condition and 3.5 kg LW in the 9 days before mating and did not differ significantly in OR from any other group.

With the significantly greater EM experienced by the ewes well fed for 18 days than experienced by those well fed for 27 days, PLR was significantly less in the former. It is suggested that certain aspects of this study require to be repeated.

6. Plasma luteinizing hormone (LH) in the prepubertal lamb
R.G. Gunn, W.F. Smith and J.M. Doney

It has been suggested that there is a genetic component in prepubertal LH level and that some of the differences are associated with differences in fecundity. Significant differences have been shown in LH level at 30 days of age between birth types, sire groups and flocks selected for different incidence of multiple births. No information is yet available on the variation in 30-day LH level that exists in our hill flocks nor on the relationship between the 30-day LH level and subsequent fecundity in those animals retained for flock replacement. Neither is there any information on the relationships which might exist between prepubertal LH level, rate of growth, size, age, parity and subsequent fecundity.

A preliminary study was therefore set up at Glenshagh to obtain some of this information. Some 380 ewe lambs on the Cairn, Birnie, Mid-Finella and West Finella hefts at Glenshagh were bled on three occasions at three-weekly intervals from the end of May. Full records of date of birth, parity and liveweights at birth and at the three occasions of sampling were taken. Analyses of LH levels await the availability of suitable radioimmunoassay equipment.

7. Dystokia in a South Country Cheviot flock
A. Whitelaw and P. Watchorn

Intensive observations and measurements were carried out in the gimmer age group of the South Country Cheviot flock at Sourhope in 1974. Observations of prelanbing behaviour in this flock accorded well with those of other workers, as did the measurement of duration of labour between those not requiring assistance and those requiring assistance.

The overall percentage of those requiring assistance was 39%. There were significant differences in body weights and body measurements between lambs not requiring assistance and those which did. The dystokias encountered exhibited features which were consistent with the relative oversize of a lamb of specific conformation and a small ewe.

The influence of housing and feeding was considered and the conclusions were that the problem at Sourhope was such that the use of this breed beyond certain limits could not be sustained.

Reference: WHITELAW, A. and WATCHORN, P. An investigation into dystokia in a South Country Cheviot flock. Vet. Rec., 1975 (in press).

LACTATION (01002)The improvement of lactation and lamb growth (01002/01004)

J.N. Peart and J.M. Doney

Gene-environmental interactions

Under hill grazing conditions the decline in milk intake of lambs coincides with a reduction in the digestibility of hill vegetation. The consequence of this is reflected in reduced lamb growth rate. Attempts to improve the nutrition of hill lambs during the later stages of lactation have been mainly centred on the herbage fraction of the diet. There is evidence that improved lamb growth can be obtained from an increased intake of milk during the later stages of lactation. However, the normal pattern of milk production and shape of lactation curves of our native hill breeds of ewes clearly indicate that they are unable to meet a requirement for a sustained lactation. The potential for sustained milk production is normally only found in milch breeds of sheep, some of which also have characteristics suitable for fat lamb production. It is intended to test the concept of sustained lactation and its influence on lamb growth.

A flock of cross-bred ewes is being produced by mating Westphalian rams with Blackface ewes. The first objectives will be to determine whether or not a cross involving native hill breeds will incorporate to any meaningful extent the lactation characteristics of the sire breed and also to establish whether or not sustained lactation is of benefit to lamb growth.

NUTRITION IN PREGNANCY (01003)

1. The effect of undernourishment during mid-pregnancy on foetal and placental development in hill sheep
A.J.F. Russel, J.M. Doney and R.G. Gunn

In the Organisation's development studies ewe numbers have in most cases increased substantially. This, together with the fact that during January and February the ewe stock is excluded from the areas of better pasture, has led to considerably increased grazing pressures on the areas of poorer quality pasture during mid-pregnancy. This has in turn resulted, in some instances, in greater weight losses during mid-pregnancy than formerly. In all cases late pregnancy nutrition has been closely controlled and nutritional states maintained within what are regarded as acceptable limits. Although there is no direct evidence from the development studies of any adverse effects of large body weight losses during mid-pregnancy on lamb birth weights, it is nevertheless considered prudent to examine more closely the relationship between the severity of undernourishment during this period and subsequent production.

The results of an experiment with 70 Blackface ewes and designed to quantify the effects of varying levels of undernourishment during the period from 30th to 100th days of pregnancy on foetal and placental weight and development at 100 days are currently being analysed. A second experiment designed to study the effects of a moderate degree of undernourishment during late pregnancy following varying levels of undernourishment during mid-pregnancy is now in progress.

2. Effect of undernourishment during mid-pregnancy on foetal development in hill sheep
J.M. Doney and W.F. Smith

Skin samples were collected from 100 day old fetuses for histological examination. These samples were processed and all sectioning and mounting

on microscope slides has now been completed. Approximately 1,000 slides and 15,000 tissue sections have been prepared and passed on to Mrs. Marjorie Derbyshire, Moredun Institute, for final examination and analysis in her study on foetal follicle development.

3. The assessment of supplementary feeding requirements of grazing and housed ewes during late pregnancy
A.J.F. Russel and T.J. Maxwell

The technique of regulating inputs of supplementary feeding during late pregnancy according to the biochemical assessment of nutritional status was continued in 1974.

The main objective of this work is to develop a practical system of feeding during late pregnancy which achieves a compromise between meeting the ewe's high requirements in full and preventing severe undernourishment with excessive depletion of the ewe's body reserves. The former is unnecessary and unjustifiable on economic grounds, and the latter will lead to reduced lamb birth weights, with high levels of mortality, and possibly to a delayed onset of lactation and a poorly developed maternal instinct in the ewe. The regulation of feed inputs according to biochemical parameters thus offers a means of maintaining an acceptable nutritional state on a flock basis during late pregnancy. It also serves as a means of achieving a degree of consistency in the nutritional state of animals in any project from one year to the next, and also between flocks in different projects.

In previous years the regulation of feed inputs during late pregnancy was based largely on experience of the effects on plasma ketone concentrations of various increments of supplementary feeding, taking into consideration the range of ketone concentrations within any group and also the change in mean ketone concentration resulting from previous feed adjustments. An attempt was made during 1974 to develop a more objective approach. This was based on a relationship between plasma ketone concentration and energy status derived in earlier experimental work on pregnant ewes. This provided a means of estimating the feed increment required to change plasma ketone concentration from the level observed to any predetermined value. A formula based on this relationship and taking account of foetal growth, ewe body weight and expected lambing percentage was developed.

This more objective approach to the regulation of feed inputs in late pregnancy was tested on groups, generally of 40 early lambing ewes and gimmers, from each of the two In-Wintering Systems (Rigg and Gairs, and Low End), from four Year-Round Grazing Systems (Hairney Law and Auchope, Mid Hill, Cairn and Birnie, and Alderhope) and from the Greyface Upland Sheep Project at Glensaugh. The climatic conditions prevailing during March and early April 1974 were such as to impose a lesser nutritional stress than would normally be encountered at that time of year, and for this reason the technique was not subjected to any rigorous tests. The Greyface flock, and particularly those lambing at the beginning of March, provided the most stringent test of the technique, and in this situation where there was little experience of either the level of production which might be expected or of feed inputs in previous years, the technique was found to be a particularly useful means of controlling nutritional management.

GENOTYPES (01004)

Use of crossbred ewes in an improved hill environment
J.M. Doney, R.G. Gunn and T.J. Maxwell

The project carried out on Mid- and West-Finella, Glensaugh, to compare the performance of first-cross ewes (Border Leicester x Blackface and Texel x Blackface) with pure bred Blackface ewes has reached a stage where the first

of the crossbred generation have been mated as gimmers. Numbers in each class are still being increased to the required level to allow for the use of sheep of known provenance in specific experimental conditions. The form of management for the whole project has been standardized and resources allocated. Some re-fencing will be carried out next year.

NUTRITION AND BODY CONDITION (02003)

Assessment of the protein status of hill ewes

A.J.F. Russel (in collaboration with A.R. Sykes, ADRA)

The principal nutritional limitation to production from hill sheep is generally believed to be an insufficient supply of dietary energy, and that protein intakes are adequate at most levels of energy intake. Preliminary evidence was presented in last year's report (1973, p.12) suggesting that this assumption may not be valid in all cases, and in particular that it may not be true in cases where heather forms a major constituent of the diet.

The study initiated in 1973 was continued during 1974, with 70 Scottish Blackface ewes from the Birnie and Cairn flocks at Glensaugh and a further 70 from the Mid Hill flock at Lephinmore being blood sampled at intervals throughout the year to assess the protein status of ewe flocks in these heather-dominant situations.

In 1973, total serum protein concentrations showed a markedly seasonal pattern in all three flocks; exceptionally low values were recorded in the Lephinmore ewes during March and April. The seasonal pattern was again evident, but to a much less marked extent, in 1974, minimum values occurring during March and April and concentrations increasing thereafter throughout the summer months to maximum values in August. The minimum concentrations in late pregnancy were generally not as low as noted in 1973 (6.8-5.6 g/100 ml at Lephinmore, and 6.8-6.6 g/100 ml at Glensaugh). Maximum concentrations in August were, however, lower in 1974 than in 1973 (7.6 g/100 ml at Lephinmore and 7.7 g/100 ml at Glensaugh-8.8 g/100 ml in 1974). Differences between Lephinmore and Glensaugh and between the two Glensaugh flocks were generally small at all sampling dates. Further analyses indicated that most of the changes in serum protein concentration were attributable to changes in the globulin fraction; serum albumin concentrations remained relatively more constant throughout the year.

In contrast to the total serum protein concentrations, blood urea nitrogen values showed a very pronounced seasonal pattern which was more marked than that noted in the previous year. Very low mean concentrations (of less than 3 ng/100 ml) were recorded at Lephinmore during February and early March, although at the latter date the preferential treatment of the gimmer age group was evident (mean 7.1 ng/100 ml). The introduction of supplementary feeding to the ewe flock was reflected in increased blood urea nitrogen concentrations (mean values for ewes and gimmers being around 11 and 21 ng/100 ml respectively). The flock mean values thereafter increased progressively to almost 20 ng/100 ml by August. Concentrations in the two Glensaugh flocks during late pregnancy were somewhat higher than in the previous year, and considerably greater than at Lephinmore. The Cairn ewes tended to have lower minimum values than those on Birnie.

In general the 1974 results indicate that the protein status of ewes in these three flocks was somewhat better than in the previous year, particularly during late pregnancy from February until April. Despite this general improvement, which is more likely to be due to seasonal differences between years than to changes in management, the results suggest that at Lephinmore a situation of severe protein inadequacy existed for a relatively short period of time before the introduction of supplementary feeding in late pregnancy. The two years

results now available would suggest that in conditions such as those prevailing at Lephinnore consideration must now be given to the provision of some source of supplementary nitrogen during the weeks prior to the introduction of normal late pregnancy feeding.

The results are now being analysed to relate the concentrations of the above metabolites to production parameters of individual ewes.

NUTRITION - HEATHER

1. The effect of palatability on the voluntary intake of heather (*Calluna vulgaris*) by sheep

Alison Tait, J.A. Milne and A.J.F. Russel

The voluntary intake of heather by sheep is low in comparison with that of other roughages of similar digestibility. It was considered that the relatively high concentrations of phenols and tannins in heather might affect palatability and hence voluntary intake. Two methods were used to study the possible effect of palatability on the voluntary intake of heather by sheep. In method A, 50% of a previously established voluntary intake was given per rumen fistula to sheep offered heather ad libitum. If total intake exceeded the previously established voluntary intake it could be concluded that palatability was limiting intake. In method B, the heather given per rumen fistula had previously been ingested and masticated by oesophageal-fistulated sheep. Five mature Scottish Blackface castrated males (wethers) were used in a simple cross-over design to compare the two methods.

The mean voluntary intake of DM (g/day \pm SE) prior to heather being given per fistula was 440 ± 41.2 . The mean total DM intake in method A (353 ± 31.2) was significantly lower than in method B (532 ± 31.5) $P < 0.01$. The respective DM digestibilities were 43 ± 1.7 , 39 ± 3.3 and 47 ± 1.1 , the difference between methods being significant ($P < 0.05$). This change in digestibility made it impossible to draw firm conclusions regarding the effect of palatability on voluntary intake.

The effects of mastication and added saliva on intake and digestibility were then examined. No difference was found between Methods A and B in the particle size distribution of heather given per fistula. However calculations indicated that DM intake and digestibility were both positively related to soluble nitrogen intake suggesting that the differences noted between methods A and B could be explained in terms of the quantity of soluble nitrogen entering the rumen. Measurements of rumen ammonia concentration, cell wall digestibility and mean retention time of indigested food residues supported this hypothesis.

2. The effect of level and source of nitrogen on the voluntary intake of heather by sheep

Alison Tait, J.A. Milne and A.J.F. Russel.

The results of the previous experiment (see p 96) indicated that increasing the intake of soluble nitrogen could increase the voluntary intake and digestibility of heather by sheep. This experiment was designed to investigate the effect on voluntary intake and digestibility of heather by sheep of (a) 3 levels of soluble nitrogen supplementation, viz. 0.5, 1.5 and 3.0 g additional N per day, and (b) 2 sources of nitrogen, casein and urea, given as 4 supplements, viz. all casein, $\frac{2}{3}$ casein: $\frac{1}{3}$ urea, $\frac{1}{3}$ casein: $\frac{2}{3}$ urea and all urea.

All four supplements were compared at each level of nitrogen. Thus there were 12 treatments with 2 rumen-fistulated Blackface wethers (mean weight 45 kg) per treatment. Within each treatment period the sheep were offered heather ad libitum for 17 days, designated as the control period. This was followed by a period of 14 days in which the additional nitrogen was continuously infused per rumen. Measurements were made on the last 7 days of the control and treatment periods.

Source of nitrogen was found to have no significant effect on voluntary intake and digestibility, and the results given in Table 1 below are the pooled means for each level of nitrogen.

Table 1. The intakes of dry matter (DM) and digestible dry matter (DDM) and the dry matter digestibility (DMD%) of heather offered ad libitum to sheep infused per rumen with levels of nitrogen

	Control	Levels of nitrogen (g/day)		
		0.5	1.5	3.0
DM Intake (g/day)	341	448	478	544
DMD%	385	52.3	53.3	55.4
DDM Intake (g/day)	131	234	255	299

The addition of 0.5 g N/day increased both DM intake and digestibility by 30% and digestible DM intakes by 80%. Although the responses were of a smaller magnitude, further additions of 1.5 and 3.0 g N/day increased DM intake and digestible DM intake in a significant positive manner. DM digestibility did not show a further significant increase. Results suggest that the increased intake and digestibility of heather was due to an increased rate of digestion and extent of digestion of the cell walls of heather in the rumen. In terms of rumen ammonia concentrations, blood plasma and urine urea concentrations and nitrogen balance, the additional supplementary nitrogen was used efficiently by the sheep, except perhaps at the 3.0 g/day level.

The results of this experiment confirm the interpretation of the results of the previous experiment and indicate the large responses in intake and digestibility that can be obtained with the addition of small amounts of supplementary nitrogen.

3. An apparatus for the measurement and sampling of urine from grazing female sheep.

A.R.M. Chambers, J.A. Milne, A.J.F. Russel and I.R. White.

Many types of nutritional and physiological investigations require the quantitative collection of urine from sheep and a representative sample for subsequent biochemical analysis. One example of such a need is outlined by Martin, Milne and Moberly (1975). Urinary measuring and sampling equipment (UMASE), which is attached to the sheep and is suitable for use with either penned or grazing female sheep, is described.

Urine, collected by an indwelling bladder catheter, drains into two glass reservoirs. The upper, smaller reservoir is joined by a narrow glass tube to the lower, larger reservoir. Light-activated switches (LAS) are located at the top of the smaller reservoir, at the narrow tube, and at the bottom of the lower reservoir. The upper and lower LAS control a relay through a bistable circuitry and the middle LAS controls a second relay. These relays operate three solenoid valves, which control the flow of urine in the UMASE, and a counter. The counter records the number of draining cycles of the reservoir system. Urine from the small reservoir comprising a representative sample is stored in a sample collector and the urine from the large reservoir is voided. By changing the size of the small reservoir different proportions of total urine output can be collected. Total urine output is calculated as the product of the value of the counter and the known volume of the reservoir system. The UMASE is operated by one 8V and one 2 x 12V rechargeable batteries.

Experiments in which the UMASE was tested on 12 sheep in metabolism cages for several periods of five consecutive days indicated that:-

- (i) catheterisation of the bladder and attachment of the UMASE did not affect daily urine output;
- (ii) the estimate of urine volume provided by the UMASE differed from total urine output by between - 1.5 and + 4.3%;
- (iii) the sample of urine collected by the UMASE was compositionally representative of total urine output;
- (iv) without change of batteries UMASE can be used continuously for 19 h or with urinary outputs of up to 6 l.

The UMASE has also been shown to operate satisfactorily under rigorous field conditions.

Reference

Martin, A.K., Milne, J.A. and Moberley, P. Urinary quinol and orcinol outputs as indices of voluntary intake of heather (*Calluna vulgaris* L. Hull) by sheep. Proc. Nutr. Soc., 1975, 34, 70A (in press).

4. The production and utilisation of grass and heather in mixed swards (02004/04005).

- a) Sown grass and heather utilised as a production area of a two pasture system
J.A. Milne, Sheila A. Grant, L. Bagley, G.T. Barthren and T.J. Maxwell

In this experiment plots with 15, 30 and 45% grass inclusion were provided and animal numbers were adjusted to achieve 40% utilisation of the heather component. At the 30% grass inclusion there were three plots with sheep numbers adjusted to achieve 25, 40 or 55% utilisation of the heather.

To simplify the experiment the grass was sown without clover and 120 units of fertilizer nitrogen added to replace nitrogen transfer from clover. Total production of the grass component over the season amounted to 2088 kg/ha. The low productivity was thought to be due to poor retention of fertilizer nitrogen in the peat soil which is in agreement with the recently reported findings of Munro (1974). In 1975 it is hoped to adjust fertilizers to achieve a production level of some 4000 kg/ha.

During the three grazing periods viz. May, July and October, serial harvests were made of the grass areas to record available grass, growth rates and utilisation. Available current season's growth and utilisation of the heather were also recorded. Measurements were made of the intake and digestibility of the grass and heather components of the diet. By the end of October grazing period the planned utilisation levels of heather were achieved. Preliminary results indicate that heather was utilised towards the end of each grazing period when the measured standing crop of the grass was low. To aid an understanding of the mechanisms involved in the utilisation of grass/heather areas a mathematical model has been developed (see p49).

NUTRITION SUPPLEMENTATION/PASTURE UTILIZATION (02005/03003)

1. Investigations into the digestive physiology of supplementary feeding (02005/02004/03003)

J.C. MacRae, J.A. Milne, S. Wilson and A. Spence

Following the preliminary studies detailed in the Annual Report 1973 p.17-19, work has progressed on the study of digestion of indigenous hill herbage by sheep.

To date, experiments have been carried out to examine the partition of digestion of heather (Calluna vulgaris) and Agrostis-Festuca diets by sheep. In addition procedures are being developed for the measurement of VFA production rates (see p. 16) and of the kinetics of N transfers between various metabolic pools. (With respect to the latter technique, J.C. MacRae is greatly indebted to Dr. J.V. Nolan and Prof. R.A. Leng, University of New England, Australia for their help and training during his six month stay in their laboratory).

Further data are now available on the partition of heather digestion (see Annual Report, 1973 p. 13). Fig. 1 shows the flows of OM and N entering and leaving the small intestine and in the faeces relative to the intake of these constituents. Apparent digestibilities of OM (47%) and N (31%) were similar to previous observations (J.A. Milne 1974) and, in general, the partitions of digestion of OM and N were similar to others reported for low quality dried roughages, viz. 55% of the digested OM, disappeared anterior to the small intestine, 30% was apparently digested in the small intestine and 10-15% was digested in the large intestine. There was considerable synthesis of non-ammonia-N (NAN) in the stomach region; at an intake of 450 g OM (5 g N) there was a net addition of over 3 g NAN between the feed and duodenum, brought about presumably by microbial synthesis of NAN from endogenous N sources and some secretion of endogenous protein.

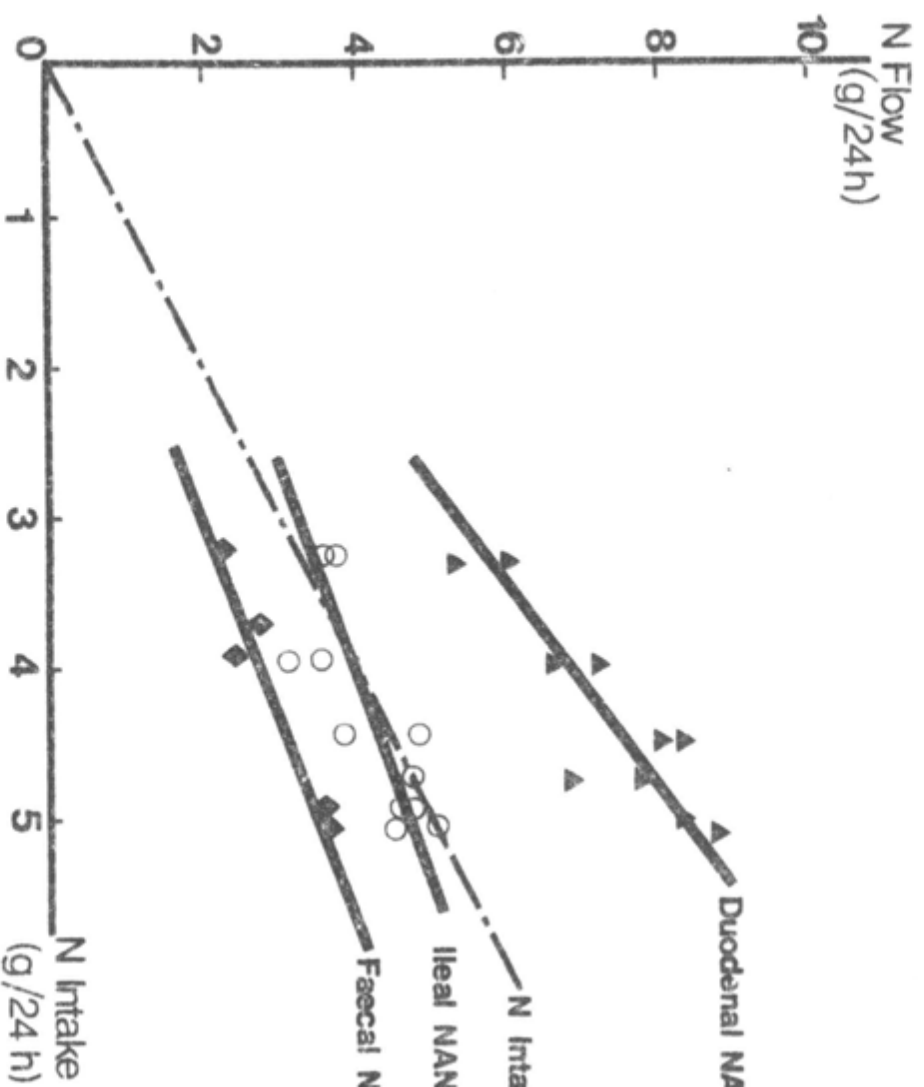
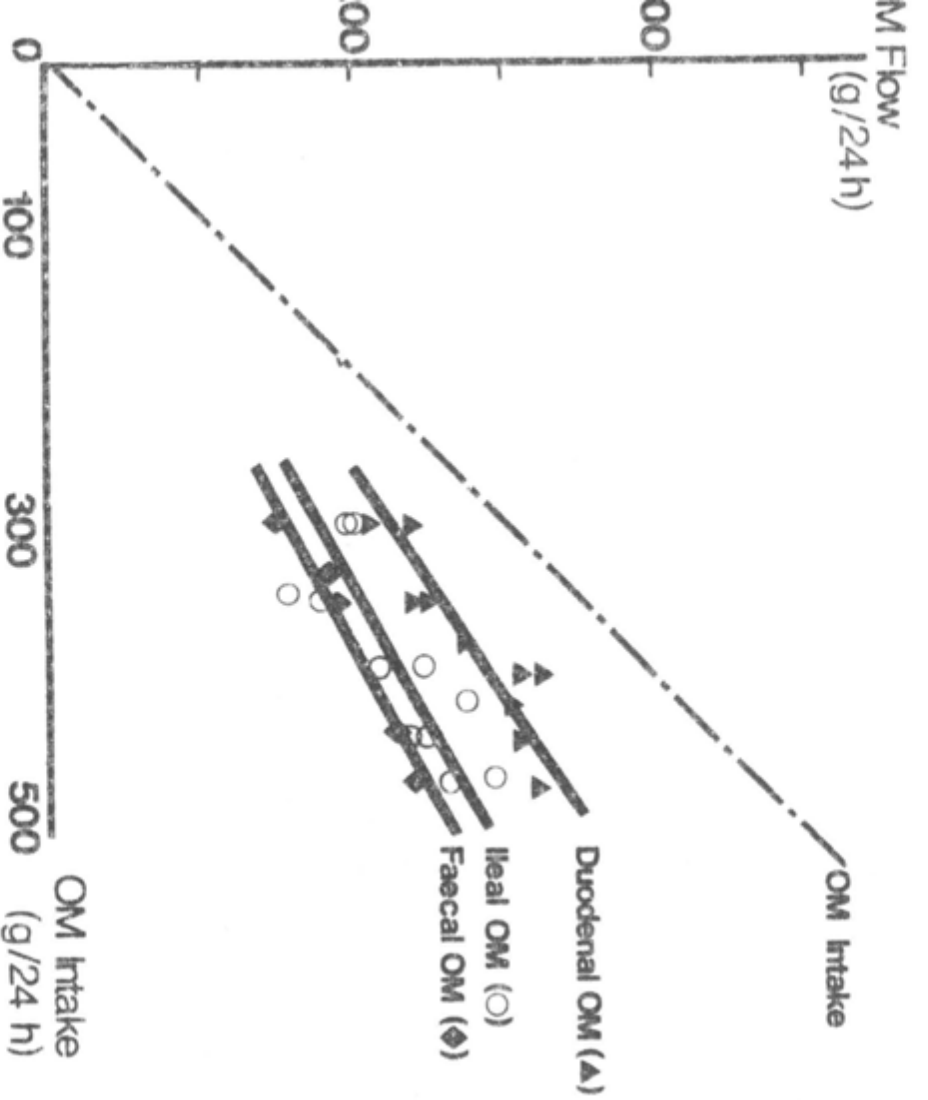
One way in which the heather data differ from previous reports of other forages, is in the amount of NAN entering the small intestine and which is apparently absorbed therein. On most diets between 55-75% of the NAN reaching the duodenum disappears before the ileum, but in the heather-fed sheep the NAN reaching the duodenum had an apparent availability of only 40-45%. Work is proceeding to investigate if this low availability is due to tannin binding of the protein.

The Agrostis-Festuca experiment has been conducted only recently and no data are available.

Reference

- Milne, J.A. (1974). The effects of season and age of stand on the nutritive value of heather (Calluna vulgaris) to sheep. J. agric. Sci., Camb. 83, 281-288.

Relationships between flows of OM & N entering and leaving the small intestine and excreted in faeces and the intake of the constituents



2. Measurement of VFA production rate by isotope dilution technique S. Wilson

A method for measuring volatile fatty acid (VFA) production in the rumen and caecum of sheep was required for the current programme of investigation into the nutritional value of hill herbage species.

It was decided to develop an in vivo isotope dilution technique currently being used in several laboratories. Unfortunately preliminary experiments revealed serious unexpected problems. Large losses of ^{14}C activity were encountered during isotope infusions. No reference had been made to this problem in the literature, but after extensive investigation the source of this loss has since been traced to probable microbial degradation of the isotopes with release of $^{14}\text{CO}_2$. As indicated in Table 1, the problem was overcome only by dissolving the isotopes in autoclaved water, or by the addition of alkali.

Table 1. Percentage loss of ^{14}C activity from solutions of (1 - ^{14}C) Sodium propionate

	Solvent* % loss of activity			
	Autoclaved water	Distilled water	Tap Water	Tap Water + NaOH
Day 1 - 3	0	18	11	0
3 - 5	0	33	32	0
5 - 7	0	41	50	0

* Includes 1 μmole carrier
VFA/0.5 μCi

It is probable that the alkali is merely keeping the $^{14}\text{CO}_2$ in solution as bicarbonate thus invalidating the use of this preparation in any isotope dilution study. ^{14}C -labelled VFA's made up in autoclaved water have recently been used to measure production rates in sheep continuously-fed Agrostis-Festuca diets. The specific activities of rumen and venous-bicarbonate were monitored to identify any isotope degradation in the rumen. Also comparative VFA production rates were determined by an in vitro incubation technique using digesta from the same sheep slaughtered at the end of the isotope dilution experiment.

3. The supplementation of winter hill herbage with cereal and cereal plus protein supplements C.S. Lamb, J.C. MacRae and J. Eadie

A preliminary description was given in the Annual Report, 1973, p. 20, of a two phase investigation into the effects of supplementing winter quality Agrostis-Festuca herbage with cereal and cereal plus protein concentrates both indoors (frozen herbage) and in the grazing situation.

a) Indoor experiment

Frozen herbage (31-35% DM; N 1.3%; dead/green ratio 81:19), harvested in December 1973 was offered to 48 sheep. Table 1 presents intake and digestibility data of sheep offered ad lib herbage fed alone or supplemented with rolled malting barley (85.3% DM; N 1.45%) or 85% barley + 15% soya-bean meal (2.32% N). Herbage was offered to 50% excess and a mean dead/green ratio of 88:12 of the refusals indicated considerable selection of the diet.

Table 1.

Supplement Level	Herbage OMI (g/w ^{0.73})	Total OMI (g/w ^{0.73})	Ration OMD(%)	Total DOMI (g/w ^{0.73})	Mean LW (kg)	Mean Grade
0	60.2	60.2	47.8	28.8	40.7	1.21
100 G	59.5	64.8	53.3	34.5	42.9	1.25
200	57.3	66.5	57.0	39.1	43.0	1.33
300	54.0	70.0	54.9	38.6	43.8	1.34
400	51.7	73.8	57.7	42.7	41.4	1.38
500	52.3	77.8	60.3	46.9	46.8	1.36
100 N*	62.9	67.9	54.6	37.3	43.3	1.33
300 N*	57.1	78.5	57.0	41.3	40.2	1.33
L.S.D. @ 5% prob.	6.3	7.1	4.4	5.6	-	-

*supplements of 85% malting barley, 15% soya-bean meal.

Intakes of herbage were relatively high for a poor quality roughage (48% OMD). Increasing the amount of cereal supplement increased the total intake of DOM, but caused a reduction in intake of herbage. There was a linear relationship between the intakes of herbage OM (Y) and barley OM (X) - $Y = 61.1 - 0.399X$ ($P < 0.01$) showing that the supplement replaced herbage intake to the extent of 40%. The supplements containing soya-bean meal caused slightly less replacement of herbage.

No associative effects could be demonstrated between the OMD of the herbage and barley components of the diet, there being a significant ($P < 0.001$) linear relationship between ration OMD (Y) and % of supplement in the diet (X) - $Y = 50.2 + 0.270X$; apparent OMD of the barley being 77%.

b) Outdoor experiment

Faecal N content of the control sheep were higher in the grazing experiment (1.62%) than indoors (1.44%) probably indicating selection of a better quality diet from the 1650 kg DM/acre available herbage on offer.

