Hill Farming Research Organisation

Annual Report 1985

The hill farming research organisation

HILL FARMING RESEARCH ORGANISATION

ANNUAL REPORT 1985

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D.A. Clark, MAgrSc., Grasslands Division, DSIR, New Zealand. April 1985 - October 1986.

T.P. Hughes, MAgrSc., Lincoln College, New Zealand. April 1986 - April 1987.

POSTGRADUATE STUDENTS

Miss J. Bass, BSc (study completed 31/12/85)
Mrs A. Burlison, BSc (study completed 31/12/85)
Miss F.A. Burnett, BSc

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1. REPRODUCTION

Research objective: Control of ovulation rate and embryo loss in ewes by manipulation of pasture and animal factors at mating (no. 001017)

1.1 The effect of sward height and supplementation on reproductive performance of Greyface ewes in intermediate body condition at 4 weeks before mating

R.G. Gunn, T.J. Maxwell, R.D.M. Agnew, I.R. White, A.D.M. Smith, C.D. Kerr and D.A. Sim

Previous studies have suggested the need to relate pre-mating stocking rate to sward height, in particular to change in height as a measure of growth rate, and to determine the effect of this relationship on reproductive performance. There is also a need to consider supplementation in relation to low sward height and the consequent effect on reproductive response. This experiment aimed to examine the effect of reducing sward height from 7-8 cm in mid-September, to both 5-6 cm and 3-4 cm in mid-October, just before mating, on live weight and body condition of Greyface ewes initially in condition score 2.75, at which score previous evidence indicates the greatest potential reproductive response, and to examine the effect on response of different stocking rates on the two sward heights over the mating period.

Two replicate fields at Hartwood were used, Nurses Home, a silage aftermath stocked at 12 ewes/ha in June and given 96 kg N in two dressings in mid- and late August, and Buttercup, a sheep-grazed sward also stocked at 12 ewes/ha and given 110 kg N in two dressings in mid-August and early September. From early August, both fields were managed to establish a sward height of 7-8 cm by mid-September by varying stocking rate as necessary, based on regular sward height and mass measurements. This management was also used to reduce the spread of ewe body condition and establish ewes in score 2.75.

In mid-September, each replicate was subdivided so that there was one paddock which was stocked with not less than 12 ewes in score 2.75/ha (core ewes) plus extra ewes as required to reduce sward height to 5-6 cm by mid-October and another paddock which was similarly stocked as required to reduce sward height to 3-4 cm. In mid-October, the core ewes were re-allocated equally from each of the previous paddocks to three mating groups in each, further subdivided, replicate. These were one group at 8 ewes/ha on 5-6 cm sward height, a second group at 16 ewes/ha on 3-4 cm and a third group also at 16 ewes/ha on 3-4 cm plus 150 g pelleted barley/head/day. Mating was synchronised and reproductive performance based on data derived from both foetal scanning and lambs born. Post-mating winter management was as for the Hartwood upland systems ewes.

Sward heights, herbage masses and stocking rates used to achieve target heights on the two replicates are shown in Table 1. There was more mass per unit height on the sheep-grazed field and it consequently required higher stocking rates to reduce it than did the silage aftermath, namely a mean 26 and 41 ewes/ha compared with 21 and 29 ewes/ha for the 5-6 and 3-4 cm target heights, respectively.

TABLE 1

Sward heights, herbage masses and stocking rates used to achieve target sward heights on replicate fields

Replicate		Silage aftermath		Sheep-grazed	
Target sward height (cm)		5-6	3-4	5-6	3-4
18 Sept.	Sward height (cm)	9.0	9.0	8.0	8.2
	Mass (kg DM/ha)	3300	3300	4050	4350
	Stocking rate (ewes/ha)	31	45	17	37
24 Sept.	Sward height (cm)	7.6	6.7	8.0	7.8
	Mass (kg DM/ha)	2750	2400	4050	3950
	Stocking rate (ewes/ha)	27	31	28	44
2 Oct.	Sward height (cm)	6.2	5.4	7.5	6.8
	Mass (kg DM/ha)	2200	1850	3800	3500
	Stocking rate (ewes/ha)	18	27	36	53
9 Oct.	Sward height (cm)	4.6	3.8	6.7	5.4
	Mass (kg DM/ha)	1250	1090	2140	1700
	Stocking rate (ewes/ha)	8	12	24	30
19 Oct.	Sward height (cm)	4.9	3.8	5.4	4.4
	Mass (kg DM/ha)	1300	1090	1710	1370

The 126 core ewes, all within 0.25 of score 2.75, gained weight and condition over this pre-treatment period. Although no difference between the groups or replicates could be shown in body condition score, the ewes on the 3-4 cm targeted sward became significantly lighter by 19 October (pooled, 72.3 vs 69.5 kg), mostly so on the heavily stocked sheep-grazed sward (72.1 vs. 68.4 kg).

From 19 October, the heights of the taller and shorter swards in the silage aftermath were reduced to respective lows of about 3 and 2-2.5 cm by 15 November while in the previously sheep-grazed field, where they were initially higher, they were only reduced to 4.5-5 and 3-3.5 cm. In neither replicate was it possible to identify any relative differences in change in sward height between the 8 and 16 ewes/ha paddocks, nor was there any significant difference in sward height between the 16 ewes/ha paddocks with supplemented and unsupplemented ewes.

In both replicates, the ewes stocked at 8/ha on the taller sward were virtually maintained in live weight and condition right through to the end of the experimental period, which was ended earlier on the shorter swards of the silage aftermath (22 November vs. 3 December). The ewes stocked at

16/ha on the shorter sward lost some 5-6 kg and about one third of a grade over the same period (70.5 to 65.1 kg and 2.93 to 2.62) and there was no apparent effect of the supplementary feeding.

The reproductive performance of the ewes according to the replicate, the pre-treatment sward height reduction, the treatment stocking rate and sward height over the mating period and the provision of supplementary feeding is shown in Table 2 in terms of conception rate (CR), lambing rate per ewe mated (LR) and litter size per ewe lambing (LS) to three matings.

Overall, there was no significant effect of treatment on any aspect of reproductive performance although the pattern was as might be expected with the highest response from the low stocked ewes on the taller sward and the lowest from the high stocked unsupplemented ewes on the shorter sward. This overall response, however, arose from very different patterns in the two replicates with the low stocked ewes on the aftermath taller sward producing significantly more than all the high stocked ewes on the shorter sward, but a non-significant opposite effect on the previously grazed replicate. This odd result cannot be simply explained except in terms of too small a group size. There was a similarly odd result in the two replicates in testing for any residual effect of the different stocking rates necessary to create the two pre-treatment sward heights, but none of the differences were significant and again there was no

TABLE 2
Pre-experimental pasture management

		Stocking rate (ewes/ha)	Supplementary feeding	No. of ewes	Aftermath CR	Aftermath LR	Aftermath LS	No. of ewes	Grazed CR	Grazed LR	Grazed LS	Both CR	Both LR	Both LS
Sward height prior to mating (cm)	5-6	8	0	23	0.96	2.00	2.09	17	1.00	1.71	1.71	0.97	1.88	1.92
	3-4	16	0	24	0.96	1.67	1.74	18	1.00	1.83	1.83	0.98	1.74	1.78
		16	150 g/hd	24	0.92	1.63	1.77	18	0.89	1.72	1.94	0.90	1.67	1.84
				All	0.94	1.76	1.87		0.96	1.75	1.82			
Pre-treatment sward height reduction from > 8 cm to			5-6 cm	36	0.97	1.75	1.80	27	0.96	1.89	1.96	0.97	1.81	1.87
			3-4 cm	35	0.91	1.77	1.94	26	0.96	1.62	1.68	0.93	1.70	1.82

overall effect. It is of interest that barrenness was highest in the supplemented groups on both replicates. Comparing the results with those of the previous year's study (1984 Annual Report p. 5) shows that response was similar at 8 ewes/ha on a pre-mating sward of more than 5 cm (LR = 1.88 and 1.80, LS = 1.92 and 1.96), but that response at 16 ewes/ha was less (P < 0.1) on a pre-mating sward of about 4 cm (LR = 1.70, LS = 1.81) than it was on one which was 6-7 cm (LR = 1.92, LS = 2.00) and had not dropped below 4 cm by a month after mating.

It is suggested that for statistical testing of the relatively small differences being obtained in response to pasture manipulation in the autumn, much larger group sizes are required. The effects of limited supplementation in relation to low sward height also require further testing.

1.2 Herbage intake of Greyface ewes on ryegrass/clover pasture in the pre- and post-mating periods

R.G. Gunn, T.J. Maxwell, J.M. Doney, R.D.M. Agnew, W.F. Smith, A.D.M. Smith, C.D. Kerr and D.A. Sim

As part of a study designed to improve knowledge of nutrient intake in the autumn and its effect on reproductive performance (1984 Annual Report, 1.2, p.5), intake measurements were made on 6-8 ewes in each of four paddocks in one field (Buttercup) using the chromic oxide dosing/faecal sampling technique on two occasions prior to mating and two occasions post-mating. Digestibility measurements were also made at the same times in two of the paddocks using oesophageal fistulated (OF) ewes. All paddocks were stocked at 12 ewes/ha until immediately prior to a synchronised mating in late October and then at either 8 or 16 ewes/ha on each of two paddocks. Digestibility measurements using OF ewes were made in one paddock of each post-mating stocking rate.

There were substantial but variable amounts of herbage on all paddocks and these led to differences in intake between replicates, the taller the sward the greater the intake. Over the range of 8-10 cm sward height in early October, there was a correlated reponse in dry matter intake (DMI) between 1300 and 1700 kg DM/ewe/day ($y = 196x - 295$, $r = 0.98$).

For comparison of intake with time, stocking rate and change in sward height, the mean values of sward height, DMI, organic matter intake (OMI), organic matter percentage (OM%), organic matter digestibility (OMD%) derived from faecal N and ash and digestible organic matter intake (DOMI) over the two replicates are shown in Table 1 according to the post-mating stocking rate.

Within paddocks there was virtually no difference in any aspect of intake between the two pre-mating October measurements at sward heights of 7 cm or more. As sward height declined and stocking rate increased post-mating, intake declined but again there was virtually no difference within paddocks between the two post-mating November measurements. The use of a month of sampling correction factor results in about a 4% decline between October and November but the decline in DMI was 12% on the low stocking rate and 18% on the high, with corresponding declines in OMI of 16 and 27% and in DOMI of 19 and 31%. The greater declines on the high stocking rate were associated with greater falls in OM% and OMD%. Ewes were still gaining in live weight on swards taller than 5 cm and DOMI levels of about 750 g/ewe/day. At 3.5 cm and DOMI levels below 600 g/ewe/day, liveweight had begun to fall.

Estimates of OM% and OMD% derived from in vitro analysis of extrusa samples collected by OF ewes in two paddocks were all higher than those derived from faeces N, chromium and ash in the same paddocks (Table 2). As a consequence, intakes estimated from the extrusa analyses were also higher.

TABLE 1

Sward height, dry matter intake (DMI), organic matter intake (OMI), organic matter percentage (OM%), organic matter digestibility (OMD%) and digestible organic matter intake (DOMI) in pre-mating and post-mating periods

	Paddocks	Pre-mating at 12 ewes/ha 3-7 Oct.	22-26 Oct.	Post-mating at 8&16 ewes/ha 7-11 Nov.	21-25 Nov.
Sward height (cm)	12/8	9.28	7.97	7.32	5.10
	12/16	8.47	7.02	5.98	3.56
DMI(g)	12/8	1529	1523	1358	1336
	12/16	1388	1302	1061	1150
OMI(g)	12/8	1245	1224	1054	1011
	12/16	1138	1060	797	813
OM%	12/8	81.4	80.4	77.6	75.7
	12/16	82.0	81.4	75.1	70.7
OMD%	12/8	76.4	76.7	74.3	73.4
	12/16	75.4	75.6	72.1	70.9
DOMI(g)	12/8	949	937	784	741
	12/16	859	802	575	577

TABLE 2

Estimates of organic matter percentage (OM%) and digestibility (OMD%) from, *in vitro* analysis of extrusa and faeces

			3-7 Oct.	22-26 Oct.	7-11 Nov.	21-25 Nov.
OM%	12/8	Extrusa	87.6	86.1	85.7	86.5
		Faeces	81.8	81.3	77.9	77.9
	12/16	Extrusa	86.9	85.4	86.9	84.4
		Faeces	82.2	80.1	76.2	71.3
OMD%	12/8	Extrusa	77.9	76.8	77.1	79.6
		Faeces	76.1	76.1	74.2	73.5
	12/16	Extrusa	78.8	79.0	76.4	75.2
		Faeces	75.7	76.7	73.0	72.7

Particularly on the paddock stocked at 8 ewes/ha post-mating, there was virtually no change in the extrusa OM% or OMD% values over time, while there was a decline in the faeces values. In the heavier stocked paddock both OM% and OMD% declined over time in both estimates and to a greater extend in the faeces OM% value, presumably associated with the low sward height to which this paddock had been grazed. The failure of the extrusa estimates to decline in the same manner as the faeces estimates suggests that OF ewes when grazing during sampling periods are more selective in their choice of herbage and graze less deeply into the sward. On this assumption, the faeces estimates appear more meaningful.

An analysis of intake by body condition score at the start of the experiment on 22 September, was unable to demonstrate any differences such as have been observed in previous experiments. The amount and quality of the available herbage in this experiment was so good that differences in condition very rapidly disappeared and there was no residual effect of initial condition on intake.

1.3 Herbage intake of North Country Cheviot ewes on ryegrass/clover swards differently managed and of different heights in the pre-mating period

R.G. Gunn, J.M. Doney, W.F. Smith, R.D.M. Agnew, A.D.M. Smith, A.J. Senior and D.A. Sim

In two studies in 1981 and 1982 on the optimisation of pasture use by North Country Cheviot ewes in different body conditions in the pre-mating period (see 1982 Annual Report p.1 and 1983 Annual Report p.4), herbage intake was measured using the chromic oxide dosing/faecal sampling technique in the week prior to mating in late November. In 1981, ewes were grazed on a series of paddocks either utilising them at 4-5 cm after a period of regrowth or at 2-3 cm after prior grazing. In 1982, ewes were grazed on the same paddocks but in this year two levels of sward height (9-10 cm and 2.5-3.5 cm) were established by different periods of regrowth so that both swards were fresh, ungrazed, leafy material. At the actual times of intake measurement, the high (H) and low (L) height swards were both down to about 2.5 cm in 1981 and to about 4.5 and <2 cm, respectively in 1982. Ewe live weights were fairly static over the pre-mating period in 1981 so that, even at the low heights to which both swards had fallen, growth rate must have been adequate to provide sufficient intake for maintenance. Ewe live weights were rising in 1982, even on the L sward, so that growth rate must have been high enough to provide a high level of intake. These differences are borne out by the estimates of intake shown in Table 1.

TABLE 1
Intake and digestibility in relation to high (H) and low (L) sward heights

Sward ht.	Year	No. of ewes	DMI (g)	OMI (g)	OM%	OMD%	DOMI (g)
H	1981	22	924	781	84.5	63.7	496
	1982	13	1042	893	85.7	73.2	654
L	1981	22	781	665	85.1	59.6	396
	1982	12	1087	912	83.9	66.9	610

Although the 1981 swards were apparently very similar in height by the end of the sampling period, DOMI was significantly greater on the H sward while DMI and OMI came close (t = 1.9) to being significantly greater. There was no significant difference in intake in 1982, although there were still differences in height between the swards. Both swards in 1982 were therefore adequate to satisfy intake quantitatively, while in 1981 they were clearly inadequate, particularly the previously grazed L sward. OMD% was substantially lower in 1981 than it was in 1982 and, more interestingly, was also lower on the L swards than it was on the H in both years. It is understandable that the 1981 L sward should be lower in digestibility since it was the base of a previously hard grazed longer sward. What is less understandable is the lower digestibility of the L sward in 1982, which was a previously ungrazed regrowth. This must presumably be due to its lower height which has forced the animal to eat down lower into the horizons which contain the sheath and stem.

Research objective: **Establish reproductive potential in ewes in relation to nutrition during growth and development (no. 001018)**

1.4 Studies on the growth and development of Brecon Cheviot ewe and wether lambs

R.G. Gunn, T.J. Maxwell, D.A. Sim, J.R. Jones* and E. James* (*Welsh Plant Breeding Station)

In the past, management arrangements at Bronydd Mawr have included the practice of grazing nursing ewes on the Range, which is a nutritionally less favourable environment than sown inbye pastures. This is a potential constraint on lifetime performance of breeding ewes and on the efficiency of finishing wether lambs.

For the last 2 years, contrasting rearing treatments have been relatively simply achieved by grazing equal proportions of ewes nursing potentially retainable single ewe lambs and single wether lambs for 3 months up to weaning (May to August) on the Range and on improved inbye pasture (the Point). The latter is in two similar fields of 9 ha each and has been stocked at an overall rate of 11 ewes nursing single lambs/ha but grazed alternatively on the two fields at double this rate for periods of up to a week to maintain sward height in the region of 4-6 cm.

Contrasting weather in the two years 1984 and 1985, very dry and very wet, has resulted in contrasting lamb performance. Ewe lambs in 1984 gained at a very much higher rate on the inbye (189 g/head/day) than they did on the Range (119 g/head/day), while in 1985 they did less well on the inbye (154 g/head/day) but slightly better on the Range (127 g/head/day). An equal proportion of ewe lambs was retained from each rearing group and, after away-wintering, all lambs were run on the Common over their second summer. A further split will take place at 18 months of age between a Range and inbye adult reproductive life and performance will be recorded over three or four lamb crops. Wether lambs responded relatively similarly to the ewe lambs, gaining in 1984 at 201 g/head/day on the inbye and 127 g/head/day on the Range, while in 1985 they only gained at 163 g/head/day on the inbye but 135 g/head/day on the Range.

In the drought of 1984, the Range appears to have suffered more than the inbye, while the relatively poorer performance on the inbye in 1985 must be due to a lower quality and quantity of intake associated with the very wet summer since the swards were as well managed as could be hoped for.

In 1984, there was a 6 kg advantage in mean weaning weight between the wethers on the inbye and Range but this had shrunk in 1985 to just over 2 kg with the inbye wethers some 4 kg lighter than in 1984. At weaning in 1984, 38% of the inbye wethers were sold fat compared to none of the Range wethers. All the remainder were then run on inbye grass. This trend towards earlier finishing continued until 1st October, by which time 78% of the inbye wethers had been sold fat compared to 38% of the ex-Range wethers. Some of the remainder were sold store in October and the overall relative disposal rates were 87% fat and 13% store off the inbye and 66% fat and 34% store off the Range. Mean live weights at disposal were 33 kg fat and 28 kg store.

Research objective: **Determine effects of nutrition on plasma FSH, prolactin, progesterone and on ovulation rate and lambing rate (no. 001019)**

1.5 Investigation of the relationships between blood metabolite and metabolic hormone concentrations and gonadotrophin profiles in ewes with different levels of intake at different levels of condition

S.M. Rhind, J.M. Doney, R.G. Gunn and I.D. Leslie

The effects of different levels of intake and of body condition on the gonadotrophin profiles of ewes have been investigated in recent experiments. Nutritional factors have been shown to affect gonadotrophin profiles but, at least in the cases of LH and FSH, there is no evidence of a direct effect of intake on gonadotrophin secretion via the nervous system and condition score is unlikely to have such a direct effect. Nutritional effects are likely to be mediated through changes in circulating metabolic hormone and metabolite concentrations. The aim of this work was to investigate the relationships between gonadotrophin, metabolic hormone and metabolite concentrations in ewes in a range of body conditions and on high and low levels of intake; this information may provide some indication of the parameters which are affected by intake and condition and can in turn modify gonadotrophin secretion.

In early October 1984, 40 Scottish Blackface ewes with condition scores of 1.5 to 2.25 were allocated to each of 2 initially similar groups of 20 ewes. They were housed in individual pens and offered a live-weight maintenance ration.

On 3 occasions, ewes were synchronised in oestrus (7/11/84; 19/12/84 and 8/2/85) using progestagen pessaries followed by an injection of prostaglandin F_2 12 days after pessary removal. At these times, the condition scores of the animals were 1.5 to 2.25, 2.0 to 2.75 and 2.5 to 3.0 respectively. From 2 weeks before the synchronised oestrus (longer at the start of the experiment) all ewes were offered a live-weight maintenance ration (11 g/kg live weight of diet AA6). From one week before oestrus, 20 ewes were fed AA6 *ad libitum* while the remaining ewes were offered the maintenance ration. The same 20 animals were fed *ad libitum* during this period on each of the 3 occasions. Following the synchronised oestrus, all ewes were fed *ad libitum* so that they gained body condition.

On the day of prostaglandin (PG) injection, catheters were inserted in the jugular vein. The following day, between 24 and 32 hours after PG injection, blood samples were collected via catheters at 15 minute

Table 1 Mean concentrations of blood metabolites and hormones for ewes with high or moderate intakes and in low (L), moderate (M) or high (H) levels of body condition

	Intake	Condition score								Significance	
		L		M		H		Overall		Intake	Body condition
		Mean	s.e.	Mean	s.e.	Mean	s.e.	Mean	s.e.		
LH	High	1.06	0.069	0.88	0.056	1.01	0.060	0.98	0.036	NS	NS
	Moderate	0.99	0.163	0.90	0.067	0.95	0.047	0.95	0.042		
	All	1.02	0.087	0.89	0.043	0.98	0.037	0.97	0.035		
Prolactin	High	18.5	2.73	21.1	1.85	42.4	3.39	27.3	2.09	***	***
	Moderate	6.8	0.92	13.6	2.16	32.0	3.64	17.5	1.98		
	All	12.6	1.70	17.4	1.53	37.2	2.59	22.4	1.50		
Insulin	High	9.67	0.532	10.17	0.749	10.69	0.626	10.18	0.368	***	***
	Moderate	5.30	0.382	7.10	0.416	9.55	0.662	7.31	0.364		
	All	7.49	0.478	8.64	0.489	10.12	0.460	8.75	0.289		
Cortisol	High	10.04	0.704	6.28	0.396	6.42	0.479	7.58	0.382	NS	***
	Moderate	10.31	0.637	5.98	0.472	6.05	0.639	7.41	0.427		
	All	10.17	0.470	6.08	0.305	6.23	0.395	7.50	0.286		
Thyroxine	High	50.3	3.82	57.4	3.69	108.2	5.54	72.0	4.20	NS	***
	Moderate	45.7	2.75	59.8	4.93	101.8	5.73	69.1	4.07		
	All	48.0	2.35	58.6	3.04	105.0	3.97	70.5	2.91		
Tri-iodo-thyronine	High	1.16	0.046	0.88	0.033	1.43	0.085	1.15	0.044	NS	***
	Moderate	0.98	0.056	0.87	0.050	1.44	0.080	1.09	0.048		
	All	1.07	0.054	0.87	0.030	1.43	0.058	1.12	0.033		
Total Protein	High	66.7	1.11	69.9	1.33	68.5	0.99	68.7	0.67	NS	NS
	Moderate	68.2	1.18	67.9	1.80	70.8	1.55	69.0	0.88		
	All	67.9	0.80	68.9	1.12	69.7	0.92	68.8	0.55		
3-OHB	High	0.52	0.027	0.51	0.029	0.47	0.031	0.50	0.017	NS	NS
	Moderate	0.40	0.025	0.51	0.040	0.49	0.022	0.47	0.018		
	All	0.46	0.021	0.51	0.024	0.48	0.019	0.48	0.012		
Glucose	High	3.29	0.067	2.96	0.060	3.07	0.038	3.11	0.036	**	***
	Moderate	2.99	0.058	2.82	0.065	3.09	0.056	2.96	0.037		
	All	3.14	0.049	2.89	0.043	3.08	0.033	3.04	0.026		
Urea	High	8.39	0.195	8.46	0.221	7.12	0.315	7.99	0.163	***	***
	Moderate	6.66	0.221	5.90	0.190	5.87	0.163	6.14	0.120		
	All	7.53	0.422	7.18	0.251	6.50	0.286	7.07	0.131		
Albumin	High	21.7	0.827	23.3	0.932	24.5	0.872	23.2	0.520	NS	**
	Moderate	21.1	0.953	22.3	0.856	24.5	0.809	22.6	0.531		
	All	21.4	0.625	22.8	0.631	24.5	0.588	22.9	0.371		

intervals. After the 6th sample the ewes were given their entire daily ration of feed; this was considered likely to induce substantial endocrine changes which might aid interpretaation of results, as differences in endocrine status with intake are likely to be enhanced at this time and the rapid changes in hormone levels following feeding may make inter-relationships more apparent. Blood samples will be analysed for LH, FSH, prolactin, insulin, growth hormine, cortisol, progesterone, thyroxine, tri-iodothyronine, NEFA, 3-hydroxybutyrate and urea and inter-relationships between these will be studied.

Using vasectomised rams ewes were tested for oestrus activity at 6-hour intervals from 24 hours after PG injection to determine the time of oestrus onset. Differences between ewes in the time of blood sample collection relative to oestrus onset and ovulation can thus be taken into account in analyses and interpretation of the results.

The results available at present are given in Table 1. While mean LH concentrations were not affected by condition score or intake, there was a consistent trend towards a higher LH pulse frequency and pulse amplitude in ewes with a high intake; these parameters were not affected by body condition.

The results indicate that changes in total protein and 3-OHB are unlikely to be responsible for changes in gonadotrophin secretion. Similarly, changes in some other parameters which were affected only by condition score are unlikely to be instrumental in inducing changes in gonadotrophin secretion association with different levels of intake.

1.6 Investigation of ovarian follicle populations and follicle physiology in Scottish Blackface ewes with different levels of intake at mating and associated endocrine profiles before and after ovariectomy

S.M. Rhind, A.S. McNeilly*, C. Tsonis*, G. Martin and S. McMillen
(*MRC Unit of Reproductive Biology)

It has been shown in previous work done in the Organisation that differences in body condition in Blackface ewes are associated with differences in the number of large (potentially ovulatory) follicles present and in circulating FSH levels. It has been shown that differences in feed intake in Cheviot ewes are associated with differences in LH pulse frequency during the 2 and 3 days before oestrus but no differences in gonadotrophin levels are present during the luteal phase.

It was hypothesised that similar numbers of large follicles would be present in animals with similar levels of body condition but different feed intakes and that differences in endocrine status during the follicular phase of the cycle (associated with different levels of intake) would result in different ovulation rates. However, the effects of intake on follicle populations and follicle physiology have not been investigated.

It is not known whether or not differences in hormone secretion with intake are a function of differences in hypothalmic activity and gonadotrophin releasing hormone (Gn-RH) secretion or of pituitary sensitivity to Gn-RH, or both. In the entire ewe, patterns of secretion are dependent on ovarian steroid feedback. Uninhibited secretion of gonadotrophins and the pituitary response to Gn-RH can only be examined in the ovariectomised animal.

The aims of this experiment were to characterise ovarian follicle populations and physiology in Blackface ewes with two levels of food intake and to determine the effect of level of intake on the pattern of Gn-RH secretion as measured by patterns of LH secretion and on the sensitivity of the pituitary to Gn-RH in these ewes.

Two initially similar groups of 12 draft Blackface ewes were fed to achieve condition scores of either 2.0 or 2.5 by mid-December. Thereafter, ewes in low condition (CS = 2.0) were fed dried grass pellets *ad libitum* and 250 g hay/head/day while high condition (CS = 2.5) ewes were offered a live-weight maintenance ration of 900 to 1100 g dried grass pellets and 250 g hay/head/day. Under this feeding regime, all ewes were in a similar level of body condition but had different intakes at ovariectomy in late January.

Ewes were synchronised in oestrus using progestagen pessaries. Half of the ewes of each intake group were ovariectomised on day 11 of the oestrous cycle (luteal phase) and the follicles removed and measured and their steroidogenic capacity measured. The remaining ewes were injected with prostaglandin F_2 and they were ovariectomised 30 and 32 h later on day 12 (follicular phase). The ovarian follicles were counted and measured and their steroid content and steroidogenic capacity determined.

On day 10 of the cycle, blood samples were collected at 15 min intervals for 12 h (luteal phase) and samples were collected from 12 ewes at 10 min intervals for 6 h from 24-30 h after prostaglandin injection (follicular phase). On days 2 and 7 after ovariectomy, samples were collected at 15 min intervals for 8 h and then for a further 3 hours after injection of 10 g of Gn-RH to provide gonadotrophin profiles of ewes in the absence of ovarian steroid feedback. All samples will be analysed for LH and FSH.

The prescribed changes in condition score and live weight were largely achieved. On 27 January, four weeks after the beginning of differential feeding, at the time of ovariectomy, mean ($\pm$ se) condition scores were 2.52 $\pm$ 0.48 and 2.41 $\pm$ 0.036 for ewes in the moderate and high intake groups respectively.

The mean numbers of corpora lutea (CL) recorded at ovariectomy were 1.42 (range: 0 to 3) and 1.83 (range: 1 to 3) for moderate and high intake groups respectively (one additional CL in the moderate group was extremely small and probably abnormal). Mean CL weights were similar for ewes of each treatment.

The mean numbers of follicles > 1 mm diameter and > 3 mm diamter for ewes of each treatment and at each stage of the cycle are given in Table 1.

The mean diameters of the largest and 2nd and 3rd largest follicles in each of the treatments and at each stage of the cycle are given in Table 2.

TABLE 1

Mean (+ se) numbers of follicles > 1 mm or > 3 mm diamter in ewes with high or moderate levels of intake (n = 6/group)

Intake	High	Moderate	Significance
No. of follicles 1.0 mm			
Luteal	36.8 ± 6.2	29.5 ± 4.0	NS
Follicular	31.5 ± 4.5	18.5 ± 2.2	P < 0.05
No. of follicles 3.0 mm			
Luteal	4.67 ± 0.62	7.33 ± 1.38	NS
Follicular	7.50 ± 1.20	5.17 ± 1.08	NS

TABLE 2

Mean (+ se) follicular diameters of 3 largest follicles from each ewe

	1st	2nd	3rd
Luteal phase			
High	7.03 ± 0.09	5.93 ± 0.29	4.27 ± 0.37
Moderate	6.58 ± 0.40	5.26 ± 0.26	4.53 ± 0.21
Follicular phase			
High	7.25 ± 0.10	6.18 ± 0.32	4.87 ± 0.15
Moderate	7.58 ± 0.38	5.49 ± 0.50	4.91 ± 0.51

The results indicate that differences in intake, unlike differences in condition score are not associated with different numbers of large (potentially ovulatory) follicles during the luteal phase of the cycle; neither was there any difference with level of intake in the mean size of the 3 largest follicles in each ewe. This is consistent with the hypothesis that the effect of intake on ovulation rate is a function of follicle selection processes at a late stage of the oestrus cycle. It is hypothesised that the large follicles (> 3 mm diameter) from the two treatment groups will have different steroidogenic capacities (this remains to be determined) which will be indicative of their maturity and ability to shed mature ova.

The significantly smaller number of follicles > 1 mm diameter, during the follicular phase, in ewes with a moderate level of intake is also consistent with a higher rate of follicle atresia (lower incidence of follicle maturation) in the ewes of this group.

Determinations of hormone concentrations in plasma and follicle fluid samples are awaited.

1.7 Investigation of the physiology of corpora lutea of ewes with high or moderate levels of body condition and feed intake

S.M.Rhind, D. Stirling*, A. Bramley* and I.D.Leslie (*MRC Unit of Reproductive Biology)

It has been shown that high levels of body condition (C.S. > 3.25) together with high levels of feed intake are associated with a reduced level of reproductive performance compared with that of ewes in moderate condition (C.S. = 2.75) and fed a live-weight maintenance ration (Rhind, Gunn, Doney and Leslie, 1984). More detailed studies (Rhind, Leslie, Gunn and Doney, 1986) have shown that at least some of this reduction is a function of abnormalities in progesterone secretion or of the preovulatory LH surge. The aim of this work was to investigate luteal function in similar groups of ewes in order to understand the causes of the luteal insufficiency.

Two groups of 10 Greyface ewes were fed so that they achieved mean condition scores of 3.31 $\pm$ 0.050 and 2.40 $\pm$ 0.076. Ewes of the high condition group were then fed dried grass pellets *ad libitum* plus 250 g hay/hd/day while ewes of the other groups were fed a liveweight maintenance ration comprising approximately 900 g pellets plus 250 g hay/hd/day. The ewes were slaughtered at approximately 11 days after a synchronised oestrus and the corpora lutea (C.L.) recovered and investigated.

The C.L. of ewes of the high condition group contained more cells, as indicated by total DNA content, and were larger than those of ewes in moderate condition (623 $\pm$ 34 v 506 $\pm$ 27 mg; $P < 0.05$). The luteal tissues were cultured and found to have similar basal rates of progesterone production, showed similar increased secretion in response to the addition of cAMP and had a similar capacity to bind gonadotrophin (hCG) which in turn stimulates cAMP production. It should be noted however, that only free receptor was measured and there may have been differences in the levels of bound hormone. However, luteal tissue from the high condition ewes contained less progesterone initially (Fig. 1) and was less responsive to gonadotrophin (Fig. 1).

To summarise, progesterone production in some ewes of the high condition/intake group was abnormally low in early pregnancy and this was associated with an increased incidence of embryo wastage and failure to conceive (Rhind et al, 1984). The results of the present experiment are broadly comparable although the luteal tissue was collected when the corpora lutea were about 11 days old instead of 2 to 6 days old. The data from this experiment indicate that the tissue of ewes of both groups had a similar steroidogenic capacity and a similar capacity to bind the luteotrophic hormone, hCG (closely related to LH in structure). However, the lower progesterone production in response to hCG, in the high condition ewes suggests that the link between the LH receptors and the enzyme systems which sustain progesterone production was inadequate. It is interesting to speculate that embryonic death is not a function of mean circulating progesterone levels but of the dynamic relationship between progesterone production and the luteotrophic LH stimulus.

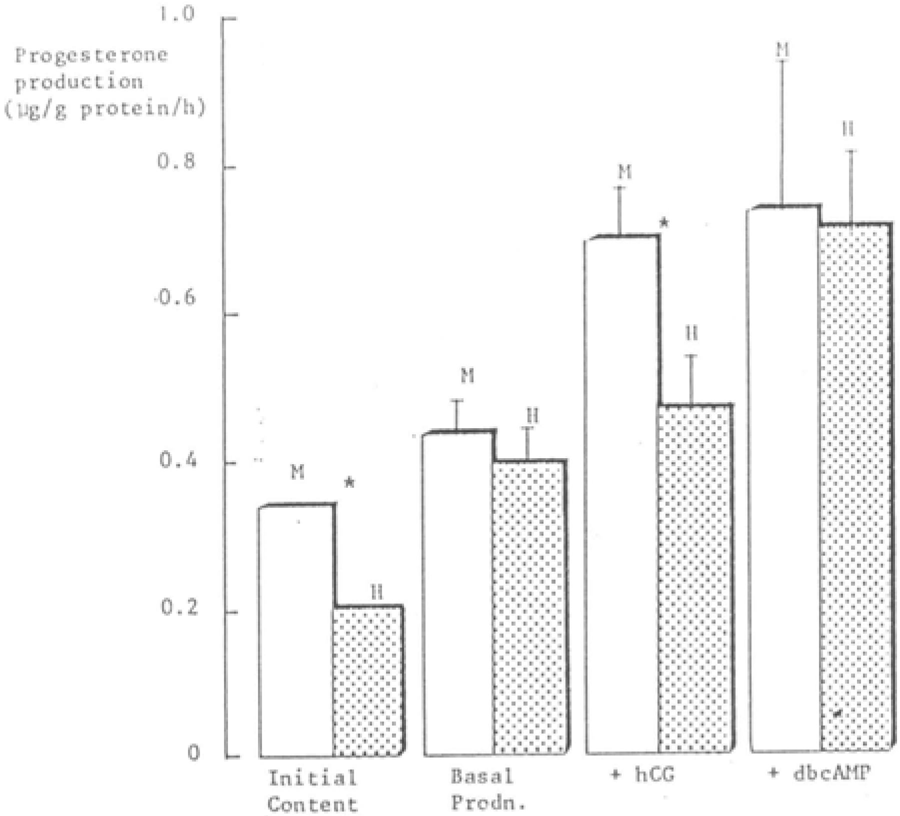

Figure 1. Progesterone content and production of luteal tissues from high (H) and moderate (m) body condition groups of ewes.

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Research objective: **Increase ovulation rate of hill and upland ewes by immunisation against steroid hormones (no. 001021)**

1.8 Investigation of the relationship between level of feed intake and reproductive performance of Scottish Blackface ewes passively immunised against testosterone

S.M. Rhind, B.A. Morris*, J. Clayton* and R.G. Gunn (*University of Surrey)

The reproductive performance of ewes in different levels of body condition at mating following passive immunisation against steroids has been investigated (Rhind et al, 1985) but the effect of level of feed intake on the response has not been examined. The aim of this experiment was to characterise the reproductive performance of ewes with condition scores of 2.25 to 3.00 at mating and with either a high or moderate intake, following passive immunisation against testosterone.

Following weaning in September, approximately 290 mature Scottish Blackface ewes were allocated, within each condition score class, to one of two target condition scores (2.25/2.50 or 2.75/3.00). Ewes which were initially in a condition score < 2.00 were allocated to the lower target. The ewes were fed to achieve their target condition scores by two weeks before mating on 21 November. From 2 weeks before to 2 weeks after the start of mating, half of the ewes of each condition score group were fed dried grass pellets and hay ad libitum while the remaining animals were given a liveweight maintenance ration comprising 0.7 kg pellets + 0.25 kg hay/head/day. At the end of this period, all ewes had their ration gradually increased/decreased to 1.5 g pellets + 0.25 kg hay/head/day.

Two days before joining with the rams, half of the ewes of each condition score/intake group were passively immunised against testosterone using 1.5 standard doses of antiserum.

Seventeen days after joining, 97 draft age ewes, taken from all of the treatment groups, were slaughtered and their reproductive tracts recovered and numbers of corpora lutea determined. The remaining ewes will be allowed to lamb and the litter sizes, lamb sexes and birthweights will be recorded.

The mean ovulation rates recorded for ewes of immunised and control ewes of each condition score and intake group are given in Table 1. As expected, there was a trend towards higher mean ovulation rates in ewes in the higher intake ($P < 0.05$) and condition score (NS) groups. Immunised ewes had a higher mean ovulation rate ($P < 0.01$) than control group ewes. The effects of intake and immunisation on ovulation rate were generally additive.

TABLE 1
Mean ovulation rate (± se) of immunised and control ewes in condition scores 2.50 or 2.75 at mating and with high or moderate (maintenance) levels of intake

Intake	Condition score	Immunised Mean	se	n	Control Mean	se	n	Significance
High	> 2.75	2.7	0.14	12	1.9	0.06	16	P < 0.1
	< 2.50	2.3	0.14	10	2.2	0.13	10	NS
Maintenance	> 2.75	2.1	0.20	9	1.8	0.20	10	NS
	< 2.50	2.1	0.16	16	1.6	0.17	14	P < 0.05

The potential litter sizes and lambing rates of ewes of each group, as determined by ultrasound scanning are given in Table 2.

