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HILL FARMING RESEARCH ORGANISATION

ANNUAL REPORT 1975

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1st April 1976

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A. ANIMAL NUTRITION AND PRODUCTION

REPRODUCTION (01001)

1. Repeatability of ovulation rate during the breeding season in Greyface ewes
J.M. Doney, A. Whitelaw and R.G. Gunn.

Field observations and experimental matings have led to suggestions that ovulation rate in this breed may be higher very early in the breeding season than at any subsequent time (Annual Report 1973 and 1974). Surviving ewes from the pregnancy/lactation study (this report, p.9) were transferred to the sheep house after weaning and individually fed to attain uniform body condition (grade 3). Vasectomised rams were used to test for onset of the second synchronised oestrus from 3rd October. It was intended that all ewes would be examined by laparoscopy within five days of mating and that this would be repeated for three distinct oestrous cycles.

On this occasion the apparent seasonal onset of oestrus was considerably delayed beyond normal expectations and the synchronisation procedure failed. Although tested daily, the first recorded oestrus did not occur until 24th October and only 23 ewes were recorded during the next 17 days. Laparoscopic examination was confined to this group. Of the remaining 21 ewes, 16 exhibited oestrus during the next 17-day cycle. Five ewes had still not been detected when killed in mid-December but four of these were found to have established ovarian cycles.

Twenty-two ewes were successfully examined in three consecutive oestrous cycles. Distribution of ewes with 0 to 4 corpora lutea (CL) in each of these cycles is shown in Table 1. Analysis of variance showed that there was no significant difference in ovulation rate (OR) according to stage of the breeding season. The difference between sheep was highly significant with an intra-class correlation of 0.55 indicating high within-season repeatability of performance.

Table 1

No. of CL	Oestrous cycle		
	1	2	3
0	0	0	1
1	5	4	1
2	9	10	12
3	8	6	7
4	0	2	1
Mean OR	2.14	2.27	2.27

These results do not agree with the previously reported results from observations of field trials, which suggested a higher ovulation rate of lambing percentage would be associated with mating earlier in the season. The results cannot be reconciled at this stage. The present results, based on ewes with an abnormally late onset of seasonal oestrus, may be aberrant, or the field results may have been influenced by interaction with other regulatory factors; e.g. the changing pattern of the climatic environment.

Table 1

	Time of mating	Low stocked Condition at mating	Low stocked No. of ewes	Low stocked No. barren	Low stocked Lambing % *	High stocked Condition at mating	High stocked No. of ewes	High stocked No. barren	High stocked Lambing % *
Early mated	7 Oct.-24 Oct.	3.33	39	3	214	3.42	62	0	202
	25 Oct.-21 Nov.	3.19	8	2	217	3.29	6	0	133
		3.30	47	5	214	3.41	68	0	196
Late mated	4 Nov.-21 Nov.	3.16	41	1	193	2.96	60	1	175
	22 Nov.-18 Dec.	3.33	3	2	100	2.75	3	0	100
		3.17	44	3	190	2.95	63	1	171

* As a percentage of ewes lambing

Mating	Stocking	25 Sept.	6 Oct.	16 Oct.	11 Nov.	21 Nov.	12 Dec.
Early	Low	70.2	72.7	72.2	71.2		71.1
		3.13	3.39	3.17	3.40		3.16
	High	66.5	68.2	68.2	65.7		63.7
		3.03	3.29	3.05	3.20		2.94
Late	Low	68.5		72.0	72.8	70.7	69.5
		3.09		3.18	3.41	3.20	3.20
	High	68.4		70.8	70.1	68.0	65.9
		3.03		3.05	3.26	3.07	2.99

The pattern of mating was as follows:-

Mating	Early				Late			
	Low		High		Low		High	
Marked in 1st 10 days	13/51	25%	15/71	21%	26/44	59%	42/66	64%
" " next 7 "	7/51	14%	11/71	15%	18/44	41%	23/66	35%
" " 1st cycle	20/51	39%	26/71	37%	44/44	100%	65/66	99%
" " 2nd "	31/51	61%	45/71	63%	-	-	1/66	1%
Returns to service after 1st cycle	0/20	0%	5/26	19%	6/44	14%	7/66	11%

3\. Fertility in North Country Cheviot ewes. The effect of level of pre-mating nutrition on ovulation rate and early embryo mortality of ewes in moderately good condition (CS = 2.5) at mating

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

In two previous experiments in 1971 and 1972, the effects of two levels of body condition (CS 3 and 2) at mating were studied on ovulation rate of NCC ewes maintained at these condition levels. In both years ovulation rate was shown to be positively related to body condition. The current experiment was designed to examine the effects of high and low levels of nutrition during the pre-mating period on ovulation rate and early embryo mortality of ewes being brought up or down in condition to a moderately good level (CS = 2.5) at mating.

In mid-August, 56 NCC ewes were group-penned in the Sourhope sheephouse and allocated to two groups. Food intake was then adjusted by differential sub-group management to bring the ewes in one group into CS 2 and those in the other into CS 3 by the middle of October. For six weeks prior to a synchronised mating, the CS 3 ewes were fed at a low level (7 g pelleted dried grass + 10 g hay/kg LW/day) and the CS 2 ewes were fed at a high level (20 g dried grass + 10 g hay/kg LW/day) to bring all ewes into CS 2.5 by mating. After mating, all ewes were fed at maintenance until killed either at return to service or at 22 ± 2 days after first mating, when the number of corpora lutea and viable embryos were counted.

Mean condition scores (CS), liveweight (LW), the number of ewes with 1-3 ova, ovulation rate (OR), the percentage of observed and potential ewes returning to service (RTS), the percentage embryo mortality (EM) and the potential lambing rate (PLR) to first mating (M) are shown in the following table:-

M-6 weeks CS	M-6 weeks LW(kg)	Pre-M food level	M CS	M LW(kg)	No. of ewes with 1-3 ova 1	2	3	OR	% RTS Obs.	% RTS Pot.	%EM	PLR
2.83	64.6	L	2.46	57.2	21	7	0	1.25	32	7	43	0.71
2.04	52.9	H	2.45	61.1	14	12	2	1.57	29	4	36	1.00

Feeding treatments successfully brought both groups of ewes into the same body condition at mating. Although LW's were significantly different at this time, they are uncorrected for differences in gut-fill and if an allowance is made related to the levels of feeding the difference would be greatly reduced. In terms of ovulation rate it would appear that the dynamic effect of good current nutrition prior to mating in ewes being raised in condition to CS 2.5 at mating has produced a positive response ($P < 0.1$) relative to those ewes being fed at a low level and falling to this condition. This is a similar result to that obtained from an experiment with South Country Cheviot ewes in 1973. Data from the relevant groups in that year are repeated here for comparative purposes:-

M-6 weeks CS	M-6 weeks LW(kg)	Pre-M food level	M CS	M LW(kg)	No. of ewes with 1-3 ova 1	2	3	OR	% RTS	%EM	PLR
2.88	58.2	L	2.50	49.1	23	6	0	1.21	7	15	1.04
2.00	47.8	H	2.48	55.4	16	26	0	1.62	5	18	1.32

Although the breeds differed in LW and size, their ovulation response to treatment was such as to suggest that it may be at or about this level of body condition (CS 2.5) that current nutrition has possibly its greatest effect. Other evidence suggests that current nutrition has a minimal effect at both lower and higher levels of condition.

The incidence of RTS was much greater in the present than in the 1973 study and was therefore associated with a higher rate of apparent EM although there was little or no difference between the treatments. This resulted in a higher PLR to first mating in the well fed group in both breeds although it was not possible to show the difference in the NCC breed to be significant.

4. 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

This is a repeat of the 1974 experiment which proved difficult to interpret for a variety of reasons.

Previous studies have shown that a short-term nutritional boost for the last eight days of oestrous cycle prior to mating has no effect on ovulation rate (OR) but that the latter is increased when body condition is improved by feeding well for at least five weeks. Information is required for ewes approaching mating in moderately poor condition, on the optimum timing and duration of feeding to produce a significant increase in OR.

Between September and early November, 160 BF ewes (55 from Glensaugh and 105 from Lephinmore) were brought into moderately poor condition (1.75 ± 0.25) by differential group management in grass paddocks. Oestrus was synchronised and, over the five weeks prior to mating, feeding management based on pelleted dried grass and hay was designed to provide high (H; *ad lib*) and maintenance (M; approx. 18 g food/kg LW) levels of feeding during 4 x 9-day periods to five groups of ewes. These were designated as follows, according to their feeding levels in the four periods: M_4, H_2M_2, H_3M, M_2H_2 and MH_3. All ewes were fed at maintenance after mating until killed at return to service or after 28 ± 8 days for ovulation and viable embryo counts.

Mean live weights (LW) and condition scores (CS) at five weeks before and at mating, the number of ewes unmated and producing 1-3 ova at mating, OR of mated ewes, percentages of observed and potential returns to service (RTS), percentage of embryo mortality (EM) and potential lambing rate (PLR) to the experimental mating are shown in the following table:-

Treatment group		M_4	H_2M_2	H_3M	M_2H_2	MH_3
No. of ewes		32	31	31	30	30
LW (kg) & CS	5 weeks before mating	48.0 1.75	48.0 1.75	48.7 1.76	48.6 1.73	47.7 1.75
	At mating	49.2 1.83	51.0 1.89	53.3 2.08	50.9 1.96	53.0 2.08
No. of ewes unmated		1	0	1	1	0
No. of ewes with 1-3 ova	1	16	17	10	6	7
	2	14	13	18	23	22
	3	1	1	2	0	1
OR of mated ewes		1.52	1.48	1.73	1.79	1.80
% RTS	observed	16	6	10	10	13
	potential	3	10	3	14	0
% EM		30	28	21	27	24
PLR of all ewes		1.03	1.06	1.32	1.27	1.37

Greater control over the experimental feeding was achieved in this year than in 1974 and LW's were raised by the H levels of feeding. CS's followed a similar pattern. Ad lib feeding for 18 days was insufficient to raise LW significantly above that of the maintained group M_4. Ad lib feeding for 27 days did, however, result in a significant increase in LW over that of the 18-day fed and maintained groups.

Amongst the ewes fed ad lib for 27 days there was no significant difference in OR according to whether or not there were 9 days of maintenance feeding just prior to mating. The existence of these 9 days of maintenance feeding did, however, reduce the OR sufficiently to cause the significance of the difference between the last 27 days ad lib and maintenance feeding groups to disappear.

When 18 days ad lib feeding was followed by 18 days maintenance feeding prior to mating, there was no improvement in OR over the maintenance group. When 18 days ad lib feeding was supplied immediately prior to mating, OR was significantly improved. This suggests a dynamic effect of current nutrition on OR of ewes in this level of body condition; an effect not apparent in the better condition ewes which had been ad lib fed for 27 days.

A source difference in response was apparent. There was no difference between them in M_4 and H_2M_2 groups but in the other better fed groups OR was significantly less in the Lephinmore ewes and within this source was non-significantly greater than in the maintenance groups. This may be partly an age effect, the Lephinmore ewes being older as well as 3.5 kg lighter, but it seems most likely due to a greater potential in the Glensaugh ewes.

The RTS rate was relatively low this year and this is largely responsible for the lower levels of EM than was the case in 1974. This may be an expression of reduced weather stress during the critical period at mating and the following 2-3 weeks.

The PLR to first mating, which assumes no further loss, was similar for each group receiving 27 days ad lib feeding but it was not possible to show either to be significantly greater than the maintenance group. Only when pooled and compared with the M_4 and H_2M_2 groups pooled was it possible to show the difference to be significant using chi-square analysis. The ewes receiving ad lib feeding for 18 days immediately prior to mating still maintained their advantage over those ewes on maintenance feeding for at least the last 18 days.

With ad lib feeding based on pelleted dried grass and hay (up to 60 g food/kg LW) producing relatively little return for a high cost, the conclusion from this study must be that there is no economic justification for such a treatment in the pre-mating period particularly if there is a period of maintenance likely immediately before mating. LW and CS responses were slow and limited and, in view of the 1974 results, very susceptible to periods of bad (particularly wet) weather. It must now be asked whether significant response can be achieved with lower inputs, perhaps from pasture. It is also suggested that it may still be best to put on body condition early when pasture and weather are better and then maintain it, rather than try and give a nutritional boost later. The apparent dynamic effect in a particular, narrow range of body condition and, presumably, metabolic state, must receive further consideration. The problem of ewe source and the associated differences in response must also receive attention, being tied up with potential and how it is established and expressed. It is certainly not yet possible to extrapolate from these results nor make positive practical recommendations to the industry.

5. The effects of nutrition during pregnancy on grazing intake, milk production, body weight recovery and on subsequent reproductive performance of Blackface ewes

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

It has been shown that body condition and/or nutritional state at mating time may be the most important nutritional factors regulating reproductive performance and that the actual pattern of post-weaning liveweight recovery has little effect. There is, however, little information to indicate the possible importance of pre-weaning recovery and the extent to which this is directly influenced by nutritional state during pregnancy or by food intake and its partition during lactation. It is not known to what extent the level of body weight recovery achieved in experimental feeding situations may be restricted by either milk production or pasture quality in a repeating, commercial situation.

An experiment has been designed to provide initial information on these serial events linking the end phase of one pregnancy to the beginning of the next within a grazing situation. A group of 116 Scottish Blackface ewes ($4\frac{1}{2}$ and $5\frac{1}{2}$ year-old) were taken from the House o' Muir flock in September and differentially fed to achieve a uniform body condition (2.75 ± 0.25). They were separated into three groups after synchronised mating in late December. All were maintained on pasture of low availability. One group received supplementary hay and concentrates designed to allow a small but steady gain in maternal liveweight throughout pregnancy. The other two groups were allowed to lose liveweight at a rate resulting in up to 15% loss by parturition.

After parturition one undernourished group will graze a low quality Nardus-dominant pasture whilst the other two groups will graze together on a highly productive ryegrass/clover sward. Grazing intake and milk production will be measured at intervals. After weaning, all ewes will be brought back to the original body condition of 2.75 ± 0.25 by November and the food required for this will be measured. They will then be killed 30 days after mating to assess the residual effect of treatments on ovulation and embryo loss.

6. Effects of age of ewe on ovulation rate and early embryo mortality
R.G. Gunn, J.M. Doney and W.F. Smith

A representative sample of 49 Blackface ewe lambs has been retained from Sourhope and is being reared on a nutritional level designed to achieve a similar live weight and size at 2½ years of age as draft ewes off the hill at 6½ years.

In the autumn of 1977, these experimental animals and the Sourhope draft age will be brought into the same level of body condition prior to mating. All will then be killed four weeks later for ovulation and viable embryo counts.

If management is successful in achieving similar live-weight and size, the results of this study should give information on the effects of age *per se*, uncomplicated by such differences associated with size and growth pattern.

LACTATION (01002)

1. Sustained lactation in ewes and its influence on lamb growth (01002/GENOTYPES:01004)
J.N. Peart and J.M. Doney

The hypothesis that sustained lactation in ewes may have a beneficial influence on the growth rate of suckling lambs has been previously outlined. The capacity for sustained lactation is probably only inherent in milch breeds of sheep and the only breed of this type available in the U.K. is the Westphalian (Syn. East Friesland). Rams of this breed were mated with Blackface ewes in 1973 and in 1974. The female progeny have been retained to form a small crossbred flock for experimental use. The crossbreds born in 1974 are now gimmers due to produce their first lambs in 1976.

The primary object in 1976 will be to establish whether or not this crossbred ewe has a capacity for a sustained lactation. It is recognised that immature ewes may not have the same pattern of lactation as adults. Therefore, the answer to this question may not be obtained in the 1976 study.

Little information is available on the lactation performance of gimmers of any breed. Therefore, in this preliminary investigation the lactation of Westphalian x BF gimmers will be compared with that of pure Blackfaces.

The 1976 study will also include a comparison of the lamb-suckling with the oxytocin technique of assessing milk production of ewes.

2. <u>Greyface pregnancy and lactation experiments</u>
(01002/NUTRITION IN PREGNANCY:02002)
T.J. Maxwell, D. McDonald, J.M. Doney, J.A. Milne, J.N. Peart and A.J.F. Russel

Experiments were initiated during 1975 to examine a number of issues related to the Greyface Systems experiment.

One of the decision rules used during the winter feeding of the ewes on the Greyface Systems experiment is dependent upon the measurement of blood ketone level as an index of the level of undernutrition during late pregnancy. The ewes on each system are offered feed in relation to the same minimum level of nutrition. The minimum level of blood ketone chosen was based on experiences in the use of this technique with hill ewes. While the technique appeared to work satisfactorily the pattern and quantity of concentrate feed inputs was different to that associated with hill ewes and was in part a reflection of the higher conception rates obtained. There was also an indication that the high feed inputs in the last week to ten days of gestation were at the limit of dry matter intake of ewes at that stage of pregnancy.

The decision rules regarding the allocation of ewes to pasture and the allocation of certain areas for conservation are determined by equalising the allowance of pasture per ewe and maintaining this allowance above a minimum value (45 kg DM per ewe) as far as pasture growth and the area allocated to the system allows.

The basis and choice of this value remains in doubt.

Further, the need to supplement the pasture diet of the ewe in early lactation by the use of concentrate feed in relation to the pasture available is not well defined.

In an attempt to elucidate some of these issues experiments were set up firstly to examine the effect of different levels of nutrition in late pregnancy on lamb's birth weight, ewe body weight change and the level of feed required to maintain these levels of nutrition so that a more precise definition of minimal level of nutrition could be established. It was also intended that the information so obtained would allow the formulation of an equation which could be used in adjusting feed inputs during late pregnancy.

Secondly, by using a selection of the same ewes, an initial approach was made in the quantification of some of the variables in relation to lactation. A study of the effects of prepartum nutrition on herbage intake, milk yield, lamb growth and ewe body weight change was made. Pasture conditions in terms of standing crop and digestibility were maintained as stable as possible.

Briefly, a group of 63 Greyface ewes, all over three years in age and having oestrus synchronised were mated to a Dorset Down ram during December 1974. In late February the ewes were X-rayed and were allocated by weight and lamb bearing type (single or twin) to one of three groups. From nine weeks prepartum all were housed in individual pens and offered a basal ration of 0.9 kg hay; a supplementary concentrate was given in relation to a requirement to maintain blood ketones within the ranges up to 2.5 mg%, 3.0-5.0 mg%, and 7.0-10.0 mg% for the three groups respectively.

The numbers of ewes available for statistical analysis, their mean weight at six weeks prepartum, bearing type and mean birth weight of their lambs is given in Table 1 as follows:-

Table 1.

Treatment	No. ewes single bearing	No. ewes twin bearing	Wt. ewe 6 wks. p-partum (kg) Single	Twin	Birth weight (kg) Single	Twin
1	6	10	67.78	71.25	5.46^{ab}	4.65^{de}
2	4	11	65.37	67.36	5.89^{ac}	4.26^{df}
3	5	10	62.40	64.50	4.70^{bc}	3.45^{ef}

a N.S. b N.S. c P = 0.05
d P = 0.05 e P = 0.001 f P = 0.01

The results of an analysis of variance is given in Table 2 as follows:-

Table 2. Mean intake (g DOM per day), Mean ketone (mg %) over last six weeks and mean birthweight (kg) (adjusted for differences in lamb numbers born per ewe and weight of ewe at six weeks prepartum)

Treatment	Ketone	DOM I	Birthweight
1	2.96	1200	4.64
2	7.1	893	4.58
3	10.9	774	3.81
Effect of treatment	P = 0.001	P = 0.001	P = 0.001
r^2	0.892	0.785	0.527

A clear and significant effect of nutritional state during late pregnancy on lamb birth weight has been demonstrated in the case of twin lambs; there were only a small number of single lambs available for analysis. The effect of nutritional state accounted for 53% of the variation in adjusted birthweights and was significant (P = 0.001).

Further statistical analysis is in progress.

The levels of nutrition used in this experiment provided an opportunity to measure the extent to which body fat is utilised during late pregnancy. The ewes were infused with 100 µCi (3 ml) tritiated water on two occasions during late pregnancy and in the week immediately after parturition to provide estimates of rate of water turnover and of body composition.

The results are at present being evaluated.

At parturition (last week in April) eleven single bearing and twelve twin bearing ewes were selected according to lambing date and prepartum level of feeding. They were transported to Glensaugh and allocated to a rested and fertilised ryegrass clover pasture (Laundry Park), along with nine barren ewes which had been on a similar diet to that used for the pregnant ewes but at levels which produced a range of body conditions similar to those obtained in the pregnant ewes on the three nutritional treatments.

Fig. 1. D.M.I (g) of Greyface nursing and barren ewes

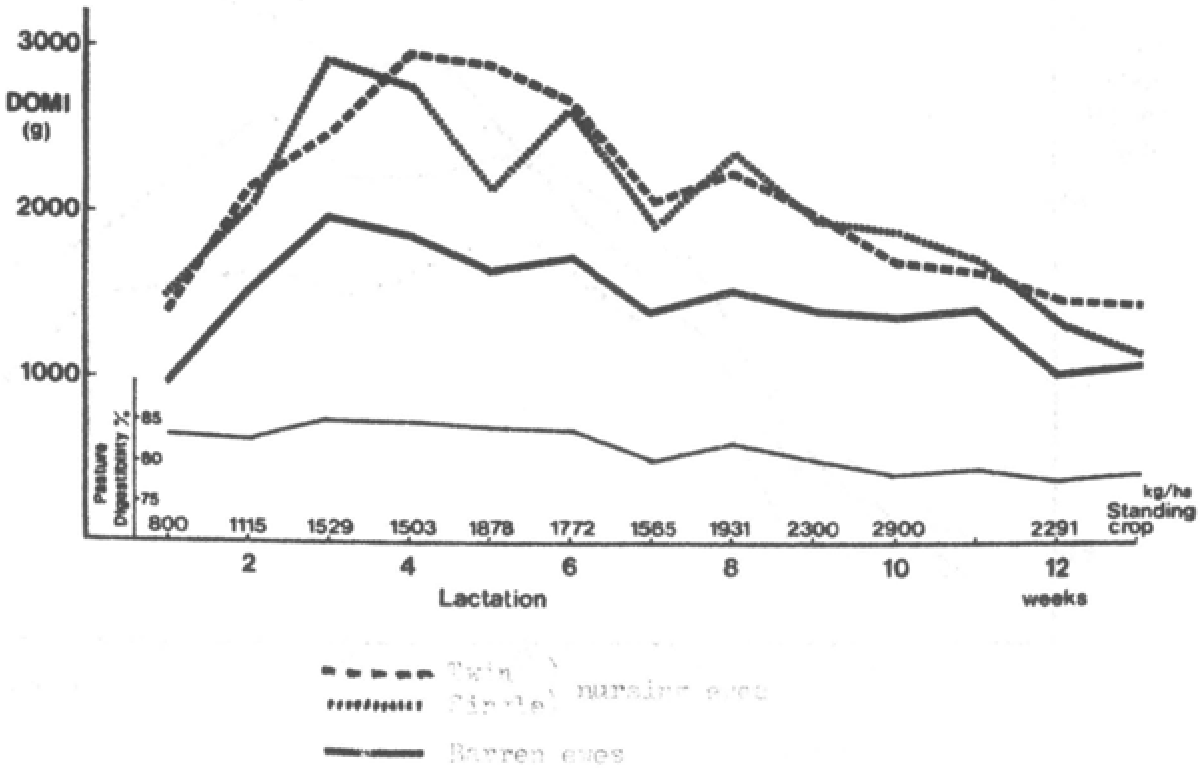


Fig. 2. Milk production of single and twin nursing Greyface ewes

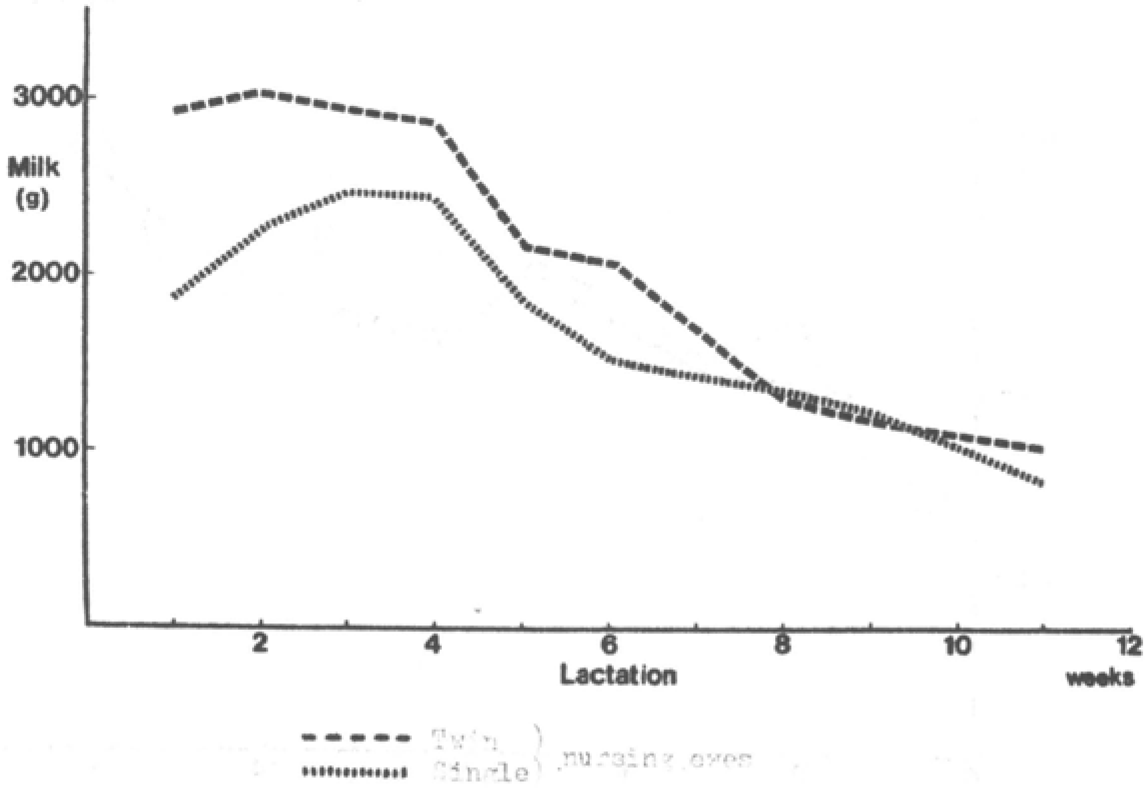


Fig. 3. Ewe body weight change during lactation

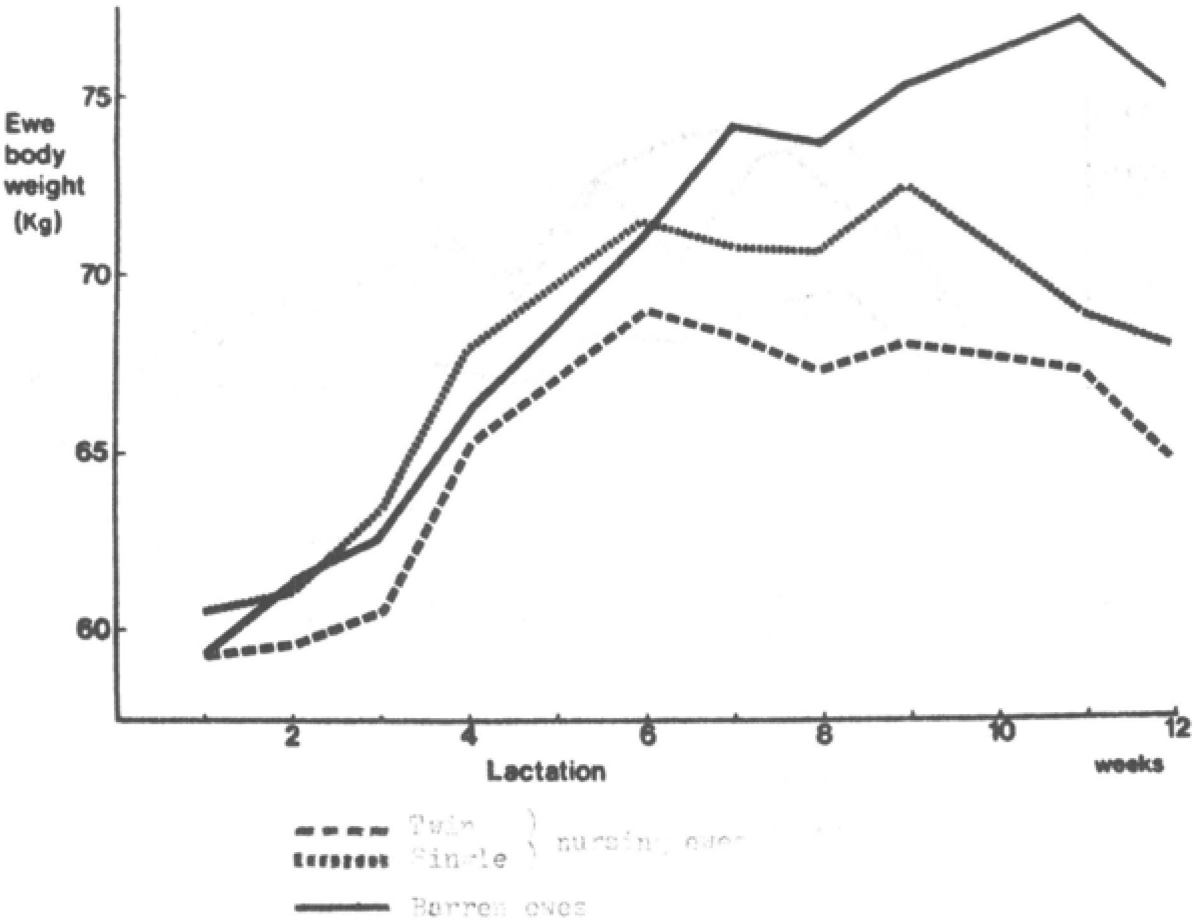
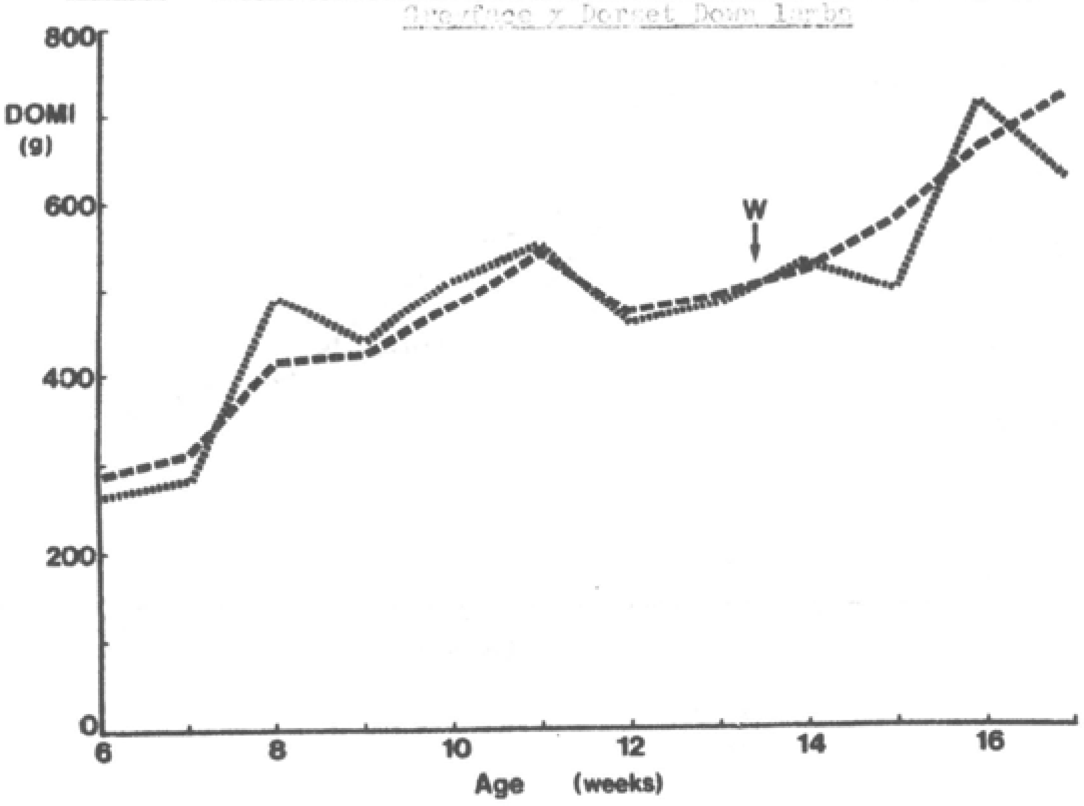


Fig. 4. Herbage DOMI (g): single (········) and twin (– – – –) Greyface x Dorset Down lambs



The herbage intakes of ewes were measured from the first week of lactation and lamb herbage intakes were measured from six weeks of age by the once daily dosing of chromic sesquioxide. Faecal grab samples were collected five days per week, once daily.

Estimates of the digestibility of pasture intake were made by collecting ingested pasture from oesophageal fistulated ewes and using in vitro digestibility analysis on the sample collected.

Ewes and lambs were weighed weekly.

Milk yield measurements were made weekly up to week 7 then in week 9 and 11 of lactation by the lamb suckling technique. All ewes were infused with 100 µCi (3 ml) tritiated water on four occasions at intervals of four weeks to provide estimates of body composition. Blood samples for tritium determination were collected on four of the seven days following each infusion to estimate rate of water turnover and by extrapolation, tritiated water space at time of infusion. The lambs were also infused with tritiated water (50 µCi in 3 ml) and blood sampled in a similar manner on three occasions at intervals of four weeks to provide data from which the usefulness of water turnover as an index of milk intake might be assessed. Preliminary, statistically unanalysed results are briefly given in Figures 1, 2, 3 and 4.

<u>WOOL</u> (01005)

1. <u>Fleece casting in Cheviot ewes</u>
W.F. Smith

Observations on South Country Cheviot ewes commenced in 1971 with the complete gimmer age group on one heft at Sourhope plus a further 55 ewes of the next age group started in 1972. Samples have been collected each year during the period late January to late March. The highest rate of brush formation of all fibres is expected during this period. Up to the present extremely few ewes have had more than 10% of all fibres with brush ends during the expected period. Fleece casting pattern has been recorded annually each July to date. Negligible fleece loss has been recorded in this group of ewes.

Examinations were completed in June/July 1975 on all surviving ewes before final culling occurred.

2. <u>Wool growth pattern, fleece structure and textile suitability of fleeces from crossbred genotypes reared under improved systems of hill management</u>
W.F. Smith

This project (in collaboration with Dr J.C. Fletcher, Wool Industries Research Association, Leeds) was started in July 1975 when the initial sample patch was prepared. The main objectives are to examine seasonal wool growth patterns and total mean fleece weights of purebred Blackface, Border Leicester x Blackface and Texel x Blackface gimmers under similar semi-intensive rearing and production (Mid and West Finella, Glensaugh). Comparison of fleece structure, i.e. fibres, types, distribution, dimensions and growth in specified periods (HFRO), and total fleece wool description (WIRA).