In the grazing situation the effects of supplementation of herbage intake had to be derived indirectly from measurement of total faeces outputs and a knowledge of the digestibility of the barley supplement as determined in the indoor experiment.

Replacement of herbage intake by supplement was 26%. This value is lower than the actual measurements of herbage intake made indoors (40%) but is similar to a value derived by regression of faeces outputs in the indoor study (22%). The fact that these observations are markedly different from other results of the effects of supplementing poor quality hay serves to emphasise the need to continue using hill herbage in future nutrition experiments.

4. The effects of level of barley and barley plus soya-bean meal supplements on the intake of winter hill herbage by sheep under two grazing regimes

C.S. Lamb and J. Eadie

The objectives of this experiment were to study:

1. the effects of level of cereal supplements on the intake of different qualities of winter hill herbage,
2. the value of added protein in the supplement on herbage intake,
3. the effect of amount of herbage available to the grazing sheep on the response to feeding supplements.

Fifty $3\frac{1}{2}$ year old Blackface wethers were allocated to 10 treatment groups by restricted randomisation from 5 classes of faeces output as determined in a 4 week covariance period. Five of the groups were designated high quality (HQ) and 5 low quality (LQ) grazing. Each of the 5 groups were allocated a supplement level 0, 200, 400 g rolled malting barley and 200, 400 g of 15% soya-bean meal + 85% barley. The experiment covered two periods each of 21 days and it was intended that there would be a difference in herbage availability between periods. Results indicate that this aim was not successfully achieved - see Table 1.

Table 1. Herbage available in each collection period (kg DM/hectare).

	<u>High quality</u>	<u>Low quality</u>
Period 1	3344	2794
Period 2	3038	2597

As in the previous experiment estimates of herbage DM intake were obtained from faeces outputs adjusted for the amount of residue originating from the indigestible fraction of the supplement. Results so far available suggest that supplementation reduced the intake of LQ herbage to a greater extent than that of HQ. Since the LQ areas were created by previous grazing, the explanation of this result may lie in pasture availability and fouling or in significant interactions between the digestibilities of the supplement and the herbage ingested.

NUTRITION : METABOLISM (02006)

A study of the effectiveness of cobalt dressing of pasture in the prevention of cobalt deficiency in weaned lambs

A. Whitelaw, A.J.F. Russel, A.R. Fawcett and Patricia Moberly

Investigations on the diagnosis and treatment of sub-clinical cobalt deficiency in weaned lambs at Glensaugh in 1973 demonstrated firstly, that the deficiency could be diagnosed by and its severity quantified in terms of concentrations of serum vitamin B₁₂ and urinary formiminoglutamic acid (FIGLU) and, secondly, that the condition could be treated satisfactorily by the administration of a single cobalt bullet or less effectively by oral dosing with cobalt chloride.

A further investigation was carried out in 1974 on the same area of ground to examine the effectiveness and persistence of application of cobalt salts to the soil in preventing cobalt deficiency in weaned lambs. The field was divided into 12 plots, each of approximately 0.33 acre, to provide four replicates of three treatments, viz. no cobalt (control) 2 and 4 lb mixed cobalt chloride plus cobalt sulphate per acre. The areas were sprayed on 21st August, and the plots were stocked, each with five weaned Blackface ewe lambs, on 11th September.

From weaning in early August until 11th September the lambs were grazed on the Brae Field, which is known to be cobalt deficient. During these four weeks the lambs lost on average about 1 kg live weight, serum vitamin B₁₂ concentrations declined (many to less than 200 pg/ml) and measurable quantities of FIGLU were found in a high proportion of urine samples. These results indicated the development of sub-clinical cobalt deficiency. The lambs were then transferred to the experimental area with the intention of studying the further development of the deficiency in lambs on the control plots and the extent of the alleviation of the deficiency in the two treatment replicates.

During the experimental period from 11th September to 20th November there were no apparent differences between lambs on the control and treatment plots. No signs of clinical cobalt deficiency developed in any lambs. Liveweight responses were poor (averaging only some 70 g/day) but there was no apparent relationship between liveweight change and pasture treatment. The biochemical analyses of serum and urine samples are not yet complete, but preliminary examination of the results available suggests the presence of a hitherto unencountered situation of high (and apparently normal) serum vitamin B₁₂ concentrations with appreciable urinary FIGLU excretions. An explanation of these apparently anomalous results must await completion of the biochemical and statistical analyses.

CATTLE (02008)

1. The effect of nutritional state during late pregnancy on the production of suckler cows

A.J.F. Russel, A. Whitelaw, J.N. Peart and A.J. Macdonald

Experiment I 1973-74

The first experiment in a research programme designed to measure the effects of nutritional state during late pregnancy on the production of suckler cows, as measured in terms of calf birth weights, milk production, and live weight response of cows and calves during lactation, was carried out at Glensaugh with cows calving in the autumn/winter of 1973/74. Effects of nutritional state during late pregnancy and of genotype on immunoglobulin production and absorption in beef cattle were also studied.

1. Effects on calf birth weight

A.J.F. Russel, A. Whitelaw, J.N. Peart and A.J. Macdonald

The first experiment was conducted on 63 cows (32 Blue Grey and 31 Hereford x Friesian). A complete non-pelleted diet comprising ground barley (52%), chopped barley straw (26%), molasses (9%) and protein concentrate, including mineral and vitamin supplements (13%), and supplying, on a dry matter basis, a calculated 2.65 Mcal ME/kg and 14% CP was fed throughout the final 15 weeks of pregnancy. During the last 12 weeks cows were randomly allocated to one of eight levels of feeding ranging in equal increments from 75% of the maintenance requirements of a non-pregnant, non-lactating cow to somewhat more than the full requirements of a pregnant cow at term (i.e. from 8.2 to 18.7 Mcal ME/day for a 500 kg cow). These levels of feeding created wide variation in nutritional state as measured in terms of blood metabolites.

Mean calf birth weights were, Blue Greys 37.2 kg, Hereford x Friesian 38.6 kg. There was an indication that the severity of undernourishment produced by the two lowest levels of feeding may have caused a reduction in calf birth weight, but the effect was small and biologically of little consequence. This suggests that levels of feeding during the last 12 weeks of pregnancy as low as 75% of maintenance are unlikely to have any material effect on calf birth weight.

2. Studies on lactation and calf growth

J.N. Peart, A.J.F. Russel, A. Whitelaw and A.J. Macdonald

See Annual Report 1973, p. 23.

3. Effects on immunoglobulin production and absorption
A.J.F. Russel and A.J. Macdonald (in collaboration with R. Halliday, ABRO)

After parturition samples of colostrum were collected twice daily for four consecutive days. Calves were blood sampled before suckling and twice more on each of the first two days after birth.

Analyses of the calf serum samples showed no effect of level of pre-partum feeding on immunoglobulin concentration. Serum IgG₁ concentrations had attained maximum values by the time of the third sampling (i.e. at approximately 24 h after birth) and these values were very highly correlated with those from the two samples in the subsequent 24 h ($r = 0.94$ and 0.96). Calves from Blue Grey cows had significantly higher IgG₁ concentrations ($26.5 \text{ ng/ml} \pm 1.59$) than those from Hereford x Friesian cows ($20.6 \text{ ng/ml} \pm 1.71$).

Immunoglobulin concentrations in the first colostrum samples were closely related ($P < 0.001$) to those measured in the calf serum samples.

The decrease in total protein concentration in the colostrum between first and second samples was significantly greater in the Blue Grey cows than in the Hereford x Friesians; this decrease was correlated with IgG₁ concentrations in the calf serum ($r = 0.64$).

Experiment II 1974/75

The particular objective of the second experiment conducted at Glensaugh with cows calving during the autumn/winter of 1974/75 was to measure the effect of relatively severe levels of undernourishment (as opposed to the somewhat less severe and wider range of nutritional states examined in the previous year) during late pregnancy on production from suckler cows.

1. Effects on calf birth weight
A.J.F. Russel, A. Whitelaw, J.N. Peart and A.J. Macdonald

The diet used in the previous experiment was modified in an attempt to lower the voluntary intakes in the lactation part of the study. Following preliminary experimentation with sheep, a diet containing more straw and less molasses than that used in the previous year was formulated; the composition by weight was ground barley (37%), chopped barley straw (42%), molasses (5%) and protein concentrate (16%). The diet was calculated to supply, on a dry matter basis, 2.37 Mcal ME/kg and 14.2% CP.

A total of 58 cows (32 Blue Grey and 26 Hereford x Friesian) were brought into the Glensaugh cattle shed as required 15 weeks before their expected date of calving. All cows were individually fed according to body weight at a level designed to provide maintenance for an initial three week period. During the final 12 weeks of pregnancy cows were randomly allocated within breeds to one of five levels of feeding ranging in equal increments from 65% to 125% of the maintenance requirements of a non-pregnant, non-lactating cow (i.e. from 7.2 to 13.9 Mcal ME/day for cows weighing 500 kg).

Biochemical analyses of weekly blood samples taken to characterise nutritional state, and statistical analyses of cow and calf weights, have yet to be completed. It is clear, however, that the levels of prepartum feeding produced markedly different cow live weight responses, ranging from losses on the lowest level of feeding of some 36 kg in 12 weeks to gains on the highest level of feeding of about 53 kg. Visual inspection of the calf birth weight data suggests an effect of feeding treatment on calf birth weights which ranged from a mean of 35.3 kg on the lowest level of feeding to 40.9 kg on the highest level. Calves from the Hereford x Friesian cows were generally heavier by some 3 kg than those from the Blue Grey cows.

2. Lactation studies with beef cows and their calves

J.N. Peart, A. Whitelaw, A.J.F. Russel and A.J. Macdonald

The 1974-75 study was almost identical to that of 1973-74 except that some modifications were made in the composition of the diet and range of nutritional levels imposed during late pregnancy. The consequences of the pregnancy nutrition treatments to parturition are given in the previous section.

After parturition the cows were fed ad libitum a diet similar to that given in late pregnancy. The calves were also offered similar food from six weeks of age but this food intake was restricted to 2.5 kg/head/day. The daily food consumption of individual cows and calves was recorded daily. The daily food intake of cows attained maximum mean values of around 20 kg in lactation week eight compared with 27 kg/day in the 1973 experiment.

The milk production of 39 cows was recorded at two-week intervals using a calf-suckling, weight-differential technique. The experiment is still in progress but a preliminary examination of the data indicates that with the Hereford x cows the mean milk production of the lowest level of feeding during pregnancy was lower than each of the other groups, but there was little difference between the remaining groups. Similar data from the Galloway x cows shows that pregnancy feeding level had no effect on subsequent milk production.

Compared with the other feeding treatments, the lowest level of feeding in late pregnancy depressed calf birth weights and this difference remained at 10 weeks of age. However, there was little difference between groups in respect of calf growth rates.

The data are summarised as follows:-

<u>0-10 lactation week period</u>		
	<u>Here. x Cows</u>	<u>Gall. x Cows</u>
Mean daily milk production (kg)	11.4	10.6
Mean daily live weight gain of calves (g)	1123	1087

As in 1973-74, severe and recurring calf scour was recorded in most calves and two deaths ensued. The cause of this scour has now been established as viral diarrhoea; details of veterinary problems are given in the section dealing with animal health.

3. Effects of immunoglobulin production and absorption

A.J.F. Russel and A.J. Macdonald (in collaboration with R. Halliday, ABRO)

Samples of colostrum and of calf blood were again collected for examination of the effects of nutritional state during late pregnancy and of genotype on immunoglobulin production and absorption.

INPUT-OUTPUT STUDIES (03002/04007)

J. Eadie, R.H. Hetherington and T.G. Common

1. Sourhope

The aim of this work is to quantify responses to a range of pasture improvement treatments on production from hill land of varying type and quality. More detailed accounts of the aims and background have been given in previous reports.

Three sites of differing soil and pasture types are under investigation:-

1. F2 (*Agrostis/Festuca*) on Brown Earth Soil
2. G3 (*Molinia* dominant) on Peaty Podzol
3. F4 (*Nardus* dominant) on Peaty Podzol

The range of treatments applied at these sites is as follows:-

- A - control grazed (fencing only)
- B - line applied
- C - line and slag applied
- D - line and slag with clover sown
- E - line and slag with clover and ryegrass sown

rates:	line	2.5 tons/acre
	slag	10 cwt/acre
	clover	2 lb/acre
	ryegrass	20 lb/acre

The collection of lat from these sites proceeded during 1974, faecal collections being made in Experiment 1.

Expt. 1. Agrostis/Festuca site.

As noted in the Annual Report, 1973, p. 27, an additional plot (F) has been included. This plot has been neither fertilized or seed applied.

Carrying capacity of all plots in terms of grazing days/acre is given in Table 1.

Table 1. Carrying Capacity (sheep).

<u>Treatment</u>	<u>A</u>	<u>B</u>	<u>C</u>	<u>D</u>	<u>E</u>	<u>F</u>
Grazing days/acre	1072	1244	1260	1372	1664	1288

The table shows a good response in terms of grazing days to treatments. The relatively high level of plot F in comparison with the control may be due in part to an upgrading of the pasture affected by previous mob stocking.

The mean liveweight changes of all sheep remaining on the plots throughout each grazing period are shown in Table 2.

Table 2. Liveweight change (kg).

<u>Treatment</u>	<u>A</u>	<u>B</u>	<u>C</u>	<u>D</u>	<u>E</u>	<u>F</u>
1st Grazing 13/5-10/6/74	+3.8	+ 1.7	+ 3.1	+ 1.3	+ 5.0	+ 4.1
2nd Grazing 29/7-26/8/74	+0.6	+ 2.0	Nil	- 0.8	+ 2.0	Nil
3rd Grazing 14/10-4/11/74	-1.0	- 0.5	- 3.8	- 3.0	- 0.5	- 1.2

The amounts of pasture dry matter available at the start of each grazing period are given in Table 3.

Table 3. Herbage Dry Matter available at start of grazing period (lb/acre)

<u>Treatment</u>	<u>A</u>	<u>B</u>	<u>C</u>	<u>D</u>	<u>E</u>	<u>F</u>
8/5/74	1046	927	1202	1030	964	899
24/7/74	1225	1616	1675	1877	1981	2030
11/10/74	1042	960	1018	906	1002	816

Expt. 2. Molinia-dominant site

The carrying capacity data are given in Table 1.

Table 1. Carrying Capacity (Sheep)

<u>Treatment</u>	<u>A</u>	<u>B</u>	<u>C</u>	<u>D</u>	<u>E</u>
Grazing days/acre	980	1008	868	1048	1258

With the exception of treatment C (lime and slag), grazing days increase with treatment intensity.

Table 2. Liveweight change (kg)

<u>Treatment</u>	<u>A</u>	<u>B</u>	<u>C</u>	<u>D</u>	<u>E</u>
1st Grazing 16/5 - 13/6/74	+ 3.9	+ 0.3	+ 3.2	+ 4.4	+ 6.8
2nd Grazing 31/7 - 28/8/74	+ 0.7	+ 6.3	+ 3.3	+ 5.9	+ 5.4
3rd Grazing 16/10 - 6/11/74	- 6.2	- 3.9	- 3.4	+ 1.2	+ 1.7

Weight gains are greater at the higher treatment levels (Table 2).

Table 3. Dry matter available at start of grazing period (lb/acre)

<u>Treatment</u>	<u>A</u>	<u>B</u>	<u>C</u>	<u>D</u>	<u>E</u>
14/5/74	618	816	595	684	655
29/7/74	1772	1722	1317	1746	1813
14/10/74	928	971	1168	974	1011

Expt. 3. Nardus dominant site

Table 1. Carrying Capacity (Sheep)

<u>Treatment</u>	<u>A</u>	<u>B</u>	<u>C</u>	<u>D</u>	<u>E</u>
Grazing days/acre	784	812	924	1204	1330

Grazing day totals show a direct response to inputs from lowest to highest levels.

Table 2. Liveweight change (sheep remaining on plots through grazings) (kg)

<u>Treatments</u>	<u>A</u>	<u>B</u>	<u>C</u>	<u>D</u>	<u>E</u>
1st Grazing 17/5-14/6/74	+ 3.1	+ 4.6	+ 4.7	+ 2.2	+ 8.9
2nd Grazing 1/8-29/8/74	+ 1.4	+ 2.7	+ 1.8	+ 4.5	+ 4.1
3rd Grazing 17/10-7/11/74	- 4.6	- 4.1	- 4.1	- 3.1	Nil

Weight gains are generally greater as treatment levels are increased. The individual treatment weight gains are reduced at successive grazing periods through the season, as is the case in all the experiments in this series.

Table 3. Herbage available at start of grazing period (lb/acre)

<u>Treatments</u>	<u>A</u>	<u>B</u>	<u>C</u>	<u>D</u>	<u>E</u>
15/5/74	951	787	830	891	993
30/7/74	1089	1109	1242	1669	1945
15/10/74	988	1217	1212	1252	1101

2. Lephinmore

J. Radic and G.R. Bolton

The objectives and design of this improvement-response experiment were given in Annual Reports 1971 and 1972.

The problems which have arisen on this site were reported in the Annual Report (1973) and are further discussed under Project 04007/03002 - "Maintenance of improved pasture on deep peat" on page 91 of this Report.

Even on the plots which appear to have been successfully reseeded pasture production, averaging only some 65% of that of 1973, was poor. This was reflected in the carrying capacity figures.

Apart from the fact that elucidation of the reasons for the partial failure of some of the reseeded areas may contribute to a better understanding of the low levels of pasture production achieved in 1974, it is thought that the problem may in part be due to overgrazing. In order to keep the Eriophorum tussocks which survived the reseeding operation in check it was thought necessary to continue each grazing period beyond the point at which the Eriophorum was grazed. This resulted in a residue of some 200 lb dry matter/acre of sown species at the end of each grazing period. This is probably a much too severe grazing policy for continued pasture production at reasonable levels of dry matter yield.

Observation has also suggested that much less severe grazing pressures allow the clover to develop in the Eriophorum tussock. The clover is eventually grazed, and, with it the Eriophorum tussock, and this may be a much better way of dealing with the problem. This hypothesis is to be tested on this site in 1975.

B. SYSTEMS DEVELOPMENT

YEAR ROUND GRAZING SYSTEMS (03004)

Introduction

An introduction to the work covered by Systems Development was given for the year-round grazing systems in the Annual Report 1969 and for the inwintering systems in the Annual Report 1970. Below are the results of each of these studies during 1974 with a brief summary of total production data for all the years.

For a brief discussion and outline of the work carried out under Development, reference should be made to the Fifth Report, 1969-70, p.70 (Hill Sheep Production Systems Development).

YRGS I: Low capital input on a grassy hill. Sourhope/Hairney Law/Auchope
R.H. Armstrong, J. Eadie, T.J. Maxwell and P. Watchorn

Land Resources

There are 283 hectares of mainly grassy pasture which has been subdivided in such a way as to enclose some 100 hectares of Agrostis-Festuca pasture. There are now five Agrostis-Festuca enclosures which are fully integrated into the grazing system, one of them being primarily used as a hogg wintering paddock. The lambing paddocks are now allocated on an all-the-year round basis to the system and during lactation are primarily used for twin nursing ewes.

During the year those parts of the Agrostis-Festuca paddocks, P₁ and P₂ which were accessible to a tractor-spreader were treated with 6.37 metric tonnes of lime plus 269 kg of ground mineral phosphate per hectare. The areas within P₁ and P₂ so treated were 19.7 and 13.4 hectares respectively. There were also 9.7 hectares of bracken-infested pasture sprayed with Asulox at the rate of 11.2 litres per hectare.

Cattle

As in previous years, the hill cows were carried from 1st May to the end of December.

Sheep Stocks

Two sheep stocks, one of North Country Cheviots (NCC) bred pure, and one of South Country Cheviots (SCC) crossed with North Country Cheviot tups are run on the area.

Total stock numbers 1968-1974

	<u>1968</u>	<u>1969</u>	<u>1970</u>	<u>1971</u>	<u>1972</u>	<u>1973</u>	<u>1974</u>
NCC	175	210	260	269	300	295	292
SCC	223	241	254	260	273	305	309
Total	398	451	514	528	573	600	601

Ewes and gimmers have increased in number by over 50% since the study began. Ewe mortality continued at a low level at 4.7% in the NCC and 3.3% in the SCC.

Livestock Reconciliation 1973/74

	<u>Ewes & gimmers</u>	<u>Cast</u>	<u>Deaths</u>	<u>Gimmers brought into flock</u>	<u>Hoggs born 1974</u>	<u>Ewes & gimmers 1974</u>
NCC	295	59	14	70	69	292
SCC x NCC	305	63	10	77	71	309

Sheep Year 1973/74(a) Winter feeding16 January

NCC ewes and gimmers

255 g sugar beet pulp

SCC ewes and gimmers

249 g/hd/day sugar beet pulp

4 March

NCC ewes and gimmers

343 g sugar beet pulp

SCC ewes and gimmers

335 g/hd/day sugar beet pulp

18/19 March

NCC ewes

381 g + 227 g hay

SCC x NCC

318 g sugar beet pulp

90 lean NCC gimmers and 1
crop ewes to P560 lean SCC gimmers and 1
crop ewes to P5

all fed 508 g/hd/day sugar beet pulp

23 March

NCC

381 g concentrate cobs

SCC x NCC

423 g sugar beet pulp

26 March

150 lean gimmers and one crop ewes put on to 508 g concentrate cobs

30 March

SCC x NCC

318 g concentrate cobs

8 April

Lean gimmers and 1 crop ewes join remaining ewes

NCC

431 g concentrate cobs

SCC x NCC

339 g concentrate cobs

10 April

NCC

431 g concentrate cobs

SCC x NCC

423 g concentrate cobs

Total feed consumption per ewe:-

NCC

Hay

4.0

Sugar beet pulp

19.5

Protein concentrate

18.8

Total cost per head

£2.37

SCC x NCC

Hay

1.3 kg

Sugar beet pulp

21.2 kg

Protein concentrate

13.5 kg

Total cost per head

£2.01

Hoggs

Total per head

12.5 kg sugar beet pulp

9.7 kg grass nuts

Total cost per head

£1.23

(b) Lambing performance in 1974

Ewes to tup

NCC

295

SCC x NCC

305

Tup eild

39

26

Kebs

1

6

Ewe losses to lambing

Total lambs born

307 (104.1%)

321 (105.2%)

Lambs marked

264 (89.5%)

289 (94.8%)

Lambs weaned

264 (89.5%)

285 (93.4%)

(c) Lamb weights (kg)

	<u>NCC</u> <u>1974</u>	<u>SCC x NCC</u> <u>1974</u>
Birth weights, singles	4.2	4.1
twins	3.5	3.3
Marking weights, singles	9.9	8.9
twins	8.9	8.2
Weaning weights, singles	26.7	26.1
twins	25.0	24.4

(d) Wool production (kg/ewe)

	<u>NCC</u>	<u>SCC x NCC</u>
Age 4 Crop	1.8	1.8
3 Crop	2.2	1.9
2 Crop	2.1	2.0
1 Crop	2.3	1.9
Gimmers	1.9	2.0
All ages	2.0	1.9

(e) Ewe body weight changes 1973/74 (kg) NCC

	<u>Nos.</u>	<u>Pre-nating</u> <u>Nov.73</u>	<u>Pre-feeding</u>	<u>Pre-lambing</u>	<u>Marking</u>	<u>Weaning</u>	<u>Pre-nating</u> <u>Nov.74</u>	<u>Nos.</u>
4 crop	47	60.3	57.4	59.5	55.8	61.2	64.6	41
3 Crop	46	59.6	56.3	58.4	56.9	61.4	62.3	42
2 Crop	47	58.4	55.2	58.0	55.7	59.2	60.3	62
1 Crop	75	54.9	50.4	53.9	51.7	56.7	55.1	77
Gimmers	80	46.4	41.4	44.5	43.5	51.2	47.2	70
All ages	295	54.7	50.8	53.6	51.6	57.1	56.7	292

Ewe body weight changes 1973/74 (kg) - SCC x NCC

4 crop	47	57.4	55.6	56.7	51.2	55.6	59.3	42
3 crop	46	57.0	53.7	56.0	52.2	55.8	58.4	47
2 crop	54	54.3	51.9	53.8	49.9	54.9	56.9	67
1 crop	72	52.8	48.3	50.0	46.3	52.8	54.3	76
Gimmers	86	47.0	41.6	43.4	41.8	49.6	49.0	77
All ages	305	52.8	49.0	50.7	47.3	53.1	54.8	309

Prenating ewe body weight (kg)

	<u>1968</u>	<u>1969</u>	<u>1970</u>	<u>1971</u>	<u>1972</u>	<u>1973</u>	<u>1974</u>
NCC	54.8	56.1	58.9	59.5	60.3	54.7	56.7
SCC x NCC	47.8	50.2	53.2	55.8	58.2	52.8	54.8

Production data

	<u>1969</u>	<u>1970</u>	<u>1971</u>	<u>1972</u>	<u>1973</u>	<u>1974</u>
Stock numbers	398	451	518	529	573	600
Weaning percentage	84.7	86.5	103.3	104.7	99.5	91.5
Total wt. lamb weaned (kg)	7359	8893	14700	13953	14202	14293
Total wt. wool	787	1005	1273	1369	1560	1452

YRGS. II. On blanket bog. Lephinnore/Midhill
T.J. Maxwell, J. Eadie, D.C. Currie and T.K. Whyte

Land Resources

The resource consists of 431 hectares mainly on blanket bog. Improved pasture falls into two categories, some 22 hectares of grassy pasture, 14.3 of which were reseeded several years ago, and two larger areas (P₁ and P₂) totalling 69 hectares of unimproved Calluna and Eriophorum moorland. Some 35% of this moorland has been surface seeded to give a mosaic of improved grassy pasture throughout the whole, 10% of which was established in 1973 (4.5 hectares in P₂ and 5.5 hectares in P₁). The remaining 340 hectares is 'open hill'. Further division fences in P₁ were erected during 1974 to increase the carrying capacity and so graze twin nursing ewes and gimmers separately during lactation on improved pasture.

Sheep stock

There has been a slight increase in stock numbers to a total of 438 Blackface ewes.

Livestock Reconciliation 1973/74

Ewes and gimmers Nov. 73	Cast	Deaths	Gimmers brought in	Hoggs born 1973	Ewes and Gimmers Nov. 74
433	77	22*	100	121	434

* includes 8 black loss

Sheep year 1973/74

(a) Winter feeding

At the commencement of supplementary feeding the gimmers were moved into P₂, the ewes remaining on the hill. The gimmers were also lambed separately.

Supplementary feeding was started early, as it was last year. Initially sugar beet pulp cubes were used and then a 14% CP concentrate. Sugar beet pulp cubes were given while the ewes were in the lambing paddock. Throughout late gestation a 14% CP concentrate was given.

	<u>Ewes</u>	<u>Gimmers</u>
February 20	-	113 g Conc.
February 26	113 g Conc.	113 g "
March 8	227 g "	283 g "
March 22	283 g "	340 g "
March 28	340 g "	397 g "
April 5	397 g "	454 g "
April 8	454 g "	454 g "
April 25	454 g "	454 g "
	227 sugar beet pulp	
Concentrates and sugar beet pulp fed until 21 May.		
Average concentrate consumption	17 kg/hd.	Cost per head @ £70/ton = £1.20.
" sugar beet pulp "	0.5 "	" " " @ £49/ton = £0.02
Hay consumption in lambing paddock	127 kg	Total @ £49/ton, cost £5.00 (12p/hd)
		Total cost/hd (ewes) £1.34

Hoggs wintered inbye and fed concentrates, sugar beet pulp and hay.

Average concentrate consumption	17.6 kg/hd.	Cost per head @ £70/ton =	£1.21
" hay	29.5 "	" " " @ £40/ton =	£1.16
" sugar beet pulp	1.9 "	" " " @ £49/ton =	£0.09

Total cost per head (hoggs) £2.46

(b) Lambing performance

	<u>1974</u>
Ewes to tup	433
Tup cild	30
Kebs	1
Ewe losses to lambing	3
Total lambs born	454 (104.9%)
Total lambs marked	426 (98.4%)
Total lambs weaned	425 (98.3%)

(c) Lamb weights (kg)

Birth weights, singles	3.9
twins	2.8
Marking weights, singles	13.3
twins	11.3
Weaning weights, singles	26.4
twins	23.8

(d) Wool production (kg/ewe)

Age 4 crop	1.7
3 crop	1.6
2 crop	1.7
1 crop	1.6
Gimmers	1.9
All ages	1.7

(e) Ewe body weight change (kg)

<u>Ages</u>	<u>Nos.</u>	<u>Pre-mating</u> <u>Nov.73</u>	<u>Pre-feeding</u>	<u>Pre-lambing</u>	<u>Marking</u>	<u>Weaning</u>	<u>Pre-mating</u> <u>Nov.74</u>	<u>Nos.</u>
4 Crop	65	51.7	45.4	49.5	48.8	51.0	52.9	57
3 Crop	70	50.2	43.4	47.8	47.7	50.0	52.9	71
2 Crop	80	49.4	42.2	46.5	47.4	50.7	50.3	103
1 Crop	105	49.4	39.5	43.5	44.2	48.1	47.0	103
Gimmers	113	43.2	36.1	40.1	40.7	43.4	39.7	100
All ages	433	48.3	40.6	44.6	45.1	48.0	47.9	434

Pre-mating Ewe Body Weight 1968-74

<u>1968</u>	<u>1969</u>	<u>1970</u>	<u>1971</u>	<u>1972</u>	<u>1973</u>	<u>1974</u>
44.9	49.3	49.4	51.2	49.9	48.3	47.9

Production Data

	<u>1969</u>	<u>1970</u>	<u>1971</u>	<u>1972</u>	<u>1973</u>	<u>1974</u>	<u>1975</u>
Stock numbers (ewes & gimmers)	339	361	373	384	422	433	434
Weaning percentage	85.0	92.5	103.5	103.6	103.3	98.2	
Total weight of lamb weaned (kg)	7207	8500	10268	9924	10218	10870	
Total weight of wool (kg)	652	772	772	814	815	856	

YRGS. III. High capital input on a grassy hill. Sourhope/Alderhope
R.H. Armstrong, J. Eadie, T.J. Maxwell and P. Watchorn

Introduction

The Systems Development Programme has been extended at Sourhope to incorporate a system which is dependent for its improved pasture component on a high input of capital in a complete reseeding operation. The principles which have already been enunciated and applied with regard to the use of improved pasture in relation to the open hill in year-round grazing systems, e.g. YRGS I Hairney Law/Auchope, are also being applied in this system. Stock numbers will be increased.

Land Resources

The resource consists of 130 hectares of mainly grassy pasture dominated by Molinia heath and Nardus heath, the latter being interspersed with Festuca. Agrostis-Festuca communities are present, but they are species-poor and represent a smaller proportion of the total area than the other sheep resources at Sourhope. During 1972, 3.0 hectares of reseed were established and in 1973 a further 6.2 hectares were sown (see Farm Reports 1972 and 1973). In 1974, a further 3.2 hectares of reseed was established.

Stock

The resource is stocked with Scottish Blackface ewes. Twenty-four Hereford x Friesian heifers nursing Angus cross calves grazed on the area from 1st May to 31st December.