TABLE 2
Numbers of ewes of each condition score, intake and treatment group with 0 to 3 embryos

Intake	Condition Score at mating	No. of embryos	Immunised	Control	Significance
High	> 2.75	0	2	1	
		1	4	7	
		2	21	17	
		3	5	1	
Mean of embryos/ewe to ram			1.91	1.69	NS
/ewe pregnant			2.03	1.76	NS
	< 2.50	0	0	0	
		1	6	7	
		2	10	16	
		3	2	0	
Mean no of embryos/ewe to ram			1.78	1.70	NS
/ewe pregnant			1.78	1.70	NS
Maintenance	> 2.75	0	0	0	
		1	4	10	
		2	12	13	
		3	1	1	
Mean no of embryos/ewe to ram			1.82	1.63	NS
/ewe pregnant			1.82	1.63	NS
	< 2.50	0	0	0	
		1	13	14	
		2	19	9	
		3	0	0	
Mean no of embryos/ewe to ram			1.59	1.39	NS
/ewe pregnant			1.59	1.39	NS
Overall mean no of embryos/ ewe put to ram			1.77	1.60	*
/ewe pregnant			1.80	1.62	*

Only 3 of the ewes examined had failed to conceive and all of these were in the highest body condition and intake category.

The reproductive performance of ewes in high body condition (CS > 2.75) was little affected by level of intake. Similarly, the performance of ewes with a high intake was largely independent of body condition. However, ewes in moderate condition (CS < 2.50) which had a high intake had a higher ($P < 0.1$) mean potential litter size and lambing rate than ewes fed a maintenance ration. The performance of ewes with a moderate level of intake and on a high level of body condition was higher ($P < 0.1$) than that of equivalent ewes in moderate condition.

Immunised ewes had a significantly higher ($P < 0.05$) mean potential litter size and lambing rate than control ewes. Although not statistically significant, this trend was recorded in each of the 4 main condition score/intake categories.

When lambing data are available, the data will be analysed in more detail but the well documented effects of body condition and intake on ovulation rate and lambing rate are evident. The results also indicate that the effects of intake and passive immunisation on both ovulation rate and lambing rate were additive.

In contrast to the observations of Rhind et al (1985) who found that immunisation failed to induce an increase in lambing rate in ewes in high body condition, in this experiment there was some evidence, although not statistically significant, that ewes in high body condition which also had a high intake did respond to immunisation. This trend may be in part a function of the slightly lower level of reproductive performance of ewes in this experiment but may also be attributed to an effect of increased intake on the numbers of ovarian follicles that can mature i.e. increased intake may increase the proportion of follicles which have the capacity to ovulate in response to immunisation.

References

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1.9 Reproductive performance of ewes passively immunised against testosterone or testosterone plus oestradiol

S.M. Rhind, B.A. Morris*, R.G. Gunn and J. Clayton* (University of Surrey)

The reproductive performance of ewes can be improved by passive immunisation against any one of a number of steroid hormones. There is, however, some evidence from earlier experiments (Land et al, 1982) that greater improvements in lambing rate may be obtained using a mixture of antibodies rather than say anti-testosterone serum alone. The aim of this experiment was to investigate the reproductive performance of ewes passively immunised against testosterone alone compared with that of ewes given a mixture of antibodies, with 15 or 30% of the anti-testosterone antiserum replaced by anti-oestradiol serum.

A flock of 124 Scottish Blackface ewes was divided into 4 similar treatment groups according to liveweight and condition score. Ewes of 3 of the groups were treated with different antiserum mixtures and the remaining group was not treated. Ewes were injected intravenously 3 days before joining with harnessed rams on 1 November. One group was injected with 10.5 ml of anti-testosterone antiserum (titre: 1:460,000) which was equivalent to 1.5 "standard doses" and was considered to be close to the optimal dose. For ewes of the other two treated groups, 15 or 30% of the anti-testosterone antiserum was replaced with anti-oestradiol antiserum (titre: 1:85,000).

Pregnancy rates and litter sixes were determined by ultrasound scanning on 20 January and the patterns of reproductive performance for ewes of the respective treatment groups are given in Table 1.

In contrast to previous experiments (Rhind et al., 1985) there was no improvement in reproductive performance following passive immunisation against steroids in this experiment.

TABLE 1
Mean liveweights, condition scores and patterns of reproductive performance, as measured by scanning, of ewes passively immunised against testosterone, testosterone and oestradiol or not immunised

Treatment		Control	Anti-T	Anti-T+anti E_2 (15%)	Anti-T+anti E_2 (30%)
No. of ewes		31	30	32	31
Mean (± se) liveweight at joining		62.4 ± 1.28	62.2 ± 1.17	59.7 ± 0.91	61.6 ± 1.01
Mean (± se) CS at joining		2.84 ± 0.03	2.84 ± 0.03	2.84 ± 0.03	2.85 ± 0.03
No. of ewes with 0-3 foetuses*	0	1	2	2	2
	1	7	6	9	7
	2	23	22	20	21
	3	0	0	1	1
Mean potential litter size of ewes pregnant		1.77	1.79	1.73	1.79
Mean potential lambing rate*		1.71	1.66	1.63	1.68

*Ewes with 0 foetuses may be pregnant but foetuses were 35 d of age at scanning

However, unlike the previous work (Rhind et al, 1985) all of the ewes in this experiment were in moderately good condition at mating and in the earlier observations, which also involved Scottish Blackface ewes, the response to immunisation was confined to ewes in lower levels of condition. Thus, while the present results do not demonstrate whether or not inclusion of anti-oestradiol antiserum can improve lambing rate under certain circumstances, they do confirm that in this breed, passive immunisation will not improve the performance of ewes in good body condition at mating.

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Research objective: Comparison of ram fertility adjudged on semen quality in relation to performance in the field (no. 001066)

1.10 Correlation of ram semen evaluation with reproductive performance

A.R. Fawcett and A.J. Macdonald (joint study with ESCA, ADRA, RDSVS)

The HFRO component involved the collection of reproduction performance data on 24 Dorset rams of various ages which had been clinically examined (general and genital) and electroejaculated 9-11 days before being turned in with ewes, in groups ranging from 12-30, in late October. Semen was also collected on the day of removal from the ewes and again in April the following year. On the first two occasions only the first ejaculate was examined. A semen score out of 10 was obtained by summating scores out of 5 for motility and density.

Twelve rams (Group A) ran with the ewes for ten days before they were replaced with the second group (B). Matings were recorded and conception rates and lambing rates calculated.

Conception rates ranged from 57-100% in the ewes mated to the initial group (A) of rams and from 67-100% in the follow-up rams (B). There was no obvious correlation between the semen scores and conception rates in this exercise in that semen scores of 2 and 10 were both associated with 100% conception rates. This highlights the need to repeat electroejaculation in cases where a poor semen sample is obtained where there is no clinical evidence of disease in the reproductive organs. Another group of ewes mated to a ram with a semen score of 9 had only a 60% conception. It could be that the ram's service technique was at fault although ewes were marked.

The futility of attempting to collect semen from rams in the middle of the mating season (collections were made on the day of removal) was aptly demonstrated by the poor quality of semen collected - in many cases only seminal fluid being obtained. This confirms the need to remove rams from ewes for 2-3 days before attempting electroejaculation.

Semen sample scores in the spring again showed a wide range of figures but since more than one electroejaculation was attempted in these animals which produced poor samples initially no comparison can be made with earlier samples.

The above problems have now been rectified and further studies are under way.

2. PREGNANCY

Research objective: Develop and evaluate means of determining foetal numbers in pregnant ewes (no. 001027)

2.1 The application of ultrasonic scanning in sheep and cattle production

A.J.F. Russel, I.A. Wright and I.R. White

Trials conducted in the Organisation in 1983 showed that real-time ultrasonic scanning offered a safe, accurate and rapid means of diagnosing pregnancy and determining foetal numbers in sheep. The technique has been taken up quickly by the industry and it is estimated that some 2,000,000 ewes were scanned during the winter of 1985/6.

The Organisation has a continuing involvement in the development of improved scanning instruments and ancillary sheep handling equipment. The most significant development in this respect has been the production by BCF Technology Ltd of Livingston of a new sector scanner. This gives a 'wide-angle' view of the tissues of the ewe from a small area of contact and enables ewes to be scanned in the standing position and without clipping wool from the belly - features which were not possible with the earlier generation of instruments.

The problem most frequently encountered in scanning ewes is poor image quality caused by the presence of excessive gas in the intestines. A trial conducted recently indicated that this difficulty could be minimised by withholding roughage (i.e. hay, silage or straw) from the sheep for 8-10 hours prior to scanning. Withholding roughage for longer than 20 hours appeared to cause image quality to deteriorate again. Results from the same work showed that image quality in sheep fed roughage was consistently better in ewes scanned in the standing position than in those turned on their backs.

The use of the technique has recently been extended to beef cows. Trials have shown that pregnancy can be diagnosed with an accuracy of greater than 98% from approximately 30 days post-conception. Relationships have been developed which enables foetal age to be estimated from measurements of foetal parts imaged on the scanner screen. In a trial in which calving dates were predicted from this information the difference between actual and predicted mean calving dates was 0.3 day; 58% of cows calved within 3 days of the predicted date and 90% within 10 days. Relationships between foetal age and size have also been developed for sheep.

Scanning is currently being used in work to determine the incidence of early foetal mortality in beef cows and preliminary results indicate that some 8% of pregnancies fail between 30 and 40 days post-conception. The technique is used routinely in work on goats and red deer and will also be employed in projected research on twinning in cattle.

3. LACTATION AND LAMB GROWTH

Research objective: **The endocrine status of lactating ewes in relation to milk production and associated nutrient partitioning (no. 001024)**

3.1 Levels and pattern of milk supply of ewes in relation to blood metabolite profiles

J. Bass, J.M. Doney, S.M. Rhind, I.D. Leslie, W.F. Smith, A.D.M. Smith and D.A. Sim

A series of experiments has been carried out, using lactating ewes, to investigate milk production and associated plasma hormone and blood metabolite status, to improve understanding of the endocrine mechanisms involved in the partitioning of nutrients between milk and body tissue.

Comparisons were made between ewes rearing single or twin lambs at two times of year (January and April), ewes fed 150 or 200 g crude protein (CP)/kg DM in the ration and ewes of different genotypes, East Friesland or Scottish Blackface. It was intended that the widely different circulating concentrations of prolactin associated with season would be an aid to the interpretation of the role of this and other hormones in milk production and nutrient partitioning. Details of the experimental methods employed are given in the 1984 Annual Report p.30 and the 1983 Annual Report p.25.

In general, milk production was positively associated with plasma NEFA, 3-OHB, prolactin, T_3 concentrations and growth hormone and negatively associated with insulin and T_4 concentrations, although these trends were not observed in all of the experiments. At present, the data is being analysed in more detail. In particular, the interrelationships between insulin and growth hormone and insulin and cortisol are being examined in relation to milk production and stage of lactation.

Research objective: **Measure the growth and body composition of lambs on grass and forage crops in relation to intake and growth before weaning (no. 001025)**

3.2 Active immunisation against fat cell membranes of lambs to manipulate growth and carcase composition

S.M. Rhind and D. Flint* (*Hannah Research Institute)

Fat is energetically expensive to produce and is required in only limited amounts in the finished lamb carcase. Furthermore, in some management systems it may be possible to meet nutritional requirements of ewes at all times of year through feed alone and so obviate the need for the energetically inefficient processes of fat deposition and mobilisation. Thus, there could be considerable economic and practical advantage in reducing fat deposition in growing lambs or adult ewes, provided that growth rate was not also reduced.

It has been demonstrated that fat depot size can be greatly reduced in rats by active immunisation against fat cell membranes. The aim of this pilot study was to determine whether or not similar effects could be achieved in lambs using this technique and to determine the effect of immunisation on growth rate and feed intake as well as carcase composition.

Nine sets of twin Scottish Blackface ewe lambs were used. The lambs were reared by their dam for the first 14 weeks and then weaned. At 1 to 2 weeks of age, one lamb of each pair was actively immunised against fat cell membranes. Control animals were injected only with adjuvent and not immunogen. Booster injections were administered 14, 35 and 56 days later.

No differences were recorded in mean daily intake or rates of growth between the lambs of the treated and control groups. All lambs were slaughtered when between approximately 25 and 35 kg live weight and the carcases will be dissected and analysed for fat, protein, water and ash content.

Research objective: **Characterise the relationship between body tissue change and live weight change of lambs to point of slaughter (no. 001026)**

3.3 Carcase composition of first-cross wethers from East Friesland or Border Leicester sires

J.M. Doney, A.D.M. Smith, I.R. White, D.A. Sim and A. Dalziel

Previous studies have shown that the first-cross ewes derived from hill ewes, especially the Scottish Blackface, and rams of a 'dairy' breed such as the East Friesland could have a useful role in producing lamb meat from grass. Little is known of the suitability of the first-cross wether lambs for specific finishing systems or the live weights at which the most acceptable carcases can be produced.

In a preliminary study, 30 lambs born in 1985 out of Blackface ewes (EFB) and 20 lambs from North Country Cheviot ewes (EFC), sired by East Friesland rams were transferred from Glensaugh to Hartwood after weaning. A further 30 Greyface (Border Leicester x Blackface, GF) wether lambs in the same weight range (25-30 kg) were purchased. After being held on grass the lambs were group-fed on a concentrate diet containing an estimated 12.5 MJ metabolisable energy and 173 g crude protein per kg DM. They were allocated to groups to be killed at different live weights (32, 38, 44, 50 and 56 kg and at 'maturity'). On reaching a live weight of 32 kg lambs were allocated to individual pens and the *ad libitum* intake was recorded until nominated killing weight was reached. Results from physical and chemical analyses of body composition are awaited. Preliminary results indicate differences in voluntary intake and daily liveweight gain between the EFC lambs (1.45 ± 0.04 kg/day and 207 ± 18.2 g/day, respectively) and the EFB or GF lambs which were similar (1.57 ± 0.049, 1.54 ± 0.031 kg/day and 252 ± 14.9, 235 ± 9.1 g/day, respectively). At 32 kg liveweight very few carcases reached the MLC grade 2, between 38 and 50 most lambs were graded 2-3L.

4. PRODUCTION EFFICIENCY

Research objective: **Determine the effects of differences in ewe mature size and lactation and reproductive capability on output from upland grazing systems (no. 001028)**

4.1 Breed of ewe effect on the utilisation of pasture maintained at two sward heights

J.M. Doney, R.G. Gunn, T.J. Maxwell, D.A. Sim, R.D.M. Agnew, A.R. Sibbald and I.R. White

A trial was initiated in 1984 to compare the performance of 3 types of crossbred ewes on old, reseeded swards maintained at different surface heights. The breeds were Greyface (GF, traditional, large size), East Friesland x Blackface (EFB, sustained lactation, intermediate size) and North Country Cheviot x Shetland (NCS, small size). Equal numbers of ewes with lambs were transferred to equal sized plots to be maintained at low or intermediate sward height profiles throughout the grazing season. There were two replicates of each treatment. Sward height in each plot was maintained by adjustment of grazing area and therefore, stock density. In 1984 the trial was abandoned before weaning due to drought conditions.

Repeated in 1985, the mean stock density from entry, when the lambs were approximately 7 weeks of age, until weaning at 20 weeks was 16.5, 15.6 and 22.0 ewes/ha for GF, EFB and NCS, respectively on the low swards (3.5 cm) and 14.4, 14.0 and 16.2 ewes/ha on the intermediate swards (5.5 cm). The difference between sward treatments, overall breeds, was greater during the first 6 weeks (19.2 v 15.7 ewes/ha) than in the remaining 7 weeks (16.3 v 15.7 ewes/ha). Pattern of live-weight change was similar for all breeds and sward treatments. Mean daily live-weight gain of lambs, overall was 263 g/d during the first period, falling to 88 g/day in the second. Lambs from NCS ewes had a lower growth rate in both periods (200 and 50 g/d, respectively). Live-weight gain in any week was not related to herbage mass, allowance or height in the same week but was significantly associated with estimated herbage growth rate (LWG = 58 + 1.82 EGR (kg/ha/d, r = 0.91). The lower lamb weaning weights but higher stocking rates of the NCS ewes led to a slightly greater lamb output/ha than in the other two breeds (799 v 757 and 754 kg/ha).

4.2 Fleece investigations

M.L. Ryder

The genotype - production efficiency experiment at Glensaugh described above provided an opportunity to examine fleece weight, grade and price in two new crosses, the Shetland x North country Cheviot and East Friesland x Blackface and to compare the values with an established cross, the Greyface (Border Leicester x Blackface). The fleeces from 36 sheep in each group were investigated. The fleece weights are shown in Table 1.

TABLE 1
Fleece weights (kg)

	Range	Mean
Greyface	1.8 to 3.8	2.83
East Friesian x BF	1.6 to 3.1	2.29
Shetland x NCC	1.2 to 3.6	1.94*

*partially cast fleece weighing 0.6 kg excluded from mean

The fleece weight of the East Friesland cross is now much less than that of the Greyface, but the low fleece weight of the Shetland appreciably reduced the fleece weight of the cross with the Cheviot.

Individual fleece grades were kindly provided by Mr S. Ballinger, Scottish Regional Manager of the British Wool Marketing Board. The figures in brackets (below) are the grade numbers.

Ten of the Greyface fleeces were graded as Cross Ewe (430) and ten as Cross Ewe Deep (long) (431), which fetches 5p/kg less than 430 and so is presumably less desirable. Eight fleeces were cast (434) (downgraded) three of them because of excess straw in the fleece (an avoidable fault). Five were cotted (435) and three were downgraded as a result of earth contamination (426).

Ten of the Friesland cross fleeces were graded Cross Ewe (430) the same as the Greyface, and as many as 12 were downgraded as a result of excess straw (434), but only one was cotted (435). It is interesting that, although this was a Blackface cross, one fleece was graded as Cheviot (616) and 13 as Cheviot Cross (457).

As many as 19 of the Shetland cross fleeces were graded as Cheviot (616) or Cast Cheviot (620) and nine were graded as Cheviot Cross (457 or 459). One was graded Cheviot Light Grey (692), the Shetland having revealed hidden colour genes in the Cheviot. Two fleeces were graded Shetland and two Shetland Cross. The group showed a range of fleece types from Cheviot to Shetland, whereas the Friesland crosses were intermediate between those of the parents.

Fleece values are shown in Table 2.

TABLE 2
Fleece value

	Range	Mean	Total
Greyface	£1.88½ - £4.26	£3.02	£108.75
East Friesland x BF	£1.72½ - £3.36	£2.49	£ 89.51
Shetland x NCC	£1.29 - £4.06	£2.27	£ 79.52

The Greyface fleeces ranged from £1.88½ to £4.26 in value with a mean of £3.02, which was calculated by dividing the total income by the number of fleeces. These were clearly more valuable than the other crosses. Only three fleeces had deductions for excess straw.

The Friesland cross fleeces ranged from £1.72½ to £3.36 in value with a mean of £2.49. It is particularly disappointing that one third of these fleeces had a deduction of 20p/kg (about 50p/fleece) for the avoidable fault of excess straw.

In the Shetland cross, if one excludes the partially cast fleece which was worth only 75p, the fleece values ranged from £1.29 to £4.06 with a mean of £2.27. It is possible that the calculation of these findings in terms of production per ha might give different results.

PROGRAMME UNIT 6: EFFECT OF NUTRIENT SUPPLY AND SUPPLEMENT USE ON THE DIGESTION, METABOLISM AND PERFORMANCE OF GRAZING SHEEP

Research objective: To establish the amount, type and feeding method of supplements to give ewes in mid pregnancy grazing different vegetations (no. 002043)

1. Interactions between the feeding of supplements in mid- and late-pregnancy

J.A. Milne, A.M. Sibbald and A.J. Senior

Supplementation of ewes grazing heather hills in mid-pregnancy has been shown to increase lamb birth weights by 10% (Lippert, 1985). In mid-pregnancy ewes received 150 g/day of a mainly cereal supplement and in late pregnancy increasing amounts of supplement up to 550 g/day at parturition, such that 8 kg DM/ewe of supplementary feed was given. Mean flock plasma 3OH butyrate concentrations were always less than 0.9mM in late pregnancy, indicating that ewes in late pregnancy were not severely under-nourished. Both single- and twin-lamb birth weights were improved by mid-pregnancy supplementation although twin birth weights were increased proportionally to a greater extent. The birth weights of the twin lambs from ewes unsupplemented in mid-pregnancy were low, and within the range where unacceptable levels of mortality could occur.

The advent of farm-scale techniques to determine foetal number makes it possible to feed supplements differentially to single- and twin-bearing ewes in late pregnancy. Since it is not possible to identify foetal number earlier than a flock average of 70-80 days into pregnancy, either all ewes have to receive supplements in mid-pregnancy or none. It is thus important to determine whether responses to mid-pregnancy supplementation could be obtained if twin-bearing ewes were differentially fed with greater amounts of supplement in late pregnancy. Our understanding of the significance of adequate placental growth in mid-pregnancy or responses in foetal growth to changes in nutrient supply are not sufficiently complete for predicting the consequences of these supplementation strategies on birth weight.

An experiment was conducted in 1984 with the 200-ewe Birnie flock at Glensaugh to examine the interactions between levels of supplementary feeding in mid- and late pregnancy on birth weight when single and twin-bearing ewes were fed differentially in late pregnancy. Because of inclement weather conditions it was not possible to impose the mid-pregnancy supplementation treatments and all ewes were offered 200 g/day of supplement. In late pregnancy two levels of supplementary feeding were imposed on the twin-bearing (8.8 and 13.2 kg DM) and single-bearing (6.6 and 8.8 kg DM) ewes. Birth weights of single or twin lambs were not influenced by level of late pregnancy supplementation, although ewes on the lower level of feeding gained less live weight. These results are described in more detail in HFRO's Annual Report 1984, pp. 41-43. In 1985 a similar experiment was conducted with the same flock of sheep (200 Scottish Blackface ewes) grazing the same land resource (0.2 *Agrostis Festuca* grassland, 0.8 heather at a stocking rate of 1 ewe/ha).

In mid-pregnancy two-thirds of the ewes were given 170 g DM/day of a supplement (Treatment P) whilst the remainder received no supplement

(Treatment O). After foetal numbers had been detected, twin- and single-bearing ewes within treatment P were allocated to two levels of late pregnancy supplementation (L and H) at day 90 of pregnancy according to age, live weight and mating date. The single- and twin-bearing ewes unsupplemented in mid-pregnancy received the same H level of late pregnancy supplementation as those that had been supplemented in mid-pregnancy. For the single-bearing ewes the L and H levels of feeding were 8.0 and 10.4 kg DM respectively and for the twin-bearing ewes 10.4 and 14.2 kg DM respectively. The daily amount of supplement offered increased from 200 g DM to 500-700 g DM as pregnancy advanced. The same supplement was used in both mid- and late pregnancy. It contained 88% barley and 12% soya bean meal.

The birth weights of lambs from ewes receiving the treatments are given in Table 1.

TABLE 1
Birth weights of lambs from ewes receiving supplementation treatments in mid and late pregnancy

Treatment		Birth weight	S.E.	No. of
Mid pregnancy	Late pregnancy	(kg)		ewes
O	Single H	4.26	0.13	26
O	Twin H	3.67	0.20	23
P	Single L	4.37	0.12	34
P	Single H	4.23	0.11	31
P	Twin L	3.45	0.20	19
P	Twin H	3.43	0.25	19

The birth weights of both single and twin lambs were within the range that lamb losses would not be predicted. There was no effect of mid-pregnancy supplementation on lamb birth weight in contrast to the results obtained previously by Lippert (1985). There was also no effect of level of late pregnancy supplementation on birth weight. The effects of the treatments on ewe live weight change are described in Table 2.

TABLE 2
Ewe live weight changes (g/d) in mid and late pregnancy

Treatment		Mid pregnancy	SE	Late Pregnancy	SE
Mid pregnancy	Late pregnancy				
O	Single H	-69	6.2	+71	7.8
O	Twin H	-66	11.2	+108	14.4
P	Single L	-11	9.7	+35	8.2
P	Single H	-10	8.7	+38	8.4
P	Twin L	+ 8	14.8	+26	5.3
P	Twin H	-16	14.9	+74	17.3

Supplementation in late pregnancy significantly (P<0.05) reduced live-weight losses in mid pregnancy by 60 g/day. Supplemented ewes also had a higher body condition score (2.3) than unsupplemented ewes (2.0) at the end of mid-pregnancy. The ewes unsupplemented in mid-pregnancy gained significantly (P<0.05) more live weight in late pregnancy than the ewes that were supplemented in mid-pregnancy in agreement with the results obtained by Lippert (1985). The twin-bearing ewes receiving the H level of feeding in late pregnancy had higher live weight gains (74 g/day) than those on the L level of feeding (26 g/day).

The lack of response in birth weight to mid-pregnancy supplementations in this experiment compared to the increase of 10% observed previously may have been associated with the higher levels of late pregnancy supplementation given in this experiment (10.4 kg DM singles, 14.2 kg DM twins) compared to a flock mean of 8 kg DM in previous experiments. The relatively generous amounts of supplement at both levels of feeding in late pregnancy may have also mitigated against identifying responses in birth weights to late pregnancy supplementation, although with twin-bearing ewes there was evidence that the ewe body condition at lambing may be slightly improved by differential late pregnancy supplementation. These results indicate that, when Scottish Blackface ewes, (which are grazing a predominantly heather hill), are given 10 kg DM or above of a conventional supplement in the last six weeks of pregnancy birth weight is not sensitive to increasing supplement input. The region of the response surface of birth weight in relation to supplementation in mid-pregnancy would appear to be at levels of late pregnancy supplementation less than 10 kg DM/ewe.

Reference

Lippert, M. 1985. Aspects of feeding the hill ewe during pregnancy. PhD Thesis, University of Edinburgh.

Research objective: **The identification of nutrient limitations in late pregnancy and the provision of supplements to remove such limitations for grazing ewes (No. 002044)**

2. Changes in blood metabolite concentrations throughout the day in undisturbed grazing ewes in late pregnancy

R.W. Mayes, C.S. Lamb and P.M. Colgrove

Indoor experiments at HFRO have shown that lamb birth weights can be limited by the supply to the pregnant ewe of absorbable protein and of glucogenic energy from the diet. Low dietary glucogenic energy supplies are associated with raised plasma 3-hydroxybutyrate and non-esterified fatty acids (NEFA) concentrations, and reduced glucose concentrations. However plasma NEFA levels in sheep are extremely sensitive to stress and there is evidence to suggest that 3-hydroxybutyrate levels may be affected by exercise (Chandler et. al., 1983); thus the process of gathering and blood-sampling ewes at pasture may affect these blood metabolite concentrations such that they do not give reliable indices of level of insufficiency in dietary supply of glucogenic energy. A method by which samples of jugular blood can be automatically removed from undisturbed grazing sheep has been developed at HFRO (see p. 39); since the apparatus can take up to twelve samples, with a time interval of 2 hr between samples, the animals can remain undisturbed for long periods of time, which enables studies to be made of the variation with time in blood metabolite concentrations of grazing ewes. In the experiment described here the effect of level of supplementation with a barley-based concentrate on the variation throughout 24-hour periods was investigated in grazing ewes in late pregnancy.

Eleven pregnant Greyface ewes which were carrying twins and had been maintained at pasture (with suplementation) throughout pregnancy were grazed on a predominantly perennial ryegrass sward at Hartwood from 4 weeks before they were due to lamb. The sheep were gathered every morning when they were dosed with a pellet containing 130 mg each of dotriacontane and hexatriacontane (for intake estimation) and given either 260 g DM/day (5 sheep) or 520 g DM/day (6 sheep) of concentrate (ESCA Sheep Nuts). Six days later the sheep were faecal grab-sampled for 5 days. Eight days after beginning the experiment jugular catheters were inserted into the animals and automatic blood sampling was started immediately. The catheters were of coaxial construction, described in the 1983 Annual Report (p.39). The antiocoagulant solution, infused into the cannula at a rate of 2.5 g/h contained 100,000 USP/l of Li heparin and 1 g/l Co-EDTA to enable dilution of blood in the collection process to be estimated. The blood was withdrawn at a rate of 13.5 g/h and collected into 25 ml sample pouches containing 0.7 g of sodium fluoride solution (4 g/l) as a preservative. The fraction collector was set to change every 80 min which allowed animals to be left unattended from 1830 h until 0900 h each following morning. Blood sampling was maintained for a total of 52 h.

Of a total 440 possible samples, 344 were successfully collected (a success rate of 78%). The principal fault was the clogging of catheters with small blood clots. There was also a loss of 16 samples resulting from the failure of a fraction collection on one sheep due to dampness causing a short-circuit of electrical components; the catheter in this sheep remained patent throughout and blood continued to be pumped successfully.

Whilst estimates of plasma metabolite concentrations are not yet available, the observed performance of the blood sampling system shows that automatic blood sampling of grazing animals is feasible on a large scale with a high success rate.

Reference

Chandler, K.D., Hemphill, P. McN, Bird, A. R. and Bell, A.W., 1983. Effect of undernutrition and exercise on interine uptake of D-(3) hydroxybutyrate in the late-pregnant ewe. Proceedings of the Nutrition Society, 42, 41A.

Research objective: To identify the amount and type of supplement to feed to ewes in relation to pasture supply in early lactation (no. 002045)

3. The influence of herbage mass and supplementary feeding on nutrient flow and performance in lactating Greyface ewes

J.A. Milne, A.M. Sibbald, C.S. Lamb and H. Dove* (*CSIRO, Australia)

In HFRO Annual Reports 1982 pp. 51-53 and 1984 pp. 44-47 an experiment was reported in which the effects of herbage mass and energy and protein supplements on ewe and lamb performance in early lactation and on the herbage intake and amounts of dry matter (DM) and non-ammonia nitrogen (NAN) passing the abomasum were described. The following four treatments were imposed on predominantly twin-bearing Greyface ewes lambing in early

May at Hartwood in the first 7 weeks of lactation:-

LO Herbage mass < 1000 kg DM/ha - no supplement
LE Herbage mass < 1000 kg DM/ha - energy supplement
LP Herbage mass < 1000 kg DM/ha - protein supplement
HO Herbage mass > 2000 kg DM/ha - no supplement

The supplement was offered to ewes individually at a level of 600 g/d at 1000 h. Twelve ewes fitted with rumen and abomasal cannulae were used to measure DM and NAN flows at the abomasum. The animals were infused continuously with Ruthenium phenathroline and Chromium EDTA as digesta markers using infusion pumps mounted on the animals. Digesta samples were taken throughout daylight hours and bulked for subsequent analyses. To test that the samples obtained were representative of 24 h flows, the ewes were reintroduced to supplements in week 14 of lactation when the herbage masses of all treatments were slightly higher and measurements made of NAN flow at the abomasum at 4 h intervals throughout a 24 hour period on 2 occasions. Sufficient abomasal digesta was obtained to measure NAN flow at each 4 h interval.

Fig. 1 shows the pattern of DM flows at the abomasum throughout the day for representative animals on each treatment. There was no effect of time

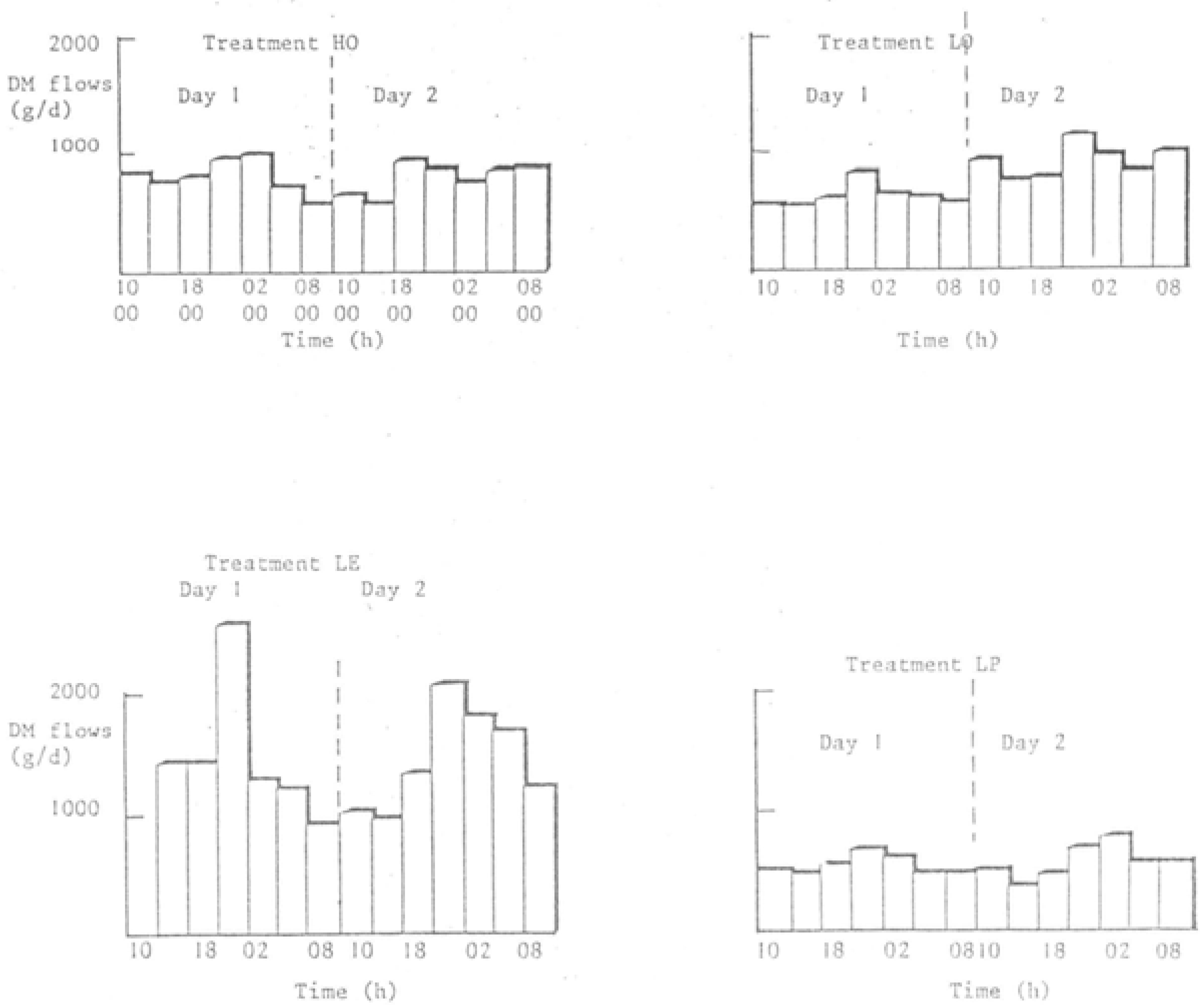


Figure 1. Daily pattern of dry matter flows at abomasum - examples for individual sheep on each treatment

of sampling on DM flows at the abomasum on the unsupplemented treatments. However with the supplemented treatments, particularly with the energy supplement, there was an increased flow rate during the night and in the early morning. To test that the variation was not random a cumulative sum test procedure was adopted which showed that the increased flow rates through the abomasum at night could not be ascribed to a random effect. The reason for the higher flow rates is not clear but it may be associated with a similar diurnal pattern of marker concentration which has been observed in the rumen and which was associated with changes in rumen volume (D. Poppi, personal communication).

When the estimates of DM flow at the abomasum using the data from all samples were compared with estimates made using the data from samples taken during daylight hours, 4 out of the 10 supplemented treatment values were significantly ($P < 0.05$) lower for the daylight hour samples. The results suggest that the data described by Dove et al (1986), which were based on the daylight hour values, underestimated the differences between supplemented and unsupplemented treatments by between 5 and 10%.

Reference

Dove, H., Milne, J.A., Lamb, C.S., McCormack, H.A. and Sibbald, A.M. 1984 The effect of supplementation on non-ammonia nitrogen flows at the abomasum of lactating grazing ewes. Proceedings of the Nutrition Society, 44, 63A.

Research objective. **The identification of factors influencing the supply of nutrients from milk and herbage to the lamb at pasture (no. 002046)**

4. Determination of herbage intake of suckling lambs using long chain n-alkanes as markers

R.W. Mayes, P.M. Colgrove and C.S. Lamb

The major determinants of nutrient supply to the lamb in later lactation are the relative intakes of milk and herbage and the efficiency with which the two feeds are digested. In a previous experiment the digestibility of the fat and protein of a milk replacer fed twice daily declined slightly as herbage intake increased with age of lamb. However, herbage intakes were low and within a small range. A further experiment was conducted to examine the effect of a greater range of intakes of herbage upon the digestibility of ewe's milk. In the same experiment the feasibility of estimating herbage intake when milk is being ingested was assessed using the n-alkane technique and these results are reported here.

From 2 weeks of age seven individually-housed male lambs received 1 kg/day homogenised ewes' milk (166 g/day dry matter (DM)) in 4 feeds from an automatic feeder. The milk was obtained by daily hand-milking of East Friesland ewes and was stored at -20^{o} until used. Freshly cut perennial ryegrass was offered to the lambs at libitum from the age of 4 weeks. A 6-day total collection of faeces was carried out when the lambs were 10 weeks of age. For 5 days before and throughout the collectin period the lambs were dosed with a gelatin capsule containing C_{32} (34 mg) absorbed in shredded paper. Samples of milk, herbage, herbage refusals and faeces were freeze-dried before analysis for n-alkanes. No alkanes were detected in the ewe's milk. Mean daily herbage DM intakes over the faecal collection period ranged from 112 g to 273 g for different lambs.

The mean faecal recoveries of n-alkanes are given in Table 1.

TABLE 1
Mean faecal recovery values of herbage odd-chain n-alkanes and dosed C32 in 7 suckling lambs

		n-alkane					
		C27	C29	C31	C32	C33	C35
Faecal Recovery	Mean	0.450	0.608	0.744	0.817	0.816	0.934
	s.e.	0.0169	0.0270	0.0251	0.0295	0.0268	0.0747

As the mean recovery of C_{33} was almost identical to that of C_{32} this pair of alkanes gave the best estimate of herbage intake from the following equation:

$$\text{Daily Herbage Intake (gDM)} = \frac{C_{32}\ \text{dose (mg)}}{\frac{F_{32}}{F_i} \cdot H_i - H_{32}}$$

where F_{32} and H_{32} represent C_{32} concentration (mg/gDM) in faeces and herbage, respectively and H_i represent respective faecal and herbage concentration of herbage odd-chain alkane, C_i. The mean discrepancy ($\pm$ s.e.) between actual herbage intake and intakes estimated from the use of C_{32} and C_{33} n-alkanes was 0.4 ($\pm$6.66) g/day.

The results of this experiment suggest that good estimates of herbage intake could be obtained for suckling lambs at pasture if herbage C_{33} n-alkanes and dosed C_{32} n-alkanes are used as markers. Further work is necessary to establish whether milk affects the patterns of excretion of alkanes throughout the day.

Research objective: **To establish supplementation strategies for finishing lambs grazing pasture or forage crops in the autumn (no. 002047)**

5. The effect of supplementation on the intake and performance of lambs grazing rape and hybrid turnip leaf crops

F. Burnett and J.A. Milne

Milne and Burnett (1985) concluded on the basis of nutrient supply data that lamb performance on leafy forage Brassica crops was likely to be limited by the supply of energy substrates to the rumen. This hypothesis was tested by supplementing lambs with an energy supplement of barley, and an energy/protein supplement containing barley and soya bean meal. If the substitution rate of the supplements is low, the energy supplement should increase lamb performance and the energy/protein supplement should increase performance to the same extent as the energy supplement, since protein supply should not be limiting.

The organic matter (OM) intakes and carcase gains of Scottish Blackface wether lambs were compared when the leaf component of rape (v Lair) and hybrid turnip (v. Typhon) crops were grazed by lambs receiving either no supplement (treatment 0), 140 g OM/day rolled pelleted barley (treatment B) or 140 g OM of a supplement containing 0.75 barley:0.25 soya bean meal (treatment BS) in a 2 x 3 factorial design. There were 8 lambs per treatment on each crop with an initial live weight of 24.5 ($\pm$ 0.20) kg. The crops were grazed at the same initial leaf allowance (7.0 kg OM/kg live weight) for a period 8 weeks. The lambs were individually offered the supplements and any refusals collected.