Samples from the standard mid side site (25 sq. cm tattooed patch) have been collected at two monthly intervals with the first sample for analysis taken in September 1975 and the final sample to be taken in July 1976. To date analysis and examination using the standard microscope and measuring techniques has proceeded on samples already collected. Full laboratory analysis and collection of data by HFRO is being taken from 25 sheep of each breed divided between Mid and West Finella, 13 and 12 respectively per breed.

WIRA will be examining and testing the complete fleeces after the July 1976 clip, approximately 40 of each breed.

NUTRITION: HEATHER (02004)

1. The effects of supplementation with nitrogen and energy on the voluntary intake and digestibility of heather
Alison Tait, J.A. Milne and A.J.F. Russel

It was reported in last year's Annual Report (1974, pp11-12) that large responses in intake and digestibility of heather could be obtained by the addition of small amounts of supplementary nitrogen. It was argued that further responses in voluntary intake and digestibility could be obtained with supplementary energy and an experiment was conducted to examine the interactions between supplementary nitrogen and energy on the voluntary intake and digestibility of heather.

During Period 1, the intake and digestibility of 12 mature Blackface wether sheep (mean liveweight 45 kg), given heather *ad libitum*, was measured. The sheep were then allocated to three balanced groups of four animals and during Period 2 the voluntary intake and digestibility of heather by sheep was measured in each of the three groups given either 0, 0.5 or 3.0 g urea-nitrogen/head/day by continuous infusion. The four sheep in each group were sub-divided further to give two balanced sub-groups and in Period 3 the voluntary intake and digestibility of heather by sheep, given the same level of supplementary nitrogen as in Period 2 but in addition, either 50 or 150 g/day of sucrose by continuous infusion, were measured.

In Period 1 the mean DM intake and digestibility were 461 g/day and 46.1% respectively. In Period 2 the addition of 0.5 g N/day gave no response in voluntary intake or digestibility but the addition of 3.0 g N/day increased DM intake and digestibility by 29% and 22% respectively. In Period 3 supplementation with energy and no nitrogen resulted in inappetance. The mean responses in DM intake and digestibility to addition of energy to 0.5 and 3.0 g N/day supplementation are given in Table 1.

Table 1

Responses in DM intake and digestibility of heather to the addition of energy to nitrogen supplements (Means of 2 observations/treatment)

Levels of supplementary nitrogen (g/day)	Level of energy supplementation (g sucrose/day)	Response to the addition of energy to N supplementation DMI (g/day)	DMD (%)
0.5	50	+148	+8.0
	150	− 20	+0.8
3.0	50	+ 70	+3.1
	150	+ 7	+5.6

In terms of digestible DM intakes the largest response to supplementation was obtained with 3.0 g N/day and 50 g sucrose/day; digestible DM intake was increased by 183 g/day or 94%. Blood urea and glucose concentrations remained relatively low even when large amounts of urea and sucrose were being infused daily indicating that urea-nitrogen and sucrose were being utilised efficiently in the rumen.

The mean half-life of a solid-phase marker in the rumen was reduced when supplementation with energy and nitrogen was given, suggesting an increased rate of removal of digesta from the rumen which would partly explain the observed increases in voluntary intake.

It was concluded that the addition of energy as continuous infusions of sucrose to nitrogen supplementation gave an additional response in voluntary intake and digestibility of heather, particularly at the lower level of energy supplementation.

2. The effect of frequency of feeding supplements on the voluntary intake and digestibility of heather
Alison Tait, J.A. Milne and A.J.F. Russel

In the experiment reported above large responses in voluntary intake and digestibility of heather were obtained with continuous infusions of energy and nitrogen *per rumen*. There is evidence that the more frequent feeding of supplements gives greater responses in the voluntary intake and digestibility of roughages. To examine this further and to test the difference between sucrose and starch as energy supplements to heather an experiment was conducted with 20 mature Blackface wether sheep.

Five treatments were compared in a randomised block design after an initial covariance period with 4 sheep/treatment. Heather was given *ad libitum* and the following supplementation treatments were compared:-

A	100 g sucrose + 3 g N as urea given			continuously daily		
B	" " "	" " "	" " "		3 x	"
C	" " "	" " "	" " "		1 x	"
D	105 g starch + 3 g N	" " "			3 x	"
E	" " "	" " "	" " "		1 x	"

The voluntary intake and digestibility of DM (± SE) of unsupplemented heather given in the covariance period were 25.7 (± 0.80) g/kg $W^{0.75}$/day and 46.9 (± 0.59) % respectively. The voluntary intake and digestibility of DM of the supplemented heather are given in Table 1.

Table 1

Voluntary intake and digestibility of DM of heather supplemented with two energy sources and at different frequencies (Means of 4 observations)

	Sucrose + Urea			Starch + Urea		SE
	Continuously	3 x daily	1 x daily	3 x daily	1 x daily	
DM intake (g/kg $W^{0.75}$/day)	31.7	27.2	24.8	27.8	32.8	±0.98
DM digestibility (%)	54.7	48.6	45.8	48.7	52.1	±0.84

There was a significant ($P < 0.01$) decline in the response in DM intake and digestibility as the sucrose and urea supplement was given less frequently, so that the voluntary intake and digestibility of heather supplemented 1 x daily with sucrose were similar to that of unsupplemented heather. When starch was the energy supplement 1 x daily feeding gave significantly ($P < 0.01$) higher voluntary intakes and digestibilities of heather than 3 x daily feeding. This somewhat surprising result was examined further in a subsequent experiment in which the effects of continuous, 1 x and 3 x daily supplementation with

105 g starch and 5 g N as urea were compared with four mature Scottish Blackface wether sheep/treatment. In this experiment the increase in voluntary intake of heather with less frequent feeding was not significant but the DM digestibility of heather was significantly ($P < 0.01$) higher for the 1 x daily feeding than for the 3 x daily or continuous feeding.

It is concluded that a reduction in the frequency of feeding of supplements reduces the response in voluntary intake and digestibility of heather when sucrose and urea is the supplement but that when starch is the supplement 1 x daily feeding produces the largest response in digestible DM intakes.

3. The utilisation of grass and heather by the grazing sheep
J.A. Milne, Sheila A. Grant, L. Bagley, T. Barthram and T.J. Maxwell (02004/EFFECTS OF UTILISATION:MOORLAND:04005)

In this experiment 0.5 ha plots, which contained 15, 30 and 45% by area of a perennial ryegrass sward with the remainder of the area as heather in the building phase, were grazed by Scottish Blackface wether sheep to remove 25, 40 or 55% of the current season's growth of heather. The five treatments compared are outlined in Table 1.

Table 1

Description of treatments

Grass area as proportion of total area (%)	15		30		45
Level of heather utilisation (%)	40	25	40	55	40
Treatment designation	15/40	30/25	30/40	30/55	45/40

The plots were grazed during June/July and October and approximately half of the level of heather utilisation was achieved at each grazing. The experiment was conducted in a similar manner in 1974 and 1975. The aim of the experiment was to determine the effect of proportion of grass by area and the level of utilisation of current season's shoots of heather on the diet selected by the sheep and upon grass productivity. The principal findings of the experiment from the data which have been processed are summarised below:

(1) The levels of heather utilisation aimed for were achieved in each year.

(2) Apart from the 15/40 treatment, which was lower than the other treatments, the annual dry matter production of grass was similar on all treatments. Mean dry matter production was 2100 kg/ha in 1974 with 120 kg/ha N applied and 4400 kg/ha in 1975 when 250 kg/ha N was applied. The mean annual dry matter production of current season's growth of heather was approximately 2500 kg/ha in both 1974 and 1975.

(3) The relationship between the amount of standing crop of grass and % utilisation of heather with time is given for treatment 30/40 in 1975, in Figure 1, as a typical example of the patterns obtained. There was a consistent pattern with all treatments of a decrease in the amount of standing crop of grass with time and a concomitant increase in the % utilisation of heather. Growth rates of grass during the June/July period ranged from 0-70 kg DM/ha/day, and during the October period were near zero. However growth rate of grass *per se* did not appear to influence % utilisation of heather. On these treatments with the same level of heather utilisation (40%), but with different proportions by area of grass, there was always a greater amount of standing crop of grass per unit area where the proportion of grass was greater; this was particularly so when treatment 15/40 is compared with 30/40 and 45/40.

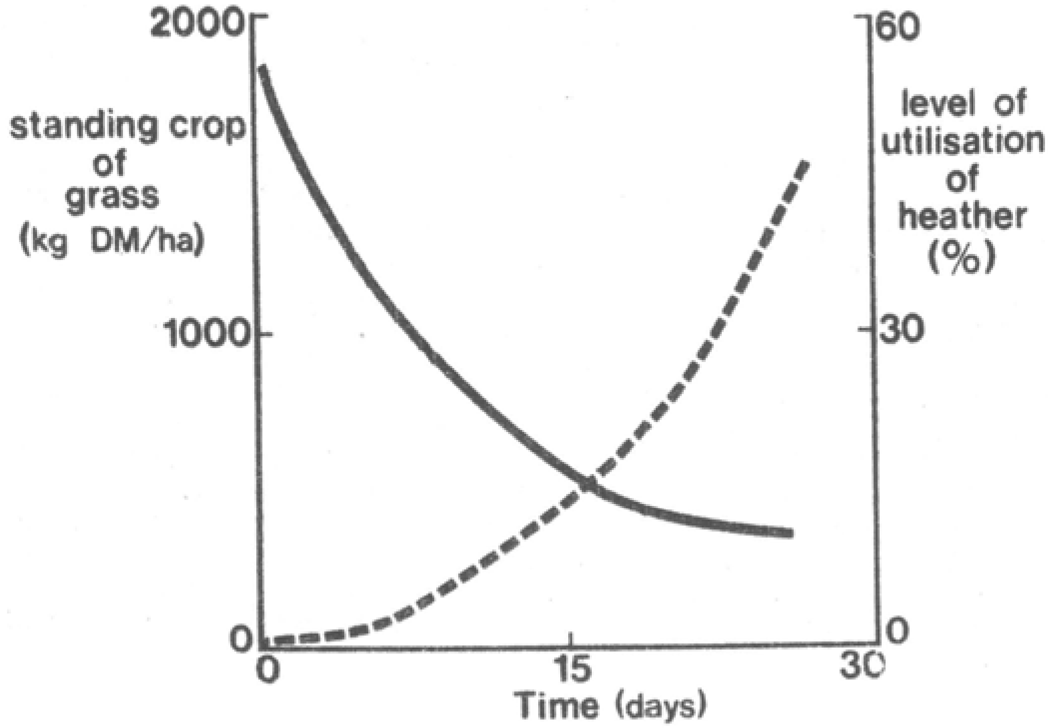


Fig. 1. Relationship between the amount of standing crop of grass (▬▬) and % utilisation of heather (▪▪▪▪) with time for treatment 30/40 in 1975.

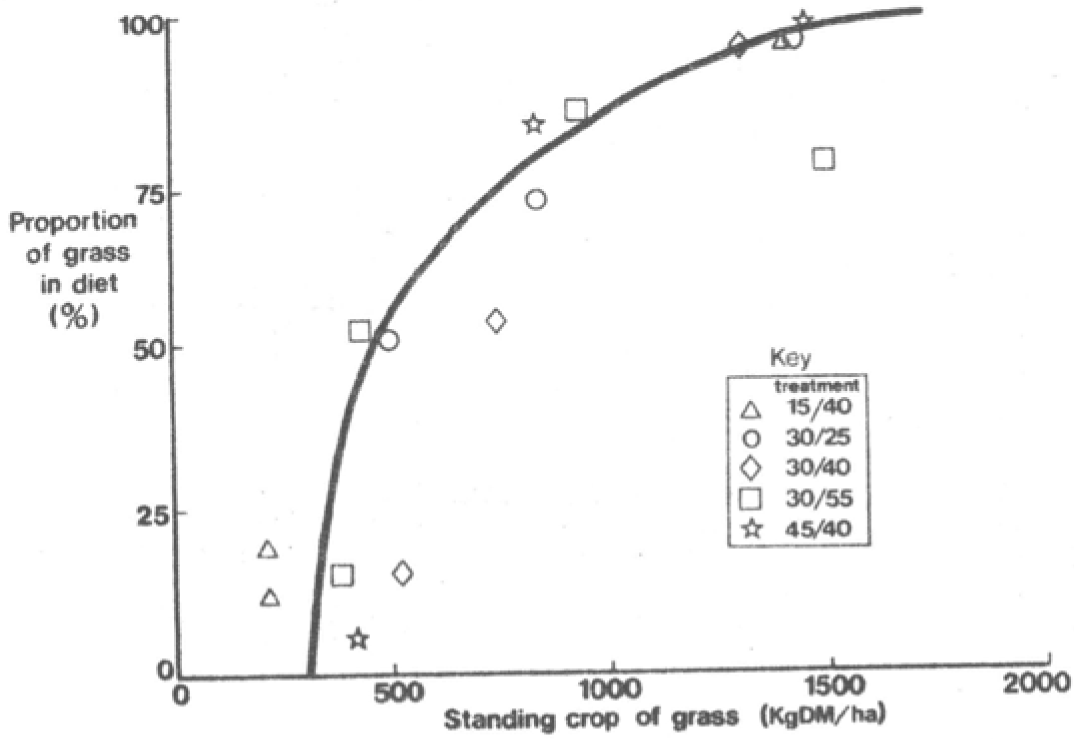


Fig. 2. Relationship between standing crop of grass and estimated proportion of grass in the diet for the July 1975 grazing period.

(4) During any grazing period the proportion of immature green leaves of grass on offer to the sheep remained constant but that of mature leaves declined and that of dead material increased. The proportion of green leaf of grass in the diet selected by the grazing sheep was always higher than that contained in the herbage on offer.

(5) The relationship between standing crop of grass and estimated proportion of grass in the diet is given in Figure 2, for the July 1975 grazing period. Similar relationships were found in other grazing periods. It is concluded that this is the central relationship governing the grazing of heather and grass swards within the range studied in this experiment. A computer simulation model (see Annual Report, 1974, p.49) was developed of the grazing of a grass and a heather sward, which also demonstrated that the output of the model was sensitive to changes in a similar relationship to that given in Figure 2. The relationship between standing crop of grass and the proportion of grass in the diet established in this experiment was determined under conditions of steadily declining standing crop of grass. In the application of these results this is likely to be the case in the autumn but not necessarily during the summer. Consequently an experiment has been planned to establish the relationship between amount of grass and % grass in the diet when levels of standing crop of grass are held constant for approximately 10 weeks.

<u>NUTRITION: SUPPLEMENTATION/PASTURE UTILISATION</u> (02005/03003)

1. <u>Investigations into the digestive physiology of supplementary feeding (NUTRITION:HEATHER:02004/02005/03003)</u>
J.C. MacRae, J.A. Milne, S. Wilson and A. Spence

Data was presented in the last Annual Report on sites of digestion of heather diets in sheep. Further experiments with sheep fed <u>Agrostis/Festuca</u> herbage suggest that although a similar partition of digestion occurs, the non-ammonia-N (NAN) entering the small intestine of the animal is more available than on the heather diet.

During the last year emphasis has been given to developing a range of tracer techniques (involving the use of ^{15}N- ^{14}C- and ^{3}H-labelled metabolites) for measuring rates of production in and transfer between various metabolite pools. These techniques were used in the <u>Agrostis/Festuca</u> experiment for measuring ruminal and caecal productions of acetic, propionic and butyric acids, bicarbonate and ammonia, and blood entry rates of CO_2, urea and glucose. The quantities of urea recycled into the rumen and caecum and bicarbonate transferred between rumen, blood and caecum pools were also measured.

Results suggest that on <u>Agrostis/Festuca</u> diets, where there is a substantial increase in N between the feed and the duodenum (2-5 g N/day), there is surprisingly little urea-N recycled into the rumen NH_3 pool (<1 g N/day). If this finding occurs on heather diets also, where the extra NAN entering the small intestine is only poorly available (40-45%; see Annual Report 1974, p.14) then it could result in a serious depletion of the animal's protein reserve.

2. <u>The effect of ruthenium-phenanthroline marker on rumen fermentation rate</u>
S. Wilson and J.C. MacRae

Non-radioactive ruthenium-phenanthroline (Ru-P) is currently used as a particulate-phase digesta marker (see Annual Report 1973, p.18). In most experiments the marker is measured in duodenal, ileal or faecal samples after being initially introduced into the rumen. Previous studies have shown that when using isotopically labelled ^{103}Ru-P at very low concentrations (10^{-9}M to 10^{-5}M) there is no detrimental effect on rumen fermentation rate (Tan, Weston and Hogan, 1971), however for accurate estimation of inert Ru, by X-ray spectrometry, marker concentration in digesta samples must be 5-10 ppm Ru, and in certain instances, rumen concentrations of Ru-P can be very nearly 10^{-5}M. An experiment was carried out to see what concentration of Ru-P could be added to *in vitro* incubations before ruminal fermentation rate was affected.

Whole rumen contents were obtained from a slaughter sheep previously given a chopped dried grass diet and *in vitro* incubations were carried out in the presence of 0, 10^{-5}M, 10^{-4}M and 10^{-3}M concentrations of Ru-P. VFA production rates, measured over 250 mins are given in Table 1.

Table 1

In vitro VFA production rates (m Mol/litre/min) in rumen liquor obtained from a sheep fed chopped dried grass (Molar proportions of VFA in R.L.:- 72/18/9) and incubated with varying concentrations of Ru-P.

VFA	conc. of Ru-phenanthroline in incubations			
	Control	M^{-5}	M^{-4}	M^{-3}
C_2	0.15	0.16	0.13	0.003
C_3	0.065	0.070	0.058	-0.002
C_4	0.037	0.043	0.049	0.036

The presence of Ru-P at concentrations of 10^{-5} and 10^{-4}M had no effect on VFA production rate. However at 10^{-3}M, production of acetic and propionic acid was totally inhibited; production of butyric acid was only slightly reduced.

References

Tan, T.N., Weston, R.H. and Hogan, J.P. (1971). Int. J. Appl. Rad. and Isotopes, 22, 301-8.

3. Comparative studies of the nutritive value of hill pasture (*Agrostis/Festuca* and heather) diets to the red deer and the sheep: Voluntary intake and digestibility

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

It has been argued that poor quality hill herbage may be better utilised by the red deer than by the sheep. In an attempt to examine this statement a comparative study is now underway on twelve castrate yearling stags (mean liveweight 73 kg) and twelve Blackface wethers (mean live-weight 49 kg) of similar age and history. In the first series of experiments the animals were housed in metabolism pens under continuous lighting conditions, and measurements of voluntary intake, digestibility and mean retention time of a particulate-phase marker (^{103}Ruthenium phenanthroline) were made on three different diets. The results are given in Table 1.

The sheep and deer ate similar amounts of a dried grass pellet diet, but the sheep digested the diet to a significantly ($P < 0.01$) greater extent, possibly due to a slower rate of passage of digesta through the gut than in the deer. On the *Agrostis/Festuca* and heather diets the voluntary intakes of the deer were significantly ($P < 0.001$) greater than those of the sheep. The digestibility of these diets and the mean retention time of the particulate-phase marker were lower for the deer than the sheep.

Table 1

The voluntary intake, digestibility and mean retention times of three diets by red deer and sheep (dried grass pellet diet - means of twelve observations, *Agrostis/Festuca* and heather diets - means of six observations)

	DM Intake (g/day)	DM Intake ($g/kgW^{0.75}/day$)	DM Digestibility (%)	Mean Retention Time of particulate-phase marker (hrs)
Dried Grass Pellets				
Deer	1552	62.1	60.6	24.7
Sheep	1493	77.4	64.5	43.4
SE	± 108.4	+ 4.04	+ 0.83	± 2.93
Agrostis/Festuca				
Deer	1199	48.4	40.1	28.9
Sheep	432	24.1	48.8	53.7
Heather				
Deer	847	34.0	45.3	38.1
Sheep	303	16.7	48.3	76.7
SE	± 58.2	± 2.29	± 1.43	± 5.11

Both the sheep and the deer ate more *Agrostis/Festuca* than heather. The sheep digested the *Agrostis/Festuca* and heather diets to a similar extent but the deer digested the heather to a greater extent than the *Agrostis/Festuca*. In both species the mean retention time of the particulate-phase marker was shorter for the *Agrostis/Festuca* than the heather.

Because the voluntary intakes of the sheep on the *Agrostis/Festuca* and heather diets were somewhat lower than values obtained in previous experiments with the same diets of similar digestibility, it is proposed to repeat the experiment. The results reported above were obtained during the period November to early January. Repeat measurements are being made in late April to establish whether seasonal effects on the voluntary intakes of the two species are important.

4. Evaluation of a protected lipid-soyabean supplement
C.S. Lamb, A.J.F. Russel and J.C. MacRae

Feeding of barley supplements to sheep given *Agrostis/Festuca* hill herbage can result in a substantial reduction in herbage intake (approx. 40% substitution; Ann. Rep. 1974 pg 17). It was considered that "protected-lipid", an ultra-high energy supplement, protected from ruminal degradation by encapsulation in an acid-reversible formaldehyde/protein complex might have the advantage that it would not affect ruminal degradation of structural components of the herbage and so would not cause substitution of supplement for herbage.

In two experiments a protected lipid-soyabean preparation (Alta Lipids Ltd) has been compared with barley as a supplement for sheep given (a) winter quality *Agrostis/Festuca* herbage (freeze-stored; OMD 43%) and (b) chopped hay (OMD 57%). Preliminary trials suggested that the 28 1½-year-old Blackface wethers used would not readily consume more than 100 g of the protected supplement when eating the hill herbage and so the sheep were allocated to seven equal groups (using a randomised block design on the basis of herbage VFI/kg $1.wt^{0.73}$ observed in a preliminary feeding period) which were given daily supplements of either 0, 50, 75 or 100 g protected lipid or 100, 150 or 200 g rolled barley. (The basal roughage was offered to 25% excess).

Intakes of roughage OM and total DOM are presented in Table 1.

Table 1

Intakes of hill herbage (Trial I) and hay (Trial II) and total DOM intakes by sheep receiving supplements of protected lipid and barley

Supplement	Trial I		Trial II	
	Intake of hill herbage ($gOM/kg^{0.73}$)	Total Intake ($gDOM/kg^{0.73}$)	Intake of hay ($gOM/kg^{0.73}$)	Total Intake ($gDOM/kg^{0.73}$)
0	29.4	12.8	55.3	31.4
50 g lipid	35.7	17.5	54.7	34.7
75 g lipid	28.6	13.5	58.1	37.3
100 g lipid	20.3	10.3	57.6	37.3
100 g barley	27.1	17.6	55.9	38.0
150 g barley	28.0	20.2	53.3	37.1
200 g barley	29.8	23.9	58.2	44.0

Voluntary intake of *Agrostis/Festuca* was substantially (21%) increased when 50 g protected lipid was given. However as more lipid was offered herbage intake dropped markedly. Total DOM intake of the 50 g "lipid" group (17.5 $g/kg^{0.73}$) might appear moderate relative to the higher levels of barley (20-24 $g/kg^{0.73}$), but it must be remembered that the lipid supplement contains nearly double the energy content and considerably more protein in its OM relative to the barley. Interestingly, supplementation with barley, up to 200 g/d, had no effect on herbage intake in this experiment.

In Trial II there was no effect of type or level of supplement on the voluntary intake of hay and total DOM intakes merely reflected the addition of supplements to the basal roughage intake.

The most significant feature emerging from these preliminary studies is the increased voluntary intake of the poorer quality roughage resulting from the feeding of 50 g protected lipid.

CATTLE (02008)

1. Lactation studies with beef cows and calves
J.N. Peart, A. Whitelaw, A.J.F. Russel and A.J. Macdonald

The interaction of one level of nutrition in late pregnancy (75% of maternal requirement) with three different levels of nutrition in early lactation is being measured in terms of milk production, calf growth and live-weight change of cows. These nutritional treatments will cease when cows and calves are put out to graze at approximately mid-May. All cows will have the same turn-out date and, therefore, the period of nutritional treatment during early lactation will vary between cows. The measurements of production will continue after turn out and the herbage intake of cows will also be measured.

The following nutritional treatments are being imposed during early lactation:

1. Maintenance of post-parturition cow liveweight (M) plus an allowance to provide for ½ gallon milk.

2. M + 2 gallons milk.

3. M + 3 gallons milk.

Six Hereford x cows and six Galloway x cows from each of the M + ½ and M + 2 nutritional treatments are being milk recorded at 2-week intervals using machine milking following oxytocin administration. In addition, a calf-suckling, weight-differential technique is being compared with the oxytocin method of estimating milk yields during the first 12 weeks of lactation.

The study is still in progress.

2. Evaluation of some aspects of a machine milking technique for estimating the milk production of beef cows
Y.L.P. Le Du*, A.J. Macdonald and J.N. Peart

Published data presents conflicting evidence on the comparative efficiency of the calf-suckling, weight-differential and the oxytocin-machine milking technique of measuring the milk production of suckled beef cows. A series of trials were made at Glensaugh in 1975 to provide further information on the relative merits of these two techniques. Eight single-suckled beef cows in later stages of lactation were used. The trials were:

1. Venous, muscular, and mucosal routes of administration of exogenous oxytocin (purified Oxytocic Principle) at dose rates of 10 and 20 i.u. The muscular and mucosal routes were further tested at 40 i.u.

2. The efficiency of milk ejection following intra-venous injection of oxytocin was examined with both housed and grazing cows. The responses to 2.5, 5.0 and 10.0 i.u. dose rates were compared.

3. The effect of size of a second (test) dose upon efficiency of milk ejection. Doses of 0.0, 2.5 and 5.0 i.u. were compared following first doses of 2.5 and 5.0 i.u. oxytocin.

4. Estimates of milk yield following oxytocin administration were compared with those obtained by calf-suckling. This comparison was made under both housed and grazing conditions of management.

It was found that each technique estimated milk yields with equal precision and it was concluded that either method could be used to give a routine measurement.

The intra-jugular route of administration of oxytocin was most satisfactory and a dose of 2.5 i.u. was sufficient to induce efficient milk ejection. However, a second (test) dose of 2.5 i.u. further increased efficiency. Greatest efficiency of milk ejection was obtained following a 10 i.u. dose. A paper has been prepared for publication.

Efficiency of milk removal (%)

Oxytocin Dose (i.u.)

0	2.5	5.0	10.0
11.1	94.7	94.1	97.8

* Now at Grassland Research Institute

3. Glensaugh Cattle: Veterinary Monitoring
A. Whitelaw, A.R. Fawcett and C. Landale

Reproduction (01001/02008)

In 1975 synchronisation of oestrus was carried out using a progestagen implant in the ear of the cows.

Implants were removed nine days later and artificial insemination was carried out at 48 hours and 72 hours thereafter.

One hundred and fifty straws were prepared from semen collected from the Glensaugh Charolais bull. Thereafter this bull was used for returns to service, and for natural service of unsynchronised animals. To obviate the difficulty of overloading the bull by too many returns presenting at the same time, the synchronisation was carried out on groups.

RESULTS - By pregnancy diagnosis.

GROUP I 15 cows

Pregnant to synchronised A.I.	40%
Pregnant in 1st 30 day period	80%
Not in calf 1	

GROUP II 16 cows

Pregnant to synchronised A.I.	25%
Pregnant in 1st 30 days period	81%

GROUP III 18 cows

Pregnant to synchronised A.I.	44%
Pregnant in 1st 30 day period	89%
Not in calf 2	

Natural Service Group - 28 cows

Pregnant to 1st service	68%
Pregnant in 1st 30 day period	89%
Not in calf 2	

The results were reasonably satisfactory if regarded against a background of experimental limitations of feeding, lactation work etc.

Batching is obviously necessary otherwise more 'bull-power' would be needed to cope with returns.

In contrast to the work in 1974 with prostaglandin - the animals did show detectable 'returns' more readily.

Taking the figures for cows settling within the 1st 30 day period the results are very satisfactory.

In future work constraints applied by experimental requirements may produce poorer results to synchronisation - but these constraints would equally apply to the use of natural service.

Disease

The incidence of disease was very low in the cows at Glensaugh. Calf health was good apart from the recurrence of viral diarrhoea.

Viral diarrhoea

As reported in 1974 an outbreak of this disease recurred in 1975. Again it showed a high morbidity and a low mortality. Rotaviruses were demonstrated by electron-microscopy at the Moredun Institute. The labour input in treating recurrent cases of scour was high. The mean weight difference between calves which did not scour and those which did was 2.2 kg over the period 0-12 weeks after birth.

Mastitis

Dry cow therapy with an intramammary antibiotic and routine spraying with an insecticide during the fly season were carried out. No cases of summer mastitis occurred in 1975.

CATTLE (no project number)

Effect of two paths of liveweight change on the efficiency of feed use and on body composition of steers
Janet Z. Foot (in collaboration with Professor N.M. Tulloh, while in receipt of a Visiting Research Fellowship to the University of Melbourne)

Cattle kept under extensive conditions experience periods of under-nutrition. The outcome of these is highly variable because of the many factors involved before, during and after the nutritional check. These factors include:- the degree of maturity, liveweight, body composition and physiological status of the animal when undernutrition starts and the previous nutritional history at this time. They also include:- the severity of the check, rate of weight loss, duration of weight loss and type of diet during nutritional deprivation and finally, after the period of undernutrition, they include the type and availability of the diet to the animal and the length of the recovery period considered.

Selected for study in this experiment was the effect of different paths of liveweight change (representing nutritional checks of different severities) on the total amount of roughage feed used by steers and on their final body composition. The treatments were: a 15% weight loss from 330 kg liveweight, at 0.5 kg per day for 100 days, followed by recovery to 330 kg on ad libitum feed intake (WL/WG group), and constant weight at 330 kg for the same length of time as corresponding pairs in the WL/WG group took to complete their treatment (constant-weight group). There were six Angus steers in each group and they were slaughtered when the WL/WG steers reached 330 kg. At the beginning of the experiment four animals (preliminary group) were slaughtered at 330 kg.

Intakes of feed were recorded and measurements of apparent dry matter digestibility were made at intervals. Tritiated water was infused for estimation of body water several times during the treatments in all animals and always immediately prior to slaughter. Chemical analyses were carried out on the right side of each carcass and on the other components of the body.

The mean total intake of the WL/WG group was 12% less than that of the constant-weight group. The daily dry matter intake in the constant-weight group fell from 5.9 kg to 4.4 kg during the experiment.

The time taken for the WL/WG steers to regain the 50 kg weight loss varied from 30 to 68 days. Their intakes at this time and their growth rates were similar to those that they experienced when they grew to 330 kg for the first time.

Apparent digestibility varied between animals but was not influenced by treatment.

The constant-weight group were fatter than the WL/WG group at slaughter and had heavier carcasses, both differences were significant ($P<0.05$). The difference between groups in empty body weight was not significant. Animals from the final slaughter groups had significantly heavier heads and feet and a higher ash content than the younger steers of the preliminary group. Liver weights were reduced by nutritional restriction and had not fully recovered in WL/WG steers when they had reached slaughter weight.

Results from tritiated water infusions are still being calculated.

UTILISATION: NUTRITION (03003)

1. The accuracy of estimation of faecal output using alternative preparations of chromic oxide at two frequencies of administration
J. Hodgson, Richard H. Armstrong

Twenty-four sheep were used in an experiment to compare the use of two preparations containing chromic oxide-chromic oxide paper and a slow-release tablet produced by a firm of manufacturing chemists. These preparations were administered, and samples of faeces collected from the rectum, once or twice daily. Two levels of consumption of a chopped hay (maintenance and ad lib) were balanced across sheep within treatments in two successive periods of 14 days. The sheep were fitted with harnesses and bags for total faecal collection to allow estimates of chromic oxide recovery for individual sheep from (a) grab samples and (b) samples taken from bulked, mixed faeces. Samples of faeces were also collected for estimates of fluctuations in Cr_2O_3 concentration throughout the day.

Chemical analyses are not yet complete, but preliminary results indicate that (a) estimates of faecal output derived from grab samples were 50% more variable for tablets than for paper, and (b) once-daily dosing and sampling increased the variability of estimates of faecal output by 47% over twice-daily routines.

Arthur H. Cox & Co. Ltd, Brighton, manufactured the tablets.

2. Digestibility of milk and forage components of mixed diets for calves
J. Hodgson, Richard H. Armstrong

This experiment was conducted as a preliminary to future studies on herbage intake in grazing beef cattle, and was designed to measure the influence of variations in the levels of intake of milk or herbage upon the digestibility of the two components in mixed diets.

Twelve male calves, 5-6 weeks old at the start of the experiment, were used. They were given fresh milk alone, in four equal feeds per day at the rate of 120 ml/kg LW, for a period of three weeks, and were then divided into groups of four receiving 60, 120 or 180 ml/kg LW for four periods of three weeks. Over these periods the calves received chopped dried grass (71% DMD) at the rate of 25, 50, 75 or 100% of voluntary intake. Voluntary intake was determined on a small group of "leader" calves, and levels of forage were allocated to calves within milk levels, over successive periods, in three 4 x 4 Latin Squares. The calves were then weaned, and in a final period were offered the dried grass either at the maintenance level of feeding or close to appetite. Faeces output was measured for the last eight days of each period.

The experiment was completed at the end of March, 1976. The digestibility of the milk was estimated to be 97.5 (± 0.14)%, but evaluation of the results from the main phase of the experiment is not yet complete.

The Edinburgh School of Agriculture supplied the calves and milk, and Ford & Etal Farms Ltd the dried grass.

RED DEER (05001)
W.J. Hamilton

Deer stocks at 31st December 1975

Stock	Stags	Hinds	Castrates	Total
Mature stags	15			15
Mature hinds		77		77
Prickets	2			2
Jinnocks		23		23
Young stags	14			14
Young hinds		51		51
Stag calves	18			18
Hind calves		53		53
Hoviers			10	10
	49	204	10	263

October 1974 Rut

Group (A) hinds which had been reared on a low plane of nutrition failed to breed - all 24 were barren.

Group (B) - of the 18 hinds, 14 conceived at their first oestrus.

Group (C) - 16 out of 18 hinds conceived at their first oestrus.

Group (E) - 15 out of 16 were successfully mated at their first oestrus.

These results confirm earlier trials where the average number of hinds successfully mated per stag at the first oestrus of the season was 15.

Synchronisation of oestrus

Of the 16 hinds synchronised with progesterone impregnated vaginal sponges, only 11 hinds conceived to mating at the first oestrus after sponge withdrawal. Four hinds proved barren in spite of being available to stags through to mid-February.

Calf weaning experiment

The effect on date of conception of dams of pre- and post-rut weaning of their calves, was that the pre-rut weaned hinds conceived on average 14 days earlier than those left with their calves during the rut.