Livestock Reconciliation 1973/74

<u>Ewes & Ginners</u> <u>Nov.73</u>	<u>Cast</u>	<u>Deaths</u>	<u>Ginners brought</u> <u>into flock</u>	<u>Hoggs born</u> <u>1974</u>	<u>Ewes & Ginners</u> <u>Nov. 74</u>
222	30	11	61	69	242

Sheep year 1973/74

(a) Winter feeding

<u>Ewes and Ginners</u>		<u>Hoggs</u>	
Total feed given was as follows:			
Hay	0.5 kg	Ewe and lamb food	0.6 kg
Sugar beet pulp nuts	8.0 "	Hay	5.1 "
Concentrate	12.2 "	Sugar beet pulp nuts	12.2 "
Total cost per head	£1.24	Concentrate	-
		Total cost per head	£1.28

(b) Lambing performance

Ewes to tup	222
Tup cild } Keb }	18
Ewe losses to lambing	2
Total lambs born	271 (122.1%)
Total lambs marked	248 (111.7%)
Total lambs weaned	242 (109.0%)

(c) Lamb weights (kg)

Birth weights, singles	4.1
twins	3.3
Marking weights, singles	11.0
twins	7.7
Weaning weights, singles	28.8
twins	24.4

(d) Wool production (kg)

Age 4 Crop	1.5
3 Crop	1.6
2 Crop	1.8
1 Crop	1.8
Gimmers	1.8
	<hr/>
	1.7

(e) Ewe body weight changes (kg)

<u>Age</u>	<u>Nos.</u>	<u>Pre- Mating Nov.73</u>	<u>Pre- feeding</u>	<u>Pre- lanbing</u>	<u>Marking</u>	<u>Weaning</u>	<u>Pre- mating Nov.74</u>	<u>Nos.</u>
4 Crop	33	53.1	51.3	56.4	50.0	53.7	58.0	35
3 Crop	37	56.0	54.8	60.9	54.0	56.4	57.3	41
2 Crop	41	53.3	51.4	56.5	51.0	54.7	58.0	50
1 Crop	54	51.4	49.1	54.2	50.4	54.7	55.6	55
Gimmers	57	47.8	43.1	48.0	46.3	52.3	51.4	61
All ages	222	51.8	49.3	54.4	50.0	54.2	55.7	242

(Alderhope) Production Data

	<u>1973</u>	<u>1974</u>
Stock numbers	217	222
Weaning percentage	112.9	109.0
Total weight of lamb weaned (kg)	6615	6534
Total weight of wool (kg)	493	487

YRGS IV. On heather moor. Glensaugh/Birnie and Cairn
T.J. Maxwell, J. Eadie, A.L. Fairlie and C.D. Kerr

Introduction

The immediate objective is to create two self-contained and similar resources in terms of acreage, vegetation and stock numbers. Management procedures on each of the resources are the same.

The establishment of two such units is a necessary prelude to the testing on a practical scale of the ideas which emerge from the current heather research programme. Because of the needs of the experimental programme neither of these areas had the established flock size and performance base line required of a development unit.

Land resources

The area is situated at the north-eastern end of Glensaugh on land rising from 190 to 460 m with a fence dividing it into 200 hectare hirsels, the Cairn and the Birnie. Associated with each of these predominantly heather resources is an area of enclosed hill (12-14 hectares) which will be used as a lanbing paddock. Further, included with each unit, there is an area of 13 hectares of improved pasture on land which has been lined, slagged and sown with grass and clover seeds. Both of the required areas have been established for some time.

The improved pasture was grazed as far as possible in accordance with the principle outlined for the other year-round grazing system.

Stock

On each of the hirsels there were approximately 200 Scottish Blackface ewes. Sampling in Spring 1974 of ewes revealed low Blood Copper levels. All ewes were given copper injections as a prophylactic measure against Swayback in the animals. All ewes and lambs were also Cobalt bulletted in 1974. The relationship of improved pastures increasing the possibility of trace element deficiencies has been noted and is being monitored.

Livestock Reconciliation

	Ewes & Gimmers Nov. 73	Cast	Deaths	Gimmers brought into flock	Hoggs born 1974	Ewes & Gimmers Nov. 74
Cairn	187	42	10	55	66	190
Birnie	202	50	6	58	66	204

Sheep year 1973/74(a) Winter feeding

Feeding commenced on 6 February and continued as follows; the gimmers were separated on 25 February.

Ewes and Gimmers

6 February	227 g SBP
26 February	113 g SBP
28 March	340 g concentrate
18 April	454 g concentrate

The total feed given per head was as follows:-

Ewes and Gimmers

Sugar Beet Pulp Nuts	7.9 kg
Concentrate	15.9 kg
Hay	44.7 kg
Total cost per head	£3.00

The hoggs were inwintered from 27 December to 26 April and fed on hay and an equal mixture of bruised oats and 16% concentrate at a total cost per head of £4.15.

(b) Lambing performance

	<u>Cairn</u>	<u>Birnie</u>
Ewes to tup	187	202
Tup cild	11	16
Keb	2	6
Ewe losses to lambing		
Total lambs born	227 (121.4%)	229 (113.4%)
Total lambs marked	187 (100.0%)	186 (92.1%)
Total lambs weaned	180 (96.3%)	182 (90.1%)

(c) Lamb weights (kg)

Birth weights, singles	4.5	3.9
twins	3.2	3.2
Marking weights, singles	12.7	13.0
twins	11.9	11.9
Weaning weights, singles	28.8	27.7
twins	26.7	24.5

(d) Wool production (kg/ewe)

	<u>Cairn</u>	<u>Birnie</u>
Age 4 Crop	1.6	1.9
3 "	1.6	1.7
2 "	1.7	2.3
1 "	1.9	2.0
Gimmers	1.8	2.0
All ages	1.8	2.0

(e) Ewe body weight changes (kg). Cairn

<u>Age</u>	<u>Nos.</u>	<u>Pre-nating Nov.73</u>	<u>Pre-feeding</u>	<u>Pre-lambing</u>	<u>Marking</u>	<u>Weaning</u>	<u>Pre-nating Nov.74</u>	<u>Nos.</u>
3 Crop	34	55.0	50.3	53.4	48.3	55.0	58.6	51
2 Crop	61	53.5	52.3	54.2	47.5	53.2	58.8	43
1 Crop	47	51.1	48.1	50.2	45.7	54.2	56.9	41
Gimmers	46	48.0	42.5	45.7	44.7	51.7	50.0	56
All ages	187	51.8	48.4	50.9	46.5	53.4	55.8	191

Ewe body weight changes (kg). Birnie

4 Crop	9	55.6	54.4	58.8	52.7	54.8	-	-
3 Crop	31	52.8	47.6	53.2	47.5	52.6	58.3	47
2 Crop	58	51.1	48.0	52.7	49.5	53.7	58.3	45
1 Crop	48	49.8	44.6	48.6	47.9	53.7	55.8	54
Gimmers	54	46.2	40.0	45.5	46.6	51.0	49.4	58
All ages	202	49.8	45.1	50.0	48.1	52.8	55.1	204

(f) Prenating ewe body weights

	<u>1973</u>	<u>1974</u>
Cairn	51.8	55.8
Birnie	49.8	55.1

(g) Production data

	<u>Cairn</u>		<u>Birnie</u>	
	<u>1973</u>	<u>1974</u>	<u>1973</u>	<u>1974</u>
Stock	188	187	202	204
Weaning percentage	97.9	96.3	99.1	90.1
Total wt. lamb weaned (kg)	5061	5076	5230	4876
Total wt. wool (kg)	-	-	375	399

INWINTERING SYSTEMS (03005)

Inwintering systems with and without land improvement

IWS I. On a grassy hill. Sourhope/Rigg and Gairs
R.H. Armstrong, J. Eadie, T.J. Maxwell and P. Watchorn

Land Resources

The Rigg and Gairs are two similar units, each of 101 hectares, each traditionally stocked with 130-140 ewes and gimmers. Both sheep stocks are inwintered for the same length of time in the same wintering house. The difference between the units, an important part of the study, is that in the Gairs a substantial acreage of improved pasture has been made available. An

area of 15 hectares of Agrostis-Festuca pasture was enclosed and lined and slagged early in the winter of 1969/70. During the summer of 1971 this was oversown with clover. Further, in the spring of 1971, 10 hectares of Molinia/Nardus grass heath at 450 m received 6350 kg lime and 1650 kg slag per hectare. It was later sprayed with Paraquat, rotovated and direct re-seeded in mid-July with 380 kg per hectare of high phosphate compound. This area was grazed for the first time in the autumn of 1971.

The improved pasture areas are used and integrated with the unimproved hill in a similar way to that outlined for the year-round grazing system.

Cattle

A cattle stock numbering 24 was grazed in such a way as to equate the number of grazing days per month spent on the Gairs with the number of days on the Rigg. They were maintained on these areas from 1 May to 31 December.

Sheep stocks

Both the Rigg and Gairs carry South Country Cheviots. Stocking rate increases have been made equally on the two units by purchase of ewe lambs in late summer which were then wintered with those hoggs retained from that season's lamb flock.

Livestock Reconciliation

	<u>Ewes & Gimmers</u> <u>Nov. 73</u>	<u>Cast</u>	<u>Deaths</u>	<u>Gimmers</u> <u>brought in</u>	<u>Hoggs*</u> <u>purchased</u>	<u>Hoggs</u> <u>Homebred</u>	<u>Ewes & Gimmers</u> <u>Nov. 74</u>
Rigg	279	40	7	66	69	-	298
Gairs	279	40	12	70	74	-	297

*Blackface ewe hoggs bought to initiate change to Blackface from South Country Cheviot

Total Stock Numbers

	<u>1969</u>	<u>1970</u>	<u>1971</u>	<u>1972</u>	<u>1973</u>	<u>1974</u>
Rigg	205	205	238	278	279	298
Gairs	209	207	233	260	279	297

Sheep Year 1973/74

(a) Winter feeding

The ewes and gimmers were housed on the 29th January and given feed as follows:-

29 January

Ewes	113 g	Conc.	227 g	SBP	567 g	Hay
Gimmers	113 g	"	227 g	"	567 g	"

13 February

Ewes	113 g	Conc.	227 g	SBP	567 g	Hay
60 lean Ewes	170 g	"	227 g	"	567 g	"
Gimmers	170 g	"	227 g	"	454 g	"

15 March

Lean ewes on high concentrate ration now number 28.

25 March

Ewes	170 g Conc.	227 g SBP	567 g Hay
28 lean Ewes	227 g "	227 g "	567 g "
Gimmers	170 g "	227 g "	454 g "

3 April

Ewes	284 g Conc.	227 g SBP	567 g Hay
28 lean Ewes	340 g "	227 g "	567 g "
Gimmers	284 g "	227 g "	454 g "

Total feed given per head(kg)

	<u>Concentrate</u>	<u>SBP</u>	<u>Hay</u>	<u>Ewe & Lamb feed</u>	<u>Grass Nuts</u>	<u>Cost</u>
Ewes & Gimmers	18.5	16.3	39.3	-	-	£3.18
Hoggs	12.5	2.3	34.1	0.5	2.3	£2.08

(b) Lambing performance.

	<u>Ewes & Gimmers mated</u>	<u>Tup eild & keb</u>	<u>Ewe losses to lambing</u>	<u>Total lambs born</u>	<u>Marked</u>	<u>Weaned</u>
Rigg	279	18	4	289 (103.6%)	257 (92.1%)	254 (91%)
Gairs	279	28	2	293 (105.9%)	249 (89.2%)	243 (87%)

(c) Lamb weights (kg)

	<u>Rigg</u>	<u>Gairs</u>
Birth weights, singles	3.9	4.1
twins	3.2	3.3
Marking weights, singles	8.9	10.3
twins	7.5	7.5
Weaning weights, singles	24.3	26.3
twins	24.0	25.9

(d) Wool production (kg)

<u>Age</u>	<u>Rigg</u>	<u>Gairs</u>
4 Crop	1.6	2.3
3 "	2.1	2.1
2 "	2.1	2.3
1 "	1.9	2.3
Gimmers	1.9	2.3
All ages	1.9	2.3

(e) Ewe body weight changes (kg). Rigg

<u>Agcs</u>	<u>Nos.</u>	<u>Pre- mating Nov.73</u>	<u>Pre- feeding</u>	<u>Pre- lambing</u>	<u>Marking</u>	<u>Weaning</u>	<u>Pre- mating Nov.74</u>	<u>Nos.</u>
4 Crop	35	54.9	49.0	49.7	46.5	51.6	54.1	25
3 Crop	27	55.5	51.3	50.6	47.4	54.3	55.4	60
2 Crop	66	54.9	49.7	49.1	48.1	55.4	52.1	77
1 Crop	78	49.6	45.1	44.7	43.3	51.1	48.0	70
Gimmers	73	43.8	40.7	43.4	39.3	46.8	43.3	66
All ages	279	50.6	46.1	46.6	44.2	51.3	50.0	298

Ewe body weight changes (kg). Gairs

<u>Ages</u>	<u>Nos.</u>	<u>Pre-mating Nov.73</u>	<u>Pre-feeding</u>	<u>Pre-lambing</u>	<u>Marking</u>	<u>Weaning</u>	<u>Pre-mating Nov.74</u>	<u>Nos.</u>
4 Crop	35	60.3	54.1	54.4	51.7	56.7	57.3	29
3 Crop	34	56.4	51.9	51.8	50.3	54.9	57.7	62
2 Crop	69	55.9	51.3	50.4	50.3	55.8	57.9	68
1 Crop	69	52.6	48.2	48.7	48.4	55.1	52.8	68
Gimmers	72	44.9	42.9	45.3	41.5	49.1	47.2	70
All ages	279	52.9	48.8	49.3	47.7	53.9	54.1	297

Prenating ewe body weights

	<u>1969</u>	<u>1970</u>	<u>1971</u>	<u>1972</u>	<u>1973</u>	<u>1974</u>
Rigg	48.3	49.7	51.5	51.2	50.6	50.0
Gairs	49.9	50.5	51.9	53.5	52.9	54.1

Production Data - Rigg

	<u>1970</u>	<u>1971</u>	<u>1972</u>	<u>1973</u>	<u>1974</u>
Stock numbers	205	202	238	278	279
Weaning percentage	83.0	87.0	100.8	87.8	91.0
Total wt. lamb weaned (kg)	3706	4432	5712	5324	6155
Total wt. wool	402	534	641	732	680

Production Data - Gairs

	<u>1970</u>	<u>1971</u>	<u>1972</u>	<u>1973</u>	<u>1974</u>
Stock numbers	210	204	233	260	279
Weaning percentage	83.0	96.0	91.4	93.1	87.0
Total wt. lamb weaned (kg)	3581	5246	5176	5675	6394
Total wt. wool	461	524	634	752	766

IWS II. On Blanket Bog. Lephinnore/Low End.

T.J. Maxwell, J. Eadie, D.C. Currie and T.K. Whyte

Land Resources

This is an area of Calluna and Eriophorum moorland, consisting of two similar units, each of approximately 160 hectares, traditionally carrying 100 ewes and gimmers. Both units have the use of 13 hectares of 'common' enclosed grassy pasture. Both sheep stocks are inwintered in the same house for the same length of time. One of the units, an area of blanket bog, has a substantial acreage of improved pasture (15 hectares) which was enclosed, lined and slagged and an oversown grass/clover pasture established. This unit is referred to as 'inwintering + land improvement'.

Sheep stocks

Scottish Blackface ewes are used. Stocking rate increases have been made equally on the 'inwintering' and 'inwintering + land improvement' sides.

Livestock Reconciliation 1973/74

	<u>Ewes & Gimmers</u> <u>Nov. 73</u>	<u>Cast</u>	<u>Deaths</u>	<u>Gimmers</u> <u>brought in</u>	<u>Hoggs</u> <u>born 1974</u>	<u>Ewes & gimmers</u> <u>Nov. 74</u>
'Inwintering'	176	65	6	71	45	176
'Inwintering + land improvement'	174	59	6	67	44	176

Total Stock Numbers

	<u>1969</u>	<u>1970</u>	<u>1971</u>	<u>1972</u>	<u>1973</u>	<u>1974</u>
'Inwintered'	106	114	143	166	176	176
'Inwintered + land improvement'	102	112	137	160	174	176

Sheep year 1973/74(a) Winter Feeding

The ewes were inwintered on 18 January. The feeding given to the early lambing ewes was as follows; (the late lambing ewes received similar amounts, the increases being made some 10 days later):-

	<u>Ewes</u>	<u>Gimmers</u>
January 22	907 g Hay, 113 g Conc.	907 g Hay, 114 g Conc.
March 7	907 g Hay, 170 g Conc.	907 g Hay, 170 g Conc.
March 16	907 g Hay, 227 g Conc.	907 g Hay, 227 g Conc.
	<u>Early lambers (e + g)</u>	<u>Late lambers (e + g)</u>
March 29	907 g Hay, 340 g Conc.	907 g Hay, 227 g Conc.
April 5	907 g Hay, 340 g Conc.	907 g Hay, 340 g Conc.
April 8	907 g Hay, 454 g Conc.	907 g Hay, 340 g Conc.
April 15	907 g Hay, 454 g Conc.	907 g Hay, 454 g Conc.

Total consumption concentrate/ewe	= 19.3 kg @ £70/ton
Total " hay/ewe	= 81.8 kg @ £40/ton
Cost per head of concentrate	= £1.33
" " " " hay	= £3.22
	<u>£4.55/head</u>

Hoggs housed 27 November to 22 March

Concentrate	14.2 kg/hd @ £70/ton,	Cost per Hogg	£0.98
Hay	79.5 kg/hd @ £49/ton,	Cost per Hogg	£3.13
Total feed		Cost per Hogg	<u>£4.11</u>

Concentrates were also fed on the hill from 23 March until 6 April (cost included in above).

(b) Lambing performance

	<u>Inwintered</u>	<u>Inwintered + land improvement</u>
Ewes to tup	176	172
Tup eild	28	32
Keb	3	7
Ewe losses to lambing	1	0
Total lambs born	155 (88.1%)	158 (91.9%)
Total lambs marked	142 (80.7%)	134 (77.9%)
Total lambs weaned	138 (78.4%)	131 (76.2%)

(c) Lamb weights (kg)

	<u>Inwintered</u>	<u>Inwintered + land improvement</u>
Birth weights, singles	3.7	3.7
twins	2.6	2.8
Marking weights, singles	12.8	14.1
twins	10.6	10.6
Weaning weights, singles	25.3	25.6
twins	21.9	20.7

(d) Wool production (kg)

<u>Age</u>		
5 Crop	1.1	1.5
4 Crop	1.2	1.1
3 Crop	1.5	1.3
2 Crop	1.6	1.5
1 Crop	1.4	1.3
Gimmers	1.6	1.5
All ages	1.5	1.4

(e) Ewe body weight changes (kg) - Inwintered

<u>Age</u>	<u>Nos.</u>	<u>Pre-nating Nov. 73</u>	<u>Pre-feeding</u>	<u>Pre-lambing</u>	<u>Marking</u>	<u>Weaning</u>	<u>Pre-nating Nov. 74</u>	<u>Nos.</u>
5 Crop	5	48.6	47.7	48.6	49.0	52.4	-	-
4 Crop	16	47.8	46.8	48.1	47.7	50.5	49.4	9
3 Crop	18	46.4	45.8	47.4	47.5	49.7	48.5	27
2 Crop	41	45.5	45.2	47.9	47.1	48.7	47.4	37
1 Crop	48	43.5	41.7	43.9	45.2	48.1	44.5	32
Gimmers	48	36.9	37.0	41.0	41.5	44.6	41.5	71
All ages	176	43.0	42.3	44.9	46.5	47.7	46.3	176

Ewe body weight changes (kg) Inwintered + Land Improvement

5 Crop	5	53.6	52.4	54.2	49.8	51.4	-	-
4 Crop	16	50.9	46.0	47.0	47.4	50.7	53.8	12
3 Crop	18	50.5	46.2	47.9	46.9	50.4	53.0	29
2 Crop	45	48.1	43.9	46.4	47.0	51.6	52.4	31
1 Crop	46	45.6	41.3	43.9	45.6	50.0	47.0	37
Gimmers	44	39.1	37.6	41.4	41.4	45.6	43.2	67
All ages	174	45.8	42.3	44.9	45.4	49.4	48.0	176

Prenating Ewe Body Weights (kg)

	<u>1969</u>	<u>1970</u>	<u>1971</u>	<u>1972</u>	<u>1973</u>	<u>1974</u>
Inwintered	50.0*	49.3	48.2	47.2	43.0	47.0
Inwintered + land improvement	49.5*	49.4	48.5	45.2	45.8	50.9

* Gimmers' weights unavailable for inclusion

Production Data - Inwintered

	<u>1970</u>	<u>1971</u>	<u>1972</u>	<u>1973</u>	<u>1974</u>
Stock numbers	107	115	143	166	176
Weaning percentage	80.0	93.0	103.5	92.8	78.4
Total weight lamb weaned (kg)	2279	2857	3775	3775	3414
Total weight wool (kg)	205	257	282	293	354

Production Data - Inwintered + Land
Improvement

	<u>1970</u>	<u>1971</u>	<u>1972</u>	<u>1973</u>	<u>1974</u>
Stock numbers	102	112	137	160	174
Weaning percentage	71.0	104.5	97.1	102.5	76.2
Total wt. lamb weaned (kg)	2015	3324	3511	3800	3232
Total wt. wool (kg)	179	246	274	304	328

Note that low lambing percentages were mainly due to a high incidence of barrenness.

BIOLOGICAL MONITORING - SOILS (03004/03005)
M.J.S. Floate

A revised programme of soil sampling of the improved paddocks within YRGS I at Sourhope has been started this year. Partly because of the time and effort involved in sampling and analysis of 25 sites per paddock, and partly because of doubts about the value of the results in the management of the system, the sampling has been reduced to 10 sites per paddock. Samples were taken from these sites on Auchope and Hairney Law late in 1974 but the results are not yet available.

Studies of nutrient uptake by improved and indigenous areas of pasture within P₁ of the Lophinmore Mid Hill System have continued with a view to assessing the residual effects of applied fertilizers, and to better understanding the significance of certain apparently anomalous values for "Available" soil nutrients in these areas: these anomalous values have also stimulated further experiments in project 04003.

Reference was made in the Annual Report (1973) to the use of moving cages on improved and indigenous areas to measure DM production and nutrient uptake in 1973. These results are now available and are presented in Table 1.

Table 1. Production and nutrient uptake and composition of improved and indigenous areas of P₁ in 1973

Total DM (kg/ha)	Improved 5213		Indigenous 3539	
	Uptake	% Comp.	Uptake	% Comp.
N (kg/ha)	144.9	2.77	66.3	1.87
P "	16.4	0.31	5.7	0.16
K "	80.1	1.54	44.6	1.26
Ca "	30.8	0.59	10.5	0.30
Al "	5.0	0.095	1.0	0.029
Cu (g/ha)	47.3	9.1 ppm	24.4	6.9 ppm

From these data it is readily seen that the DM production of the improved pasture greatly exceeds that of the indigenous vegetation. Because of this, and also because the improved pasture composition is higher in all constituents than the indigenous vegetation by a factor of almost x 2 in many cases, the total uptake by improved pasture is very much higher (by a factor of almost x 3) than that of the native species.

When these data are considered together with the apparently anomalous data for "available" soil nutrients, (Table 2), the discrepancies can be explained.

Table 2. Nutrients in "available" soil fraction and taken up by pasture for improved and indigenous areas of P1

	Improved (kg/ha)	Indigenous (kg/ha)
P 'available' in soil	10.3	12.0
P taken up by plants	16.4	5.7
Total labile-P in soil/ plant system	26.7	17.7
K 'available' in soil	77.3	104.6
K taken up by plants	80.1	44.6
Total labile K in soil/ plant system	157.4	149.2

"Available" nutrients determined by extraction techniques measure the amount of the nutrient in soil at a particular point in time; the values represent a balance between uptake by plants and release by mineralisation or other means. It is noteworthy that under indigenous vegetation the "available" amounts of P and K in the top 10 cm of soil greatly exceed the seasonal uptake by native species. Under the improved pasture on the other hand, both "available" P and K are less than the amounts taken up by the introduced species.

Values for both "available" P and K in the soils under indigenous vegetation are higher than under improved pasture, apparently implying a higher "fertility status" of the soil which has not been improved. As stated above, however, these values only reflect the soil nutrient status at the time of sampling and do not consider the dynamic influence of uptake by improved pasture. When the amounts of nutrients in the whole system, i.e. in soil and plant (referred to as total labile P and K) are considered, it is seen that the improved pasture system is operating at a higher level of "fertility" than the indigenous vegetation.

These conclusions obviously raise questions as to the validity of conventional means of assessing the nutrient status of hill soils, and alternative means of assessing and expressing phosphorus status are reviewed under Project 04003.

BOTANICAL MONITORING: Year-round Grazing System Paddocks of Lephinmore
J.A. Rogers

This has continued on the reseeded areas. Several new sampling stations were recorded on the freshly reseeded areas in P2. It is not possible at this stage to state whether changes in the botanical composition are due to long-term trends or to short-term fluctuations following seasonal weather differences, or slight variation in grazing intensities in relation to weather and plant phenology. It is expected that this work will continue for several more years.

UPLAND (03008)Sheep Production Systems in the Uplands

T.J. Maxwell, J. Eadie, J.D. Macdonald, A.L. Fairlie, C.D. Kerr and R.D.M. Agnew

Sheep production from upland pastures; an examination of the relationships among pasture production, stocking rate and lambing date.

Introduction

In a sheep enterprise based on pastoral resources output is influenced by the level and seasonal pattern of pasture production and by stocking rate. These two factors interact to create a nutritional pattern which influences individual sheep performance. The choice of lambing date will affect the relationship at any stocking rate between nutrient provision from pasture and nutrient need and will have nutritional and therefore production consequences.

Most animal production systems in the uplands include the conservation of pasture surplus to grazing requirement, to provide bulk food for the winter. The choice of stocking rate and lambing date will influence the magnitude of these surpluses.

It is desirable to examine relationships among pasture production, stocking rate and lambing date within the context of whole systems of production because the impact of a decision made at one point in time will have effects throughout the whole production process. It is also important to recognise that within production systems decisions cannot be made independent of the levels and timing of inputs (e.g. stock number, fertiliser inputs, time of lambing) particularly since these inputs must ultimately be economically justified.

Previous investigations concerning the levels of output achieved from pastoral sheep systems have tended to be conducted as stocking rate experiments, the aim being to establish the effects of different stocking rates at various levels of pasture production on individual animal performance. Many of these experiments have lacked objectivity and have often been conducted without reference to the constraints that are a feature of pastorally based sheep production systems. The parameters used in deciding when to move sheep from one grazing to another are rarely defined. The conservation of surplus pasture is often an integral part of these systems but the area of pasture conserved is frequently unrelated either to the maintenance of adequate levels of nutrition from the remaining grazed area or to the amount of conserved feed required for the winter. Winter nutrition is set at a level which is often unrelated to the animal's performance at pasture during the grazing season. Furthermore these experiments are invariably short term experiments lasting for one or two seasons. They, therefore, do not take account of the long term effects of the various treatments on animal performance.

The conduct of the systems experiment is carried out with reference to a number of management decision rules. The more important of these are concerned with the timing and application of fertilisers, the closing of areas of land for conservation, the movement and stocking of sheep, the timing and level of feeding of ewes during gestation and lactation.

The measurements taken to assist in the implementation of these rules include 4" soil temperature, availability of pasture and nutritional status of the ewe in terms of blood ketone analysis.

The four systems of production under study are as follows:-

1. Greyface ewes at low stocking rate, lambing 7 March.
2. " " " high " " " " "
3. " " " low " " " 7 April.
4. " " " high " " " " "

Land Resources

In October 1973 an area of land was designated to the Greyface Systems experiment. This consists of the Bowes Field, 5.11 ha, (5-6 year ley), the Hard Park, 4.73 ha, (1st year ley), the Hogg Park, 4.02 ha, (2nd year ley) and the Forestry Park, 4.83 ha, which is permanent pasture, together with approximately 10 hectares of hill the 'Loch Hills'. Each field was subdivided into four paddocks, each system having one paddock in each field. The acreages of the respective systems were 4.71, 5.13, 4.43 and 4.47 hectares. The hill area (14.0 ha) was fenced to give wintering paddocks, two large paddocks for the high stocking rate and two small paddocks for the low stocking rate systems. Each pair of paddocks are alternated between the two 'early' and 'late' systems on an annual basis.

Sheep Stocks

The ewes were allocated to four systems as follows:-

<u>System</u>	<u>Age:</u>	<u>2</u>	<u>3</u>	<u>4</u>	<u>5</u>	<u>Total</u>
1		15	12	16	3	46
2		23	21	20	4	68
3		16	14	14	2	46
4		23	21	20	4	68

Dorset Down rams were used.

Livestock Reconciliation

<u>System</u>	<u>Ewes & Gimmers 1973</u>	<u>Cast</u>	<u>Deaths</u>	<u>Gimmers bought in</u>	<u>Ewes & Gimmers 1974</u>
1	46	10	0	15	51
2	68	11	5	20	72
3	46	15	0	13	44
4	68	19	2	19	66

The number of ewes for each system is now up to the total required. Mortality averaged 3.1% for the four systems.

Sheep Year 1973/74

(a) Winter feed

Hay was offered from 10th December at the rate of 0.9 kg per head. It was estimated that 0.75 kg was eaten. Concentrate feeding (14% C.P. Supplement) to early lambers began on 7th January (8 weeks prepartum) and to late lambers on 13th February. Pre-lambing concentrate feeding was based on fortnightly weighing and measurement of blood ketone levels, in a sample of 20 ewes from each of the early and late lambing flocks. As concentrate consumption rose to 1.14 kg, hay consumption fell to 0.38 kg. Feeding into lactation continued until 20th May at a rate of 1.5 kg per ewe.

Mean plasma ketone levels and subsequently determined concentrate feed levels*

Early lambers

Date	7/1/74	16/1/74	30/1/74	6/2/74	13/2/74	20/2/74	27/2/74
Mean Plasma Ketone Level (ng%)	2.56	2.73	2.78	2.25	3.53	5.78	2.82
Current Feeding	hay+4oz	hay+4oz	hay+6oz	hay+8oz	hay+22oz	hay+22oz	hay+4oz
Additional Feeding	+ 0	+2 oz	+2 oz	+4 oz	+10oz	+18 oz	
New Feed Levels	hay+4oz	hay+6oz	hay+8oz	hay+12oz	hay+22oz	hay+40oz	hay+4oz

*Aim was to keep plasma ketone levels below 3 ng%.