Organic matter intakes of herbage were estimated in weeks 3 and 6 from faecal output measurements determined by the Cr_2O_3 dilution method and from the *in vitro* digestibility of extrusa samples obtained from a group of oesophageal-fistulated lambs. Intakes of herbage when supplements were offered were estimated by partitioning faecal output into that of herbage and supplement origin. The OM digestibility of the supplement (0.87) was obtained from an indoor experiment in which similar crops and supplements were offered to lambs. A representative group of 14 lambs at the start of the experiment and 6 lambs/treatment at the end of the experiment were slaughtered to measure energy and protein carcase gains.

Total OM intakes and carcase gains for the treatments are given in Table 1.

Herbage intakes of rape leaf were greater than those observed in previous studies at HFRO and higher than those for hybrid turnip leaf, particularly towards the end of the experiment. The OM digestibility of rape leaf was 0.842 and that of hybrid turnip leaf, 0.854. Whilst there was complete substitution of the rape leaf by both supplements, there was virtually no substitution of the hybrid turnip leaf with either supplement. Although the initial herbage allowance on both crops was similar, there was a higher proportion of leaf which senesced or was damaged by treading on the hybrid turnip crop, thus reducing its actual herbage allowance. This offers an explanation for the lower intakes of the unsupplemented hybrid turnip leaf and lower substitution rates compared to rape leaf.

TABLE 1.
Total OM intakes, liveweight and carcase protein and energy gains

	Rape leaf			Hybrid turnip leaf			SE of mean
Supplement treatment	0	B	BS	0	B	BS	
OM intake (g/kg LW)	31.3	28.3	31.3	25.3	32.8	28.6	2.13
Liveweight gain (g/d)	230	254	245	183	206	191	15.2
Carcase protein gain(g/d)	16.1	15.0	13.5	10.3	16.4	17.0	1.59
Carcase energy gain(MJ/d)	2.22	2.21	2.92	1.38	1.99	2.05	0.147

The high live-weight gains on all treatments reflects the high herbage intakes. As in other experiments, the differences in live-weight gains between treatments on forage brassica crops are not necessarily reflected in differences in carcase gains. The protein and energy carcase gains were significantly ($P < 0.05$) higher for the rape than the hybrid turnip leaf crop. There was no difference between the supplement treatments on the rape crop in carcase protein or energy gains. With the hybrid turnip turnip crop supplementation with either the B or BS supplement significantly ($P < 0.05$) increased protein and energy carcase gains to the same level as those obtained from the rape crop. With neither crop did the BS supplement increase carcase protein nor energy gains above that of the B supplement. Protein and energy gains of the empty body for the treatments followed the same pattern as the carcase gains.

The carcase gains when taken together with the total OM intakes are consistent with the hypothesis that carcase gains are limited by energy substrate rather than non-ammonia nitrogen supply to the tissues. The results also demonstrate the importance of herbage allowance in determining whether supplementation will lead to higher lamb performance through its effect on substitution rate of forage crop by the supplement.

Reference

Milne, J.A. and Burnett, F. 1985. Nitrogen digestion of forage brassica crops by lambs. In Proceedings of Better Brassicas '86 Conference, St. Andrews, September 1984, pp. 67-71. Scottish Crop Research Institute, Dundee.

Research objective: **To measure the amount of absorbed nutrients and their metabolism in the grazing sheep (no. 002050)**

6. The use of long-chain n-alkanes for estimating intake and digestibility of herbage in cattle.

R.W. Mayes, I.A. Wright, C.S. Lamb and A. McBean

Studies with sheep suggest that accurate estimates of herbage intake can be obtained by using the herbage alkane tritriacontane (C_{33}) and dosed doctriacontane (C_{32}) as markers, since the faecal recoveries of both alkanes have been shown to be very similar. To validate the technique for herbage intake estimation in grazing cattle there is a need to compare in cattle, the faecal recoveries of both herbage and dosed n-alkanes. It has been observed in sheep that the faecal recoveries of n-alkanes increase as their chain lengths increase, suggesting that the recovery of hexatriacontane (C_{36}), an alkane absent from herbage but available commercially at low cost, should be complete. C_{36} may therefore have potential as a dosed marker for estimation of faecal output. Thus it may be possible to obtain estimates of both herbage intake and diet digestibility in the same individual grazing animal using n-alkanes as markers. The purpose of the experiment described here was to determine the faecal recoveries in cattle of odd-chain n-alkanes from fresh herbage and of C_{32} and C_{36} dosed n-alkanes.

Five mature beef cows were housed in stalls for 4 weeks and throughout which period were offered fresh perennial ryegrass (4.0 kg dry matter (DM/day) in two feeds. From the fourteenth day the cattle received each day, for 14 days, a pellet containing 604 mg C_{32} and 490 mg C_{36} absorbed into shredded paper. Total collections of faeces were made over the final 7 days of the dosing period.

The faecal recoveries of the predominant herbage odd-chain alkanes and of dosed C_{32} and C_{36} are shown in Table 1.

TABLE 1
Mean faecal recoveries of C_{27}-C_{33} odd-chain n-alkanes and of dosed C_{32} and C_{36} n-alkanes in cattle (n=5)

		n-alkane					
		C27	C29	C31	C32	C33	C36
Faecal recovery	Mean	0.270	0.364	0.594	0.770	0.807	0.931
	s.e.	0.0159	0.0155	0.0155	0.0198	0.0163	0.0233

As with sheep the faecal recovery increased as alkane chain length increased. However, the recoveries were lower than have been found in sheep. Of the herbage n-alkanes, C_{33} had the faecal recovery value which was closest to that of the dosed alkane, C_{32}. Thus the best intake estimate was obtained by using these two alkanes; the mean discrepancy between calculated and actual DM intake was 0.068 kg/day (s.e. 0.0608 kg/day). The mean estimate of DM digestibility obtained by using C36 to determine faecal DM output and C_{32} and C_{33} alkanes to estimate DM intake (0.752, s.e. 0.0091) was slightly less than the DM digestibility estimated from actual intake and faecal excretion (0.775, s.e. 0.0078).

These results suggest that whilst further evaluation of C_{36} as a faecal marker is necessary, C_{32} and C_{33} n-alkanes can be used to obtain good estimates of herbage intake in grazing cattle. Further work is in progress to determine the variability throughout the day in faecal alkane concentrations such that recommended frequencies of dosing and faecal 'grab' sampling can be established.

7. The potential use of n-alkanes to determine the dietary composition of animals given opportunity to select different herbage species.

R.W. Mayes, C.S. Lamb and A.M. Sibbald

In the 1984 Annual Report (p.70) the suggestion was made that the compositon of the diet of a grazing animal could be estimated from the pattern of n-alkanes found in the faeces and a knowledge of the alkane patterns of the component herbage species. Preliminary estimates of dietary composition were made using faecal n-alkane patterns from an experiment in which heather and *Agrostis/Festuca* herbage were fed to wethers in known proportions.

Further studies have been made to establish whether this technique could be used to determine the proportion of white clover in the diet of animals grazing mixed perennial ryegrass/white clover swards. The concentrations of odd-chain n-alkanes were determined in samples of herbage and faeces from an experiment performed at the (then) Grassland Research Institute, Hurley, Berks (Gibb & Treacher, 1983) in which 36 lactating ewes were fed known mixtures of freshly cut white clover and perennial ryegrass; the diets were as follows (proportion white clover/proportion perennial ryegrass): 00/1.0, 0.2/0.8, 0.4/0.6, 0.60/0.4, 0.8/0.2 and 1.0/0.0.

Before estimates of dietary composition could be made it was necessary to adjust the observed faecal alkane concentrations according to their faecal recoveries. Since actual faecal recoveries were not known in this experiment assumed recoveries were used, which were mean values from previous experiments in which faecal recoveries had been determined. The assumed faecal recovery values for the C_{29} - C_{35} odd-chain alkanes, together with the concentrations of the major n-alkanes in white clover and perennial ryegrass, are given in Table 1.

TABLE 1
Concentrations of C_{29} - C_{35} odd-chain n-alkanes in white clover and perennial ryegrass and assumed faecal recoveries

	n-alkane			
	C29	C31	C33	C35
Concentration in white clover (mg/kgDM)	220	238	19	0
Concentration in perennial ryegrass (mg/kgDM)	130	161	122	18
Assumed faecal recovery	0.691	0.803	0.870	0.926

The compositin of the diet was calculated by computer using an iterative minimisation routine (Numerical Algorthims Group, 1981; Program). The function to be minimised was as follows:

$$\sum \left(\text{Calculated faecal alkane proportion} - \text{Actual faecal alkane proportion, corrected for recovery} \right)$$

where for alkane i, calculated faecal alkane proportion

$$= \frac{x.\ A_i + (1 - x)\ B_i}{x.\ A_t + (1 - x)\ B_t}$$

x = chosen proportion of herbage A in diet
A_i = concentration of alkane i in herbage A
B_i = concentration of alkane i in herbage B
A_t = sum of concentrations in herbage A of alkanes used in minimisation procedure
B_t = sum of concentrations in herbage B of alkanes used in minimisation procedure

The results are summarised in Figure 1 in which the calculated proportions in the diet of white clover have been plotted against actual proportions. These results are very encouraging, suggesting that proportions of the

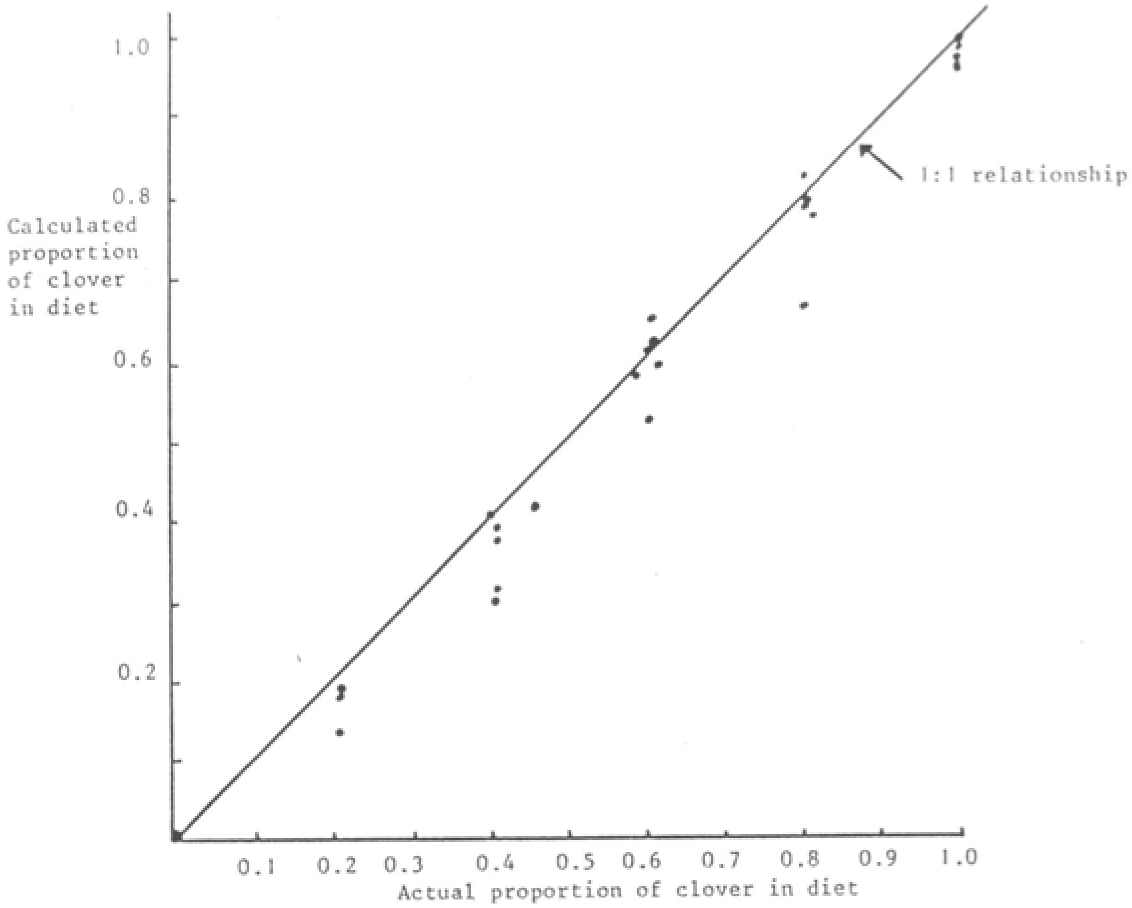


Figure 1. Relationship between proportion of clover in diet of sheep calculated from faecal n-alkane patterns and the actual proportion of clover in the diet.

dietary components can be estimated with acceptable precision from a knowledge of the concentrations of alkanes in the faeces and in herbages. It is not known from this work whether the precision could be improved by dosing with mixtures of even-chain alkanes, as suggested in the 1984 Annual Report (p.71), although the observed estimates appear to be relatively insensitive to alterations in faecal recovery corrections.

Reference

Gibb, M. J. and Treacher, T.T., 1983. The performance of lactating ewes offered diets containing different proportions of fresh prennial ryegrass and white clover. Animal Production; 37, 433-440.

8. Application of the n-alkane technique to predict dietary composition in the grazing sheep - the proportions of perennial ryegrass and heather in the diet as affected by season and herbage mass of a perennial ryegrass sward

J.A. Milne, R.W. Mayes, A.M. Sibbald and D. Elston (AFRUS)

In the HFRO Annual Report 1984 pp. 70-72 it was demonstrated that the different patterns of concentrations of n-alkanes between plant species could be used to determine successfully the relative proportions of Agrostis-Festuca and heather in the diet of sheep. This approach was modified to enable the organic matter (OM) intakes of two plant species, perennial ryegrass (PRG) and heather, by sheep to be estimated from a knowledge of the n-alkane concentration of faecal samples.

The concentrations of C_{29} and C_{33} alkanes in the faeces and in oesophageal extrusa of sheep grazing PRG or heather were determined, since the most marked differences between the two plant species are in those two odd-chain alkanes. The faecal concentrations were adjusted for their different recoveries in faeces, using the values obtained from previous indoor experiments. A minimisation routine (Numerical Algorithm Group) using the faecal output of the different alkanes and their concentrations in the ingested plant species allowed the estimation of the PRG and heather OM intakes. Since faecal outputs had been determined, total OM digestibility values could also be estimated.

The faecal samples were derived from an experiment which was conducted from 22 May to 3 August, where adult wether sheep grazed swards containing 0.25 PRG and 0.75 heather with the herbage mass of the PRG component maintained at 450, 900 or 1500 kg DM/ha. Each of the 3 plots were grazed by a core group of 5 sheep, on which measurements were made, and additional sheep were added as required to maintain the herbage mass.

Although the herbage mass was maintained for each treatment throughout June and July and the in vitro digestibility of the extrusa samples remained close to 0.80 throughout this period, the OM intakes of PRG declined during June and continued at a low level in July (see Fig. 1). There was an increase in heather intake throughout June and July (see Fig. 2). Apart from a period at the beginning of June when PRG intakes were positively related to herbage mass of PRG there was no relationship between PRG intake and herbage mass during the rest of June. Sheep on 450 kg DM/ha PRG sward treatment had lower intakes of PRG than those on PRG swards with greater herbage masses in July. Heather intakes were not related to the herbage mass on the PRG swards. The total OM digestibility on all treatments declined from 0.80 at the beginning of June to 0.68-0.70 by the end of June reflecting the increase in the proportion of heather from 0.10 to 0.50 over the same period. Throughout July the total OM digestibility and the proportion of heather in the diet were 0.70 and 0.50 respectively for all treatments.

The lack of positive relationships between PRG intake, proportion of PRG in the diet and herbage mass of the PRG component of the sward can be explained in terms of a reduction in the amount of green leaf in the PRG sward during June which, although it did not influence in vitro digestibility of the PRG diet selected, may have reduced PRG intakes. The reduction in green leaf mass in the sward was related to a decline in herbage growth rate which was associated with a prolonged period without rain. When PRG green leaf was in short supply the intake of heather increased considerably.

The results obtained from this experiment provide a good example of how the n-alkane technique can be used to address important issues in studies of grazing ecology.

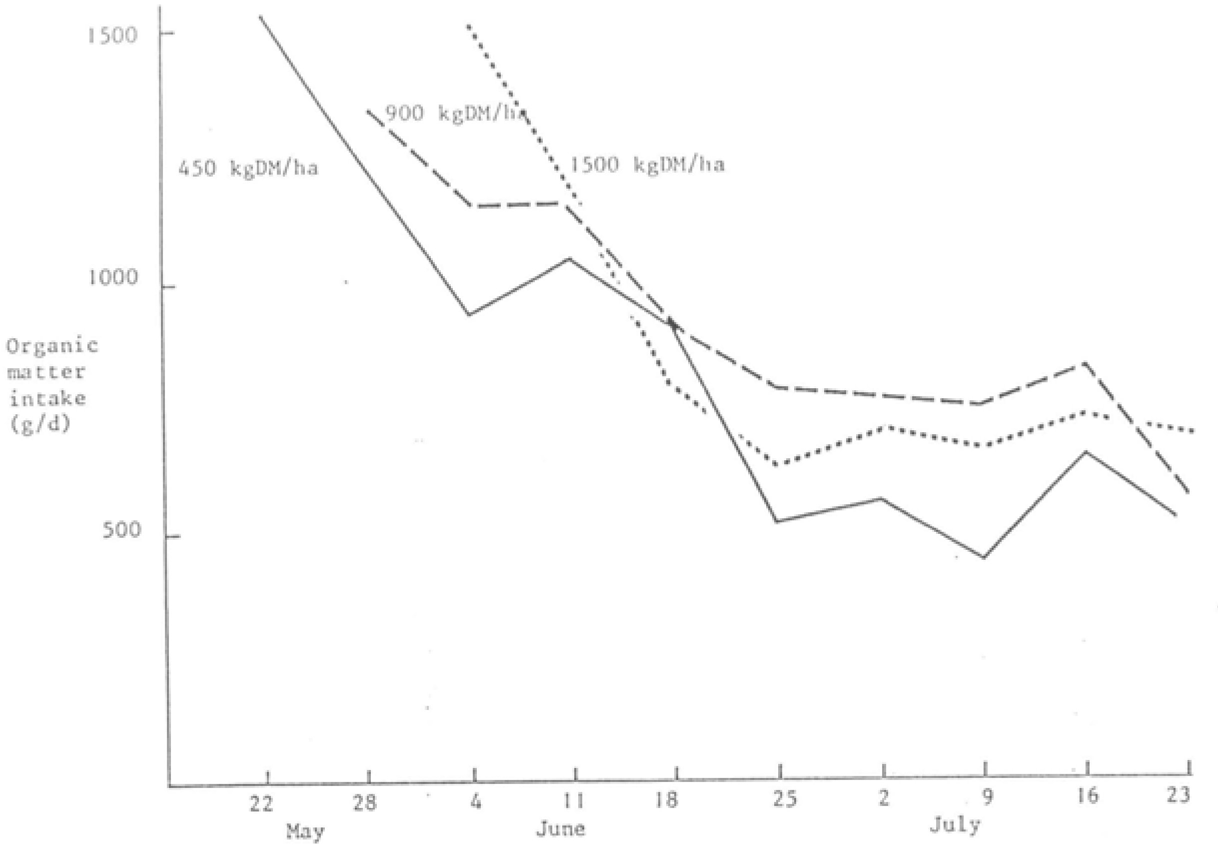


Figure 1. Organic matter intake of perennial ryegrass by sheep grazing grass/heather swards varying in herbage mass of the perennial ryegrass component.

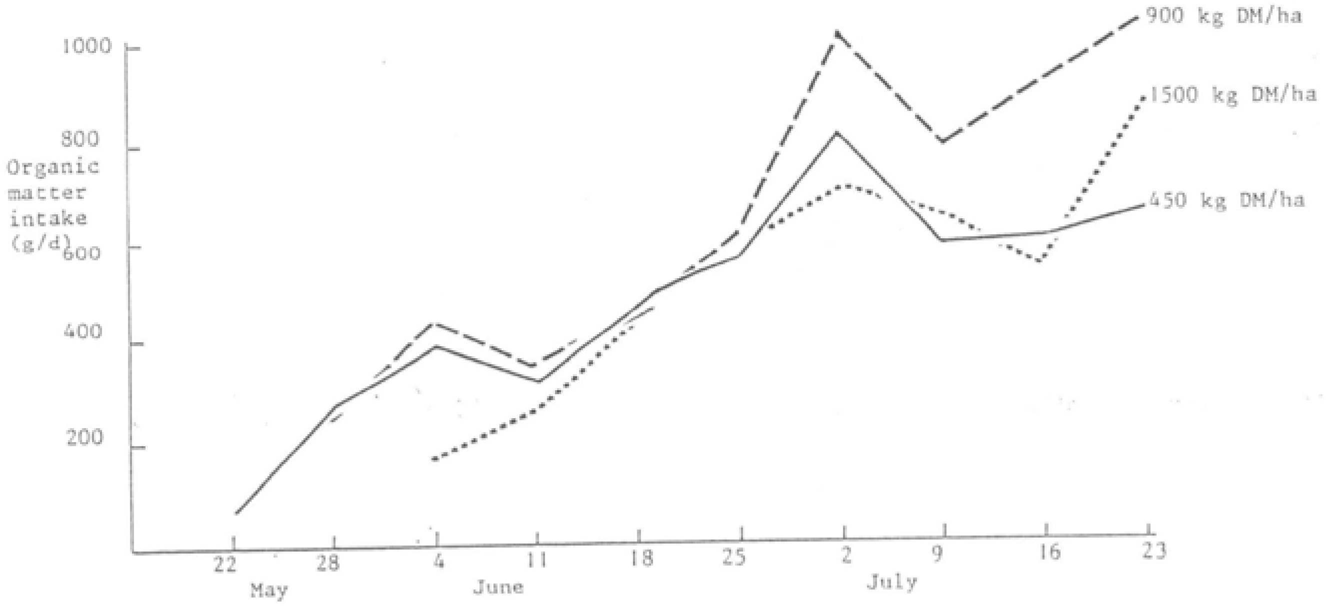


Figure 2. Organic matter intake of heather by sheep grazing grass/heather swards varying in herbage mass of the perennial ryegrass component.

9. <u>The development of infusion and sampling systems for digesta and blood in the grazing animal - a system for automatic blood and rumen sampling</u>

R.W. Mayes and C.S. Lamb

A portable fraction-collector based upon a motorised 6-way rotary valve, developed for taking blood samples in grazing sheep, was described in the 1984 Annual Report (p.62). The design has been further improved. Both infusion pump and fraction collector have been incorporated into a single box which halves both the size and weight of the equipment. The rotary valve has been replaced by a 12-way version. Modifications have also been made to the electronic circuitry. The means by which retriggering of the timer is prevented as the switch pole passes over the switch contact, has been altered. The position of the rotary valve is indicated by an array of light-emitting diodes, switched on by means of a reed switch activated externally by a magnet. The equipment has been successfully used in an experiment with grazing pregnant ewes (p. 27).

<u>Research objective:</u> **To establish the requirement by ewes for supplements around the mating period (no. 002051)**

10. <u>The effect of supplementation on the herbage intake by Greyface ewes grazing perennial ryegrass swards in the late autumn</u>

J.A. Milne and A.M. Sibbald

In most circumstances sward height declines after the pre- and post-mating periods in the autumn. Relationships between herbage intake and sward height in the autumn have not been described nor has the effect of supplements on herbage intake at this time of year been examined. The advent of n-alkane technique makes it possible to measure herbage intakes when supplements are fed and thus it may be possible to explain some of the previously observed variation in responses in reproductive performance to supplementary feeding at pasture in the autumn in terms of sward height and the substitution rate of herbage by the supplement.

The herbage intakes of 3 groups of Greyface ewes, given either no supplement (Treatment O), 500 g OM/day pelleted rolled barley (Treatment BS) or 500 g OM/day of pelletted supplement containing 0.86 rolled barley: 0.14 white fish meal (Treatment BPS), were compared at 3 sward heights (5.0, 4.0 and 3.0 cm). The supplements were chosen to be the same as those used in the experiments described in the HFRO Annual Report, 1983 pp. 44-47, and in the HFRO Annual Report, 1984 pp. 72-73. The 5.0 cm sward was grazed in mid-October 1984 prior to mating by 18 ewes (mean live weight 71.2 kg) with 6 ewes per treatment. The 4.0 and 3.0 cm swards were grazed after mating in November and mid-November respectively by a further 18 ewes (mean live weight 70.1 kg).

The 4-year old sward grazed was dense and composed primarily of perennial ryegrass. Supplements were offered daily to the ewes individually and refusals recorded. Organic matter intakes of herbage were estimated from the concentrations in herbage, supplement and faeces of C_{31}- and C_{33}-alkane and of dosed C_{32}-alkane. Samples of herbage were obtained from oseophageal-fistulated ewes.

The herbage intakes of the ewes grazing the 3 sward heights and given the 3 supplement treatments are shown in Table 1. As sward height declined from 5 to 3 cm from mid-October to mid-November herbage intake declined by a half from 1333 to 660 g OM/day, stressing the importance of sward height to nutrient supply in the autumn.

TABLE 1
Effect of supplement treatments on herbage intake (g OM/day) at 3 sward heights over the mating period (means of 6 observations)

Date	Sward height (cm)	Treatment 0	Treatment BS	Treatment BPS	S.E. diff between means
Mid-October	5.0	1333	1107	1036	130.6
Early-November	4.0	1056	729	724	83.6
Mid-November	3.0	660	537	421	83.6

Herbage intake by ewes was similar for the two supplemented treatments but herbage intakes by supplemented ewes were significantly ($P<0.05$) lower than those by unsupplemented ewes. However, supplementation increased total OM intake by 0.16, 0.06 and 0.33 in mid-October, early November and mid-November respectively.

Substitution rates of herbage by supplement for the mid-October, early-November and mid-November periods were 0.56, 0.51 and 0.30 g OM herbage/g OM supplement. Substitution rate thus declined with declining sward height. In the latter 2 periods there were significant refusals from 40% of the ewes. These ewes had lower herbage and total OM intakes and higher proportions of herbage in their diet than those that ate all their supplement, implying that appetite potential is also an important determinant of substitution rate. The ewes that refused supplements had higher substitution rates of herbage by supplement, resulting in overall mean substitution rates of 0.84 and 0.48 g OM herbage/g OM supplement in early- and mid-November respectively.

These preliminary results indicate that with cereal-based supplements over the range of sward heights studied, which are confounded with time, substitution rates are relatively high. The intake of herbage when other supplements are fed is currently being studied more thoroughly in relation to sward height, fatness of ewe and period in the autumn.

Research objective: **The uptake and fate of radionuclides from the environment by ruminants (no. 002068)**

11. Uptake by ewes and lambs of radionuclides from ingested saltmarsh vegetation harvested from the Esk Estuary, Cumbria

B.J. Howard* (*Institute of Terrestrial Ecology), R.W. Mayes and C.S. Lamb

From field studies carried out by the Institute of Terrestrial Ecology (ITE) it was found that 5-month old lambs grazing an estuarine saltmarsh on the Esk Estuary, close to the Sellafield reprocessing plant, had higher ^{137}Cs levels and similar concentrations of transuranic elements in their tissues compared with ewes grazing the saltmarsh for much longer periods. In order to understand the reasons for these observed differences between ewes and lambs in radionuclide uptake, a series of collaborative experiments between ITE and HFRO have been initiated.

In the first experiment the apparent absorption, urinary excretion and tissue uptake of radionuclides in saltmarsh vegetation, harvested from Newbiggin, Cumbria, were determined in ewes and wether lambs. The saltmarsh vegetation which consisted mainly of *Halimione portulacoides*, *Pucinnellin maritima* and *Armeria maritima*, was harvested with a small forage harvester and was mixed with dry ice for transportation before storage at -20^{o}C. Eight Scottish Blackface ewes and 5-6 month old lambs were obtained from an uncontaminated source (House O'Muir farm). Three ewes and three lambs were slaughtered initially to provide tissue samples for determining background levels. The remaining animals were housed in metabolism cages and were fed the saltmarsh vegetation at slightly below *ad libitim* intake levels (ewes 920 g DM/day; lambs 562 g DM/day) for 8 weeks. The rations were given as two feeds at 0900h and 1630h each day; refusals were removed each morning. After 3½ weeks and over the final week of the experiment 7-day total faecal and urine collections were carried out; to avoid faecal contamination of the urine bladder catheters were used in the ewes and urine collection funnels were strapped onto the lambs. At the end of the experiment the animals were slaughtered and the following tissues were removed for radiochemical analysis: liver, lungs, kidney, spleen, pancreas, mammary gland (ewes), thyroid and hind limb (for muscle and bone tissues); blood (500 ml) was also collected. Herbage, faeces, urine and tissue samples were analysed for -emitting radionuclides on Ge(Li) detectors; feed and faeces were freeze-dried and tissue samples were ashed before counting.

Although analysis is incomplete some results concerning ^{137}Cs apparent absorption and urinary excretion (from the second collection period) are summarised in Table 1.

TABLE 1
Intake and excretion of ^{137}Cs in ewes and lambs given contaminated saltmarsh vegetation for 8 weeks (Mean ± SE; n = 5)

	Ewes	Lambs
^{137}Cs Intake over 7 days (Bq)	8700 ± 33.8	5098 ± 80.0
Faecal ^{137}Cs output over 7 days (Bq)	8199 ± 141.1	5000 ± 81.6
Urinary ^{137}Cs output over 7 days (Bq)	450 ± 17.2	228 ± 16.5

Tissue concentrations of ^{137}Cs have not yet been determined in all animals. Some preliminary results are summarised in Table 2.

TABLE 2
Concentrations of ^{137}Cs in tissues of a control lamb and ewe and those from contaminated saltmarsh vegetatin for 8 weeks

	^{137}Cs concentration (Bq/Kg DM)				
	Muscle	Liver	Lung	Kidney	Bone
Control lamb	0.2	0.8	5.8	14.4	<0.6
Control ewe	0.1	<0.1	<0.2	2.5	<0.5
Experimental lamb	64.0	56.2	49.2	148.0	11.8
Experimental ewe	39.6	45.9	40.0	121.7	1.7

12. Secretion of 137Cs and 239/240Pu in the milk of ewes grazing on estuarine saltmarsh near Sellafield reprocessing plant, Cumbria

B.J. Howard* (*Institute of Terrestrial Ecology) and C.S. Lamb

The observation that lambs had higher ^{137}Cs levels and similar levels of transuranic elements in their tissues compared with the tissues of ewes grazing the same estuarine saltmarsh in Cumbria suggests the possibility that lambs may receive radionuclides from milk in forms which may be more readily absorbed than the radionuclides of saltmarsh vegetation. One basis for this suggestion lies in the fact that most radionuclides in the saltmarsh vegetation are closely associated with silt particles. Before carrying out indoor trials to compare uptakes by lambs of radionuclides from milk and from saltmarsh vegetation a preliminary study was made with lactating ewes from a commercial flock grazing the saltmarsh near Drigg, Cumbria. The outputs of -emitting radionuclides and transuranic elements in the milk of ewes were determined every two weeks from late May to mid-August 1985, covering about week 2 to week 14 of lactation. Thus the approximate intakes of these radionuclides by lambs via milk could be estimated.

These preliminary results show that after 8 weeks of receiving contaminated saltmarsh vegetation in both ewes and lambs, the total excretion of ^{137}Cs in faeces and urine closely matched the intake. It is possible that the slight weight losses of both ewes (4.1 kg) and lambs (4.0 kg) may have accounted for the slight negative ^{137}Cs retention figures. Whilst it is not, at present, known to what degree the faecal ^{137}Cs is derived from secretion into the gut after previous absorption the small proportion of ingested ^{137}Cs which is excreted via the urine suggests that the degree of absorption is very low.

The preliminary tissue data concerning ^{137}Cs concentrations is in agreement with results of previous field studies. However, since the lambs ingested more ^{137}Cs per unit of body size than did the ewes it is still not clear whether the efficiency of ^{137}Cs deposition is greater in the lambs. It is intended that future work will establish true absorption of saltmarsh radionuclides, their biological half lives in ewes and lambs, and their relative availabilities to suckling lambs from milk and from saltmarsh vegetation.

PROGRAMME UNIT 4: FACTORS AFFECTING BEEF COW AND CALF PERFORMANCE IN HILL AND UPLAND ENVIRONMENTS

Research objective: To study factors determining nutrient partitioning between body tissue and production in beef cows (no. 001030)

1. Nutrient partitioning in lactating beef cows

A.J.F. Russel, I.A. Wright, T.K. Whyte and E.A. Hunter* (*AFRUS)

Most systems of beef production from suckler cows use of the cow's ability to catabolise body reserves to maintain relatively high levels of production during periods of dependence on conserved or purchased feeding, and to replenish these reserves in times of more plentiful and less expensive food supply. Results from earlier experiments have provided valuable information on the magnitude of the effects on production of a range of nutritional inputs in late pregnancy and during lactation. Other work here has yielded useful information on the effects of both production and rate of replenishment of body reserves of improved levels of nutrition following periods of prolonged undernourishment. In this general area of use and replenishment of body reserves and of the effects of cyclical changes in nutrition on production, the partitioning of nutrients between body tissue and production is clearly of central importance. We do not, however, have any clear understanding of the factors which influence nutrient partitioning and of how these may be manipulated to improve the efficiency of production from suckler cows.

It was against this background that an experiment was initiated in late 1983 at Hartwood to study nutrient partitioning in lactating beef cows. It was designed with the primary objective of examining the effects of nutrient intake, body composition and genotype on the partitioning of nutrients by single-suckling beef cows during the first six months of lactation. Because body composition is of central importance in any study of nutrient partitioning and is the factor most difficult to quantify in the lactating cow, the experimental design included an ancillary study with the second objective of extending the use of indices of *in vitro* body composition to lactating beef cows. The number of animals required to meet both objectives was greater than could be accommodated within the available resource in any one year and it was accordingly decided to conduct the experiment over a two-year period.

In the first year (1983/84) the factorial design was based on two genotypes (Blue Grey (BG) and Hereford x Friesian (HF)), three levels of body composition (characterised in terms of condition scores 2.0, 2.5 and 3.0 at calving) and three levels of nutrient intake during the first six months of lactation (calculated to meet the requirements for maintenance plus 4, 9 or 14 kg milk/day) with three animals per cell (total 54). The same design, but with two individuals per cell (total 36), was adopted in the second year (1984/85). In addition the design incorporated the slaughter of 24 cows in each year, six soon after calving, nine in mid-lactation and nine at 26 weeks after calving, in connection with the *in vivo* estimation of body composition. The final nine cows in each year came from within the main experiment; the remaining 15 were in addition to the main experiment.

The measurements made in the experiment included cow live weight and condition score, calf live weight and cow milk production. In addition all cows were blood sampled at regular intervals to provide additional information on nutritional adequacy and on the utilisation and replenishment of body tissue. The in vivo indices of body composition, which will be used to estimate changes in body tissue, included in addition to live weight and condition score, deuterium oxide space, ultrasonically measured back fat depth and linear measurements of size. In addition, the measurement of the speed of transmission of ultrasound through body tissue was examined as a further index of body composition in collaboration with the Food Research Institute (Bristol).

Only unanalysed mean values for the main measurements are available at this stage. Preliminary examination of these crude data (Table 1) shows

TABLE 1
Preliminary estimates of effects of nutritional treatments and body condition at calving on performance over first six months of lactation, as measured in the second year of the experiment. (First year observations are given in parenthesis).

Cow genotype	Blue Grey			Hereford x Frisian		
Treatment Group	Low	Medium	High	Low	Medium	High
	Effects of Nutritional Treatments					
Cow live-weight change (kg)	-70 (-64)	7 (-5)	34 (48)	-96 (-87)	-50 (-58)	4 (-4)
Cow condition score change	-0.28 (-0.09)	(0.27)	0.64 (0.82)	-0.23 (-0.25)	-0.14 (0.05)	0.23 (0.34)
Mean milk production (kg/day)	7.5 (5.6)	7.4 (6.5)	9.1 (7.7)	8.0 (6.6)	9.6 (8.8)	9.9 (10.3)
Calf live-weight gain (kg)	147 (105)	153 (134)	184 (159)	158 (115)	187 (161)	206 (186)
	Effects of Target Condition Score at Calving					
Cow live-weight change (kg)	-8 (0)	-6 (-8)	-4 (-9)	-32 (-34)	-49 (-43)	-62 (-76)
Cow condition score change	0.39 (0.35)	0.32 (0.36)	0.17 (0.36)	-0.07 (0.22)	-0.01 (0)	-0.06 (-0.09)
Mean milk production (kg/day)	8.2 (7.2)	7.9 (7.2)	7.9 (6.2)	8.8 (8.3)	9.8 (8.5)	8.9 (9.0)
Calf live-weight gain (kg)	156 (132)	170 (139)	162 (125)	181 (150)	193 (151)	178 (157)

evidence of a genotype effect on nutrient partitioning. Over the course of the first six months of lactation the average live-weight changes of BG cows on all treatments were substantially less than those observed in the HFs. This was mirrored by changes in condition score, and was inversely related to average levels of milk production. Differences in milk production were reflected in calf performance data.

In both genotypes the nutritional treatments imposed during lactation appear to have larger effects on cow live weight, condition score and milk production and on calf performance than did body composition at calving. Within these general effects nutritional treatment had greater effects on cow live weight and condition score in the BGs than in the HFs, whereas the body composition effects on these parameters were greater in the HFs than in the BGs. As regards milk production and calf performance the effects of the nutritional treatments appear to be greater in the HFs than in the BGs, but this ranking was reversed with respect to the effect of initial body composition.

Research objective: **Study the influence of herbage characteristics as those affect intake and performance of beef cattle (no. 001032)**

2. The effect of sward height on beef cow and calf performance

I.A. Wright, A.J.F. Russel, T.K. Whyte and A. McBean

To date a number of experiments with beef cows and calves have shown that under continuous stocking management the height of the sward grazed by cows and calves has a large influence on animal performance. However within any one experiment only two sward heights have ever been compared. In this experiment a range of sward heights was used so that the general shape of the animal response curves to sward height could be established.

Four Hereford x Friesian and Five Blue-Grey cows with their spring-born Charolais cross calves were allocated to one of five sward surface heights, to be maintained nominally at 4, 6, 8, 10 or 12 cm. Sward heights were maintained by the addition and removal of non-experimental cows and calves.

The experiment started on 22 May and it was intended to continue until the end of September. Because of the excessive rainfall in 1985, and the resultant poor herbage growth rates and very wet soil conditions, the number of cows had to be reduced below nine on some treatments and the shortest two sward height treatments had to be abandoned in mid-August.

The mean sward heights, along with cow and calf performance, are given in Tables 1 and 2. Cow and calf performance were more closely related to sward height than herbage mass. Sward height had a significant effect on cow and calf live-weight gain at all times. Maximum cow live-weight gain occurred at a sward height of 9 cm, with a decline at the higher sward height. The response of calf live-weight gain to sward height was much greater in August-September than earlier in the season, indicating the calves' decreasing dependence on milk and greater dependence on herbage.