Breeding performance

Eighty hinds were put to the stag on 4th October 1974. Some 73 calves were born alive and recorded but three calves were lost without trace in their first week of life in the Goyle paddock.

Calf disposal

Apart from one stag calf sold to RRI, the entire calf crop was retained for experimental purposes on the farm.

Calf rearing

Twenty-two wild deer calves were bought in and reared artificially. Three calves died during the initial rearing period. The remainder are destined for use on the Upper Farm.

Monitoring

Gatherings at monthly intervals continued throughout the year. All stock were weighed and measured, dentition scored, and inspected for the presence of parasites.

Castrate - entire experiment

Four castrates and two entire stags were slaughtered in September at the farm. The occasion was used to gain information as to the dimensions required for a proper slaughter facility. The carcasses were taken to the RRI for dissection and analyses. Part of each carcass was sent to Baxters of Fochabers and to the MRI at Bristol.

For a repeat exercise in September 1976 ten stag calves born in June 1975 were castrated and 10 female calves and 10 stag (entire) calves were selected and earmarked for slaughter at the same time in September 1976.

Heather utilisation

The annual survey was extended to cover as well as the Goyle and West Greenshiels, the Panhandle and East Greenshiels paddocks. Utilisation ranges from 18.3% in the Goyle to 48.8% in the East Greenshiels.

Forest

The road-line fence was removed and the Forestry Commission extracted the blown timber during the summer months. The paddock is now back in use and a new drain has helped to stop the surface water erosion but the situation has still not been stabilised. Three hundred trees were damaged, mostly bark stripping, by stags during October.

Upper Farm

The 53 hinds and 8 stags reared on the main farm over winter were put out to the Upper Farm in April.

The low density plantation was planted-up in April and May and with the hot dry summer losses occurred. The lost plants will be replaced in the spring of 1976.

The areas selected for re-seeding received three tons of lime and half a ton of slag in early August. The two seeds mixtures used were sown out at the end of the month and three cwts per acre of compound fertiliser applied. Both mixtures took well as did the 'inoculated' white clover. The deer stock was used to trample in the seed. Twelve acres in all were treated.

Advisory work

Mr C.D. Young of the NOSCA was seconded to the Red Deer Project and took up his appointment on 12th August 1975. He will spend one year on the farm to gain first hand experience of deer farming before becoming a specialist adviser in deer farming.

Highlands and Islands Development Board

The H.I.D.B. appointed Mr M. Alexander as Farm Manager designate of their development project in the Highland area. Mr Alexander joined the project on 1st September to learn the techniques of farming red deer. He has been seconded to the project for a period of one year.

Handling pens and office

Problems have been experienced over the years with the soil eroded from the forest enclosure being deposited in and around the handling area. Plans are now afoot to resurface, with local till, the whole area, and some retaining walls and drains will be built to ensure good working conditions.

Feed and equipment store

Part of the food store was converted into an office for the two seconded officers. Storage space is not now sufficient to meet the needs of an increased breeding herd and it is planned to erect another Farran prefabricated building on the north side of the pens.

Visitors

The Departments of Forestry, Zoology, Biology, Soil Science, and Agriculture of the University of Aberdeen now make annual visits with groups of students. The number of visitors overall is similar to last year at 320.

Films

The BBC filmed on the farm in the spring, summer and autumn and have completed a 30 minute programme but the film has yet to be screened.

Disease

Tuberculosis is still a problem, although regular testing continues and reactors are found. Slaughtering of the reacting animals has not been practised until a clearer picture emerges.

Calves overwintered at the farm suffered a serious set-back in early winter. Some calves died and most lost weight for a period of 2-3 weeks. The post mortem findings suggested digitalis poisoning and investigations continuing appear to confirm the diagnosis. Foxgloves are found in several of the enclosures and particularly those adjacent to the forest.

Parasites

Warbles
Liquid treatment for warble fly was applied in September and has not been successful. The organo-phosphorus fluid was much more effective when applied in December.

Nasal botfly
A young calf which died as a result of an accident in August was found to have an infestation of the parasitic larvae. All stock were treated with rafoxonide in November as a precautionary measure. The main problem is still one of identifying an infected animal while it is still alive.

Head fly
Studies continue on population density and sex ratio during July and August but no progress has been made on the identification of biotypes where the larvae overwinter.

Lungworm (Dictyocaulus)

An experiment was set up to monitor the infestation of calves of different groups over the winter period. In the main young and small calves are most vulnerable but the level of nutrition appears to be of prime importance.

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 1975 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, 1967-70, p.70 (Hill Sheep Production Systems Development).

YRGS I: Low capital input on a grassy hill - 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 1975, 10.1 hectares of the *Agrostis-Festuca* area was oversown following surface cultivation*. The seed mixture applied at 28 kg/ha comprised 18 kg Perennial ryegrass, 7 kg Timothy and 3 kg White Clover. This was followed by 250 kg/ha of a 21.14.14 compound fertiliser and heavy rolling.

*with a spiked bar cultivator

Cattle

As previously hill cows were carried from May 1st to the end of December.

Sheep Stocks

The data for the Hairney Law and Auchope flocks have been combined. The breed differences between the two flocks that existed at the beginning of this project have been substantially reduced as a consequence of the breeding policy adopted in recent years.

Livestock Reconciliation 1974/75

Ewes and Gimmers Nov. 74	Cast	Deaths	Gimmers brought into flock	Hoggs born 1975	Ewes and Gimmers Nov. 75
601	107	12	139	154	621

Total Stock Numbers 1968-1975

	1968	1969	1970	1971	1972	1973	1974	1975
NCC	175	210	260	269	300	295	295	
SCC	223	241	254	260	273	305	309	
Total	398	451	514	528	573	600	601	621

Ewes and gimmers have increased in number by over 50% since the study began. Ewe mortality continued at a low level at 2.0% overall.

Sheep Year 1974/75

(a) Winter feeding

The ewes and gimmers were fed on their original hefts, Hairney Law and Auchope, carrying 292 and 309 respectively. Cereal based feed blocks were made available from late January to the end of the lambing period.

16-18 February
Hairney Law 174 g Sugar Beet Pulp per head per day

19 February to 17 March
Hairney Law 261 g Sugar Beet Pulp per head per day
Auchope 261 " " " " " " " "

11 March to 14 April
Hairney Law 140 g Hay per head per day

17-24 March
Hairney Law 348 g Sugar Beet Pulp per head per day
Auchope 247 " " " " " " " "

25 March
Hairney Law 348 g Concentrate Cobs per head per day
Auchope 328 g Sugar Beet Pulp " " " "

26 March to the onset of lambing
Hairney Law 348 g Concentrate Cobs per head per day
Auchope 329 g " " " " " "

A total of 82 kg Hay was fed to Auchope ewes and gimmers during the entire feeding period. Thereafter feeding continued in the lambing paddocks according to need.

Total feed consumption per ewe:

Hairney Law and Auchope combined -

Hay	2.4 kg
Sugar Beet Pulp	9.4 kg
Protein Concentrate	11.6 kg
Cereal Feed Blocks	5.7 kg

Total cost per head = £2.10

Hoggs, consumption per head:

Hay	9.2 kg
Sugar Beet Pulp	12.4 kg
Protein Concentrate	5.1 kg
Grass Nuts	11.3 kg
Ewe and Lamb feed	0.4 kg

Total cost per head = £2.30

(b) Lambing performance in 1975

Ewes to tup	601
Tup eild) Kebs)	49
Ewe losses to lambing	4
Total lambs born	706 (117.5%)
marked	630 (104.7%)
weaned	617 (102.5%)

(c) Lamb weights (kg)

	1975
Birth weights, singles	4.0
twins	3.5
Marking weights, singles	10.0
twins	9.0
Weaning weights, singles	25.5
twins	27.1

(d) Wool production (kg/ewe)

Age 4 crop	2.1
3 crop	2.1
2 crop	2.2
1 crop	2.1
Gimmers	2.1
All ages	2.1

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

	Nos.	Pre-mating Nov.74	Pre-feeding	Pre-lambing	Marking	Weaning	Pre-mating Nov.75	Nos.
4 crop	83	61.9	58.2	62.0	55.5	58.4	62.7	79
3 crop	90	60.2	57.5	61.6	54.4	58.4	62.3	119
2 crop	129	58.5	55.8	58.9	52.4	57.1	61.0	142
1 crop	153	54.7	52.1	55.4	49.5	54.8	55.8	142
Gimmers	147	48.1	43.7	45.5	41.8	49.5	50.8	139
All ages	292	55.7	52.5	55.5	49.9	55.0	58.0	621

(f) Premating ewe body weight (November) (kg)

	1968	1969	1970	1971	1972	1973	1974	1975
NCC	54.8	56.1	58.9	59.5	60.3	54.7	56.7	58.0
SCC x NCC	47.8	50.2	53.2	55.8	58.2	52.8	54.8	

(g) Production data

	1969	1970	1971	1972	1973	1974	1975
Stock numbers	398	451	518	529	573	600	602
Weaning percentage	84.7	86.5	103.3	104.7	99.5	91.5	102.5
Total weight of lamb weaned (kg)	7785	9189	14178	14046	14193	14329	16042
Total weight of wool	850	1017	1253		1561	1454	1535

YRGS II. On blanket bog - Lephinmore/Midhill

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

Land Resources

The resource consists of 444 hectares mainly on blanket bog. Improved pasture falls into two categories, some 26 hectares of grassy pasture, 14.3 of which was reseeded several years ago, and two larger areas (PI and PII) totalling 69 hectares of unimproved *Calluna* and *Eriophorum* moorland, within which some 35% of the area has been surface seeded to give a mosaic of improved grassy pasture throughout the whole. Ten per cent of this area was created during 1973, 4.5 hectares being established in PII and 5.5 hectares in PI. The remaining 349 hectares is 'open hill'. Further division fences in PI were erected during 1974 to increase the capacity to graze twin nursing ewes and gimmers separately during lactation on improved pasture.

Sheep Stocks

There has been an increase in stock numbers to a total of 458 Blackface ewes.

Livestock Reconciliation 1974/75

Ewes and gimmers Nov. 74	Cast	Deaths	Gimmers brought in	Hoggs born 1974	Ewes and Gimmers Nov. 75
434	73	18	115	125	458

Sheep Year 1974/75

(a) Winter feeding

At the commencement of supplementary feeding the gimmers were moved into PII, the ewes remaining on the hill. The gimmers were also lambed separately. Supplementary feeding began on February 17th.

	Ewes	Gimmers
	Concentrates (g)	
February 17th	-	113
February 18th	-	170
February 26th	113	170
March 17th	227	284
March 18th	284	284
March 21st	340	340
March 24th	454	454
March 31st	567	567
	Early lambers	Late lambers
April 9th	681 g	681 g
April 10th-lambing	567 g	567 g

Supplementary feeding ceased on May 14th. Hay was provided prior to lambing but only 150 g/head was consumed.

Total feed per head	Concentrates	Hay	Total
	20.2 kg	150 g	
Cost	£1.63	£0.01	£1.64

Hoggs: housed November 4-18 to establish hay and concentrate feeding. From November 19 until April 8 they were fed on inbye paddocks as follows:-

November 19	113 g concentrate per head per day
November 20-21	113 g " " " " " plus 300 g hay per head in frosty conditions
December 16	Hoggs separated into 61 better and 57 leaner
January 7	Better hoggs fed 227 g hay and 113 g concentrate
January 13	Leaner hoggs fed 227 g hay and 113 g concentrate
January 23	All hoggs fed 454 g hay and 113 g concentrate
February 17	All hoggs fed 680 g hay and 113 g concentrate

During March any refusals of hay were weighed. Feeding ceased on April 8th and hoggs went to the hill with eild ewes.

Total feed per head	Concentrates	Hay	Total
	17.0 kg	48.4 kg	
Cost	£1.34	£1.91	£3.25

(b) Lambing performance

	1975
Ewes to tup	434
Tup eild	39
Kebs	7
Ewe losses to lambing	7
Total lambs born	435 (100.2%)
marked	403 (92.9%)
weaned	395 (91.0%)

(c) Lamb weights (kg)

Birth weights, singles	3.9
twins	3.1
Marking weights, singles	10.8
twins	10.4
Weaning weights, singles	24.7
twins	22.9

(d) Wool production (kg/ewe)

Age 4 crop	1.7
3 crop	1.8
2 crop	1.6
1 crop	1.8
Gimmers	2.0
All ages	1.8

(e) Ewe body weight change (kg)

Ages	Nos.	Pre-mating Nov.74	Pre-feeding	Pre-lambing	Marking	Weaning	Pre-mating Nov.75	Nos.
4 crop	57	52.9	42.6	48.2	48.4	49.5	52.3	60
3 crop	71	52.9	43.4	48.4	47.9	49.3	50.5	95
2 crop	103	50.2	39.4	44.4	45.3	47.9	48.3	95
1 crop	103	47.0	35.9	40.7	42.0	44.6	44.1	93
Gimmers	100	39.7	35.4	40.5	38.8	41.3	43.2	115
All ages	434	47.9	38.7	43.7	43.8	46.0	47.2	458

(f) Premating ewe body weight (November) (kg)

1968	1969	1970	1971	1972	1973	1974	1975
44.9	49.3	49.4	51.2	49.9	48.3	47.9	47.1

(g) Production data

	1969	1970	1971	1972	1973	1974	1975
Stock numbers (ewes and gimmers)	339	361	373	384	422	433	434
Weaning percentage	85.0	92.5	103.5	103.6	103.3	98.2	91.0
Total weight of lamb weaned (kg)	7207	8500	10268	9924	10218	10870	9638
Total weight of wool (kg)	652	772	772	814	815	856	934

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 at Sourhope includes 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. Hairney Law/Auchope YRGS I, 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 1970, 3.2 hectares of reseed were established with further reseeds added in 1972 (3 ha), 1973 (6.2 ha) (see Farm Reports 1972 and 1973), and in 1974 a further 3.2 hectares. During 1975 all reseeds were treated with 6.3 tonnes per hectare of ground magnesium limestone and 880 kg of superslag (16% P_2O_5) per hectare.

Sheep Stocks

The resource is stocked with Scottish Blackface ewes.

Livestock Reconciliation 1974/75

Ewes and Gimmers Nov. 74	Cast	Deaths	Gimmers brought into flock	Hoggs born 1975	Ewes and Gimmers Nov. 75
242	42	11	67	59	255

Sheep year 1974/75

(a) Winter feeding

During February and March cereal feed blocks were provided.

4-24 March — 210 g Sugar Beet Pulp per head per day

25 March - post lambing — 315 g protein concentrate per head per day

Total feed consumption per head	Ewes and Gimmers		Hoggs	
	Hay	1.5 kg	Hay	4.8 kg
	Sugar Beet Pulp	4.2 kg	Sugar Beet Pulp	10.2 kg
	Protein concentrate	13.0 kg	Grass nuts	8.8 kg
	Feed blocks	2.5 kg	Ewe and lamb feed	1.0 kg
Total cost per head		£1.57		£1.49

(b) Lambing performance

Ewes to tup	242	
Tup eild, Kebs	12	
Ewe losses to lambing	3	
Total lambs born	310	(128.1%)
marked	289	(119.4%)
weaned	282	(116.6%)

(c) Lamb weights (kg)

Birth weights, singles	3.9
twins	3.5
Marking weights, singles	11.4
twins	8.3
Weaning weights, singles	29.8
twins	26.7

(d) Wool production (kg)

Age 4 crop	1.7
3 crop	1.6
2 crop	2.0
1 crop	2.0
Gimmers	2.0
All ages	1.9

(e) Ewe body weight changes (kg)

Age	Nos.	Pre-mating Nov.74	Pre-feeding	Pre-lambing	Marking	Weaning	Pre-mating Nov.75	Nos.
4 crop	35	58.0	55.1	60.6	50.5	52.5	55.8	36
3 crop	41	57.3	54.7	58.2	49.5	53.5	58.1	44
2 crop	50	58.0	56.1	59.9	51.7	55.4	58.0	51
1 crop	55	55.6	52.0	55.1	51.3	55.3	54.2	58
Gimmers	61	51.4	47.1	51.2	46.1	51.8	49.3	67
All ages	242	55.7	52.6	56.5	49.7	53.7	54.5	256

(f) Premating ewe body weights (November) (kg)

1972	1973	1974	1975
54.4	51.8	55.7	54.5

(g) Production data

	1973	1974	1975
Stock numbers	217	222	242
Weaning percentage	112.9	109.0	116.6
Total weight of lamb weaned (kg)	6615	6534	7981
Total weight of wool (kg)	493	490	560

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 for sheep 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 lambing paddock. Further, included with each unit, there is an area of 13 hectares of improved pasture on land which has been limed, slagged and sown with grass and clover seeds. Both of the improved areas have been established for some time.

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

Livestock Reconciliation 1974/75

	Ewes and Gimmers Nov. 74	Cast	Deaths	Gimmers brought into flock	Hoggs born 1975	Ewes and Gimmers Nov. 75
Cairn	190	24	10	50	65	206
Birnie	204	36	8	62	62	222

Sheep Year 1974/75

(a) Winter feeding

Ewes and Gimmers: Concentrates were fed as follows:-

	Cairn g/hd/d	Birnie g/hd/d
February 10	113	113
March 1	284	284
March 17	454	454
March 28 - April 20	681	568

Hay was provided during February, March and April at 500 g per head per day.

Ewes and Gimmers: Total feed given per head was as follows:-

	Cairn kg	Birnie kg
Concentrate	31.3	27.9
Hay	45.0	45.0
Total cost per head	£4.23	£3.96

Hoggs inwintered from 19 December to 29 April. Cairn and Birnie hoggs on identical ration.

	Concentrate g	Bruised Oats g	Hay g
December 19 - February 16	85	85	680
February 17 - April 29	170	85	680

Total feed cost per head:			
	Concentrate	17.09 kg	£1.35
	Bruised Oats	11.05 kg	0.61
	Hay	88.40 kg	3.48
	Total		£5.44

(b) Lambing performance

	Cairn	Birnie
Ewes to tup	190	204
Tup eild	4	7
Kebs	6	5
Ewe losses to lambing	-	3
Total lambs born	260 (136.8%)	279 (136.8%)
marked	223 (117.4%)	236 (114.6%)
weaned	214 (112.6%)	233 (114.2%)

(c) Lamb weights (kg)

	Cairn	Birnie
Birth weights, singles	4.0	4.0
twins	3.4	3.4
Marking weights, singles	13.4	14.8
twins	11.7	12.3
Weaning weights, singles	26.3	28.1
twins	23.5	25.1

(d) Wool production (kg)

	Cairn	Birnie
3 crop	2.1	2.1
2 crop	2.1	2.3
1 crop	2.2	2.2
Gimmers	2.3	2.3
All ages	2.1	2.2

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

Age	Nos.	Pre-mating Nov.74	Pre-feeding	Pre-lambing	Marking	Weaning	Pre-mating Nov.75	Nos.
4 crop	-	-	-	-	-	-	53.6	32
3 crop	50	58.6	53.3	59.7	52.8	53.0	53.0	36
2 crop	43	58.8	52.6	57.7	52.7	52.6	53.4	36
1 crop	41	56.9	49.1	54.0	51.4	51.7	47.8	51
Gimmers	56	50.0	42.5	46.1	45.2	47.0	45.2	49
All ages	190	55.8	49.1	53.9	50.3	50.9	50.0	204

Ewe body weight changes (kg) - Birnie

Age	Nos.	Pre-mating Nov.74	Pre-feeding	Pre-lambing	Marking	Weaning	Pre-mating Nov.75	Nos.
4 crop	-	-	-	-	-	-	55.5	22
3 crop	47	58.3	55.4	59.2	49.8	53.9	57.4	41
2 crop	45	58.3	52.6	57.4	50.5	55.0	56.6	46
1 crop	54	55.8	50.3	55.5	48.9	53.3	52.8	51
Gimmers	58	49.4	44.9	48.3	45.9	50.4	43.3	62
All ages	204	55.1	50.5	54.8	48.6	53.1	52.0	222

(f) Premating ewe body weights (November) (kg)

	1972	1973	1974	1975
Cairn	52.8	51.8	55.8	50.0
Birnie	49.8	49.8	55.1	52.0

(g) Production data

	Stock Numbers	Weaning %	Total Weight lamb weaned	Total Weight Wool (kg)
Cairn 1973	188	97.9	5061	-
1974	191	96.8	5078	-
1975	190	111.6	5307	410
Birnie 1973	204	99.1	5230	-
1974	206	81.9	4459	-
1975	204	115.2	6151	485

YRGS V. Barnacarry/Feorline

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

Introduction

The recent acquisition by the Forestry Commission of Feorline which marches with the Lephinmore, Barnacarry hirsel gave both parties an opportunity to pursue the possibility of integration.

Barnacarry has been of limited value to the Organisation because of difficulty of access.

The Organisation and the Forestry Commission examined the whole area of Feorline and Barnacarry to see whether some re-allocation of land could be made to provide an area of plantable land for the Commission at least as large as would have otherwise been available to them and at the same time provide an agricultural unit with development potential and with suitable access. It was intended that the new unit be used to examine the production and economic implications of the integration of improved land with the unimproved blanket bog vegetation.

Ultimately an exchange of land was agreed. Briefly the Organisation acquired 156 ha of Feorline (71 ha deemed plantable) and the Forestry Commission acquired 95 ha acres of Barnacarry, 92 ha of which were plantable. On the basis of this land exchange the Forestry Commission agreed to provide access roads in advance of the date they would normally have been required for extraction.

The new unit Barnacarry/Feorline extends to some 349 hectares of which approximately 30-40 ha are improvable and accessible for improvement.

Stock numbers will be increased gradually over the next three to five years. This has to be done gradually to assess performance in relation to the new unit. The Feorline hill will be fenced into three areas during 1975-76, viz. a hill area and two smaller areas suitable for improvement but initially used for lambing.

Winter feeding will be based, at least in the early years, on cereal based blocks.

Hoggs will be wintered off the hill.

Land improvement will be done in relation to the increase in stock numbers and levels of individual ewe performance achieved.

Sheep Stocks

Barnacarry/Feorline is stocked with Scottish Blackface ewes.

Livestock Reconciliation 1974/75

Ewe Numbers Nov. 74	Cast	Deaths	Gimmers brought in	Hoggs purchased	Hoggs lambed	Ewes and Gimmers Nov. 75
227	40	11*	67	12	82	243

* (includes 7 'black loss')

Sheep Year 1974/75

(a) Winter feeding

Standard Rumevite blocks were provided for all ewes and gimmers from February 25th on Feorline hill.

Consumption rates were as follows:-

Week 1	77 g/head/day
" 2 and 3	147 g/head/day
" 4	215 g/head/day

High energy Rumevite blocks were introduced on March 27th but consumption dropped sharply; consequently they were replaced with standard blocks on April 11th.

Small numbers of blocks were also used on Barncarry hill for early lambing ewes and in the Croft during lambing.

Total consumption

Feorline	60 standard blocks	1361 kg
	11 high energy blocks	250 kg
Barnacarry	11 standard blocks	250 kg
	8 high energy blocks	181 kg
Croft	4 high energy blocks	91 kg
Cost	71 standard blocks	£163.30
	23 high energy blocks	55.20
		£218.50

Cost per ewe £0.96

(b) Lambing performance

Ewes and Gimmers mated	227
Tup eild and Kebs	28
Ewe losses to lambing	-
Total lambs born	216 (95.2%)
marked	188 (82.8%)
weaned	178 (78.4%)

(c) Lamb weights (kg)

Birth weights	singles	4.4
	twins	3.7
Marking weights	singles	15.1
	twins	14.6
Weaning weights	singles	25.2
	twins	27.2

(d) Wool production (kg)

Age	
5 crop	1.6
4 crop	1.6
3 crop	1.8
2 crop	1.6
1 crop	1.8
Gimmers	1.6
All ages	1.7

(e) Ewe body weight changes (kg)

	Nos.	Pre(74) mating	Pre-feeding	Pre-lambing	Marking	Weaning	Pre(75) mating	Nos.
5 crop	25	51.4	45.9	48.6	50.8	48.9	48.5	19
4 crop	33	52.2	46.7	50.4	51.1	50.8	47.3	33
3 crop	35	50.4	46.7	49.2	49.6	49.4	45.5	39
2 crop	41	46.9	42.9	45.2	48.1	47.9	46.6	42
1 crop	47	47.5	43.0	45.8	48.4	47.9	42.6	43
Gimmers	46	41.5	36.9	38.1	43.3	44.0	41.3	67
All ages	227	47.7	43.1	45.7	48.1	47.8	44.5	243

(f) Production data

	1975
Stock numbers	227
Weaning percentage	78.4
Total weight lamb weaned (kg)	4530
Total weight wool (kg)	468

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 limed 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 reseeded 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. In 1975, ground magnesium limestone at 6.3 tonnes/ha and super-slag (16% P_2O_5) at 880 kg/ha was applied to the Gairs reseed E2.

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 1st May to 31st December.

Sheep Stocks

Both the Rigg and Gairs have carried 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. In 1974 Blackface hoggs were purchased to replace the Cheviot hoggs on both units. It is intended to progressively replace both Cheviot ewe stocks by Scottish Blackfaces.

This has been done in order to test whether, at the given level of inputs and stock number, a greater level of lamb production can be achieved by the use of the Scottish Blackface.

Livestock Reconciliation 1974/75

	Ewes and Gimmers Nov. 74	Cast	Deaths	Gimmers brought in	Hoggs	Ewes and Gimmers Nov. 75
Rigg	298	39	17	65	75	307
Gairs	297	44	13	65	75	305

Total Stock Numbers

	1969	1970	1971	1972	1973	1974	1975
Rigg	205	205	238	278	279	298	307
Gairs	209	207	233	260	279	297	305

Sheep Year 1974/75

(a) Winter feeding

Rigg ewes and ginmers were housed on January 20th
Gairs " " " " " " 29th

Rigg and Gairs were fed identically per head per day from respective housing dated until 16th February as follows:-

		Concentrate g	Sugar Beet Pulp g	Hay g
	Ewes	113	227	567
	Ginmers	113	227	454
	66 Lean Ewes	170	227	567
17/2 - 7/3/75	Ewes	113	227	567
	Ginmers	113	227	567
	Lean Ewes	170	227	567
8/3 - 16/3/75	Ewes	113	227	567
	Ginmers	170	227	567
	Lean Ewes	170	227	567
17/3 - 23/3/75	Ewes	170	227	628
	Ginmers	170	227	567
	16 Lean Ewes	227	227	628
24/3 - 30/3/75	Ewes	227	227	628
	Ginmers	227	227	567
	Lean Ewes	284	227	628
31/3 - 6/4/75	Rigg Ewes	284	227	628
	Gairs Ewes	227	227	628
	Ginmers	227	227	567
	Lean Ewes	341	227	628
7/4/75-post lambing	Rigg Ewes	341	227	628
	Gairs Ewes	284	227	628
	Ginmers	284	227	567
	Lean Ewes	397	227	628

Total feed per head (kg):

	Concentrate	Sugar Beet Pulp	Hay	Ewe and Lamb Feed	Grass Nuts	Cost
Ewes and ginmers	18.2	18.8	49.0	-	-	£4.53
Hoggs	15.1	5.3	39.7	0.7	5.3	£3.48

(b) Lambing performance

	Ewes and Ginmers mated	Tup eild and Keb	Ewe Losses to lambing	Total Lambs born	Marked	Weaned
Rigg	298	14	3	308 (103.4%)	280 (94.0%)	267 (89.6%)
Gairs	297	31	3	311 (104.7%)	265 (89.2%)	259 (87.2%)

(c) Lamb weights (kg)

		Rigg	Gairs
Birth weights	singles	4.0	4.1
	twins	3.5	3.2
Marking weights	singles	9.6	9.7
	twins	10.5	9.3
Weaning weights	singles	23.5	25.3
	twins	23.1	22.0

(d) Wool production (kg)

	Rigg	Gairs
4 crop	1.9	1.9
3 crop	2.0	2.1
2 crop	2.0	2.2
1 crop	1.7	2.2
Gimmers	2.1	2.2
All	2.0	2.2

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

Ages	Nos.	Pre-mating Nov.74	Pre-feeding	Pre-lambing	Marking	Weaning	Pre-mating Nov.75	Nos.
4 crop	25	54.1	53.0	57.3	47.7	51.6	56.6	57
3 crop	60	55.4	52.0	57.1	49.8	54.1	53.8	66
2 crop	77	52.1	48.9	53.8	47.1	51.3	52.4	62
1 crop	70	48.0	46.4	50.9	44.4	49.6	48.7	61
Gimmers	66	43.3	43.9	47.3	40.9	46.2	48.2	65
All ages	298	50.0	48.2	52.6	45.8	50.3	51.8	311

Gairs

Ages	Nos.	Pre-mating Nov.74	Pre-feeding	Pre-lambing	Marking	Weaning	Pre-mating Nov.75	Nos.
4 crop	29	57.3	54.9	58.8	50.0	52.9	56.4	57
3 crop	62	57.7	54.4	58.3	49.9	55.3	58.0	51
2 crop	68	57.9	55.0	59.2	51.3	56.6	55.2	64
1 crop	68	52.8	50.1	54.3	47.4	53.3	51.5	68
Gimmers	70	47.2	46.6	48.9	42.3	48.7	49.3	65
All ages	297	54.1	51.7	55.4	47.8	53.2	53.8	305

(f) Premating ewe bodyweights (November) (kg)

	1969	1970	1971	1972	1973	1974	1975
Rigg	48.3	49.7	51.5	51.2	50.6	50.0	51.8
Gairs	49.9	50.5	51.9	53.5	52.9	54.1	53.8

(g) Production data - Rigg

	1970	1971	1972	1973	1974	1975
Stock numbers	205	205	238	278	279	311.
Weaning percentage	83.0	87.0	100.8	87.8	91.0	89.6
Total weight of lamb weaned (kg)	3706	4432	5712	5324	6155	6257
Total weight of wool (kg)	402	534	641	732	680	670

(g) Production data - Gairs

	1970	1971	1972	1973	1974	1975
Stock numbers	209	207	233	260	279	305
Weaning percentage	83.0	96.0	91.4	93.1	87.0	87.2
Total weight of lamb weaned (kg)	3581	5246	5176	5675	6394	6381
Total weight of wool (kg)	461	524	634	752	766	732

IWS II. On blanket bog - Lephinmore/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, limed 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 1974/75

	Ewes and Gimmers Nov. 74	Cast	Deaths	Gimmers brought in	Hoggs born 1975	Ewes and Gimmers Nov. 75
'Inwintering'	176	20	10	46	71	192
'Inwintering + land improvement'	174	24	8	45	70	187

Total Stock Numbers

	1969	1970	1971	1972	1973	1974	1975
'Inwintered'	106	114	142	165	176	176	192
'Inwintered + land improvement'	106	112	137	160	174	174	187

Sheep Year 1974/75

(a) Winter feeding

Treatment and control ewes and gimmers were housed on 21st January and fed same rations per head per day as follows:-

	Concentrate g	Hay g
January 22	113	907
March 4	170	907
March 10	284	907
March 21	397	907
March 31	510	907
April 7	as above except that early lambing ewes concentrate increased to 567 g	
April 21	Ewes 567 g concentrate, 907 g hay Gimmers 454 g concentrate, 907 g hay	
May 12	All concentrate feeding ceased	

Total amounts fed per head were as follows:

Concentrate	26.1 kg	cost	£2.05
Hay	81.9 kg	cost	£3.23
		Total cost	£5.28

(b) Lambing performance

	Inwintered	Inwintered + land improvement
Ewes to tup	176	174
Tup eild	20	26
Keb	2	2
Ewe losses to lambing	2	2
Total lambs born	162 (92.0%)	171 (98.3%)
marked	148 (84.1%)	151 (86.8%)
weaned	144 (81.8%)	145 (83.3%)

(c) Lamb weights (kg)

		Inwintered	Inwintered + land improvement
Birth weights,	singles	3.9	3.9
	twins	3.1	3.1
Marking weights,	singles	11.9	13.1
	twins	11.1	10.3
Weaning weights,	singles	27.2	26.8
	twins	20.5	22.4

(d) Wool production (kg)

	Inwintered	Inwintered + land improvement
4 crop	1.5	1.5
3 crop	1.7	1.7
2 crop	1.6	1.7
1 crop	1.6	1.5
Gimmers	1.8	1.8
All ages	1.7	1.7

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

Age	Nos.	Pre-mating Nov.74	Pre-feeding	Pre-lambing	Marking	Weaning	Pre-mating Nov.75	Nos.
4 crop	9	49.4	48.5	52.9	50.4	48.9	48.0	18
3 crop	27	48.5	47.3	53.0	50.3	49.7	49.0	34
2 crop	37	47.4	45.1	50.5	48.9	48.8	47.6	28
1 crop	32	44.5	42.4	47.0	46.7	47.0	44.1	66
Gimmers	71	41.5	40.3	44.6	44.0	44.8	40.9	46
All ages	176	46.3	43.2	48.0	46.8	47.0	45.2	192

(e) Ewe body weight changes - Inwintered + Land Improvement (kg)

Age	Nos.	Pre-mating Nov.74	Pre-feeding	Pre-lambing	Marking	Weaning	Pre-mating Nov.75	Nos.
4 crop	12	53.8	48.5	53.0	55.0	54.0	49.1	24
3 crop	28	53.0	46.6	52.0	51.0	50.8	50.5	25
2 crop	31	52.4	46.7	51.8	53.5	53.7	47.2	33
1 crop	37	47.0	42.4	47.3	47.4	49.0	44.9	63
Gimmers	66	43.2	40.7	45.5	43.7	44.2	41.5	45
All ages	174	48.0	43.6	48.6	48.1	48.6	45.7	187

(f) Premating ewe bodyweights (kg)

	1969	1970	1971	1972	1973	1974	1975
Inwintered	50.0	49.3	48.2	47.2	43.0	46.3	45.2
Inwintered + land improvement	49.5	49.4	48.5	49.2	45.8	48.0	45.7

(g) Production data - Inwintered

	1970	1971	1972	1973	1974	1975
Stock numbers	106	114	142	165	176	176
Weaning percentage	80.0	93.0	103.5	92.8	78.4	81.8
Total weight lamb weaned (kg)	2279	2857	3775	3775	3414	3902
Total weight wool (kg)	205	257	282	293	354	363

Production data - Inwintered + Land Improvement

	1970	1971	1972	1973	1974	1975
Stock numbers	106	112	137	160	172	174
Weaning percentage	71.0	104.5	97.1	102.5	76.2	83.3
Total weight lamb weaned (kg)	2015	3324	3511	3800	3232	3799
Total weight wool (kg)	179	246	274	304	328	355

UPLAND (03008)

Sheep production systems in the uplands
T.J. Maxwell, J. Eadie, R.D.M. Agnew and I. Stephen

1. 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.