Late Lambers

Date	16/1/74	30/1/74	13/2/74	20/2/74	5/3/74	12/3/74	19/3/74	26/3/74
Mean Plasma Ketone Level (ng%)	1.75	1.64	1.76	4.29	3.0	3.83	2.31	2.67
Current Feeding	hay+0oz	hay+0oz	hay+4oz	hay+4oz	hay+20oz	hay+24oz	hay+36oz	hay+36oz
Additional "	+ 0	+4oz	+ 0	+16oz	+ 4 oz	+12oz	+ 0	
New Feed Levels		hay+4oz	hay+4 oz	hay+20oz	hay+24oz	hay+36oz	hay+36oz	hay+36oz

Total Feed Inputs and Cost per Ewe

Systems 1 and 2

	<u>Prelambing</u>		<u>Lactation</u>		<u>Total</u>	
	kg	£	kg	£	kg	£
Concentrate	42.8	3.15	72.3	5.32	115.1	8.47
Hay	68.0	2.00	10.6	0.31	78.6	2.31
Total Cost		5.15		5.63		<u>10.78</u>

Systems 3 and 4

Concentrate	50.5	3.72	35.5	2.62	86.0	6.34
Hay	86.5	2.55	5.6	0.17	92.1	2.72
Total Cost		6.27		2.79		<u>9.06</u>

(b) Lambing Performance

System	Ewes to tup	Eild	Ewe losses to lambing	Total lambs born		Total lambs marked		Total lambs weaned	
				No.	%	No.	%	No.	%
1	46	3	0	87	189	79	184	78	170
2	69	1	3	124	180	107	167	105	152
3	46	1	0	80	174	79	176	78	170
4	67	1	1	125	187	113	174	111	167
	228	6	4	416	182	378	173	373	163

Lamb types

System	No. Ewes lambled	Ewes producing:					
		Singles		Twins		Triplets	
		No.	%	No.	%	No.	%
1	43	6	14.0	30	70.0	7	16.0
2	65	14	22.0	43	66.0	8	12.0
3	45	11	24.0	33	73.0	1	3.0
4	65	12	18.0	46	71.0	7	11.0
	218	43	20.0	152	70.0	23	10.0

(c) Lamb Weights (kg)

System	<u>Birth Weight</u>		<u>Marking (35 days old)</u>		<u>Weaning</u>	
	Singles	Twins + Mult.	Singles	Twins + Mult.	Singles	Twins + Mult.
1	5.5	4.0	17.1	13.3	38.1	30.3
2	5.1	4.1	16.7	12.8	37.2	30.4
3	5.6	4.4	18.4	15.1	35.6	30.6
4	5.4	4.2	15.8	14.1	33.0	29.6

Lamb Mortality

System	Total Lambs born	<u>Born Dead</u>		<u>Birth-Marking</u>		<u>Birth-Weaning</u>	
		Nos.	%	Nos.	%	Nos.	%
1	87	4	4.6	4	4.6	3	10.3
2	124	7	5.6	10	8.1	12	15.3
3	80	-	-	1	1.3	2	2.5
4	125	6	4.8	6	4.8	8	11.2

(d) Wool Production (kg per ewe)

System	<u>Age of Ewe</u>				Mean
	2	3	4	5	
1	2.6	2.3	2.7	3.0	2.6
2	2.7	2.6	2.6	3.0	2.7
3	2.3	2.6	3.1	2.7	2.7
4	2.7	2.4	2.2	2.5	2.4

(e) Ewe Body Weight Change (kg) 1973/74

Flock	Pretupping	Prefeeding	Prelambing	Marking	Clipping	Weaning	6/9/74
1	71.5(8/10)	69/5(7/1)	68.2(20/2)	60.4(25/4)	62.3(4/6)	62.3(8/7)	71.2
2	70.3(8/10)	67.9(7/1)	68.0(20/2)	58.6(25/4)	60.0(4/6)	64.7(8/7)	69.2
3	66.8(5/11)	61.2(30/1)	68.9(26/3)	60.7(15/5)	58.1(4/6)	61.0(1/8)	63.7
4	70.2(5/11)	64.6(30/1)	71.6(26/3)	59.7(15/5)	57.5(4/6)	60.7(1/8)	63.4

TOTAL PRODUCTION DATA

System	<u>Ewe Number</u>	<u>Weaning Percent</u>	<u>Weight Lamb</u>	<u>Weight Lamb/Ewe</u>	<u>Weight Lamb/ha.</u>	<u>Weight of Wool (kg)</u>
1	46	170	2410	52.4	469.8	107
2	69	152	3370	48.8	715.5	186
3	46	170	2441	53.1	540.1	124
4	67	167	3330	49.7	751.7	161

FERTILISER INPUTSNitrogen Application units/ha

<u>System</u>	<u>Bowes Field</u>	<u>Hard Park</u>	<u>Hogg Park</u>	<u>Forestry Park</u>
1	312	247	247	312
2	247	247	247	312
3	247	247	247	312
4	247	247	247	312

PASTURE MEASUREMENTSAmount of herbage DM cut to ground level (kg/cwe)

<u>System</u>	<u>8 May</u>	<u>22 May</u>	<u>5 June</u>	<u>19 June</u>	<u>3 July</u>	<u>17 July</u>	<u>31 July</u>	<u>14 Aug</u>	<u>4 Sept</u>	<u>25 Sept</u>	<u>31 Oct</u>
1	48.6	63.3	54.6	78.0	102.5	176.5	262.5	278.0	261.1	242.8	200.4
2	40.0	54.6	69.8	92.0	118.0	110.8	154.8	189.9	143.3	142.8	112.3
3	37.0	46.8	42.5	56.6	67.0	122.0	135.5	163.3	168.2	200.7	209.9
4	35.0	35.8	33.8	45.5	69.9	66.5	56.7	111.9	83.4	82.4	84.2

Amount of herbage DM cut to ground level (kg/ha)

1	777.6	890.6	768.3	1097.9	1443.2	1513.5	2251.7	2547.0	2392.6	2366.1	1992.2
2	525.9	718.3	919.1	1211.5	1553.1	1459.0	2038.4	2500.2	1883.9	2183.2	1715.9
3	753.3	795.4	722.9	961.9	1138.2	1229.3	1364.2	1644.1	1693.7	1975.4	2056.2
4	720.4	731.4	689.9	915.7	1009.5	960.3	819.4	1642.2	1223.9	1227.3	1254.4

Net accumulation of herbage on two of the Hard Park Paddocks (kg/day/ha)

<u>System</u>	<u>8 May till 22 May</u>	<u>22 May till 5 June</u>	<u>5 June till 19 June</u>	<u>19 June till 3 July</u>	<u>3 July till 17 July</u>	<u>17 July till 31 July</u>	<u>31 July till 14 Aug</u>	<u>14 Aug till 4 Sept</u>	<u>4 Sept till 25 Sept</u>
1	34.28	31.15	91.61	77.65	160.40	79.53	58.00	41.33	25.06
2	41.83	86.48	55.94	117.70	205.37	78.03	52.78	91.94	32.24

Estimate of hay production

The yield estimates are based on pasture sampling measurements taken on 19th June when it was believed that the grass was at an optimum for cutting to achieve a high digestibility and high yield.

<u>System</u>	<u>Area Conserved</u>	<u>Total Hay Yield (tonnes)</u>	<u>Total Yield (tonnes/hectare)</u>
1	2.008	11.00	5.48
2	Nil		
3	1.815	11.08	6.10
4	1.250	6.28	5.02

The above estimates were obtained from herbage cut to a shorter stubble and dried to a greater degree than would be possible in practice.

SUMMARY

This year's results must be regarded as a 'run in' to the effects that may emerge from the different systems. The ewes were allocated to each of the systems by age and weight and differences in terms of conception rates were not expected. Ewes in the early lambing systems were slow to come to the tup, only about one-third of the ewes showed oestrus in the first 17 days. The late lambing ewes on the other hand all showed oestrus within the first 17-18 days following tup introduction.

The weight of lamb produced appeared to be influenced by stocking rate but not by lambing date.

The weight of the ewes on 6th September, however, appeared to be influenced by lambing date but not by stocking rate.

The amount of conserved pasture was influenced both by stocking rate and lambing date.

SIMULATION (03009)

1. Agrostis/Festuca Grazing Model
A.R. Sibbald, T.J. Maxwell, A. Vine and J. Eddie

Introduction

The objective of the modelling programme is to understand more fully the interactions amongst the various components of systems of sheep production based on the utilisation of pasture; to establish the relative importance of the component variables and test those which appear to significantly affect output in grazing systems.

The Development Section is now in the process of constructing a mathematical model of a hill grazing situation on an Agrostis-Festuca pasture. The intention at the inception of the model was to start at the animal/pasture interface and progressively develop the model in terms of the separate animal and plant components as these become necessary to its accuracy and/or validity.

Pasture Component

An early decision had to be made regarding the manner in which pasture was to be represented since the wide ranges of both quality and quantity of hill pasture available to the grazing animal have a significant effect on intake through the mechanism of selection. It was therefore decided to represent pasture as quantities of dry matter contained within a range of discrete digestibility classes so that a selection procedure, sensitive to digestibility distribution, could be used and so that at any point in time during the application of the model, a precise measure of both quantity and quality would be available.

Using this representation of pasture, changes in the distribution of quantity with quality are related to two rates; one the net accumulation rate of pasture and, secondly, the rate at which quality of pasture declines; this has been termed 'deterioration rate'. There is little published information on rate of change of digestibility within pastures. It was therefore decided to view the deterioration rate of pasture quality in terms of the proportion of material in a digestibility class that would move into the next lowest class in a day.

The growth of pasture is at present represented by a curve of typical net accumulation rates per week throughout the year for an Agrostis-Festuca pasture and the quality of this growth is represented by a curve of mean digestibility of new growth as it could be expected to vary throughout the year. Thus at any time period during the application of the model a quantity of growth and its expected digestibility can be determined and the calculated quantity introduced into the correct digestibility class.

It is assumed that deterioration rates change with season and can also operate at different levels over the range of digestibility classes represented. Material deteriorating from the lowest digestibility class is assumed to be unavailable to the grazing animal and falls out of the system. The actual levels of deterioration rates related to season and digestibility have been the subject of much of the initial testing of the model.

By providing a starting quality/quantity pasture distribution and rates of growth and deterioration, the model can represent the changes in quality and quantity of pasture throughout the year.

Computation of Intake

Intake ($\text{g/DM/kg}^{0.73}$) is assumed to be linearly related to the digestibility of the ingested material with a ceiling limit of $90 \text{ g/kg}^{0.73}/\text{day}$ for all values of digestibility above 75% (Blaxter). Since digestibility and quantity of intake are related, an estimate of the expected digestibility is used to establish an initial quantity of ingested material (in the model the mean digestibility of the previous week's intake is used). An iterative procedure, described later, then ensures that the digestibility used to determine quantity of ingested material relates closely to the digestibility finally calculated. Intake is limited relative to body condition (body weight in the model) such that intake for animals in good body condition is reduced (Foot, Osbourne).

Intake is further restricted according to the total quantity of pasture available (Arnold & Dudzinski, Hodgson).

The resulting calculated intake, adjusted for the number of grazing animals, is notionally harvested from the existing available pasture assuming that the grazing animal is selective and that the degree of selection is related to grazing pressure, expressed as the ratio of total calculated intake requirement (kg DM) to the total pasture available (kg DM). At high grazing pressures (> 0.4) no selection is possible and below 0.4 the degree of selection increases with reducing grazing pressure. The calculated intake can therefore be partitioned into selected and unselected material.

Since the spatial distribution of different digestibility classes will influence the ability of the animal to graze then, a limitation to the maximum proportion to be removed from the material in any digestibility class is calculated. This limitation is determined in two ways based on the vertical and horizontal distributions of the digestibility classes.

The vertical distribution assumes that the most highly digestible material will tend to be near the top of the pasture and will therefore be readily accessible to the grazing animal while the least digestible material will tend to be near the base and be less readily accessible. Thus the limit set for classes of high digestibility allows a greater quantity to be removed than the limit for lower digestibility classes.

Horizontal distribution of digestibility classes within the pasture is assumed to be represented by the ratio of quantity of material in a digestibility class to the quantity of total pasture available. Digestibility classes which represent a large proportion of the total pasture available are assumed to be readily available while those which represent a small proportion are assumed to be less readily available to the grazing animal. Thus the limit to maximal removal from each digestibility class is further adjusted, those which are large proportions of the total having a lesser limit than those which are a smaller proportion.

The two components of intake are now determined subject to the limits to maximum removal from digestibility classes set by the spatial distribution relationships. The unselected part is assumed to be harvested at random and this is done by having the individual digestibility classes represented in that part in the same proportions as they appear in the total pasture. The selected part is harvested as follows: the maximum permitted quantity is removed from the highest available digestibility classes in turn until the quantity required for the partition is satisfied. The mean digestibility of each of the selected and unselected partitions and the mean digestibility of the whole intake are calculated.

The calculated mean digestibility of the intake is compared with the digestibility used to determine quantity of intake in the first instance and if the two values fall within a reasonable range ($< 0.5\%$) then the grazing/intake component of the model is assumed to be satisfactorily completed and a digestible organic matter value for intake is calculated; if they do not fall within this range, then the newly calculated digestibility of ingested material is used to determine another intake quantity and the intake computation is re-run. The model iterates through this computation until a satisfactory comparison can be made. The quantities of material removed by grazing are deducted from the relevant digestibility classes in the pasture distribution.

Animal Component

At present the grazing animals in the model are assumed to be wethers and a starting mean body weight and number per hectare are supplied to the model as initial data. The maintenance requirement of the grazing animals is determined (g DOM) and an excess of intake to requirement causes an increase in body weight. A deficit of intake to maintenance requirement correspondingly causes a body weight loss. The rates of weight change are related to degree of under/over nourishment and condition (body weight) of animal.

Cycling of Model

The new values for pasture digestibility distribution and animal mean body weight are passed to the next time interval in the model for a new set of calculations. At present the time period used is one week and the model runs for one year. The model can also be used to run a number of years consecutively and this feature allows the stability of the model to be tested. Stability is achieved when, after a number of years of application of a particular grazing system, a repeatable within year pattern of movement of animal weights and pasture quantity and quality is established.

Present Results

The model has been tested against data from the development projects in terms of a year-round grazing system at different stocking rates and it responds in terms of both animal and pasture components in an acceptable manner and stability in the above terms is achieved. Much testing of the effect of changes in level and nature of deterioration rates has been done and notions of how these are best applied are being sharpened up.

The model has to a lesser extent been used to represent on/off grazing systems and again has responded in an acceptable manner although much work remains to be done in each of its components.

2. Grass/Heather Grazing Model

A.R. Sibbald, T.J. Maxwell, J.A. Milne and S.A. Grant

Introduction

It has been argued that one of the ways to improve the nutrition of hill sheep, grazing predominantly heather moorland, would be to include an area of high quality grassland. It is also considered that this would allow an increase in the utilisation of heather without necessarily producing unacceptable levels of nutrition or causing levels of utilisation that would impair the productivity of grass or heather swards. An experiment was designed in which varying areas of grass were associated with areas of heather to test these hypotheses (see p. 13 of this Report). From the results of previous experiments (see Annual Reports 1972, 1973) together with the preliminary results of the experiment described, relationships were established among the variables likely to be important in determining the effects on the plant and the animal grazing grass/heather swards.

The objects of the modelling exercise are to:-

- (a) check the validity of the model over a range of grass/heather areas and grazing pressures;
- (b) test the sensitivity of the component relationships;
- (c) assist in the design of future experimentation concerned with the utilisation of grass/heather land resources.

The part of the model which deals with utilisation of grass is based to a large extent on the Agrostis-Festuca grazing model (see p. 46 of this report).

Grass/Heather Sward Components

The grass sward is represented as in the Agrostis-Festuca grazing model, the net accumulation curve with time being based on data from Glensaugh.

Heather is represented by a growth curve also derived from data from Glensaugh and this is used simply to establish an available fund of current season's shoots of heather changing with time. A curve of digestibility of current season's shoots with time is also supplied to the model as initial data.

Intake Component

The intake component of the Agrostis-Festuca grazing model has been modified by the inclusion of two relationships which derive ingested quantities of grass and heather ($\text{g DM/kg}^{0.73}/\text{day}$) from the availability of grass (g DM/head) and the quality of ingested grass (mean digestibility). Since the grass sward in this model is represented in the same way as in the Agrostis-Festuca grazing model, availability can be determined at any time.

The first relationship used determines the percentage of grass in the diet from the quantity of grass available per head. The relationship gives increased percentage of grass in the diet with increasing availability and is also sensitive to changes in the quality of ingested grass. Grass of a higher digestibility provides a larger proportion of the diet than grass of a lower digestibility.

The second relationship is based on the percentage of grass in the diet and is used to determine quantity of ingested grass and heather separately ($\text{g DM/kg}^{0.73}/\text{day}$). At low proportions of grass in the diet, heather contributes a large part of the intake although the total intake is relatively low ($\sim 24\text{g DM/kg}^{0.73}/\text{day}$). With an increasing percentage of grass in the diet, total intake increases and the intake of heather also increases to a maximum of $\sim 40\text{g DM/kg}^{0.73}/\text{day}$ at 30% of grass in the diet. At percentages of grass in the diet above 30, total intake continues to increase but at a decreasing rate to a maximum of $80\text{g DM/kg}^{0.73}/\text{day}$ for a wholly grass diet, while over this range the intake of heather decreases from its maximum to zero.

By using the two relationships the model computes the total intake from its grass and heather components.

The calculated grass part of intake is derived from the same selection procedures as the *Agrostis/Festuca* model.

The calculated heather part of intake is derived assuming that no selection is possible, that only current season's shoots are grazed and that their digestibility will change with time using the digestibility curve provided as initial data to the model.

The mean digestibility of the grass component of intake is dependent on the selection relationships which determine how the animal harvests that part of its diet. Clearly the digestibility so obtained may not be the same as that used in the first relationship which estimated the proportion of grass in the diet (this is initially set to the digestibility of the previous week's ingested grass). The model therefore repeats the computation of intake using the newly calculated digestibility of ingested grass until it falls within 0.5% of the digestibility at the end of the computation.

The mean digestible organic matter of the total intake is then calculated, the grazed quantities of grass are removed from the relevant digestibility classes of the pasture distribution and the total fund of current season's shoots of heather is reduced by the amount of heather grazed.

Animal Component

Again the *Agrostis-Festuca* grazing model treatment is applied. Growth or weight loss of wethers is based on the excess or deficit of total intake (g DOM) to maintenance requirement and dependent on the current animal body weight.

Cycling of the Model

The new values of pasture digestibility distribution, available fund of current season's shoots of heather and animal body weight are passed to the next time interval in the model for a new set of calculations. The model uses a time interval of one week and runs for a calendar year; it has been used to represent on/off grazing systems.

Results

The model has been validated against experimental results from a grazing trial on different ratios of area of grass to heather (see p. 13). In terms of percentage utilisation of current season's heather growth, cycling of pasture quality and quantity and movement of animal body weights, the model responds in an acceptable manner.

The calculation of quantities of ingested material is more sensitive to the percentage grass in diet/grass availability relationship than to the intake/percentage grass in diet relationship. The more sensitive relationship is the less well-established and needs to be more accurately determined experimentally.

The results to date have also shown that the model is sensitive to the shape and timing of the heather growth curve. This too has not been sufficiently accurately determined in the field and is an area from which an improvement in accuracy of data would allow more confidence to be placed in the testing of other components of the model.

3. Lactation Model

A.R. Sibbald, T.J. Maxwell and Colleagues

A start has been made to modelling lactation using such parameters as digestibility of intake, condition of ewe, number of lambs suckled and ewe appetite expansion. A preliminary model has been designed and results produced for different situations.

It is hoped that after discussion with our colleagues and further modification, the model will be used as a component of the larger grazing models to extend their use to breeding sheep.

4. Upland Grazing Systems Model

T.J. Maxwell and A.R. Sibbald

Another model which has been given consideration is one which will allow a range of decision rules relative to stocking rate, time of lambing etc. in an upland grazing system to be compared. The model is at a preliminary stage of development but incorporates a number of components of the larger grazing models.

5. Ryegrass Pasture Model

A. Vinc

The decision to represent pasture by the dry weight of material in each digestibility class, as explained in the Agrostis-Festuca grazing model, was made for conceptual reasons regardless of what data was available. Very little information was found on the amounts and rates of deterioration of material within each digestibility class. Experiments were therefore set up to enable quantitative expression of this method of pasture representation.

The structure of S24 ryegrass vegetative tillers is being investigated in terms of heights, weights, digestibilities and ages of successively older leaf blades and sheaths, with a view to assessing the nature and availability of the pasture to a grazing animal.

Two sets of measurements were made: these are related to time of year, soluble nitrogen content of the soil and meteorological records. The first set came from monthly samplings when tillers were cut to ground level, separated into first, second, third etc. leaves, which in turn were divided into blade and sheath. The heights, weights and digestibilities of the fractions were determined.

The second set of observations was made at three-day intervals on permanently labelled tillers. Dates of leaf appearance, leaf death, tiller formation and tiller death were recorded.

Measurements on tillers growing outdoors show that the living leaves vary little in digestibility throughout the year, the youngest leaf varying between 85-90% dry matter digestibility, the second youngest 82-86% and the third 77-84%. Dead, however, ranges from 30% plus over the winter months to 56% in June. It would appear that the observed variation in whole plant digestibility throughout the year is almost entirely attributable to the 'dead' material in the sward. 'Dead' here embraces loose standing litter and any 5th or older leaves still attached to the plant.

Increasing the level of nitrogen fertiliser from 0 to 200 kg N/ha in June decreased by about 4 units, the digestibility of those leaves that emerged during the next seven weeks; by this time the soluble nitrogen content of the soil under all treatments was again very low.

Analysis of the leaf age data is in progress. When complete, rates of change of digestibility and rates of movement of dry matter through the sward will be calculated. The experimental results will be used in building a dynamic model of the pasture at leaf and tiller level, to which selective grazing models can be added. The whole can be incorporated in the larger grazing system models.

DATA HANDLING (03004, 03005, 03008, 01004)

Records and Statistics

A.R. Sibbald, E.V. Deans and T.J. Maxwell

The programme of maintenance, checking, summarising and analysis of sheep records from each of the development projects has continued. During the year records from 10 projects, amounting to 3693 ewes, 4413 lambs and 852 hogs have been handled.

A guide to the record handling system has been produced, a copy of which is available in the library.

The number of analyses have been started during the year based on data compiled to date.

(a) Lamb birth weight

An analysis of lamb birth weight related to age of ewe, ewe prenatating body weight, ewe weight changes during pregnancy, number of lambs born and year of record has been started. Data from development projects and from earlier HFRD records for more traditionally managed systems will be included for comparison.

(b) Lamb mortality

An investigation of lamb mortality has also been started. Preliminary results show that lambs born at weights of less than 3 kg appear to be at risk, those of 2.5 kg birth weight appear to have a 1 in 3 chance of dying and that birth weights of less than 2.5 kg are related to an increasing likelihood of premature death.

(c) Wool production

Another investigation which is at an early stage is wool production. Preliminary results suggest that while differences in wool production can be expected when comparing barren and fertile ewes, no significant difference is apparent between single and twin-bearing ewes.

VETERINARY MONITORING

A. Whitelaw, A.R. Fawcett and C. Landale

Faecal worm-egg counts	2600
Pasture larvae counts	80
Tracer lamb post-mortems and total worm counts	16
Snail counts	52
Nematode worm cultures	30
Blood samples, Serum vitamin B ₁₂ estimations	300
Plasma copper estimations	1000+

Monitoring of the patterns of disease at all farms has two facets. The first to safeguard the health of the Organisation's stock, the second to expose areas requiring investigation, particularly in the development projects. The co-operation of the farm staff in keeping records of ill-health and in assisting at samplings is appreciated.

I. Lephinmore (03004) (03005)(a) Sheep

The overall losses in 1974 have been low.

1. Evaluation of intensive dosing against liver fluke

This has been carried out in the YRGS and IWS flocks over a period of two years and the object is to assess the efficiency of strategic dosing designed to eliminate the liver fluke before it becomes an egg-laying adult, i.e. whilst it is immature and thereby to remove the large-scale deposition of eggs upon the pasture. It is considered that the application of this strategy even in times of low incidence can considerably reduce the egg population available for the snail intermediate host. It is also considered that where the disease is present the application of at least three dosages per annum is mandatory and that the cost of two extra doses per year is more than justified in the improved overall control of the disease.

The position in the YRGS flock and in the IWS (C) flock at the end of 1974 was very satisfactory. The position in the IWS (T) flock whilst it had improved over previous years was not as good and an alteration in the dosing programme to take care of this will be instituted in 1975. The use of 'tracer' lambs to check the timing of doses will also be intensified.

2. Cobalt deficiency

Serum vitamin B₁₂ estimations in representative groups of sheep has demonstrated the existence of cobalt deficiency in certain pasture areas. Preventive measures have been adapted and further monitoring will be carried out in 1975.

3. Indoor lambing (IWS)

The implementation of measures to minimise disease in the indoor lambing (IWS) in 1974 was largely successful.

Abortion due to toxoplasmosis did occur but the incidence was low. Colibacillosis was present in the later lambs and underlines the need to ensure that standards of hygiene must be kept high.

Ostertagiasis type II. The occurrence of a small outbreak before lambing in 1974 led to adjustments in the anthelmintic dose level for 1975. This problem of housed sheep has only recently been identified although it has been a problem in inwintered calves for many years. It is due to the emergence of hypobiotic larvae from the gut wall to become adults and is related to the pick-up of infective *Ostertagia* larvae in the autumn.

4. Tracer lambs

These were employed at Lephinmore to check the efficacy of strategic dosing. High worm burdens were picked up by these lambs particularly in the reseeded areas.

(b) Cattle

There were no serious disease problems in the herd at Lephinmore.

II. Sourhope(a) Sheep (03004/03005)

1. Overall losses in sheep were low.
2. Investigation into aspects of prevention and control of cobalt deficiency at Sourhope, complementary to work at Glensaugh, has been carried out. The serum vitamin B₁₂ estimations are incomplete at this time but should provide valid information. Similar investigations into copper deficiency are also in progress.
3. The incidence of dystokia in the South Country Cheviot flocks was again much higher than in other breeds at Sourhope. A summary of an investigation into this problem in the gimmer age group of the S.C.C. flock is reported on p. 7.

(b) Cattle

Disease problems in cattle were minimal.

III. Glensaugh(a) Sheep (03004)

The overall health of the sheep stock has been good.

1. Toxoplasma abortion

A relatively higher incidence occurred in the Cheviot sub-flock on Finella. Overall losses were not high and in the absence of treatment or control measures the only practical advice available was to mix gimmers and older ewes before the 1974 tupping.

2. Copper deficiency

In the Cairn and Birnie flocks plasma copper levels of ewes and gimmers approaching the 1974 lambing were very low, with means well below the acceptable minimum level of 60 µg/100 ml. All pregnant sheep in these areas were injected with a proprietary copper injection. No cases of 'swayback' occurred.

Monitoring pre-lambing in 1975 is planned, leaving small numbers undosed as controls.

3. Cobalt deficiency

The prophylactic use of cobalt bullets was employed in all lambs in 1974 save for a number required for an experimental project which is reported elsewhere.

4. Anthelmintic dosing programme

As assessed by monitoring these would appear to be giving good control. An intensive dosing programme was instituted in the Greyface project in view of higher stocking rates and intensive use of paddocks. The incidence of liver fluke at Glensnaugh would appear to be low and relaxation of the dosing programme against fluke will be undertaken. Control of the situation will be by routine monitoring and by prophylactic dosing of all incoming sheep.

(b) Cattle (02008)

(i) Cows

The sudden death of two cows in the cattle shed led to routine vaccination of the herd with *Clostridium oedematiens* vaccine, and since then there have been no further cases.

Vaginal prolapse occurred in three cows and was considered to be related to the fat condition, the high food intake with soft faeces, and the slight slope of the cubicle floors.

Limb lesions due to housing in cubicles were rare. Foot-trimming on a routine basis is necessary however.

Summer mastitis did not occur in 1974. All cows underwent dry cow therapy at weaning and spraying of the udder area during the fly season was carried out. Some cases of mastitis occurred in the herd but the incidence was not high.

(ii) Calves

1. Calf diarrhoea was a major cause for concern in the 1973-74 crop of calves. The outbreak commenced in the older calves and from its salient features appeared to be digestive in origin. Morbidity was high but mortality was low. Treatment was symptomatic and calves responded well. The labour input in this situation was high, and undoubtedly the presence of this scour interfered with lactation work.

Bacteriological examinations did not reveal a common cause and the factors involved would appear to have been related to excessive intakes by cows and a high milk yield plus the presence of molasses and urea in the diet. However, the character of the scour changed and faeces of affected calves examined by electron-microscopy at the Moredun Institute showed the presence of some of the viruses associated with viral diarrhoea in calves.

Veterinary knowledge of this disease is far from complete and investigation into the epidemiology of this disease is actively underway at the Animal Diseases Research Institute at Compton and other centres.

During the 1974-75 calving sampling of cows and calves will be carried out and examinations done at the Moredun Institute.

Salient features of the disease

- 1) It would appear to be endemic in the North-east of Scotland area.
- 2) It is a disease affecting housed calves.
- 3) Cows may be carriers.
- 4) The virus attacks the mucosa of the intestine.
- 5) Recurrent attacks are a feature.

- 6) Mortality can be severe - especially where hygiene and environment are poor.
- 7) Symptomatic treatment with adsorbents and sulphonamides is superior to antibiotic therapy and it is important that calves continue to drink cows' milk.
- 8) Little is known about immunity.
- 9) It is not known whether this is a 'new' disease, or whether 'normal' calves have the virus present in their faeces.

2. In the autumn of 1974 weaned calves at pasture showed some evidence of ill-thrift. Blood copper and serum vitamin B₁₂ estimations showed evidence of hypocuprosis and cobalt deficiency. Response to copper injections and cobalt drenches was excellent.

Reproduction Glensaugh cows (02008/01001)

In 1974 synchronisation of oestrus by use of an analogue of prostaglandin F_{2α} was undertaken to look at the possibilities of narrowing the calving interval.

At the end of January and beginning of February all calved cows were checked internally for evidence of 'cycling' and in particular for the presence of corpus luteum.

Two vasectomised bulls had been running in the cattle shed daily to detect oestrus in association with checking by staff. One bull was of no value in the house and this left the other bull with too much to do. This led to an unsatisfactory level of accurate detection of oestrus.

Group 1

Forty cows were selected as having cycled, having a corpus luteum present, and had not been in oestrus from the 7th February 1974. On the 11th of February at 1600 hours each was injected subcutaneously with 25 µgm of the prostaglandin F_{2α} analogue. Mass insemination was carried out on the 14th of February at 1400 hours and on the 15th February at 0900 hours.

Group 2

Eight cows were injected with the analogue on 12th March, again on 22nd March and mass inseminated on 25th and 26th March.

Group 1

Number in calf to synchronised service	22/40	55%.
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Group 2

Number in calf to synchronised service	3/8	37.5%.
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One of the features was the lack of evidence of return to first oestrus, complicated by the limitations of the one teaser bull.

Another feature worthy of note was the overfat condition of some of the cows. According to evidence available this does reduce the conception rate in herds. It is difficult to have an ascending plane of nutrition in such conditions. The overall figure of 55% in Group 1 compares well with results obtained with oestrus synchronisation elsewhere (Hafs). It also accords well with the recent observations that conception to first service in the national herd is probably much lower than was thought and probably ranges from 38-50% (Barden).

Nematodirus Forecasting (03004/03005)
A. Whitelaw, A.R. Fawcett and C. Landale

Lamb infection with the parasite *Nematodirus battus* in the spring can result in heavy losses. The infection results from a mass hatch of overwintered larvae, the time of the hatch varying each year according to the prevailing climatic conditions. The risk of infection therefore varies yearly, i.e. an early hatch may occur before lambs are grazing.