TABLE 1
Sward height, herbage mass and cow and calf performance (mid-May to mid-August)

	Sward height (cm)					s.e.
	4.4	6.0	7.0	9.1	11.0	
Herbage mass (kg DM/ha)	1280	1800	1890	2480	2730	
Number of cows	9	6	6	5	9	
Cow live-weight gain (kg/d)	-0.52	-0.05	0.32	0.75	0.40	0.118
Calf live-weight gain (kg/d)	0.88	0.91	0.98	1.04	1.06	0.048

TABLE 2
Sward height, herbage mass and cow and calf performance (mid-August to end of September)

	Sward height (cm)			s.e.
	5.4	7.8	9.2	
Herbage mass (kg DM/ha)	1204	1430	2130	
Number of cows	6	5	9	
Cow live-weight gain (kg/d)	-0.31	0.57	0.59	0.108
Calf live-weight gain (kg/d)	0.98	1.22	1.35	0.047

In addition to individual animal performance, output per hectare must also be considered. The cow and calf gain per hectare is given in Table 3 for

TABLE 3
Output per hectare (mid-May to mid-August)

	Sward height (cm)		
	4.4	7.0	11.0
Calf gain (kg/ha)	353	252	273
Cow gain (kg/ha)	-208	82	103

three of the treatments. Total calf output was greatest on the 4.4 cm sward and was similar on the 7.0 and 11.0 cm swards. Total cow weight gain per hectare increased with increasing sward height.

Although output per hectare, as measured by calf gain, may be increased by maintaining swards of low heights cow performance is unacceptably low. A sward height of about 8 cm would appear to allow high individual cow and calf performance while at the same time maintaining a reasonable output per hectare.

Research objective: **Study the relationships between pre- and post-weaning nutrition on performance of weaned suckled calves (no. 001036)**

3. The effect of vegetation type on compensatory growth in weaned suckled calves

I.A. Wright, A.J.F. Russel, A.J. Senior and A. McBean

A considerable body of information has now been accumulated within the Organisation on the relationships between nutrition of weaned suckled calves during their first winter after weaning and their subsequent performance. These experiments have all been carried out with the cattle grazing sown ryegrass pastures in summer.

There is considerable interest in the retention of weaned calves on the farm of birth as a means of increasing the output and profitability of suckler herds in hill and upland conditions. It was therefore decided to examine the relationship between winter feed level and summer performance with cattle grazing a number of different vegetation types.

Fifty-four Charolais-cross spring born weaned suckler calves were fed during their first post-weaning winter to grow at three different rates, and then allocated during summer to graze one of three vegetation types. They grazed either a sown ryegrass pasture maintained at 6-8 cm sward surface height, a hill reseed dominated by perennial ryegrass and *Agrostis* spp. maintained at the same height or part of an unimproved hill. Approximately 1/3 of the hill area was *Agrostis/Festuca* spp., 1/3 *Calluna/Festuca* mosaic and 1/3 was dominated by *Festuca* spp., *Juncus effusus* and bracken.

Live-weight gains are given in Table 1. Herbage intake data is not yet available, but compensatory growth was evident on all three vegetation types, although live-weight gain was lower on the unimproved hill. It would seem therefore that there may be scope for reducing winter feed inputs to weaned suckled calves irrespective of the type of vegetation they are to graze during the following summer, although only moderate levels of performance can be expected on unimproved hill vegetation.

TABLE 1
Live-weight gains

	Winter feed level		
	Low	Medium	High
Winter live-weight gain (kg/d)	0.498	0.745	0.951
Summer live-weight gain (kg/d)			
Sown perennial ryegrass	1.06	0.86	0.70
Hill reseed	1.15	0.95	0.71
Unimproved hill	0.77	0.54	0.50

Research objective: **Evaluate uses of real-time ultrasonic scanning in diagnosis of pregnancy, estimation of foetal age and identification of foetal mortality (no. 001037)**

4. Foetal death in beef cows

I.A. Wright, I.R. White, A.J.F. Russel and A. McBean

During the course of scanning the HFRO cows over the past few years there have been a number of cases where pregnancy has been diagnosed, but the cows did not calves, indicating that foetal death had occurred. To ascertain how widespread the problem is, and to establish at which stage the foetuses are being lost it was decided to scan, on a regular basis, a number of commercial suckler herds. At present three herds are being studied. Scanning is being carried out every two weeks during the mating period and will continue until the cows are 80-90 days pregnant, or until 6 weeks after mating ends.

Since scanning can only detect pregnancy in cattle from day 30 onwards no indication will be given as to the incidence of embryo mortality before that stage. However of the 212 cows in the study, to date 17 cases of foetal death have occurred, with another 3 suspected cases. Most of foetal death is occurring between days 30 and 45. See also p. for further reports on the application of ultrasonic scanning in cattle production.

RED DEER

PROGRAMME UNIT 5: THE HUSBANDRY OF RED DEER

Research objective: Measure the lifetime performance in red deer (no. 001039)

1. Red deer lifetime performance

W.J. Hamilton

Studies of the lifetime performance of red deer hinds involve three cohorts born in 1970, 1971 and 1972. During 1985 two of the age groups performed less well than previous years. The percentage of calves born dropped to 86.9 and the numbers weaned to 70.5. Hind live weights remain good and two hinds died over the year. The overall performance of the cohorts to date is shown in Table 1.

From the current levels of performance and the physical condition of the hinds at present, it would seem reasonable to expect a commercial life of 15 years with 14 calf crops.

TABLE 1
Overall performance of red deer hinds 1970-1985

Year of birth	1970	1971	1972
Level of nutrition (4 to 10 months in kg conc/hd/day)	1.0	0.91	0.68
No. of hinds at start	4	43	23
No. of possible calf crops	14	13	12
No. of hinds died (1970-1985)	2	5	4
No. of possible pregnancies	49	545	261
No. of hinds barren	1	32	18
No. of calves born (1970-1985)	48	513	243
Percent of possible pregnancies	98.0	94.0	93.0
No. of calves died (birth to wean)	4	62	25
Percent of calves born	8.3	12.1	10.3
No. of calves weaned	44	451	218
Percent of hinds to stag	89.8	82.8	83.5

Research objective: The utilisation of upland pastoral resources in whole systems of deer meat production (no. 001040)

2. The effect of early rutting stags on the time of conception of barren and lactating red deer hinds

W.J. Hamilton, S. Busby and T.J. Maxwell

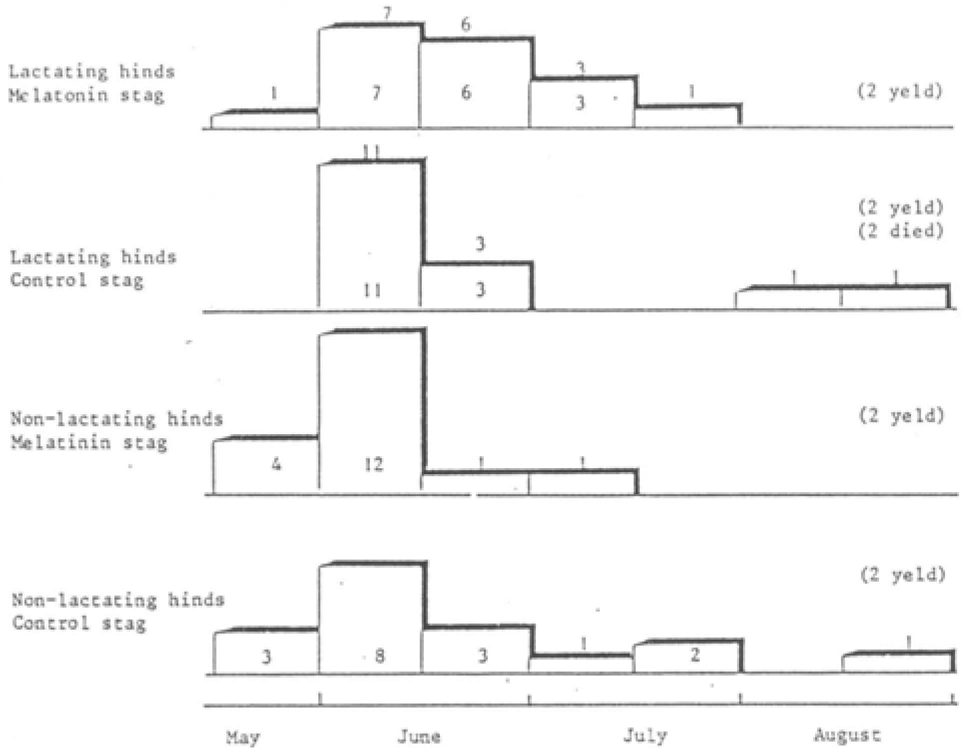
Should it be possible for red deer hinds to produce calves earlier than June, a longer period of calf growth prior to winter inappetance would be achieved and thus provide the potential for reaching an acceptable slaughter weight for the Christmas venison market.

Melatonin is known to have effects on the onset of oestrus in hinds but the effect of giving 10 mg melatonin daily in the feed of red deer stags from early July to late August was not known. Stags having received such treatment were exposed to two well separated groups of 20 hinds. One group was of nursing hinds while the other was a group of barren hinds. Two similar well separated groups of 20 hinds each received an untreated stag. Table 1 records the onset of the roaring and rutting behaviour of the stags and Fig. 1 shows the distribution of the calving dates of the hind groups. The indications are that the melatonin-treated stags showed early roaring behaviour but, early, full rutting behaviour was only evident in the group of stags with barren hinds; the calving data confirms that there was a rather earlier and greater concentration of calving in this group.

TABLE 1
The roaring and rutting behaviour of stags

Behaviour	Melatonin treated stags		Control stags	
	lactating hinds	barren hinds	lactating hinds	barren hinds
Roaring only	1st Sept	1st Sept	18th Sept	11th Sept
Full rutting behaviour	17th Sept	1st Sept	6th Oct	26 Sept

It can be concluded from the limited data that treating stags seems to reduce the number of very late births without having an effect on the timing of the majority of births. Non-lactating hinds at the time of the rut calved about one week earlier than lactating hinds.



3. <u>The economics of store calf production systems (with research objective 001059)</u>

W.J. Hamilton and T.J. Maxwell

Studies of hind longevity and animal performance from component and systems experiments have provided data which allows an assessment of the relative economic performance of systems of deer production for hill and upland land resources. Basic assumptions in these assessments are that hinds have a productive life of 15 years, stags 8 years and the main differences in individual animal performance between hill and upland systems are likely to be in reproduction and calf growth rate. Calving rates of 85 and 90 percent and weaning weights of stags of 38 and 42 kg and hinds of 36 and 39 kg are assumed for hill and upland farms respectively.

The economic assessments outlined below are based on one man units of 750 hinds, 45 stags and 68 replacement calves. Details of the type of land and the area required to accommodate the herd is given in Table 1. Stocking rate on the sown pastures are based on the assumption that just over 20% of the sown pasture area is conserved as hay or silage for winter fodder. The farm perimeter is assumed to be fenced with heavy quality deer net 1.8 m high (£3.00 per m erected) while internal fences are high tensile mains electric 1.5 m high (£1.50 per m erected). A set of handling pens to hold 250 hinds and their calves at any one time has been included in the capital expenditure (£6,000).

TABLE 1
Land resources and stocking rates

Land	Pasture Type	Stocking Rate (Hinds/ha)	Fertiliser	Total Area (ha)
Hill	a) Heather dominant	0.66	-	1.130
	b) Acid Grasslands	1.5	-	500
Upland	a) Sown Pasture	10.0	150 kg N/ha	75
	- Heather dominant wintering only	1.5		500
	b) Sown Pasture only (winter housed or wintered on sacrifice area)	10.0	150 kg N/ha	83

Product prices are based on recent auction market prices for store stag calves, hind calves for breeding and cull stock. As a consequence of a special dispensation to humanely slaughter farmed deer, abattoir killed venison is being sold in supermarkets which has provided a firmer basis for the market price of store calves destined for slaughter at 16 or 27 months of age; prices for breeding stock have increased markedly over the last three years and reflect the steady development of the industry. Current prices are £2.00/kg live weight for weaned stag calves, £4.00/kg live weight for weaned hind calves and £2.20 kg dressed carcass weight for culled hinds and stags.

The capital outlay, annual servicing changes (pay back and 15% interest charges) and gross margin for each of the examples is given in Table 2. On sown upland pastures, the advantage of having a hill outrun to winter the stock, which reduces winter feed costs per hind by at least 50 percent, is clearly demonstrated. More detailed information and costs are given in Hamilton (1986).

Reference

Hamilton, W.J. 1986. Farming red deer : the management and economics of store calf production in landowning in Scotland. Landowning in Scotland. In press.

TABLE 2
Economic performance and capital costs of hill and upland store calf producing systems

	Capital Expenditure Per Breeding Hind (£)	Annual Servicing Charge per Breeding Hind (£)	Gross Margin Per Hind (£)	Per Enclosed Hectare (£)	Per Farm (£)
Hill					
(a) Heather	85	15	50	34	37770
(b) Acid Grassland	58	10	53	78	39082
Upland					
(a) Enclosed Grass + Hill	74	13	72	94(723)+	54277
(b) Enclosed Grass only	41	7	55	500	41490

+ Gross margin per enclosed sown grassland hectare

Research objective: **Study the effects of nutrition of hind and stag calves in their first winter in relation to their subsequent performance at pasture (no. 001041)**

4. The effect of castration and Compudose 365 on the growth of young red deer stags

W.J. Hamilton, T.J. Maxwell and M.J. Robson* (*Local vet.)

Little information exists about the effect of castration on the growth of young red deer stags. Castration if performed before any antler growth occurs will prevent the growth and development of antlers, and thus make the handling and marketing of stags very much easier. Hard antlers can be removed from stags before being transported to an abattoir for slaughter but this entails extra management handling at a time when the animals are big and strong. The removal of antlers in velvet for this purpose is illegal. In order to meet the welfare needs of the animals while being transported and presented at abattoirs for slaughter, it is essential to wait until the entire stags are in hard antler before marketing. The marketing of the animals may not be at the optimum time in terms of carcass tissue composition and market requirements.

After weaning and during the autumn/winter of 1984/85 and spring/summer of 1985 an experiment was carried out to ascertain the effect of castration, implantation of Compudose 365 and the surgical amputation of the antler buds.

Four similar groups of 20 stag calves, randomised on age and weight were allocated to one of four treatments. One group was left entire, one was castrated, one was left entire but had their antlers surgically amputated when growth had reached 3-5 cm and the final group was castrated and given a Compudose 365 ear implant. The calves were housed from 30 October and fed hay and concentrate until turnout on 17 May. They were grazed on a predominantly ryegrass sward at 7-8 cm during the summer and early autumn and slaughtered over four weeks from 7-28 October. The weight gain of each group during the experimental period up to slaughter was 24.1 kg, 20.6 kg, 24.3 kg and 25.8 kg respectively. Thus the group castrated and then given a Compudose 365 ear implant grew as well as the entire group and 20% better than the castrate group. The amputate group grew almost as well as the entire group but experience with the procedure suggests that it is not one which is suitable for commercial use. The carcases were similar (Table 1) in terms of the proportions of bone, trim and boneless meat but the differences in the weights of the carcases between treatments reflected the differences in live weight. Part of the experiment will be repeated in 1986.

TABLE 1
The liveweight and carcass characteristics of young red deer stags and castrates

	A (Entire)	B (Castrate)	C (Amputate)	D (Castrate & Compudose)
Slaughter weight (kg)	74.9 +5.08	71.3 +6.67	75.0 +6.80	76.5 +6.89
Carcass weight (kg)	40.5 +3.10	38.9 +4.05	40.4 +3.21	42.1 +4.14
Killing out percentage	54.0 +1.33	54.6 +1.91	53.7 +2.72	55.1 +1.69
Boneless meat percentage	60.6 +2.33	61.6 +2.59	59.8 +1.81	61.4 +3.27
Percentage bone	28.2 +1.18	27.9 2.27	28.5 1.72	27.5 2.01
Percentage trims	11.6 +1.45	11.3 +1.58	11.2 +1.34	11.5 +3.04

Research objective: **Determine the relationships between nutrition and performance in grazing red deer hinds and calves** (no. 001042)

5. The crossing of red deer hinds with a Wapiti bull

W.J. Hamilton and T.J. Maxwell

During the ruts of 1983 and 1984 a Wapiti bull (*Cervus elaphus canadensis*) was given the opportunity to mate with 28 and 25 red deer hinds respectively. The results are shown in Table 1.

The poor performance achieved by the Wapiti bull (55%) is similar to that found in New Zealand trials in Invermay. The problem with the Wapiti may be that certain hinds refuse to stand for him, or the difference in size makes mating difficult or that the bull may lack libido. In a direct comparison with red deer hinds bred to a red stag in the autumn of 1984 - a single red deer stag successfully bred with all 25 hinds selected as being similar in age and body weight as those hinds rutted with the Wapiti bull.

TABLE 1
Reproductive performance of red deer hinds crossed with a Wapiti bull

	1984	1985	Both
No. of hinds to the bull	28	25	53
No. of hinds pregnant	14	15	29
No. of calves born alive	13	13	26
No. of calves still born	1	2	3
No. of calves died (birth to wean)	0	2	2
No. of calves weaned	13	11	24
Percentage of hinds bulled	50	60	55
Percentage of calves weaned as of calves born	92.8	73.3	82.7

Of the 29 hinds which became pregnant to the Wapiti bull seven were given some assistance at parturition. The subsequent reproductive performance of the red deer hinds which reared a hybrid calf during the summer of 1984 was that 12 out of 13 rebred with the red deer stag and produced calves in 1985. One hind had died during the autumn and one hind was yeld. Calving dates are on average 14 days later than the red deer.

The live-weight data from 22 Wapiti x red hybrid calves is summarised in Table 2. The 1984 calves performance shown in 1984-85 was better than in 1985-86. This seasonal effect was probably due to the climate extremes experienced between the warm dry summer of 1984 and the cold and wet summer of 1985. There are no differences in the growth rates of bull and cow calves for the first 100 days while being suckled by their dams, but towards the end of the winter period the bull calves grew much faster. The data indicates the considerable potential of the hybrid calf in terms of growth rate and venison production.

TABLE 2
The live weight of hybrid calves from birth to nine months

	Birth Weight (kg)	100 day Weight (kg)	Live weight on 21 Dec (kg)	Live weight on 20 Feb (kg)	Live weight on 29 March (kg)
A Bull and cow calves (11) 1984-85	9.70	46.20	59.50	72.45	80.36
B Bull and cow calves (11) 1985-86	9.84	40.47	57.07	66.30	74.60

6. Effect of passive immunisation against testosterone on the calving rate of red deer hinds

S.M. Rhind, B.A. Morris* and J. Clayton* (*University of Surrey)

It is widely accepted that the incidence of twin births in red deer is normally extremely low. Increasing the incidence of twin births could increase the efficiency of meat production provided that the calves, born as twins, had an adequate birth weight and growth rate. The aim of this trial was to determine the reproductive response of red deer hinds to passive immunisation against testosterone using 3 different doses of ovine antiserum.

Three groups of 6 hinds of mixed age were injected intravenously with 1.5, 3.0 or 4.5 standard sheep doses of anti-testosterone antiserum; 3 days before joining with the stag on 27 September. The doses comprised 10, 20 and 30 ml of antiserum (titre 1:495,000) respectively. In view of the very low incidence of twin births under normal circumstances, no control group was considered necessary.

Three months after joining, 16 of the 18 animals were subjected to ultrasound scanning. All but one of these was pregnant and 3 were diagnosed twin-bearing. Two of these had been given the highest antibody dose and one the intermediate dose.

These preliminary results suggest that it may be possible to induce twin pregnancy in the deer by passive immunisation against steroids but their ability to sustain twin foetuses throughout pregnancy so that they have an adequate birth weight and growth potential remains to be demonstrated.

Research objective: The regulation of appetite cycles and reproductive activity in seasonally breeding deer

7. The effects of melatonin and prolactin on the voluntary intake of red deer hinds

J.A. Milne, A.M. Sibbald, S. Busby, A. McNeilly* (*MRC Unit of Reproductive Biology), A.S.I. Loudon+ and J. Curlewis+ (+Institute of Zoology)

In the study of the relationships between appetite, lactation and reproduction of a seasonally breeding animal such as the red deer, the role of the hormone, prolactin, has not been elucidated. Prolactin is known to be elevated during lactation, is influenced by daylength and temperature and is declining at the onset of the breeding season. Two experiments were conducted in an attempt to shed light on the significance of prolactin in the regulation of appetite.

Experiment 1. The effects on voluntary intake and onset of the breeding season of daily oral dosing of 5 mg melatonin at 1600 h (Treatment M) and daily oral dosing of 5 mg melatonin at 1600 h together with 20 mg of domperidone at 0900 h (Treatment M + D) were compared with a control treatment (Treatment C). The treatments were imposed from early July to mid-November on 8 non-lactating hinds per treatment. The hinds were offered a complete pelleted diet (AA6) *ad libitum*. Melatonin is known to bring forward the onset of the breeding season and to cause a depression in plasma prolactin concentrations. Domperidone, a dopamine agonist, is known to increase plasma prolactin concentration. It was hoped that the combination of treatments would indicate whether the effect of melatonin was mediated through prolactin. Fig. 1 shows the effect of the treatments on plasma prolactin concentration measured at 1300 h. Melatonin reduced prolactin concentrations and there was a seasonal decline in prolactin concentration on the control treatment. The oral domperidone treatment did not increase prolactin concentration and the dose level was increased to 40 mg/day on September 10 with only a small effect on prolactin concentration. From 4 October the domperidone was given by a subcutaneous injection of 3 mg/day until the end of the experiment. This resulted in a temporary increase in prolactin concentration. The voluntary intakes are given in Fig. 2. The melatonin-treated animals reached a peak intake 3 weeks before the control animals and their intakes declined 3 weeks earlier but at the same rate. Three weeks after the start of the domperidone injections voluntary intakes rose and continued to do so in comparison to the other treatments until the end of the experiment. Both of the melatonin treatments advanced the onset of the breeding season by a mean of 25 days and the live-weight patterns of the hinds reflected the voluntary intake patterns with the control hinds being 4 kg heavier than the melatonin-treated animals at the end of the experiment.

The objective of the experiment was not completely met since the domperidone did not increase plasma prolactin levels except towards the end of the experiment. This however did coincide with an increase in voluntary intake. The rapid decline in hinds' intakes in the autumn has not been reported before but in a similar experiment at Whipsnade Zoo, as part of the same project, a similar decline in intake with a higher quality diet was also observed.

Experiment 2. Domperidone was not particularly successful in elevating plasma prolactin levels. Ovine prolactin would be a more successful

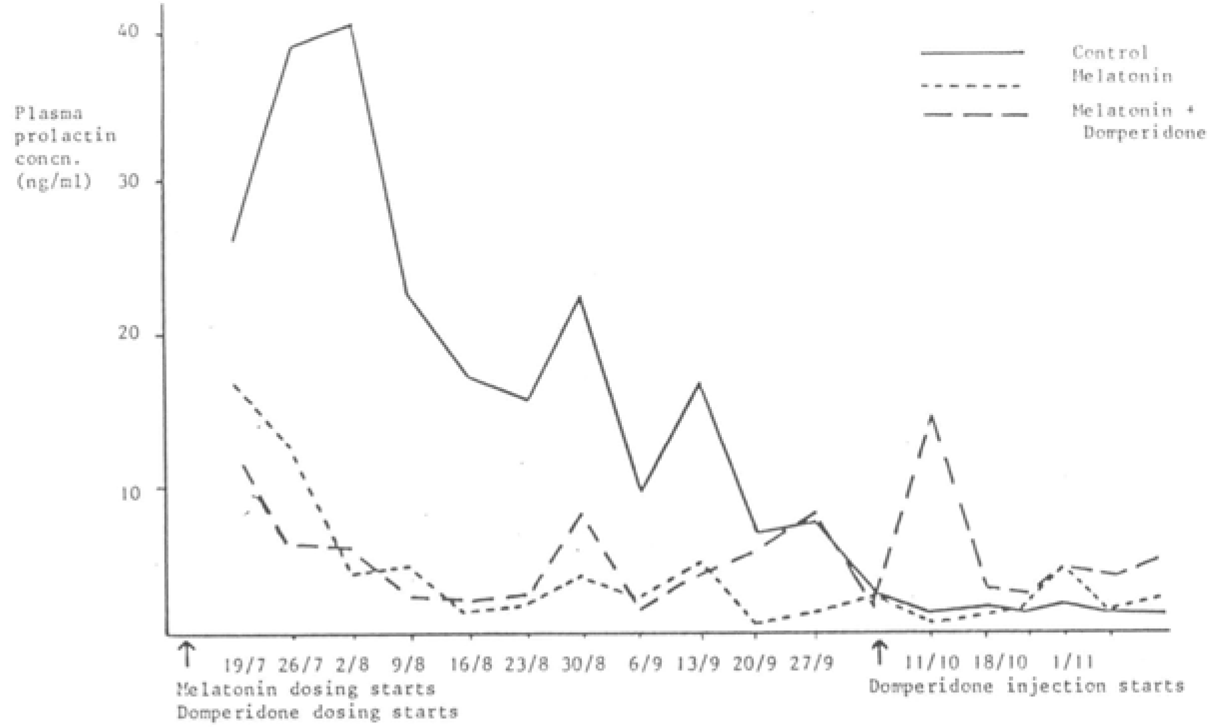


Figure 1. Seasonal patterns in plasma prolactin conentrations of red deer hinds as influenced by treatments in Experiment 1.

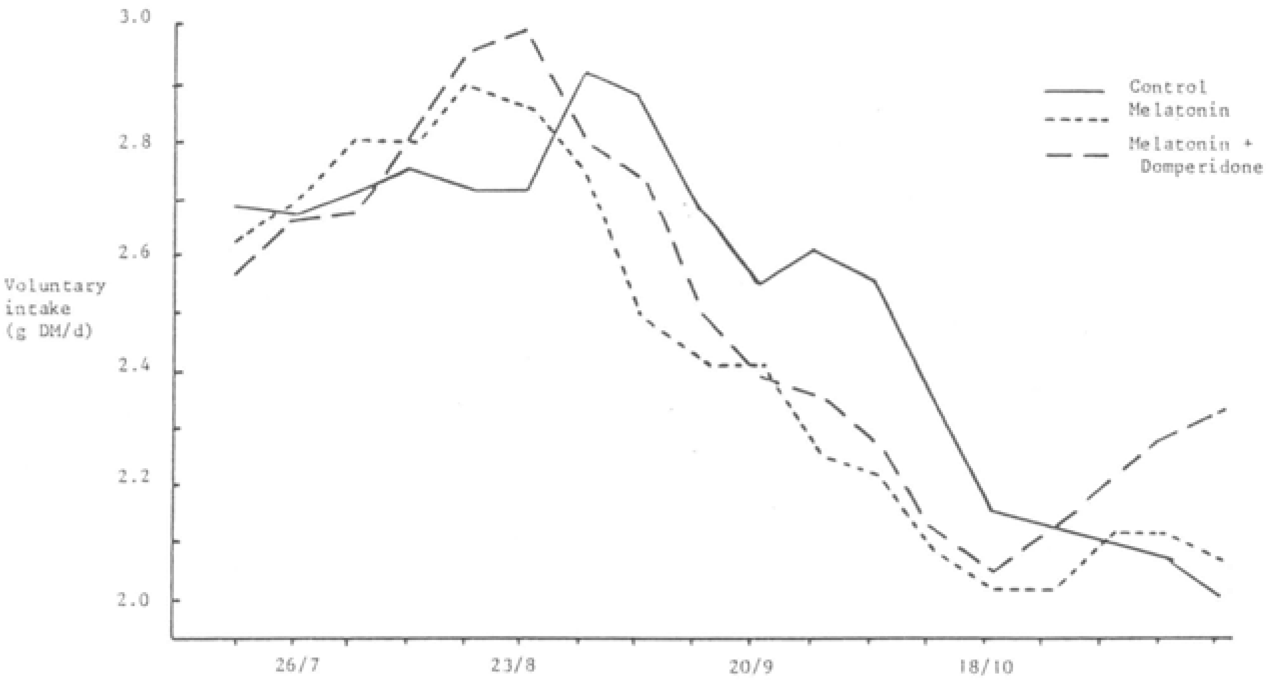


Figure 2. Seasonal changes in voluntary intake of red deer hinds as influenced by treatments in Experiment 1.

candidate for increasing prolactin levels but is not readily available. Sufficient ovine prolactin became available to allow the effect of prolactin on voluntary intake to be examined with hinds in February when plasma prolactin levels are gradually increasing from their winter nadir. It was thought that the animals might be responsive to prolactin at this time. Twice daily injections at 0900 and 1600 h of 3 mg ovine prolactin were compared with a similar regime of 3 mg domperidone injections and with a control group. There were six hinds per treatment and the treatments were imposed for a period of a month. The hinds were offered a complete diet *ad libitum* from February until mid-April.

The prolactin injections increased plasma prolactin levels such that they were 20-30 ng/ml three hours after injection compared to control values which were approximately 5 ng/ml. The domperidone treatment had an intermediate effect on prolactin levels. There was no effect of treatments on voluntary intake during the period of treatment imposition but, as can be seen from Fig. 3, voluntary intakes on the domperidone and prolactin treatments increased subsequently compared to the control treatment by 8 and 14% respectively.

Further experimentation is planned to clarify the role of prolactin in appetite regulation of the red deer.

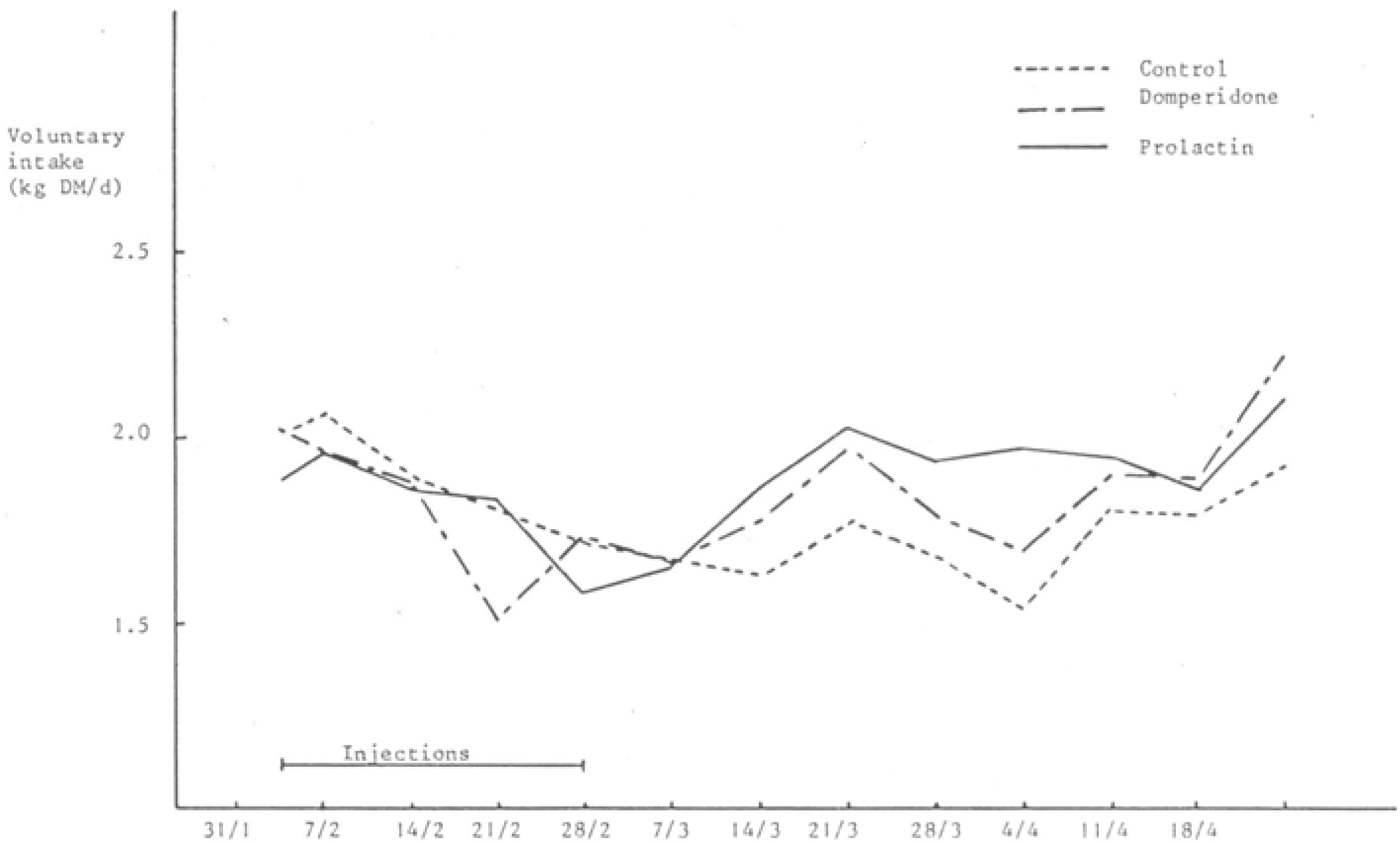


Figure 3. Voluntary intakes by red deer hinds in Experiment 2.

PROGRAMME UNIT 8: POSSIBLE ROLE FOR GOATS IN HILL AND UPLAND SHEEP FARMING SYSTEMS

Research objective: To study the separate and complementary grazing of sown and indigenous hill pastures by goats and sheep (no. 001063)

1. Control of the rush (Juncus effusus)

M. Lippert, A.J.F. Russel, S.A. Grant and J.H. Burnett

The experiment on the separate grazing by goats and sheep of rush-infested reseeded hill pasture (Festuca rubra - Trifolium repens) was continued for a third and final grazing season. As in previous years there were two replicates of each of three treatments and stock numbers were adjusted to maintain sward surface heights of 3-4 cm on plots grazed by either sheep or goats and of 5-6 cm on plots grazed only by goats.

In 1985 the plots were stocked from 7 June to 23 August using both dry and lactating feral goats (30.5 kg live weight) and dry ewes (48.5 kg live weight). Measurements of rush utilisation and stock grazing days on each treatment are presented in Table 1. On the 3-4 cm grass height plots grazed by goats there were insufficient rush stems even at the start of the grazing season on which to make measurements.

TABLE 1
Measurements made on rushes and stock grazing days on plots with sward surface heights maintained at 3-4 cm by grazing with goats or sheep and at 5-6 cm by grazing with goats (means of 2 replicates)

	Treatment		
	Sheep 3-4 cm	Goats 3-4 cm	Goats 5-6 cm
Pregrazing			
Green stem density (m^{-2})	3766	-	969
Green stem height (cm)	51	-	20
4 July			
Proportion of green stems grazed	0.43	-	1.00
Grazed stem height (cm)	52	-	8
31 July			
Proportion of green stems grazed	0.79	-	0.98
Grazed stem height (cm)	53	-	7
Grazing days			
Sheep	391		
Goats (dry)		301	20
(+ kids)		273	336

The results show that while some grazing of rushes by sheep was observed, this was insuffient to have any real effect on their vigour or density.

The more lax grazing by goats (5-6 cm grass height treatment) progressively weakened the vigour and density of the rushes, while the heavier goat grazing (3-4 cm grass height) had effectively eliminated the rushes early in the second grazing season.

The experiment on the complementary grazing by goats and sheep of a predominantly Agrostis tenuis pasture invaded by rushes was continued for a second grazing season. There were two replicates, each of three treatments in which goats were stocked at the equivalent of 10, 20 and 30/ha and to which sufficient numbers of sheep were added to maintain sward heights at 4-5 cm (cf. 3-4 cm in 1984). In the previous year the proportion of rush stems grazed and the closeness of the grazing had increased as goat stocking rate increased from 10 to 20/ha; the vigour and density of the rushes were effectively reduced at 20 goats/ha and differed little at the end of the season from the 30/ha treatment. The effects of these first year treatments are evident in the pregrazing data in Table 2. The effects of the treatments in the second season on the proportion and height of the green rush stems grazed are also shown in Table 2.

TABLE 2
Measurements made on rushes and stock grazing days on plots grazed by goats at different stocking rates and maintained at 4-5 cm sward surface height by adding sheep (means of 2 replicates)

	Goat stocking rate (per hectare equivalent)		
	10	20	30
Pregrazing			
Green stem density (/m^2)	4390	3138	2301
Green stem height (cm)	44	36	31
16 July			
Proportion of green stems grazed	0.37	0.85	0.85
Grazed stem height (cm)	57	42	32
5 August			
Proportion of green stems grazed	0.85	0.96	0.94
Grazed stem height (cm)	58	32	19
27 August			
Proportion of green stems grazed	0.86	0.95	0.94
Grazed stem height (cm)	52	26	12
15 September			
Proportion of green stems grazed	0.87	0.92	0.92
Grazed stem height (cm)	49	30	13
Grazing days			
Sheep	347	142	93
Goats	168	336	504

The results illustrate the progressive weakening of rush vigour and density as goat stocking rate increased and demonstrate that rushes can be effectively controlled in sheep-grazed sown pasture by heavy grazing with goats.

2. The grazing behaviour of goats on grass-heather mosaics

M. Lippert, A.J.F. Russel, S.A. Grant and J.H. Burnett

The experiment designed to study the grazing behaviour of goats on grass-heather mosaics was continued for a second grazing season. Plots containing either 60% or 80% heather (i.e. 40% and 20% grass respectively) were each stocked with 4 feral goats (28 kg live weight) and grazed from 2 July until a heather utilisation of 0.40 or greater was achieved. Each plot contained discrete areas of heather of markedly different height, and the effect of height of heather stand was examined in one of the two replicates. Heather utilisation (400 points per plot) was estimated at weekly intervals from 1 to 22 August and again on 2 September. Goats were removed from the 60% heather plot on the second replicate on 15 August and from the remaining three plots on 3 September. Heather utilisation and grass height measurements are presented in Table 3 and data on the pattern of utilisation in tall and short heather stands are given in Table 4.

TABLE 3
Heather utilisation and grass heights in grass-heather mosaics grazed by goats

	Replicate 1		Replicate 2			
% heather in mosaic	80	60	80		60	
Height of heather stand(cm)	19.0	18.4	27.3	8.8	26.0	9.9
1 July						
Heather utilisation	0	0	0	0	0	0
Grass height (cm)	9.3	9.5	6.1		6.1	
18 July						
Heather utilisation	0.09	0.14	0.06	0.11	0.18	0.16
1 August						
Heather utilisation	0.19	0.22	0.18	0.20	0.33	0.32
Grass height (cm)	9.1	8.9	6.9		8.1	
7 August						
Heather utilisation	0.25	0.28	0.24	0.26	0.42	0.34
15 August						
Heather utilisation	0.32	0.36	0.27	0.33	0.57	0.44
22 August						
Heather utilisation	0.34	0.37	0.29	0.35		
2 September						
Heather utilisation	0.42	0.49	0.41	0.47		
Grass height (cm)	5.0	5.7	4.4			

TABLE 4

The pattern of utilisation of tall and short heather stands by grazing goats, expressed as the proportion of grazed shoots in the categories A < 50% of current season's growth, B > 50% of current season's growth, and C grazing into old wood

% heather in mosaic		80		60	
Height of heather stand		Tall	Short	Tall	Short
18 July					
Proportion class	A	0.48	0.49	0.26	0.37
	B	0.48	0.47	0.55	0.61
	C	0.05	0.04	0.20	0.03
15 August					
Proportion class	A	0.15	0.32	0.27	0.27
	B	0.39	0.53	0.49	0.67
	C	0.46	0.15	0.23	0.06
2 September					
Proportion class	A	0.11	0.14		
	B	0.65	0.80		
	C	0.35	0.07		

The results in Table 3 confirm the previously observed finding that, in contrast to sheep, goats utilise heather to a greater extent where it forms a smaller proportion of the available grazing. The data in Table 4 likewise confirm the previous year's finding that goats graze a greater proportion of shoots into the previous season's growth on tall than on short stands.