Four systems of production under study are as follows:-

1.	Greyface	ewes	stocked	at	4	ewes/acre	starting	lambing	7th	March
2.	"	"	"	"	6	"	"	"	7th	"
3.	"	"	"	"	4	"	"	"	7th	April
4.	"	"	"	"	6	"	"	"	7th	"

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, 4.78 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 acreage of the respective systems were 5.13, 4.71, 4.47 and 4.43 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

Scottish Blackface x Border Leicester (Greyface) ewes are used and are mated with a Dorset Down ram.

Livestock Reconciliation 1974/75

System	Ewes and Gimmers 1974	Cast	Deaths	Gimmers brought in	Ewes and Gimmers 1975
1	51	15	3	18	51
2	72	15	6	21	72
3	44	9	3	12	44
4	65	8	4	13	66

The number of ewes for each system is now up to the total required. Mortality averaged 6.9% for the four systems.

Sheep Year 1974/75

(a) Winter feed

Hay and concentrates were offered to the early lambing flocks from 7th January (8 weeks prepartum) at the rate of 0.7 kg and 113 g respectively. From 14th January all four flocks were offered 113 g concentrate whilst hay allowance for the late lambers started at 0.9 kg and continued at 0.7 kg for the early lambers until 21st January. Thereafter 0.9 kg hay per head per day was offered to all four flocks, diminishing in proportion to concentrate feeding towards lambing. Prelambing 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 1.4 kg for the early and 1.1 kg for the late lambing flocks, hay consumption fell to 0.23 kg. Feeding into lactation continued until 22nd May except in the case of flock 2 where it continued until 11th June.

<u>Mean plasma ketone levels and subsequently determined concentrate feed levels</u>

(Aim was to keep plasma ketone levels below 3 mg %)

Early lambers	7/1/75		14/1/75		21/1/75		28/1/75		4/2/75		11/2/75		18/2/75		25/2/75	
Mean plasma ketone level (mg %)	3.79		2.18		2.68		4.97		3.69		4.14		3.47		3.97	
	Hay	Conc.	Hay	Conc.	Hay	Conc.	Hay	Conc.	Hay	Conc.	Hay	Conc.	Hay	Conc.	Hay	Conc.
Current feeding (kg)	0.7	0.11	0.7	0.11	0.7	0.11	0.9	0.17	0.9	0.34	0.9	0.51	0.8	0.65	0.8	0.80
Additional feeding (kg)	-	-	-	-	+ 0.2	+ 0.06	-	+ 0.17	-	+ 0.17	- 0.1	+ 0.14	-	+ 0.15	- 0.3	+ 0.11
New feed levels (kg)	0.7	0.11	0.7	0.11	0.9	0.17	0.9	0.34	0.9	0.51	0.8	0.65	0.8	0.80	0.5	0.91

Late lambers	28/1/75 ...		————→		18/2/75		25/2/75		6/3/75		13/3/75		18/3/75		25/3/75	
Mean plasma ketone level (mg %)	2.70				2.24		3.04		-		5.67		1.99		4.00	
	Hay	Conc.	Hay	Conc.	Hay	Conc.	Hay	Conc.	Hay	Conc.	Hay	Conc.	Hay	Conc.	Hay	Conc.
Current feeding (kg)	0.9	0.11	0.9	0.11	0.9	0.11	0.9	0.22	0.9	0.34	0.8	0.45	0.8	0.68	0.8	0.91
Additional feeding (kg)	-	-	-	-	-	+ 0.11	-	+ 0.11	- 0.1	+ 0.11	-	+ 0.23	-	+ 0.23	- 0.35	-
New feed levels (kg)	0.9	0.11	0.9	0.11	0.9	0.22	0.9	0.34	0.8	0.45	0.8	0.45	0.8	0.91	0.45	0.91

Total Feed Inputs and Cost per Ewe

Systems 1 and 2

	Prelambing kg	Prelambing £	Lactation kg	Lactation £	Total kg	Total £
Concentrate	36.1	2.91	82.7	6.51	118.8	9.42
Hay	48.8	1.92	9.1	0.36	57.9	2.28
Total cost		4.83		6.87		11.70

Systems 3 and 4

	Prelambing kg	Prelambing £	Lactation kg	Lactation £	Total kg	Total £
Concentrate	32.6	2.56	44.5	3.50	77.1	6.06
Hay	73.8	2.90	6.4	0.25	80.2	3.15
Total cost		5.46		3.75		9.21

(b) Lambing performance

System	Ewes to tup	Eild	Ewe losses to lambing	Total lambs born %	Total lambs marked %	Total lambs weaned %
1	51	1	-	93(182.4)	75(147.1)	72(141.2)
2	72	-	-	135(187.5)	116(161.1)	114(158.3)
3	44	1	-	78(177.3)	70(159.1)	70(159.1)
4	65	1	-	105(161.5)	92(141.5)	92(141.5)
	232	3	-	411(177.2)	353(152.2)	348(150.0)

Lamb types

System	No. ewes lambed	Ewes producing - Singles No.	Singles %	Twins No.	Twins %	Triplets No.	Triplets %
1	43	4	9.3	28	65.1	11	25.6
2	69	14	20.3	44	63.8	11	15.9
3	42	10	23.8	28	66.7	4	9.5
4	62	21	33.9	38	61.3	3	4.8
	216	49	22.7	138	63.9	29	13.4

(c) Lamb weights (kg)

System	Birth Singles	Birth Twins + Mult.	Birth All	Marking Singles	Marking Twins + Mult.	Marking All	Weaning Singles	Weaning Twins + Mult.	Weaning All
1	4.1	4.2	4.2	14.9	12.2	12.7	34.4	29.2	30.0
2	4.3	4.2	4.2	15.0	11.5	12.1	33.8	28.1	29.1
3	4.4	4.2	4.3	18.4	15.1	15.7	37.3	30.9	32.1
4	4.9	4.3	4.5	19.4	14.2	15.8	34.5	29.8	31.2

Lamb mortality

System	Total lambs born	Born dead No.	Born dead %	Birth-Marking No.	Birth-Marking %	Birth-Weaning No.	Birth-Weaning %
1	93	2	2.1	16	17.2	19	20.4
2	35	2	5.5	17	12.6	19	14.1
3	78	2	2.6	6	7.7	6	7.7
4	105	2	1.9	12	11.3	12	11.3

(d) Wool production

System	Age of ewe: 1 crop	2 crop	3 crop	4 crop	5 crop	Mean
1	2.6	2.8	2.9	3.1	2.8	2.8
2	2.8	2.9	2.8	2.7	4.0	2.8
3	2.9	2.7	2.8	3.0	-	2.8
4	2.7	2.6	2.7	2.6	-	2.7

(e) Ewe body weight change 1974/75 (kg)

System	Pre-mating	Pre-feeding	Pre-lambing	Marking	Clipping	Weaning	Premating
	7/10/74	7/1/75	25/2/75	17/4/75	12/6/75	3/7/75	6/10/75
1	72.4	73.1	75.8	63.7	69.8	64.0	72.7
2	70.6	68.4	72.2	60.8	64.2	62.6	68.2
	4/11/74	4/2/75	25/3/75	16/5/75	26/6/75	29/7/75	11/11/75
3	69.3	63.7	71.3	64.0	69.5	64.5	72.8
4	65.7	59.4	65.6	61.2	68.9	65.1	70.1

(f) Total production data

System	Nos.	Weaning %	Total weight lamb weaned (kg)	Weight of lamb per ewe	Weight of lamb per hectare	Weight of Wool
1	51	141.2	1850.4	36.3	361.4	123.7
2	72	158.3	2724.6	37.8	578.5	186.1
3	44	159.1	2233.0	50.8	499.6	109.7
4	65	141.5	2870.4	44.2	647.9	160.1

(g) Fertilizer inputs

Nitrogen was applied to all treatments at the rate of 247 units per hectare per annum.

When the 10 cm soil temperature reached 5.5°C in mid-April, the Bowes Field (A) and the Forestry Park (D) received 185 units of nitrogen per hectare, whilst the Hard Park (B) and the Hogg Park (K) received 124 units per hectare.

After conserved pasture had been harvested on June 28th paddocks A and D received 62 units of nitrogen per hectare and 27 units each of phosphorus and potassium per hectare.

Paddocks B and C received 62 units of nitrogen per hectare on June 10th and the final 62 units per hectare after weaning in early August.

Pasture Measurements

Weight of herbage DM cut to ground level - kg per ewe

Flock	30/4	8/5	15/5	21/5	28/5	11/6	25/6	10/7	23/7	7/8	20/8	3/9	17/9	2/10	25/11
1	45.3	74.6	48.6	51.0	49.4	52.0	69.7	200.4	199.0	268.9	301.4	285.9	240.6	249.0	180.4
2	14.3	25.9	24.9	34.0	24.9	49.3	65.0	89.1	113.6	171.7	168.5	164.2	149.6	119.1	64.2
3	41.6	77.7	45.2	46.7	53.3	47.8	49.7	153.7	118.4	168.7	236.6	233.4	234.3	208.1	156.0
4	20.2	37.3	44.5	44.5	44.5	52.6	74.8	78.1	86.8	127.8	134.5	144.0	139.0	111.8	70.4

Amount of herbage DM cut to ground level - kg per hectare

1	450	624	668	702	681	713	960	1680	1629	2202	2468	2843	2392	2476	1793
2	219	304	293	469	344	681	897	1249	1591	2406	2254	2510	2286	1821	954
3	410	695	681	704	802	720	730	1306	1006	1434	2011	2298	2307	2048	1536
4	300	436	453	623	603	713	979	1058	1176	1731	1823	2146	2071	1666	1049

Estimate of hay production

The yield estimates are based on pasture sampling measurements taken on 25th and 26th June, when the grass was at an optimum for cutting to achieve a high digestibility and high yield.

System	Area Conserved	Total hay yield (tonnes)	Total yield (tonnes/hectare)
1	2.008	7.48	3.72
2	-	-	-
3	1.815	7.57	4.17
4	-	-	-

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

2. Botanical Analysis

Pasture sampling results and carrying capacity during the 1974 and 1975 grazing seasons have demonstrated differences in productivity between the various pastures available (Table 1). A preliminary study to examine some of the reasons for this was made in 1975.

Table 1. Estimated herbage production (kg DM/ha)

	Bowes Field	Hard Park	Hogg Park	Forestry Park
1974	7782	5961	7587	9387
1975	5765	6021	6959	8217

Forestry Park is an area of old permanent pasture reseeded once in 1959 whilst the Hard and Hogg Parks were reseeded with a predominantly ryegrass mixture in 1973 and 1972 respectively. It is notable that Forestry Park has produced between 55 and 18 per cent more herbage than Hard Park and Hogg Park during 1974 and 1975.

The first stage of the study was a botanical survey carried out during September and October 1975. This was confined to Hard Park, Hogg Park and Forestry Park.

A point quadrat method was used to characterise the three areas of pasture whereby individual species occurring at each of 1200 points was recorded.

Table 2 gives the percentage ground cover of the main pasture grasses, clover and bare ground.

Table 2.

Species of Pasture Grasses	Hard Park	Hogg Park	Forestry Park
Lolium perenne	91	95	27
Agrostis tenuis		2	31
Festuca rubra		1	30
Poa pratensis	1	13	37
Phleum pratense	9	12	25
Dactylis glomerata	-	1	38
Holcus lanatus	-	1	20
Trifolium repens	14	5	11
Bare ground	14	7	3

The total number of species identified was 28 of which 13 were present in the Hard Park, 16 in the Hogg Park and 24 in the Forestry Park. A statistical analysis is in progress.

SIMULATION (03009)

1. Agrostis/Festuca grazing model

A.R. Sibbald, T.J. Maxwell, D.A. Vine and J. Eadie

The nature of the selection process in the grazing model has been under investigation and as a result a new selection procedure has been incorporated. The model originally represented selection by the partitioning of the calculated intake quantity into selected and unselected material. It was considered that this approach was too inflexible in relation to the application of other parameters that might be considered to influence selection.

The new procedure relates a Selection Index (in the range 0 to 1) to grazing pressure, the lower the grazing pressure the higher the value of the index. The Selection Index is then used to establish the slope of a line of 'Grazing Bias', related to digestibility class of the pasture. The bias is used to "distort" the current digestibility distribution so that the more preferred, higher digestibility classes appear larger. A random number generator, based on the "distorted" pasture distribution, is then used to allocate composite bites to the actual pasture distribution, the effect being that the more preferred classes are grazed more frequently than their actual contribution to the current pasture distribution would allow if grazing was unbiased. (Composite bites are a bulked up effect of a number of individual bites, to reduce computing time). The selection procedure continues until the required quantity of intake is achieved.

The new procedure produces results from the grazing model which respond in a similar manner to the original partitioned selection procedure but is more easily manipulated to test the sensitivity of the model's response to changes in the degree of selection permitted. The slope of Grazing Bias can also be further changed by the action of other parameters, both animal and pasture, that might be considered to influence selection.

2. Land use

T.J. Maxwell, A.R. Sibbald and Forestry Commission

The basis for decision making with regard to land use in the hill areas between agricultural and forestry may be improved if the consequences of particular allocation strategies were more precisely defined in terms of production and economic criteria.

An initial approach to this problem is to build a model which can take account of the various components of decision making which lead ultimately to solutions of agricultural and forestry integration; the objective being that integration proceeds on the basis of the highest common factor of mutual interest.

The use of linear programming has been employed to test a number of alternative solutions. The nature of forestry activity and decision making is such that linear programming is a useful means of approach; this mainly arises out of the fact that land units can be treated as being largely independent of other land units with respect to levels of production, i.e. they are additive. This is not so in agriculture. To overcome the limitations of linear programming a more flexible model which deals with the choice of land blocks and which incorporates the decision rules for these choices for agriculture is being built. This limits the number of solutions for integration in relation to the particular objective function chosen, e.g. financial output, labour units, capital, etc.

DATA HANDLING (03004, 03005, 03008, 01004, 48001)
A.R. Sibbald, E.V. Deans, T.J. Maxwell

The programme of maintenance, checking, summarising and analysis of records from each of the development projects has continued. During the year records from 10 projects amounting to 3921 ewes, 4592 lambs and 903 hoggs have been handled.

For the recording year 1975/76 a proportion of the records, in fact all those from Glensaugh projects, have been transferred from the Regional IBM 370 computer to the PDP 11/20 computer at SIAE, Bush Estate. The experience of this service, in conjunction with other factors, will be used to determine the feasibility of running all the routine data handling on a PDP 11 computer.

In addition a new data handling system for the Hill Sheep Development Project, organised under the auspices of the Scottish Agricultural Development Council and for which Dr. Robin H. Armstrong is consultant, has been planned, again using the PDP 11/20 at SIAE. The programs for updating, checking and summarising the data are presently being tested.

BIOLOGICAL MONITORING (03004/03005)

1. The influence of changes in management associated with the development of new systems on the occurrence of premature broken mouth
R.G. Gunn and W.F. Smith

In the Sourhope IWS on Rigg and Gairs, after a similar incidence of broken mouth (20%) in the draft age in 1971, a differential pattern has developed over the four years 1972-75. The incidence in the control flock on Rigg has risen to a mean 67% while that in the Gairs flock has stabilised at a significantly lower 40%. Since 1971 the Gairs flock has had available a substantial area of improved pasture.

In the YRGS flocks this year there has been a tendency for the incidence to rise relative to previous years. This has been particularly the case on Sourhope/Alderhope (50%) and Sourhope/Hairney Law (33%) with even Lephinmore/Midhill rising from a mean 6% to 22% this year.

In the Lephinmore IWS on Low End, the use of hay racks with plastic mesh covers has been compared with that of racks with metal mesh, on the amount of physical stress imposed on the incisor teeth during the inwintering period. Within each age group, ewes were allocated to the two types of hay rack cover in January 1973 or when subsequently entering the flock as hoggs. All animals remained under their respective treatments each successive winter and their mouths were examined annually in March over four years. Counts were made of the number of permanent incisors erupted and missing, and the bite position on the pad and degree of looseness of the teeth were subjectively assessed by a single operator.

The teeth moved forward and became looser with age and they began to be lost from about four years of age but there were no differences between the treatments in any of these parameters studied. This study has therefore been terminated.

2. Monitoring soil changes in improved areas of development systems
M.J.S. Floate and A.D. Ironside

The sampling of soils in the improved paddocks of Hairney Law and Auchope was completed early in 1975. The samples have been prepared for analysis but results are not yet available.

Plant DM production data have been collected for P_I at Lephinmore in 1975 but no data have been collected this year for the adjacent indigenous areas. No soil samples were taken from this site in 1975 as the problems regarding the relative fertility of improved and unimproved areas had been resolved and reported in the Annual Report for 1974 (HFRO 206).

3. Botanical monitoring of paddocks in the year-round grazing system at Lephinmore
J.A. Rogers

The programme of sampling each reseeded area every two years has continued. No major changes in botanical composition have been recorded as yet.

VETERINARY MONITORING (03004, 03005)

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

		1974	1975
Faecal worm egg counts		2600	3164
Pasture larvae counts		80	106
Tracer lamb postmortems and total worm counts		16	24
Snail counts		52	72
Nematode worm cultures		30	60
* Blood samples for Vitamin B_{12} estimations		300	1400
* Blood samples for Copper estimations		1000	1900
Miscellaneous:	Haematology Plasma pepsinogens Bacteriological Fleece samples	30	97

* These estimations are carried out in the biochemistry departments under C.C. Evans and E. Skedd and we are grateful for their co-operation.

These figures show an increase in the laboratory work by the veterinary section and this will probably continue to expand. Development work requires constant monitoring for the presence of disease. It is apparent that when systems are extended beyond certain limits some of the consequences may be expressed in disease. This can be illustrated by reference to the build up of roundworm infestations in lambs in particular. High stocking numbers can create high pasture worm burdens. Where there is no clean pasture available protection can only be achieved by strategic dosing with anthelmintics. This only removes the worms from the lamb without preventing the re-acquisition of worms from the pasture. It may be possible where cattle and sheep are integrated in a system to formulate species grazing regimes which will help to provide a measure of clean pasture for young lambs.

The monitoring has also revealed areas for investigation and research - such as liver fluke disease at Lephinmore and copper and cobalt deficiencies at Sourhope and Glensaugh.

Records kept at the farms of ill-health and deaths, combined with post-mortem results from the investigation centres, provide an accurate assessment of the disease picture at each farm. The co-operation of farm staff in this and in assisting at samplings is acknowledged.

LEPHINMORE

SHEEP

The overall losses in sheep were low in 1975. More sheep were lost through 'couping' and injury than through disease.

Liver fluke disease

The inclusion of rafoxanide doses into the veterinary preventive programme has resulted in a marked reduction in the percentage of ewes passing fluke eggs in the faeces. There have been no cases of clinical fascioliasis in the sheep and no evidence of liver fluke has been found in sheep sent for post-mortem to the Veterinary Investigation Centre at Oban. The dosing strategy was designed to kill the majority of flukes before they reached egg-laying capacity (i.e. whilst immature) and thereby to severely limit the deposition of eggs upon the pasture.

Percentages of ewes passing eggs in faeces were as follows:-

YRGS Midhill	70% in February 1973	Nil in February 1975
IWST Lowend	86.5% in " 1974	16% " " 1976
IWSC Lowend	18% in " 1974	Nil " " 1976

This work has been prepared as a paper for publication.

Cobalt and copper deficiencies (02006)

Monitoring for the level of these continues. Cobalt bullets have been used prophylactically in the sheep stock.

Nematodirus forecasting

On the plots larvae began to appear in appreciable numbers during the second and third weeks of April and continued until the beginning of June. The weekly mean 4" soil temperature rose above 40°F during the week ending April 12th giving a good correlation with the start of larval activity. There was no significant difference this year between hatching periods of the plots at sea level and 700 feet.

Lephinmore P1. The level of larvae was such as to produce burdens in lambs which were unlikely to affect lamb performance.

Lephinmore P2. The level of larvae was such as to produce heavy burdens in lambs with a severe setback in performance - accordingly prophylactic anthelmintic treatment at routine intervals during the danger period was instituted.

The levels in 1975 could be significant in producing a high risk of nematodiriasis in 1976 and monitoring will continue in that year.

Indoor lambing IWS T & C

Good standards of hygiene were maintained in the house. The incidence of disease was very low. A few cases of Toxoplasma abortion did occur but the level did not give cause for concern.

Contagious opthalmia

A reduced incidence of this disease was noted.

CATTLE

There were no disease problems in the herd at Lephinmore.

SOURHOPE

SHEEP

Overall losses were low.

Cobalt and copper deficiencies (02006)

Investigations into these continue at Sourhope.

Studies include -

a) The persistence of cobalt bullets in ewes, hoggs and lambs and the protection derived from their use.

b) The investigation of life-time performance between cobalt-bulletted and undosed sheep.

c) A comparison between cobalt-bulletted and Vitamin B_{12} injected lambs.

d) The effects of copper deficiency upon lambs, reared in a copper deficient production pasture, in lamb performance.

Parasitic gastro-enteritis

This has not been a problem in lambs at Sourhope. Tracer lambs indicated that without strategic dosing, problems could be encountered.

The season in autumn 1975 after the warm summer resulted in a high uptake of larvae in hoggs which were housed. These were of the 'inhibited' type and being fairly resistant to anthelmintic treatment were unaffected by the dose given ten days after housing. They later matured and faecal egg counts were high, necessitating a further dose. This type II ostertagiasis is a very serious disease in housed calves and its occurrence in housed sheep will be checked in future years.

Dystocia in South Country Cheviot gimmers

Further to the work in 1974, published in 1975, an investigation into this problem was carried out in 1975.

The level of assistance required was almost identical in 1975 but between-group differences in prelambing nutrition showed more readily defined differences in the group levels of dystocia.

Perinatal losses

These have been low. A more accurate form of recording of losses has been adopted for 1976.

Scrapie

A major cause for concern was the occurrence of scrapie in the Rigg South Country Cheviot sub-flock. There were three clinical cases in 1975, all confirmed histologically. The Rigg portion of the Rigg/Gairs project is the one under pressure and it may be that the occurrence of clinical cases on that side alone is a manifestation of that pressure.

All female relatives of these animals still in the flock have been culled. The position will be under close scrutiny in 1976 and subsequent years.

CATTLE

The incidence of disease has been low. A clinical case of listeriosis with atypical symptoms was of academic interest.

GLENSAUGH

SHEEP

There have been disease problems in the sheep in 1975 which require careful investigation. Recording of ill-health has been improved and the co-operation of staff in this is acknowledged.

Louping ill

The emergence of this disease in hoggs on the Cairn in July has led to vaccination being implemented on the Cairn and Birnie. There are no records of this disease having occurred during the period when the farm has been used by the Organisation.

The introduction of the disease may be related to either the increase in the hare population bringing in infected ticks to the area, or to grouse providing infection to the ticks resident in the area, or to both. Grouse are known to be reservoir hosts of the virus. Alternatively, the disease may have been present already and have shown an increase in virulence to susceptible hosts.

Jaagsiekte

The occurrence of this disease in two Greyface ewes is a cause for concern. Like scrapie this disease has a long incubation period and there is no specific diagnostic test for pre-clinical cases, It can be a serious disease in intensive flocks and particularly in housed sheep. It is probable that the disease was bought in with the Greyface flock. The Greyface flock is segregated from all other sheep and no lambs are retained for breeding.

Copper deficiency

As in 1974 Cairn and Birnie ewes showed low blood copper levels in early pregnancy and copper injections were given to remove the risk of sway-back.

Ill-thrift in lambs

A complex of parasitism, cobalt and copper deficiencies exists at Glensaugh. It is difficult to determine the relative importance of each component, and poor lambs occurred principally post-weaning. The factor of most importance is thought to be the lack of 'clean' pasture. Difficulties occur associated with yearly climatic variations, particularly temperature and rainfall - influencing worm larval survival, the degree of leaching of trace elements and pasture availability.

Intensive scanning investigations are proposed for 1976 and it is hoped to obtain lambs from different flocks and to follow these through to give information on this problem which will be of use in proposing preventive procedures.

Type II Ostertagiasis

Ostertagiasis occurred in housed hoggs despite anthelmintic treatment after entry. The uptake of inhibited larvae in the autumn was a consequence of the climatic conditions in autumn 1975 and the lack of clean pasture.

Close monitoring will be done in 1976.

Pneumonia

A group of ewes of draft age kept low in condition for work in reproduction suffered losses from pneumonia. Pastuerella organisms were isolated.

In housed hoggs an outbreak of pasteurella type pneumonia necessitated antibiotic treatment over a period. The disease had an adverse effect upon these animals which also suffered from the type II ostertagiasis. The house is of poor design from the point of view of respiratory disease - having a low roof and having ventilation problems. Alterations have been suggested which may help.

It is worth noting that pneumonia was prevalent in the country in the autumn and winter of 1975 both in sheep and cattle.

CATTLE

See Animal Nutrition and Production Section (02008).

SURGERY

Cannulation Rumen	15
Duodenal and Ileal cannulation	4
Oesophageal fistulation	6
Ruminal plug insertion	6
Vasectomies for Teaser tups	21
Endoscopies Reproduction	43

Pre-operative preparation and post-operative care is performed by the veterinary staff.

DEER (05001)

Transport of deer between House o' Muir and the metabolism room at Bush is facilitated by the use of Immobilon and Revivon injected on a weight basis, and this has also been used for simple procedures such as castration and foot trimming.

C. PLANTS AND SOILS

NUTRIENT INTERACTIONS (04001)

Relationships between aluminium, organic matter and lime requirement in hill soils

Field plot experiments have been established on peat and brown forest soils with the following objectives:-

a) to measure the soil pH response to field lime application

b) to observe the establishment and survival of ryegrass and white clover under a range of pH conditions

c) to provide soil for further laboratory studies of the distribution of exchangeable Al^{3+} and H^{+}.

1. Lime response on brown forest soil (St-1)
M.J.S. Floate and A.D. Ironside

The Site at Stanhope was prepared in spring 1975 and after rotovation was seeded in April. The very dry season was not conducive to good establishment but plant counts were made in May, June, July and a harvest cut was taken in August. Slow growth due to dry weather, and grazing by rabbits and hares prevented any further harvest cuts being made. The plant count results are presented in Table 1: data for DM production are not yet available and await the completion of grass/clover separations.

Table 1. Plant counts on lime response expt. (St-1)

Treatment (ton/ac)	Grass			Clover		
	22.5.75	24.6.75	31.7.75	22.5.75	24.6.75	31.7.75
0	105	110	94	46	41	33
¼	96	91	89	46	38	34
½	84	87	75	49	39	31
¾	79	87	86	28	27	25
1	67	78	76	42	34	27
2	71	87	72	46	34	32

all units plants per 4 quadrats (x1.11 = plants/m^2)

There were no significant differences in plant numbers on any occasion due to treatment but there is some indication that plant numbers are falling. Overall there was a 2% fall in grass numbers and a 29% fall in clover numbers between first and third counting dates. There was also some indication that grass numbers may be falling more rapidly on the lower lime treatments but no such trend can be observed for clover. Lime treatments were applied in April and soil samples for pH and exchangeable Al^{3+} and H^{+} determination were taken in June. pH values ranged from 4.2 to 5.9 but there was a wide range of values for each lime treatment despite careful spreading of lime by hand. The results are illustrated in Fig.1.

In view of the wide spread of pH values for each treatment the plant count data were evaluated to see if there was any relationship between plant numbers and soil pH. There was no correlation between the numbers of either grass or clover plants and pH.

Field response to added lime has been compared with results obtained in the laboratory and the results are illustrated in Fig.2. The lab. response is much greater than in the field and this may be due to the more intimate mixing possible on a small scale and to the resultant effects upon exchangeable acidity and exchangeable Al^{3+}.

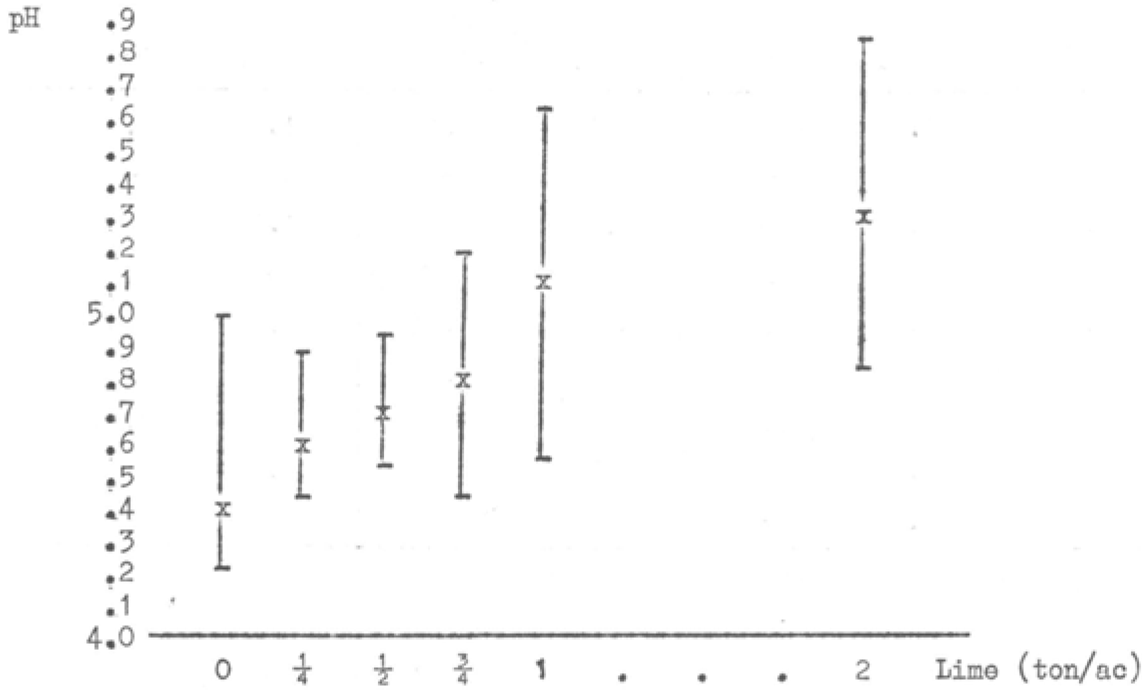


Fig.1. Field response to added lime (Expt St-1)

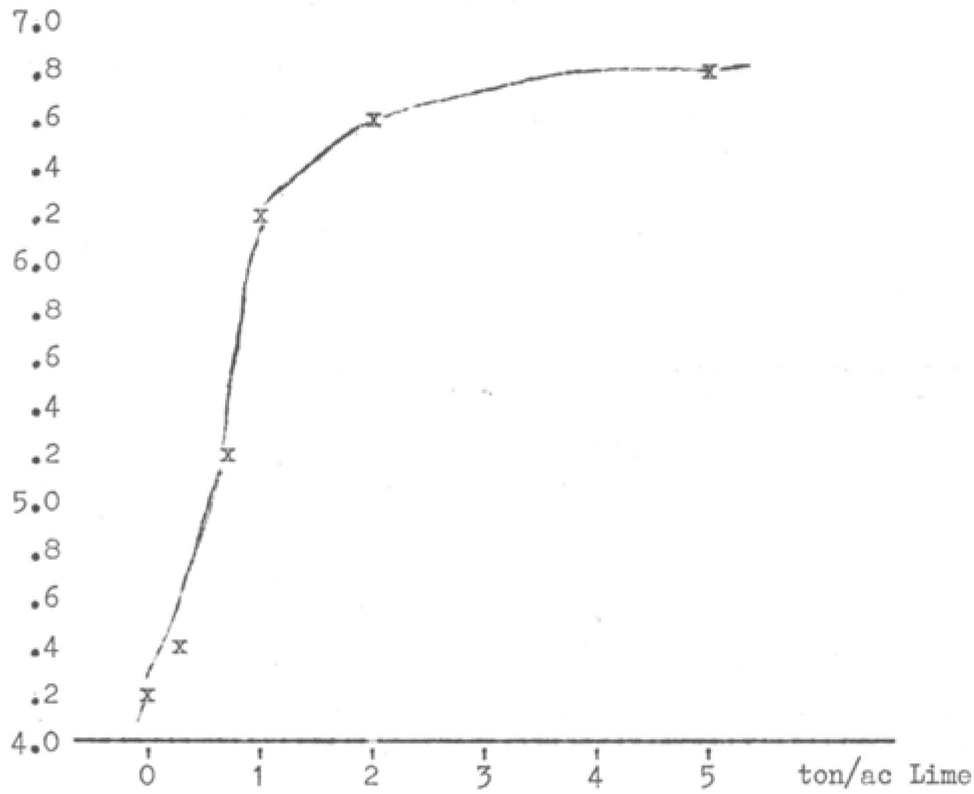


Fig.2. Laboratory response to added lime (Linhope soil)

The following results have been obtained from laboratory and field treated samples for exchangeable acidity and Al^{3+}. (Table 2)

Table 2. Distribution of exchangeable H^+ and Al^{3+} in field and laboratory lime treated samples of Linhope Brown Forest Soil

Treatment Lime (ton/ac)	pH		Exchangeable Acidity ($H^+ + Al^{3+}$)		Exchangeable Al^{3+}	
	lab.	field	lab.	field	lab.	field
0	4.2	4.4	4.10	5.14	1.70	4.34
.05	4.3	-	4.65	-	0.40	-
.1	4.4	-	2.50	-	1.30	-
.25	-	4.6	-	4.29	-	3.87
.5	5.2	4.6	3.40	4.14	0.25	3.62
.75	-	4.7	-	3.60	-	3.11
1.0	6.2	5.2	1.40	2.95	0.10	2.41
2.0	6.6	5.4	.30	1.41	0.10	.93
5.0	6.7	-	.25	-	0	-

(Exchangeable ions extremed as meq/100 g)

Both total exchangeable acidity ($H^+ + Al^{3+}$) and exchangeable Al^{3+} decline in lab. and field treated samples as pH increases as a result of treatment. However, the lab. treated samples not only give a greater pH response per unit of lime added, but the corresponding reduction in exchangeable acidity and Al^{3+} is also greater in the lab. treated samples than in the field. The percentage of the total exchangeable acidity due to Al^{3+} also seems to be much higher in the field samples than in the lab. treated samples. For the field samples this decreases from 85% (at pH 4.4) to 65% (at pH 5.4) compared with the reduction from 41% (at pH 4.2) to 0 (at pH 6.7). In the lab. treated samples, in fact, exchangeable Al^{3+} is reduced to negligible levels at pH values just above 5 while in the field significant amounts of exchangeable Al^{3+} were present at all pH levels. This may be due to the time taken for the lime to react with the exchange complex in the field and it is proposed to re-examine the situation in field samples in 1976.

2. Lime response on peat (Le-3)
M.J.S. Floate, G.R. Bolton and A.D. Ironside

The field experiment on peat was established in 1974 and preliminary results were described in the Annual Report, 1974 (HFRO - 206) under project 07D/02C.