The production paddocks used on HFRO farms are particularly susceptible to a build up of infection because the parasite, by nature of its life cycle, passes directly from one lamb crop to the next and high stocking rates intensify the infection. Outbreaks occurred at Bog Hall, Sourhope and Lephimore in 1973.

Forecasting of the hatching period, which lasts for 6-8 weeks can be done by monitoring soil temperatures and artificially infected plots. The Ministry of Agriculture produce a national forecast but this does not take into account local variations, particularly in hill farming areas.

A pilot programme was initiated during 1974 to examine the feasibility and value of producing forecasts for each farm. The peak hatch dates observed were:-

M.A.F.F.	England and Wales	End of April
Bush		End of April
Bog Hall		Late May
Lephimore @ 500 ft.		Mid May
	@ Sea level	Late March

The above peak hatch dates demonstrate the differences within HFRO indicating a need for individual farm forecasting so that necessary dosing schedules can be altered or implemented accordingly.

Forecasting is in progress for 1975.

The influence of changes in management associated with the development of new systems on the occurrence of premature broken mouth (03005: Development:IWS)
R.G. Gunn and W.F. Smith

The incidence of broken mouth amongst the IWS ewes at Sourhope and Lephimore continues at a high level (between 45% and 80% at 6½ years) compared with that amongst the YRGS ewes (currently <10%). Recording continues on the Low End IWS ewes inwintered on either plastic or metal mesh hay racks. Although of necessity a long-term study, preliminary examination after two winters shows little sign of any difference in the condition of the incisors between the sheep on the two types of mesh.

C. PLANTS AND SOILS

NUTRIENT INTERACTION (04001/04003)Relationships between Aluminium, Organic Matter and Lime requirement in hill soils
M.J.S. Floate(a) Interpretation of data from fence-line soils

In a review of existing data on exchange acidity and pH in the soils collected for the Fence-Line study it was stated in the Annual Report, 1973, p. 30, that there was a broad inverse relationship between pH and exchangeable Al^{3+} in the mineral soils and that in organic soils exchangeable Al^{3+} was lower than would be predicted from this broad relationship. It was further pointed out that in these organic soils exchangeable Al^{3+} appeared to be only a small component of exchangeable acidity. It was suggested that this could be explained as an artefact of the techniques employed, or it could be that exchangeable H^+ is a larger component of exchange acidity in organic soils than is normal in mineral soils.

Further investigation in which exchangeable Al^{3+} and H^+ have been measured in KCl leachates of these soils, has shown that the results quoted above are not wholly an artefact of technique, and that exchangeable H^+ accounts for a large part of the exchangeable acidity in some hill soils. Mean results for organic and mineral groups of soils are presented in Table 1, together with ranges for each group and these data clearly show that the pH and total exchange acidity of the two groups is similar but that the mineral soils are dominated by exchangeable Al^{3+} and exchangeable H^+ never exceeds 1.0 meq/100 g. In the organic soil group exchangeable H^+ averages 5.0 meq/100 g and accounts for more than half the total exchangeable acidity.

Table 1. Exchangeable Al^{3+} and H^+ components of exchangeable acidity in 'Fence-line' soils

Soil Type	%C	Exch. Al^{3+} (meq/100 g)	Exch. H^+ (meq/100 g)	Total Exch. Acidity	%Al
Organic soils (pH 3.5-4.0)	33.5 (25 - 43)	3.5 (1 - 10)	5.0 (3 - 7)	8.5 (10 - 15)	40 (20 - 60)
Mineral A, B horizons (pH 3.6-4.2)	5.2 (1 - 10)	8.4 (3 - 24)	0.4 (0.1 - 0.9)	8.8 (3 - 24)	93 (77 - 99)

From these organic and mineral groups of soils examples with relatively high and low levels of exchangeable Al^{3+} were selected to examine the influence of these factors upon the response to added lime in the laboratory. The results, given in Table 2, show that in each group the soil with higher level of Exchangeable Al^{3+} requires more lime to raise the pH to the same level, but that the organic soils require more lime than the mineral soils. This is contrary to the frequent field observations that peaty soils appear to require less lime than mineral soils.

This apparent anomaly may be partly explained by differences in bulk density between mineral and organic soils, but it does agree with a result reported in the Annual Report, 1973, p.30, in which Cowie peat appeared to require more lime than Sourhope Brown Forest Soil to achieve the same unit increase in pH.

Table 2. Relationships between Exchangeable Al^{3+} , and pH response to lime in organic and mineral soils

		Exchangeable Al^{3+} (meq/100g)	Total Exchange acidity (meq/100g)	CaCO ₃ needed to raise soil pH to 5.0	
				(g/10 g soil)	(ton/ac)
Organic Soils	high Al	9.0	15.2	0.253	1.5
	low Al	1.2	6.0	0.144	1.0
Mineral Soils	high Al	23.4	23.7	0.078	0.8
	low Al	3.2	4.2	0.025	0.4

Further comment will be made on these results in the section on prediction of lime requirement.

(b) Soils from long-term field experiments

With the assistance of ADAS staff at Bangor, soil samples were obtained from a top-dressing field experiment which had been established on a peaty podzol in 1952. The soil is of the Hiraethog Series which is closely related to the Minchmoor Series (peaty podzol) of the Ettrick Association which is widespread in the Southern Uplands of Scotland.

Only selected treatment plots from this experiment were sampled and the first results showed only minor differences in pH and 'Available' P which were not clearly related to treatment effects (Table 3).

Table 3. Residual effects of lime and P treatments applied to Hiraethog Soils at Llansannan

Treatment	L_0P_0		L_0P_2		L_2P_0		L_2P_2	
	1952	1952+ 1959	1952	1952+ 1959	1952	1952+ 1959	1952	1952+ 1959
pH	3.9	4.5	3.7	4.2	4.4	4.9	4.0	5.1
Truog-Pmg/100g	3.4	6.8	3.8	4.8	5.3	4.7	6.5	2.5
Truog-Pg/n ²	.38	.58	.41	.48	.50	.64	.76	.36
Exchange acidity meq/100 g	11.4	4.7	11.4	6.7	1.7	1.7	3.7	1.1
Exchangeable Al^{3+} meq/100 g	5.9	1.1	6.0	2.1	0.2	0.1	1.3	0.1

L_0P_0 = No lime or phosphate

L_2 = 30 cwt/ac CaO applied 1952, 1959

P_2 = 150 lbs/ac P_2O_5 applied 1952, 1959

Exchangeable Acidity, and especially Exchangeable Al^{3+} were, however, higher in all the L_0 plots than L_2 plots where Exchangeable Al^{3+} was still low despite the low pH of these soils. Thus, whilst residual effects of lime applied 15 and 22 years ago were not clearly seen in pH differences, marked differences in Exchangeable Al^{3+} and H^+ are attributable to past treatments.

The effects of these differences in exchangeable acidity status upon the response of these soils to unit application of lime, and upon the determination of lime requirement has been investigated. It was found that 10 g of soil from L_0P_0 treatment required .110 g $CaCO_3$ to raise the pH to 5.0 compared with only .064 g $CaCO_3$ per 10 g soil from L_2P_2 treatment. This result shows that more lime is required to raise the pH of the soil containing most Exchangeable Al^{3+} and the amounts may be compared with the data presented in Table 2.

Using the p. nitro phenol buffer method for lime requirement (as used by ADAS) it was also found that the soil with highest Exchangeable Al^{3+} (L_0P_0) gave the highest value for lime requirement but the amounts of lime apparently required by all the soils were excessive.

(c) Prediction of lime requirement

A number of procedures are available for the laboratory determination of lime requirement and these are usually based upon measurement of exchangeable hydrogen, buffering capacity, soil reaction, exchangeable calcium or calcium saturation or the determination of readily soluble aluminium, iron and manganese.

Current work has suggested that KCl-exchangeable Al^{3+} , Exchangeable Al^{3+} (i.e. KCl-exchangeable Al^{3+} less water soluble Al), soil organic matter, and total exchangeable acidity are related to the response of hill soils to unit additions of lime in the lab.

Predicted lime requirement values have been calculated for nine soils (from the Fence-line study, Lephinmore, Sourhope, Stanhope and Llansannan) by the following methods:-

- (i) p-nitro phenol buffer method (Woodruff, 1948).
- (ii) Woodruff method with calculation modified to allow for shallower depth and bulk density.
- (iii) Exchangeable Al^{3+} - calculated n. equivalents of Ca^{2+} needed to neutralise.
- (iv) Exchangeable $H^+ + Al^{3+}$ (total exchangeable acidity) - calculated as for (iii).
- (v) Total cation exchange capacity - also calculated as equivalents of Ca^{2+} required to neutralise either 100% or 50% of exchange capacity.

The work is still in progress but the indications are that the closest agreement between measured laboratory response to $CaCO_3$ addition to soil, and predicted value is that based upon 50% CEC. It has also been noted that there is a close relationship between CEC and organic matter content for this group of soils.

(d) Field response to added lime

Two field experiments have been established where the objectives are

- (a) to measure the soil pH response to increments of lime applied in the field,
- (b) to observe the establishment and survival of improved pasture species under a range of lime treatments, and (c) to provide soil for further laboratory studies of the distribution of Exchangeable Al^{3+} and H^+ .

The experiments consist of four replicates of lime treatments equivalent to 0, $\frac{1}{4}$, $\frac{1}{2}$, $\frac{3}{4}$, 1 and 2 tons/ac $CaCO_3$ and are situated at Lephinmore and at Stanhope (thanks to the co-operation of ABRO). These are on deep peat and a Brown Forest Soil of the Linhope series respectively.

Some preliminary observations on the Lephinmore experiment are reported under Project 04007/03002 and no results are yet available for the Stanhope experiment.

PASTURE ESTABLISHMENT (04002)Determination of conditions for optimum germination of selected grasses and white clover under hill conditions

1. Effects of different sowing dates on germination and early establishment of selected cultivars of grass and clover species
J.A. Rogers

An earlier trial (described in Annual Report, 1973, p. 31) showed that certain strains of perennial ryegrass, particularly the early maturing types, Grenie and S24, during their first year performed better following a late autumn sowing than spring sowing. It was, therefore, decided to follow this up with a second trial in which a number of different grass species, as well as white clover, were sown on different dates and at different sites. The sites chosen, at House o' Muir and at Headquarters, Dush, differed in their altitude and exposure. Again seed was sown on two dates, early December and in March.

Perennial Ryegrass (Lolium perenne L. ssp. perenne)

Four diploid and two tetraploid strains were used. The former were the early maturing Grenie and Preno and the late maturing S23 and Lanora; Grenie and S23 had been included in the earlier trial. Grenie performed in much the same manner as in the previous experiment in giving higher yields following the late autumn sowing, than the spring. The other varieties showed slight (but not statistically significant) yield differences between sowing dates. The rate of emergence of three cultivars from the March sowing was, at the lower altitude so rapid that seedling numbers exceeded those sown in December, within 27 days. The exception was Lanora. At the higher altitude the December sown seedlings remained more numerous throughout.

The germination of both tetraploid cultivars, the early Barvestra and the late maturing Barpastra progressed much more slowly than the diploid varieties, but even so, at the higher altitude, the December sown seedlings were still at a numerical advantage.

Italian Ryegrass (Lolium perenne L. ssp. multiflorum (Lam.) Husnot)

Two strains, Aberystwyth S22 and the Belgian Lental were sown. Both behaved similarly, emerging very rapidly. Dry matter determinations showed the December sown plants to be more productive than those sown in March. There was a striking similarity in the responses of Italian ryegrass and the perennial ryegrass variety, Grenie.

Timothy (Phleum pratense L.)

December sown S352 germinated rapidly and maintained a high seedling count over the winter period. At the lower altitude the March sown plants did not reach such high numbers, whereas at House o' Muir they exceeded the earlier sowing. The December sowing resulted in significantly higher yields than the March for both varieties (S48 and S352).

Red Fescue (Festuca rubra L.)

Two cultivars were sown, the Aberystwyth S59 and Monnersteeg's 'Novorubra'. Both varieties came away rapidly from the December sowing at the two sites; germination count at the higher altitude was about 14 days later than at the lower. After the March sowing, the difference between the two sites tended to increase with time. There was little difference between dry matter yields relative to sowing date at the House o' Muir site, but at the lower, Dush, site the December sown plants gave significantly heavier yields of both cultivars.

Tall and Meadow Fescue (*F. arundinacea* Schreb. and *F. pratensis* Huds.)

One variety of each of these species (formerly grouped together as *F. elatior* L.) was grown; these were, respectively, S170 and S215.

Tall Fescue showed little difference between the emergence curves from the two sowing dates at the lower altitude, but at House o' Muir the March sowing resulted in much lower counts than December. Meadow fescue gave higher final counts from December than from March sowing. Both species give higher dry matter yields when sown in December than in March.

Smooth-Stalked Meadow Grass (*Poa pratensis* L.)

The two cultivars sown were the American "Merion" and the Dutch "Delft". Germination was extremely slow, particularly following the December sowing. Dry matter determinations showed that the December sowing resulted in heavier yields, the difference being more marked at the higher altitude.

White Clover (*Trifolium repens* L.)

Four cultivars were studied. These were the 'wild white' S184 and Kent and the cultivated strains S100 and Kersey. At House o' Muir, the December sowing of the two 'wild' types resulted in a slightly higher yield (not significant at the second cut). The S100 was severely damaged by the winter conditions, so that the later sowing was much more productive; Kersey, on the other hand, gave a much enhanced yield following December sowing. Indeed, this yield was somewhat greater than that of any of the wild types. At the lower altitude, the yields of all the cultivars after December sowing was about twice that of the March sowing.

Then the extra growing time which the early December sowing allowed, resulted in greater yields, at least during the first year, at the lower altitude. At the higher altitude, presumably because of the lower temperature and higher incidence of severe frosts, this advantage did not exist. Extrapolating to even higher altitudes would lead one to assume that the December sowing would be even less advantageous for clover than at House o' Muir.

2. Effects of applied fertilizers on germination and establishment
J.A. Rogers

a) Pot Experiments

A pilot trial in which seed was sown on to peat indicated that there was some relationship between germination and the relative time at which fertilizer was applied. However, in this trial, the most rapid germination occurred following simultaneous sowing and fertilizer application for perennial ryegrass and for clover, while petri dish tests showed that higher concentrations of fertilizers were more likely to inhibit, rather than promote, germination. A second experiment was therefore done to elucidate this. Two soil types were used and two levels of fertilizer were applied 10 days before, at the same time as and 10 days after, sowing. Again, perennial ryegrass and white clover were used. The soils were Sourhope series Brown Earth and commercial filled peat. Each pot received the equivalent of 1 ton of ground limestone and 2 cwt of basic slag per acre before the experiment started. The fertilizer was S.A.I. No. 1 applied at 1 and 2 cwt/acre. One-hundred seeds were sown in each pot.

In both peat and soil the ryegrass germinated most slowly when the fertilizer had been applied at the same time as the seed at both levels.

Table 1. % Emergence of PRG after 14 days (means of 2 levels of fertilizer application)

	Soil	Peat	Mean
T ₁	70.5	75.5	73.0
T ₂	42.5	60.4	55.0
T ₃	59.3	72.1	65.7
lsd (P = 1.0%)		17.07	12.02
" (P = 5.0%)		12.63	5.93

For clover the pattern was less clear. Germination in the soil proved to be somewhat erratic, and was much slower than in peat. Simultaneous application in the peat resulted in slower germination than the other two application times. The higher level of fertilizer resulted in slower germination.

Table 2. % Germination of clover at 8 days from sowing following prior (T₁), simultaneous (T₂) and post (T₃) fertilizer application (i.e. before T₃ had been applied)

	Peat		Mean	Soil	
	1 cwt/acre	2 cwt/acre		1 cwt/acre	2 cwt/acre
T ₁	55.5	50.5	53.0	25.8	14.8
T ₂	46.0	46.0	46.0	30.5	17.8
T ₃	61.8	55.8	58.8	33.8	39.0
lsd (P = 5.0%)		16.9	12.8		

Dry matter yield of ryegrass was related to soil type and fertilizer level, but not to time of application; soil and the higher level fertilizer gave higher yields than peat or the lower level. For clover, peat gave a slightly greater yield than soil, whereas 2 cwt/acre of fertilizer gave a marginally heavier yield than 1 cwt, there was no effect due to the time of application.

b) Petri Dish Experiments

Since the most likely way in which varying the time of fertilizer application might affect germination is likely to be through concentration effects, it was decided to investigate this in petri dish culture. The most convenient way to do this was by placing the seeds on agar jelly containing the desired concentration of fertilizer, and to incubate until germination occurred.

In the first experiment white clover and perennial ryegrass were sown on agar with concentrations equivalent to 0, 100, 200 and 400 kg/ha of S.A.I. No. 1 fertilizer. Clover germination was depressed by all three levels when compared with the control, while ryegrass was only depressed by the highest level.

In another experiment, KNO₃ was used in a similar manner, and white clover and 3 species of grass were sown, Poa pratensis, Festuca rubra and Lolium perenne spp. perenne. Again, clover proved to be the most sensitive species, all levels of KNO₃ depressed germination. The other 3 species were only slightly affected.

In a third experiment the effects of N and P were examined. Clover was the most sensitive to both P and N. The effect of P in depressing germination was the greater. These effects may be due to higher osmotic pressure restricting inhibition, but as different ions have different effects, this does not appear to be a complete explanation.

Appendix:

The Seed Store

A rodent-proof seed store has been established to accommodate experimental stocks of seed used in the Plants and Soils Department. A catalogue is kept, and seed stocks are checked from time to time and replaced with fresh material when necessary.

PLANT NUTRITION (04003)

Improved production of white clover

1. Field experiments on the major nutrient requirements and the need for inoculation with effective rhizobia on hill soils
P. Newbould, W.G. McDermott (resigned 30/9/74) and Anne Rangeley in collaboration with Drs. A.J. Holding and J.F. Lowe, MD/ESA.
- (i) Experiment on deep peat at Lephinnore
as above with G.R. Bolton

Details of the design of this experiment were given in the Annual Report, 1972, and some preliminary data were presented in the Annual Report, 1973, p. 33.

During 1974 the plots were re-sampled on 26th July. The vegetation was divided into white clover, sown grass and indigenous vegetation, dried and weighed. The results are given in Table 1 together with the results from earlier harvests. The latter are repeated from the 1973 Report because our re-calculations showed that an incorrect factor had been used to convert the sub-sample weights to yield in kg/ha. Since all the results were similarly affected this correction has no effect on the conclusions. The results show that inoculation with effective strains of Rhizobium is still having a significant effect on the dry matter production of both white clover and its companion grass. Inoculation enhanced the mean yields over the three harvests; the production of white clover was increased by a factor of seven ($P < 0.001$) and production of sown grass by a factor of more than two ($P < 0.05$).

During the winter of 1973-74 surface water of low pH from unimproved areas of the hill outside the experimental layout flowed over some of the plots. This resulted in the death of many white clover and ryegrass plants in some of the plots of two replicates of the experiment, causing the magnitude of error in all the statistical analyses to increase considerably. This increase, coupled with the extreme variability of the experimental site, resulted in an average coefficient of variation for the two sown crops at the three harvests of 44%. Despite this high error some effects of the applied fertilisers on the growth of both white clover and ryegrass were significant.

At the first harvest (10/10/72) there was a significant response of white clover to phosphorus ($P < 0.005$) and to lime, phosphorus and potassium taken together ($P < 0.005$). At the second harvest similar effects were observed with a higher statistical significance ($P < 0.01$). In addition at this harvest the presence of trace elements (30 g copper sulphate, 3 g cobalt sulphate and 0.1 g of sodium molybdate per plot) significantly increased the yield of white clover, i.e. from 373 to 504 kg/ha ($P < 0.005$). The experiment was also designed to investigate the effect of two levels (20 and 40 kg/ha) of nitrogen added as a starter dressing. The additional nitrogen had no effect on the yield of white clover but increased the yield of sown grass significantly ($P < 0.01$) at the first harvest. At the second harvest (10-12/6/73) it was without effect on the

grass but apparently increased the yield of white clover from 379 to 493 kg/ha. There were no significant effects at the third harvest (26/7/74).

At the second harvest (10-12/6/73) the herbage was analysed for its content of N, P, K and Ca. The mean values determined for all treatments expressed as a percentage of the dried matter are shown in Table 2. The main treatments in the experiment had little effect on these concentrations, there being only two effects significant at the 5% level: line increased the percentage nitrogen in clover from 4.34 to 4.58% and the presence of trace elements increased the percentage P in ryegrass from 0.28 to 0.30%.

It will be noted that the percentage of K in both white clover and perennial ryegrass, but particularly the former, is extremely low by comparison with published values and with values obtained in pot experiments (see p. 68). It is therefore surprising that the white clover plants showed little evidence of response to an enhancement in the level of added potassium fertiliser. Samples of white clover herbage are now being analysed for their content of Magnesium to see if this is higher than normal so compensating for the low potassium levels.

These results give encouragement to the further analysis of major nutrient effects (especially that of potassium) on the growth of white clover under the more controlled environmental conditions of the glasshouse at Dush and with uniformly mixed soils. The planned programme of work on this subject is described in a later section (p. 68).

Lephinmore

Table 1. The effect of inoculation of white clover seed with effective rhizobia and the level of line and other fertilisers on the yield (kg/DM/ha) of the plants and companion PRG in blanket peat (sown 28/6/72)

Line (tonne/ha)		2.5		7.5		LSD P=0.05
Phosphate as slag		52		85		
Potassium		56		112		
Inoculation		0	+	0	+	
Yield of Dry matter (kg/ha)						
10/10/72	Clover	11	39	19	57	32
	PRG	13	27	21	16	12
10-12/6/73	Clover	24	311	19	564	192
	PRG	108	124	106	305	114
26/7/74	Clover	79	225	72	341	172
	PRG	63	313	83	285	202
Total 3 harvests	Clover	114	575	83	963	343
	PRG	189	465	210	606	296

Lepinnore

Table 2. The mean concentrations of some of the major elements in the herbage of white clover, perennial ryegrass and indigenous blanket bog vegetation sampled in June 1973

Crop	% in DM			
	N	P	K	Ca
White Clover	4.46	0.32	0.72	2.30
Perennial Ryegrass	1.63	0.29	1.48	0.85
Indigenous	2.54	0.29	1.22	0.64

Significant effects:-

Line	2.5	7.5	LSD (P=0.05)
% N in clover	4.34	4.58	0.15
Trace elements	0	+	
% P in PRG	0.23	0.30	0.01

(ii) Experiment on a peaty podsol at Glensaugh
as above, with T.G. Barthram and A.L. Fairlie

In the Annual Report, 1973, p.34, the difficult weather conditions at the time of sowing this experiment were described. Sufficient plants survived the winter for it to be considered worthwhile continuing the experiment without reseeding. A light dressing (30 kg/ha) of nitrogen fertiliser was applied to the whole experiment in an effort to encourage rapid growth of the remaining plants. There was little response, and on two of the replicates the indigenous heather appeared to respond more to the fertilisers than the white clover and the perennial ryegrass. Inoculation had no apparent effect on the establishment and growth of white clover. On 28th August, 1974, samples were taken from the treatments with the lowest and highest levels of added lime, phosphate, potassium and nitrogen. The herbage was separated, dried and weighed.

The results are shown in Table 1. Although only statistically significant for total herbage yield and not for the component species the high level of fertilisers tended to increase the yield of white clover, perennial ryegrass and indigenous vegetation. This experiment has now been concluded, but it is hoped to obtain more information on the problems of establishing white clover on soils of this type from a further field trial to be described later, and from pot experiments.

GlensaughTable 1. The effect of line, phosphate and potassium on the yield of white clover, PRG and Calluna vulgaris on a peaty podsol at Glensaugh

Line (tonne/ha)	2.5	7.5
Phosphate	52	85
Potassium	56	112
Trace elements*	0	+
Inoculation of white clover	+	+
<hr/>		
<u>Yield of dry matter (kg/ha)</u>		
Clover	46	161
PRG	140	238
Calluna vulgaris	480	720
Total	666	1119
LSD (P = 0.05)		111
* See p. 66 of text for description		

(iii) Experiment on a poorly drained brown earth soil at Sourhope
(as above, with Robin H. Armstrong)

Preliminary results of this experiment were given in the Annual Report, 1973, p.34. Statistical analyses have now confirmed that coated seed performed poorly on this site ($P < 0.0001$) and that N.Z. strains of Rhizobium performed significantly better than either the introduced Edinburgh or the indigenous strains when placed on bare seed. The combined treatment which produced the highest yield of both white clover and companion grass was the bare seed with N.Z. Rhizobium. This data is shown in Table 1 together with the quantity of nitrogen that was found in the vegetation; seed treatment had no significant effect on the latter. The plots were re-sampled on two occasions in 1974 and the total yield of herbage (white clover and ryegrass) was determined; the results are also shown in Table 1. No attempt was made to separate herbage samples into white clover and perennial ryegrass. The effects of coating and strain of Rhizobium observed in the first year were no longer apparent. This result demonstrates the adaptability of white clover to growth in a fertilised brown earth soil once establishment has been achieved. The early transient benefit of using N.Z. strains of Rhizobium further illustrates the need for more information on the relationships between Rhizobia and white clover genotype, particularly in this soil type. It is hoped that the field trials described on p. 68 and the laboratory based work described on p. 72 will elucidate these problems. This experiment has now been concluded but discussions are taking place with the manufacturers of the coated seed in New Zealand to continue investigation of some aspects of the use of coated seeds in pot experiments at Bush.

Sourhope

Table 1. The effect of coating and rhizobial inoculation on total yield of herbage (white clover and PRG) and content of nitrogen in white clover (NZ Huia) grown on poorly drained brown earth soil at Sourhope

Rhizobium	<u>COATED</u>			<u>BARE</u>			<u>LSD</u>
	0	NZ	Ed.	0	NZ	Ed.	P = 0.05
Yield of Herbage (white clover and PRG) (kgDM/ha)							
5 - 7/9/73	645	536	735	920	1213	727	194
3 - 6/6/74	241	242	245	276	270	260	NS
/10/74	219	295	104	214	236	244	NS
% N in herbage at 1st Harvest (5 - 7/9/73)							
White clover	4.29	4.48	4.39	3.92	4.42	4.36	NS
PRG	3.01	3.07	3.06	3.37	2.93	3.24	NS

(iv) Collaborative series of field trials

(as above, with Dr. A. Haystead, Mr. H.A. Waterson and Dr. J. Frame (WSAC), Mr. G.J. Copenan and Mr. J.S. Black (NSCA), Dr. J.C. Holmes and Dr. J.B.D. Herriott (ESCA), Mr. J. Thompson, Mr. M. Roberts and Mr. J.S. Parker (ADAS), Mr. G.J. Davies (ARCUS), Mr. J.M.M. Munro (WPBS).

A series of small scale field trials to investigate the benefits of inoculating white clover with Rhizobium trifolii over a range of hill soils and environments throughout the UK have been planned during 1974 and will commence in spring 1975. There will be 16 trials in all: four on forest brown earth soil, four on dry peaty podsol, four on wet peaty podsol, one on a peaty gley and three on deep peat. There will be two variables - the level of starter nitrogen fertiliser (either 0 or 30 kg/ha), and the presence or absence of strains of Rhizobium trifolii. There will be eight replicates of each treatment. The inoculant will consist of three strains of R. trifolii each of which has been genetically labelled using a different antibiotic resistant marker. This will enable the microbiologists to distinguish between each of the three introduced strains and indigenous strains when isolated from nodules on the white clover plants. It is hoped that the results of these trials will be available in August 1975.

2. Pot experiments on the major nutrient requirements of white clover grown in hill soils

P. Newbould, W.G. McDermott (resigned 30/9/74) and Anne Rangeley.

Results of the preliminary pot experiment with deep peat soil to examine effect of form (NH_4^+ or NO_3^-) and quantity (0, 20, 40, 30 kg N/ha) of 'starter' nitrogen fertiliser on the establishment of two varieties of white clover (S184 and NZ Huia) which was described in the Annual Report, 1973, p. 34, are now available (Table 1). There was a tendency for the dry matter yield (g/pot) of the shoots of both varieties after 7 weeks growth to increase with increasing level of NO_3^- and decrease with increasing level of NH_4^+ but this was only statistically significant for NZ Huia. The herbage was analysed for content (g/100 g DM) of some of the major elements (N, P, K and Ca); results are given in Table 2. The percentage of N significantly increased with increasing level of NH_4^+ in both varieties of white clover; in S184 only, increasing the quantity of NO_3^- resulted in a significant lowering of the %K and raising of %Ca. It was not possible to examine the root systems of the plants in detail,

but there were superficial indications that the form of nitrogen fertiliser affected the thickness and branching patterns of the roots. It is hoped to examine these effects in more detail in subsequent experiments.

A pot experiment to determine the combination of levels of major nutrients which will give the best yield of white clover on the peat soil from Lephinmore, the peaty podzol from Glenssagh and the brown earth from Sourhope is now in progress in the glasshouse. It is a factorial experiment with four levels of nitrogen (0, 20, 40 and 80 kg/ha) as calcium nitrate, four levels of phosphate (0, 40, 80 and 160 kg/P/ha) as calcium orthophosphate and five levels of potassium (0, 40, 80, 160 and 320 kg/ha) as potassium chloride. The variety of white clover is NZ Grasslands Huia and line at 5 tonne/ha and a standard dressing of trace elements - copper, cobalt, molybdenum, zinc and boron - were added to all the pots. There are three replicates of each treatment. It is proposed to take two cuts of the above-ground herbage and to sample roots after the second harvest so as to count and grade the nodules according to size, colour and shape. The contents of N, P and K will be determined in the herbage.

Table 1. The effect of form and quantity of nitrogen fertiliser on the yield (g DM/pot) of two varieties of white clover grown on a shredded peat soil

<u>Fertiliser Treatment</u>		<u>Variety of white clover</u>	
		<u>S134</u>	<u>NZ Huia</u>
Form of N	Quantity (kg/ha)		
-	0	2.50	2.73
NH ₄ ⁺	20	2.32	3.03
	40	2.30	2.63
	80	1.93	2.45
NO ₃ ⁻	20	2.02	3.19
	40	2.30	3.39
	80	2.71	3.64
LSD (P = 0.05)		NS	0.49

Table 2. The effect of form and quantity of nitrogen fertiliser on the concentration of N, P, K and Ca in the shoots of two varieties of white clover grown in shredded peat (g/100 g D Matter)

		NH_4				NO_3			LSD ($P = 0.05$)
		0	20	40	80	20	40	80	
S104	% N	3.07	3.37	3.49	3.66	2.94	2.80	2.85	0.37
	% P	0.33	0.38	0.40	0.39	0.39	0.38	0.36	NS
	% K	1.36	1.26	1.46	1.45	1.24	1.18	1.07	0.15
	% Ca	2.05	1.96	1.93	1.79	2.10	2.26	2.43	0.20
NZ Huia	% N	3.20	3.65	3.76	4.19	3.62	3.74	3.51	0.40
	% P	0.33	0.41	0.45	0.48	0.43	0.43	0.44	NS
	% K	1.40	1.46	1.56	1.82	1.73	1.62	1.57	NS
	% Ca	1.72	1.75	1.65	1.67	1.80	1.71	1.83	NS

3. Effect of inoculation on establishment of white clover surface sown on peat

A. Haystead and A.G. Lowe

An experiment designed to separate the effects of rhizobial inoculation and nutrient coating of clover seed surface sown on peat is now complete. The purpose of the experiment was twofold. Firstly, it was necessary to demonstrate that the substantial increases in establishment and production observed by Newbould *et al* (Annual Report 1973, p. 33) were the result of increased clover nodulation and consequent nitrogen fixation and not an effect of the dilute nutrient solution in which the inoculum was applied (see Annual Report, 1973, O3D 4b, p.35). Secondly, the effect of inoculation on the early establishment stages of a surface sown clover-ryegrass sward has been studied in more detail than was possible in the field trial.