Research objective: **To study cashmere production in domestic and feral goats and their crosses (no. 001064)**

3. The harvesting of cashmere

M. Lippert, M.L. Ryder, A.J.F. Russel, and J.H. Burnett

A trial was conducted in 1985 to evaluate the feasibility of harvesting cashmere by combing as opposed to shearing. The experience gained in this work indicated that the time taken for one person to comb a goat varied from about 10 to more than 30 minutes, depending principally on the quantity of cashmere harvested. Although this is clearly a time-consuming and hence expensive operation, the cost is considered to be less than that of housing and feeding the animals for a period of weeks or months as would be required if they were shorn.

The trial involved the combing of different classes of animals (dry and lactating females, castrates, entire males, yearlings and adults) on different numbers of occasions and at different times between April and June. The final results are still being evaluated, but the indications are that the earlier dates appear to be the more appropriate. Some of the preliminary results are given in Table 5.

TABLE 5

Down and hair characteristics, minutes combed and weight of down plus hair (g) of productive and barren feral females and castrates

		Hair length (mm)	Down length (mm)	Minutes combed	Weight down plus hair (g)	No goats
I	Productive feral females					
	(a) April combed	61.6	34.1	16.8	55.5	22
	repeat June			3.9	8.3	
					63.8	
	(b) April (sample only)	62.0	32.5			
	Combed June			11.8	58.5	20
	(c) April combed	66.3	38.7	17.7	47.5	29
	repeat June			3.8	8.8	
					56.3	
	(d) June comb only	54.3	24.3	9.5	38.9	31
II	Feral Castrate and barren					
	(a) April	58.0	35.0	16.9	43.5	14
	repeat May			5.0	6.7	
	repeat June			2.4	2.9	
					53.1	
	(b) April	68.2	38.2	16.9	44.4	14
	repeat June			4.1	6.5	
					50.9	
	(c) May	53.6	27.5	10.2	24.2	11
	repeat June			5.8	9.0	
					33.2	
	(d) June only	53.3	30.8	8.6	31.6	

The collection of skin biopsy samples for histological examination of the initiation of fibre growth and of shedding has been continued but no histology has yet been carried out. This work will, however, provide essential basic information on the seasonality of fibre production and will also give a guide as to the optimum time of harvesting.

There appears to be a substantial discrepancy between the estimates of fibre production obtained from clipping mid-side patches and the amounts actually harvested, indicating a possible loss of cashmere prior to harvesting. This problem will be examined in the coming year.

4. Breeding for cashmere production

A.J.F. Russel, M.L. Ryder and M. Lippert

In breeding for increased cashmere production male kids are selected on the basis of fibre samples taken in late September at which time it is estimated that some 40% of the annual production is present in the coat. This allows time for the samples to be evaluated and the superior individuals selected for use in the November breeding season. The main criteria considered in addition to weight of cashmere produced are fibre diameter and colour.

In addition to the pure feral stock in which improved production of fine white cashmere is being sought, various crosses with feral stock are being examined. Pure feral animals appear to have certain limitations with respect to growth rate and the production of sufficient milk to rear twins satisfactorily - traits which are desirable in relation to meat production. Earlier results showed that of the dairy breeds examined, the Anglo Nubian was least well suited to hill conditions and produced the lowest quantities of undercoat; it has consequently been decided not to pursue further work with this breed or its crosses. Similarly, it has been decided on the basis of previous years' results that the British Saanen had less to offer in terms of fibre characteristics than the Toggenburg, and consequently purebred British Saanens are no longer being maintained in the herd although some crossbreds still remain. Of the dairy breeds studied the Toggenburg appears to have the greatest potential for the combined production of both fibre and meat, and crosses with feral stock are currently being evaluated.

A further option which is being examined is the crossbred containing some Angora influence. The results to date indicate that the feral-Angora crosbred produces considerably more fibre than the pure feral, but that the greater quantity is associated with an increased fibre diameter. Care is being exercised in the selection of first-cross animals for further breeding and the preliminary results from the second generation crosses indicate that substantial increases in down weight with acceptable fibre diameters are being achieved. It will be necessary to evaluate other fibre characteristics before reaching a conclusion on the potential value of the Angora in cashmere production.

The principal cashmere characteristics of the 1985-born male kids of the main breeds and crosses currently being examined are shown in Table 6. These data show the very fine diameters of the pure feral and the feral-Toggenburg cross animals, and the greater levels of production of the somewhat coarser fibre of the crosses containing 25% Angora genes.

TABLE 6
Live weight and cashmere characteristics of male kids of different breeds and crosses (September 1985)

Genotype	Live weight (kg)	Down Sample Weight (g)	Estimated Down Weight (g)*	Down Diameter(u)
Feral	13.8	0.158	48.1	13.7
Feral x Toggenburg	18.8	0.113	41.4	13.5
Toggenburg x Feral	13.9	0.125	39.1	13.5
Angora x Feral	14.7	0.585	193.0	19.2
(Angora x Feral)x Feral	14.9	0.331	106.4	15.2
(Angora x Saanen)xFeral	18.0	0.201	80.7	15.6
(Angora x Saanen)x Toggenburg	20.9	0.195	85.1	15.4

*from estimate of body surface area and representing approximately 40% of first year's production

Research objective: **To study meat production from domestic and feral goats and their crosses (no. 001065)**

5. Live weights and growth rates of yearling kids

A.J.F. Russel, M. Lippert and J.H. Burnett

To date there have been only a small number of animals surplus to breeding requirements and suitable for detailed carcass studies. Twenty-four yearlings representing the major breeds and crosses of interest have been slaughtered. Carcass measurements and dissections have been completed and samples of tissues have been chemically analysed to provide information on carcass and whole body composition, and particularly on the distribution of fat throughout the body. These data are now being analysed.

In considering the potential of different breeds and crosses for meat production, performance in terms of weaning weight and subsequent growth rate are clearly of importance. During the summers of 1984 and 1985 lactating feral and domestic females and their pure and cross-bred kids were grazed on good quality sown pasture to facilitate comparisons of growth rates of different genotypes of kid. Weights at birth, weaning and 11 months of age of kids born in 1984 are presented in Table 7. Birth weights of feral kids and cross-bred kids from feral dams were lower than those of kids born to the larger and heavier females of the domestic breeds. Kids reared by feral dams were also lighter at weaning than those reared by dams of the domestic breeds, and the comparison of the feral x domestic and domestic x feral gains to weaning indicates that the level of milk production of the feral dams is limiting early kid growth rate. Performance at this stage is, however, also influenced by genotype of kid as well as by genotype of dam, as cross-bred kids from feral dams were heavier at weaning than pure-bred feral kids. The superior milk production of the domestic dams is best illustrated by the fact that their multiple-born and reared kids were heavier at weaning than singles born to and reared by feral females. These findings were confirmed by performance to weaning of the 1985-born kids (Table 8). The rankings of weight at 11 months of age of the 1984-born kids were the same as at weaning (Table 7). Growth rates of cross-bred kids (feral x domestic and domestic x feral) from weaning to the yearling stage were largely unaffected by genotype of dam.

TABLE 7
Weights (kg) (± s.e.) of 1984-born breeds and crosses at birth, weaning and 11 months of age (numbers given in parenthesis)

	Birth (April/May)		Weaning (13 Aug)		Yearling (20 March)	
	Single	Multiple	Single	Multiple	Single	Multiple
Feral	(14)2.5±0.10	(2)1.5±0.10	(13)14.7±0.60	(2) 7.3±0.35	(13)21.0±1.15	(1)17.5
*Domestic breeds	(8)3.4±0.05	(39)2.8±0.05	(10)20.6±0.40	(20)19.7±0.58	(7)31.5±0.85	(19)34.2±0.84
**Domestic sire x Feral dam	(20)2.7±0.06	(4)2.0±0.28	(20)16.4±0.31	(3)13.8±1.92	(6)24.7±1.08	(3)22.0±1.44
Feral sire x **Domestic dam	(7)3.7±0.16	(34)3.0±0.05	(8)21.0±0.58	(29)17.3±0.41	(8)28.9±0.96	(29)26.4±0.54

* includes Anglo Nubian, British Saanen, Toggenburg and British Toggenburg
** includes above breeds plus Angora crosses

TABLE 8
Birth weights and gains to weaning (± s.e.) of 1985-born kids (numbers in parentheses)

	Birth weight (kg)	Gain to weaning (g/day)
Feral (singles only)	(33) 2.5 ± 0.07	(27) 77 ± 3.1
*Domestic sire x feral dam (singles only)	(64) 2.7 ± 0.04	(61) 93 ± 4.5
**Domestic dam		
singles	(23) 3.6 ± 0.10	(22) 145 ± 6.3
twins	(80) 3.1 ± 0.10	(74) 112 ± 6.2
triplet/quads	(7) 2.5 ± 0.15	(6) 85 ± 11.4

* includes British Saanen, Toggenburg, British Toggenburg, Angora, Angora x Domestic and Feral x Angora

** sires predominantly feral, but including some feral x domestic

PROGRAMME UNIT 2 : ECOLOGY OF GRAZING SYSTEMS

1. HILL SWARDS

Research objective: **Identify the characteristics of hill plant communities determining their suitability for sheep and cattle (no. 003009)**

1.1 The influence of plant structure and physical breakdown on intake

R.H. Armstrong, T.G. Common, M.M. Beattie, E.A. Hunter (AFRUS)

Earlier work (HFRO Biennial Report, 1982-3, p.24) showed that potential intake (OMI) and *in vivo* digestibility (OMD) in herbage harvested from hill pastures were broadly related to plant maturity as is the case with sown grasses. Also, though OMI and OMD are generally lower in 'hill' herbages than in sown grasses, the slope of the relationship between OMI and OMD is broadly the same in both types of herbage. Further investigation is taking place into the influence of internal plant structure and of physical breakdown on OMI in these herbages, in collaboration with Dr G. Moseley of the Welsh Plant Breeding Station.

Recently it has been shown that the content of acid detergent fibre (ADF) in the herbages is related to OMD less closely than is the proportion of herbage organic matter which disappears in the conventional *in vitro* digestion process. Also the recovery of the 'indigestible' ADF from hill herbages (HFRO Biennial Report 1982-83, p.24) is inconsistent, which means that its use for direct prediction of OMI in grazing animals would be invalid.

Research objective: **Investigate the scope for manipulation of the composition and nutritive value of hill swards by controlled grazing (no. 003010)**

1.2 Studies on Nardus and Molinia grassland

S.A. Grant, Richard H. Armstrong, L. Torvell, M.M. Beattie, T.G. Common, D.E. Suckling, E. Sim and J. Small

The two grazing trials on *Nardus* grassland which were started in 1984 were continued in 1985. In both trials plots were continuously stocked by groups of a single animal species and management regimes were adopted whereby the preferred, between-tussock grasses were maintained at pre-determined sward surface heights by adjusting animal numbers as necessary in relation to twice weekly measurements of sward height. Trial 1 occupied a 3 ha site and included 1 cattle plot (sward height 4.5 cm) and 2 sheep plots (sward heights 4.5 cm and 3.5 cm). Trial 2 occupied a 0.6 ha site and included 1 sheep plot (sward height 4.5 cm) and 3 goat plots (sward heights 6.5 cm, 5.5 cm and 4.5 cm). Adjacent holding paddocks were available at both sites.

Measurements of diet organic matter digestibility (OMD) and herbage organic matter intake (OMI) were made at intervals through the growing season on Trial 1, the sheep and cattle site. The diets were also characterized in terms of their floristic composition. Records were collected from both trials, at times coincident with the measurement periods and also at the end of the grazing season, to characterize both the proportion of Nardus leaves and tillers showing signs of grazing and the average amina length remaining after grazing. Sward floristic composition is recorded annually to follow changes over time.

TABLE 1
Proportions of Nardus leaves grazed (G) and lengths of lamina remaining after grazing (L) in cms

Trial 1	CATTLE 4.5 cm		SHEEP 4.5 cm		SHEEP 3.5 cm	
	G	L	G	L	G	L
July 1984	0.81	3.6±0.2	0.24	7.9±0.3	0.60	5.5±0.3
October 1984	0.45	2.3±0.2	0.15	6.3±0.4	0.44	4.5±0.4
July 1985	0.79	3.4±0.3	0.16	9.7±0.8	0.38	5.0±0.4
October 1985	0.51	3.5±0.2	0.07	7.6±0.4	0.38	4.9±0.2

Trial 2	SHEEP 4.5 cm		GOATS* 4.5 cm		GOATS* 5.5 cm		GOATS* 6.5 cm	
	G	L	G	L	G	L	G	L
July 1984	0.63	7.9±0.5	0.88	2.6±0.2	0.61	5.5±0.3	0.18	8.8±0.5
October 1984	0.39	4.0±0.3	0.63	2.8±0.3	0.42	4.5±0.3	0.19	5.0±0.3
July 1985	0.42	7.8±0.4	0.42	6.5±0.4	0.29	8.8±0.6	0.14	13.6±0.7
October 1985	0.28	7.2±0.6	0.21	5.9±0.3	0.34	7.1±0.4	0.12	10.4±0.4

*In 1984 mature goats with an average body weight of 50 kg were used, while in 1985 yearlings with an average body weight of 32 kg were used.

Selected data showing the mid- and end of season records for utilisation of Nardus (Table 1) clearly show that the cattle grazed Nardus more readily and more closely than did the sheep, and that the goats were intermediate in behaviour.

The digestibility (OMD) of the herbage eaten in the sheep:cattle comparison was much higher in May-June 1985 than it was in 1984 for all three treatments (Table 2), but July values were similar to those of 1984. The higher June 1985 values reflect lower proportions of overwintered dead herbage in swards this is especially so on the cattle plot where the effect persists into September. Levels of digested organic matter intake (DOMI; Table 3) in June and July 1985 are higher than in 1984, especially for sheep, though OMD was similar in July for sheep in both years. Patterns of live-weight change reflect DOMI in that after the end of June animals on all treatments lost weight.

TABLE 2
Nardus plots : diet digestibility (OMD) (1984 values in parentheses)

Treatment period:	SHEEP 3-4 cm	SHEEP 4-5 cm	CATTLE 4-5 cm
May-June	.74 (.64)	.72 (.67)	.72 (.65)
July	.64 (.65)	.64 (.66)	.62 (.57)
September	.59 (.64)	.63 (.63)	.63 (.57)

S.E. (periods x plots) = .008

TABLE 3
Nardus plots : digested organic matter intake (DOMI; g/kg LW/day) live-weight change (LWC; g/day) for sheep and cattle (1984 values in parentheses)

	SHEEP 3-4 cm		SHEEP 4-5 cm		CATTLE 4-5 cm	
	DOMI	LWC	DOMI	LWC	DOMI	LWC
May-June	16.2 (11.2)	158	18.4 (14.1)	250	12.2 (11.7)	994
July	12.4 (7.0)	-32	13.9 (8.0)	-157	10.4 (9.3)	-290
September	13.3 (ND)	ND	12.6 (ND)	ND	10.9 (ND)	ND

ND - not measured

Estimates of stock-carry (expressed as kilogram days per hectare Table 4) show that, as expected from studies on sown swards, levels for sheep at 3-4 cm exceeded those for sheep at 4-5 cm because of lower individual intakes and higher utilisation of herbage. Because of initial differences in sward composition between sheep plots the stock carry differences should be treated with caution. However, initial differences between the cattle plot and sheep plots were slight, and cattle values exceeded those for sheep, especially in early summer; this would be expected because of the greater willingness of cattle to graze Nardus tussocks.

TABLE 4
Nardus plots : stock-carry (kg d/ha, '000)

	SHEEP 3-4 cm	SHEEP 4-5 cm	CATTLE 4-5 cm
8 May - 30 June	34	14	59
30 June - 13 August	53	23	50
13 August - 26 September	25	12	23
Total	112	49	132
(1984 Totals)	(80)	(38)	(123)

Measurements of the growth rate of Nardus tillers on the grazed plots were made over a two week period in mid-summer 1985. All plots on Trial 1 were sampled but only two plots, the 4.5 cm sheep and 4.5 cm goat plots, of Trial 2. Three, paired transects of 10 caged and uncaged tillers, i.e. thirty tillers of each category, were marked and measured per plot.

Individual tiller size in terms of total green leaf length per tiller was poorly correlated with individual rates of leaf extension per tiller. Correlation coefficients were calculated separately for the caged and uncaged tillers of each plot; nine out of the ten possible correlations were very low and non-significant, while the tenth, though significant, accounted for only 35% of the variation. Mean green leaf lengths per plot on the other hand, showed a highly significant correlation with the mean rates of leaf extension per tiller per plot ($r^2 = +0.82$, $P < 0.001$). The mean grazed lamina lengths of Nardus tillers per plot at the close of the 1984 grazing season also showed a significant correlation with the mean rates of leaf extension per tiller ($r^2 = +0.70$, $P < 0.01$). It was concluded that grazing history had affected the growth of Nardus and that the more severely the Nardus had been grazed in 1984 the poorer was its growth in 1985.

The explanation for the poor relationship between tiller size and rate of leaf extension on an individual tiller basis was thought to be associated with a difference in the potential for growth of tillers of different age class. According to Perkins (1969) Nardus tillers are long-lived and survive for two or three seasons. In their second summer just over half of the tillers flower, but those which do not flower grow on for a third season and do not subsequently flower. Perkins reported that the tillers of the different phenological classes exhibited differences in relative growth rate, weight increments being greatest on flowering tillers in May/June. Growth in terms of lamina extension was not reported, though it was stated that lamina extension took place as early as mid-April, at which time there was no apparent accumulation of metabolised products in the tillers. The tillers marked in the present study were all vegetative tillers chosen at random. At the time of marking a note was made for each tiller of the number of missing laminae (sheaths only present) and wholly dead laminae. The mean leaf extension rate of the youngest tillers, i.e. those with no dead or missing laminae, was compared with that of the older tillers. The mean of the average growth rate per plot of young tillers (15.53 ± 1.11 mm/tiller/week) was 50% greater than the mean of the average growth rate per plot of the older tillers (10.31 ± 0.70 mm/tiller/week).

It is quite probable that differences exist in the seasonal pattern of leaf extension on tillers of different phenological class, and also that the interdependence of the tillers may differ. In 1986 cutting experiments are planned in which a) the effects of different severities, timings and frequencies of defoliation of individual tillers on current season's lamina production (both extension rates and weight of lamina) of a standard age of tiller and b) the effects of different seasonal patterns and levels of cutting of Nardus tussocks on the mineral and carbohydrate levels in tiller bases in autumn, and on the amount and nature of herbage produced in the subsequent year, will be monitored. In addition it is hoped to compare the leaf extension growth of tillers of different phenological age class and to investigate the interdependence of family groups of tillers by examining the effects of selective defoliation of each age class of tiller on the growth of all age classes of tiller within the group.

Grazing studies on Molinia grassland were begun in 1985. Molinia grassland affords plentiful herbage of high feeding value during June-August and is thought to have good potential for summering hill cattle. However, Molinia is severely reduced by heavy grazing (Hodgson, 1985). The aim of the present work is to determine the proportion of current growth that can be utilised if Molinia dominance is to be maintained. Plots have been set up at two sites, a set of large plots at Bell Hill, Roxburghshire and a set of a smaller plots at Cleish in Fife. The plots are continuously stocked by cattle with numbers adjusted so that Molinia leaves are maintained at one of two pre-determined lengths (10 cm and 5 cm). The target lengths were set in relation of seasonal accumulated herbage height measurements in 1984 and approximate with removal of one third or of two thirds of the leaf produced. Ungrazed control areas are also incorporated in the trials. Intake and diet OMD and floristic composition are measured at intervals through the season on the larger plots at Bell Hill, and diet OMD and floristic composition only on the smaller plots at Cleish. Sward floristic composition is recorded annually and tissue turnover on Molinia tillers in both grazed and ungrazed areas is being monitored.

Diet digestibility values on both sites were higher than for cattle grazing on the Nardus community. Because of the wet season no intake estimates were made in August. OMD (Table 5) in period II was higher than in period I (July), probably because the fistulates concentrated their grazing on small patches of Holcus which had been ungrazed for several weeks previously. Levels of OMI, and consequently DOMI in period I were slightly higher than on the Nardus plots.

The grazing studies are supported by detailed observations on seasonal growth rythms of Molinia and by cutting experiments. Molinia tillers have large swollen tiller bases and the mineral and carbohydrate reserves in the tiller bases are thought to be important in supporting the current season's growth. The seasonal patterns of depletion and build up of reserves and of leaf extension rates are being monitored as also is the extend to which the reserves are able to buffer the grass against the immediate effects of defoliation. A short term cutting experiment was carried out in 1985 in which leaf production on control, uncut tillers was compared with that of defoliated tillers with 50% or 100% of the lamina length of all leaves removed in June only, in July only or in June and July. Results are summarised in Table 6 and it is clear that reserves in tiller bases were ample to sustain current growth.

TABLE 5
Molinia plots : diet digestibility (OMD), digestible organic matter intake (DOMI: g/kg LW/d) and stock carry (kg d/ha)

	OMD		DOMI (g/kg LW)		Stock carry (kg d/ha,000)	
	5 cm	10 cm	5 cm	10 cm	5 cm	10 cm
Riccarton:						
July	0.71	0.72	14.1	15.1	54	28
August	0.76+	0.75+	-	-	-	-
Cleish:						
July	0.72	0.71	-	-	-	-
August	0.70	0.72	-	-	-	-
SED		0.010				

+Cows grazing Holcus

TABLE 6
Influence of different severities of leaf removal by cutting on the total weight of leaf produced (mg/tiller) of Molinia. The data are means of three replicates, each replicate being the mean six tillers per treatment

Treatment	Site 1 Cleish	Site 2 Sourhope
CONTROL - uncut	65.0	71.2
50% removal June	69.0	93.0
100% removal June	74.5	75.0
50% removal July	74.6	85.0
100% removal July	83.0	67.2
50% removal June and July	74.4	73.2
100% removal June and July	85.6	83.8
SED	15.4	20.0

Leaf extension began in May and the rate of extension accelerated to reach maximum levels in late June and thereafter declined steadily through July and stopped altogether around mid-August. Senescence on the other hand did not begin until early July and increased relatively slowly up till the end of August. Senescence rates increased steeply during September with the absiccion layer becoming evident by September/October. The final shedding of leaves was delayed until November. The amount of green leaf remaining in late summer reflects defoliation history and, presumably, has an important influence on the amount of reserves which are built up to support growth the following season. This aspect is being studied in longer term cutting experiments the first results of which will become available in the 1986 growing season.

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2. SOWN SWARDS

Research objective: Investigate the manipulation of clover content in grazed swards and the effect on herbage production (no. 003012)

2.1 Management of continuously stocked grass/clover swards

S.A. Grant, G.T. Barthram, L. Torvell, E. Sim and J. Small

The aims of this study are to determine the conditions that must be provided to encourage a high clover content in grass clover swards and also to assess and determine the possible causes of variation in clover performances between years. To this end, a long term experiment was set up in 1984 in which three sets of sward conditions (swards maintained at 2.5, 3.5 or 5 cm height) at each of two N levels (no added N and N at 20 kg/ha every three weeks) were provided. Measurements have concentrated on a) characterisation of clover morphology and of sward composition in terms of grass and clover population densities and b) the measurement of clover branching rate. It was considered most important that an understanding of the factors controlling branching rate in clover was gained, and attempts are being made to interpret the data by examining seasonal patterns and treatment effects in relation to competition for light, space and nutrients.

The results to date are summarized below:-

Climate. The summer of 1984 was much drier and warmer than that of 1985. Monthly mean maximum temperatures over the period April-September inclusive ranged from 12°C to 20°C in 1984 and 10°C to 17°C in 1985, while rainfall over this period was 311 mm in 1984 and 791 mm in 1985.

Population densities. The effects of treatments and the changes over time on grass tiller and clover growing point population densities are shown in Figure 1. Grass tiller numbers were slightly increased by added N and in short compared with tall swards. Clover growing point numbers were markedly and significantly reduced by added N. No significant sward height effects were obtained in the analyses of variance. However, coefficients of variation for clover growing point densities were higher than for the grasses and this together with the degree of within-plot variation in sward height was thought to mask treatment effects. There were significant negative within-treatment correlations between individual turf sample height and clover growing point numbers; in September 1985 coefficients ranged between -0.56 and -0.63 (18 df, $P < 0.01$) for the three sward height treatments at N_0 but there was no relationship at N_1

(where growing point numbers were very low). The relationship between height and growing point number at N_0 was not uniform across sward heights. Higher grass tiller densities and lower clover growing point densities were attained in 1985 than 1984.

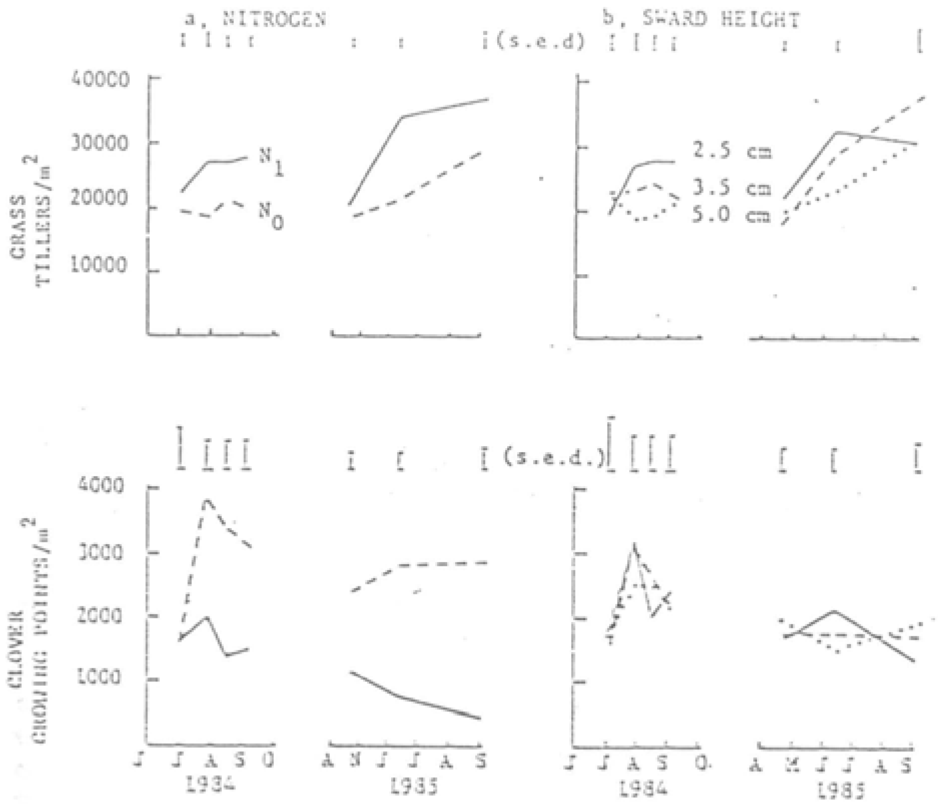

Figure 1. Effect of nitrogen and sward height on grass and clover population densities (s.e.d. = standard error of difference between means).

Clover morphology. The amount of stolon (m/m^2) was affected by treatment and also differed between years. In autumn 1984 above-ground stolon on the N_0 and N_1 treatments respectively averaged 79.1 and 35.4 m/m^2 (SED 7.93, $P < 0.01$) while in 1985 the figures were 34.3 and 4.0 m/m^2 (SED 9.70, $P < 0.001$). The averages for the 2.5 cm, 3.5 cm and 5.0 cm swards respectively in autumn 1984 were 41.2, 56.1 and 74.4 m/m^2 (SED 9.70, $P < 0.05$) and in 1985 they were 11.5, 18.9 and 27.0 m/m^2 (SED 4.1, $P < 0.05$). Stolon internode lengths, averaged over all treatments, were 5.7 $\pm$ 0.18 in autumn 1984 as compared with 3.3 $\pm$ 0.10 mm for autumn 1985, a difference suggestive of poorer overall growth. Both nitrogen ($N_0 > N_1$) and height (5.0 cm > 3.5 cm > 2.5 cm) showed significant effects on stolon internode and mean individual stolon branch length in 1984, though significant effects attributable to N disappeared in 1985. Clover leaf size was unaffected by N supply but leaves were larger (longer petioles, larger laminae) in taller swards, the differences being significant in 1984 ($P < 0.01$) but not in 1985. The average number of intact, i.e. ungrazed, leaves per stolon was low, usually less than 1.5, and was unaffected by treatment.

Clover growth. The number of leaves appearing per week in four separate 7-day measurement periods between 4 July and 11 September 1984 ranged from 1.28 ± 0.05 to 0.78 ± 0.03. This compares with average leaf appearances in 1985 of 0.75 ± 0.04 for the period 9 July - 22 August and 0.60 ± 0.03 for the period 20 August - 18 September, and provides further evidence of poorer clover growth in 1985 compared with 1984.

The adverse conditions in 1985 were such that 40-50% of the stolons marked to assess branching rates were lost by burial in mud. This reduced the ability to assess treatment effects, and consistent significant differences were confined to stolon extension rates which were faster in taller swards ($P < 0.05$ in three periods). Both stolon extension rates

TABLE 1
Seasonal patterns in rates of clover growth (expressed as means per stolon per week ± standard error)

PERIOD 1985	STOLON EXTENSION (mm)	LEAF APPEARANCE (leaves)	PRODUCTION OF FLOWER AND STOLON BUDS (numbers)
7 May - 5 July	1.70±0.123	0.51±0.015	0.104±0.014
5 June- 7 August	2.11±0.161	0.58±0.031	0.057±0.011
9 July- 22 August	2.16±0.216	0.75±0.043	0.034±0.013
20 Aug - 18 Sept	2.10±0.106	0.60±0.029	0.009±0.003

and leaf appearance rates were lowest in May-July (Table 1); stolon extension rates showed little seasonal variation thereafter while leaf appearance rates increased to a maximum in July-August. By contrast the production of axillary meristems (flower and stolon buds) was at a maximum in the first period and declined thereafter. Flower buds were few and the pattern was similar if these were omitted.

The proportion of leaf nodes occupied by flower or stolon buds for the morphology samples indicated that branch development was higher in 1984 than in 1985. The trends were consistent with a seasonal pattern of declining branching rate after mid-summer. For example, in 1984 the proportion of all nodes occupied declined from 0.26 ± 0.07 on 4 July to 0.15 ± 0.04 by 3 September and in 1985 from 0.16 ± 0.04 on 28 June to 0.08 ± 0.06 on 28 August. Expressed as a proportion of nodes of leaf age 4 or older (the mean youngest age for visible signs of stolon bud development) the figures for 1984 were 0.56 ± 0.09 on 4 July and 0.27 ± 0.07 on 3 September, and for 1985 were 0.37 ± 0.05 on 28 June and 0.19 ± 0.16 on 28 August. The proportion of leaf nodes appearing within the measurement periods on the marked stolons in 1985 which showed flower or stolon bud development declined steadily from 0.20 ± 0.02 for the first period (7 May - 5 July) through intermediate values of 0.11 ± 0.02 and 0.04 ± 0.02 to 0.01 ± 0.01 in the fourth period (20 August - 18 September).

Light profiles. Light transmission to ground level was reduced by increasing sward height (10-30% transmission in 5 cm swards compared with 30-60% in 2.5 cm swards) as also was the red/far red ratio (0.43-0.68 in 5 cm swards compared with 0.58-0.80 in 2.5 cm swards). There were no differences in light quality or quantity at ground level or clover lamina height associated with N treatment.

Consideration of clover performance in relation to sward canopy structure effects on both the light and spatial micro-environment allows a partial explanation of results. For example, the differences in clover morphology associated with sward height (longer stolon internodes, longer petioles, larger leaves and reduced axillary branching in taller of shorter swards), together with the measured differences in quality and quantity of light penetration into the canopy, accord with general theory of the effects of light on morphogenesis. Similarly, though phenological control cannot be ruled out, the within-season changes in clover branching rate are explicable on the basis of the seasonal variation in incoming radiation, the seasonal changes in tiller density and canopy structure, and the changing light micro-environment of the sward.

The differences in clover growing point numbers in N_1 compared with N_0 swards, however, are not explicable solely on the basis of light. Some further reduction in clover as a result of the reduced space afforded in N_1 swards (because of the increased grass tiller density) is to be expected. However, examination of the relationship between clover growing point numbers and grass tiller density on individual turf samples across N treatments at the same sward height (Figure 2) while providing evidence of the limiting effects of grass tiller density, also shows that this effect is inadequate to explain the extent of reduction in clover in N_1 swards. It is concluded that more work is needed on plant-soil interactions in the presence of grazing animals.

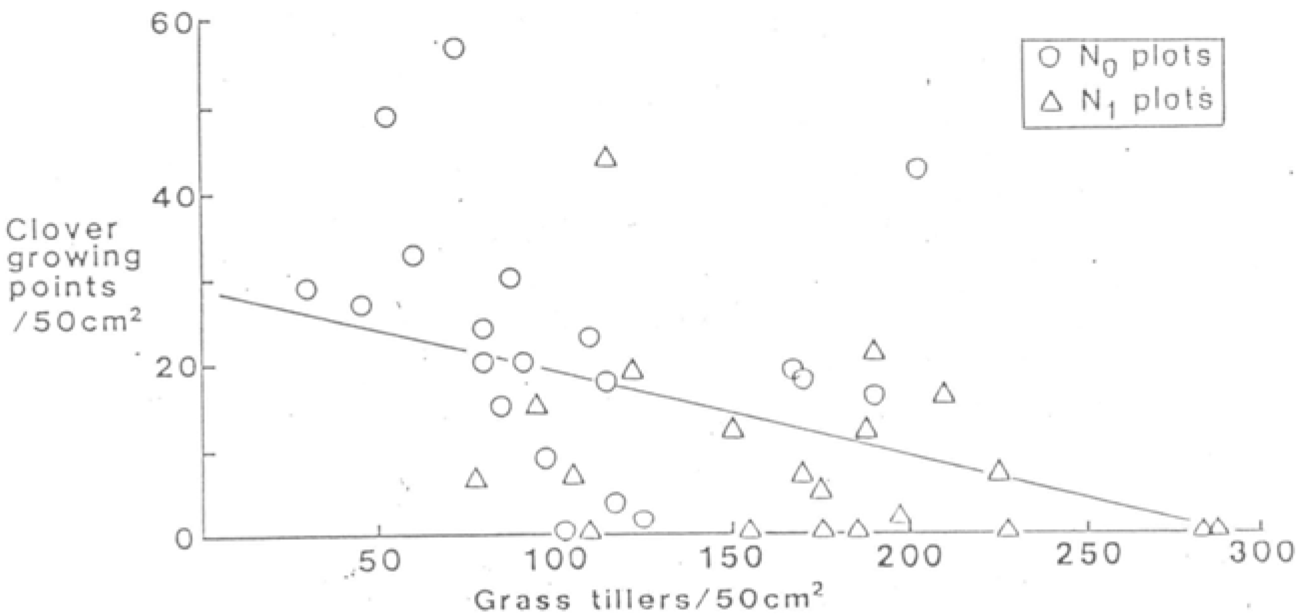

Figure 2. If the decrease in clover in the N_1 swards was explicable on the basis of the spatial limitations associated with the increase in grass tiller density, the scatter of points from the N_0 and N_1 swards should be even about the line describing the general relationship for the two populations. χ^2 analysis ($\chi^2 = 6.4$, $p<0.05$) shows this not to be so.

Figure 2 also shows that the variance in clover growing point numbers is greater at lower than at higher grass tiller densities. The data, however, are for 1984 in the early years of clover establishment. It would be useful to see whether the pattern of variance has changed with time.

In 1986, in addition to the basic follow-up of treatment effects on grass and clover population densities, and on clover branching rate, it is proposed to incorporate extra plots and measurements, as appropriate, to investigate a) whether the seasonal trends in clover branching rate are subjected to phenological control or whether they are the result of changes in the sward micro-environment and b) which of a range of factors are most strongly associated with the spatial heterogeneity of clover distribution within the sward.

The results of the associated animal observations are reported on pages 84-86.

Research objective: **Evaluate seasonal patterns of herbage production and the response to grazing of potential plant material (no. 003013)**

2.2 Seasonal patterns of grass production

D.E. Suckling, P. Newbould and J. Hodgson

As part of an FAO study throughout Europe under the coordination of the AGRI, a trial was set up at Hartwood during 1983. Two cultivars of perennial ryegrass (Cropper and Perma) are harvested in an overlapping series of cuts at four-week intervals throughout the grazing season. Phosphorus is applied at the start of the season (30 kg/ha) and N and K are applied weekly to give a total of 600 kg N/ha and 230 kg K/ha over the season.

Figures 1 and 2 show the growth curves for the two cultivars in 1984 and 1985. 1984 had a total of 480 mm rainfall between the end of March and the end of October whereas the similar total for 1985 was 837 mm, though direct comparisons of weather effects are complicated because 1984 swards were in their second harvest season whereas the 1985 swards were in their first season. In the dry 1984 summer, maximum growth rates of 100 kg/ha/day in Cropper and 120 kg/ha/day in Perma was obtained. Spring growth rates were higher in 1985, but growth rates during the second half of the season remained much higher in 1984 than in 1985 despite the much wetter 1985 summer when water was not a limiting factor.

In both varieties, the colder spring of 1984 delayed the onset of growth by about two weeks. By the end of October in both years, low temperatures had depressed the growth rate to under 10 kg/ha/day.

The project is being repeated annually to further quantify the seasonal production of ryegrass under varying climatic conditions.