Plant count data have been collected in September, and October 1974, and in February, May and June 1975. Harvest cuts and grass/clover separations were taken in June, August and October 1975, and surface water and peat samples have been taken for pH and exchangeable acidity and Al^{3+} determination in March, June and November 1975. Some of the data are presented in Tables 3 and 4.

On no occasion were there any significant differences in the numbers of grass plants due to treatment but the 20% reduction in numbers between the first two counts for low lime treatments was significantly different from no change at L_2 level. Comparing the numbers in May '75 with September '74 shows a 40% reduction for low lime treatments but only 20% reduction for 1 and 2 tons lime. This difference just failed to reach significance.

Table 3. Plant counts on lime response expt (Le-3)

(all units plants per 4 quadrats: x 6.25 = plants/m^2)

Treatment Lime (ton/ac)	Grass 24. 9.74	Grass 1.11.74	Grass 27. 2.75	Grass 5. 5.75	Grass 16. 6.75	Clover 24. 9.74	Clover 1.11.74	Clover 27. 2.75	Clover 5. 5.75	Clover 16. 6.75
0	80	63	53	40	35	21	20	1	2	19
$\frac{1}{4}$	97	75	62	54	46	25	24	2	3	21
$\frac{1}{2}$	75	60	56	57	43	27	28	4	4	40
$\frac{3}{4}$	94	73	60	44	30	31	25	2	2	17
($\frac{3}{4}$*)	(106)	(82)	(61)	(57)	(48)	(29)	(26)	(3)	(4)	(27)
1	81	76	64	61	54	32	34	8	9	35
2	74	74	66	53	51	34	33	6	8	38
LSD 5%	37	35	35	30		11	12	4	4	
1%	50	49	49	42		16	17	5	5	
.1%	70	68	68	59		22	23	6	7	

(*) omitting anomalous plots in Blocks A + D

Table 4. Field pH values for surface water samples from lime response expt (Le-3)

Treatment	March 75	June 75	Nov. 75
0	5.03	4.23	4.32
$\frac{1}{4}$	5.49	4.79	4.61
$\frac{1}{2}$	5.62	5.14	4.76
$\frac{3}{4}$	5.15	4.78	4.61
($\frac{3}{4}$*)	(5.54)	(5.39)	(4.89)
1	5.73	5.35	5.12
2	5.93	5.46	5.11

(*) omitting anomalous plots in Blocks A + D

Statistical analysis is not yet available for counts taken in June '75 but there was by this time a 50% reduction in grass plant numbers on the low lime treatments compared with a 30% reduction for 1 and 2 ton/ac lime levels.

There are significant treatment differences in clover plant numbers on all occasions and the decline in clover was dramatic. By February '75 there had been > 90% reduction on all treatments of less than 1 ton/ac and for 1 and 2 ton treatments 70-80% of the clover plants had been lost. Accordingly an oversowing treatment with inoculated seed was applied to all plots in May 1975. By June 1975 clover plant numbers were approximately restored to the Sept. 1974 level, there being approximately twice as many plants on L_1 and L_2 treatments as on L_0, $L_{\frac{1}{4}}$ levels. No statistical analysis is yet available for these data.

Treatment mean pH values for surface water samples taken from each plot on three occasions are given in Table 4. These mean values indicate trends of responses on each occasion, and that for all plots pH is falling with time. However there are wide variations in pH range for each treatment (Fig.3) especially for $L_{\frac{3}{4}}$ where two of the plots have abnormally low values and where plant numbers are correspondingly low. This is believed to be due to the inflow of acid surface water at the ends of two blocks with resultant effects on soil pH and plant survival. Consideration is being given to alternative methods of analysis of the results - either omitting these anomalous results, or relating the observed results to measured pH values rather than to applied treatments.

Results for DM production of grass and clover from each treatment are presented in Table 5. No statistical analysis of these results is yet available but it appears that there are notably lower yields of both grass and clover on L_0 $L_{\frac{1}{4}}$ treatments. The yields for $L_{\frac{3}{4}}$ are also low unless the results for the anomalous plots are omitted. It appears in fact that yield is more closely related to the measured pH values for individual plots than

Table 5. DM production from lime response expt (Le-3)

all units g per 5 quadrats (x1.11 = g/m^2)

Treatment Lime (ton/ac)	Grass				Clover			
	June	Aug.	Oct.	Total	June	Aug.	Oct.	Total
0	26.5	20.4	16.7	63.6	1.1	6.7	3.1	10.9
$\frac{1}{4}$	24.4	22.6	15.0	62.0	1.7	15.7	7.1	24.5
$\frac{1}{2}$	28.2	37.1	29.7	95.0	2.0	26.3	11.9	40.2
$\frac{3}{4}$	18.8	23.1	15.7	57.6	3.0	22.2	6.3	31.5
($\frac{3}{4}$*)	26.5	37.1	24.1	87.7	3.8	33.3	10.2	47.3
1	29.2	36.0	23.2	88.4	3.0	32.7	8.3	44.0
2	24.2	39.2	22.4	85.8	3.3	25.1	9.0	37.4

(*) omitting anomalous plots in Blocks A + D

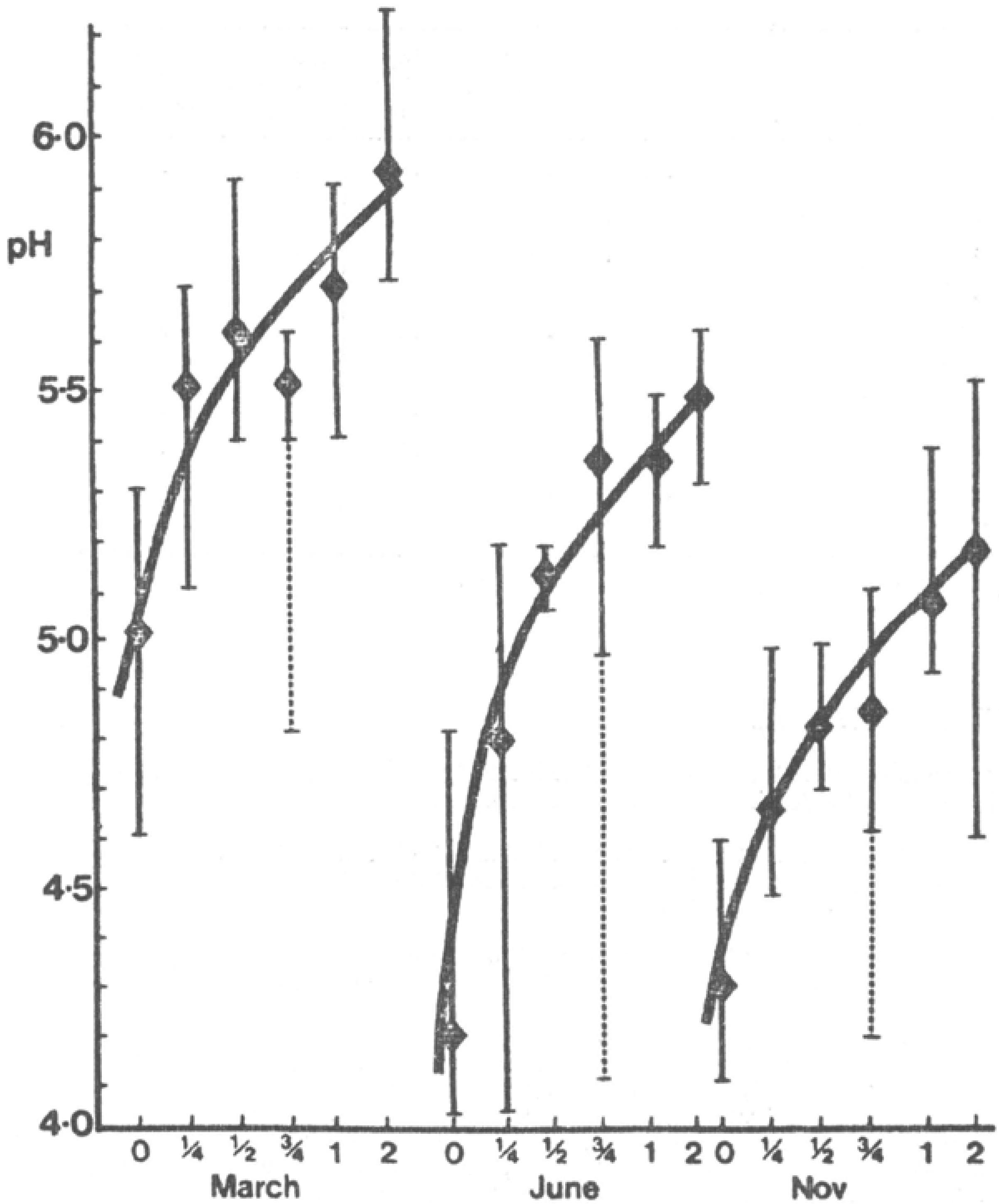
to mean values for each treatment. The results suggest that there is a threshold value in the pH range 4.0 - 4.5 below which grass yields are dramatically reduced. At these low pH values clover yields are also very low but there is a general trend for clover yield to increase as pH increases. Curvilinear regression analysis of the data may aid the interpretation of individual plot results.

The fall off in yield below a possible threshold is of great interest and a search for its cause leads us to an examination of the laboratory analysis of the soils from these plots.

Peat samples taken in March were analysed for pH, exchangeable acidity and exchangeable Al^{3+} and the results have been compared with samples of the original peat treated with increments of lime in the laboratory. The results for treatment mean values are given in Table 6.

Both total exchangeable acidity ($H^+ + Al^{3+}$) and exchangeable Al^{3+} decline in lab. and field treated samples as pH increases as a result of lime treatment. Lab. treated samples show a greater pH response per unit of lime applied, but the distribution of exchangeable acidity and Al^{3+} at any given pH value is very similar in both sets of samples. In contrast with the results for the Brown Forest Soil, the peat samples have a low percentage of

Fig. 3. Surface pH changes with time - (1a-2)



Al^{3+} in the exchangeable acidity which does not exceed 20% at the lowest pH levels, and which decreases to 0 at about pH 5.0 it is possible that the reduction of exchangeable Al^{3+} to negligible levels in the pH range 4.5 to 5.0 is related to the observed results for plant numbers and plant DM production.

Table 6. Field and laboratory effects of lime applied to peat

Treatment Lime (ton/ac)	pH lab.	pH field	Exchangeable Acidity ($H^{+}+Al^{3+}$) lab.	Exchangeable Acidity ($H^{+}+Al^{3+}$) field	Exchangeable Al^{3+} (meq/100 g) lab.	Exchangeable Al^{3+} (meq/100 g) field
0	4.2	4.22	5.35	4.78	.60	.74
.05	4.5		3.83		.40	
.1	4.7		3.32		.15	
.25		4.58		2.83		.56
.5	5.9	4.72	1.23	2.27	0	.20
.75		4.42		3.58		.64
(.75*)		4.74		2.28		.20
1.0	6.5	4.90	0.63	1.94	0	.05
2.0	6.6	5.32	0.82	2.32	0	0
5.0	6.7		0.65		0	

(*) omitting anomalous plots in Blocks A and D

PASTURE ESTABLISHMENT (04002)

Determination of conditions for optimum germination and establishment of selected grasses and clover under hill conditions

1. Effects of different sowing dates on germination and early establishment - population dynamics of seedlings
J.A. Rogers and D. Bruce

In the experiment to investigate the effect of time of sowing, described in the Annual Report for 1974, seedlings were not marked.

It was not known, therefore, whether the number of seedlings present at any time represented the total germination or this total, less an unknown number which had died, and whether any of those which had apparently died had only been killed to ground level and recovered later. This was, of course of particular interest for clover, where a high percentage of those seedlings which had emerged had subsequently died, the numbers later increased by an amount equivalent to the number of "hard" dormant seeds present.

Sowings were made in boxes of compost, each seed being placed within a square of a marked grid. Each sample consisted of 100 seeds. Each grid square was recorded as containing or not containing a seedling. Thus the fate of individual seeds and seedlings could be traced over the whole period of the experiment. This process was facilitated by a computer program written by A.R. Sibbald.

Four cultivars were sown on 22nd August and on 11th December. The boxes were placed at c 1000' OD at House o' Muir. When sown in August, Gremie reached 50% emergence in 55 days. The actual numbers of seedlings present thereafter remained constant. However, a further 23% emerged while an equal number died. In addition, 13% were killed to ground level (i.e. disappeared) and subsequently recovered. When this variety was sown in December, emergence was much more rapid, with the 50% level occurring only 34 days after sowing. Seedlings began to die after 40 days and the actual number reached a peak of 67% after 60 days, after which there was a gradual decline to 53%. New seedlings continued to emerge during this time so that a total of 77% of the seeds produced seedlings. Of those which "disappeared", only 3.5% recovered. It is interesting that the total numbers of seedlings resulting from these two sowing dates were remarkably similar, although the 'dynamics' of the two populations were quite different.

Kent Wild White Clover was sown on the same two dates. Following the August sowing, the pattern was quite similar to that of Gremie sown in December. Fifty percent emergence occurred at 50 days, maximum seedling numbers were reached after 60 days after which the decline was slight (7%). A total of 77% of the seeds produced seedlings, of which 22% died. The December sowing proved disastrous. Although the seedlings emerged rapidly to 50% in 28 days, and to a peak of 62% in 40 days, they then died off rapidly, and by 110 days from sowing, only 11% of the seedlings remained (including 4% recoveries). There was no later germination which could be attributed to hard seed, although as there was 30% hard seed in this lot, and only 70% emerged, it is assumed that the hard seed had not germinated. It is unfortunate, therefore, that cattle broke in to this experiment and destroyed it at a very interesting stage. It is, however, evident that some of the 'hard' seed sown in August did germinate as the total emergence figures exceeded the number of non-hard seed present by 7%. It appears that the hard seed started to germinate and emerge 90 days from sowing, that is in mid November. This coincided with the first seedling deaths and the first severe frost, recorded at 5 cm depth in the soil (there had been lower air temperatures in September).

2. <u>Germination at low temperatures</u> - J.A. Rogers and D. Bruce

The work on seedling emergence and establishment in relation to the time of sowing (see Annual Report 1974) indicated that while establishment of pasture species from seed sown in late Autumn was feasible, there was some considerable difference between varieties. Germination at temperatures below 10 °C is of great interest, and it was decided to investigate this under laboratory conditions. Two lines of approach were adopted. Firstly, the rates of germination at fixed temperatures in the range 5 to 10 °C were determined and secondly, the lowest temperature at which each variety would germinate was determined using a thermal gradient bar. First trials in incubators at low temperatures showed considerable variation between replicates within the incubators, and between successive experiments. Close examination showed that the temperatures within the incubators varied considerably between shelves (by as much as 3 °C).

Since this variation ruled out the possibility of replicated experiments, each shelf was regarded as a 'treatment' and up to four temperatures were studied in each incubator.

At the lower temperatures (5.6 and 6.4 °C) there were greater differences between cultivars whilst at 10 °C, with the exception of Barpastra, all the cultivars reached 50% germination in 9 or 10 days. Further, as the temperature approaches the low limit for germination, the time for 50% of the seeds to germinate increases sharply.

When these results are compared with those from the time of sowing experiment, it is apparent that those varieties of ryegrass which respond most successfully to late Autumn sowing, namely the early heading Gremie, S.24 and Premo, germinate most rapidly at the lower temperatures. At higher temperatures, there is little difference. All that can be said, at this stage, about the clovers is that, apart from Alsike, they germinate more rapidly than the ryegrasses and that Kent Wild White and S.100 white germinate more slowly at the lowest temperatures. In the box trial at House o' Muir and

Bush, there was little difference in the rates of emergence between the different varieties.

Table 1 shows results obtained for nine varieties of Lolium perenne.

Table 1. Time for 50% germination at different temperatures (days)

Mean temperature	5.6 °C	6.4 °C	10 °C
Standard Deviation	0.73	0.58	-
Early heading cultivars			
Gremie	18.9	12.5	9.4
Premo	20.9	13.6	9.2
S.24	17.7	15.2	10.0
Late heading cultivars			
Melle	∞	16.2	10.4
S.23	∞	16.4	9.8
Lamora	∞	32.4	10.3
Tetraploid			
Barvestra	∞	20.8	10.0
Barpastra	∞	∞	17.2
Italian			
Lemtal	15.9	14.5	9.1

(∞ indicates that less than 50% of viable seeds germinated during trial)

Six varieties of clover have also been studied. Results from one experiment are shown in Table 2.

Table 2.

Mean Temperature	6.1 °C	7.5 °C	8.9 °C
Standard Deviation	0.80	0.44	0.53
S.184	6.8 days	7.0 days	6 days
Kent	13.8	8.7	6.8
Huia	<6	<6	<6
Kersey	6.9	6.9	6.3
S.100	10.5	6.8	<6
Alsike	23.0	24.0	6.4

Other species of grass have been included in these investigations, which are continuing. These include Festuca rubra, F. arundinacea, F. pratensis, Phleum pratense and Poa pratensis.

3. Use of a thermal gradient bar to determine low temperature limit to germination

J.A. Rogers, A.R.M. Chambers and D. Bruce

To facilitate these investigations, and in particular to determine the low temperature limits to germination, a thermal gradient bar has been constructed by A. Chambers (see p.116). This is capable of maintaining temperatures controlled to within ±0.1 °C over a predetermined range. The first trials on this bar have shown that for Gremie the low temperature germination limit lies between 6.3 and 4.4 °C while for Huia white clover, this limit is apparently below 4.4 °C.

Results from the first test runs are shown in Table 3.

Table 3. Times for 50% germination using thermal gradient bar

Temperature	Huia Clover	Gremie Ryegrass
8.4 °C	7.03 days	10.1 days
7.1	8.5	12.4
6.3	13.1	15.2
4.4	(38.6*)	∞
1.7	∞	∞
-0.2	∞	∞

(* value obtained by extrapolation)

It is now intended to readjust the temperatures so as to span a narrower temperature range and to determine the low limits more precisely.

4. Test conducted with a 'supersonic' seeder device
J.A. Rogers

Mr Maxwell W. Davidson of Maxwell Davidson Ltd, Moray Place, Edinburgh (a member of the Brockway Group) submitted a supersonic seeding device to HFRO for assessment. This device, it was claimed by Mr Davidson, accelerated seeds to supersonic speeds by means of compressed air. Thus accelerated, the seeds would enter the soil undamaged by virtue of an "incompressible layer of air in contact with the forward surface" (sic).

A preliminary test indicated that a proportion of the seeds sown by the device were capable of germinating. It was, therefore, agreed to carry out a small scale trial in which the emergence of Huia clover seeds sown by the machine were compared with hand sown seeds. Turves of Agrostis Festuca grassland on Sourhope Series soil from House o' Muir were imported into the glass house. Two moisture treatments were imposed, one was watered three times each week and the other was watered whenever the native grass showed signs of wilting. Two hundred seeds were sown in each box. In the wet treatment, the hand sown, broadcast seeds germinated more rapidly than those sown by the machine. However, after 100 days from sowing, the number of machine sown seedlings exceeded the number sown by hand. In the drier treatment, emergence was slower than in the wet treatment and the numbers of hand sown seedlings remained slightly (but not significantly) higher than sown by the machine.

Table 1. % Emergence

Wet treatment	after 22 days	118 days
Broadcast	37.5	24.5
Machine sown	13.0	32.5
difference	24.5*	-8.0*
Dry treatment	35 days	110 days
Broadcast	3.7	25
Machine sown	0.0	18.5
difference	3.7 ns	6.5 ns

(* 1% < P < 5%; ns P > 5%)

Further investigations showed that the device injected seed at depths ranging from 0 to 2 cm. All the seeds were within the organic horizon.

On the basis of this trial, it was considered that this technique may be of some value in establishing hill pastures. Although emergence was slow compared with surface sown seed - this is to be expected as the seedlings must penetrate the overlying soil - final seedling numbers may be at least as high. Under field conditions where wind drying is a problem, this machine may be more advantageous. The fact that this technique does not necessarily require previous cultivation is important economically and practically. A particular application for which it may be specially suitable would be sowing clover into an established (or partially established) grass sward.

There are, of course, limitations to the method. For example, the maker has not yet demonstrated any form of seed metering or control, either of seed rate or depth. Our trial did not sow the seed into a mineral soil - all the seeds remained in the organic layers - and consequently it is not known, at present, whether seed will sustain damage in less resilient media. Further, for the device to be worth while for a firm to manufacture and market, it must be shown to be capable of sowing a wide variety of seed types into a wide variety of soil types, and in a completely controlled manner.

PLANT NUTRITION (04003)

Major Nutrient Requirements

1. The response of white clover to nitrogen, phosphorus and potassium
A. Rangeley and P. Newbould

A series of pot experiments were set up to study the response of white clover var. Grasslands Huia to increasing levels of nitrogen, phosphorus and potassium fertilisers when grown on three hill soils. The soils used were a deep peat, a dry peat from a peaty podzol and a brown earth. The levels of nitrogen, phosphorus and potassium in terms of kg/ha were as follows:-

N - 0, 20, 40 and 80 kg/ha

P - 0, 40, 80 and 160 kg/ha

K - 0, 40, 80, 160 and 320 kg/ha

The levels were chosen to span the normal rates of application of fertiliser for the establishment of reseeded hill pasture. The high level of potassium was given because Irish workers reported responses at similar levels. Clover shoots were harvested twice, after nine weeks and 13 weeks. Further information for this experiment can be found in the Annual Report 1974, p.69.

The experiment was carried out in three parts at different times of the year, therefore dry weights are not comparable between soils.

There was no increase in dry weight of shoots at any level of nitrogen in any of the soils during either of the growth periods.

There was a positive response to phosphorus by white clover grown in all soils, but the response was greatest in the peats (Table 1).

White clover responded to potassium in all soils at each harvest except in the brown earth during the first period of growth (Table 2). The greatest increase in dry weight of shoots was between 0 and 80 kg K/ha.

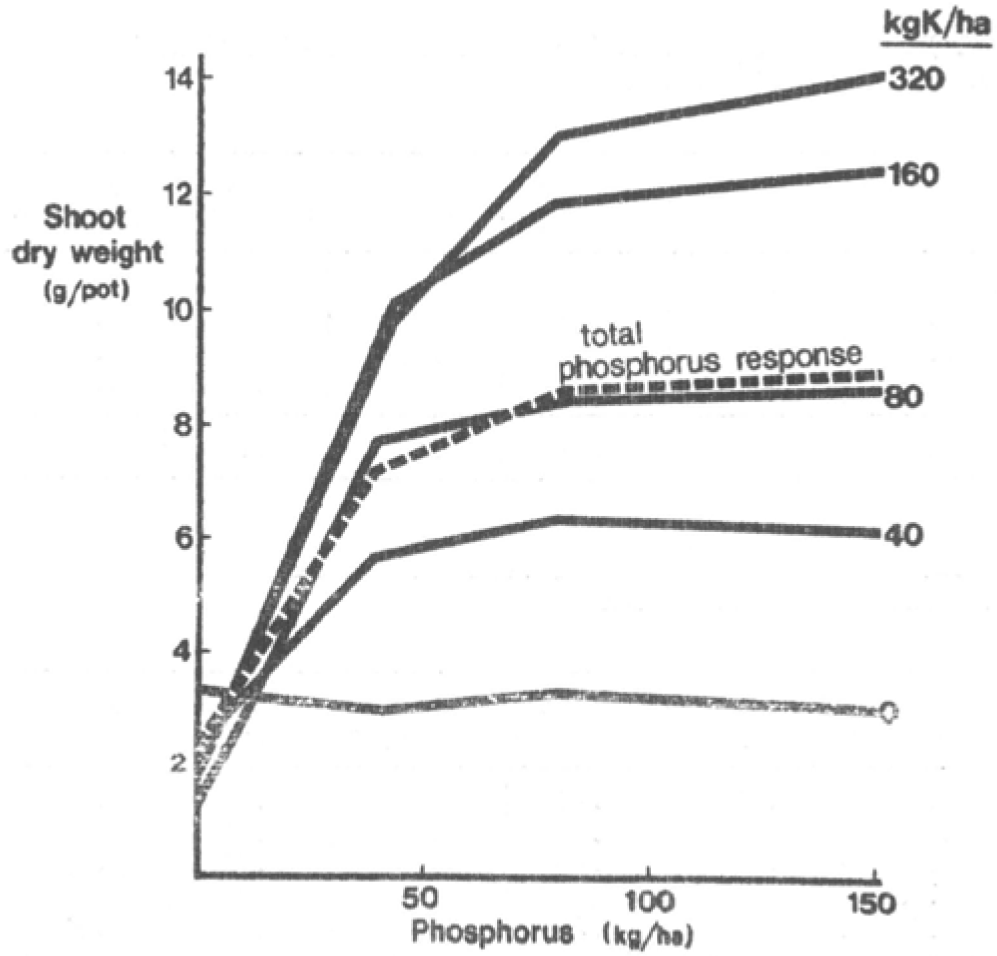


Fig. 1. The response to phosphorus of white clover grown in dry peat for nine weeks.

In all soils there was a positive interaction between phosphorus and potassium, e.g. Fig.1, the dry weight of white clover shoots grown in dry peat for nine weeks.

Chemical analysis of herbage is in progress and soils analysis will be made if necessary.

Table 1. The response (g/pot) of white clover to phosphorus when grown in three hill soils

Phosphorus kg/ha	Deep Peat Harvest 1	Deep Peat Harvest 2	Dry Peat Harvest 1	Dry Peat Harvest 2	Brown Earth Harvest 1	Brown Earth Harvest 2
0	0.28	0.88	2.01	1.27	2.17	4.43
40	1.64	1.78	7.27	3.07	2.55	4.86
80	2.87	3.08	8.60	2.99	2.86	5.19
160	3.85	4.87	8.92	2.86	3.26	5.05
LSD	0.14	0.24	0.41	0.16	0.18	0.29

Table 2. The response (g/pot) of white clover to potassium when grown in three hill soils

Phosphorus kg/ha	Deep Peat Harvest 1	Deep Peat Harvest 2	Dry Peat Harvest 1	Dry Peat Harvest 2	Brown Earth Harvest 1	Brown Earth Harvest 2
0	0.59	0.92	3.17	1.39	2.68	3.38
40	2.14	2.11	5.08	2.37	2.82	4.18
80	2.60	2.80	6.53	2.61	2.79	5.03
160	2.68	3.31	9.02	2.99	2.84	5.52
320	2.80	4.14	9.69	3.38	2.42	6.31
LSD	0.16	0.27	0.46	0.17	0.20	0.33

2. The effect of magnesium on the growth of white clover

A. Rangeley and P. Newbould

White clover (New Zealand Grasslands Huia) was grown in three hill soils, a brown earth, a deep peat and a shallow dry peat, in pots in the glasshouse. Each soil was limed to two levels of pH, 5.0 and 5.5, with calcium carbonate. Magnesium as $MgSO_4$ was applied to each soil/pH level at rates equivalent to 0, 10 and 100 kg Mg/ha. Basal dressings of phosphorus, potassium and trace elements were applied.

A harvest was taken after eight weeks' growth. Plants grown in shredded deep peat grew slower than those grown in the brown earth or the dry peat.

Soil	Shoot dry weight (g/pot)
Brown Earth	2.67
Deep peat	1.67
Shallow dry peat	2.75
LSD	0.16

There was no difference in shoot dry weight at pH levels 5.0 and 5.5. There was a depression in shoot dry matter yield at 100 kg Mg/ha compared with 10 kg Mg/ha, but there was no difference in shoot dry weight in plants receiving 0 and 10 kg Mg/ha.

Table 1. Effect of level and time of application of a starter dressing of $(NH_4)_2SO_4$ on growth of S100 white clover (g DM - shoots/pot)

N level (units)	Applied with seed					Applied after Nodulation			
	Harvest 1	2	3	Total		Harvest 1	2	3	Total
N_0	1.98	1.68	2.73	6.39		1.98	1.68	2.73	6.39
N_{30}	1.67**	1.23**	2.41	5.31**		2.03	1.67	2.58	6.28
N_{60}	2.17	1.71	2.33	6.41		2.07	2.31	2.46	6.84
N_{120}	2.39	1.69	2.33	6.41		2.13	2.87	3.14	8.14
LSD (5%)	0.30	0.33	0.69	0.75		0.30	0.33	0.69	0.75

(** significantly different at $P < 0.01$ level)

Magnesium level (kg/ha)	Shoot dry weight (g/pot)
0	2.43
10	2.39
100	2.26
LSD	0.09

Chemical analysis of soil and shoot material will be made.

3. Effect of timing and level of nitrogen fertilisation on growth and N_2-fixation by white clover in hill pasture
A. Haystead, A.G. Lowe and C. Marriott

The spectrum of recommended "starter" dressings of N-fertiliser for sown swards in hill situations ranges from as low as a single dressing of 30 units applied at sowing to an initial dressing of 100 units followed by annual dressings of up to 60 units. The investigation is designed to determine economically optimal levels and timing of N-fertiliser application to ensure the rapid establishment of a grass/clover sward independent of fertiliser-N after the establishment year.

There are a number of reasons to suppose that the traditional practice of applying N-fertiliser at or immediately before sowing may not give the best results in terms of clover establishment. For example, it is known that combined-N inhibits both the nodulation and nitrogen fixing processes, and that competition from associated grasses is most severe under high-N conditions.

The experiments are designed to determine whether any advantage can be gained from early (4 weeks prior to sowing) or late (after nodulation) applications of fertiliser-N. Early application of N could stimulate the soil microflora with consequent increases in the rate of soil-N mineralisation. On the other hand, clover root nodulation may be optimised in a low-N environment and a late N-fertilisation would serve to increase the rate of root and nodule growth of already nodulated plants and so bring forward the time at which the plants attain full N_2-fixing capacity.

The investigation is being carried out in three phases:

(1) A pot experiment investigating the effect of N-level and timing on clover growth, nodulation and N_2-fixation.

(2) An experiment conducted in boxes to investigate in detail the effects of N-level (0, 30, 60, 90 and 120 units) and time of application (early, sowing time and after nodulation) on nodulation, N_2-fixation and DM-production of grass and clover in competition with each other in peat and brown earth soils.

(3) A field trial with the same objects as the box experiment.

Results

(1) Pot experiment Inoculated S100 White Clover was sown at a rate of 40 seeds per pot into limed (pH 6.5) and fertilised Lephinmore peat. N, in the form of $(NH_4)_2SO_4$, was added at sowing or after nodulation at a rate of 0, 30, 60 or 120 units. Pots were sacrified at weekly intervals after the first four weeks to determine whether nodulation had occurred. The pots were harvested three times during the period of the experiment (Nov. 1974 - April 1975) by clipping to 2 cm from the soil surface. Table 1 shows the effect of time of application and level of N-fertilisation on DM-production in the three harvests.

Nitrogen applied after nodulation has occurred stimulates total DM-production but when applied at sowing does not increase total accumulated DM and in fact at 30 units depresses total yield. This inhibition of growth occurs during the first and second growth periods.

At the third harvest no significant depression in growth rate is observable. Results similar to these have been obtained for other legumes (Pate and Dart 1961) in which case the effect was attributed to a delay in nodulation and the onset of N_2-fixation caused by the combined-N in the soil. In an experiment of this duration the affected plants do not catch up. Acetylene reduction assays of total N_2 fixing capacity per pot conducted prior to harvest three showed no significant difference between treatments although all pots were fixing N_2 rapidly. ($\sim$1 μ mole C_2H_4/plant/hour).

(2) Box experiment In practice white clover is not grown in pure stands so an experiment was designed to determine the effects of N-level and time of application on S184 white clover grown in mixed stand with S24 perennial ryegrass. The experiment was conducted in wooden boxes (40 cm wide x 60 cm long x 10 cm deep) filled with either Lephinmore peat or brown earth from Sourhope both limed and fertilised as in the pot experiment. In this experiment an early N application treatment (four weeks prior to sowing) was introduced and five N levels: N_0, N_{30}, N_{60}, N_{90} and N_{120} were used. The weather during the seedling establishment phase of the experiment was hot and dry and surface soil drying resulted in a poor establishment of clover. The grass was less affected and responded to N-application at all levels and application times. Clover establishment was poorest at high fertiliser-N levels where competition from the grass was most severe. The grass grew abundantly at N_0 indicating a high rate of mineralisation in both soils. This effect, it is thought, could be the result of high soil temperatures. (c.f. M.J.S. Floate Ann. Rep. 1976 p. 85).

(3) Field experiment A field trial laid down at Sourhope suffered the same fate as the box experiment - high temperatures and low rainfall led to surface soil drying with consequent poor seedling establishment. Again white clover was most severely affected. The sward became overrun with deeply rooted indigenous grass species, particularly H. lanatus, and the experiment was abandoned. New field trials have been set up at Lephinmore and Sourhope for the 1976 season.

Inoculation With Rhizobia

4. The response of white clover to inoculation with effective strains of Rhizobium trifolii in a range of soils and environments - collaborative series of field trials

P. Newbould, A. Haystead, A. Rangeley, G.R. Bolton, G.T. Barthram and Dr R.H. Armstrong, with Mr H.A. Waterson and Dr J. Frame (WSAC), Mr G.J. Copeman and Mr D. Younie (NSCA), Dr J.C. Holmes and Dr J.B.D. Herriott (ESCA), Dr A.J. Holding (MD-ESA), Mr J. Thompson, Mr J. Wray, Mr M. Roberts and Mr J.S. Parker (ADAS), Mr J.M.M. Munro and Mr A. Davies (WPBS) and Mr G.J. Davies (ARCUS).

The objective and design of these trials were described in HFRO 206. Fourteen out of the 16 trials planned were sown (Table 1). On all the trials the establishment and growth of white clover was severely affected by the very dry summer, and germination at the trial at Sourhope was so poor that work at this site was abandoned. In addition, the trial at Carlops was subsequently affected by the growth of indigenous white clover and rapidly regenerating grasses and although a few measurements of the sown seeds were possible it was later dropped from the series. The sowing scheme for the trials was complicated by the relatively low number of rhizobia per seed (50-95) in the initial batch of inoculant. A second improved inoculant which gave 4,000-28,500 rhizobia per seed was used on all the later sown trials and as a precautionary measure half the treatments in the earlier trials were resown with this inoculant. The difference in sowing treatment at each trial is shown in Table 1 by describing them as Sown (all plots with 2nd inoculant) and Resown (half plots with initial and half with 2nd inoculant). The white clover seeds were sown with (N1) and without (No) nitrogen fertiliser, and with (R1) and without (Ro) inoculant. Results are presented only for plots receiving the second inoculant.

Emergence of white clover was significantly enhanced by inoculation (R1 > Ro) on two deep peat and one forest brown earth soils (Table 1). Nitrogen fertiliser significantly reduced emergence (N1 < No) on two brown earth soils. No other effects were significant.