The experiment was carried out on 0.055 m² x 15 cm deep cores taken from an area of unfertilised peat at Lophinmore. The cores were sealed into pre-sterilised cuvettes (Figure 1) and returned to the glasshouse in Edinburgh. In all subsequent operations measures were taken to prevent the ingress of effective rhizobia other than those applied as an inoculum. The peat cores were burned, fertilised and sown with white clover and perennial ryegrass in the same manner and at the same rates as the field trial (p. 64). Inoculation and nutrient coating treatments were applied factorially in a 4 x 4 latin square arrangement.

The cuvettes were kept at ambient glasshouse temperature and light intensity for 11 weeks at which time the clover and perennial ryegrass plants were dissected out of the peat as rapidly and carefully as possible. The clover was assayed for acetylene reducing activity and a visual examination made of the size, distribution and appearance of the nodulated roots. Tables 1, 2 and 3 show respectively the total production, nodule size distribution and acetylene reducing activity of the clover plants at the end of the growth period. The data clearly demonstrates that inoculation increases DM production and that the effect is not attributable to nutrient coating (Table 1). Further, it is demonstrated that increased production is probably due to better nodulation (Table 2) and a consequently increased supply of nitrogen. Grass production is unaffected by inoculation in the early stages of sward establishment. In all treatments the grass showed signs of apparent nitrogen deficiency. Although fertiliser uptake was poor in the sown species (3-4 per cent) the clover seemed to compete strongly for the limited amount of soil-N available. No evidence of an N-sparing effect could be seen in the uninoculated treatments. These data are discussed more fully in Haystead, Low and Lowe, 1975 (in prep.). Table 4 shows the effect of inoculation on the free-living soil population of *Rhizobium trifolii*. It can be seen that soil into which inoculated seed is sown supports a population of the nodulating organism at least 20- to 40-fold higher than does the virgin peat. However, it remains to be demonstrated whether under field conditions this population will remain viable and effective enough to produce a sufficiently high level of nodulation during the second and subsequent season's growth of the sward.

Table 1. Effect of inoculation and nutrient coating on fresh weight, DM-production, N-yield and plant number of white clover on peat

Variate	Treatment (mean of 4 replicates)				S.E.D. (6 df)
	I+ N+	I+ N-	I- N+	I- N-	
fresh weight (g)	6.23	6.92	1.92	4.03	1.02
DM-production (mg)	896	1091	224	593	130
shoot DM (mg)	756	831	193	503	1.37
root DM (mg)	117	191	46	87	52
nodule DM (mg)	23.0	19.9	5.0	7.9	3.8
N-yield (mgN)	23.7	25.8	5.1	13.7	5.8
plant No.	19.3	20.8	16.3	20.3	7.33

Table 2. Effect of inoculation and nutrient coating on small, medium and large nodule numbers

Nodule size	Treatment (mean of 4 replicates)				S.E.D. (6 df)
	I+ N+	I+ N-	I- N+	I- N-	
small 0.5 mm	20.3	35.5	24.0	23.0	10.4
medium 0.5 - 1.5 mm	43.0	43.3	28.5	45.3	12.3
large 1.5 mm	43.5	37.8	6.3	18.5	7.6
total	106.8	116.5	58.8	86.8	19.4

Table 3. Effect of inoculation on acetylene-reducing activity of clover plants and decapitated roots

Whole Plants	Treatment (mean of 3 replicates)		Significance
	Inoculated	Uninoculated	
n moles C_2H_4 /plant/hr	3.6	1.5	($P < 0.01$)
n moles C_2H_4 /cuvette/hr	33.3	27	($P < 0.01$)
n moles C_2H_4 /g nod. DM/hr	3.4	4.2	($P < 0.05$)
Decapitated plants	45.0	27.2	N.S.

Table 4. Most probable number of effective rhizobia in uninproved peat and in fertilised peat sown with inoculated and nutrient coated white clover seed

Uninproved virgin peat: samples 1 - 6			0.0 rhizobia/gn soil	
Replicate	I+ N+	I+ N-	I- N+	I- N-
1 (rhizobia/g soil)	920	920	0	40
2	230	1470	150	0
3	920	2300	40	0
4	1470	920	0	40
mean	855	1400	43	20

I = inoculation, N = nutrient coating.

4. Selection of strains of *Rhizobium trifolii* for clover inoculation for pasture improvement on brown earth soils
A. Haystead.

Only one report has appeared in the literature of a beneficial effect of clover seed inoculation in brown earth pasture improvement trials. In most cases the failure to demonstrate increased sward production in response to inoculation has been attributed to the presence of a highly effective indigenous population of *R. trifolii*. The purpose of the current series of collaborative investigations with the microbiologists at Edinburgh School of Agriculture, is to select and test effective strains isolated from clover nodules in brown earth soils to produce an inoculum strain sufficiently virulent and symbiotically effective to produce a yield response in brown earth. Initial strain selection using sterile clover seedlings growing on nutrient agar is carried out at MD/ESA and the promising strains are tested for competitive ability on a range of clover genotype in pot trials at HFR0.

Fourteen new brown earth strains were tested in 1974 along with three strains already field tested at Lephimore and Sourhope (See 1(i) and (iii)) and two commercial strains from Australia and uninoculated pots containing the Sourhope indigenous population as controls. None of the inoculum strains tested performed consistently better than the indigenous rhizobia on the three clover genotypes tested. Several strains, although highly competitive, were less effective and gave poorer rates of DM and N production.

5. Studies on the specificity of symbiosis between strains of *Rhizobium trifolii* and genotypes of *Trifolium repens* growing in hill soils
P. Newbould and Dorothy M. Vernon

There are indications from published work (Robinson, 1969; Russell & Gareth Jones, 1975) and from our own field experiments that different genotypes of legumes including *Trifolium repens* only form a highly effective symbiosis with certain strains of *Rhizobium trifolii*. It is proposed to investigate this relationship in some detail for all the genotypes of white clover commonly recommended for hill land improvement (S.104, S.100, Kent Wild White and NZ Grasslands Huia) when grown in a range of hill soil types. However, before venturing to work with soils, a preliminary appraisal of strain-genotype compatibility will be conducted with single plants grown in test-tube culture. Because white clover is an out-breeding species, and therefore heterogeneous, and variable within a cultivar, the spectrum of genetic variation within each cultivar will first be determined. One hundred seeds of each white clover cultivar chosen at random from a certified stock and graded by size will be surface sterilised and scarified in concentrated sulphuric acid before germinating and transferring singly to mineral agar slopes containing nitrate, in cool conditions. Seedling fresh and dry weights will be determined at a suitable time and used to assess genetic variability.

Subsequent experiments will look at the growth of the white clover cultivars when inoculated with a series of strains of *Rhizobium trifolii*. Some of the latter will be provided by Drs. Holding and Lowe (MD/ESA), some will be from commercial stocks of inoculum (from Rothamsted, from Australia and New Zealand) and some will be strains freshly isolated from native white clover plants growing on hill soils. This work will initially be carried out on agar slopes in test-tubes but as soon as sufficient basic information has been obtained the effects of mineral nutrients, soil type and soil physical conditions upon the efficiency of the symbiosis will be examined in a series of pot experiments with a range of hill soils.

Robinson, A.C. (1969). Competition between effective and ineffective strains of *R. trifolii* in the nodulation of *T. subterraneum*. Aust. J. agric. Res. 20, p. 32.

Russell, P.E. and D. Gareth Jones (1975). Variation in the selection of *Rhizobium trifolii* by varieties of red and white clover. Soil Biol. and Biochem. 7, p. 15.

Assessment of the availability of phosphate to plants from hill soils
 Meera Pinplaker, M.J.S. Floate and P. Newbould.

The aim of the study was to evaluate different methods for the assessment of phosphate availability in hill soils. Some of the results obtained from extraction, sorption and L-value techniques have been presented in earlier reports (1972 and 1973).

Comparison of extraction methods

Preliminary results for samples from Lephinmore and Linhope (Stanhope) were presented in the Report for 1973, p. 37. Laboratory work on these soils has now been completed and additional data is available for samples from Sourhope and Minchnoor.

The samples from the Sourhope site were taken both from soils to which phosphate fertiliser (30 kg/ha) had been added four years previously (described as + P) and from unamended soil (- P), while those from Minchnoor included both 'A' and 'B' horizons. The quantity of 'available' P extracted by four methods from these soils is given in Table 1.

Extraction methods for the Sourhope soil, (see results for the Linhope soil described in the previous report, 1973), showed no large differences between the 'available' phosphorus in + P and - P samples, and the quantity of 'available' phosphorus was not always larger in the + P sample. By contrast, all the methods gave a consistently positive difference between the 'A' and 'B' horizons of the Minchnoor soil. The quantities of 'available' P extracted from the Lephinmore soil by all the methods, given in the previous report, were higher than from the other three soils and that from the + P areas always exceeded those from - P areas. These results suggest that the Lephinmore soil should supply the most P to plants, whereas experience in the field suggests that plants grown in this soil are short of phosphorus. The inconsistent results given by all the extraction methods especially when the total quantity of 'available' P was low or when only small differences between samples were under test suggests that none of the extractants is completely satisfactory for use in hill soils.

Other methods which include measurement of total-P phosphate sorption, phosphate extracted by anion-exchange and use of radioactive phosphorus have been examined. The radioactive tracer was used to measure the quantity of labile P either by isotopic dilution in uptake by plants (L value) or by isotopic exchange in soil suspensions (E value).

L-value measurements were made on four soils (Lephinmore, Glensaugh, Sourhope and House o' Muir), and the results have been given in the Annual Report, 1973, p. 42. The following ranking of soils for their P-availability was obtained: $L < G < S < H$.

As part of the L-value studies, the same soils were used in a pot experiment with no phosphate added, but with other nutrients in adequate supply. Under these conditions the DM production and P-uptake data can be used to establish a comparative ranking of these soils. Results for Total-P, L-value, DM yield and P-uptake are summarised in Table 2. The data in this table show that 'L'-values and total-P (expressed on a volume basis) place the soils in the same order of ranking as DM production and P uptake whereas the other methods do not. So, it appears that L-value and Total-P measurements may be more suitable for P-assessment in hill soils than extraction techniques.

As suggested in the previous report, labile soil phosphate by isotopic exchange (the E-value) using the technique of Russel et al, 1957, has now been measured.

Preliminary experiments were carried out in which 5 g samples of soil were shaken with P-32 labelled KH_2PO_4 solutions for varying lengths of time up to 21 days. The results are given in Table 3.

From the results it was concluded that:-

1. The P_1 level (5 mg P/5 g soil) is the most suitable carrier level as less variation was observed in P-31 measurements.
2. A seven day period of shaking may be suitable for peaty soils but a longer period is needed for mineral brown earth soils to attain equilibrium.
3. E-value measurements give ranking of soils similar to that obtained in earlier sorption studies and do not reflect the ability of the soils to supply phosphate, as indicated by DM production and P-uptake data at the P_0 level (with no phosphate added) or L-value measurements. The ranking of soils obtained is as follows: $L > G > H \approx S$.
4. Variation in E-values between experiment I and II was thought to be due to temperature fluctuations and the use of different sub-samples. Further investigation is necessary before any definite conclusion on the suitability of this technique can be drawn.

P-assessment by an anion-exchange resin technique is currently being undertaken. Some preliminary experiments were conducted with two types of resins (Amberlite IRA-410 and Dowex 2-X8) to determine the range over which phosphate adsorption is quantitative. The method gave 80% recovery of added phosphate and hence attempts are being made to improve the efficiency of the experimental procedure.

It is hoped to develop or select a method for routine use to suit a wide variety of soil types. The suitability of any method will be judged by the reliability with which it can be used to assess the ability of the soil to supply phosphate for plant growth in the absence of any other limitations. The method should also be able to detect small differences between soils caused by fertiliser treatments.

Since no data on the uptake of P by plants are available for Linhope and Minchmoor soils, it is proposed to run a pot experiment using all the soil types with four levels of added P (0, 40, 80, 160 kgP/ha). DM production and P-uptake at the P_0 level will be used to establish a basic ranking of soils in order of P-availability: DM data at the P_{140} , P_{260} and P_{3130} levels will be used to estimate the response of the test crop to fertilisers. The results of this experiment will be compared with the predictions of phosphorus availability based on all the methods which have been tested.

Reference

- Russel, R.S., Russel, E.W. and Marais, P.J. (1957). Factors affecting the ability of plants to absorb phosphate from soils. 1. The relationship between labile phosphate and absorption. J. Soil Sci. **3**, 243.

Table 1 "Available" P extracted by different extractants (mg/100g)
(04003)

Soil	Method	Morgan (NH ₄ OAc)		Bray (NH ₄ F)		Truog (H ₂ SO ₄)		Olsen (NaHCO ₃)	
		Mean	Range	Mean	Range	Mean	Range	Mean	Range
Sourhope + P		1.06	0.96 - 1.14	2.42	1.92 - 2.88	1.74	1.40 - 2.10	1.44	1.36 - 1.68
		0.95	0.86 - 1.04	1.76	1.54 - 2.04	1.86	1.60 - 2.30	1.71	1.60 - 1.80
		1.03	0.92 - 1.08	1.87	1.39 - 2.04	1.50	1.30 - 1.70	1.12	1.04 - 1.20
Sourhope - P		0.84	0.78 - 0.90	2.84	2.32 - 3.12	2.38	2.00 - 2.70	1.71	1.40 - 1.84
		0.79	0.66 - 0.92	2.01	1.49 - 2.32	2.31	2.00 - 2.50	1.99	1.84 - 2.08
		0.74	0.68 - 0.82	2.24	2.01 - 2.35	2.19	2.00 - 2.40	1.23	1.12 - 1.28
Minchmoor A - P		0.31	0.26 - 0.38	0.40	0.35 - 0.52	0.65	0.56 - 0.78	0.26	0.24 - 0.35
		0.29	0.26 - 0.34	0.32	0.17 - 0.56	0.69	0.62 - 0.76	0.34	0.26 - 0.45
		0.34	0.29 - 0.38	0.26	0.22 - 0.30	0.43	0.32 - 0.80	0.47	0.41 - 0.52
Minchmoor B - P		0.12	0.06 - 0.18	0.08	0.05 - 0.11	0.11	0.02 - 0.22	0.08	0.05 - 0.15
		0.15	0.08 - 0.22	0.07	0.03 - 0.19	0.37	0.30 - 0.44	0.11	0.09 - 0.17
		0.29	0.26 - 0.31	0.06	0.04 - 0.09	0.09	0.04 - 0.12	0.16	0.13 - 0.20
Sourhope difference (+P) - (-P) ratio (+P):(-P)			0.22 1.28		-0.34 0.86		-0.59 0.74		-0.22 0.87
Minchmoor difference (A) - (B) ratio (A):(B)			0.12 1.63		0.26 4.71		0.40 3.11		0.24 3.00

Table 2 L-value, DM yield, P-uptake, Total-P, Extractable-P, Sorbed 'P' in Hill Soils

Soil	L-value	DM yield at Po level g/pot	P-uptake at Po level mg/pot	Total P		Extractable P mg/100g a.d.s.	Sorbed 'P' mg/5g soil	"1/S" A 1/s
				mg/100 g a.d.s.	Kg/ha			
Lephinmore	0.16	0.796	0.82	50.0	100	2.69	1.5	0.11
Glensaugh	0.19	1.359	2.09	82.5	165	0.31	9.4	0.11
Sourhope (Dud site)	0.36	2.639	3.69	97.8	538	3.05	3.8	0.26
House o' Muir	0.77	2.222	3.51	101.9	560	0.21	9.4	0.65
L S D 5% level	0.166	0.319	1.459					

Table 3 E-values (E) and Sorption of Phosphate (S) in Hill Soils

All values in mg/5g soil and represent mean of three replicates

Experiment	Soil	Carrier Phosphate Level (mgP/60ml)	Duration of Shaking (days)							
			1		7		14		21	
			E	S	E	S	E	S	E	S
I	Lephinmore	P ₁ - 5	0.54	0.45	0.79	0.50	0.89	0.36		
		P ₂ - 9	0.67	1.12	1.84	<u>-0.10</u>	1.22	0.70		
	House o' Muir	P ₁ - 5	0.30	3.75	0.45	0.41	1.28	4.45		
		P ₂ - 9	0.35	5.23	0.73	6.32	1.85	6.68		
II	Lephinmore	P ₁ - 5			3.43	<u>-0.16</u>	4.22	<u>-0.20</u>	8.57	-0.67
	Glensaugh	P ₁ - 5			1.85	3.94	1.37	3.99	3.77	3.44
	Sourhope	P ₁ - 5			0.80	3.07	0.86	3.29	0.78	3.36
	House o' Muir	P ₁ - 5			0.70	3.81	1.02	4.04	0.87	4.14

The ranking of soils for their P-status: L > G > S = H

Underlined values represent desorption of phosphate.

PASTURE ESTABLISHMENT (04004)The effect of a reduction in bracken density on the production of underlying grass.

G.E. Davies

An introduction to the work was given in the Annual Report, 1973, p. 43. Spraying with 'Asulox' in July 1973 was successful and gave a reduction in bracken fronds of almost 100% on the two sites.

In the spring of 1974, one half of each site was fenced to exclude stock and records were taken during 1974, whereas the unfenced half was subject to the grazing programme of production paddock (P₂) of the Hairney Law/Auchope Project. The latter area will be recorded in 1975.

Accumulated dry matter yields and percentage green material are given in Table 1. Although statistical analyses were carried out for each site separately for the purpose of this report the mean results for sites 1 and 2 are given, since further analyses combining the data for the two sites showed no significant site or site x treatment differences.

Table 1. Accumulative dry matter yield (kg/ha) and percentage green material of underlying vegetation

Harvest	Date	Control		Sprayed		Significance	
		Yield	% green	Yield	% green	Yield	% green
1	10/6/74	952.4	52.0	973.2	50.0	NS	NS
2	29/7/74	1230.7	62.0	1233.8	56.2	NS	NS
3	2/9/74	1434.6	73.2	1571.4	61.9	NS	NS
4	4/11/74	1311.9	61.5	1560.3	49.9	NS	*
10/6/74							
Regrowth -	9/9/74	761.6	73.4	507.2	64.2	*	*

Results show little difference in accumulative yield between control and sprayed treatments except in the final harvest where the control gave the higher yield. None of the differences was significant. Regrowth from Harvest 1 cut plots gave a significantly higher yield on the control than in the spray treatment. The bracken fronds had hardly emerged when these plots were first cut, so that in contrast to subsequent harvests the influence of the current year bracken cover would only operate on regrowth. No regrowth measurements could be carried out on later harvested plots because prior to cutting the grass vegetation, the bracken itself was cut and therefore subsequent treatment effects were lost. The percentage green material is consistently higher on the control than on the spray treatment, although only significant in Harvest 4 and the regrowth harvest.

Botanical analyses were carried out on all the harvested plots. Table 2. gives results expressed as the means of the four harvests with only the relevant species listed.

Table 2. The effect of spraying on species change and the amount of bare ground. Percentage cover assessed using 10 point quadrat.

Site	Treatment	Bare ground	At.	Ac.	Pp.	Fo.	Df.
1	Control	11.7		41.3			14.4
"	Sprayed	23.2		13.7			25.2
2	Control	3.1		29.9			42.5
"	Sprayed	11.3		12.2			54.9

Key: At. = *Agrostis tenuis*; Ac. = *Agrostis canina*;
 Pp. = *Poa pratensis*; Fo. = *Festuca ovina*;
 Df. = *Deschampsia flexuosa*.

Results indicate a considerable reduction in the broad-leaved species - *A. tenuis*, *A. canina* and *P. pratensis* and an increase in the fine-leaved grasses - *F. ovina* and *D. flexuosa* on the sprayed plots. The increase in the latter only partially compensates for the decrease in broad-leaved grasses thus giving an increase in bare ground.

Temperature data for both sites are summarised in Table 3 below. Of interest is the insulating effect of bracken cover on night temperatures even on Site 2 with a comparatively low bracken density.

Table 3. Mean temperatures from 23/7/74 to 28/8/74

Site	Treatment	Time	Soil temperatures (°C)				Bracken cover	
			Surface	Minimum	2"	4"	No. per sq/m	Height(cm)
1	Control	10.00	13.5	7.3	11.3	11.6	51	94
"	Sprayed	"	17.3	3.7	13.2	12.2	0	-
2	Control	"	15.1	6.2	12.4	11.9	26	55
"	Sprayed	"	16.7	3.9	12.4	11.9	0	-

Soil moisture tensions were measured throughout the growing season on both sites but no differences could be detected either between treatments or sites.

The data obtained in 1974 has not been fully analysed statistically, as yet. The relationships between dry matter yield of herbage and soil temperature will be further examined.

The sites chosen are very exposed and this, together with the 'puffy' nature of the upper soil horizon, would mean that until the sprayed areas become stabilized there is little prospect of increased yields. Even then it is possible that the shelter afforded by the bracken plant will more than compensate for the disadvantages of its shading effects and nutrient and water competition. An additional factor is the poor nature of the soil which would tend to minimize the effects of the other factors mentioned. Finally, it is worth noting that the substantial reduction in *A. tenuis* on the sprayed plots makes one suspect 'Asulox' toxicity. Whether 'Asulox' has also reduced growth in general, either through root storage from the previous year or through the soil, is questionable. A small pilot experiment to investigate this possibility using indicator species grown in soil in boxes in the glasshouse gave inconclusive results.

EFFECTS OF UTILISATION : MOORLAND (04005)

1. Effects of utilisation by grazing hill sheep on the stability and productivity of blanket bog.

S.A. Grant, W.I.C. Lamb, C.D. Kerr and G.R. Bolton

The introduction of two pasture systems into areas dominated by blanket bog gives rise to changed patterns and levels of use of the vegetation by grazing stock. Blanket bog vegetation is known to be vulnerable to over-grazing and the present study arose from the need to identify levels of use compatible with sustained dry matter production. It is also important to know something of the annual pattern of use among the various bog species if the possible outcome of changed level of use at a particular time of year is to be predicted.

The study, which is necessarily long-term, was begun in 1971. Plots at three different stocking rates were set up at three sites. At two of those sites, patterns of use were consonant with periods of use of the hill in two-pasture year round grazing systems; at the remaining site the pattern reflected that of two-pasture off-wintering systems.

During the first three years detailed records of levels of use of the six main bog species were collected at monthly intervals during the periods of grazing. The plots were too small to allow continuous grazing and were grazed at monthly intervals by three or four sheep for one to three days during a 'grazing period'. Records were collected after each monthly grazing. A paper reporting on this phase of the study is currently being prepared for publication.

During the present phase of the investigation, effort is being concentrated on monitoring changes in floristic composition and productivity of the vegetation. Point quadrats are recorded annually each July; standing crop, the total above ground dry matter and the weight of dry matter due to each species. Current season's growth (for heaths) or green dry matter (for other herbs, sedges and grass) are determined by cutting sample quadrats at two to three year intervals. Such harvests were made in 1971 and 1974. Some material from the 1974 harvest still remains to be separated, dried and weighed thus statistical analysis to test utilisation effects on productivity has yet to be done.

To date floristic trends are not marked but as these may accelerate with time the decision when next to harvest and when to review stocking rates will be assessed annually.

Subsidiary projects

- (a) Serial sampling of bog species to determine in vitro dry matter digestibility and chemical composition as measured by the van Soest chemical technique.

Recent work within HFR0 has indicated that oven drying of poorer herbage types results in lower in vitro dry matter digestibility (IVD) than freeze drying of the same sample. Both to check on the first year's results and the effect of method of drying samples of various bog species were collected in May, July, September 1974 and February 1975. The samples are currently being processed and early results indicate that for some species and dates the difference in IVD between freeze and oven dried samples is substantial.

- (b) Cuticle identification in faeces: This study was completed for the Annual Report, 1973, p. 45.
- (c) Selective grazing behaviour of sheep as between *Calluna vulgaris* and *Eriophorum vaginatum*: A trial in which four sheep were placed in crates on the open hill so as to limit their grazing to small pre-selected areas allows the following observations:-
 - (i) When *Calluna* and *Eriophorum* were growing together and when it was possible to distinguish which species was eaten first, the sheep chose to graze the *Calluna* first.
 - (ii) Visible evidence of utilisation indicated higher levels of utilisation for *Calluna* than *Eriophorum*.
 - (iii) Bitten off leaves of *Eriophorum* were always found in tussocks seen to be grazed; however, in some cases, discarded or fallen drawn leaves were also found.
 - (iv) It was impossible by observation of the grazing sheep to judge the ratio of bitten off to drawn leaves and thereby gain an idea of the extent to which visual estimates of utilisation are underestimates.
 - (v) Young *Eriophorum* flowers deep in the tussock and averaging about 1 inch height are rarely drawn.

To gain more information on the ratio of heather to cotton grass eaten and on the proportions of drawn to bitten off leaves of the latter, extrusa from oesophageal fistulated sheep are necessary. Such sheep are available at Glensaugh, thus a site of mixed Calluna-Eriophorum has been selected on Big Hill and it is intended to collect samples periodically during 1975.

2. On carbohydrate reserves and regrowth of heather (04005)
W.I.C. Lamb

Samples were collected in May, August and October from all plots of the heather grazing experiment (see p. 82). Both grazed and ungrazed shoots were sampled. After separation into green shoots and wood and weighing of these fractions to characterise the shoots, water soluble carbohydrate levels will be determined. This work is currently in progress and insufficient results are available for further comment.

3. On growth form and productivity of heather moor

(a) Cutting experiment at Bush
Sheila A. Grant and W.I.C. Lamb

Heather plants growing in boxes are being subjected to different seasonal patterns and levels of clipping with the objective of determining the effects of utilisation on both quality and quantity of dry matter production.

In previous years the van Soest chemical method of assessing quality had been used as in vitro dry matter digestibility (IVD) methods had proved unsatisfactory. However, with improvements in the IVD technique following the work of Dr. Milne, it was considered worth using this technique to measure quality of the clippings removed in 1974.

The clippings were freeze dried and heather standards were included during digestion as well as grass standards. However the quality of the material on test was superior and outwith the range of the heather standards and linear extrapolation clearly gave false estimates of IVD. The results summarised below are therefore with respect to the grass standards. The order of the fall in quality with advancing seasonal maturity was similar to that found by Dr. J.A. Milne for *in vivo* DMD of heather; in May mean IVD was 53.6%, plants first cut in July averaged 51.5% and those first cut in September 44.3%. The improvement in quality of regrowth material was fairly substantial. The average IVD of clippings removed in September was, for plants uncut previously, 44.3% (vide supra) plants cut once in May, 50.5%, plants cut once in July, 51.3%, and plants cut in both May and July, 54.4%.

Differential cutting treatments have now been discontinued. The plants will be allowed to grow on until August 1975 when the final harvest will take place. At this harvest the effect of a prehistory of four years of differential cutting on above ground dry weight and weight of current season's shoots will be measured. Opportunity will also be taken to look at digestibility gradients within the shoot. As weights of material removed as clippings during the four years of treatment are known and also a description of the distribution of dry matter among current growth, flowers, older green, dead wood from previous harvest dates which allows for estimates of litter production, total dry matter production over the lifetime of the plant can be examined.

The questions the experiment is designed to answer are:-

- a) How does increasing level of utilisation affect dry matter output?
- b) Is sensitivity of the heather plant to cutting different between early, mid and late parts of the growing season?
- c) Is there interaction between level and frequency within the season?

With regard to the second question if one examines total weights of clippings removed each year in terms of percentage of total dry matter attributable to each cutting regime in each year, there are three possible outcomes viz. treatments which show improvement with time, those which show little change and those which show a worsening position. All treatments in the first category were uncut in September; all those in the third category received a severe cut in September, but were uncut in July.

- (b) Grazing experiment - Big Hill, Glensnaugh (04005/02004)
Sheila A. Grant, J.A. Milne, G.T. Barthram, L. Bagley and W.I.C. Lamb

This experiment was designed to investigate the effects of levels and patterns of utilisation on the growth form and dry matter production of heather and on the quality and quantity of the diet selected by grazing sheep. There were two periods of grazing, viz. June-July and September-October, and three levels of utilisation, viz. 0, 40% ($\frac{1}{2}$) and 80% (1) removal of available current season's dry matter. All permutations of time of year and level of utilisation were provided, thus there were nine treatments. The experiment was begun in 1973, treatments now having been imposed for two years.

Effect of first year's treatments on production

At the start of the experiment the standing crop averaged 3500 kg/ha (June 1973). The treatments, utilisation levels achieved in 1973, standing crops and % current season's growth as at June 1974 together with the calculated amounts of current growth are shown in the Table 1 below:-

<u>Treatment</u>		<u>Utilisation</u> <u>achieved in 1973</u>	<u>Standing crop</u> <u>1974</u>	<u>% current</u> <u>growth</u>	<u>Amount current</u> <u>growth</u>
0	0	Nil	5920 ± 426	15.9 ± 3.8	946
0	$\frac{1}{2}$	27.3	6312 ± 339	11.7 ± 0.9	739
0	1	50.1	3416 ± 162	15.7 ± 0.9	537
$\frac{1}{2}$	0	23.4	5534 ± 326	11.9 ± 1.0	663
$\frac{1}{2}$	$\frac{1}{2}$	37.5	5136 ± 294	10.1 ± 1.1	521
$\frac{1}{2}$	1	69.3	4040 ± 357	20.8 ± 1.5	841
1	0	38.5	5544 ± 419	11.2 ± 1.1	623
1	$\frac{1}{2}$	44.9	6352 ± 309	14.5 ± 1.3	919
1	1	73.5	4600 ± 140	18.3 ± 0.6	842

Sampling errors are large but the trend for higher levels of utilisation to be associated with lower standing crop compensated for by higher % current growth is apparent.

Distribution of grazing

It was noted in the Annual Report, 1973, that the sheep grazed the plots unevenly so that mosaics of heavily utilised and ungrazed areas tended to develop. It was also noted that the heavily grazed areas were usually associated with proximity to discrete grassy patches (now since killed with weedkiller because

of problems caused by their uneven distribution as between plots), bare areas, fences, water troughs etc. Both to record variation in heather cover and distribution of grazing, and to follow changes with time, it was decided to map the plots annually. Mapping was done by recording both mean heather cover and extent of grazing on a five point scale in successive 3 metre x 3 metre squares. Correlation coefficients between % heather cover and % grazed were calculated. High coefficients were associated with low grazing pressure and variable heather cover, low coefficients with high grazing pressure and/or even heather cover. The treatments, coefficients and percentage of mapped squares with less than 25% cover (to indicate variability in heather cover) are given in the Table 2 below:-

Table 2.