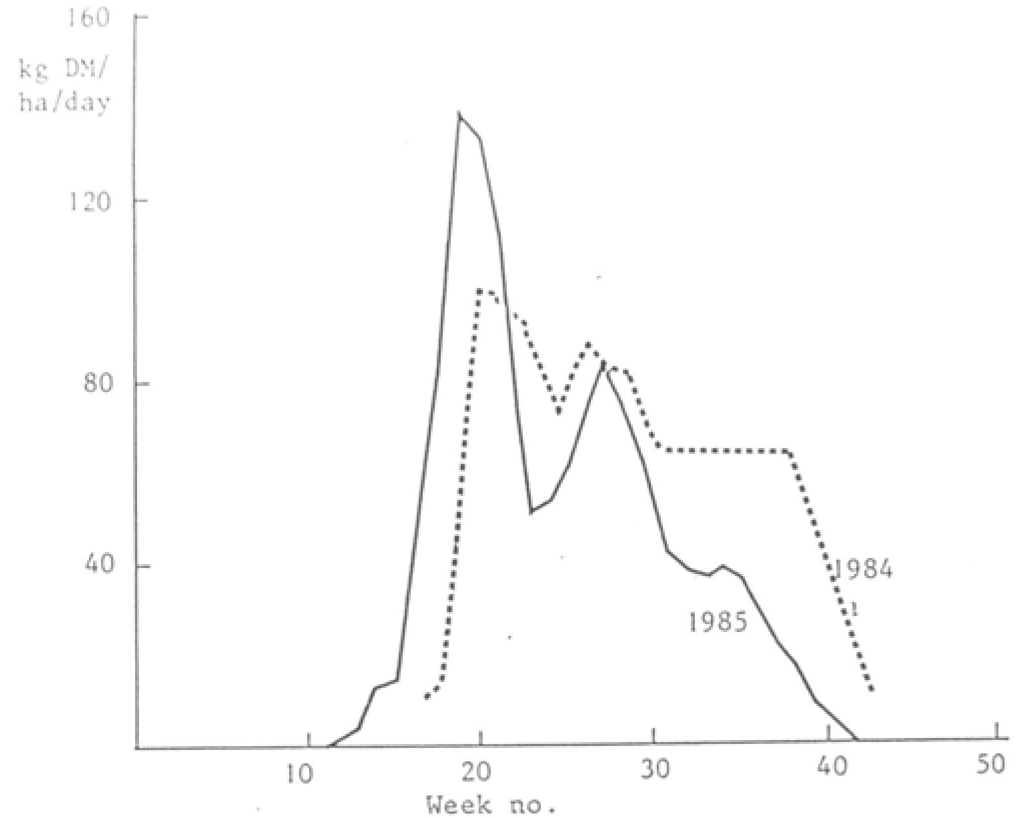

Figure 1. Growth of perennial ryegrass cultivar Cropper in 1984 and 1985

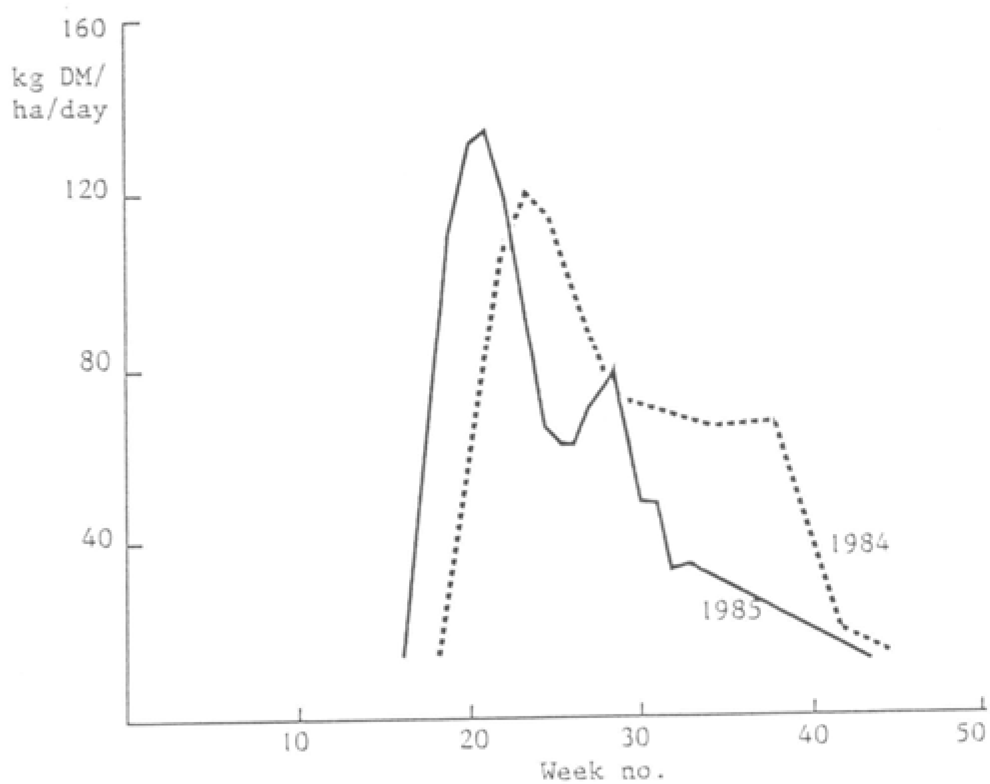

Figure 2. Growth of perennial ryegrass cultivar Perma in 1984 and 1985.

2.3 Comparative evaluation of Trifolium ambiguum and Trifolium repens under grazing and cutting conditions

G.R. Bolton, J. Hodgson and P. Newbould

The objectives and design of this experiment were outlined in the 1984 annual report, page 132. In an attempt to improve the low leaf production of 1984 and encourage the spread of T. ambiguum plants by leaving more photosynthetic material after each defoliation, the two replicates that had been used for an acclimatization period before each measurement period in 1984 were cut to a height of approximately 5 cms whilst the other two replicates were grazed. All replicates were defoliated once every four weeks. Potassic superphosphate to supply 30 kg P/ha and 55 kg K/ha was applied to all replicates in early spring. Production figures are shown in Table 1.

TABLE 1
1985 Production Data

	T. ambiguum						T. repens	
	Summit (2n)		Treeline (4n)		Prairie (6n)		Huia	
	Grazed	Cut	Grazed	Cut	Grazed	Cut	Grazed	Cut
% Death over winter	7.8		32.8		12.5		6.2	
No. leaves produced	49	66	75	75	77	83	420	571
% plants with rhizomes	20	41	38	33	3	28	-	-
Spread (cms)	11.0	12.5	12.8	17.7	10.0	17.5	38.1	46.7

Winter survival of the tetraploid variety (Treeline) was very poor but the numbers of diploid and hexaploid varieties surviving were similar to the numbers of T. repens.

There was very little difference in leaf production between T. ambiguum varieties but this was far below the production of T. repens.

There was a gradual increase in rhizome production over the season but final numbers were not high. There is no obvious reason for the extremely low number of rhizomes produced by the grazed hexaploid variety. Distance of spread from the parent plants was not great for any variety of T. ambiguum and was far less than the spread of T. repens.

Another possible cause of poor performance of the T. ambiguum could have been competition from the surrounding grass population. In 1985 a small area adjacent to the existing plots was divided into four replicates and the grass on two replicates sprayed with 'Round-up' whilst the grass on the other two replicates was left as normal. Plants of T. ambiguum and T. repens that has been left in pots after the 1984 planting were planted out in these replicates on a 1 m square basis in late June and left to establish. Eight weeks later all replicates were cut to a height of approximately 5 cms and after a further seven weeks leaf and rhizome production measured. Figures are shown in Table 2.

TABLE 2
Leaf and rhizome numbers on sprayed and unsprayed plots

		Leaves produced in 7 weeks	% of plants with rhizomes at 10/85
SPRAYED	Diploid	33	64
	Tetraploid	28	46
	Hexaploid	25	50
	Huia	73	-
UNSPRAYED	Diploid	10	37
	Tetraploid	4	8
	Hexaploid	19	40
	Huia	44	-

Leaf production in the sprayed plots after the initial cut was very similar to that in the grazed/cut plots for the same time period and was much lower in the unsprayed plots, probably due to severe competition by the grass whilst the plants were establishing. As in the grazed/cut plots *T. repens* had a distinct advantage over *T. ambiguum*.

In order to test establishment of *T. ambiguum* from seed under field conditions, four one metre square plots of cultivated ground were sown with three or four inoculated seeds of the *T. ambiguum* varieties and *T. repens* at 10 cm intervals in late June. After emergence the weakest plants were removed to leave one plant at each position. No detailed plant measurements were taken but at the end of the season the visual impression was that *T. repens* had a ground cover of 75-80% and all *T. ambiguum* varieties had only 20-25% cover.

This work has been discontinued.

2.4 Comparative evaluation of Holcus lanatus and Lolium perenne under grazing

G.R. Bolton, J. Hodgson and P. Newbould

The objectives of this experiment for 1985 were described in the latter part of the 1984 annual report, p. 132. All plots received 150 kg N/ha, 62 kg P/ha and 62 kg K/ha in three equal dressings over the growing season. Organic matter production is shown in Table 1.

TABLE 1
OM production (kg/ha)

Post-grazing residue (kg OM/ha)	Massey Basyn	German	Perennial Ryegrass
500	6160	6070	6240
1000	6540	7710	7970

By reducing grazing pressure to leave more organic matter at the end of each grazing, production of German commercial H. lanatus and Lolium perenne appeared to increase.

Proportions by weight of the sown grasses, other poorer grasses and clover at the beginning and end of the growing season are shown in Table 2.

TABLE 2
Proportions of sward constituents (% by weight)

		SOWN SPECIES		OTHER GRASSES	CLOVER
Beginning of 1985		Green	Dead		
500 kg/ha	Massey	51.37	4.33	38.65	3.85
	German	63.58	2.37	28.30	3.51
	PRG	82.31	4.75	8.50	3.77
1000 kg/ha	Massey	60.27	3.21	29.40	5.55
	German	46.34	2.72	42.19	3.84
	PRG	87.02	3.07	5.10	4.13
End of 1985					
500 kg/ha	Massey	11.63	1.68	83.95	2.10
	German	6.62	1.35	86.31	4.03
	PRG	55.90	2.06	38.00	3.40
1000 kg/ha	Massey	19.76	6.26	69.89	3.62
	German	8.24	4.36	87.38	2.25
	PRG	59.02	2.10	34.50	4.13

By the end of the season, at both grazing pressures, the proportions of both Holcus varieties were unacceptably low and correspondingly the proportions of poorer grasses unacceptably high. The proportion of Lolium perenne was still at a reasonable level.

Ground cover as indicated by a point quadrat analysis (100 points per plot) at the end of 1985 is shown in Table 3.

TABLE 3
% ground cover

	Bare ground	Holcus Green	Holcus Dead	RG Green	RG Dead	Clover	Other Grasses	Weeds
500 kg/ha								
German	23.0	9.5	2.5	1.0	-	9.0	55.0	1.5
Massey	10.5	18.0	3.0	1.0	-	6.5	59.5	1.0
PRG	21.5	-	-	36.0	5.5	8.0	24.5	3.0
1000 kg/ha								
German	10	17.0	2.5	1.5	-	11.5	60.0	0.5
Massey	9.5	26.5	4.5	2.0	-	11.0	45.0	1.5
PRG	21.5	0.5	-	36.5	5.5	8.0	26.5	0.5

It would appear that ground cover of the *Holcus* varieties was reduced by continuing the high grazing pressure of 1984 and barely maintained at the 1984 level by easing of the grazing pressure. The ground cover of *Lolium perenne* seemed to be unaffected by grazing pressure. In all cases it appears that bare ground was not colonized by sown grasses or weeds but by poorer grasses such as *Poa* and *Agrostis* spp.

It is concluded that *Holcus* is not persistent enough to merit its use as an alternative to ryegrass under intensive grazing management in upland situations.

Research objective: **Quantify the interrelationships between sward structure and the ingestive behaviour and nutrient intake of grazing animals (no. 003014)**

2.5 Inter-relationships between the effects of body size and sward state on ingestive behaviour and herbage intake in grazing sheep

D.A. Clark, J. Hodgson, E. Robertson, M.M. Beattie and E.A. Hunter (AFRUS)

Most studies on the effect of sward structure on herbage intake and grazing behaviour have been carried out with a single class of grazing animal. This trial was intended to study the effects of variation in body size and productive state upon these variables, and their interactions with sward conditions. Four ewe genotypes (Halfbred, Greyface, Cheviot x Shetland and Welsh Mountain), half of each genotype suckling twins and half being dry, were allocated initially to three swards (2-3, 4-5 and 7-8 cm surface height) and re-allocated across swards in successive three-week period. Measurements of herbage intake and grazing behaviour were made in each period and related to measurements of ewe body weight and weight change, milk yield and lamb performance.

Information on grazing behaviour is derived from Vibracorders, Penning bite meters and visual observations. Lactating ewes grazed longer than dry ewes, frequently for longer than 14 hours per day, and Halfbred ewes in mid-lactation grazed for 17.7 hours. Smaller genotypes had faster biting rates during grazing and faster chewing rates during rumination than did larger genotypes, and also had a lower ratio of masticating to biting jaw movements during grazing. Information on diet composition, herbage intake and animal performance is currently being analysed.

Research objective: **Investigate the influence of the clover content of grass/clover swards on animal performance and output (no. 003015)**

2.6 Influence of sward height and fertiliser N use on animal production from mixed grass/clover swards

G.T. Barthram

Yearling Greyface ewes (initial weight 75 kg) were used to control plots of a mixed sward at three heights (2.5, 3.5 and 5.0 cm), each with (N_1) or without (N_0) fertiliser N (see p. 75) and the weight gain and stocking densities of the sheep were monitored continuously. As expected the shorter swards carried more stock than the taller (e.g. 75/ha and 60/ha at 2.5 cm and 5.0 cm respectively in early July) and the N_0 swards carried fewer sheep than the N_1 swards (Fig. 1). In these conditions the seasonal patterns of stocking rate will have a similar shape to the seasonal pattern of herbage production. The results show that with constant sward height and continuous stocking the herbage production curve has a single mid-summer peak, which contrasts with the spring and summer peaks observed in cut swards (see p.).

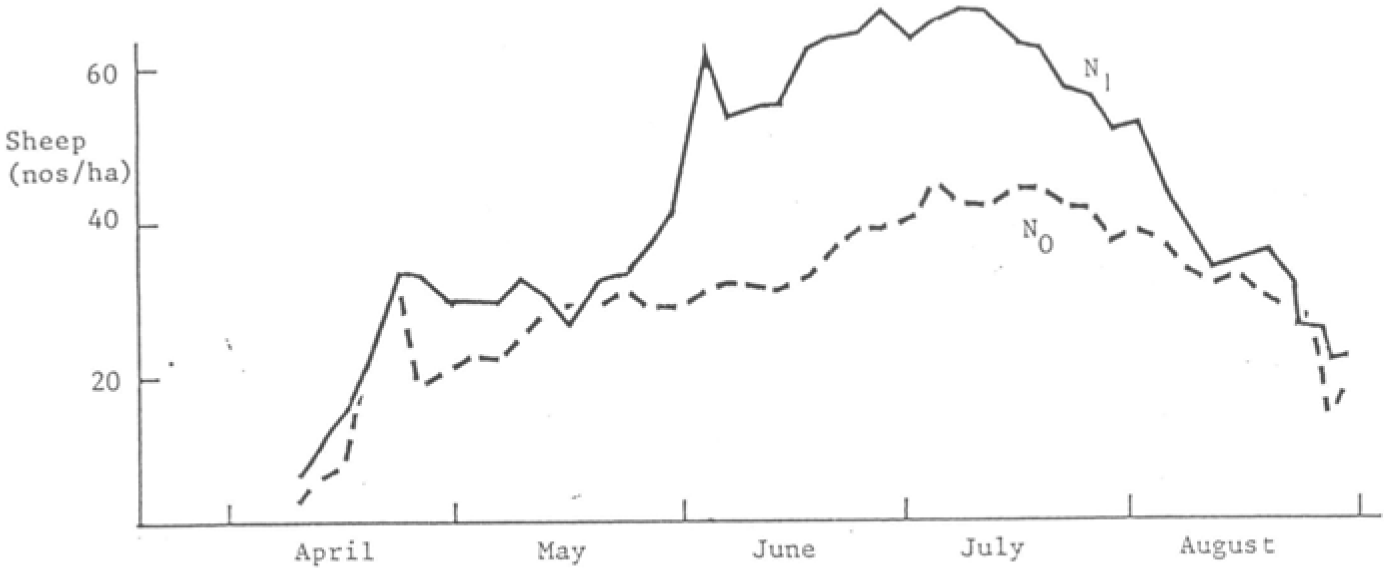

Figure 1. Seasonal variations in stocking rate (sheep per hectare) in swards with or without nitrogen.

During May and June weight gain per sheep was greater on tall than on short swards (30 g/day and 242 g/day, SED 20, on 2.5 cm and 5.0 cm swards respectively). This advantage more than affect the difference in stocking densities, so that weight gain per hectare was also substantially greater on taller swards (1.7 and 5.7 kg/ha/day, SED 0.5 0.5, on 2.5 cm and 5.0 cm swards respectively. Weight gains per sheep and per hectare were similar on N_0 and N_1 swards (3.7 and 4.0 kg/ha/day, SED 0.4). During July and August weight gains per animal and per hectare were not affected by either sward height or N use (mean 3.1 kg/ha/day, SED 0.4).

Measurement of diet composition and herbage intake were made in the autumn of 1985 (see below), and will be continued in 1986, in order to explain these effects.

2.7 Diet selection and herbage intake by cattle and sheep from mixed grass/clover swards

D.A. Clark, J. Hodgson, E. Robertson and G.T. Barthram

In September 1985 measurements were made of diet composition and herbage intake in sheep grazing the clover management trial described under 2.6 above. Clover leaves contributed 1.2% and 12.2% (point contact basis) of the diet on N_1 and N_0 plots respectively when sward contents were 2.3% and 7.7% (DM basis) respectively. The clover content of the diet was not influenced by sward height on N_1 plots, but on N_0 plots the dietary clover contents were 7.2%, 16.9% and 12.5% (point) for the 2.5, 3.5 and 5.0 cm sward height treatments. Corresponding sward clover contents were 8.1%, 10.5% and 4.6% (DM).

Adjacent areas of the same mixed grass/clover sward were grazed by mixed groups of sheep and cattle in the autumn of 1985. One area had a mean clover content (lamina plus petiole) of 9.3% and 23% of the clover was present in the top half of the sward canopy; the second area had a higher clover content (20.7%) and a substantially higher proportion (41%) of this was in the top half of the canopy. The mean dietary proportions of clover were 21.7% and 5.0% for sheep and cattle respectively on the first sward, and 44.6% and 39.3% on the second.

These results suggest that selection for clover by sheep is greater at low than at higher sward clover contents, and that dietary clover contents are more sensitive to variations in sward structure in cattle than in sheep. However, evaluation of the results must await the analysis of detailed information on sward structure.

2.8 Discrimination by sheep between swards of differing white clover content

D.A. Clark and J. Hodgson

The effect of contrasting white clover contents on diet selection by grazing sheep provides an insight into grazing behaviour mechanisms. When sheep have a choice between 'strips' containing either 70% white clover or 100% graass they consistently choose to graze the former. When clover is intermingled with grass in normal sheep-grazed swards evidence for selective grazing is less clear. The objectives of this experiment were, firstly, to define the pattern of discrimination in response to variation in the contrast in clover content between alternative swards and, secondly, to test whether the pattern is affected by the mean clover content about which the range is established.

Two 'base' levels of clover content 30 and 60%, together with 7 'contrast' levels from -30 to +30% of 'base' level were planned. Swards of equal content were included as controls. Thus the 30% base was contrasted with 0, 10, 20, 30, 40, 50 and 60%; and the 60% base with 30, 40, 50, 60, 70, 80 and 90% white clover. Each combination of treatments was repeated at two nitrogen levels: 0 and 30 kg N/ha and the whole replicated twice. The experimental area was at Grasslands Division, Palmerston North, New Zealand. The pasture comprises well-established Ruanui ryegrass - Huia white clover with some weed species. Fifty-six plots (5.6 x 3.5 m), each containing 2 'contrast' areas at 2.8 x 3.5 m were sprayed with different herbicides on 29 July 1983 to achieve the above contrasts. Experimental grazing on 13-16 December 1984 was preceded by training of sheep to accustom them to experimental procedures on reserve plots. Seven plots were each grazed by 3 sheep morning and afternoon. Three observers recorded grazing activity and position at 30 sec. intervals for 30 minutes. The proportion of time spent grazing each sub-plot was calculated. Multiple regression analysis was used to test the effects of: clover contrast (%), mean clover content (%), nitrogen, herbage mass, weed species (%) and dead matter (%) on the proportion of time spent grazing the 'base' plots.

The herbicide treatments failed to achieve as wide a range of contrasts as planned, but were sufficiently effective to provide a range similar to that found in grazed pastures. The planned and actual contrasts, mean contrast/base clover content and proportion of time spent grazing the base plot are shown in Table 1. The planned contrasts proved difficult to achieve and a range of -23 to +15% instead of -30 to +30% occurred. Mean clover levels were close to those planned for the base level of 30%, but were lower than required at the 60% base.

The relationship between the proportion of time spent grazing base plots (Y) and pasture parameters was best described by the following equation:

$$Y = 0.49\ (\pm\ 0.01)\ -0.0118\ (\pm\ 0.002)X_1\ +\ 0.0002\ (\pm\ 0.00007)X_2 \quad \ldots\ldots(1)$$

d.f. = 11, R-sqaured (adjusted) = 82.1% RSD = 0.03

where X_1 = actual difference in white clover content from base plot

X_2 = interaction of actual difference in white clover (X_1) with the mean content of white clover in contrast and base plots

TABLE 1
Planned and actual white clover contrasts (%), mean contrast/base clover content (%) and proportion of time spent grazing base plot (30 or 60% white clover). (Averaged for 2 nitrogen levels and 2 replicates).

Planned contrast/base	(% difference from base)	Actual difference from base	Mean clover in contrast + base	Proportional time grazing base
0/30	(-30)	-23	12	0.73
10/30	(-20)	- 3	23	0.53
20/30	(-10)	- 2	30	0.52
30/30	(0)	- 1	33	0.51
40/30	(+10)	13	36	0.46
50/30	(+20)	- 7	35	0.45
60/30	(+30)	12	45	0.42
30/60	(-30)	- 6	40	0.54
40/60	(-20)	-15	33	0.58
50/60	(-10)	-15	33	0.58
60/60	(0)	6	40	0.51
70/60	(+10)	9	42	0.46
80/60	(+20)	- 2	51	0.49
90/60	(+30)	15	46	0.41

The intercept in equation (1) shows that sheep were grazing plots of equal clover content indiscriminantly (i.e. not significantly different from 0.5). Sheep spent a greater proportion of their grazing time on plots containing a higher proportion of white clover. However, this preference decreased as the mean content of clover in the sward increased. If this trend continued 'switching' of preference to plots lower in clover might occur, but mean clover levels above 50% are needed to test this hypothesis. There is a possibility that the interaction resulted from strong discrimination against plots containing no clover. If they are considered as outliers then the best equation is:

$$Y = 0.50\ (\pm\ 0.009) - 0.0045\ (\pm\ 0.0009)X_1 \quad \ldots\ldots (2)$$

d.f. = 11, R-squared (adjusted) = 67.0% RSD = 0.03

In this case the interaction term is non-significant but a continuous discrimination in favour of clover areas still exists. If patches containing no clover are rejected more strongly than suggested by a linear change of discrimination then clover plants existing in discrete patches in a grass dominant sward will suffer more grazing pressure than those in pastures with more even distribution. The results fit a very simple model of sheep grazing behaviour that involves random movement during grazing coupled with decisions to graze particular patches based solely on clover content. The probability of grazing increases linearly with increasing clover content.

3. FORAGE CROPS

Research objective: **Investigate the influence of the structure of forage crops upon nutrient intake and grazing efficiency of animals (no. 003016)**

3.1 Comparison of intake and live-weight gain in lambs fed ryegrass or rape

R.H. Armstrong, J. Hodgson, M.M. Beattie, E. Robertson and D. Elston (AFRUS)

Recent studies on the forage intake and performance of lambs grazing brassica forage crops have been limited by partial crop failures in two years. However, indoor measurements using mature rape stem of relatively low *in vivo* digestibility (0.646 OMD) and voluntary intake (15.1 g OM/kg LW) provided an opportunity to extend the range (0.65-0.85) and improve the accuracy of the equation used to predict the OMD of forage eaten in grazing studies from the *in vitro* digestion (IVOMD) of samples of forage:

$$OMD = 19.44 + 0.788\ IVOMD\ (r^2 = 0.98)$$

Analysis of samples of rape (*Brassica napus*) components from the two previous indoor trials (1981 and 1982) by S.C.R.I. showed that there were no simple relationships of intake to contents of total glucosinolates, progoitrin or S.M.C.O. as suggested by Bradshaw *et al* (1984) and Barry *et al* (1984) respectively.

Previous studies (1984 annual report, p.138) showed that digestibility of rape was usually higher than of sown grass but suggested strongly that intake of rape was lower than might be expected on the basis of digestibility, though no good comparisons have been made. Even though antimetabolites may depress intake, the physical condition of sown swards also affects intake (Hodgson and Milne, 1978), through the influence of mouthpart size and ingestive behaviour (Penning, 1983). Consequently direct comparisons were made between intake on ryegrass/clover swards and giant rape at each of two initially similar herbage allowances (5% and 10% of liveweight/day). The ryegrass was a vegetative regrowth following close grazing in August.

Digestibility of grass was high, especially in the first period (Table 1) but that of rape was consistently higher. Levels of intake were also usually higher for rape, and more variable within treatments than for grass. Levels of live-weight gain or final carcass weight were not significantly different between treatments, and the higher gain on grass at 5% allowance may reflect greater gut fill, see equations (1) and (2).

Equation (1) Carcass wt. (grass) = $-5.1 + .58LW$, RSD = 0.70, $R^2 = 0.88$
(2) Carcass wt. (rape) = $-1.2 + .48LW$, RSD = 0.82, $R^2 = 0.85$

Relationships between digested organic matter intake and live-weight gain were poor:-

LWG (grass) = $41.5 + 0.15$ DOMI, $R^2 = .28$, RSD = 30

LWG (rape) = $-47.5 + 0.22$ DOMI, $R^2 = .47$, RSD = 50

Consequently there is no good evidence of differences between grass and rape in the efficiency of utilisation of DOMI for gain.

TABLE 1

	OMD		OMI (g/day)		Carcass wt. (kg)	LWG (g/d) (21/10-5/12)
Period	I	II	I	II		
Rape 10%	.88	.88	1148	1088	16.06	150
Rape 5%	.87	.88	864	827	15.88	118
Grass 10%	.83	.82	974	864	16.11	149
Grass 5%	.83	.77	864	651	15.95	149
SED	.007		90		-	23

Estimation of diet composition and its relationships to grazing behaviour, herbage mass and composition are not yet available.

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Hodgson, J. and Milne, J.A. 1978. The influence of weight of herbage per unit area upon the grazing behaviour of sheep. 7th Gen. Meeting European Grassland Federation, Ghent, 4.31-4.38.

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PROGRAMME UNIT 1: FACTORS AFFECTING PRODUCTION OF HERBAGE FROM HILL AND UPLAND PASTURE

1. NITROGEN TURNOVER

Research objective: **Establish the role of organic nitrogen for grass growth in grazed swards (no. 004001)**

1.1 Improvements in efficiency of N fertiliser applications to grass sward

R.J. Thomas, K.A.B. Logan, A.D. Ironside, G.R. Bolton

Growth rate or yield of grass is a hyperbolic function of total herbage N concentration (e.g. Smith et al, 1985). When grass is fed increasing concentrations of N fertiliser containing nitrate (e.g. nitram) yield can also be represented by a hyperbolic function (or Michaelis-Menten kinetics) as shown in Fig. 1. In addition at or near maximum yield the concentration of nitrate in herbage increases from low levels (Fig. 1). The accumulation of nitrate in herbage with increasing yield can be separated into three zones (Fig. 2 and van Burg, 1966).

1. A deficiency zone where yield increases markedly at constant low nitrate concentrations.

2. A transitional zone, when both yield and internal nitrate concentration increase.

3. A sufficiency zone, when yield increases little but internal nitrate concentration increases markedly.

These relationships have been tested in the growth chamber with pots of ryegrass given a range of nitrate concentrations (0.1 - 100 mm NO_3^--N solutions). Nitrate in ryegrass leaves is rapidly measured using Merkoquant strip tests. Cell sap is extruded from leaf blades using a 1 ml syringe onto the test strips. The semi-quantitative analysis of nitrate in cell sap is completed within 1 min. Results show that at nitrate levels of 500 mg NO_3^--N/l cell sap growth is at a maximum in pots fed once weekly with nitrate concentrations greater than 60 mm NO_3^--N (Fig. 3).

Attempts are also being undertaken to relate colour (green) to total herbage N using Munsell colour charts. A combination of leaf colour and nitrate concentration will then be used to assess the N fertiliser requirements of grass in the field using the observed relationships between growth rate, total N (colour) and leaf nitrate. Initially the tests will be used to improve the efficiency of N fertiliser use by determining when grass does not require further fertiliser additions.

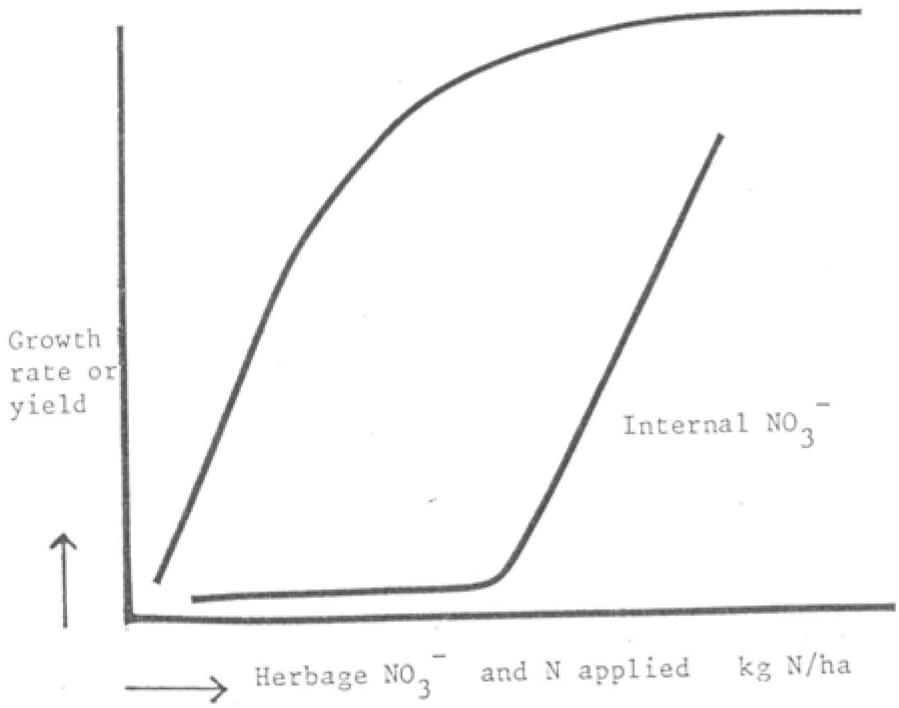

Figure 1. Relationship of growth rate or yield and herbage NO_3^- concentration with applied nitrogen.

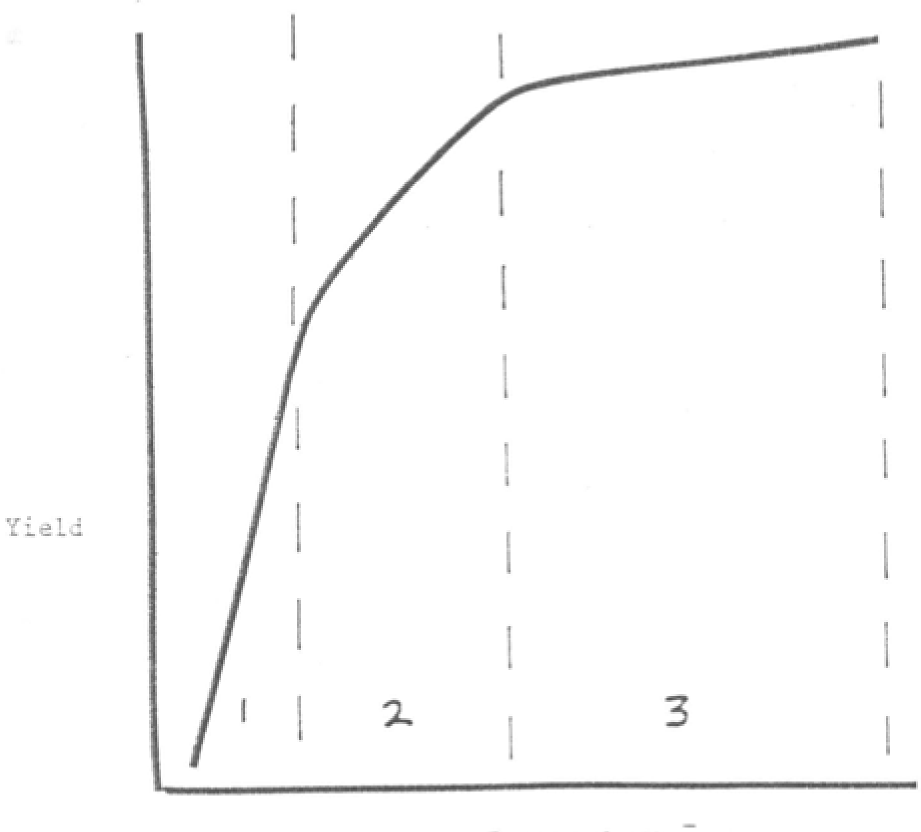

Figure 2. Relationship of yield with herbage NO_3 concentration.

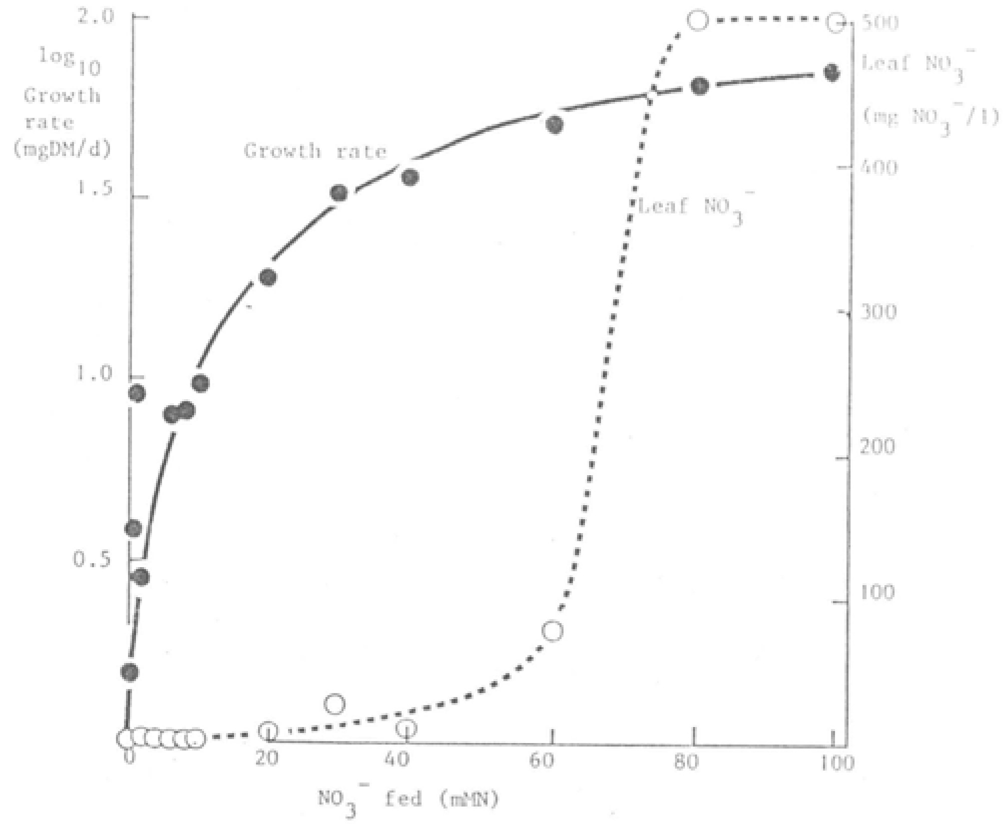

Figure 3. Effect of applied NO_3^- on growth and NO_3^- concentrations in leaves of ryegrass.

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1.2 Net N uptake by ryegrass in grazed swards with and without excretal returns

R.J. Thomas, K.A.B. Logan, A.D. Ironside and G.R. Bolton

As described in the HFRO annual report 1984 p.143, a modified version of Grazing Ecology's tissue turnover technique was used to estimate net N uptake in continuously grazed grass-only swards maintained at a steady state height of 5 cm on Minefield, Hartwood in the latter part of 1984. This study was continued in 1985 to obtain measurements over a whole growing season for replicate grazed plots with and without excretal returns. Ewes were bagged for the latter plots.

Rates of N uptake were significantly greater in plots with normal returns from June onwards (Table 1). Mean N uptake values for with and without returns over the whole growing season in 1985 were 1.00 and 0.63 kg N/ha/day respectively, compared with 0.54 and 0.46 kg N/ha/day in late 1984.

Work on assessing the significance of excretal returns on pasture production is continuing.

TABLE 1
Effect of excretal returns on N uptake by grass

		KG N $ha^{-1}day^{-1}$	
Measurement period (1985)		+ Excretal returns	- Excretal returns
23/4 - 30/4		0.34 ± 0.04	0.47 ± 0.05
17/5 - 24/5		1.08 ± 0.07	1.17 ± 0.07
5/6 - 11/6		1.62 ± 0.18	0.59 ± 0.04
19/6 - 27/6		1.14 ± 0.14	1.06 ± 0.70
17/7 - 24/7		1.21 ± 0.19	0.48 ± 0.06
7/8 - 14/8		0.86 ± 0.13	0.19 ± 0.08
4/9 - 11/9		0.72 ± 0.10	0.43 ± 0.04
	$\bar{x}$	1.00	0.63

Research objective: **Investigate how nitrogen fixation is affected by grazing management and seasonal inputs of fertiliser nitrogen (no. 004002)**

1.3 <u>The effect of temperature on growth, assimilation of mineral N and fixation of atmospheric nitrogen by white clover</u>

C.A. Marriott, M.A. Smith and M.A. Baird

The effects of temperature and N source interactions on clover growth were investigated in a growth room experiment. This work complemented a field study at Glensaugh which assessed the effects of different forms of N fertiliser on sward yield and species composition, and nitrogen fixing activity of white clover.

White clover plants (cv. Huia) were grown in 50:50 acid washed silver sand:perlite under two temperature regimes: Low temperature (8°/5°C day/night) and High temperature (20°/15°C), with either N_2 fixation, ammonium or nitrate as N source.

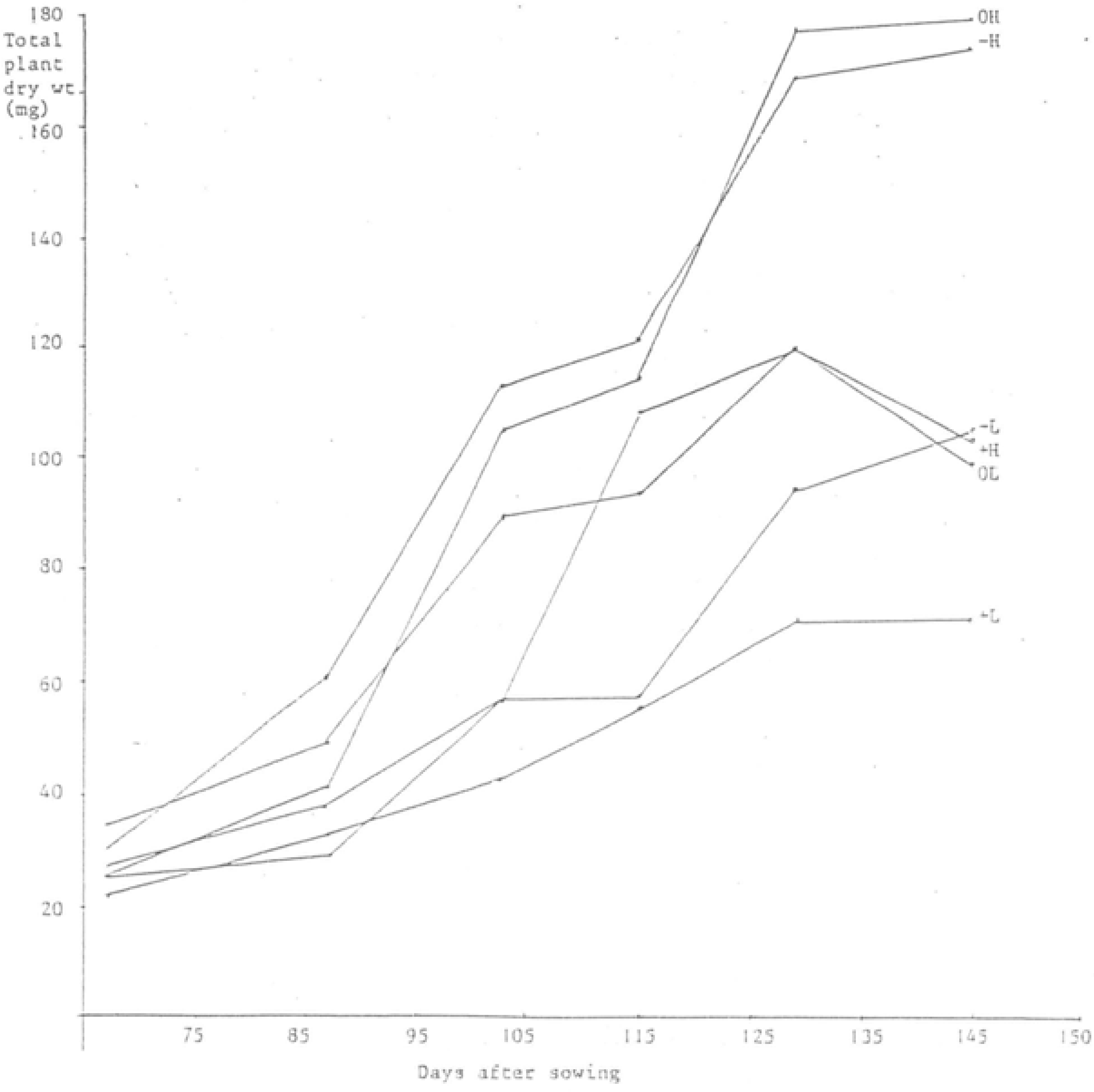

Figure 1 Total plant dry weight of clover grown at different temperatures (H = 20/15°C, L = 8/5°C) with different N sources. (0 = inoculated, + = ammmonium and - = nitrate).