Dry matter yield was assessed at some sites (Table 2). The application of inoculant significantly enhanced yield of white clover but not total herbage yield at both deep peat and one wet peaty podzol sites. At a second wet peaty podzol site (Dunduff) the total yield of herbage was significantly increased by inoculation and although the yield of white clover was higher with than without inoculation this effect did not attain statistical significance. Both white clover and perennial ryegrass responded significantly to the starter dressing of nitrogen on the brown earth site at Trees but the significant effect of inoculation on emergence at this site (Table 1) was not followed by a statistically significant effect on dry matter yield although the data show a trend in this direction.

Microbiological work is still in progress; 2,400 nodules were processed for the isolation of rhizobium and approximately 2,100 were found to contain genetically marked rhizobium strains. The inoculant strains failed to establish themselves and form nodules at the Carlops brown earth site but this site contained a large indigenous population of rhizobia. There were few mutants in the nodules of the other brown earth and the more freely-draining podzolic sites. A surprising feature of the white clover plants at these sites was the high proportion which did not possess nodules even after inoculation.

At the peat and wetter peaty podzol sites the inoculant strains were prominent in the nodules of the plants.

In summary it appears that where white clover established satisfactorily, positive responses to inoculation occurred on the deep peat and wetter peaty podzol soils confirming earlier results (Jones et al, 1964; Newbould et al, 1974). There was little effect of inoculation at the drier sites except at one brown earth site. A detailed examination of the strain of rhizobium in the nodules of plants from this site may reveal useful pointers for future work with brown earth soils.

Because of the difficult season for growth of white clover and the high coefficients of variation for the data obtained in 1975 even at the sites where inoculation had significant benefits, it has been decided to start a small number of additional trials in 1976 concentrating on the drier types of hill soil. The growth of white clover in the trials which established satisfactorily in 1975 will also be monitored during 1976. No fertiliser nitrogen will be used in the new trials, but the performance of two varieties of white clover (S184 and N.Z. Grasslands Huia) will be compared. To reduce the labour involved in plant counts and when separating white clover from grass herbage only white clover will be sown.

References

Jones, D.G., Munro, J.M.M., Hughes, R. and Davies, W.E. (1964) The contribution of white clover to a mixed upland sward. 1. The effect of Rhizobium inoculation on the early development of white clover. Pl.Soil, 21, 63-69.

Newbould, P., McDermott, W.G. and Bolton, G.R. (1974) Improved production of white clover. 1. Major nutrient requirements on blanket peat. HFRO Annual Report 1973. (HFRO 199).

Table 1. Brief description of sites and preliminary results on the benefits of inoculation with effective strains of *Rhizobium trifolii* with and without 'starter' nitrogen fertiliser on the emergence of white clover plants

Soil type and site	Initial pH	Date Sown	Date Resown	Emergence counts of white clover (Plants/m^2) Treatment NoRo	NoR1	N1Ro	N1R1	Statistically significant effects
FOREST BROWN EARTH								
WSAC (Trees)	4.1		12/6/75(6)	416	470	259	318	N1 < No**, R1 > Ro*
ESCA (Carlops)	5.7	11/6/75(5)		79	53	58	39	N1 < No*, R1 < Ro*
HFRO (Sourhope)	4.4	19/6/75		Poor germination - died out				NS
DRY PEATY PODZOL								
NSCA (Dell)	4.2		11/6/75(7)	225	194	210	193	NS
ESCA (Gifford)	3.8	10/6/75(9)		270	248	250	230	NS
HFRO (Glensaugh)	4.0		13/6/75(6)	424	398	488	526	NS
WET PEATY PODZOL								
WSAC (Dunduff)	3.8		12/6/75(6)	431	518	454	489	NS
NSCA (Bunachton)	4.0		11/6/75(7)	320	244	281	209	NS
ADAS (Redesdale EHF)	3.5	13/6/75(8)		156	144	89	129	NS
ADAS (Great House EHF)	3.5		19/6/75(6)	518	664	714	663	NS
WPBS (Pant Y Dwr)	4.0	23/6/75(14)		39	34	40	41	NS
DEEP PEAT								
WSAC (A/longford)	3.1		12/6/75(6)	659	815	644	769	NS
NSCA (Achany)	3.6		12/6/75(7)	407	377	387	586	R1 > Ro*
HFRO (Lephinmore)	3.7	20/6/75(14)		76	170	98	221	R1 > Ro***

( ) Weeks from sowing or resowing to taking emergence counts

Table 2. The effect of 'starter' dressing of nitrogen fertiliser and inoculation on the dry matter yield of white clover, and white clover plus perennial ryegrass and indigenous species

Soil Type and Site	Herbage	DM Yield (kg/ha) Treatment				Statistically significant effects
		NoRo	NoR1	N1Ro	N1R1	
BROWN EARTH						
WSAC (Trees)	Clover	65	61	93	125	N1 > No*
	Clover + grasses	1342	1172	1872	2007	N1 > No*
DRY PEATY PODZOL						
HFRO (Glensaugh)	Clover	133	127	103	150	NS
	Clover + grasses	320	306	311	453	NS
WET PEATY PODZOL						
WSAC (Dunduff)	Clover	114	143	91	200	NS
	Clover + grasses	294	397	281	445	R1 > Ro**
ADAS (Great House EHF)	Clover	21	21	1	20	R1 > Ro*, N1 < No*
	Clover + grasses	813	806	761	903	NS
DEEP PEAT						
WSAC (A/longford)	Clover	115	264	144	248	R1 > Ro**
	Clover + grasses	1024	1198	1068	1237	NS
HFRO (Lephinmore)	Clover	4	35	15	31	R1 > Ro**
	Clover + grasses	1414	1480	1707	1913	NS

5. Studies on the specificity of symbiosis between strains of *Rhizobium trifolii* and genotypes of *Trifolium repens* growing hill soils

D.M. Vernon and P. Newbould

In the Annual Report, 1974, p.72, it was proposed to investigate the compatibility of a number of *Rhizobium trifolii* strains with the four main white clover cultivars used in hill pasture improvement (S184, S100, Kent Wild White and New Zealand Grasslands Huia). An assessment has been made of the variability within each cultivar due to genetic variation resulting from the breeding system of the plant. Subsequently rates of nitrogen fixation by a number of *Rhizobium trifolii* strains were compared when inoculated on to two white clover cultivars. In addition, techniques which will enable growth of inoculated clovers in soil without external contamination are under investigation.

(a) Variability within four white clover cultivars

Before beginning experiments involving comparisons between the growth of single white clover plants, an estimate was required of the inherent variability in combined nitrogen utilisation and dry matter production within each cultivar to be studied. Plants were grown as single, uninoculated, fully enclosed seedlings in sterile test tube culture.

One hundred seeds of each cultivar, surface sterilised and scarified with conc. H_2SO_4, and pre-germinated on sterile inverted 1% water agar plates at 20°C, were grown in sterile mineral (+ nitrate) agar slopes in 6 x 1" test tubes, loosely covered to allow gaseous diffusion yet minimise entry of micro-organisms.

Table 1 contains a summary of dry matter yields after 10 weeks' growth.

Table 1. Total plant dry weight (mg) of single plants of four white clover cultivars, grown in sterile test tube culture (Means of 100 plants)

	NZGH	KWW	S184	S100
Cultivar mean	21.8	20.0	21.9	21.4
Range	11.7-28.9	9.0-26.3	10.0-30.1	6.5-32.4
C.V. (%)	13.373	13.721	13.709	16.370

There was considerable variation in total plant dry weight within all four cultivars. Differences between cultivar means were small in comparison with the range of values obtained within each cultivar. The large variation in dry weights within cultivars indicates that a high degree of replication will be required in future experiments using single plants.

At the beginning of the experiment seeds were arbitrarily divided into 'large' and 'small' categories, and it was noted that plants arising from small seed had smaller dry weights than those from large seed in NZGH ($P < 0.01$), S184 ($P < 0.01$) and S100 ($P < 0.05$), but not in KWW ($P > 0.05$). The extent to which seed size, rather than genetic factors within the seedling alone, governs plant growth rate is under investigation in a sterile test tube culture experiment in which seed of NZGH and S184 white clover has been graded by weight into five categories (< 0.4 mg, 0.4-0.5 mg, 0.5-0.6 mg, 0.6-0.7 mg, > 0.7 mg) of 35 seeds each. Seed has been surface sterilised and scarified with conc. H_2SO_4, and plants grown in sterile test tube culture as uninoculated half-enclosed seedlings

(Gibson, 1963). If seed size is shown to have an important effect upon plant size it should be possible in subsequent work to reduce within-replicate error by using seed size as a blocking factor.

(b) Comparison of the symbiotic effectiveness of six strains of *Rhizobium trifolii* with two white clover cultivars, grown in sterile test tube culture

A selection of *Rhizobium trifolii* strains, collected from various sites in Scotland, were compared on two white clover cultivars (NZGH, S184) in sterile test tube culture, in controlled environmental conditions, using Gibson's (1963) half-enclosed seedling technique.

Long mineral agar slopes were prepared in 6 x 1" test tubes capped with aluminium foil. Clover seed was surface sterilised and scarified with conc. H_2SO_4, and pre-germinated on inverted 1% water agar plates. Two small (3 mm) holes were made in the foil cap of each tube; at one aperture, adjacent to the agar, a germinated seed was placed so that the radicle lay along the agar surface; through the other, nutrient solution was injected to fill the tube to within 12 mm of the top, and the hole was plugged with cotton-wool. Strict precautions to maintain sterility were taken throughout.

There were six rhizobial strains and one uninoculated control treatment. Inocula were prepared by suspending 14 day old rhizobial cultures in sterile nutrient solution, counting cell numbers (Coulter counter), and adjusting to a constant cell concentration. One ml of inoculum (11 million cells/ml) was added to each tube 8 days after transfer of seedlings; one ml of ammonium nitrate in nutrient solution (to give a final concentration of 70 ppm N) was added to the uninoculated controls at this time.

Seedlings were grown in a growth chamber (temp. 15/10 $^{\circ}$C ± 1 $^{\circ}$ day/night, RH 70%, light intensity approximately 83 wm^{-2} (0.4-0.7 μ)/16 h day) and were fed with sterile nutrient solution as required. Plants were harvested after nine weeks' growth.

A summary of total plant dry matter yields is given in Table 2. There was no interaction between clover cultivars and rhizobium strains so data have been averaged over both cultivars.

Nitrogen content of herbage was determined by Kjeldahl digestion, followed by colorimetric analysis; nitrogen yield data are also given in Table 2.

Table 2. Total plant dry matter yields (mg/pl) of white clover inoculated with six *Rhizobium trifolii* strains (Means of 24 plants)

Rhizobium strain	Dry weight (mg/pl)	Log (Dry weight)	N yield (μgx10/pl)	Log (N yield)
N (uninoculated)	295.7	5.66	532.8	6.26
23	195.4	5.18	671.0	6.40
24	154.0	4.88	494.9	5.99
35	152.6	4.92	463.9	5.97
49	66.6	3.54	155.9	4.28
10	19.9	2.80	42.7	3.58
55	7.7	1.76	15.9	2.50
LSD 5%		0.41		0.46

Since the standard deviation of the data was proportional to each mean and these varied over such a wide range, a log transformation was carried out to equalise the variances.

There were marked differences between rhizobium strains; 23, 24 and 35 being highly effective, 49 intermediate, and 55 ineffective. Ten appeared initially to be ineffective but after approximately six weeks the clover inoculated with this strain began to grow.

Nodules were large, red and few in number with the effective strains, and mostly confined to the crown of the plant; with strains 10 and 55 nodules were very small and numerous, white, and scattered over the root system, though some nodules on plants inoculated with strain 10 were red and larger. Strain 49 was variable, some plants being very large, with large red nodules, while others showed no growth at all; this may indicate a highly specific relationship with certain white clover genotypes only.

Further work with these rhizobium strains will assess their nitrogen-fixing ability at low temperatures, with the aim of selecting strains capable of providing a source of combined nitrogen for early spring growth of clover in hill pastures.

(c) Technique for comparing *Rhizobium* strains in soil

When inoculated clovers are grown in open pot culture it is difficult to avoid the ingress of airborne rhizobia and other micro-organisms. Studies are in progress towards developing a technique which will prevent contamination of pots. Modifications of a method used by Rothamsted Experimental Station, in which surface contamination is reduced by a covering of sterile waxed sand, are being tested at present. It is hoped that it will eventually be possible to investigate the ability of introduced rhizobial strains to compete with the indigenous microflora, including ineffective rhizobia, and nodulate white clover, in a range of soil types.

Reference

Gibson, A.H. (1963). Physical environment and symbiotic nitrogen fixation. I. The effect of root temperature on recently nodulated *Trifolium subterranean* L. plants. Aust. J. Biol. Sci. 16, 28-42.

6. Assessment of methods for determining P-availability

M. Pimplaskar, M.J.S. Floate and P. Newbould

In the annual report for 1974 (HFRO 206) results were given for 'Available-P' by extraction, isotopic tracer, and sorption methods and for Total-P by digestion. Plant production data for four sites showed the availability of phosphate to vary in the sequence Lephinmore < Glensaugh < Sourhope < House o' Muir. It was stated that further studies would be carried out to improve the recovery of P in the anion exchange method and that an extended range of soils would be used in a glasshouse trial of ryegrass growth with and without added-P.

This work has now been completed and a brief account follows. A paper presented to the Society of Chemical Industry (Floate and Pimplaskar, 1976) described some of the results and a detailed account is being prepared for publication.

Preliminary experiments with the anion exchange method only gave 80% recovery of added-P but this was improved to 90-98% by pre-saturation of the resin with P-solution followed by regeneration with HCl. Using this pretreatment, this method gave values which are higher than for other availability estimates (HFRO 206). The method clearly distinguished between P-treated and control soils but still gave high values for organic soils.

The only valid test for the suitability of a method for assessing soil P-status is by comparison with plant growth. Two such glasshouse trials have been run; the first was carried out in winter 1974 and was reported in HFRO 206 and gave the ranking L < G < S < HoM which was in good agreement with "L"

Table 1. Available-P determined by Anion Exchange

Soil	Available-P mg/100 g	Available-P g/m^2	Pair difference (+P) - (-P)	Pair ratio (+P) :(-P)
L+P	26.43	1.27	18.26	3.24
L-P	8.17	0.41		
St+P	1.85	0.49	-9.82	0.16
St-P	11.67	3.41		
S+P	6.12	2.09	1.95	1.47
S-P	4.17	1.10		
Min A	1.70	0.51	1.45	6.80
Min B	0.25	0.07		
G	5.92	0.59		
H o M	0.77	0.21		

value and Total-P but related poorly to other measures of P-status. The second trial was conducted in the summer 1975 and gave results reported in Table 1 of the next article (no.7). For the four soils previously used in the winter trial the ranking (based on DM and P-uptake) from the summer trial was HoM < G < L < S, thus reversing the order for three of the soils.

Differences in conditions between the two trials included higher lime application and higher temperature in the summer experiment and it was thought that the observed results could have been attributed to mineralisation of P from soil organic matter during the summer growth period. An incubation experiment was mounted to test this hypothesis.

Incubation experiment

Three soils (L-P, L+P and HoM) were mixed with the equivalent of 1 and 2 tons/ac lime and incubated at 10 °C and 25 °C for periods of four and eight weeks at field moisture capacity. The results are given in Table 2 and show that significantly more P was mineralised from L-P soil under conditions analagous to the summer trial than under conditions of lower lime and lower temperature (underlined). For the other soils there were no significant differences in the amounts of P mineralised under any conditions.

The amount of P which, to account for the uptake by grass during the summer trial, must have been released from the soil during the growth period can be calculated if the available-P content of the soil before and after the growth period are known. Such calculations suggest that 3.3 mg and 3.1 mg are required from L-P and HoM soils respectively. When these amounts are compared with the net mineralisation of P in the incubation experiment it can be seen that the experimentally measured amounts are adequate to account for uptake in L-P soil but suggest that the grass in HoM soil may have been in a deficiency situation. Such observations would account for the reversed ranking of these soils between winter and summer trials.

Thus we can account for some of the differences in ranking of soils based on performance of ryegrass on different occasions, but the problem remains which set of results gives the correct evaluation of the soils P-status.

Table 2. Net Mineralised P in incubation experiment

Soil	Lime Treatment	4 weeks		8 weeks	
		10 °C	25 °C	10 °C	25 °C
L+P	L_0	9.5	9.1	9.1	14.2
	L_1 = 1 ton/ac	7.5	9.4	12.0	12.0
	L_2 = 2 ton/ac	8.3	9.9	10.7	10.3
L-P	L_0	1.3	2.3	0.4	2.1
	L_1	1.7	1.7	1.1	2.7
	L_2	2.4	5.8	3.7	5.1
HoM	L_0	0.3	0.8	0.4	0.4
	L_1	0.6	0.7	0.4	0.4
	L_2	0.3	0.6	0.4	0.6

Comparison of laboratory and glasshouse assessments

For four soils mentioned above we now have laboratory results for P-status by six different types of procedure, and glasshouse results for DM production and P-uptake in two separate trials. For comparative purposes the data are presented together in Table 3 which shows laboratory results on w/w basis and w/v basis. DM production and P-uptake were directly proportional so only DM data are used in this comparison (see also Fig.1).

Using the winter DM production from P_0 treatments as the reference, the best correlation between DM and P-status was obtained for Total-P and L-value (w/w basis). Total-P and E-value gave the best correlation on w/v basis, with L-value also giving a fair relationship. Anion exchange and extraction methods gave poor relationships with DM production under winter glasshouse conditions.

Using the summer DM production from P_0 treatments as the reference, the best correlation between P-status and DM was obtained for anion exchange and E-value methods (w/w basis) and for extraction methods (w/v basis).

It therefore appears that conventional extractants or anion exchange methods may give the best assessment of the ability of soils to supply P for plant growth under near-optimum conditions, but Total-P or L-value may give a better assessment of the P-supplying power of the soil under sub-optimum conditions more characteristic of the natural environment in the hill situation.

We may conclude that it is difficult to select a single procedure which is suitable for the assessment of the P-status of all soils for the growth of improved pasture species under all conditions.

Fig. 1. P-status of hill soils measured by different methods

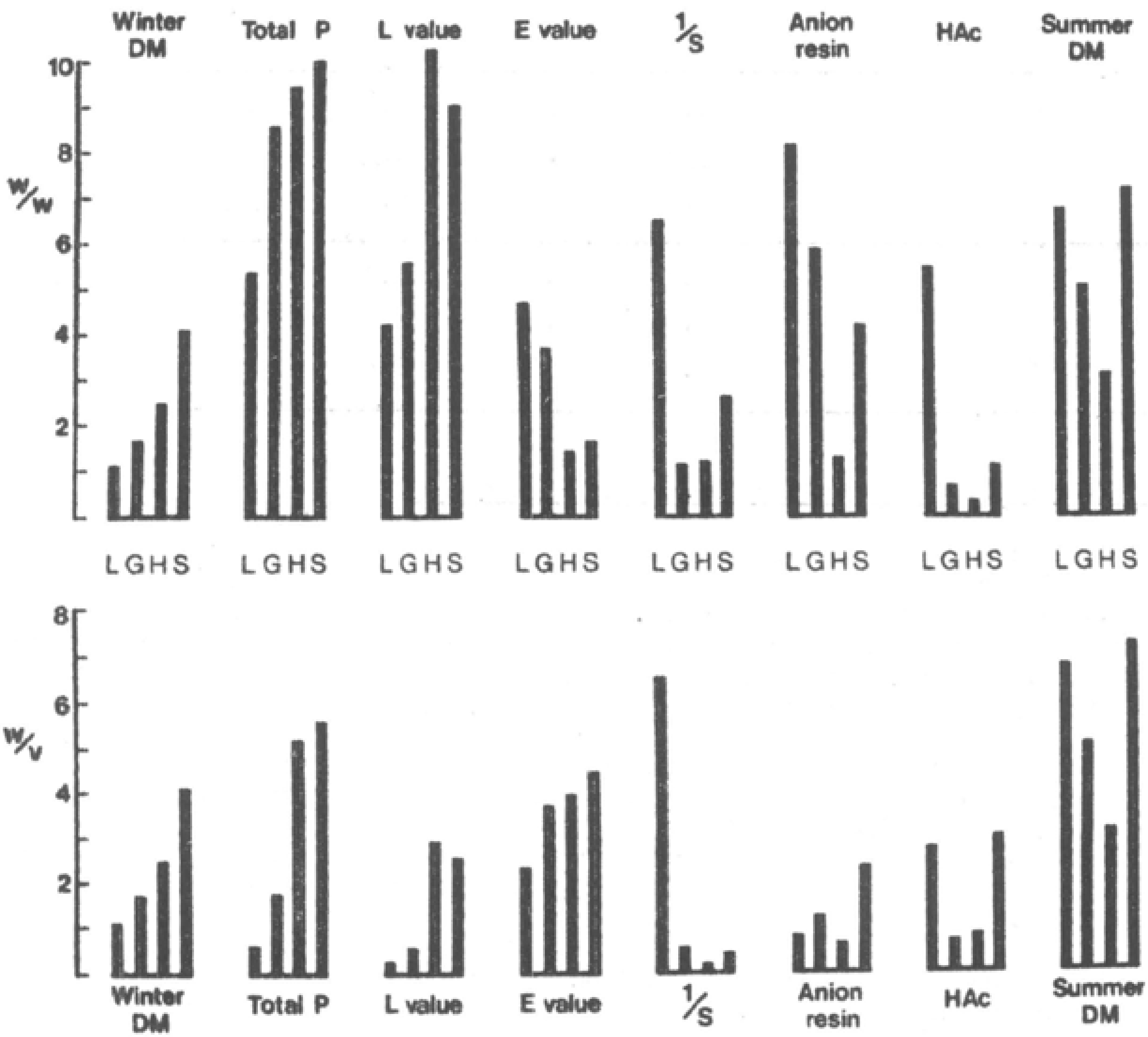


Table 3. P-status of hill soils measured by different methods

Soil:-		Lephinmore Peat	Glensaugh Peaty Podzol	House o' Muir Brown Earth	Sourhope Brown Earth
Soil data:-	pH	3.8	4.0	5.1	4.4
	OM%	94.0	36.1	11.5	11.6
Glasshouse results:-	DM(g/pot) winter	1.02	1.68	2.45	4.06
	summer	6.78	5.03	3.07	7.26
P-status: Laboratory results:- (mg/100 g)	Acetic Acid	5.48	0.66	0.28	1.08
	Anion Resin	8.17	5.92	1.22	4.17
	1/S(1)	0.65	0.11	0.11	0.26
	E-value	46.9(2)	37.0	14.0	16.0
	L-value	4.2	5.6	10.6	9.0
	Total-P	53.3	85.6	94.6	100.9
P-status: Laboratory results:- (g/m^2 to 5 cm depth)	Acetic Acid	0.27	0.07	0.08	0.30
	Anion Resin	0.41	0.59	0.34	1.15
	1/S	0.65	0.05	0.02	0.05
	E-value	2.3	3.7	3.9	4.4
	L-value	0.21	0.56	2.9	2.5
	Total-P	2.69	8.56	26.02	27.75

(2) Best available estimate

(1) Derived from P-sorbed by 5 g soil from 15 mg P added to suspension.

7. The response of perennial ryegrass to phosphorus

M. Pimplaskar, M.J.S. Floate and P. Newbould

Following the suggestion in Annual Report 1974 (HFRO 206) a further glasshouse pot experiment was conducted during the summer 1975, to establish the relative ranking of 10 soils in the absence of added P, and to measure the DM and P uptake response to increments of added P.

Ryegrass was grown in a replicated layout with 10 soils at 4 levels of P corresponding to 0, 40, 80, 160 kg/ha. Nutrients other than P, lime, and water were applied at adequate levels, and harvest cuts were taken 5, 10, and 16 weeks after sowing. The following results refer to the total yield from harvests 1 and 2.

DM production and P-uptake in absence of added P

The results for the 10 soils are given in Table 1 for DM and P-uptake by ryegrass in the absence of added P. The soils have been arbitrarily grouped into categories based on DM production between which the differences are highly significant but within which the differences are smaller. P-uptake data broadly fit the same pattern except that P-uptake is exceptionally high from (St-P), and (L-P) has a low value compared with DM yield. The high yield from this soil is surprising in view of its known low total P content. The low P-content of the herbage, and rapidly declining yields from harvest 1 to harvest 3 suggest exhaustion of P supplies from this soil. By contrast the production of ryegrass DM from House o' Muir soil increased from harvest 1 to harvest 2.

Table 1. DM yield of ryegrass at Po level

Soil	Abbreviation	Category	Yield (kg/ha)	P-uptake (kg/ha)
Sourhope-Control	S-P	high	9220	9.2
Stanhope-control	St-P	high	8608	28.2
Lephinmore-control	L-P	high	8608	6.2
Sourhope-P treated site	S+P	high	8359	9.8
Minchmoor A horizon	Min A	med.	6849	8.1
Glensaugh	G	med.	6378	5.4
Lephinmore-P treated site	L+P	med.	5033	6.1
Stanhope-P treated site	St+P	low	4204	3.4
House o' Muir	HoM	low	3899	2.6
Minchmoor B horizon	Min B	low	677	0.4
LSD 5%			593	2.4
1%			782	3.2
0.1%			1008	4.1

DM yield from field P-treated sites was surprisingly lower than from adjacent control sites, but P-uptake quantities were similar for corresponding members of each pair except at Stanhope where the DM and P-uptake values are exceptionally high from the control site.

Table 2. Ryegrass DM response to added P

Soil	Po Category	DM (kg/ha) P_{40}	DM (kg/ha) P_{80}	DM (kg/ha) P_{160}	DM response per 10 kg P added
S-P	high	10293	10840	10022	267
St-P	high	8433	8075	7950	-
L-P	high	11963	11999	10990	840
S+P	high	8655	7923	8316	74
Min A	med.	7443	7847	7822	153
G	med.	9509	10045	11132	789
L+P	med.	5642	5850	5877	153
St+P	low	6376	6708	6849	547
HoM	low	9710	10388	10323	1451
Min B	low	5791	6238	5964	1286

Table 3. Response in P-uptake by ryegrass to added P

Soil	Po Category	kg/ha P-uptake P_{40}	kg/ha P-uptake P_{80}	kg/ha P-uptake P_{160}
S-P	high	19.1	28.5	39.8
St-P	high	31.4	31.8	34.0
L-P	high	25.8	43.2	65.3
S+P	high	19.1	23.8	31.2
Min A	med.	16.8	23.7	33.9
G	med.	16.3	25.7	38.9
L+P	med.	19.0	25.6	34.1
St+P	low	10.5	25.7	38.9
HoM	low	12.3	16.3	22.0
Min B	low	9.3	12.1	17.4

DM and P-uptake response to added P

When increments of P fertiliser were applied there were positive responses in grass DM production and P-uptake with all soils except (St-P) (Tables 2 and 3). In general there was a marked response in DM from Po to P_{40} and little further response to additional P above that level, but for P-uptake the response continued up to P_{160} level. The highest responses were recorded for the soils in the low P category (from Table 1) and correspondingly the smallest responses were found among the high P category. There were a few soils in the middle of the range which showed greater responses than might have been expected from their Po ranking (viz. - Glensaugh and Lephinmore control) and this could be related to the high organic matter content of these soils.

For the paired samples from P-treated and control sites the greater responses were recorded for the control areas with the exception of the Stanhope pair where it has already been noted that (St-P) has given outstandingly high performance.

It may be concluded that P fertiliser gives a worthwhile response on most soils studied and that increased quality (i.e. higher mineral content of herbage) results from the higher levels of P addition.

A detailed report of this work is being prepared for publication.

8. Improvement of the growth and nutrition of herbage plants by the use of earthworms
P. Newbould, G.R. Bolton and E.G. Hallsworth (CSIRO)

Work on this project was resumed in 1975 with the arrival of a second batch of earthworms from Australia. These were taken straight from the airport to the plots at Lephinmore (see HFRO 196) in December and within half-an-hour of being placed on the surface of the vegetation they had disappeared from sight. Soil samples were taken at the time of the introduction and the effect of the earthworms on the soil and the vegetation will be followed by a monitoring programme.

PASTURE ESTABLISHMENT: BRACKEN CONTROL (04004)

The effect of a reduction in bracken density on the production of underlying grass
G.E. Davies and G.J. Baillie

In the spring of 1975, plots reported on in the Annual Report 1974, p.78, were opened up for grazing and the unfenced plots enclosed. Botanical and bracken frond cover records were taken of both sets of plots. Dry matter yield estimates were recorded only on the 1975 enclosed plots.

Bracken cover

The seasonal fluctuations in bracken frond numbers and height and the degree of control obtained after spraying with 'Asulox' in July 1973 are given in Table 1.

Results show that the high degree of control achieved in 1974 has been maintained in 1975. The remaining fronds show a reduction in mean height of approximately 50%. Controls at both sites in 1975 show a significant reduction in mean height. This can be attributed to a period of drought experienced prior to full frond development. There is no evidence that the reduction had any effect on yield.

Table 1. Number of bracken fronds per m^2 (nearest whole number) and mean height measurements (nearest cm)

Site 1

	Control		Sprayed		% reduction	
Year	Number	Height	Number	Height	Number	Height
1973	34	73)	33	77	-	-
1974	39	67)=	1	35	97.9	47.8
1975	34	56**	1	28	97.4	51.1

Site 2

	Control		Sprayed		% reduction	
Year	Number	Height	Number	Height	Number	Height
1973	28	59)	26	58	-	-
1974	34	57)=	<1	28	98.6	50.6
1975	33	49*	1	28	98.2	41.9

Dry matter yield

In the 1974 report results were given as the mean of two sites since they showed little difference. In 1975 however differences are apparent; thus Table 2 gives the results separately for each site, together with 1974 results for comparison.

Table 2. Accumulative dry matter yield (kg/ha) and percentage green material of underlying vegetation

Site 1

		Control		Sprayed		Significance	
Harvest	Date	Yield	% green	Yield	% green	Yield	% green
1	10. 6.74	854.5	51.8	1033.7	52.8	NS	NS
	20. 5.75	917.2	70.3	807.6	76.5	"	"
2	29. 7.74	1210.1	63.5	1201.9	60.3	"	"
	14. 7.75	1400.3	69.1	1966.7	75.8	"	"
3	2. 9.74	1518.4	74.3	1456.9	64.8	"	"
	18. 8.75	1352.9	81.4	1979.1	73.4	"	"
4	4.11.74	1816.9	63.9	1401.4	49.2	"	"
	4.11.75	2072.9	62.9	3038.9	48.4	"	"
Regrowth	10. 6.74 - 9. 9.74	762.3	83.1	477.7	68.9	NS	NS
"	20. 5.75 - 8. 9.75	931.7	86.3	1215.1	78.6	"	"

Site 2

		Control		Sprayed		Significance	
Harvest	Date	Yield	% green	Yield	% green	Yield	% green
1	10. 6.74	1050.3	54.8	912.6	49.5	NS	NS
	20. 5.75	897.1	51.3	1015.8	63.3	"	*
2	29. 7.74	1251.3	63.5	1375.8	53.1	"	*
	14. 7.75	905.8	64.4	1336.5	66.4	*	NS
3	2. 9.74	1450.8	72.4	1685.9	60.8	NS	"
	18. 8.75	1327.1	73.0	1818.1	62.1	*	"
4	4.11.74	1806.9	59.6	1719.1	51.0	NS	"
	4.11.75	1750.1	69.7	2068.7	39.2	"	*
Regrowth	10. 6.74 - 9. 9.74	760.8	78.1	536.7	63.3	NS	NS
	20. 5.75 - 8. 9.75	644.5	85.2	837.3	73.3	"	*

Table 2 shows that, although not significant, a substantial increase in accumulative yield was obtained on the sprayed treatment at Site 1 in 1975 with only a slight increase in Site 2. It is apparent however that drought conditions in mid-summer 1975 affected yield for both treatments in Harvest 3 Site 1. Percentage green material at each site and both treatments tend to be higher in 1975 than in 1974. The spray treatment at both sites in Harvest 1 and 2 show a marked increased on the 1974 results. As in 1974 the control gives the greater percentage of green material in the last two harvests.

In contrast to 1974 the spray treatments give higher regrowth yields at both sites in 1975 but as in 1974 the percentage green material is higher on the control. Both sites show an increase of approximately 10% green material on the sprayed treatments in 1975.

Botanical analysis data

Table 3. The effect of spraying on species change and the amount of bare ground

Percentage cover assessed using a 10 point quadrat placed at 60 and 120 locations in 1975 and in 1974/76 respectively

Site 1

Plots	Year	Treatment	Bareground	At.Ac.Pp.	Fo. DF.	Dicots
74R	1974	Control	11.1	42.2	14.7	9.6
		Spray	22.7	18.9*	25.1*	5.4
74R	1975	Control	2.9	44.4	17.9	16.2
		Spray	8.8	29.4*	33.2*	6.1
75R	1975	Control	9.8	42.5	9.0	12.9
		Spray	2.0	46.8	4.0	9.3

Site 2

Plots	Year	Treatment	Bareground	At.Ac.Pp.	Fo. DF.	Dicots
74R	1974	Control	3.0	30.5	42.1	11.2
		Spray	11.2	10.2	56.5	4.8
74R	1975	Control	1.2	27.5	41.7	17.1
		Spray	1.9	21.2	52.4	9.3**
75R	1975	Control	10.2	15.0	50.1	13.1
		Spray	3.8	17.4	44.3	11.1

Key: Species At = Agrostis tenuis; Ac = Agrostis canina; Pp = Poa pratensis
Fo = Festuca ovina; DF = Deschampsia flexuosa;
Dicots = Dicotyledonous herbs.

Plots 74R = plots enclosed and recorded in 1974, grazed and recorded in 1975.
75R = plots grazed but unrecorded in 1974, enclosed and recorded in 1975.

The 1974 results suggest that 'Asulox' severely reduced the percentage cover of A. tenuis, A. canina and P. pratensis on both sites. This resulted in an increase of bare ground with F. ovina and D. flexuosa taking advantage of this and consequently increasing their cover. By 1975 however bare ground had been considerably reduced, in Site 1 by the recovery of the broad-leaved species and the still increasing cover of the fine-leaved species and in Site 2 by the recovery of the broad-leaved species. The sward on the latter site is not very different to its original composition, Site 1 however has approximately twice the cover of F. ovina and D. flexuosa and considerably less Agrostis species and P. pratensis than originally. As shown in Table 3 results for Site 1 are significant for both years. Plots on Site 1 and 2 that were grazed in 1974 have more or less returned to their original composition in 1975. Species that account for the decrease in bare ground on the sprayed treatment are not shown in Table 3 but for Site 1 they are Festuca rubra and Holcus mollis and for Site 2 Anthoxanthum odoratum and Deschampsia caespitosa.

Although dicotyledonous herbs contribute little to yield it is of interest to note, that, though not significant there does seem to have been a reduction in their number at both sites in the spray treatment initially and at Site 2 in 1975 this difference is significant. However cover on the controls has also increased in 1975 probably due to the absence of grazing in 1974. In the 1974 grazed plots there is little difference between treatments.