Treatment		Correlation Coefficient	% mapped squares with less than 25% cover
0	$\frac{1}{2}$	- 0.760***	17.3
0	1	- 0.244*	6.1
$\frac{1}{2}$	0	- 0.258**	2.5
$\frac{1}{2}$	$\frac{1}{2}$	- 0.389***	2.6
$\frac{1}{2}$	1	- 0.309**	3.2
1	0	- 0.474***	7.7
1	$\frac{1}{2}$	- 0.678***	10.9
1	1	- 0.399***	9.7

1974 Treatments

The plots were grazed according to schedule. Grazed and ungrazed heather shoots were sampled from all plots to determine water soluble carbohydrate levels in May, at the start of the growing season, in August immediately after the first grazing period and in October at the close of the second grazing period. The nature of the material eaten was assessed by the method of recording utilisation whereby, as well as recording the extent of grazing, the proportion due to each of three categories viz. A, less than half the current season's long shoot length, B, more than half but not into the old wood, and C, all of the current season's shoot plus some old wood was also noted. At the close of the year's grazing treatments, all grazed plots were sampled to estimate damage due to uprooting or snapping off of heather shoots. The results with respect to utilisation achieved in 1974, percentage of grazing in each category and weight of uprooted shoots are summarised in Table 3 below:-

Table 3.

Treatment		Utilisation achieved 1974	% Grazing by category			Uprooted and broken shoots kg/ha
			A	B	C	
0	$\frac{1}{2}$	43.3	25.4	42.9	31.7	139
0	1	90.0	3.5	17.1	79.4	318
$\frac{1}{2}$	0	50.7	11.6	43.3	40.1	158
$\frac{1}{2}$	$\frac{1}{2}$	47.7	9.1	59.7	31.2	149
$\frac{1}{2}$	1	102.5	1.5	7.8	90.7	539
1	0	42.6	23.4	52.2	24.5	198
1	$\frac{1}{2}$	69.6	8.7	43.9	47.5	395
1	1	101.3	1.3	7.1	91.6	586

The correlation coefficient between percent utilisation achieved and weight of uprooted shoots was $r = 0.926$, $P < .001$. The damage expressed as uprooted shoots as a percentage of the standing crop as at October 1974, varied from 2% on lightly grazed plots to over 14% on the most heavily grazed plot.

Somewhat higher levels of utilisation were achieved in 1974 than 1973. Bare patches have increased in size on some of the plots. Mapping of the plots is scheduled for April 1975. Earliness of growth will be recorded in May and the pre-grazing samples of June 1975 will be used to assess the effects of two years of differential grazing treatment on standing crop and production.

4. On the production and utilisation of grass and heather in mixed swards

(a) Sown grass and heather utilised as a production area of a two pasture system

A joint report will be found under 02004/04005 (see p. 13).

(b) Indigenous grass and heather utilised as the hill component of a two pasture system (04005/02004)

J.A. Milne, Sheila A. Grant, L. Bagley, G.T. Barthram and T.J. Maxwell

The typical heather hill contains a small percentage by area of indigenous grass. Variation in both pattern and level of utilisation during the summer could be expected to result in differences in quantity and quality of the grass component of the hill at the onset of winter as sheep usually graze grassy areas preferentially. The objective of this experiment is to determine the effect of stocking rate and management system on the utilisation of mixed native grass and heather swards and particularly to determine the quantity and quality of the diet selected by the grazing sheep during the winter.

Four plots containing 10% indigenous grass were set up during winter 1973-74. On one plot, the management system adopted was the set stocked year round grazing system (system A). On the remaining three plots, the sheep grazed the plots in a pattern consistent with the use of the hill component of a two pasture system (system B). The first system gives a high summer:winter stocking rate ratio, the second a high winter:summer ratio. With the system B, three stocking rates were provided. Floristic analyses were made of both the grass and the heather component of the sward to record floristic composition at the start of the experiment.

There were three main grazing periods, viz. May-July, August-October and January-March. The nature and quantity of available grass (standing crop, percentage green and *in vitro* dry matter digestibility) were determined at the beginning and end of each grazing period. Heather standing crops and percentage current growth are measured annually prior to the winter grazing treatment and the level of utilisation of the heather is estimated both before and after winter grazing. Animal measurements, viz. faecal output and percentage heather in the diet, were recorded for all three grazing periods for sheep on system A but only during late summer and winter for sheep on system B.

The experiment was begun in May 1974, the first year's treatments being completed by the end of March 1975. Samples and data collected are currently being processed so that results are not yet available for comment.

EFFECTS OF UTILISATION : PASTURE (04006)

1. Effects of defoliation on pasture regrowth

J. King and M. McGregor

A second experiment was carried out to supplement the results obtained last year (Annual Report 1973, OGD, p.49). Micro-swards of S.23 ryegrass were grown in ten inch pots and subjected to the following cutting regimes:-

F₁L cut weekly to 2 cm

F₁H cut weekly to 4 cm

F₃L cut 3 weekly to 2 cm

F₃H cut 3 weekly to 4 cm

These treatments were applied for six weeks and produced four wholly vegetative swards of contrasting leafiness and growth-form. A three week period of uninterrupted regrowth was then allowed during which measurements were made. In the following account the results of both the 1973 and 1974 experiments are considered together.

The following are the main points that emerge:-

1. The production of new leaf was largely unaffected by the treatments despite the differences in leaf area that were produced. This was apparently due to the compensating effect of reserve carbohydrates in swards where photosynthesis was inadequate for respiration and growth.
2. Defoliation is followed by considerable losses mainly of carbohydrates, stem weight and weight of old leaf material. Some of this must represent material translocated for new leaf production, the rest appears to be a shedding of older tissues, and represents a reduction of the respiratory burden. These losses are greatest in those treatments where the greatest call is made on carbohydrate reserves (e.g. F_3L) or where there is large amount of leaf, presumably old leaf in the sward (e.g. both H treatments cut to 4 cm).
3. The net result of these weight gains and losses is that only on one treatment, namely the weekly low cut sward (F_1L) was there a net gain in yield in the first seven days after defoliation (Table 1). All swards showed large gains from 7-21 days but the high cut ones gained less than the low cut ones.
4. In terms of Relative Growth Rate (RGR) (Fig. 1) the weekly low cut sward (F_1L) stands out as the only one to have a linear RGR. This indicates the same exponential growth rate over the whole 21 days. In all other treatments RGR in the first seven days is lower than the rate from 7-21 days. The highest RGR overall occurs on swards cut to 2 cm.

There is no doubt from these results that the most productive swards are those produced by treatments F_1L and F_3L . These swards suffer the smallest weight losses by senescence or have the least requirement for translocated assimilates. Their low stubble height (down to 2 cm), low stubble biomass and in F_1L , a high stubble leaf area of photosynthetically efficient leaf are advantageous and give rise to high relative growth rates. For a given RGR the most productive sward will be that with the largest integrated leaf area index (LAI) over the full regrowth period, and in this respect the three weekly low cut sward has the advantage despite the high stubble LAI of the weekly cut sward.

Essentially, it seems that we can regard growth as a function of net canopy photosynthesis (Pnc) and therefore of LAI x photosynthetic efficiency of the leaf canopy, except when defoliation causes photosynthesis to be low relative to the respiratory load (R). In the absence of defoliation, growth will be exponential (i.e. relative growth rate will be linear) at least until leaf age and mutual shading by leaves in a tall canopy causes the rate to fall (Fig. 2). The effect of defoliation is to reduce the photosynthetic capacity relative to respiration and so to reduce growth rate for about seven days. The extent to which this happens depends on the nature of the defoliation regime and is least in the frequently and closely defoliated swards. It is not clear, however, whether the effect of defoliation is simply to reduce Pnc relative to R or whether a temporary increase in R is also involved.

However, harvested yield depends on % utilisation (Table 2) and on weekly cut swards; where the cutting interval is less than the probable life span of a leaf this must be measured in terms of the production rate of new material and not in terms of standing crop. The best estimate of this from the data

available is based on % utilisation of the terminal leaf or of total leaf. The former value is an underestimate since during the life-time of a leaf it will be grazed more than once and the estimate in Table 2 takes this into account. The % utilisation of the 3 weekly cut leaves may also be underestimated if some leaves have senesced during the 21 days before harvest.

It appears therefore that the % utilisation in the weekly and three weekly low cut swards (F_1 and F_3L) is rather similar and is higher than in the high cut swards. From these data it appears that a good grazing management should seek to obtain close defoliation whether the frequency is high as in continuous grazing or low as in rotational grazing. Which of the latter alternatives gives the greatest animal production will depend on the % utilisation rate that can be achieved under rotational grazing (it is assumed always to be high with continuous grazing) and on the maximum LAI (and hence growth rate) that can be achieved on a continuously grazed sward.

The alternatives appear to be:-

1. for continuous close-grazing to maintain LAI near to 4 without letting herbage length exceed 3 cm.;
2. for rotational close-grazing to achieve a short clean stubble, to minimise the respiration losses, and to achieve a regrowth with a high proportion of young leaf, to maintain a high (15%?) carbohydrate reserve level and to find the optimum interval between grazings and so reduce senescence losses at this time. There will also be a period of reduced photosynthetic efficiency while grazing is in progress but this has not been evaluated.

Table 1. Dry weight of total green crop at successive intervals.
(1974 data) gm/dm²

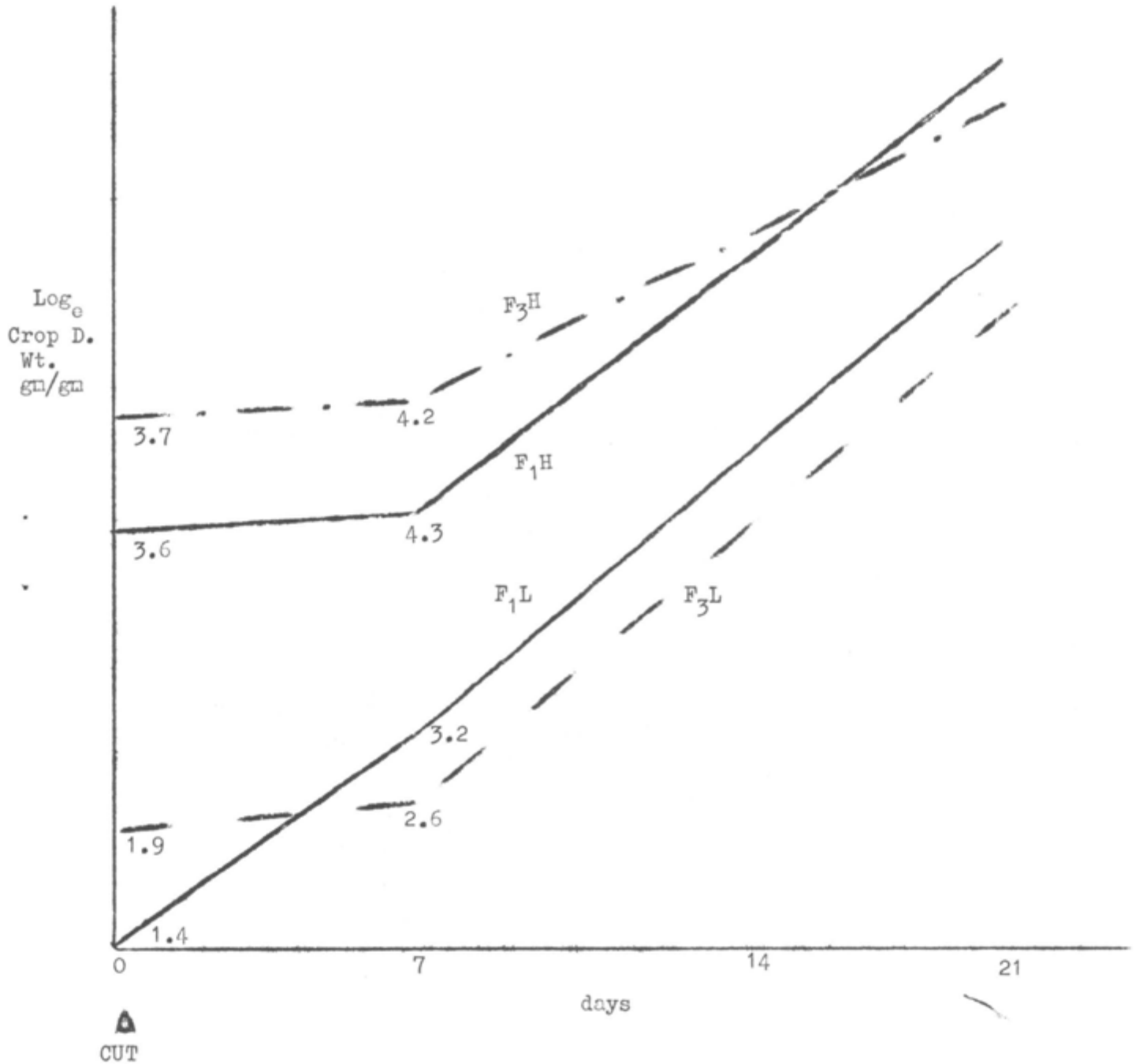
Cutting regime	Days		
	0	7	21
F_1L	0.90	1.13	2.06
F_1H	1.53	1.60	2.53
F_3L	1.02	1.03	1.91
F_3H	1.75	1.79	2.31
LSD	0.23		

Table 2. % Utilisation calculated on different bases

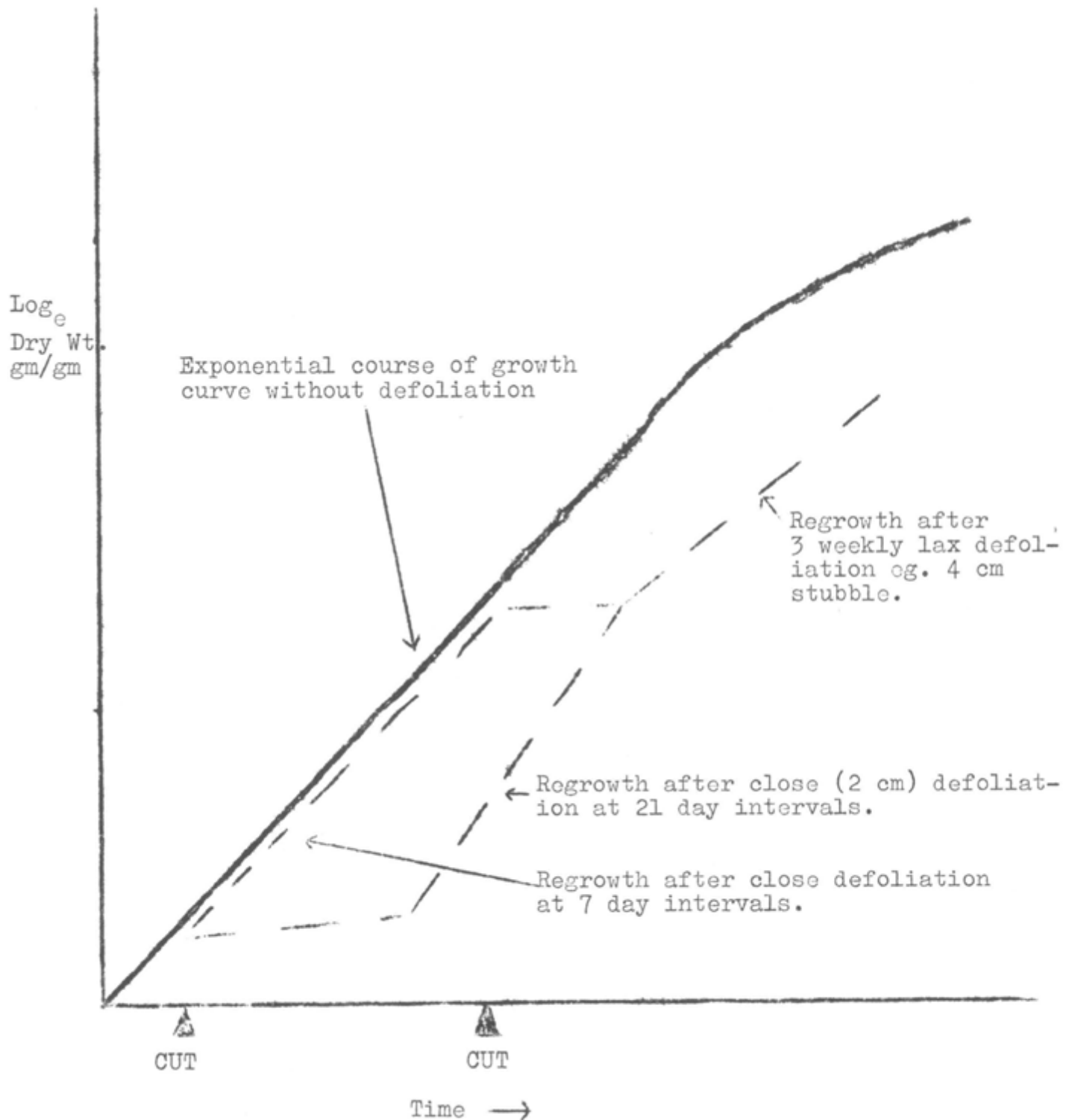
Cutting regime	% of green standing crop harvested	% of leaf production harvested		
		Terminal leaf	Lateral leaves	Terminal & lateral leaves
F_1L	26.9	63.5	29.7	74.3
H	13.0	25.2	2.9	27.4
F_3L	73.8	32.5	73.8	77.1
H	36.8	56.9	23.6	33.2

Fig. 1. Relative Regrowth Rate of swards previously subjected to different frequencies and intensities of defoliation.
(04006)

Values on graph lines are for Leaf Area Index in stubble at day 0 and in crop at day 7.



(04006) Fig. 2. Effects of defoliation regime on regrowth of an S23 sward.



2. Net photosynthesis of continuously grazed pastures

J. King and M. McGregor

A pure sward of S.23 ryegrass was divided into three $\frac{1}{4}$ acre paddocks grazed by sheep as follows:-

A ₂	Grazed continuously to 2 cm sward height
A ₃	" " " 3 cm " "
A ₄	" " " 2 - 15 cm height

It was possible to graze A₂ and A₃ to a uniform height but at the lighter stocking rate necessary on the A₄ paddock grazing became patchy and the sward varied from 2 cm to 15 cm high in what appeared to be relatively neglected patches.

Turf samples (4-5 dm²) were removed from the paddocks and measurements made of net canopy photosynthesis (Pnc) at an air temperature of 18°C and a light intensity of 100 W/m². Sampling was carried out on two occasions in July and September respectively. After measurement of Pnc the swards were dissected and leaf area measured.

Regression analyses of net photosynthesis were made on a variety of sward parameters and the results are summarised in Table 1.

The relationships between Pnc and various sward parameters were curvilinear the best being with total Leaf Area Index (LAI) (Fig. 3 and Table 1), though LAI for young and old leaf separately were not greatly inferior. The relationship with total green crop weight was not good. Pnc/unit LAI showed the normal relationship with LAI being very high when LAI was small declining rapidly as LAI increased (Fig. 4).

This trial was carried out partly to test measurement and sampling procedures. The measurement method proved to be reasonably successful but too cumbersome for large numbers of samples. Also the variation between samples was rather high and means are being sought of reducing this and of the time taken for each measurement. No difference in photosynthetic rate was found between the July and September sampling periods and both have been combined in Fig. 3.

The results themselves are of interest in that they show clearly how much production is lost when pasture LAI is reduced by close-grazing. It was not found possible to have a pasture longer than 3 cm (in this case equivalent to LAI 3-4) without causing patches of longer herbage 10-15 cm tall (LAI 6-7) to develop. At LAI 3 the Pnc rate was about half what it was at LAI 6. No data on sward utilisation were collected but it seems probable that the longer patches of grass were associated with a low utilisation rate so that much of their higher Pnc rate would be wasted by an excessively large rate of senescence. Thus on a patchily grazed pasture we can have a situation where perhaps one-third of the area is poorly utilised but growing at 0.43 mg CO₂/dm²/min., while the remaining two-thirds is well utilised but growing at perhaps 0.26 mg CO₂/dm²/min. It would be interesting to know what effect this has on grazing intake/ha.

If the data from the cut micro-swards (p. 84) is extrapolated to these grazed swards one might expect that, although the short 2-3 cm pastures had a lower Pnc rate than the longer swards, they would have a high relative growth-rate and therefore a high proportion of the products of photosynthesis would appear as new leaf growth. The tall patches on the other hand probably had a lower RGR and much of their leaf production doubtless senesced and decayed uneaten.

Fig. 3. Net canopy photosynthesis in relation to LAI of continuously grazed S.23 ryegrass pasture. High Field 1974.
(04006)

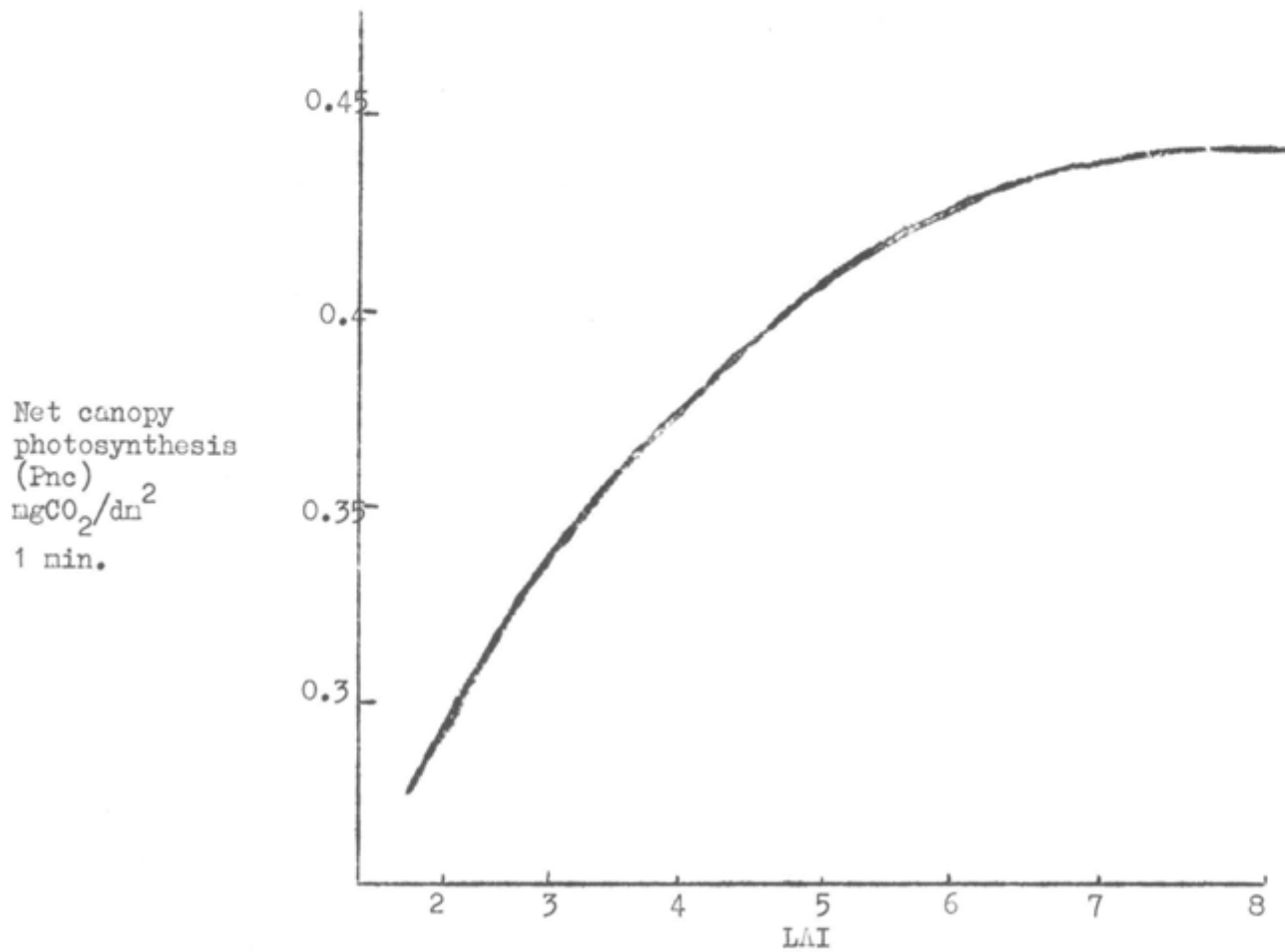


Fig. 4.

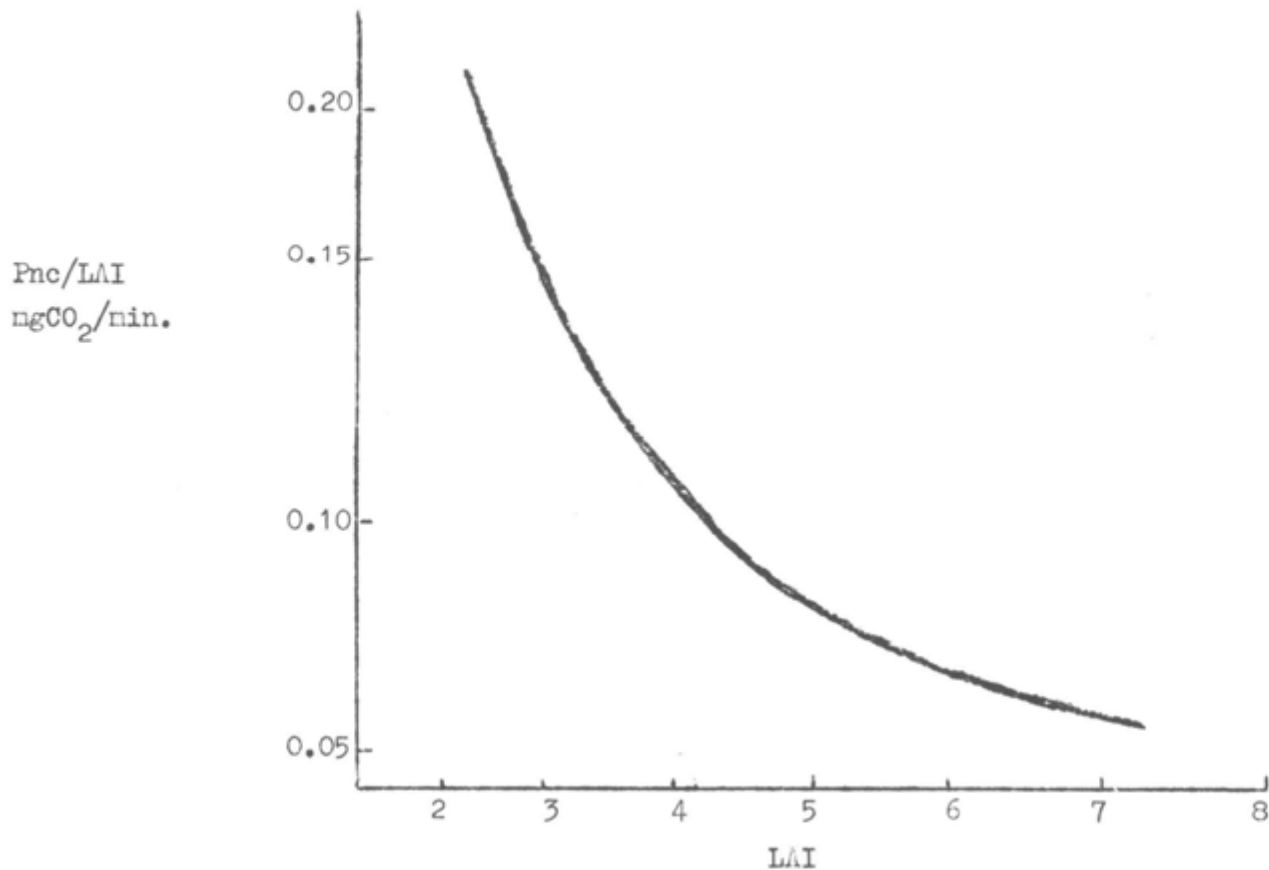


Table 1. Correlation coefficients and % of total SS accounted for by quadratic regression of Pnc/dm² and Pnc/unit LAI on various sward parameters

Pnc/dm ² ground area	r	% accounted for by regression
on total LAI	0.854	72.83
on LAI young leaf	0.839	70.47
on LAI old leaf	0.838	70.14
on D wt of green crop (leaf and stem)	0.734	61.40
Pnc/unit leaf area		
on total LAI	0.933	86.96
on LAI young leaf	0.856	73.29
on LAI old leaf	0.933	86.97
on D wt of green crop (leaf and stem)	0.872	76.03

NUTRIENT CYCLING (04007)

1. Effects of lime on the mineralisation of nutrients from plant and faecal materials
M.J.S. Floate

The series of incubation experiments using herbage and faecal materials from control areas of Input-Output expt. F-1 (*Agrostis-Festuca*) and G-3 (*Molinia-Nardus*), treated with different amounts of lime has now been completed.

Some preliminary results were presented in the Annual Report, 1973, p. 54, which indicated trends similar to those previously obtained in an experiment in which ineffective inoculation was suspected. The trends were confirmed with all other materials and strongly suggested that the results were an artefact of the laboratory incubation conditions which were in closed containers. The closed containers are believed to result in the absorption of NH_3 in the moist incubating substrate resulting in a rise in pH to near 7.0 irrespective of starting pH and of lime treatment. The results showed only minor differences between lime treatments for each material. This was contrary to the expectation that lime would stimulate decomposition.

It is proposed that further experiments be conducted using open containers when NH_3 will be free to escape. Problems then arise because it will not be possible to measure evolved CO_2 or mineralised -N, but it may be possible to measure gross decomposition rate, at the different rates of applied lime, by measuring oxygen consumption by the oxygen monitor.

2. Maintenance of improved pasture on deep peat (04007/03002)
M.J. S. Floate, A.D. Ironside, G.R. Bolton and J. Eadie

Problems arising on the Improvement-Response experiment at Lephinmore were reported in the Annual Report, 1973, p. 56. The first problem concerned the interpretation of "Available-P" in peat soils and this is the subject of a report under project 04003, p. 73. Because of the uncertainties attached to the values, the analyses of routine samples have not been conducted. The second problem concerned the failure of introduced species of pasture plants in some areas of the nominal 1 ton/ac Lime-treated plots. These kinds of failure did not arise on the nominal 2 ton/ac Lime-treated plots where lime was mechanically applied in two directions perpendicular to each other.

Crudely one can conclude that the minimum lime requirement would appear to be 2 tons/ac and that lesser amounts may lead to failure: calcium deficiency was not the cause, nor apparently were the differences in pH between normal and abnormal areas large. It was concluded that there is probably a low lime induced cause of failure.

In 1974 a lime-response small plot experiment has been established on an adjacent area with lime treatments corresponding to 0, $\frac{1}{4}$, $\frac{1}{2}$, $\frac{3}{4}$, 1 and 2 tons lime/ac. The objectives of this response experiment are:-

- (1) to observe the survival of introduced species,
- (2) to measure the field response of soil to incremental rates of lime application, and to compare this with laboratory procedures for the assessment of Lime Requirement (04001/04003), and
- (3) to provide soil samples covering a wide pH range for laboratory studies of the role of Aluminium.

are given in Table 3 and suggest that a larger part of the soil-N pool is in re-circulation in this system than in some of the mineral soil systems so far investigated.