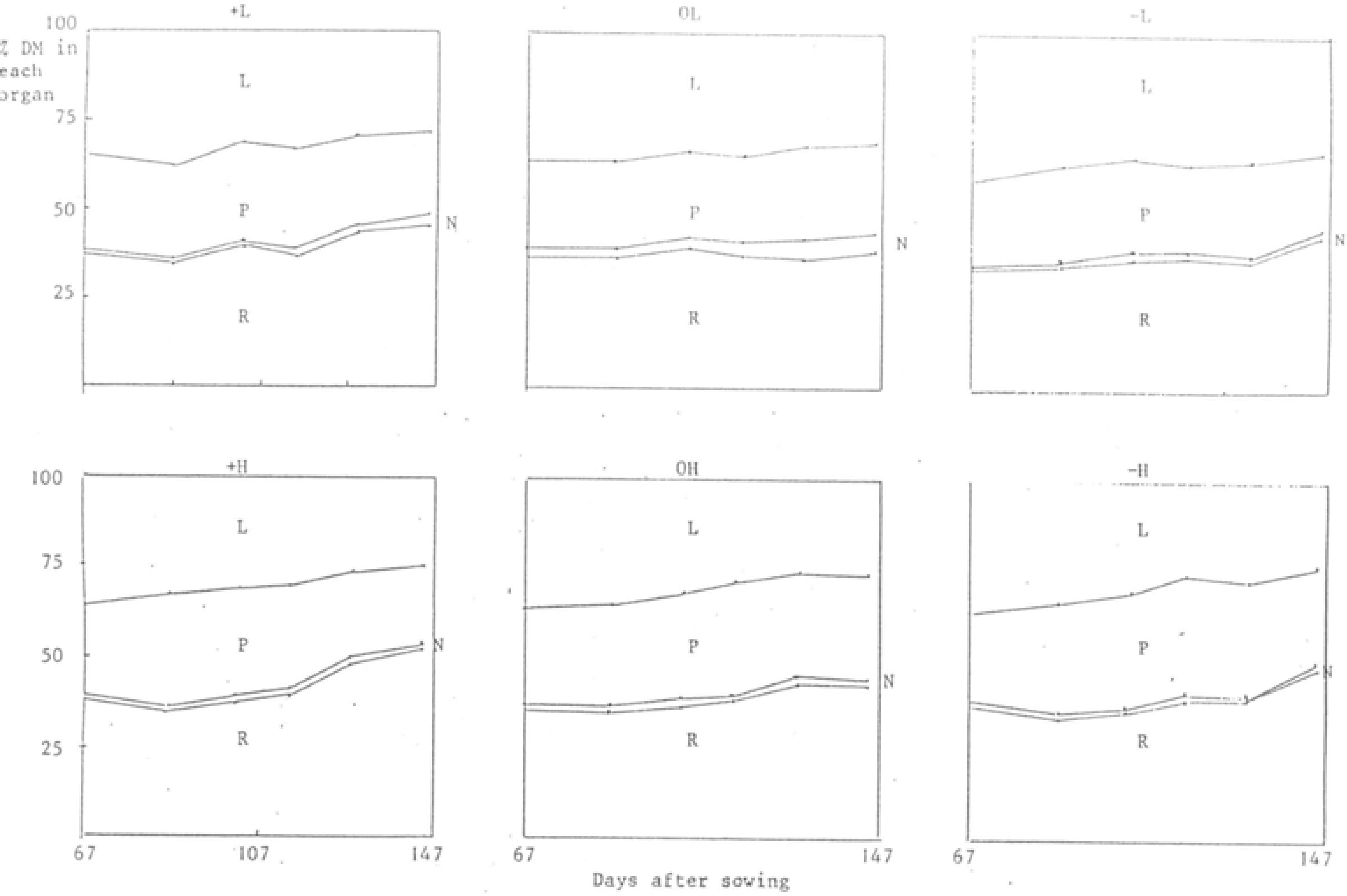

Figure 2. Partitioning of plant dry matter
in leaves (L), petioles (P), nodules (N) and roots (R) of plants grown at different temperatures (H = 20/15°C, L = 8/5°C) with different N sources (O = inoculated, + = ammonium, - = nitrate).

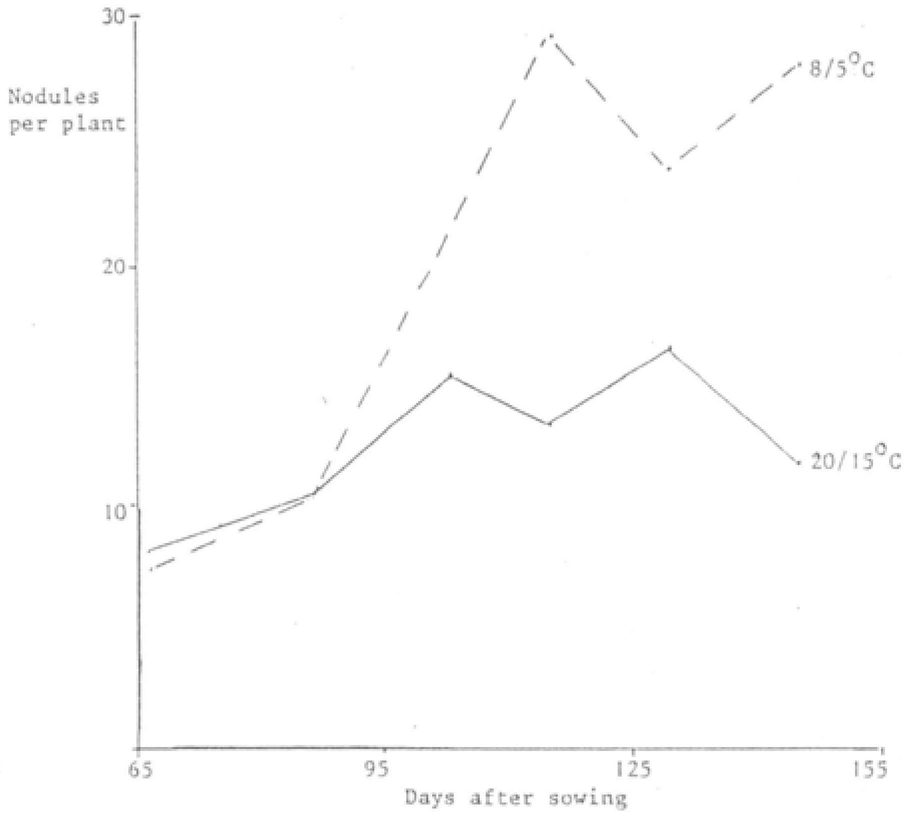

Figure 3. Nodule numbers in nitrogen-fixing plants.

Greatest growth occurred at the high temperature with no difference between plants fixing N_2 or assimilating nitrate; plants assimilating ammonium grew less well at both temperatures (Figure 1). There were only small differences in dry matter partitioning, but plants supplied with ammonium tended to have a lower shoot:root ratio at later harvests, particularly at the high temperature (Figure 2).

The relatively low rates of mineral nitrogen supplied did not prevent nodulation, but nodule number and mass (Table 1), and nitrogen fixing activity (Table 2) were reduced when compared with plants receiving no mineral N.

TABLE 1
Nodule DM/plant (mg) (n = 4)

	8/5°C			20/15°C			SED
Days after sowing	NH_4	NO_3	N_2Fix	NH_4	NO_3	N_2Fix	
67	0.18	0.23	0.48	0.30	0.30	0.43	0.09
87	0.42	0.56	0.69	0.54	0.80	0.83	0.20
103	0.73	1.21	2.35	1.18	1.35	1.96	0.44
115	1.04	1.22	4.21	1.55	1.56	2.66	0.52
129	1.68	1.73	5.50	1.61	1.86	3.46	0.54
145	1.92	2.08	5.11	1.68	1.78	3.63	0.65

TABLE 2
N_2 fixing activity per plant (nmol C_2H_4 min^{-1} $plant^{-1}$)

	8/5°C			20/15°C			SED
Days after sowing	NH_4	NO_3	N_2Fix	NH_4	NO_3	N_2Fix	
67	0.10	0.18	0.48	0.90	0.64	1.92	0.15
87	1.83	0.37	1.58	2.97	2.43	4.36	0.96
103	1.23	1.80	4.70	2.70	4.19	5.09	1.41
115	1.49	2.39	10.26	3.14	3.31	6.95	1.62
129	2.50	4.84	13.05	2.28	4.83	6.70	1.17
145	2.55	4.49	11.23	0.74	2.64	4.61	0.97

Although greatest growth of nitrogen fixing plants occurred in the warm temperature, nodule mass was greater at the low temperature. This can be interpreted as a compensatory mechanism for the reduced N_2 fixing activity per unit weight of nodule tissue at the early harvests of plants grown at low temperature (Table 3). The increased nodule mass was due to increased nodule numbers (Figure 3) rather than increased dry weight per nodule.

TABLE 3
N_2 fixing activity on a nodule DM basis (nmol C_2H_4 min^{-1} mg^{-1} nodule DM) for plants receiving no mineral nitrogen

Days after sowing	8/5°C	20/15°C	SED
67	1.18	4.36	0.81
87	1.60	4.03	1.16
103	1.96	2.51	0.33
115	2.40	2.57	0.26
129	2.37	2.11	0.44
145	2.26	1.25	0.17

Nitrogen concentrations of laminae did not differ significantly when different nitrogen sources were supplied but, from the second harvest onwards, were significantly greater ($p<0.01$) at the higher growth temperature (Table 4). Higher petiole nitrogen concentrations were

TABLE 4
%N in laminae from high and low temperature regimes (mean from all N treatments; n = 12)

Days after sowing	L	H	SED
	%N		
67	2.69	2.84	0.20
87	2.38	2.92	0.19
103	1.95	3.48	0.12
115	2.40	3.55	0.18
129	2.70	3.67	0.12
145	3.34	3.73	0.19

obtained when ammonium nitrogen was supplied, and also at high compared with low temperature. Nitrogen concentration of roots was significantly ($p<0.01$) increased in plants supplied with ammonium (Table 5), largely due to differences between plants grown at 8/5°C. The per cent N of roots of N_2 fixing plants was greater at 20/15°C but there was no significant effect of temperature when either ammonium or nitrate was supplied. Total plant nitrogen followed a similar pattern to dry matter production, with greatest accumulation of nitrogen at high temperature; N levels at high temperature were lower when NH_4 rather than NO_3 was supplied, but there was little difference in total N between plants grown with mineral N at low temperature.

The results suggest that, at temperatures typical of those in spring and summer at Hartwood, nitrate fertiliser will be less detrimental to clover performance than ammonium.

TABLE 5
%N in roots from different N regimes (mean from H and L temperature; n = 8)

Days after sowing	NH_4	NO_3	N_2Fix	SED
67	2.98	2.69	2.41	0.16
87	2.61	2.36	2.34	0.17
103	2.51	2.27	2.42	0.09
115	2.77	2.29	2.43	0.11
129	2.94	2.19	2.54	0.11
145	3.14	2.42	2.65	0.11

1.4 Nitrogen fixing activity of white clover in grazed swards maintained at 2.5, 3.5 and 5 cm with and without N

C.A. Marriott, M.A. Smith and M.A. Baird

The measurement of N_2 fixing activity of white clover continued over the spring-summer period in all sward height and N level treatment combinations. N_2 fixing activity on a ground area basis (Figure 1) depended mainly on the clover leaf content and to some extent on the previous grazing management i.e. whether sward heights were increasing or decreasing to reach target heights.

N application reduced the clover leaf content at all sward heights and consequently reduced levels of N_2 fixing activity were obtained. There appeared to be no consistent differences in specific N_2 fixing activity per g white clover leaf material (Figure 2) in contrast to results obtained with 3.5 cm swards in 1984 where specific activity was reduced by N application.

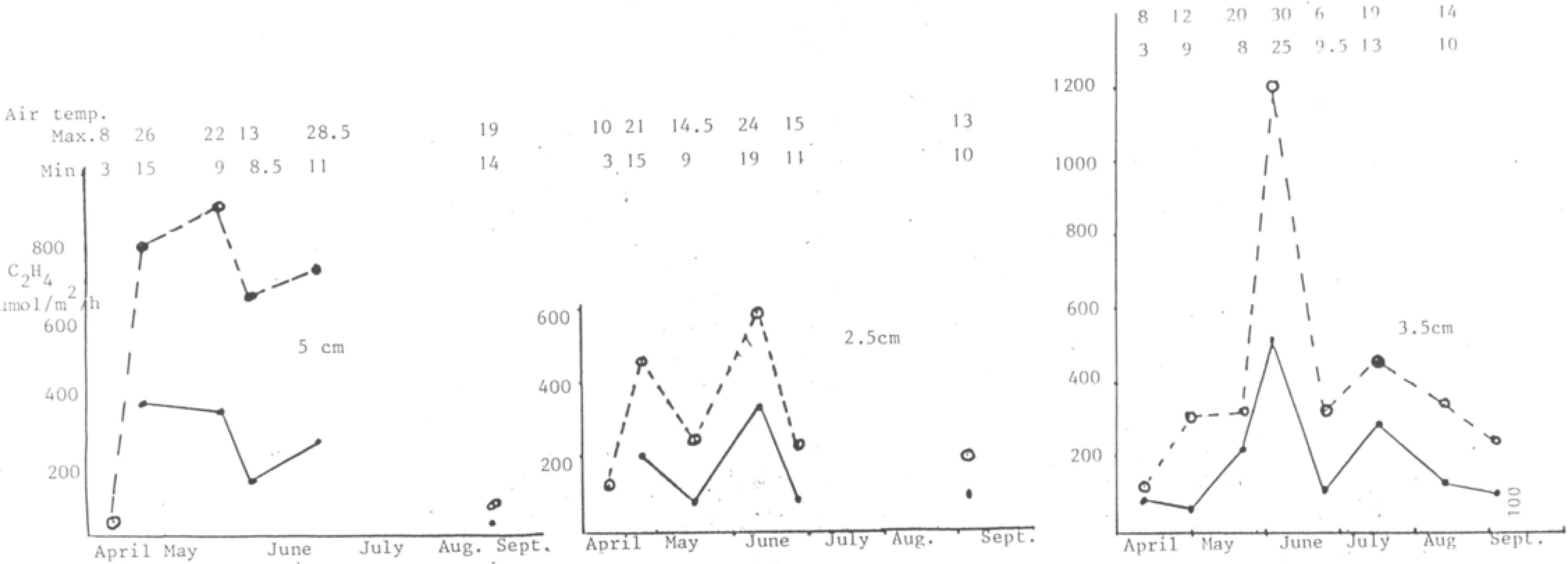

Figure 1. Nitrogen fixing activity at 3 sward heights with (———) and without (----) N. (Ground area basis).

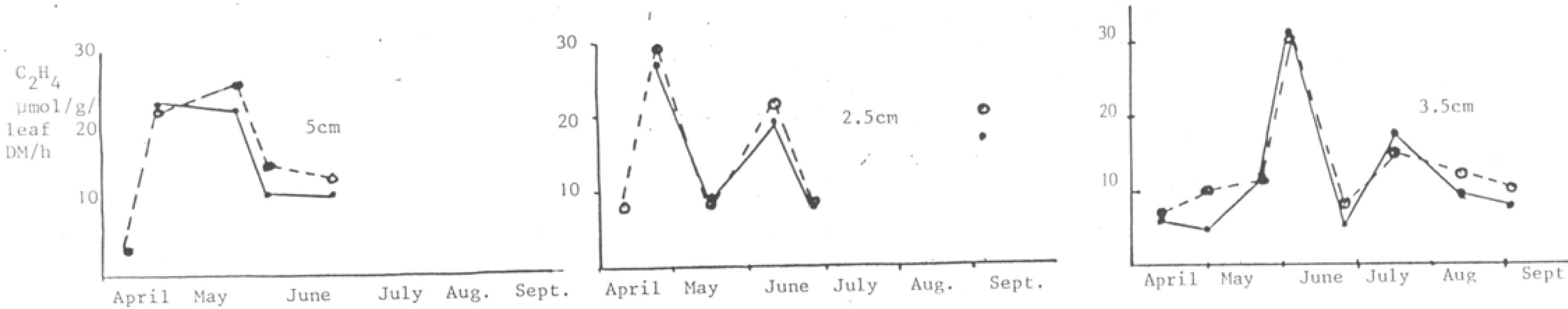

Figure 2. Nitrogen fixing activity at 3 sward heights with (———) and without (-----) N. (Per g clover leaf basis)

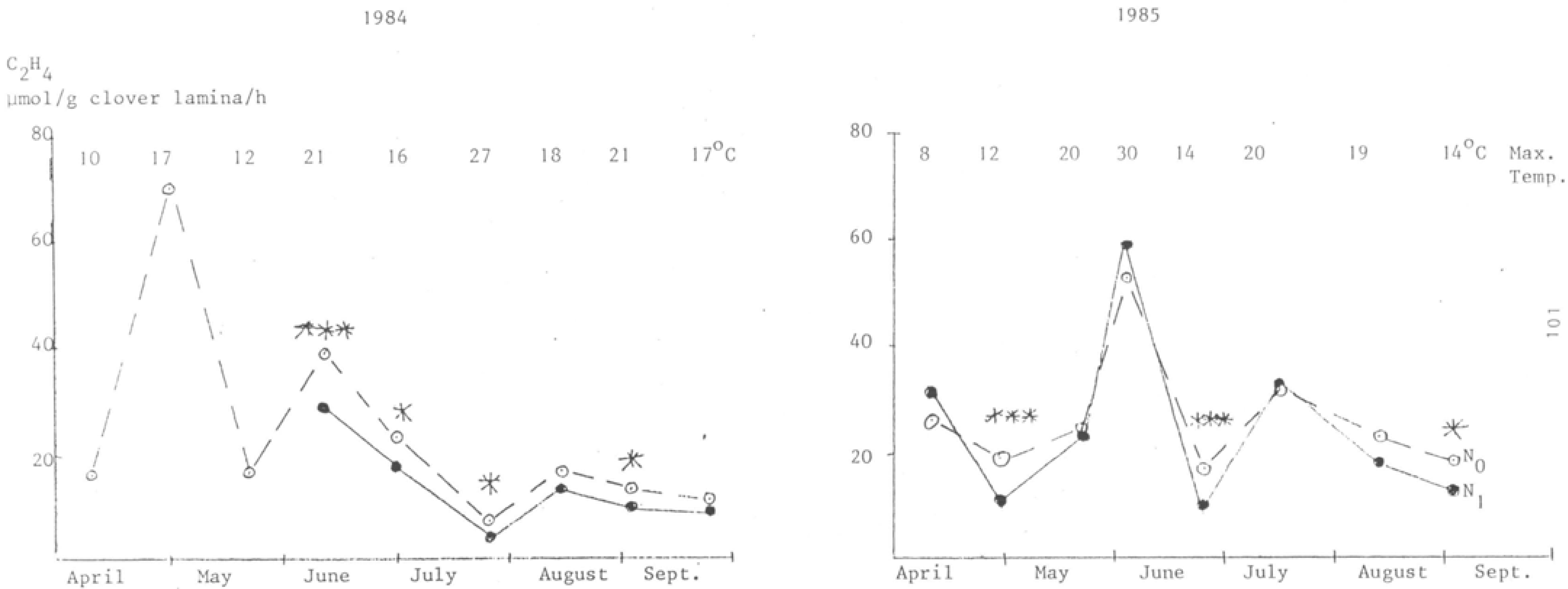

Figure 3. Nitrogen fixing activity (C_2H_4 production/h/g clover lamina) of white clover in 3.5cm swards in 1984 and 1985

There was less clover material in shorter swards and N_2 fixing activity tended to decrease with decreasing sward height, with more pronounced differences in the unfertilised swards.

A comparison of N_2 fixing activities in the 3.5 cm treatment in 1984 and 1985 (Figure 3) showed broadly similar maximum levels of C_2H_2 reduction per g clover lamina but the seasonal patterns differed, largely due to differences in temperature between the two seasons (maximum assay air temperatures are shown in the figure). Lack of moisture, which limited N_2 fixing activity in July 1984 was not a problem in the wet summer of 1985.

1.5 Herbage and root nitrogen concentrations in grass and clover from swards grazed to 2.5, 3.5 and 5 cm with and without N

C.A. Marriott, M.A. Smith and M.A. Baird

Roots and clover stolons from the acetylene reduction assay cores and herbage from the Grazing Ecology Department's measurements were analysed for total nitrogen concentration.

At the beginning of the growing season there was no difference in grass root N concentration between N treatments in the 3.5 cm swards ($\bar{x}$ 1.12 $\pm$ 0.04%N) but clover root N concentrations were significantly ($p<0.05$) less in the swards where N had been applied ($\bar{x}$N = 2.87, $\bar{x}$NO = 3.21, SED = 0.15). This may have been a result of a smaller amount of nodule tissue in the N treatment, but this cannot be verified since no nodule data were collected.

The nitrogen concentration of above ground stolon material collected from all treatments in late April was not significantly affected by either N treatment or sward height ($\bar{x}$ 2.40 $\pm$ 0.11%N), but there was a slight increase in nitrogen concentration of below ground stolon material due to nitrogen treatment ($\bar{x}$ NO = 1.66 $\pm$ 0.10%N, $\bar{x}$ N1 = 1.76 $\pm$ 0.04%N). There were no significant differences in herbage N concentration of any grass species (*Lolium*, *Poa* or other grasses) or white clover between nitrogen or sward height treatments for material harvested during April population measurements, but in June lower nitrogen concentrations were found in herbage from the unfertilised 5 cm swards.

Herbage material from the C_2H_2 reduction assay cores was divided into grass laminae and bases and clover laminae and petioles. Nitrogen application increased the nitrogen concentration in grass laminae at all sward heights, but had little effect on the concentration of N in grass bases; in April and May however nitrogen significantly ($p<0.05$) reduced the %N level in grass bases in the 2.5 cm sward. Nitrogen application and sward height had no significant effect on nitrogen concentration of clover laminae or petioles.

1.6 Seasonal profile of soil mineral N levels in grazed swards maintained at 2.5, 3.5 or 5 cm with or without nitrogen

C.A. Marriott, M.A. Smith and M.A. Baird

In the Annual Report for 1984 (p.160) the seasonal profile of nitrate and ammonium nitrogen levels in 0-10 cm soil depth for the 3.5 cm swards was presented. Measurements were continued in 1985 to examine year to year variations, and in addition mineral N levels were measured in the 2.5 and 5 cm swards to examine the relationship between soil mineral nitrogen levels and sward height.

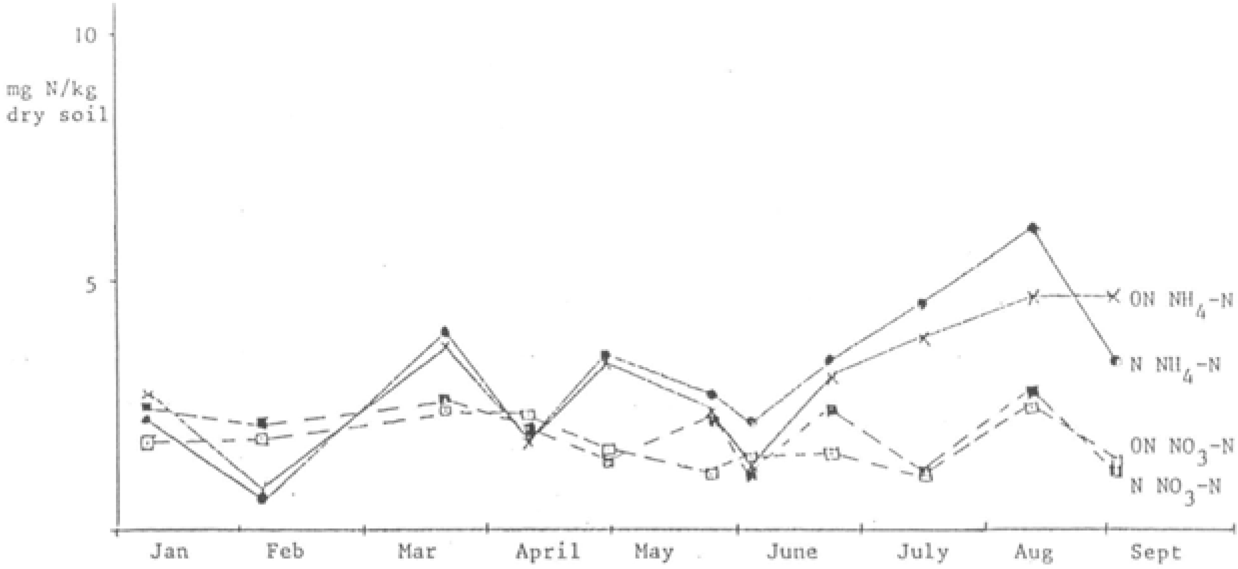

Figure 1. Soil mineral nitrogen concentrations (0-10 cm depth) from 3.5 cm swards with (N) and without (ON) nitrogen fertiliser in 1985.

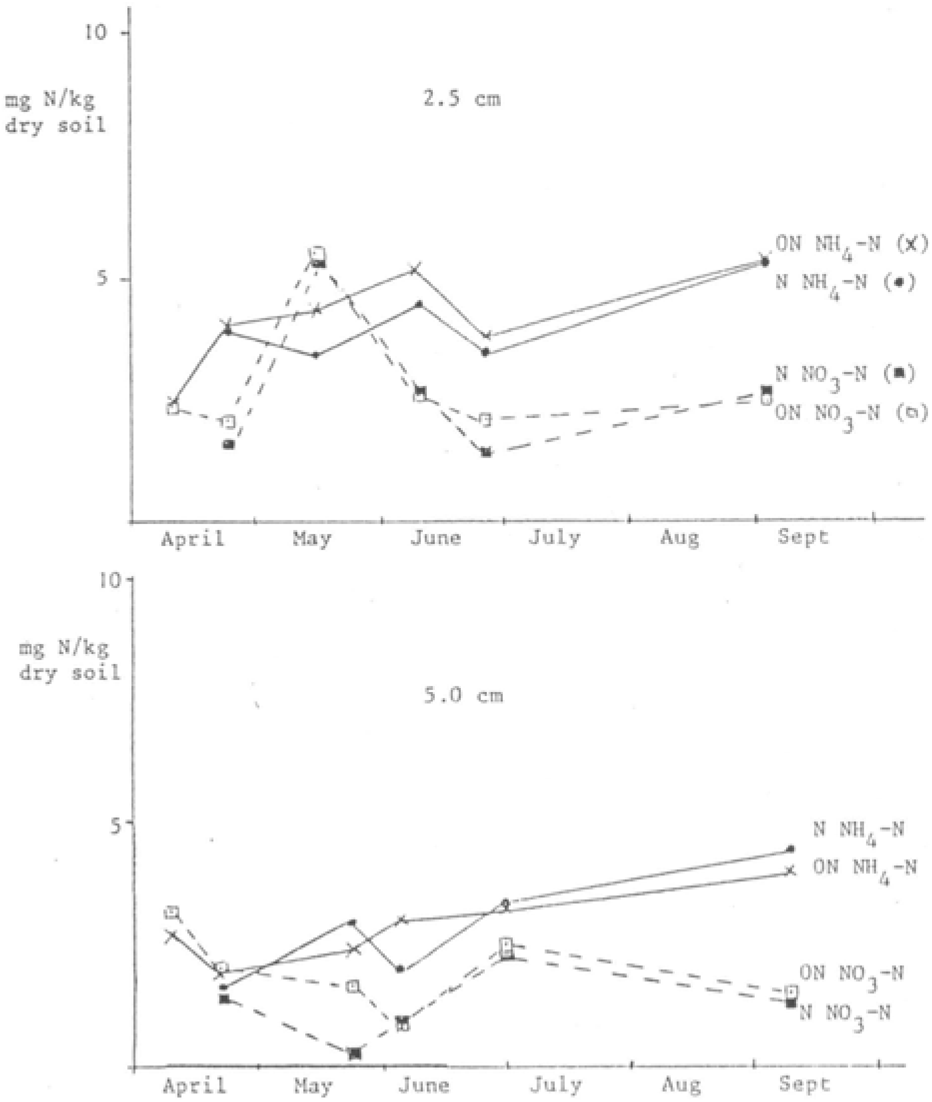

Figure 2. Soil mineral nitrogen concentrations (0-10 cm depth) in 1985 in 2.5 and 5.0 cm swards with (N) and without (ON) nitrogen fertiliser.

The profile of soil inorganic nitrogen levels for the 3.5 cm swards in 1985 is presented in Figure 1. Levels of KCl extractable ammonium nitrogen were on average lower than in 1984, with no appreciable differences between nitrogen treatments. Levels tended to rise from mid June until August, but otherwise there were few differences during the year. This contrasted markedly with 1984 where high levels of soil ammonium nitrogen were measured during March to May. Soil nitrate levels were also lower than those measured in 1984, and they showed no seasonal patterns of variation or differences due to nitrogen treatment.

The differences between the data for 1984 and 1985 could be attributed to the markedly different weather conditions of the 2 years. The summer of 1984 was much drier and warmer than that of 1985. Monthly mean maximum air temperatures over the period April-September inclusive ranged from 12°C to 20°C in 1984 and 10°C-17°C in 1985, while rainfall over this period was 311 mm in 1984 and 791 mm in 1985. Mineralisation of organic N would be reduced by lower soil temperatures; the cooler wet conditions may have reduced nitrification, or any nitrate formed was rapidly taken up by the plants. There was also an increased possibility of leaching of nitrogen to lower depths in the soil profile.

Under the 2.5 and 5 cm swards soil nitrogen levels were broadly similar to those in the 3.5 cm sward (Figure 2). However inorganic N levels tended to be higher under the 2.5 cm sward, where there were higher levels of nitrate-N during a drier period in May.

1.7 The effect of urine on clover performance in a grazed sward

C.A. Marriott, M.A. Smith and M.A. Baird

The grazing animal influences pasture production in three ways : grazing defoliation, treading and excretion of faeces and urine. Most of the nutrients ingested by the grazing animal are returned to the pasture in excreta. Quantitatively urine N is the most important form of excreted N in ruminants (70-75% of the total excreted N). Urine affected areas have large inputs of biologically labile N - between 300 and 600 kg N/ha (Whitehead, 1970). Previous studies have reported the effects of urine on soil N (e.g. Keeney and MacGregor, 1978), pasture botanical composition (e.g. Mundy, 1961), herbage elemental composition (e.g. Joblin and Keogh, 1979) and nitrogen fixing activity of white clover (Ledgard et al, 1982). In this study we investigated the short term effect of urine on clover performance in a continuously grazed sward stocked with sheep.

Treatments

The sward was not grazed during the three-week period prior to the start of the experiment in late June 1985, to minimise the influence of previous urine patches. Two treatments were assigned at random to 4 replicate blocks: sheep urine (provided by the Animal Nutrition Department), at a rate equivalent to that from a grazing sheep (i.e. $5L/m^2$) and a control treatment of application of an equivalent amount of water. The total amount of nitrogen added in urine was 566 kg N/ha of which 141 kg was urea N and 180 kg was NH_4^+ N. The experimental areas were protected using 'graze-through' cages which allowed assessment of the effect of urine under grazing conditions but excluded the effects of treading and subsequent excretal return. A strip, 43 cm wide, along each length of the cages was grazed and a central strip, 39 cm wide, remained ungrazed.

Sward heights were measured twice weekly in the grazed strips and sheep numbers were adjusted to maintain a sward height of 3.5 cm. The central ungrazed areas were cut to grazing height when a sward height of 10 cm was first reached.

Measurements

Grazed areas

Population densities and dry weights of grass and clover components were determined at the start of the experiment and again 7 and 13 weeks after urine application. Grass and clover morphology changes were monitored by weekly examination of marked cohorts. Acetylene reduction assays to measure nitrogen fixing activity were carried out on 11 occasions over a 10 week period, and on the same dates soil samples were taken for determination of moisture content, pH (H_2O) and inorganic and total nitrogen. The cores provided herbage and nodule tissue for total nitrogen analysis.

Cut areas

Four cuts of herbage were made and, after separation into grass and clover components, provided material for dry weight and total nitrogen measurements.

Results

Population densities and morphology

Urine application significantly reduced both clover growing point density and stolon length (or weight) per unit area after 13 weeks (Table 1). This response is similar to the response to fertiliser nitrogen found by the Grazing Ecology Department (see p. 75).

The number of laminae per meristem and the mean leaf weight were significantly greater outside the caged area, reflecting a preferential grazing of caged areas compared with the open plot. Mean leaf weight was significantly increased by urine 7 weeks after application but the difference had disappeared by 13 weeks. This was perhaps due to differences in grazing defoliation between the two treatments; sward heights tended to be greater in the urine treated areas, but the differences were not statistically significant.

Grass tiller numbers and dry weight were increased slightly by urine treatment, but the differences were not statistically significant.

The weekly monitoring of the changes in clover morphology proved difficult during the wet summer, due to burial of a large number of marked stolons. The limited data available suggested that leaf appearance (node formation) was reduced by urine but this requires further investigation. Mean values for the period 27/6/85-18/7/85 were 0.43 $\pm$ 0.06 for urine treatment and 0.59 $\pm$ 0.12 for control, and 0.43 $\pm$ 0.12 and 0.87 $\pm$ 0.21 respectively for the period 18/7/85-8/8/85.

Lamina width of the youngest fully expanded ryegrass leaf (at a standard 1 cm from the ligule) was slightly increased by urine application, but the differences disappeared after 4 weeks. Lamina width was always greater in the open plot.

TABLE 1a
Clover growing points m^{-2} (at day 0 = 2530 ± 491)

	7 wk	13 wk
	AFTER URINE	
Control (C)	3708	2455
Urine (U)	1658	895
SED (Uvs C)	1154	471
Open Plot (O)	2850	1450
SED (U or C vs O)	734	375

TABLE 1b
Stolon length m m^{-2} (at day 0 = 32.78 ± 8.86)

	7 wk	13 wk
	AFTER URINE	
Control (C)	30.0	18.2
Urine (U)	27.9	9.1
SED (Uvs C)	13.6	3.5
Open Plot (O)	25.6	12.2
SED (U or C vs O)	8.0	2.9

TABLE 1c
Grass tillers m^{-2} (at day 0 = 20500 ± 2181)

	7 wk	13 wk
	AFTER URINE	
Control (C)	17667	20240
Urine (U)	20300	25340
SED (Uvs C)	2717	2994
Open Plot (O)	25300	22280
SED (U or C vs O)	3464	2074

Soil pH

In the top 5 cm depth, soil pH (H_2O) was increased significantly ($p < 0.01$) in the three days following urine application (Figure 1). A smaller increase in pH was measured in the 5-10 cm depth.

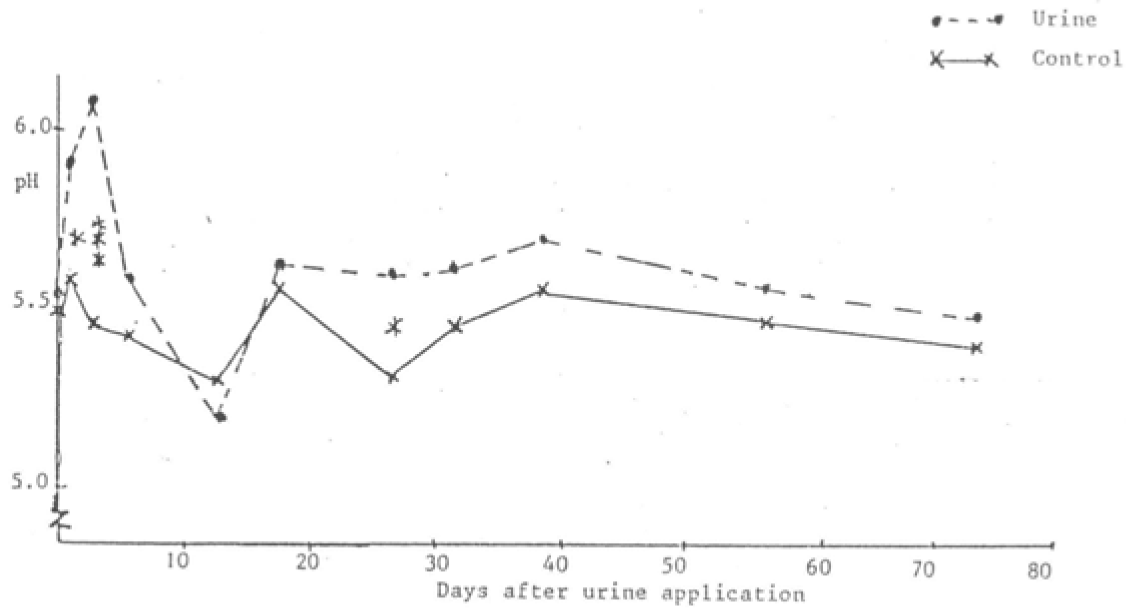

Figure 1. pH (H_2O) in 0-5 cm soil depth.

Soil Inorganic Nitrogen

Both soil ammonium and nitrate nitrogen levels increased in response to urine application (Figure 2). Ammonium nitrogen levels in the 0-5 cm soil depth were significantly greater ($p < 0.01$) than control levels in the 13 day period following urine application. Peak values occurred between days 1 and 6, and represented an increase of about 100 kg NH_4^+-N/ha over control values. In the 5-10 cm soil depth NH_4^+-N levels were significantly ($p < 0.001$) increased only on day 6 after urine application. Nitrate levels in the 0-5 cm depth began to rise above control levels by 6 days after urine treatment and remained significantly higher ($p < 0.01$) until day 18; the pattern for nitrate in the 5-10 cm depth was broadly similar. Nitrate levels were considerably less than ammonium levels, with maximum increases of about 30 kg NO_3^--N/ha in the 0-5 cm depth. Urea hydrolysis was rapid and only trace amounts of urea (< 1 kg N/ha) were detected 24 hours after urine application.