Summing up, it appears that on a dry heath type community such as Site 2 with a low potential for increased growth, reducing the bracken cover has little effect. Perhaps the only advantage to be expected is an increase in utilisation during the summer months. A site richer in the cover of Agrostis species and a greater soil potential such as Site 1 is more promising but due to the 'puffy' nature of the soil horizon a year after treatment together with a large amount of bare ground an increase in yield cannot be expected till the second year after treatment. The soil surface is now more consolidated and bare ground has been reduced.

The increase in percentage green material in 1975 is mainly due to seasonal differences. However, on the spray treatment, recovery after 'Asulox' toxicity might be an additional factor. It is suggested that the more humid microclimate afforded by the bracken cover in mid-summer results in a higher percentage of green material in the control treatment in later harvests.

The deleterious effect of 'Asulox' on species composition, especially when combined with lack of grazing is clearly evident two years after treatment on the 1974 ungrazed plots in Site 1. This is not so marked in Site 2 where a large cover of fine-leaved species was present originally and the sward probably only lightly grazed even before treatment.

EFFECTS OF UTILISATION: MOORLAND (04005)

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

S.A. Grant, G.R. Bolton and L. Torvell

This experiment was set up at Lephinmore to investigate the effects of increasing stock numbers on blanket bog vegetation. There were three sites and at each site plots at three different stocking rates were established. The lowest rate, 1.5 ha per sheep, was equivalent to the average for the Cowal area of Argyll. This rate results in the utilisation of about 15% of the annual production of the vegetation. The intermediate and high stocking rates were two and three times the low rate respectively. Grazing treatments were begun in 1971.

The experiment was closely monitored during the first three years to record patterns and levels of use of the main bog species. A report has been prepared on this phase of the study and is to be published later in 1976.

Current effort is being directed at measuring the effects of increasing utilisation on productivity and floristic composition of the vegetation. Harvests were made in August 1971 before the grazing treatments were started and in late July 1974 after three years of grazing. The sites differed in both floristic composition and age since last burned so that significant site differences, found at both harvest dates, were not unexpected. Plots destined to receive different grazing treatments showed no significant differences in 1971 prior to grazing. However, in 1974, after three years of grazing, significantly lower standing crops and total green dry matter were found at the high stocking rate ($P < 0.05$). The results are summarised in Table 1 below.

Table 1. Effect of stocking rate in DM yields (kg/ha)

	STOCKING RATE		
	Low	Intermediate	High
1971 - prior to grazing			
Standing crop*	2780	2720	2977
Green dry matter	1543	1508	1655
1974 - after 3 yrs of grazing			
Standing crop	4157	4235	3362
Green dry matter	1469	1487	1146

* Two of the three sites were recently burned; increase in standing crop between 1971 and 1974 is largely the result of build up of the woody stems of heaths.

Variability in cover and distribution of individual species was such that with quadrat numbers it was possible to handle, harvested quadrat data were thought to provide a somewhat inadequate and insensitive measure of the effects of stocking rate on individual species. This data is supplemented therefore by annual floristic analyses using point quadrats to estimate cover. Fluctuations in cover between years occur as a result of sampling error and also in relation to both seral changes in cover (stage of development of burn sub-sere) and climatic variation between years which affects annual production. Thus data need to be accumulated over a number of years to distinguish definite trends from such fluctuation. Though it is premature to comment on grazing effects on individual species, the results of the 1975 floristic analysis with respect to area of bare ground/bare Sphagnum and density of vegetation (total strikes against vascular plants) show significant differences among plots at different stocking rates ($P < 0.01$). The results are summarised in Table 2. The area of bare Sphagnum increases and density of vegetation (this includes green leaf, dead leaf and woody stems) decreases as stocking rate is increased.

Table 2. Floristic analysis 1975
Effect of stocking rate on extent of bare ground and density of vegetation

% Cover due to bare ground/bare Sphagnum

	STOCKING RATE				
	Low	Intermediate	High	Mean	
Site 1	13	20	27	20.0	
2	12	15	26	17.7	
3	6	16	26	16.0	
Mean	10.3	17.0	26.3	5.0	LSD between means

(Cont'd)

Table 2. (Cont'd)

Density of vegetation (Total strikes against vascular plants)

		STOCKING RATE			
	Low	Intermediate	High	Mean	
Site 1	1054	955	887	965	
2	959	921	727	869	
3	1042	996	782	940	
Mean	1018	957	799	91	LSD between means

Subsidiary projects

a) Serial sampling of bog species to determine in vitro dry matter digestibility.

All material collected in 1973 was oven dried at 45 °C. Evidence that method of drying could be important with some hill species emerged at this time from work of Dr Milne with heather (Calluna vulgaris). Thus in 1974 and 1975, if sample quantity was sufficient samples were split, half being freeze dried and half oven dried at 45 °C. Where samples were small all the material was freeze dried. The results are summarised in Table 3. The main findings are as follows:-

(1) With the exception of the grass Molinia caerulea which is unaffected by method of drying, freeze dried samples give in vitro dry matter digestibility results some 4-10 units above those of the same sample when oven dried.

(2) The drawn bases of Eriophorum vaginatum leaves have substantially higher digestibilities than green leaves.

(3) Many bog species have digestibilities of over 60 per cent in May, some maintain this quality until July but all have poor digestibility by September.

(4) The results for Juncus squarrosus are indicative of the failure of the method with this species rather than exceptionally poor digestibility.

b) Selective grazing behaviour of sheep in relation to Calluna vulgaris and Eriophorum vaginatum.

Calluna vulgaris and Eriophorum vaginatum are known to be the main dietary constituents of sheep grazing blanket bog vegetation in winter. However the relative importance of the two species can not be properly assessed from estimates of their utilisation based on visual scoring techniques. This is because grazed leaves of Eriophorum vaginatum may be drawn or bitten off. As drawn leaves can not be detected and we have no knowledge of the ratio of drawn to bitten off leaves, the extent to which visual estimates of utilisation are underestimates is also unknown.

To obtain further information on this matter a small area of boggy vegetation with co-dominant Calluna and Eriophorum was found at Glensaugh and fenced so that samples of grazed herbage could be collected using oesophageal fistulated sheep. The area was grazed for short periods during April, June and September 1975 and two samples were collected from each of four sheep at each sampling date. Random pinches of carefully drawn Eriophorum were also collected at each date to characterise the ratio of drawn base: green leaf: dead leaf of herbage on offer for comparison with ratios in the ingested material.

There was a disadvantage in having to conduct this study at Glensaugh rather than at Lephinmore in that it was not possible to accustom the sheep to grazing bog vegetation for a few days before collecting the samples. Eriophorum vaginatum is rare on accessible parts of Glensaugh and the unfamiliarity

Table 3. In vitro dry matter digestibility of separated green material of various bog species

Month	Year	Method of drying	Trichophorum caespitosum	Molinia caerulea	Eriophorum vaginatum Green leaf	Eriophorum vaginatum drawn base	Eriophorum augustifolium	Juncus acutiflorus	Juncus squarrosus
May	1973	oven	66.6	67.0	61.6		66.4	-	28.9
	1974	freeze	69.1	67.5	57.2	63.1	62.6	63.3	38.6
	1975	oven	61.4	-	44.2		60.5	-	25.9
		freeze	66.7	-	46.4	58.4	64.5	62.9	31.1
July	1973	oven	58.1	52.5	36.7		40.0	64.0	26.7
	1974	oven	57.7	53.3	51.7		54.2	55.0	23.6
		freeze	67.4	53.3	57.0	57.0	65.5	72.0	23.5
	1975	oven	60.7	-	45.6		57.4	58.4	24.0
		freeze	68.0	-	52.2	60.3	61.8	66.9	27.2
September	1973	oven	38.2	46.7	41.3		37.4	49.4	20.3
	1974	freeze	53.3	47.8	41.8	52.3	57.0	55.0	34.0
	1975	oven	49.9	50.9	38.2		39.3	45.1	22.0
		freeze	53.6	50.2	43.2	52.2	44.4	50.5	24.8

of the sheep with this species may have biased the results.

Heather was found to average four times the frequency of Eriophorum in the fistula samples in April and June and five times the frequency in October. Ratios of drawn base: green leaf: dead leaf were quite variable among the sheep and sometimes between different samples from the same sheep. Some samples contained no drawn leaf bases and others had ratios which indicated that green leaf had been selected and all leaves drawn. Calculations based on the ratios obtained after summing all counts all samples for each category on each date indicate that substantial proportions of the leaves are drawn and that the amount drawn was affected by season. The leaves would appear to be more readily drawn in April and June than October. The results are summarised in Table 4.

Table 4. Nature of ingested herbage in oesophageal fistula samples from a Calluna-Eriophorum co-dominant site at Glensaugh

	Percent frequency Calluna		Percent frequency Eriophorum		Calculated percentage Eriophorum leaves drawn	
	Mn	(range)	Mn	(range)	if grazed to stubble	if grazed to 60% length
April	82.1	(65–100)	16.9	(0 – 31.5)	74	66
June	74.6	(36– 95)	19.3	(3 – 39.5)	88	81
October	82.2	(53– 98)	8.3	(2 – 12.5)	32	22

2. Effects of utilisation by the grazing hill sheep on the growth form and productivity of heather moor
S.A. Grant, J.A. Milne, G.T. Barthram, L. Bagley and L. Torvell

Plots on an almost pure stand of young heather were grazed during the period of rapid extension growth of long shoots (June/July) and the period of lignification, seed set and build up of carbohydrate reserves (September/October). Sheep numbers were adjusted to remove 0, 40 or 80% of the current years shoots. All permutations of time of year and level of utilisation were provided. Grazing treatments were begun in June 1973. Two years of grazing had a large effect on the swards (see below) and in spring 1975 it was decided to protect a portion of each plot from further grazing to allow comparison of the short and longer term effects of the grazing treatments.

Effects of grazing on dry matter production

Quadrats were harvested at fortnightly intervals on the control plot to record the annual growth curve for new shoot production. Growth started in early May, reached 7 kg/ha/day by mid-May, 20 kg/ha/day by mid-June and peaked at 36 kg/ha/day in late July. Growth rate fell slowly through August and September and thereafter more rapidly.

Production data from the experimental plots for 1975 are summarised in Table 1 below.

The capacity of heather to recover from short periods of heavy grazing is indicated by data for June 1975. The removal of long shoots reduces the rate of build up of the woody framework of the plant so that standing crops are reduced on grazed plots. However the stimulation to production of new shoots is such that similar yields are often obtained from widely varying standing crops. Indeed the amount of current growth produced per unit area by June 9 was unaffected by grazing history. However, as earliness of growth is also affected, the degree to which this compensatory mechanism operates can not be properly assessed at this early date. In September the amount of current shoots available obviously will be reduced on plots grazed in June/July

Table 1. Dry matter production for 1975 of heather stands with different previous grazing history. Grazing treatments were begun in 1973.

Grazing Treatment June/Sept.		JUNE Standing Crop (kg/ha) adjusted for cover	JUNE % current shoots	JUNE Weight current shoots kg/ha	SEPTEMBER Weight current shoots kg/ha
0	0	7330	4.3	315	2640
0	40	4271	10.2	389	2569
0	80	3072	12.2	399	2174
40	0	4926	13.0	623	1649
40	40	4108	9.4	387	1754
40	80	1850	15.2	303	1246
80	0	4094	10.0	410	1319
80	40	3179	14.9	454	939
80	80	1788	20.0	328	691
Correlation (treatments ranked in order of amount grazed)		−0.934***	+0.841**	−0.361 N.S.	
Analyses of Variance					
Level of use in June		N.S.	N.S.	N.S.	***
Level of use previous September		**	N.S.	N.S.	**

($P < .001$), but variation attributable to grazing in the previous September is also significant ($P < .01$) and indicates that grazing had reached levels causing reduced production on some plots. This was mainly due to reduced production on plots grazed to remove 80% of the current growth in September.

Site of new shoot growth

Heavy grazing in autumn results in a higher percentage of shoots being grazed into the old wood than in summer, perhaps because of the greater degree of lignification by September. In addition more shoots are broken or uprooted. By 1975 a thinning of the stand was noticeable on these plots. The cause was found to lie in the nature of the sward response in terms of the site of new shoot growth. Mohamed and Gimingham (1970) reported that light grazing of heather at the periphery causes a) the growth of a few of the uppermost short shoots into new long shoots and b) the appearance of clusters of new shoots from the lower woody parts of the branches. They claimed that if grazing is heavy or repeated the response becomes confined to the second category. On plots heavily grazed in autumn some shoots showed an extreme form of the second response in that the whole aerial part of the twig remained bare and new shoots were confined to the bases of the twigs (c.f. heather newly regenerating after fire). Such growth was found with 15% of shoots on the 0/80 plot, 55% on the 40/80 and over 80% in the 80/80 plot. Such regrowth was rare on other plots being confined to the vicinity of bare patches.

Seasonal patterns of growth and susceptibility to grazing

With evergreen woody perennials current seasons shoots do not produce sufficient assimilate to support their own growth during the early part of the growing season; assimilate is usually imported from overwintering green shoots and carbohydrate reserves are used.

Carbohydrate reserves are usually high at the start of the growing season, fall steadily during the rapid phase of long shoot extension and reach their lowest level at the onset of flowering (early August in the case of heather). Thereafter there is a steady build up of reserves which are restored to normal levels by the end of the growing season. Such a pattern has been demonstrated for heather (Grace & Woolhouse 1970).

Samples were collected for the measurement of total water soluble carbohydrate from all plots on three occasions in 1974 viz. May, August and October. Shoots were separated into green and woody fractions, the percentage green by weight was recorded, and water soluble carbohydrate measured for each fraction. Results are summarised in Table 2.

Table 2. Mean water soluble carbohydrate levels of shoot fractions, expressed as a percentage of dry weight

Grazing treatment June/Sept.		MAY Green	MAY Wood	AUGUST Green	AUGUST Wood	OCTOBER Green	OCTOBER Wood
0	0	12.90	6.41	13.01	2.17	11.80	6.05
0	40	10.10	5.54	10.93	3.03	11.89	5.27
0	80	12.20	4.29	11.27	3.16	12.23	4.69
40	0	11.93	6.75	9.49	3.29	10.92	5.83
40	40	10.35	5.03	9.81	3.69	10.96	4.99
40	80	12.19	5.84	9.88	2.99	9.70	3.97
80	0	11.45	6.07	10.74	3.02	13.36	5.19
80	40	11.11	5.59	10.27	3.00	10.22	4.31
80	80	11.51	5.98	8.95	3.09	9.92	3.81
Analyses of Variance							
June		N.S.	N.S.	N.S.	N.S.	N.S.	**
September		N.S.	N.S.	N.S.	N.S.	N.S.	***

The mid-season depletion of reserves was clearly shown by the wood fraction in August. It was evident from the analysis of variance for the wood fraction in October that grazing affects the ability of the plant to build up reserves. The relationship between the carbohydrate reserve level and ratio of assimilating to non-assimilating tissue of the shoot (percent green) was examined using regression analyses. In the initial analyses, using plot means, significant regressions were found for the wood fraction in both May and October, 58 and 71 per cent of the variation respectively being accounted for by the regression. Water soluble carbohydrate levels were greater in shoots with more green tissue. Such a relationship did not exist in August.

Effects of grazing on the digestibility of heather

The in vitro dry matter digestibility was determined on samples of separated current season's shoots collected from grazed plots. The results are shown in Table 3.

The data were statistically analysed taking account of variation due to level of use in the present grazing period, the immediately preceding grazing period and date. Variation attributable to the level of use in the preceding grazing period was significant ($P < .05$). This is in agreement with the cutting experiment (see 1974 report) where clippings from plants with a history of previous cutting had higher dry matter digestibility than clippings from unclipped, less recently or more lightly clipped plants.

Effect of continued grazing or resting on bare areas

Transects were marked out across bare areas on three plots. One plot was due to be grazed for five weeks in summer only, one for the same period in autumn only and one in both summer and autumn. A portion of each plot was fenced to protect it from further grazing. The transects were recorded in June prior to grazing and again in November after grazing was over. On grazed areas heather cover showed no increase (one plot) or was reduced (two plots); the next most frequent species *Rumex acetosella* showed little change (two plots) or was reduced (one plot). On all three rested areas ground cover due to both heather and *Rumex* increased substantially.

Table 3. *In vitro* dry matter digestibility of current season's shoots

Grazing Treatment June/Sept.		July 1975	September 1975
0	0		52.9
0	40		57.8
0	80		59.4
40	0	59.0	
40	40	58.6	57.9
40	80	68.8	61.7
80	0	57.7	
80	40	58.5	61.1
80	80	62.0	64.5

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

A joint report will be found under 02004/04005, item no.3.

EFFECTS OF UTILISATION: PASTURE (04006)

Defoliation and pasture regrowth
J. King, W.I.C. Lamb and M. McGregor

It is to be expected that as a result of reducing leaf area index, defoliation of a grass sward will lead to a lower growth rate.

Increased cutting frequency, which at a given stubble height will decrease leaf area, is well known to have this effect. However, raising the cutting height to leave a longer stubble can reduce regrowth and it is therefore apparent that factors other than leaf area are involved. It is necessary to distinguish between the effects of cutting on regrowth itself and on the proportion of the regrowth that is harvested. Some cutting treatments appear to have their main effect only on the latter. Differential removal of old or young leaves can influence the subsequent regrowth rate and it has been suggested also that plants can compensate for the removal of leaf tissue by increased activity of the remaining leaves. Loss of leaves by senescence before harvesting has also been implicated, but the concentration of soluble carbohydrates does not normally seem to be important. However this may depend on the severity of the defoliation.

It is evident that another effect of defoliation is to alter the growth-form of the sward, not only in respect of height, density, leaf angle etc. but also affecting the proportion of young and old leaves and presumably also photosynthetic rate, carbohydrate concentration and other characteristics. It follows therefore that the effect of a given defoliation is likely to differ between swards according to how they have been defoliated previously. To investigate the effect of defoliation in this context two cutting experiments have been carried out. The first of these in 1974 yielded some tentative conclusions now amplified and confirmed by a second experiment reported here.

Treatments

The following treatments were applied to pure swards of S23 ryegrass maintained in a wholly vegetative state.

Cut weekly to 2 cm	(F_1L)
" " " 4 "	(H)
" 3 wkly " 2 "	(F_3L)
" " " 4 "	(H)

These treatments gave rise to four swards which differed in growth-form measured here in terms of leaf angle and stubble leaf area. Weekly cutting (F_1) produced the most prostrate swards while the leafiest swards resulted from weekly or 3 weekly cutting at high stubble height.

Table 1.

	Mean leaf angle	Stubble LAI
F_1L	54.6	1.13
H	59.6	2.49
F_3L	72.5	0.26
H	64.2	1.90
LSD	12.0	

Measurements were then made of the effect of a single cut in each of these regimes.

The % of different sward components removed by this cut was measured and is shown in Table 2.

Table 2. % of sward components harvested by a single cut

	Terminal Leaf %	1st lateral leaf %	T + 1st lateral %	Total Green Crop %
F_1L	49.4	31.1	34.3	26.7
H	45.0	25.0	35.6	20.2
F_3L	92.2	87.5	91.4	63.8
H	70.9	74.3	72.6	41.6

These figures show that a single weekly cut (F_1) removed only a small (20-27%) proportion of the total green crop and a rather larger fraction (34-36%) of the new leaf (T + 1st Lateral). In comparison a single cut at 3 weekly intervals removed a much higher proportion especially when cutting height was low. The stress imposed by an individual defoliation was therefore much smaller on the frequently cut swards and was greatest on the infrequently cut swards especially when the cutting height was low.

Results

1. On the leafy swards, i.e. F_1L, F_1H and F_3H, regrowth in terms of production of new leaf was exponential throughout. (Fig.1). That is to say Relative Growth Rate was constant and there was no evidence of reduced rate of leaf production in the first few days after cutting. The data suggest that on these swards regrowth was largely a function of current photosynthesis and not dependent on translocated carbohydrates. Sward F_3L differed in having a very small stubble leaf area. Nevertheless new leaf production was similar to that of the other swards. This was apparently at the expense of translocated carbohydrates within the plant as evidenced by the very high but progressively declining Relative Growth Rates in the first 12 days (Fig.1). After this Relative Growth Rate appeared to become constant.

2. When regrowth was expressed in terms of weight change of the Total Green Crop lower growth rates in the first week after cutting were found especially on the 4 cm (H) swards. (Fig.2). This was due to weight losses by older leaves and tiller bases which offset the weight increase by the younger leaves. (Fig.3).

This effect was greatest on those swards which had the largest weight of old-leaf and tiller bases (i.e. those cut at 4 cm) and least on those with the smallest stubble weight. After the first four days of regrowth no reduction in the rate of regrowth was apparent and growth became exponential on all swards.

This early weight loss included a loss of soluble carbohydrates following defoliation (Table 3). In percentage terms this was greatest on the 3 weekly and least on the weekly cut swards.

Table 3. % Soluble carbohydrates in tiller bases

	Day 0	4	8	12	25
F_1L	16.0	9.4	18.2	20.6	28.9
F_1H	19.2	14.0	18.6	28.6	32.7
F_3L	21.4	9.4	15.1	17.6	26.2
F_3H	24.9	15.4	21.9	28.8	32.4

Thus the greatest percentage loss of carbohydrates took place on the sward where cutting imposed the greatest stress (F_3L) and in which the Relative Growth Rate data indicated that translocation to new leaf meristems had taken place. The smallest loss occurred on the weekly cut swards where stress was least. The actual weight loss in the 3 weekly cut treatments (F_3) is small compared with the loss in weight by the old leaves and tiller bases.

Measurements were made of net canopy photosynthesis (Fig.4) and canopy respiration under standard light intensities. The comparative values correlated only moderately well with rate of dry matter production or leaf area index as the following rankings show:

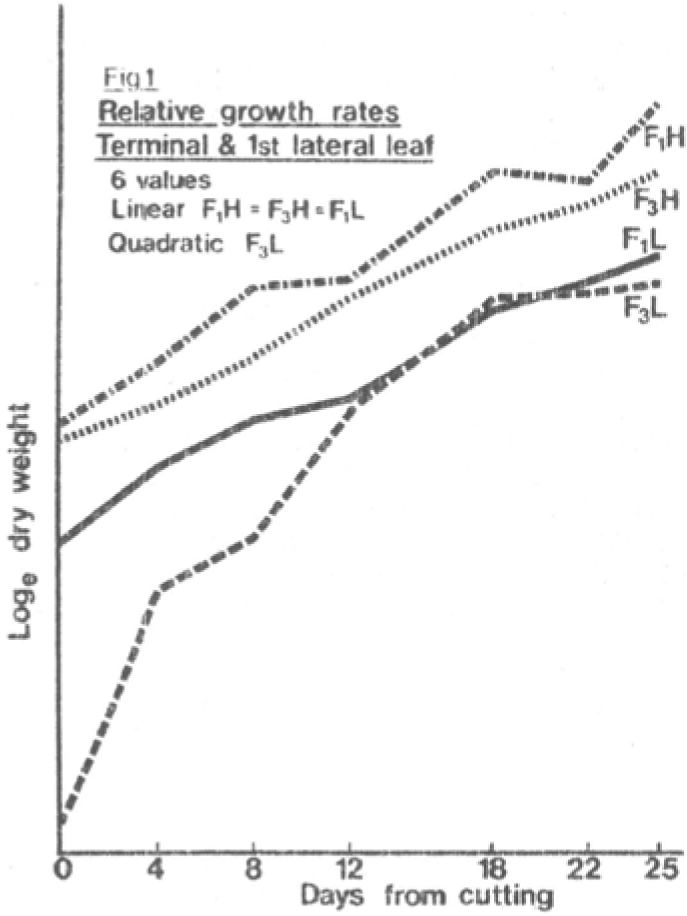


Fig.1
Relative growth rates
Terminal & 1st lateral leaf
6 values
Linear F1H = F3H = F1L
Quadratic F3L
F1H
F3H
F1L
F3L
Loge dry weight
0 4 8 12 18 22 25
Days from cutting

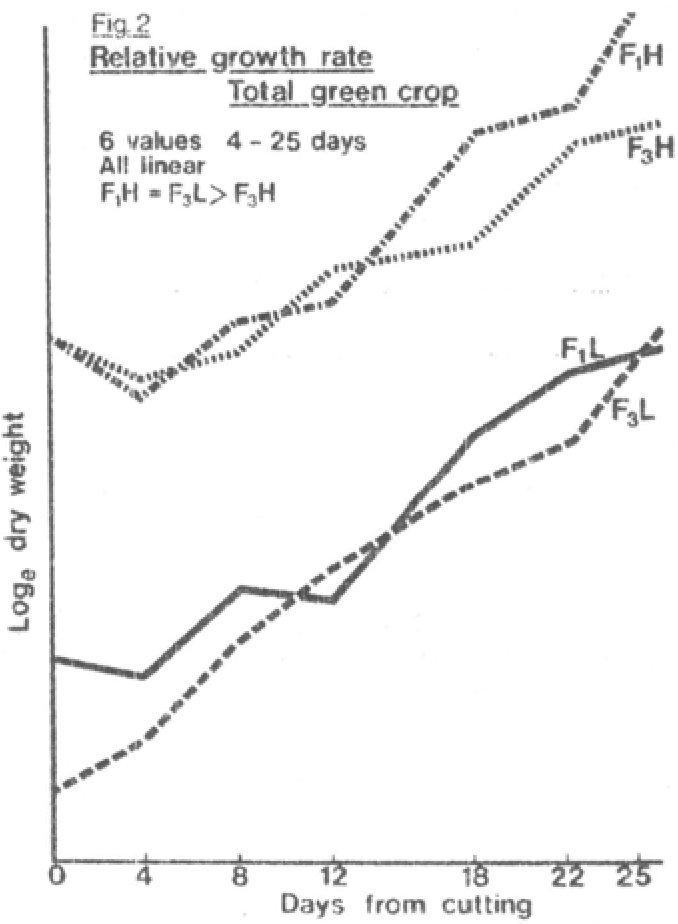


Fig.2
Relative growth rate
Total green crop
6 values 4 - 25 days
All linear
F1H = F3L > F3H
F1H
F3H
F1L
F3L
Loge dry weight
0 4 8 12 18 22 25
Days from cutting

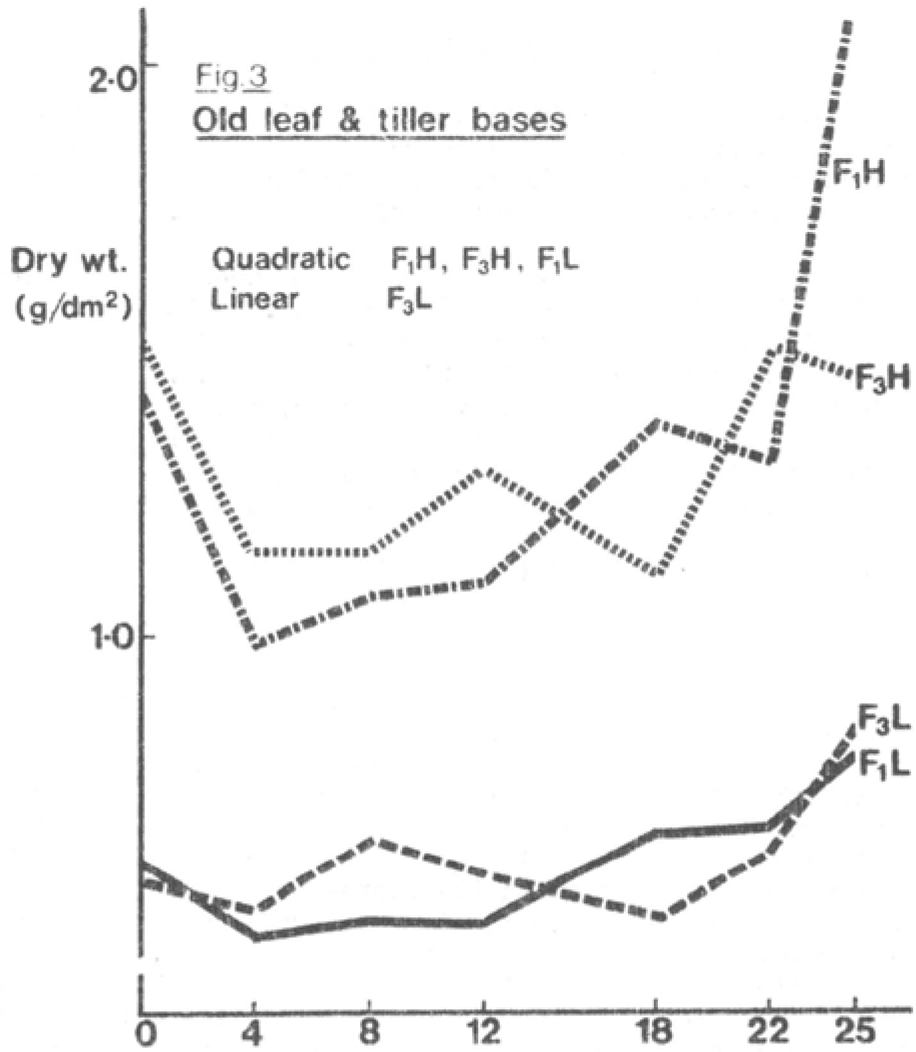


Fig.3
Old leaf & tiller bases
Dry wt. (g/dm²)
Quadratic F₁H, F₃H, F₁L
Linear F₃L
2·0
1·0
F₁H
F₃H
F₃L
F₁L
0
4
8
12
18
22
25

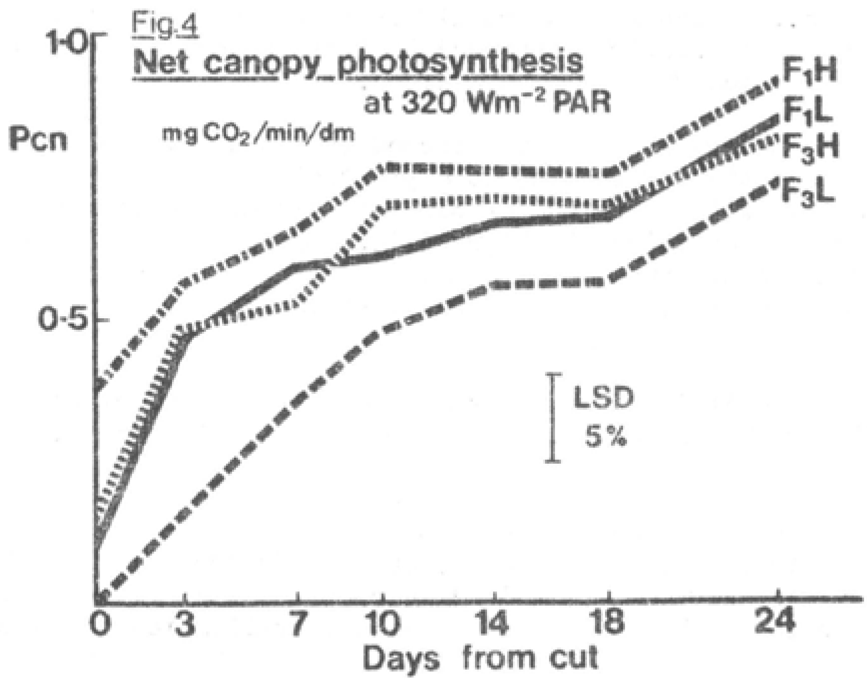


Fig.4
Net canopy photosynthesis
at 320 Wm⁻² PAR
Pcn
mg CO₂/min/dm
1·0
0·5
F₁H
F₁L
F₃H
F₃L
LSD
5%
0
3
7
10
14
18
24
Days from cut

P net canopy	:	$F_1H > F_3H = F_1L > F_3L$
Green crop growth rate	:	$F_1H > F_3H = F_1L = F_3L$
New leaf growth rate	:	$F_1H = F_3H > F_1L = F_3L$
Leaf area index	:	$F_1H > F_3H > F_1L > F_3L$

The highest net photosynthetic rate was associated with the highest crop growth rate but the lowest photosynthetic rate gave a better crop growth rate than might have been expected. The reasons for this are at present not clear but may be connected with the method of measurement.

There also occurred qualitative differences between the canopies on different swards which affected photosynthetic rate. Thus photosynthetic rate per unit leaf area from 5 days after cutting onwards was greater on the low (2 cm) cut swards than for the high (4 cm) cut swards. The interaction of this with leaf area index led to similar photosynthetic rates being measured for swards F_3H and F_1L despite the larger leaf area of the former. This qualitative superiority of the close cut swards was due to the comparative absence of old leaf and the preponderance of new leaf after 5 days regrowth. It should be noted however that the sward with the highest growth rate had a canopy of comparatively low efficiency but of high leaf area.

Conclusions

These results suggest that in swards of adequate leaf area index, irrespective of defoliation regime, regrowth in terms of new leaf production is a function of net photosynthesis and is an exponential function of the area of young leaf. Translocation of assimilates within the plant for new leaf growth seems likely to occur only at very low leaf areas after severe defoliation. Normally therefore regrowth of new leaf will be reduced by defoliation but only to the extent that leaf area and its photosynthetic efficiency is reduced. Weight losses by other sward components in the first few days after defoliation are interpreted as respiration and senescence losses. These lead initially to a smaller rate of gain in total crop weight, but after 4-8 days the rate of crop growth becomes exponential and a function of leaf area and unit photosynthetic rate. Much of the early weight loss after cutting is in the form of old leaves and represents the senescence of leaves which would be lost in any case. Such leaves are likely to be photosynthetically inefficient and their loss could be expected to increase canopy efficiency but there was no evidence that this took place.

Sward growth-form is greatly affected by the cutting regime, frequent defoliation in particular leading to a prostrate sward and close defoliation leading to swards with a minimum of old leaf tissue and low senescence losses. The latter are characterised by high efficiency in terms of photosynthesis per unit leaf area and although this parameter is not independent of herbage length the superiority of these swards persisted up to the end of the measurement periods.

High canopy efficiency is clearly a desirable attribute but on these data, for high growth rates, high leaf area is more important.

Growth form has a major effect on the proportion of the standing crop removed by cutting and hence on the stress imposed. Utilisation rate is similarly affected. For the 3 weekly cut swards gross utilisation is adequately measured by the % total green crop removed. The values were 42% and 64%. For the weekly cut swards however, utilisation is better expressed in terms of the amount removed of the terminal and 1st lateral leaves amounting to 34-36%. Utilisation of old leaf was negligible so that in these swards the utilised fraction was almost entirely young leaf, the residue eventually being lost by senescence.