Table 3. Re-cycling of N in Le1 site (1973)

Treatment	Ca ₁ P ₁	Ca ₁ P ₂	Ca ₁ P ₁	Ca ₂ P ₁	Ca ₂ P ₂	Ca ₂ P ₁
Soil-N (kg/ha)	1523	1455	1063	1345	1524	1925
Re-cycled N (kg/ha)	52.6	63.8	60.9	62.8	72.0	66.5
% Re-cycled	3.4	4.7	5.7	4.6	4.7	3.4

3. Maintenance of improved pastures on mineral soils

M.J.S. Floate, A.D. Ironside, R.B. Hetherington and J. Eadie.

The series of three Improvement-Response sites at Sourhope (together with an older and now abandoned site) have been described in previous Annual Reports and are the subject of evaluation in terms of nutrient cycling efficiency.

These sites all consist of varying degrees of improvement and consequent production, but all are managed under the same equalized grazing pressure regime. The range of treatments are essentially similar on all sites but the soil and vegetation types are different.

Each site was carefully sampled before treatments were applied and these base-line analyses have appeared in previous Annual Reports.

An elaborate programme of plant material and excreta sampling and analysis is conducted in annual sequence around the three sites and a considerable backlog of data is now available for appraisal.

In order to measure nutrient uptake it is necessary to measure plant dry matter production and nutrient composition but the first of these poses considerable problems under grazing conditions. The best practical solution to the problems has been found to consist of a series of random quadrat samples cut and protected at 3-week overlapping intervals during the grazing period. This gives a moderately reliable estimate of total available herbage at the start of grazing, and a growth per unit time during each grazing period. However for whole season production data, the results are less reliable because of cumulative errors and the impossibility of allowing for senescence especially during the longer intervals between grazing periods.

An alternative approach to estimating plant DM production is available through the computation of DM ingested by grazing sheep, derived from excreta output and composition data.

Similar considerations apply to nutrient uptake data derived on the one hand from plant DM production and analytical composition, or on the other hand from faecal output and composition. It must be assumed that data derived from faecal output are minimal estimates because of small losses and because of incomplete utilisation of pasture production. Data for the Fasset (F.1) site for 1971 presented in the Table 4 illustrate the results.

Table 4. Plant DM production and nutrient uptake/return for the F.1 site (1971) derived from herbage samples and excreta output

Treatment	Plant DM from se- quence cuts (kg/ha)	Plant DM from In- gestion data	P-uptake from plant data	P-return from excreta data	N-return from excreta data	N-uptake from plant data
Grazing Control	3045	3691	8.31	9.21	88	69.9
+ Lime	4293	3983	9.44	9.27	101	94.9
+ P	3768	3973	11.60	11.31	84	89.8
+ Clover	3755	4003	12.38	11.83	111	95.3
+ Grass	5296	5619	19.47	16.39	155	140.9

These data show that the measured values for plant DM production are usually 10-20% less than the values computed from intake. Perhaps the most reliable data (involving least losses and no assumptions) are those for faecal-P return which are very close to the P-uptake values from plant DM production and composition data. However, the faecal-P return figures make no allowance for incomplete utilisation (which is not likely to be better than 80%), so that the indications are again that the plant data may be of the order of 20% low.

Similar calculations have been made for this site for 1969 and 1974 and for the G₃ site for 1972 and the results all lead to similar conclusions. These conclusions are that estimates of plant DM production (and hence nutrient uptake) are likely to be at least 20% low and that the most reliable data are those derived from excreta output and composition. In this regard, the P data are reliable in the sense that all excreted P is accounted for (for these sheep) in the faeces but assumptions have to be made for the partitioning of N between urine and faeces based upon derived digestibility values. Such assumptions are believed to be justified but it is proposed to check these in future with urine collection and an analysis for selected sample sheep.

In the Annual Report, 1971, p. 19, the intention was stated that soil changes should be evaluated five years after the start of each experiment. Although this is now due, it is not yet possible owing to delays in the analysis of soil samples. It is, however, possible to examine the changes in the extent of nutrient re-cycling during the course of these experiments.

The data for the F.2 experiment for 1969 (pre-treatment) and for 1971 and 1974 where available and for G₃ site for one year only are presented in Table 5.

Table 5. Re-cycling of N and P in F.2 site

Re-cycled N: Kg/ha and (as % of Soil-N Pool) F.2

	Grazing Control	+ Lime	+ P	+ Clover	+ Grass
1969	61 (1.51)	63 (1.64)	63 (1.65)	66 (1.78)	67 (1.75)
1971	88 (2.18)	101 (2.62)	84 (2.19)	111 (2.99)	155 (4.04)
1974	92 (2.28)	122 (3.18)	119 (3.11)	140 (3.77)	165 (4.30)

Re-cycled P: Kg/ha and (as % of Soil-P Pool) F.2

	Grazing Control	+ Lime	+ P	+ Clover	+ Grass
1969	6.4 (1.05)	6.1 (0.97)	6.7 (0.93)	7.1 (1.05)	6.1 (.90)
1971	9.2 (1.49)	9.3 (1.46)	11.3 (1.41)	11.9 (1.53)	16.4 (2.14)

Re-cycled N: Kg/ha and (as % of Soil-N Pool) G.3 1972

	Grazing Control	+ Lime	+ P	+ Clover	+ Grass
1972	58.3 (1.31)	55.2 (1.23)	44.8 (0.95)	89.8 (1.87)	107.7 (2.26)

These data show that there were only minor differences between treatments in 1969 (pre-treatment) with respect to both N and P recycling: on average 1.66% of soil-N and 0.93% of soil-P was being recycled at the start of the experiment. With the more comprehensive improvement treatments, and with increasing time from the start of the experiment, gradually more of the soil pool of nutrients is being brought into circulation.

4. The failure of improved pasture reseeded on deep peat within the Input-Output experiment at Lephinmore. (04001/04003/03004)
J. Eadie and M.J.S. Floate

Introduction

Previous reports have given the background to the failure of patches of improved pasture within certain treatments of the Input-Output experiments.

The position was reviewed in March 1975 and it was decided that plots A, B and C should be subdivided and used to investigate the effects of varying intensity of grazing upon the balance of native and introduced species.

Further work should also be carried out to elucidate the causes of failure on plots D, E and F where a nominal 1 ton/ac lime had been applied. A lime response experiment (04001) was established in 1974 with objectives which are related to this problem, but which is not likely to produce unequivocal reasons for plot failure in the Input-Output experiments. Because of the more general importance (03004) attached to knowing these reasons, a further review of possible causes and of the experimental approaches to their resolution was undertaken. It was decided that of the possible causes of failure -

disease, deficiency, toxicity or seriously impaired water relationships - that deficiency of one or more elements was the most likely cause. It was further decided that since the problem had arisen in the field, an in situ pot experiment in the field offered the best experimental conditions for the study. The possibility of attempting to restore the failed areas by a variety of treatments was considered, but because of the difficulties in defining the current nutrient status of these areas it was decided that a fresh experiment on a fresh site (similar to the Input-Output site) was required for this study.

Experimental

An area of ground, similar to the peat site of the Input-Output experiment, and adjacent to the Establishment experiment (04003) within the enclosure created for the Lime Response experiment (04001), was found to be suitable for the purpose.

The basic design is a comparison between control treatments (all nutrients applied) and individual treatments in which each of K, Mg, Mo, B and S are subtracted singly. Similar layouts will be set up at 3 lime levels as indicated below:-

L ₀ C	L ₀ -K	L ₀ -Mg	L ₀ -S	L ₀ -B	L ₀ -Mo	L ₀ C
L ₁ C	L ₁ -K	L ₁ -Mg	L ₁ -S	L ₁ -B	L ₁ -Mo	L ₁ C
L ₂ C	L ₂ -K	L ₂ -Mg	L ₂ -S	L ₂ -B	L ₂ -Mo	L ₂ C

C is the complete treatment in proportions suggested in Middleton, K.R. and Toxopeus, M.R.J. (1973). "Diagnosis and measurement of multiple soil deficiencies by a subtractive technique". Plant and Soil, 1973, 38 (1), 219-226. Instead of the pot experiment described in this paper in situ ring pots will be created by inserting 25 cm diameter plastic rings 10 cm into the peat, leaving 2.5 cm above ground. These rings give individual treatment areas of 0.055 m².

Lime will be applied as soon as rings are established in the ground at rates equivalent to 0, 1 and 2 tons/ac = 0, 2.5 and 5.0 tonne/ha. All other nutrients will be applied in solution at the time of seeding, and regularly during the growing season.

Seeds will be the same as in the Lime Response experiment, i.e. PRG - Gremie and Caprice and White Clover - Huia and S.184 in proportion 12.5:12.5:2:1 but at a higher rate to give ~ 100 plants per treatment.

Statistical design calls for randomised blocks in which $m_c/m_t = \sqrt{n}$ where m_c = number of observations on control treatments, m_t = number of observations on each of n treatments. Where the number of treatments is 5, this condition is most nearly satisfied by including two controls in each replicate set. There will be 2 replicates of the L₀ series and 4 replicates of each L₁ and L₂ series giving a total of 70 individual pots. A detailed randomised layout is being prepared by the statistical adviser.

It is hoped that rings will be sited and lime applied early in April and that pots can be seeded in May.

One month after seeding a count of germinated plants will be carried out, and a further germination count will be taken after two months.

Later assessments will be made from dry matter production from individual pots, plant counts of individual pots as necessary, and possibly nutrient uptake measured by analysis of samples bulked from all replicates of each treatment.

It is hoped that some treatment differences will appear in the first season, and certainly by the second season it is hoped that most treatment differences would be detectable. Because of the possibly delayed effects of deficiency symptoms appearing at L_1 and L_2 levels it may be necessary to continue the experiment for three seasons.

NITROGEN FIXATION (04008)

Measurement of nitrogen fixation in hill pasture

A. Haystead and A.G. Lowe

In the past estimates of the contribution of the legume-rhizobium symbiosis to the nitrogen economy of pasture ecosystems have been obtained indirectly in comparisons of production rates in legume-grass and grass only swards. The response in production due to the legume component of a mixed sward, is, however, the net result of a number of interacting plant and soil processes and does not measure the rate at which atmospheric nitrogen is being fixed.

A more recent approach to the problem has been to use the acetylene reduction assay for nitrogenase as a more direct measure of the rate of N-fixation. In this technique acetylene, a substrate analogue for nitrogenase, is reduced to ethylene by the legume root nodules. Although a number of workers, probably attracted by the rapidity and convenience of the method, have reported rates of acetylene reduction of plant-soil cores and isolated root systems from grass-legume pasture, the usefulness of these data is questionable. Three main disadvantages are apparent in the method:-

1. When applied to soil cores the rate at which ethylene is produced is affected markedly by physical characteristics of the soil. for example, the degree of soil compaction and wetness will affect the rate at which substrate and product diffuse through the system.
2. The ratio between the rate at which acetylene is reduced and that at which nitrogen is fixed is not the same for all systems; reported values varying from 2 to 20. These factors in combination render assays of nitrogenase activity in plant-soil cores or isolated root systems highly variable. Table 1 shows results obtained from a sown ryegrass/white clover sward on brown earth at Sourhope, in which isolated roots were incubated in a gas tight container with 10% C_2H_2 in air (v/v). Although rates of ethylene production by the roots were linear for up to 6 hours, the coefficient of variation of the mean rate was extremely high. Extremely high levels of sample replication would be needed to obtain representative estimates of the rate at which nitrogen was being fixed at a particular site.
3. A third disadvantage of the acetylene reduction assay technique in the field is the relatively short period of time (1-4 hours) over which nitrogenase activity can be measured before the assay conditions themselves affect the level of nitrogenase activity in the legume nodules. Since it is well documented that legume nitrogen fixation in the field shows complex seasonal and diurnal variation it would be necessary to perform the assays at many points in time to obtain estimates of the amount of nitrogen fixed by, for example, the white clover component of a hill pasture sward over a period of time sufficiently long to permit the evaluation of a new management technique.

Tables 2 and 3 show the summarised results of an experiment carried out on a ryegrass-clover sward at Sourhope, in which the rate of nitrogen fixation in a 0.055 m^2 'microplot' was determined using the stable isotope of nitrogen: ^{15}N . The assay method is based on the fact that whilst grass, in a pure stand, derives its nitrogen exclusively from the soil, and hence will reflect the ^{15}N content of a labelled soil-N pool over a given growth period, a nitrogen fixing legume will dilute the enriched soil nitrogen with unlabelled nitrogen from the atmosphere. The extent of this dilution is a function of the rate of nitrogen fixation over the period of time in question. Small quantities of highly enriched ammonium sulphate were sprayed on to clipped, grass and grass-clover microplots in early July. In August the grass and grass-legume regrowth was harvested and the total-N yield determined. Isotope determinations performed on the harvested plant material were used to calculate the amount of nitrogen fixed and transferred by the white clover over the twelve week period. These values are shown in Tables 2 and 3 along with the coefficients of variation of the means.

It is concluded that the apparent economy and convenience of the acetylene reduction method are more than offset by the high levels of replication in both site and time required if meaningful estimates of nitrogen fixation are to be obtained; and that despite the cost of ^{15}N and the instrumental difficulties inherent in ^{15}N analysis, the isotope technique should be used in future studies of N turnover in hill pasture.

Table 1. Acetylene reducing activity of detached root systems of white clover and rhizosphere soil

Sample	nmoles C_2H_4 / mg root/hr	nmoles C_2H_4 / mg nod/hr	$\frac{\text{m}}{10^3} \text{C}_2\text{H}_4$ / $\frac{\text{cm}^3}{\text{cm}^3 \text{ hr}}$	$\frac{\mu\text{g}}{10^3} \text{N}_2$ fixed/ $\frac{\text{cm}^3}{\text{cm}^3 \text{ soil/6 hr}}$
Clover root system	CV = 27%	CV = 37%	CV = 54%	CV = 54%
1	6.9	79	2.50	17.5
2	10.4	120	6.90	48.2
3	10.3	93	2.67	18.7
4	12.1	113	4.94	34.6
5	9.2	157	7.62	53.3
6	12.5	92	2.00	14.0
7	6.4	49	1.45	10.1
8	6.2	83	1.85	12.9
9	11.5	165	4.87	33.5
10	7.8	68	3.86	27.0
11	4.7	104	3.32	23.2
12	6.9	41	1.85	12.9
mean	(8.8)	(97)	(3.65)	(25.49)
Rhizosphere soil				
1-6	0	0	0	0

Table 2. DM-production and N-yield of Shoot, Root and Nodule per microplot over the interharvest period. July 11 to August 22, 1974.

<u>Sample</u>	<u>DM production</u> (g)	<u>CV%</u>	<u>N-yield</u> (mg)	<u>CV%</u>	<u>Percent N</u>	<u>CV%</u>
Clover shoots	3.963	32.8	151	34.4	3.85	7.6
Grass shoots (pure stand)	5.850	22.5	103	18.9	1.62	12.3
Grass shoots (mixed stand)	5.484	23.9	115	22.5	2.13	5.6
Grass roots*						
July 11	-	-	71	20.5	-	-
August 22	-	-	88	19.1	-	-
Clover roots*						
July 11	-	-	65	15.9	-	-
August 22	-	-	73	13.1	-	-
Nodules*						
July 11	-	-	7	37.2	-	-
August 22	-	-	6	47.4	-	-

* Values shown for roots and nodules were obtained from
10⁻³m³ quadrats.

Table 3. Measured ¹⁵N abundance, proportion of plant N derived from atmosphere and total N fixed per microplot per IHP.

<u>Sample</u>	<u>Atom-% ¹⁵N</u>	<u>CV%</u>	<u>Percent</u> <u>fixed-N</u>	<u>N-fixed/</u> <u>microplot</u>	<u>Kg N-fixed/</u> <u>ha</u>
Clover	0.509	6.8	89	134 mg/IHP	24.6/IHP
Grass (mixed stand)	1.547	10.4	0	0	-
Grass (pure stand)	1.560	7.6	-	-	-

IHP = Interharvest period July 11 - August 22,
1974.

Germination counts made one and two months after the effect of treatment upon ryegrass although the clover germination was suppressed at the lower pH. These data are presented in summary in Table 1.

Table 1. Germination of grass and clover in Lough Beg experiment and surface water pH

Treatment	0	$\frac{1}{4}$	$\frac{1}{2}$
Grass plants/m ² (1/11/74)	392	470	372
Clover plants/m ² (1/11/74)	123	150	175
Surface pH	5.03	5.49	5.62

Although these experiments will give useful information on peat they will not provide unequivocal results for the Improvement-Response experiment. Accordingly, on this aspect with the objective of identifying the factors which have led to failure, and which appears to have been a field experiment will be established in 1975.

It has been decided to discontinue the experiment but computation of the existing data on peat is completed. Agreement between data derived from sequence cuts and computed from ingested DM is not good for the mineral soils (04007/03002). The data which are presented in Table 2.

Table 2. Plant DM production and nutrient uptake (1973) derived from herbage samples

Treatment	Plant DM from sequence cuts (kg/ha)	Plant DM from ingestion (kg/ha)	Total N (g/m)		
Ca ₁ P ₁	2537	2079			
Ca ₁ P ₂	2956	2913	73.9	22.9	96.8
Ca ₁ P ₁	1971	2353	49.3	20.3	69.6
Ca ₂ P ₁	2411	2746	60.3	20.9	81.2
Ca ₂ P ₂	2397	3457	72.4	24.0	96.4
Ca ₂ P ₁	2675	2946	66.9	22.2	89.1

The values for DM production from sequence cuts are, on average, some 10% lower than values computed from herbage intake. Furthermore, the estimated total-N return data are broadly similar to the N-uptake data from plant DM production, but the former make no allowance for incomplete utilisation. Thus one is led again to the conclusion that plant DM production data from sequential cutting appears to give results which may be as much as 20% low.

P-data are not yet available but the amounts of N re-cycled via excreta can be expressed as per cent of N in the Soil-N pool (0-10 cm). These data

RED DEER (05001)

J.M.M. Cunningham and W.J. Hamilton

Deer stocks at 31 December, 1974:-

<u>Stock</u>	<u>Stags</u>	<u>Hinds</u>	<u>Castrates</u>	<u>Age</u>	<u>Total</u>
Mature stags	6	-	-	3 yrs +	60
Mature hinds	-	54	-	3 yrs +	
Prickets	9	-	-	2 to 3 yrs	35
Jinnocks	-	26	-	2 to 3 yrs	
Young stags	4	-	-	1 to 2 yrs	33
Young hinds	-	24	-	1 to 2 yrs	
Young castrates	-	-	5	1 to 2 yrs	
Stag calves	13	-	-	0 to 1 yr	69
Hind calves	-	56	-	0 to 1 yr	
TOTALS	32	160	5		197

October 1973 rut

The results of the rutting groups, based on the calving dates of the hinds, showed again that 15 hinds appear to be the maximum number a mature stag will serve at the first oestrus in October. One stag successfully mated all 12 hinds in his group, the best single stag performance to date. All the other groups had a "chaser" stag in addition to the dominant stag. The number of hinds in each group was as follows, stags in brackets:-

A = 12(1), B = 13(2), C = 18(2), D = 24(2), E = (15) synch.

The number of hinds served in each group at first oestrus was:-

A = 12, B = 8, C = 15, D = 15, E = 10.

Synchronisation of oestrus

Oestrus was synchronised with progesterone impregnated vaginal pessaries in 15 hinds. Although synchronisation was successful, the yearling stags failed to mate all the hinds. A mature rutting stag was removed from his group and, when introduced to the synchronised group, mated four hinds in five minutes. Ten hinds calved to the first mating, three to the second (18 days later) and two were barren.

Udder scoring technique

On 25 May, 25 hinds were selected as having the most advanced udder development, and were set-stocked in the Goyle paddock. Twenty-four of these hinds calved before any of the remaining 56 hinds had calved.

Breeding performance

Eighty-three hinds were put with the stag in October 1973 and two died over the winter period. Of the 81 hinds remaining, 74 produced calves and 7 were barren. Four calves were removed for artificial rearing, 4 were still-born, two calves were accidentally separated from their dams, and one calf was lost without trace in the Goyle in August. Sixty-three calves were weaned in September.

Calf disposal

All the hind calves were retained for the "Upper Farm". Twelve stag calves were sent to Headquarters at Bush for intake/digestibility studies. Six stag calves were sold to the Ministry of Agriculture, Fisheries & Food Veterinary Laboratory at Lasswade for studies in virology, and nine stag calves were sent to the Rowett Institute, Aberdeen.

Calf rearing

A total of 43 wild calves were brought in and artificially reared. Three calves died before reaching Glensaugh, one calf died shortly after arrival from severe bruising and internal injuries and five calves, four of which were very small, died from bacterial infections following digestive upsets. One of the purchased calves was transferred to the Rowett.

Monitoring of the skeletal growth, body weight, teeth eruption and checks for broken mouths, continues at the monthly round-ups.

Castrate experiment

Two castrates and two entire stags were slaughtered in September at 15 months old. A half of each animal was retained for carcass analysis, two quarters were sent to the Meat Research Institute at Bristol for bacteriological studies, and two quarters were sent to Baxters of Fochabers for the tasting panel.

Stress experiment

Four calves were removed from their dams at birth, one, three and eight days of age. The hinds were observed for four days after removal of the calf. No overt behaviour could be detected which indicated stress and the udder regressed after the first 24 hrs by which time it had reached maximum size.

Warbles

Seventy-five percent of the adult stock were found to have warble larvae present in mid-winter, and the entire stock was treated with Hypolin. The treatment caused irritation and most of the animals lost all their hair at the site of application.

Nasal Bot Fly

The first bot larvae were found in February, in the tonsil crypts of hind A1. During the summer several flies were caught and identified as the Nasal Bot Fly (*Cephanomyia auribarbis*). Because of the increased numbers of the fly on the farm, all stock were dosed with Rafoxonide in September.

Headfly (*Hyrdotea irritans*)

Work continued with the examination of various biotypes for larvae, with regular population density counts and sex ratios during the months of July and August. No animals were treated.

Tuberculosis

Under a special Ministry of Agriculture, Fisheries & Food dispensation, B.C.G. vaccine was given to half of the home-bred calves, and half of the bought-in calves, at the December gathering. Ministry tests will be carried out on these animals at three-monthly intervals to determine the level of reaction to the standard comparative TB test.

Lungworm

A good calf which died in December was found to have a very heavy infestation of lungworms. Egg and larvae counts on a faecal sample did not reveal such a high level of parasitism.

Radiotelemetry

In collaboration with the University of Edinburgh and the Wolfson Micro-electronics Liaison Unit, Drs. J. Lockie and W. Morris, trials were conducted to examine the effect of weight of collar with respect to behavioural changes, discomfort, or irritation and bruising to the skin. Stags and hinds carried up to 3 lb without any changes being apparent, but a collar weight of 4 lb, although having no noticeable effect on behavioural patterns, caused hair loss on the neck and bruising and sores on the chin. A radio transmitting collar is now being designed which will weigh around 2 lb with a signal range of 5 miles and a battery life of 12 months. A radio transmitting licence has been granted by the Post Office for trials to be conducted on the farm.

Heather utilisation

A survey of the Coyle and West Greenshiels paddocks, carried out in late March, indicated the degree of utilisation to be 22% and 25% respectively. Grazing intensity maps were drawn for both areas.

Forest area

During the late winter and early spring southerly gales blew down most of the remaining Contorta pines. The total area blown is now 5 acres. Because of the lack of vegetation in the forest and the very wet winter, the surface peat layers are being slowly eroded and most of the eroded material is being deposited in the handling area. The Forestry Commission have offered to redrain the area once the timber has been removed. Grass seed will be sown to stabilise the soil surface.

Upper Farm

Some 164 acres of Forestry Commission land lying north and east of the Main Farm was enclosed with a 6 ft., 12 wire deer fence. The area was sub-divided with 10 wire 5 ft. fences to provide 9 paddocks. Part of the Coyle was fenced off and included in the new farm, making the total acreage available some 210 acres. An experimental low density tree plantation will cover some 16 acres of the Upper Farm land, and this land was ploughed with a Cuthbertson plough in September in preparation for planting in the spring of 1975. The farm will be stocked in April 1975.

Visitors

Three hundred and twenty-five people visited the farm during the year.

Films

Short films were made by ITV and BBC 1.

Report

The first report entitled "Farming the Red Deer" was published in December by Her Majesty's Stationary Office, Edinburgh.

GLASSHOUSES/MICROCLIMATE (54001)

D.E. Suckling

The second glasshouse is in full service and both houses are being used to capacity. The glasshouse preparation room in the Plant/Soil Unit extension is also in use.

Four growth chambers have been installed and are at present being commissioned. Each chamber is approximately 6' wide by 9'3" deep by 8' high, and will be able to maintain temperatures variable between 5°C and 25°C with a differential of $\pm 1^\circ\text{C}$. An adjustable bank of fluorescent lights is provided within each chamber.

The automatic weather stations are nearly ready for field operation. One will be installed at Lephinmore and one at Glensnagh. The equipment will provide hourly summaries of solar radiation, rainfall, wind run, humidity and temperatures using magnetic tape data loggers.

ANALYTICAL SERVICES (54002)Inorganic Chemistry

C.C. Evans

The routine analysis of plant, soil and faecal samples has continued. During the year 8300 analyses were made from 3600 samples.

A continuous flow indophenol-blue colorimetric method for total Kjeldahl nitrogen analysis has been introduced. This method has a much higher potential throughput than distillation methods. However an efficient sample digestion system is necessary to optimise the whole analytical procedure and to date only limited use of the Kjeldahl digestion facilities has been possible due to some problems of fume removal and purification still awaiting resolution.

Method developmentAluminium in soil extracts and plant digesta

X-ray methods for Al analysis are relatively insensitive and consequently a rapid and sensitive procedure has been introduced for low concentrations of Al in solution. Briefly, the method is a continuous flow colorimetric procedure modified from a method published elsewhere (J. Sci. Fd. Agric., 1974, 25, 4, 381-386). This involves the photometric measurement of the colour produced in the reaction between Al and sodium alizarin sulphonate buffered to pH 4.2. Fe interference is removed by complexing with thioglycollic acid. The modifications of the published procedure include alterations to the manifold configuration and increased buffering capacity of the complexing buffer solution. The lower limit of detection (LLD) is 0.1 ppm Al in the analysed solution and when the analysis is run at 40 samples/hour the relative precision is 3 per cent for Al concentrations between 2 and 10 ppm.

Copper in Blood Plasma

Owing to the lengthy sample preparation employed in the X-ray method outlined on p.37 of the 1972 Annual Report, a more rapid and efficient atomic absorption spectrometric method is being investigated. Sample preparation is similar to that in the SP90 Pye Unicam method sheet Cu3. Protein is precipitated from an aliquot of plasma with an equal volume of 25 per cent trichloro acetic acid and centrifuged at 3000 rpm. The supernatant solution is introduced into the spectrometer using a Carlo Erba distributor SD3 through an 0.5 mm capillary tube attached to the SP90 spectrometer nebuliser. Readout is by a chart recorder set to maximum sensitivity. This allows relatively less sensitive spectrometer settings

resulting in a more reproducible recorder trace. Between 25 and 150 μg Cu/100 ml plasma (0.25 - 1.50 ppm Cu) the relative precision is 1.5% when the distributor is run at 90 samples/hour with an LLD of 4 μg Cu/100 ml plasma. Comparative tests of the method have yet to be made.

TRACER CHEMISTRY

A.R.M. Chambers

1. Isotope counting (54002)

Methods have been developed for the counting of ^3H , ^{32}P , ^{14}C , ^{57}Co , ^{103}Ru and ^{51}Cr and these are now operating on a routine basis.

2. The development of a method for the measurement of urinary output in grazing sheep (02004)

The equipment described in the Annual Report, 1973, has been modified so that the volume of urine being sampled is accurately measured by means of a counter, which is triggered at the end of each emptying phase. At the end of the sampling period the volume sampled is calculated by multiplying the volume of the glass vessel by the count. The equipment has undergone vigorous field trials and was described in a paper given to the Nutrition Society in February.

Further developments are being carried out to increase the time the equipment can be used without the batteries being changed. This is being done by replacing the TTL components with CMOS components and by pulsing the logic circuit so that it switches 'on' for 1 m sec. every 100 m sec. Work is also being carried out to investigate the use of a single three position stopcock tap, driven by an electric motor, to replace the three solenoid valves.

3. Thermo-gradient bar (04002)

A thermo-gradient bar has been designed and built for the purpose of investigating the response of germinating seeds to temperatures over a critical range. It consists of a 1 m x 150 cm x 1.5 cm aluminium bar which is heated at one end, and cooled at the other with thermo-electric cooling modules. Both the heating and cooling units can be controlled so that the range and span of temperature can be adjusted. The temperature along the bar is measured using thermistors.

4. Duodenal fluid sampler (02004)

In conjunction with Dr. A.E. Field (Moredun Institute) a duodenal fluid sampler has been designed and built to be used on sheep fitted with re-entrant cannulae. The equipment operates as follows: the duodenal fluid flows continuously from the proximal cannulae into a beaker attached to a balance. When the beaker reaches a predetermined weight three electronic timers are triggered consecutively, which operate a sequence of air valves, liquid valves and a peristaltic pump. This results in a known volume of duodenal fluid being pumped either into the distal cannulae, or else into a sampler container where the fluid is kept for analysis. In the case where a sample is taken an equal amount of duodenal fluid, from a donor sheep, is pumped into the distal cannulae. The number of sequences between each sampling can be altered, as can the volume being pumped over every sequence.

5. Automatic turf feeder

Plans have been drawn for an automatic device for delivering swards of different composition to sheep, to investigate their selective grazing behaviour.

The swards will be in the form of turfs approximately 2' x 3' and will be able to be offered to the sheep either in the form of a continuous stream or else singularly for fixed periods.

6. Biomass estimator (02004)

Equipment has been designed for measuring the standing crop biomass in the field by a non-destructive method. The equipment consists of a box which has on one side a light source and on the opposite side a group of photo-diodes. The wavelength of the light is chosen so that it matches the minimum absorbance wavelength of the material being measured. The box is placed on the turf so that the sward to be measured interrupts the light. The absorbance of the light gives an indication of the biomass present. Initial trials have been carried out, which have been encouraging. A more elaborate equipment is being built.

7. An audible respiration monitor for anaesthetised animals (02003)

An audible respiration monitor is being built using a light dependent resistor coupled to a relaxation oscillator based on a uni-junction transistor. The light dependent resistor is sited immediately below the diaphragm of one of the uni-directional valves of a circle system anaesthetic apparatus; so that when the animal inhales the lifting of the diaphragm allows light to fall on the light dependent resistor, thus changing the frequency of oscillation.

8. Mass spectrometer (04008)

A second-hand mass spectrometer was obtained from the Meat Research Institute and, although the electrometer head was functional, it was found that the amplifier was faulty; this was investigated and rectified. A digital panel meter was then fitted to the output side of the amplifier to increase the accuracy of the equipment and to make it easier to take readings. A circuit was also designed and built to energise solenoids for variable times and at variable frequencies used to operate a pump in a continuous gas feed system for the mass spectrometer.

9. General electronic work (54002)

Various electronic instruments have been repaired and maintained and advice on electronics has been given to other members of staff.

VETERINARY

Surgery 1974

- 21 Rumen cannulation
- 5 Ileal and duodenal cannulation
- 4 Oesophageal fistulation
- 82 Endoscopies
- 5 Vasectomies

HILL FARMING RESEARCH ORGANISATION

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