These data have implications for grazed swards in that, if allowance is made for wastage in grazing the taller 3 week old stands, utilisation rates of continuously and intermittently grazed swards may not be very different. The mean digestibility of the herbage removed from the former is likely to be the highest. Comparison of cut and grazed swards in terms of composition (leaf class, sheath, stem etc.) shows them to be reasonably similar especially the high (4 cm) cut swards, so that extrapolation to the grazing situation may not be too fanciful.

NUTRIENT CYCLING/PLANT NUTRITION (04007/04003)

1. Investigation of patchy growth in improved pasture on deep peat (Le-5)
M.J.S. Floate, G.R. Bolton and A.D. Ironside

The problems of patchy growth on improved pastures on deep peat treated with a nominal 1 ton/ac dressing of lime were described in the Annual Report 1974 (HFRO 206). The patchy growth is thought to be related to uneven lime spreading and associated induced nutrient deficiencies: two field experiments to examine these possibilities are in progress. The first was established in 1974 and consists of a series of lime treatments (Le-3): this is described under project 04001. The second (Le-5) was established in 1975 and consists of a replicated micro-plot layout on peat sited near the lime-response experiment. The micro plots are 25 cm diameter rings sunk into the peat and the treatments consist of three lime levels:- 0, 1, 2 tons/ac; and six nutrient treatments:- complete, -Mg, -K, -B, -Mo and -S. The micro plots were trimmed and surface seeded with ryegrass and white clover in May. The plots are watered regularly with appropriate nutrient solutions and plant counts were made in June and July and October, harvest cuts and grass/clover separations were carried out in August and October. The results are presented in Tables 1 and 2.

Clover failed to germinate on L_0 treatments and whilst some grass germinated it failed to survive more than three months. Although there was a smaller number of clover plants on -Mo treatment at L_1 level there were no significant effects due to lime or treatment. Between June-October grass and clover numbers fell by 7 and 52% respectively.

There was not sufficient grass to harvest on any L_0 plot or on any treatment plot in October. Grass yield was significantly (.1%) greater at L_2 than L_1 levels, but there were no significant differences in clover yield due to lime level. There were no significant differences in grass yield due to nutrient treatments but there were significantly lower yields from clover on the -Mo and -K treatments as indicated in Table 2. The latter observation agrees with the results of glasshouse trials with white clover reported elsewhere in this report (p. 74).

2. Responses of hill soils and pasture to improvement
M.J.S. Floate, J. Eadie, A.D. Ironside, R.A. Hetherington and G.R. Bolton

This project was reviewed in some detail in the Annual Report for 1974 (HFRO 206) when problems concerning the non-agreement of pasture production data and calculated intake data were discussed. Some comparisons were also made at that time of the changes in the amounts of nutrients recycled related to improvement treatment and to duration of the experiment.

Both G-3 and F-2 sites at Sourhope have now been in progress for over five years and it is appropriate that a thorough study be made of the effects of improvement at this stage. Carlos Gomez is currently carrying out a study of these effects during tenure of a Fellowship from the IRI Research Institute.

Table 1. Plant numbers in Expt Le-5 (plants/.05 m^2)

Treatment	Grass			Clover		
	17. 6.75	18. 7.75	8.10.75	17. 6.75	18. 7.75	8.10.75
L_0 Complete	13	12	-	0	0	0
-K	18	24	-	0	0	0
-Mg	18	14	-	1	0	0
-B	14	18	-	0	0	0
-Mo	17	21	-	0	0	0
-S	18	17	-	1	0	0
L_1 Complete	27	29	22	29	31	16
-K	28	32	26	29	28	14
-Mg	23	31	23	30	31	15
-B	23	26	19	29	33	15
-Mo	22	29	21	24	23	12ns
-S	22	29	20	29	31	16
L_2 Complete	25	28	27	29	31	15
-K	30	32	26	27	28	14
-Mg	26	28	22	30	31	12
-B	27	31	25	33	31	12
-Mo	20	28	24	28	29	13
-S	25	29	22	31	33	14

Table 2. Plant DM production in Expt Le-5 (g/.05 m^2)

Treatment	Grass		Clover	
	15. 8.75	7.10.75	15. 8.75	7.10.75
L_0 Complete	-	-	-	-
-K	-	-	-	-
-Mg	-	-	-	-
-B	-	-	-	-
-S	-	-	-	-
-Mo	-	-	-	-
L_1 Complete	0.8	-	0.7	0.5
-K	1.0	-	0.4*	0.2**
-Mg	0.9	-	0.7	0.6
-B	0.7ns	-	0.7	0.6
-S	0.8	-	0.7	0.4ns
-Mo	0.7ns	-	0.4*	0.4ns
L_2 Complete	1.1	-	0.8	0.4
-K	1.4	-	0.7	0.3
-Mg	1.1	-	1.0	0.4
-B	1.2	-	0.7	0.4
-S	1.0	-	0.6	0.3
-Mo	1.1	-	0.6ns	0.2ns

The title of his study is "Evaluation of the effects of hill land improvement treatments on the Field Experimental Station, Sourhope". So far all existing data has been gathered together and further chemical and statistical analyses will be carried out. The project will finish in September 1976.

The input-output project at Lephinmore has been discontinued but a subsidiary experiment on the diagnosis of the causes of patchy growth in reseeds on deep peat is described under Project 04007.

NITROGEN FIXATION (04008)
A. Haystead and C. Marriott

1. Measurement of N_2-fixation in the collaborative field trials on inoculation of white clover

Both the acetylene reduction assay and the ^{15}N "microplot" techniques (see HFRO Ann. Report 1974, pp 97-8) have been used to compare rates of N_2-fixation by inoculated and uninoculated white clover in the series of trials mounted collaboratively by HFRO, the three Scottish Colleges of Agriculture, WPBS and the EHF's at Redesdale and Great House (see p. 79). Poor clover establishment at all sites due to the dry period following sowing made it impractical to randomly select plant/soil cores for acetylene reduction assays since most cores did not contain clover plants. Instead, the difference in reducing activity of growing clover plants in the inoculated and uninoculated treatment plots was measured. In no case was there a significant difference in the capacity of inoculated (i.e. bearing a proportion of inoculum strain nodules) and uninoculated (i.e. bearing exclusively indigenous or contaminant strain nodules) plants. A very high level of variation was observed in the capacity of the clover to reduce acetylene both between sites and between plots, coefficients of variation in some cases exceeding 60%.

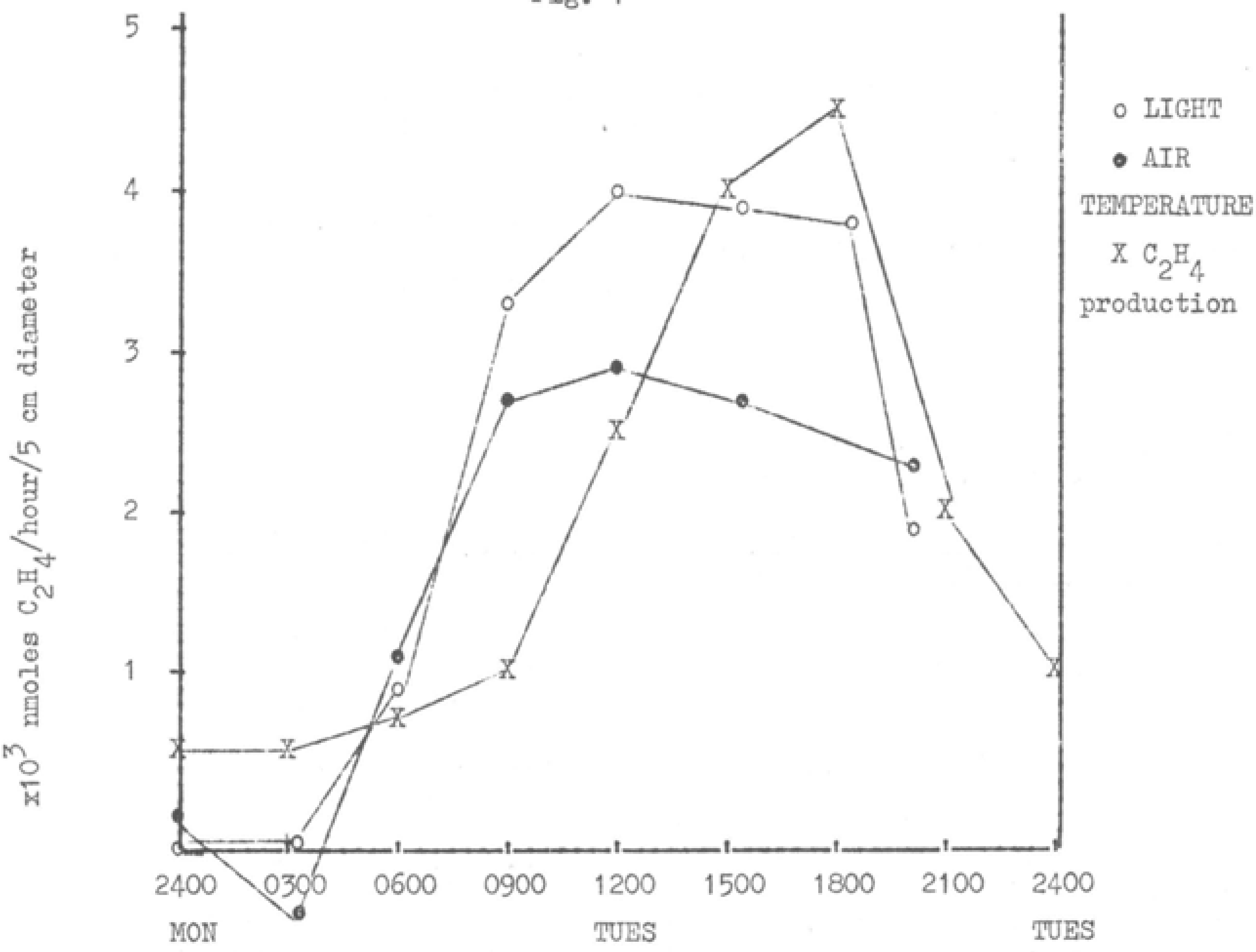
A ^{15}N "microplot" assay set up at Glensaugh demonstrated no significant difference between inoculated and uninoculated plots. However it was possible to show that even in the N_1 treatment (30 units of N applied at sowing) the clover fixed over 70% of its N. When total-N-yield data becomes available for this site it will be possible to calculate the amount of N fixed by the clover per hectare during the 1975 growing season.

2. Patterns of N_2-fixation in the hill pasture ecosystem
A. Haystead and C. Marriott

An investigation is being carried out to determine the rate at which white clover fixes N_2 throughout the year. Acetylene reduction assays are being carried out at 4 grazed sites, two at Lephinmore and two at Sourhope to determine the seasonal pattern of N_2-fixation. These patterns will be correlated with meteorological data and with details of sward management operations recorded over the same period. The results for 1975, a pilot year, were quite encouraging: N_2-fixation started in late March after a very cold spring and reached a first maximum in late May. A midsummer decrease to almost zero was correlated with soil dessication. A second maximum, lower than the first, was observed in September.

Fig.1 shows the diurnal rhythm of N_2-fixation (C_2H_2-reduction) observed in early summer 1974. The maximum rate of fixation occurs some two hours after maximum light intensity and air temperature is reached. It seems that clover, unlike more leafy legumes, does not respond quickly to changes in the rate of photosynthate production. These studies continue.

Fig. 1



JUNE 1974

Diurnal rhythm in nitrogen fixation activity of white clover in a peat soil

3. Optimising the transfer of clover-fixed-N to associated grasses (04008/PLANT NUTRITION: 04003)

The contribution made by white clover to the N yield of a clover/grass stand is measurable in two forms: a direct contribution in the form of clover-N and an indirect contribution which is seen as a stimulation of grass N-yield. The direct and indirect contributions are frequently inversely related in the short term, that is, conditions which depress clover growth increase the rate at which clover-N is released into the soil. In intensive grazing systems the role of the animal in returning fixed-N to the soil and hence to the non-fixing components of the sward is probably of major importance. In extensive systems, hill pasture for example, leaf litter decomposition and the underground release of N from decaying roots and nodules may be equally important, particularly in the first year after reseeding. N released in this way is mineralised slowly and is consequently less susceptible to leaching and unlike animal excreta is evenly distributed throughout the sward. Major fluxes of N into the soil occur after severe defoliation and with the onset of winter conditions.

Experiments at HFRO (see for example HFRO Ann. Rep. 1974 p.98) and elsewhere (Simpson (1965), Chu and Robertson (1974)) have shown that although extensive root and nodule breakdown occurs in defoliated, chilled and shaded swards there is a considerable lag before the released-N becomes available for assimilation by companion species. Released N, it seems, is bound into a relatively stable form and is released into the plant - available-N pool only slowly. A more detailed knowledge of the transfer process may facilitate its optimisation by the farmer.

The current investigation is designed to determine the fate of the complex mixture of low and high M.W. compounds released into the soil when clover roots and nodules decay. S184 white clover was grown in 4" pots for 12 weeks after which the tops were cut at 1 cm from the soil surface. Defoliated and control pots were harvested over an 18 day period and the following parameters investigated.

(1) DM content of shoots.

(2) Acetylene reducing activity of root and nodules.

(3) Total viable rhizosphere biomass.[1]

(4) Metabolic activity of rhizosphere microflora.[2]

(5) Soil "free amino acid pool" contents.

Fig.1 shows the effect of defoliation on the N_2-fixing activity of the plants. The severe defoliation treatment arrests N_2-fixation almost immediately, activity returning slowly in parallel with foliage regeneration.

Fig.2 shows the effect of defoliation on the total viable cell numbers in the clover rhizosphere. After 6-9 days a twelvefold increase in the rhizosphere population is observable. This increase in bacterial numbers is equivalent to about 5 mg of bacterial-N per pot (calculated from data in Babiuk and Paul (1971)) which in turn is equivalent to a third of the root and nodule-N which would be lost in response to defoliation (Chu and Robertson (1974)). The direct count method does not take into account actinomycete and fungal components in the soil microflora so it is possible to say that at least one third of the N released by roots and nodules of clover in response to defoliation is bound up in the form of microbial protein. This fraction of the soil organic-N has been demonstrated to be only slowly mineralised in a variety of soil types (Broadbent and Tyler (1962)).

Fig.3 shows the effect of defoliation on rhizosphere respiration. In this case a threefold increase in activity is observed in about 15 days. This increase probably represents the metabolically active component of the rhizosphere microflora whilst the FITC count represents the total undecomposed population. Greaves et al (1973) have discussed similar high "viable" cell counts in peat soils. Since FITC conjugates with protein in cell walls, it may be that in peat soils protein in the walls of bacterial cells which are actually non-viable is not decomposed and may form the FITC-protein complex characteristic of living cells. The FITC cell count is, however, highly relevant in the context of this investigation since it represents the total pool of legume root-N immobilised in the form of bacterial protein. Further studies are being carried out to confirm the results already obtained and describe in greater detail the mechanism of the underground transfer of N from clover to associated grasses.

References

Babiuk, L.A. and Paul, E.A. (1970). Canadian J. Microbiol., 16, 57-62.

Broadbent, F.E. and Tyler, G. (1962). Soil Sci.Soc.Am.Proc., 26, 459-462.

[1] Viable cells were counted by staining soil smears with fluorescence-isothiocyanate (FITC) and observing in U.V. light (Babiuk and Paul (1970)).

[2] Metabolic activity of Rhizosphere soil samples was estimated by measuring $^{14}CO_2$ evolution from ^{14}C-glucose solution (Hubbard (1973)).

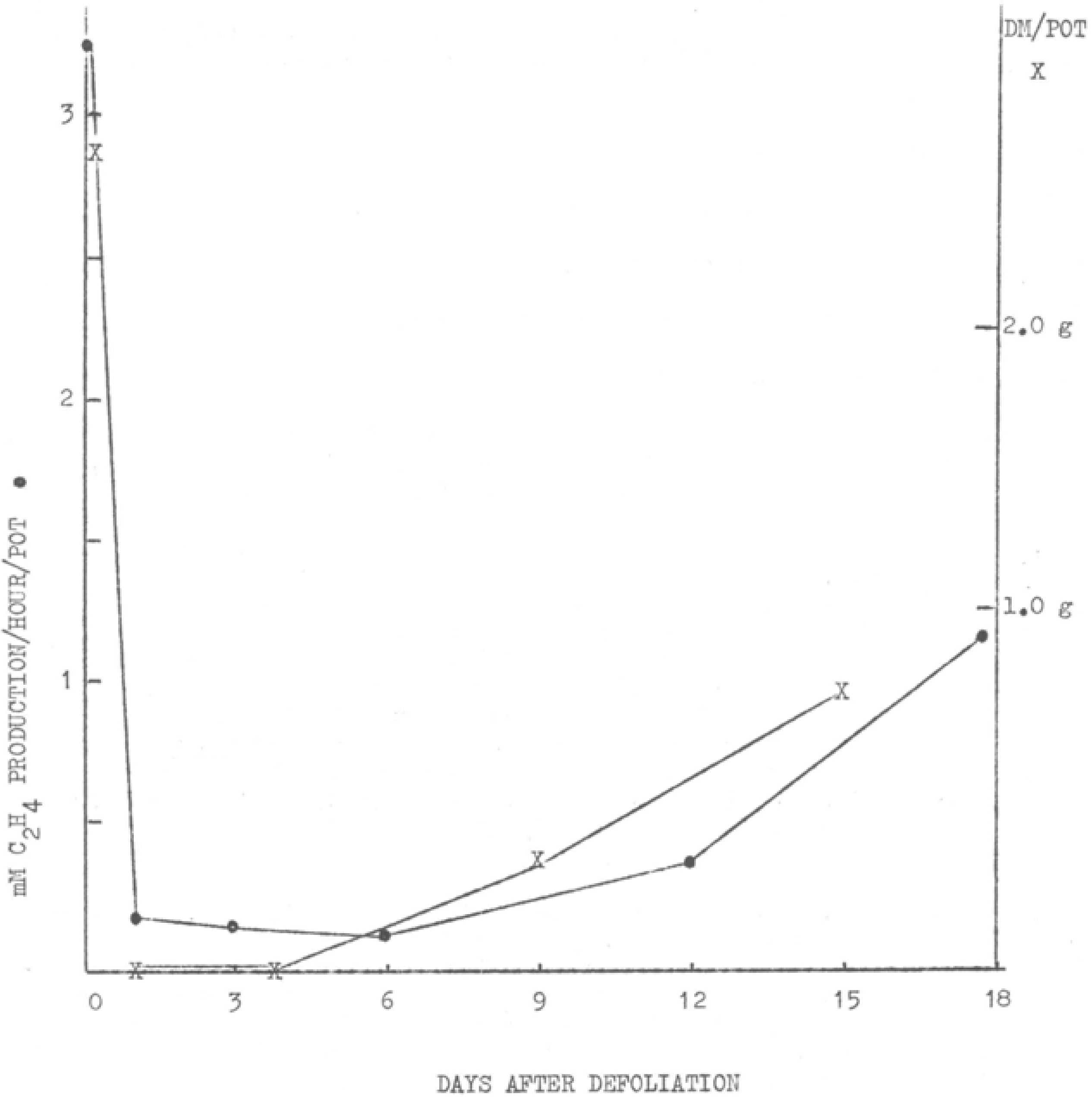


Fig.1. Effect of defoliation on N_2-fixing activity (C_2H_2-reduction) and shoot DM production by white clover

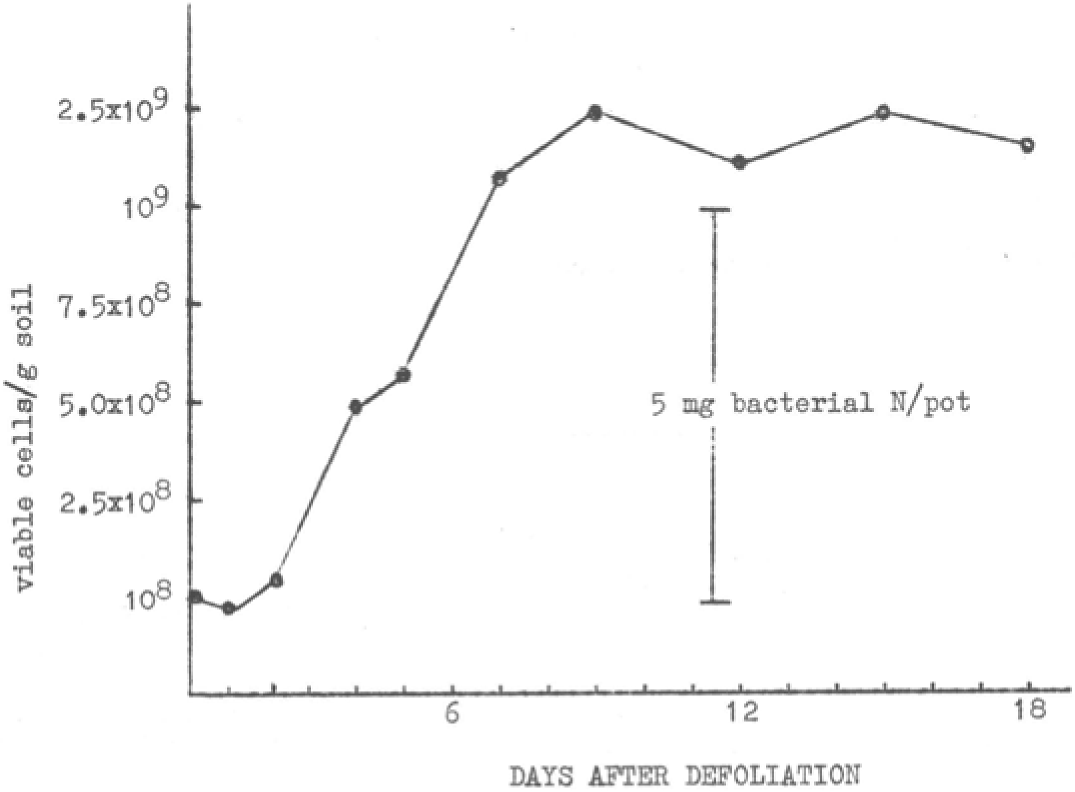


Fig.2. Effect of defoliation on total "viable" bacterial cells in the rhizosphere microflora of white clover

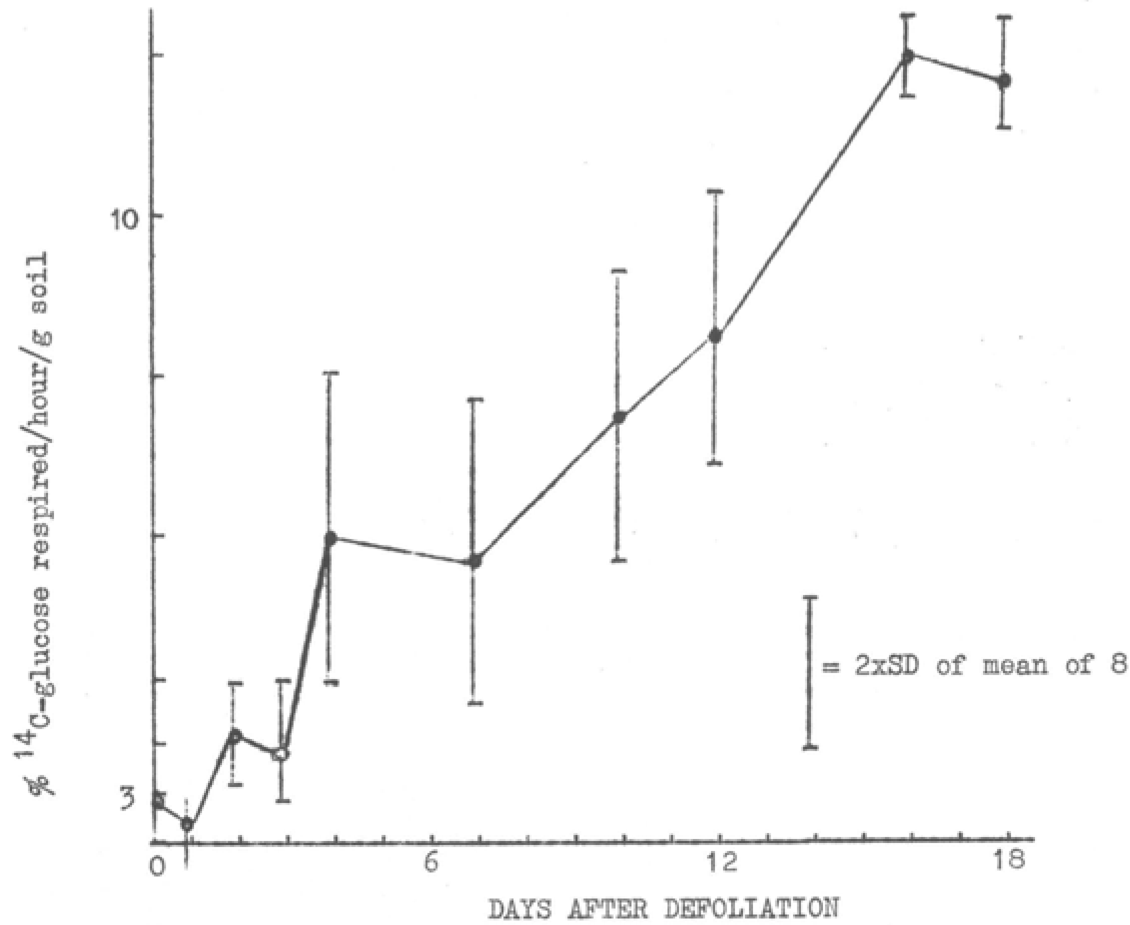


Fig.3. Effect of defoliation on glucose respiring activity of the rhizosphere microflora of white clover

Chu, A.C.P. and Robertson, A.G. (1974). Pl.Soil, 41, 509-519.

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GLASSHOUSES, GROWTH ROOMS, MICRO-CLIMATE (54001)

D.E. Suckling

During the year four growth chambers were commissioned. Each chamber is fitted out with a bench (2.75 m x 0.9 m), a humidifier and an adjustable bank of fluorescent lights. Time clocks control both the number of hours of light each chamber receives and also the period during which a lower "night" temperature is applied.

A cooling system has been installed in the constant temperature room which is now capable of its proper function. The room is especially suitable for working between 15 °C and 30 °C with a differential of ± 1 °C.

The battery powered automatic weather stations at Glensaugh (Forestry Park) and Lephinmore (Big Hill) are both in use providing quarter hourly summaries of solar radiation, rainfall, wind run, soil and air temperatures. The magnetic tape casettes are translated at the East of Scotland College of Agriculture using a "Microdata" translator coupled to a PDP 11 computer. The resulting paper tape version is then put into the EMAS computing system at SIAE. Editing of the data, which may be necessary due to equipment malfunction, may take place at this point, and the final version of the data is run with a program developed by Miss P. Ballan, which gives daily means and totals of the data.

ANALYTICAL SERVICES (54002)

1. Inorganic Chemistry

C.C. Evans and J. MacKenzie

The routine analysis of plant, soil, faecal and blood samples has continued. During the year 10,100 analyses were made from 5,700 samples. An increasing demand for mineral nutrient analysis of blood has been apparent.

An IL 251 Double Beam Atomic Absorption Spectrophotometer has been installed and is now in routine use. Sample throughput has been significantly increased with a marked improvement in precision of all atomic absorption determinations.

Successful negotiations were completed in December for the purchase of an automatic X-Ray Fluorescence Spectograph (Philips PW 1212) from the Poultry Research Centre (Roslin). At the time of writing the instrument has been installed but not commissioned and will replace the nine year-old PW 1540 manual instrument. The PW 122 will require a substantial amount of development work before routine use but thereafter it is anticipated that this automation of X-Ray Spectrometry will significantly increase throughput of samples requiring major element analysis.

Method Development

Destruction of Organic Matter by Wet Digestion

Wet digestion procedures involve the use of oxidising acids (perchloric and nitric) for the analysis of mineral elements and a separate Kjeldahl digestion using sulphuric acid and a catalyst, commonly a mercuric salt, for nitrogen (protein). The two procedures are not interchangeable. Low recoveries of nitrogen have been reported in methods using perchloric acid while the mercury catalyst, as used in the Kjeldahl digestion, interferes with some mineral element determinations. Consequently an investigation into the feasibility of using a digestion procedure for both nitrogen and mineral elements has been undertaken.

The procedure finally adopted was one based on the method of Parkinson and Allan. This uses selenium (catalyst), hydrogen peroxide (oxidant), lithium sulphate (to increase the rate of reaction) in sulphuric acid. It was found necessary to increase the hydrogen peroxide concentration and digestion time in order to obtain a complete digestion. Preliminary results show excellent agreement between the standard Kjeldahl and peroxide procedures for nitrogen analysis. Evaluation of other elements has yet to be completed.

Chromic Oxide in Faeces

The method of Williams _et al_ was modified by a reduction in sample weights and a _pro-rata_ reduction in quantities of reagents. Briefly the method involved the hotplate digestion of the residues from ashing 0.25 - 0.50 g of the sample with a mixture of phosphoric acid, manganese sulphate and potassium bromate. The resultant diluted and filtered digest solution was analysed by atomic absorption spectrometry after the addition of calcium chloride as a releasing agent for phosphorus and silicon interferences. The relative precision of replicate analyses was found to be <1 per cent and a comparison of the above procedure with an X-Ray Spectrometric method showed acceptable agreement.

Chromium in Rumen Fluids

A technique widely used to measure liquid flow rates and rumen volume in studies of ruminant nutrition is to inject a solution of chromium (complexed with EDTA) and determine the rate of disappearance or the dilution of the chromium by sequential rumen fluid sampling and analysis. Consequently a method for the atomic absorption determination of rumen fluid chromium has been developed.

Samples of rumen fluid were clarified by centrifuging at 17,000 g for 45 minutes and the supernatant taken for analysis. Standards were prepared from a clarified bulk sample of untreated rumen fluid. This was necessary because of the difference in viscosity of the rumen fluid and water and also to overcome the interfering effect of protein. The relative precision was found to be approximately 1.5 per cent.

Unmodified methods which have been introduced include that for the determination of magnesium in blood plasma by atomic absorption spectrophotometry after Dawson and Heaton, 1961, and that for calorific value by adiabatic bomb calorimetry as given in the manufacturers' operating instructions.

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2. Tracer chemistry
A.R.M. Chambers

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

3. Electronics

Various electronic instruments have been repaired and maintained, and advice on electronics has been given to other members of staff.

(a) Thermo-gradient bar for project 04002
A.R.M. Chambers, J.A. Rogers and D. Bruce

The bar as described in the 1974/75 annual report has been modified considerably. The temperature of the 'hot' and 'cold' end is now controlled to within better than ±0.1 °C through thermistor sensors. The hot end temperature is maintained using a zero voltage switch which is used to fire a triac in series with a 250 v A.C. heater element. The zero voltage switch circuitry is designed so that the number of cycles applied to the heater, in a particular time interval, is proportional to the temperature difference of the thermistor from the desired temperature. This means that at this desired temperature the heater is given just sufficient power to make up the system losses.

The temperature of the 'cold' end is maintained by regulating the current through the thermo-electric cooling modules with a transistor in series with them. The transistor is controlled with a differential amplifier such that the current through the modules is proportional to the temperature difference of the thermistor, from the required temperature.

The temperature along the bar is monitored using platinum resistance thermometers, the resistance of which is measured on a Wheatstone bridge. The output of the bridge is amplified and the amplified signal is recorded on a pen recorder.

The bar has been used in germination trials over the range 0 to 10 °C.

(b) The development of a method for the measurement of urinary output in grazing female sheep for project 02004
A.R.M. Chambers, I.R. White, A.J.F. Russel and J.A. Milne

The Urine Measuring and Sampling Equipment (UMASE) built in 1974/75 has been used extensively at Glensaugh. The battery protection circuit has been modified to increase battery life but they still require changing twice in a 24-hour period.

A modified design of UMASE has been built this year and has been tested at HQ. The main modification is the use of a specially designed three position stopcock, driven by an electric motor, to replace the solenoid valves, which will greatly reduce power requirements and improve reliability. The electronic circuitry has been radically altered and by pulsing the level detection sensors the power used by the control section has been reduced. Both batteries are protected from discharging below fixed limits and it is hoped to run the new UMASE for over three days without changing the batteries.

(c) A proposed method for the estimation of plant biomass and its distribution in grass swards for project 03003
A.R.M. Chambers, J.A. Milne and J. Hodgson

As the result of work carried out in 1974/75 (see Annual Report) apparatus consisting of a 12 volt 'strip' light situated 15 cm from an array of light detectors has been built and tested. The light detector array consisted of three rows of photodiodes 2.5 cm apart, with five diodes per row, each row being 11 cm long. After testing this apparatus was modified by adding a further four rows of detectors below the original rows, spaced over a height of 3 cm, which were to take account of the dense plant matter near the ground. A photo diode was also positioned next to the strip light to measure the intensity of light beam before it passed through the sward as this was found to fluctuate. The modified apparatus was tested over a wide variety of sward types. A linear relationship was found between the plant biomass (as estimated by destructive harvesting) and $\log_e$ (1-A) where A is the total light absorbed by the sward. With swards with a high biomass there was deviation from linearity because of complete absorbence of light in the bottom of the sward. A new apparatus has been built to overcome this problem and is presently being tested.

(d) The measurement of jaw movements by the grazing sheep for project 03003
A.R.M. Chambers, J.A. Milne and J. Hodgson

To measure grazing and ruminating jaw movements of sheep a two channel, 5-digit counter has been made using CMOS integrated circuits. Various sensing devices have been examined. Firstly, a micro-switch which operates with movement of the jaw, secondly a mercury switch which is positioned, and thirdly, an impulse monitor. The impulse monitor is used to measure the animal's head movement while grazing which consists of sharp backwards or forwards movement as the animal bites the grass and then pulls. Various sensors have been tried and tests are being carried out to investigate the reliability of the equipment.

(e) Duodenal fluid sampler for project 03003

The equipment described in the 1974/75 Annual Report has been built and tested. It was found that the volume of fluid which was either sampled or pumped into the distal cannulae was not sufficiently controllable and that for any one setting would fluctuate by as much as ±6%. This fluctuation was found to be caused by the perstaltic pump not pumping consistently.

The equipment is now being modified so that the required volume of fluid is measured by passing it under suction into a glass measuring vessel in which the volume is controlled by an electrode such that when the surface of the fluid reaches it, the input valves are closed and the fixed volume trapped in the vessel is pumped to the required place.

(f) Mass spectrometer for project 04008

A circuit was designed and built to convert the output of the digital panel meter into a format suitable for feeding into a Data Dynamics teletype. This was carried out by converting the parallel output format of the meter into a serial one and by outputting it through optically-coupled isolators. The circuit was designed so that the eight bit output was compatible with computer input requirements.

A circuit was fitted to the mass selector part of the control unit so that the '28' and '29' peak could be measured directly by depressing the appropriate switch.

Various modifications were made to the electron beam control circuit to improve its reliability.

HILL FARMING RESEARCH ORGANISATION

PUBLICATIONS
1975/76

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