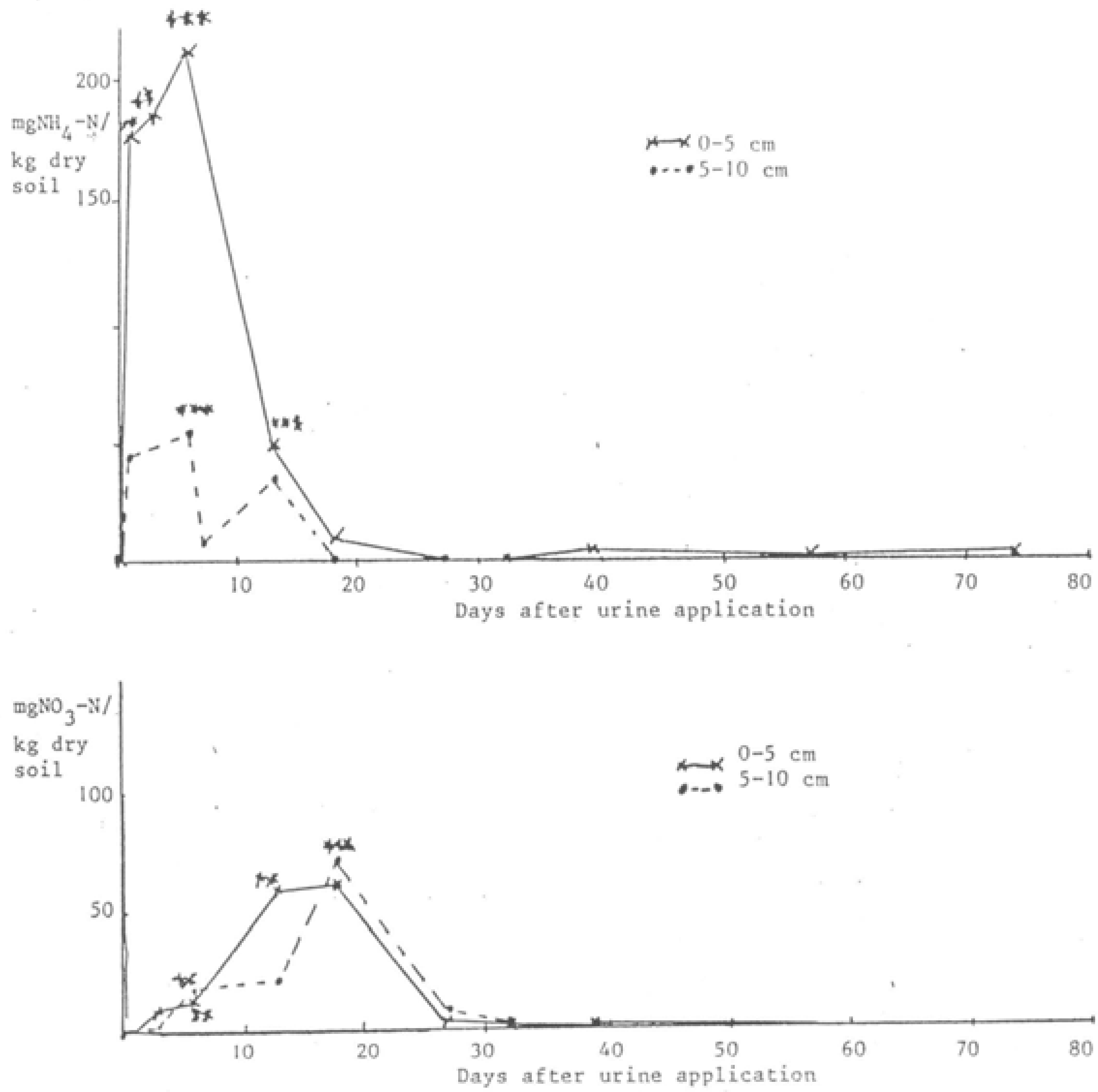

Figure 2. Urine increase of nitrate and ammonium over control levels.

Soil Total Nitrogen

Urine application had no significant effect on soil total nitrogen concentration, which was in the range 0.27-0.33% for the top 5 cm and 0.25-0.30% for the 5-10 cm depth.

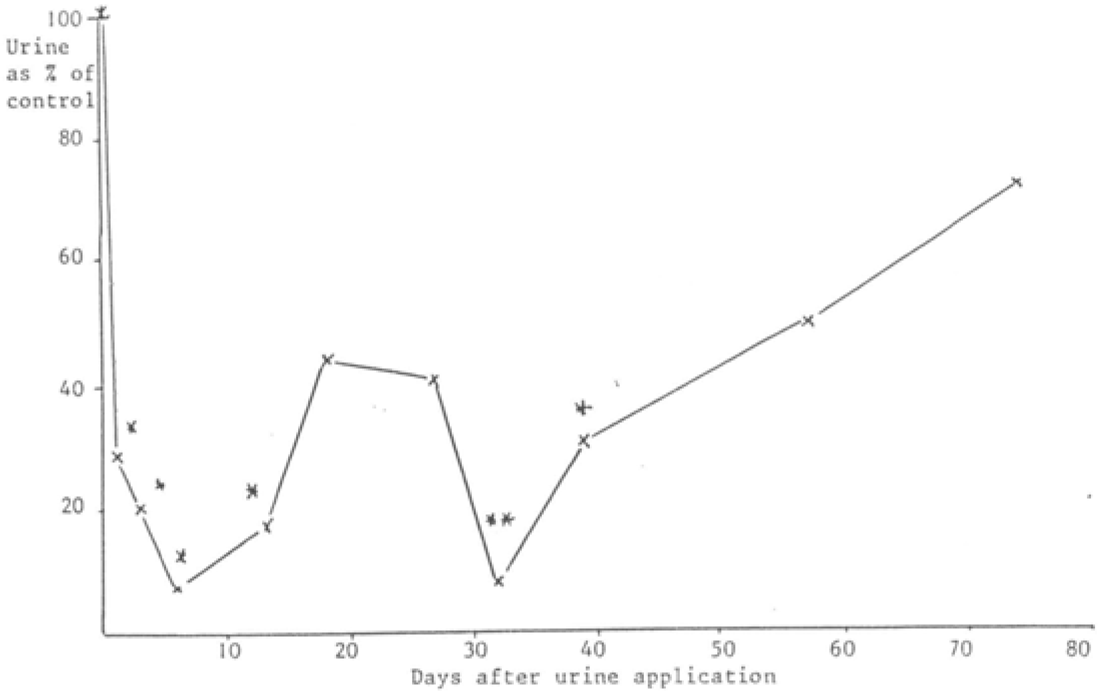

Figure 3. Nitrogen fixing activity on an area basis.

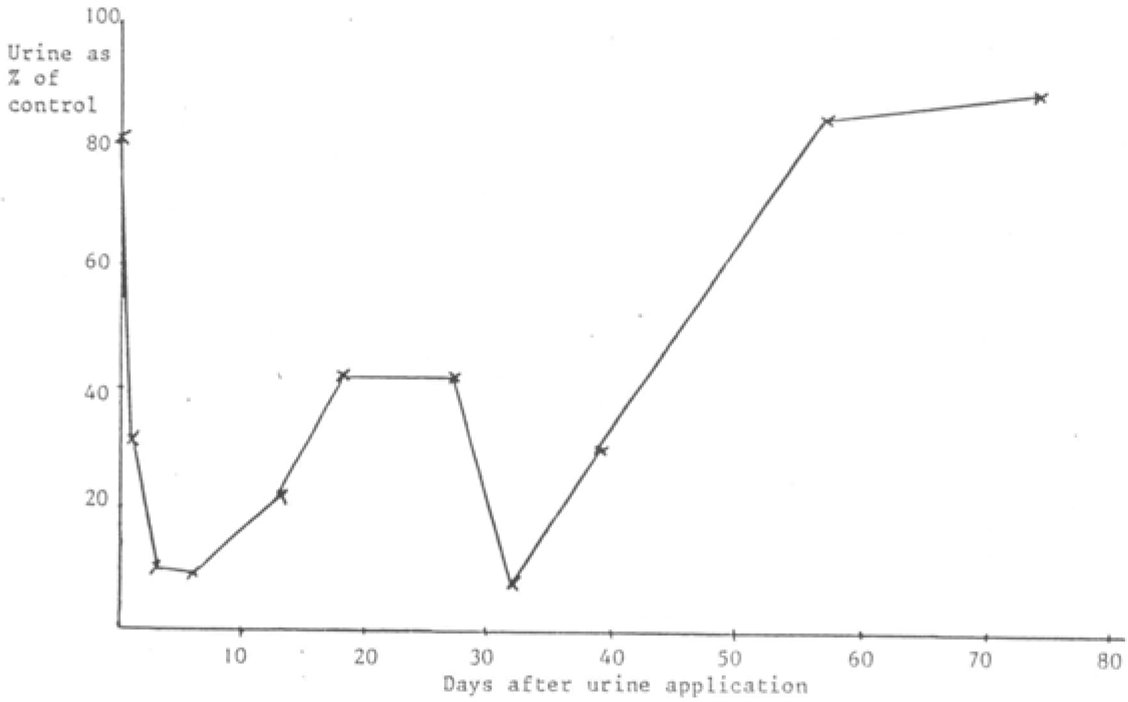

Figure 4. Nitrogen fixing activity per unit leaf area index.

Nitrogen Fixing Activity

Nitrogen fixing activity was reduced to a low level immediately following urine application (Figure 3). By 18 days later, when soil inorganic nitrogen levels were returning to control levels, some recovery had occurred, but levels of activity remained less than 50% of the control values until 57 d after urine application. On day 32, a cold day with torrential rain, very little activity was measured in the control treatment and still smaller amounts (2 mol C_2H_4/m/h) in the urine treatment. The value for day 32 in Figure 3 reflects the adverse weather conditions rather than indicating any reversal in recovery of nitrogen fixing activity following urine treatment.

Examination of root and nodule condition proved difficult but there was some indication of decay of underground tissue in the 6-day period following urine application. This was supported by results from a pot experiment, in which there were obvious signs of nodule damage from as early as 1 day after urine application.

The values presented in figure 3 represent differences in nitrogen fixing activity on an area basis, which could be due to different clover contents or differences in activity per unit of clover. When the results were expressed on a nodule number or clover leaf area basis (Figure 4) the differences persisted. After 7-8 weeks reduced clover content was the major factor responsible for reduced nitrogen fixing activity in the urine treated areas.

Herbage Nitrogen

Urine application increased the nitrogen concentration of both grass and clover herbage. The concentrations of nitrogen in grass and clover laminae are presented in Figure 5; those for grass bases and clover

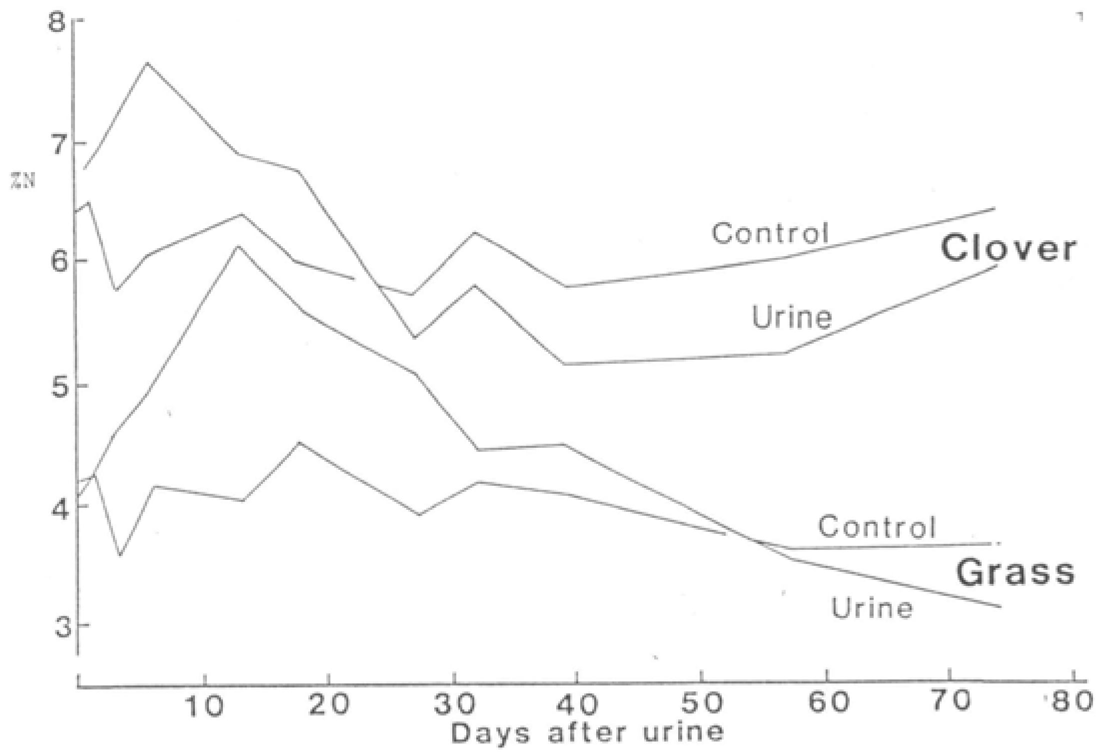

Figure 5. Percentage nitrogen in grass and clover laminae.

petioles followed a similar pattern, but the % N values were lower than for the associated laminae. Since the urine was watered on to the herbage it is possible that urine retained on the surface of the herbage may have contributed to the values obtained for nitrogen concentration on day 1; increased concentrations of nitrogen were, however, found only in clover laminae and petioles fractions. The nitrogen concentration of clover laminae was increased by urine application for about three weeks, with a peak value at 6 days and thereafter falling as soil NO_3^--N levels increased. Peak grass nitrogen concentrations occurred 13 days after urine application and remained greater than control values for some 6 weeks.

Cut Herbage

The herbage from the central strips of the caged areas was cut 7, 20, 47 and 81 days after urine application. Herbage dry matter accumulation was severely reduced by urine at the first cut, but was increased at the two subsequent harvests (Table 2). The reduction at the first cut was due to severe scorch damage. The proportion of clover in the cut herbage was reduced by urine ($p < 0.05$ at the 3rd and 4th cuts only); there were no differences in mean clover lamina dry weight. Herbage nitrogen concentration of both grass (at the first three cuts) and clover (at the first two cuts) was increased by urine application (Table 3).

TABLE 2
Herbage dry matter accumulation in cut areas (kg DM ha^{-1})

	U	C	SED	
GRASS				
Cut 1	181	481	53	**
2	1026	631	266	ns
3	1314	625	127	**
4	617	458	79	ns
CLOVER				
Cut 1	18.4	125.7	29	**
2	70.7	158.7	45	ns
3	72.7	243.9	54	*
4	39.7	172.2	45	*

Differences : ns = not statistically significant, * = significant $p < 0.05$, ** = significant $p < 0.01$.

TABLE 3
Nitrogen concentration of cut herbage (% N)

	U	C	SED	
GRASS				
Cut 1	4.89	3.92	0.31	*
2	5.16	3.42	0.21	***
3	3.55	2.85	0.08	***
4	3.21	3.41	0.16	ns
CLOVER				
Cut 1	6.14	5.76	0.18	ns
2	6.01	5.56	0.19	ns
3	4.65	4.83	0.21	ns
4	5.31	5.42	0.21	ns

Differences : ns = not statistically significant, * = significant $p < 0.05$, ** = significant $p < 0.01$.

Recovery of Urine Nitrogen

At best only 27% of the added nitrogen was recovered in the soil mineral N pool in the 0-10 cm depth 6 days after urine addition (Table 4). No measurements were made of either volatilised nitrogen or nitrogen in the lower horizons of the soil; leaching losses may have been quantatively important since weather conditions were extremely wet during the experiment. The increase in apparent recovery at day 6 may be due to mineralisation of organic nitrogen constituents which were not measured at earlier samplings. Microbial immobilisation may have occurred; there was no flush of soil mineral nitrogen at later samplings but grass nitrogen concentrations remained higher in the urine treatment for 3 weeks after differences in soil mineral N had disappeared.

TABLE 4
Apparent recovery of added nitrogen in 0-10 cm soil depth

	% recovery
Day 1	22.5
3	17.7
6	26.8
13	15.2
18	12.4
27	1.2

TABLE 5
Apparent recovery of added nitrogen in cut herbage

	Grass	Grass + Clover
Days	% recovery	
7-20	5.6	4.8
20-47	5.0	3.7
47-81	0.8	-2.3

The herbage production data were obtained from the cut central strips and provide an estimate of apparent recovery of added nitrogen in the herbage (Table 5). The period 0-7 d after urine application was excluded since scorch damage severely reduced herbage production and N content in the urine treated areas. A similar effect did not occur in the grazed areas. The estimated apparent recovery of urine N in grass herbage between days 7 and 81 was 11.4%. However the contribution of clover-N to total herbage N was reduced and overall the increase in herbage nitrogen was only 8.5% of the added nitrogen. Nitrogen may have been immobilised in the unharvested plant parts. Roots and stubble were not measured but previous work (Troughton, 1967 and our present work in Minefield) suggests that these organs are less responsive to nitrogen than plant shoots.

Conclusions

The addition of urine nitrogen significantly reduced the clover population density and stolon length, and only slightly increased the contribution of the grass component of the sward. Overall very little of the added nitrogen appeared in herbage. Using the figures for sheep numbers on the 3.5 cm swards in the main Minefield experiment where no N was applied and assuming each urination covers an area 0.029 m^2 (Doak, 1952) and a frequency of 20 urinations per day (Doak, 1952) it can be calculated that over the grazing season (18.4.85-20.9.85) 27% of the plot area was covered by urine. The area in which herbage production is affected is on average 0.064 m^2 and using this figure some 60% of the plot was affected by urine. If the distribution of urine patches is essentially random, it may be an important factor in determining the development of patchy clover distribution in the mixed sward.

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1.8 Effect of low temperature and N source on N assimilation and growth of clover

R.J. Thomas, K.A.B. Logan and A.D. Ironside

The growth and N assimilation of NZ Huia were compared at 20/15°C (warm) and 8/5°C (cold) with N_2 fixation, nitrate or ammonium as N source. Leaf area was greater at the warm and cold temperatures with N_2-fixing and nitrate growth plants compared with ammonium grown plants (Figure 1).

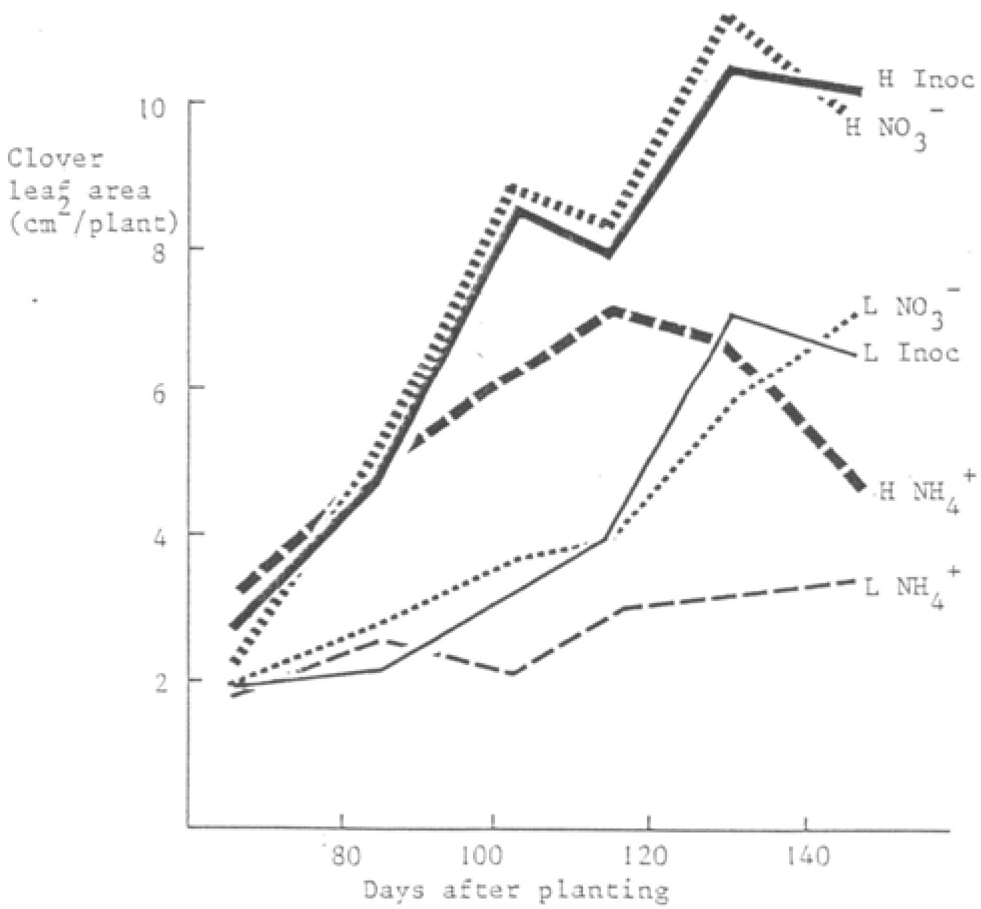


Figure 1. Clover leaf area of plants grown with different nitrogen sources at high (20/15°C) or low (8/5°C) temperatures.

The first and often rate-limiting step in the assimilation of nitrate is the reduction of nitrate to nitrite catalysed by the enzyme nitrate reductase. In nitrate-fed plants _in vivo_ nitrate reductase activities (NRA) per g fresh weight were 2 to 5 times greater in roots, petioles and leaves of cold grown plants compared with warm grown. There was little or no activity in N_2-fixing or ammonium fed plants. The relative distribution of total plant NRA between plant parts differed with temperature; % of total activity in roots increased with decreasing temperature (Table 1). The results suggest that at temperatures similar to those in the field (i.e. sub-optimal) clover will assimilate most of any available nitrate in roots and is therefore a root reducer of nitrate rather than a shoot reducer as stated in the literature (e.g. Pate, 1973). This finding will have implications for work on comparative costs (in terms of energy and C) of N_2-fixation versus inorganic N assimilation.

TABLE 2
In vivo NRA in nitrate-fed plants

Activities expressed as a % of total plant activity ± S.E. Means of 5 harvests

Growth temp °C		
20/15	Leaf	33 ± 2
	Petiole	38 ± 4
	Root	29 ± 5
8/5	Leaf	21 ± 6
	Petiole	32 ± 8
	Root	47 ± 7

Reference

Pate, J.S. 1973. Uptake, assimilation and transport of nitrogen compounds by plants. _Soil Biology and Biochemistry_, _5_, 109-119.

1.9 Fertiliser response experiment at Hartwood

A. Rangeley and H.A. Stott

The field experiment with mixed swards of perennial ryegrass and white clover was carried out in 1982/3 using small cut plots. With perennial ryegrass, lime slightly decreased dry matter (DM) production in 1982 (the sowing year) but increased it in 1983 (the first harvest year) by about 1 t ha/yr. Applications of N and P produced small increases in DM in 1982 and greater increases in 1983. In the latter seasonal annual DM production varied from an average of about 3.5 to about 10 t/ha/yr with 0 or 480 kg N/ha/yr (applied in 3 equal sized dressings throughout the growing season). Application of 40 kg P/ha in 1982 increased DM production by about 2.5 t/ha/yr in 1983 but higher rates had little effect. Fifteen mg extractable P/kg soil seemed sufficient to support levels of production normally expected from ryegrass pastures in upland Scotland. Applications of K did not affect DM production. N increased tiller weight and sward height of ryegrass; lime and P tended to increase tiller weight but this effect was not statistically significant. Leaf appearance rate and tiller number were not affected by treatments.

The white clover content of the pasture was decreased (96%) by application of N and increased (45 and 46%) by lime and P respectively. The DM response to P was most apparent in limed soil and was also affected by the siting of the plots in the experimental area. Effects of lime and P on growth of white clover were to increase the number of stolon growing points and root nodule numbers per unit area.

The results emphasise the importance of lime and P fertilizer for establishment and growth of pasture in this soil and the differences between white clover and ryegrass in their responses to these compounds.

1.10 Fertiliser requirements for maintenance of a perennial ryegrass/white clover pasture on a humus iron podzol at Glensaugh

A. Rangeley and H.A. Stott

Ryegrass/white clover pastures were reseeded in a mosaic pattern on heather moor in NE Scotland in 1978/79. By 1982, despite moderate fertiliser applications, the pasture had deteriorated and dry matter (DM) production was low. After preliminary soil and herbage analysis an omission trial was carried out in 1982/3 at 2 sites (A and B) to identify the factors which were limiting production.

At site A depressions in growth occurred in the absence of N, P and K but the latter effect was not quite significant. Perennial ryegrass was severely N deficient with N concentrations in leaves less than 20 mg/kg in spring and summer even after application of 120 kg N/ha/yr. Rates of nitrogen fixation were high in spring but rapidly declined in June and July as the soil moisture tension increased. Application of N fertiliser also reduced the N_2 fixation rate. Deficiencies of P and K occurred despite apparently high level of extractable nutrients in the soil. It was thought that uptake of these nutrients was inhibited in the dry soil during the summer. White clover seemed more susceptible to drought than perennial ryegrass because it was shallower rooting.

Growth at site B was limited by acidity and the absence of N and K. The soil pH was 4.5 (s.e. = 0.75) at 1-5 cms depth. Application of 2½ t lime/ha in spring 1982 had not altered the pH by autumn 1983. The relationship between DM production and soil pH indicated that pH 5.0 or more is required for optimum growth.

It was concluded that methods of incorporating lime with the soil together with ways of increasing the rates of N_2 fixation by white clover and transfer to grass should be investigated further. Regular small applications of P, S and K may be necessary if DM production exceeds 4.5 t/ha/yr.

1.11 The effect of nitrogen fertiliser applications to a perennial ryegrass/white clover pasture on a humus iron podzol at Glensaugh

A. Rangeley and H.A. Stott

Applications of N fertiliser, supplied at the rate of 40 kg N ha^{-1} and totalling 120 kg N/ha/yr, were made to perennial ryegrass/white clover pastures on the Cairn o' Mount at Glensaugh in 1982 and 1983. The apparent efficiencies were low, for each dressing they ranged between 1.9 and 14.2 kg dry matter (DM)/(kg N) and averaged over the 1982 and 1983 seasons were 8.4 and 9.3 kg DM/(kg N) respectively. When a total of 240 kg N/ha/yr was applied DM production was 5.3 and 8.0 t/ha/yr in 1982 and 1983 representing average annual apparent efficiencies of 6.3 and 17.1 respectively. It was found that, in both grazing and cut plot experiments, applications of N in spring and summer increased the efficiency of use of N applied in August.

Reasons for these low and variable apparent efficiencies were investigated. Whilst application of N undoubtedly decreased the rates of N_2 fixation the maximum rate in the no N treatment was not sufficiently high to explain the low efficiencies. The peaty soil had a C:N ratio of 23:1 but there were no indications of N immobilisation in soil incubation experiments. The concentrations of N in the living leaves of perennial ryegrass were <20 mg/(kg DM) for most of the growing season and this is equivalent to a C:N ratio of >25.1 even before N is remobilized during senescence. The result suggests that N fertiliser could have been immobilised to break down grass litter. Competition may have occurred between roots and micro-organisms for N. Apparent efficiencies were least in dry periods when N fertiliser granules lay on the soil surface without being washed into the soil by rain and when humidity from low cloud was great enough to allow microbial activity. As N fertiliser was used for decomposition the amounts of litter were reduced and apparent efficiencies increased.

It is recommended that further work be carried out to investigate ways of increasing the input of N into the pasture by increasing the production of white clover and the rate of N_2 fixation. Also maximising the utilisation of pastures by the grazing animal could minimise the amount of litter available for decomposition and consequent N immobilisation on the soil surface.

1.12 The effectiveness of different forms of N fertiliser for pasture growth at Glensaugh

A. Rangeley and H.A. Stott

In the 1984 Annual Report (p. 169) it was reported that N supplied as nitrate and ammonium were equally efficient at DM production on the reseeds at Cairn o' Mount, Glensaugh. A commercial slow release N fertiliser SAI 'Long Life' was more efficient than the other two forms when applied in spring but because we do not know the formulation of this fertiliser no further analysis of its effects can be made. Ammonium seemed to reduce the growth of white clover and 'Long Life' increase it.

Samples from this experiment have been processed further during the year. The herbage separations are almost completed and the soil mineral N analysis from ^{15}N microplots is completed. Many soil extracts containing $^{15}N/^{14}N$ have yet to be steam distilled before they are ready for mass spectrometry.

Research objective: Quantify the transfer of N via the grazing animal from ingested herbage to the available soil N pool (no. 004004)

1.13 Fate of sheep urine-N applied to an upland sward

R.J. Thomas, K.A.B. Logan, A.D. Ironside and G.R. Bolton

In August 1984 the fate of sheep urine-N when applied to a grass-only sward at Minefield, Hartwood was followed. This was repeated at three times during the season in 1985 when conditions were very different from those in 1984.

Amounts and forms of N recovered in the top 20 cm soil with time after application are shown in Figures 1-4. Urea-N was only present in trace amounts even though about 65% of the urine-N was in this form. Conditions during August 1984 were warm and very dry and most of the N recovered in soil extracts was in the ammonium form (Figure 1). In May 1985 with normal rainfall and temperatures, most of the N recovered was in the ammonium form until four weeks after application when greater than 50% of the total mineral N was nitrate (Figure 2). Substantial amounts of nitrate were present after seven weeks. Conditions in July and August 1985 were cool and very wet and there was little apparent nitrification of the ammonium (Figures 3 and 4). Recoveries of applied urine-N in soil extracts varied with environmental conditions, being highest during the cool, wet summer (Table 1).

TABLE 1
Maximum recovery of applied-N in soil extracts

Application date	Days after application	% recovered as $NH_4^+ + NO_3^-$
August 1984	1	26
May 1985	15	43
July 1985	14	65
August 1985	7	63

TABLE 2
Recovery of urine-N in harvested herbage

Application date	N applied (gN/m^2)	% recovery (3 cm cuts)
August 1984	48.0	19
May 1985	52.1	28
July 1985	51.6	14
August 1985	39.8	8

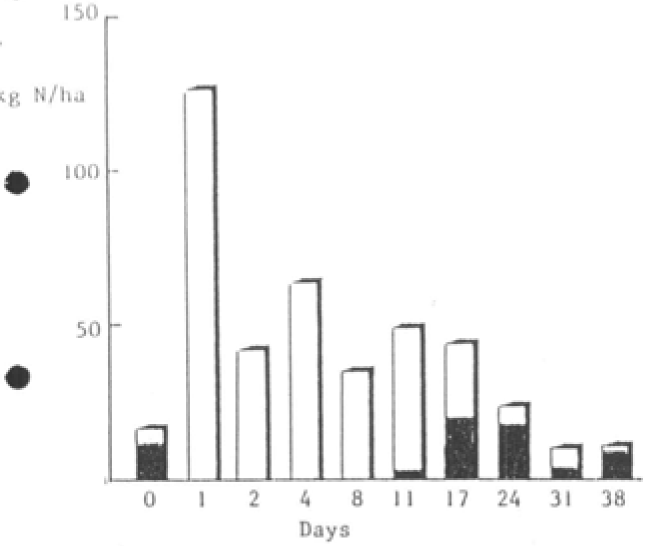


Figure 1. Nitrogen recovered in top 20cm soil in August 1984. NH_4- □ ; NO_3- ■ .

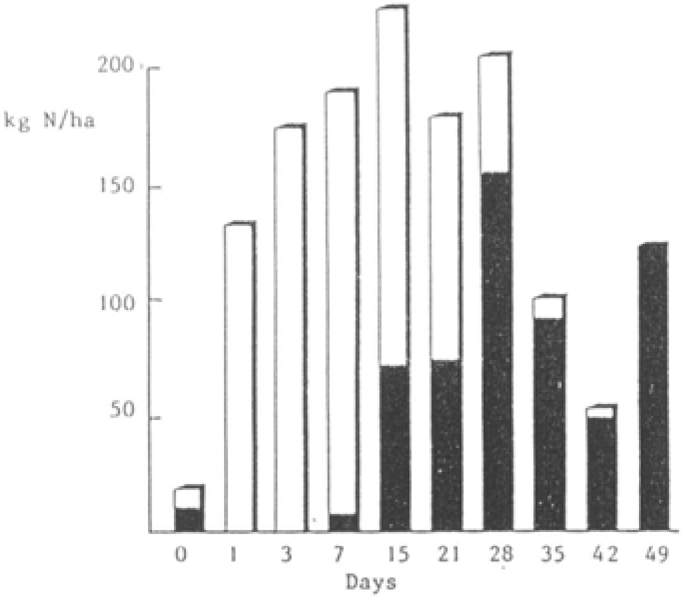


Figure 2. Nitrogen recovered in top 20cm of soil in May 1985. NH_4- □ ; NO_3- ■ .

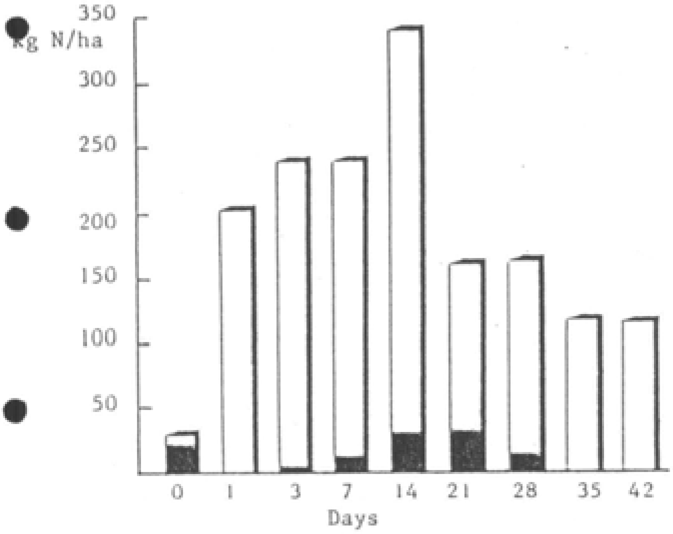


Figure 3. Nitrogen recovered in top 20cm of soil in July 1985. NH_4- □ ; NO_3- ■ .

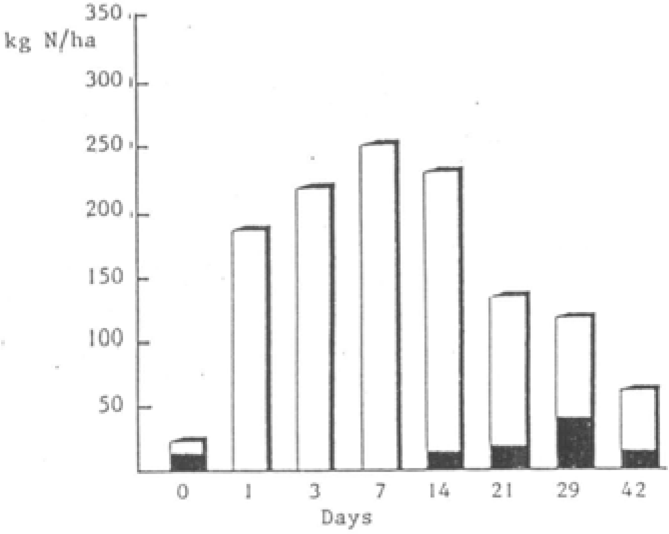
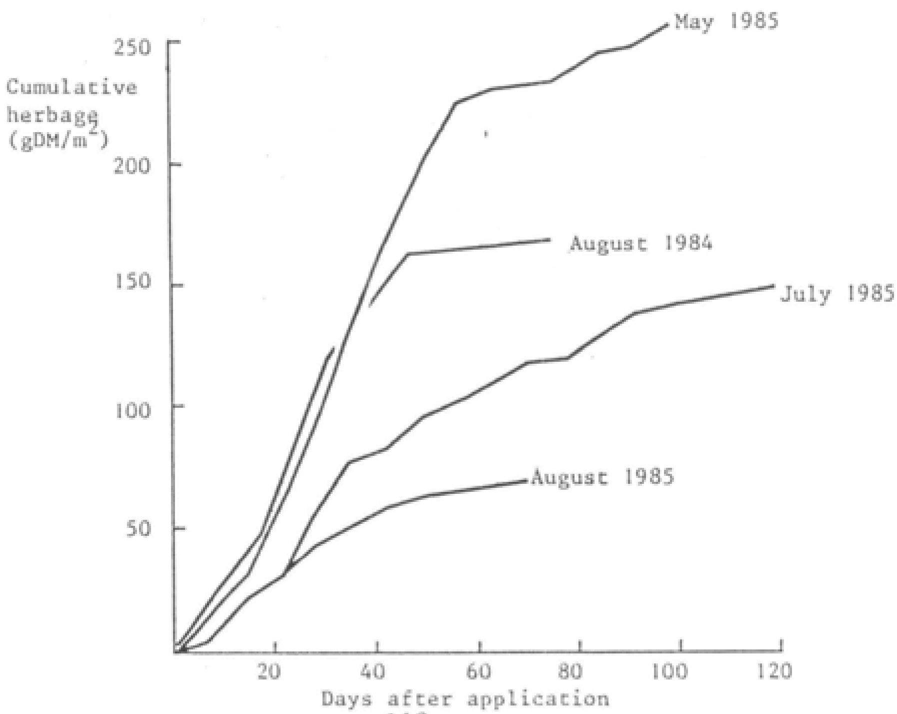


Figure 4. Nitrogen recovered in top 20cm of soil in August 1985. NH_4- □ ; NO_3- ■ .

Figure 5.

Herbage dry matter production following application of sheep urine nitrogen.



Herbage dry matter production was increased 3- to 8-fold and herbage-N 6- to 12-fold as a result of urine application, with greatest response after the May 1985 application (Figure 5). Recoveries of urine-N by herbage were, however, low and were generally less than 30% at all application dates (Table 2). Whatever the exact pathway of N loss (leaching, volatilisation and/or denitrification), it is clear that substantial amounts of N can be lost from pasture via animal excreta. These data are currently being used in attempts to model the flux of N in grassland.

2. PLANT NUTRITION: TRACE ELEMENTS

Research objective: **Understand the soil and plant factors which influence the content of Cu, Mo and S in herbages from improved hill pasures (no. 004006)**

2.1. The seasonal variation in the uptake of copper molybdenum and sulphur by reseeded hill pastures

C. C. Evans, G. J. Baillie and D. E. Suckling

Previous work has shown that across a range of soils and environments the reseeding of previously unimproved hill pastures will lead to increases in Mo and S uptake by pasture plants. The grazing of reseeded pastures with elevated levels of Mo and S by ruminant animals reduces the absorbability of dietary copper which can lead to induced copper deficiencies under certain conditions of animal and pasture management.

It is widely accepted that for many trace elements significant changes in their concentration in pasture plants occur during the growing season. However, little relevant data is available for Mo, S and Cu which refer to their seasonal variability in reseeded hill pastures and experiments have been instituted both to evaluate this seasonal variability and to examine some of the more important factors and soil/plant/environmental relationships which are involved.

These studies are intended to examine the following:

a) Seasonal changes in plant growth rate and its influence on Mo, S and Cu concentrations in grasses and white clover from reseeded hill pastures.

b) The effect of soil drainage by comparing trace element uptakes by plants from a well drained soil with those from a poorly drained soil of the same type and classification.

c) The influence of geographical aspect of the pasture by comparing plant trace element concentrations from pastures of south and north facing aspects.

d) The effect of some components of weather and plant microclimate by measurement of: Air temperature (wet and dry bulb); soil temperature (10 cm); rainfall; solar radiation and wind.

e) Seasonal changes in trace element availability of the soil as measured by laboratory extraction procedures

g) A preliminary assessment of the degree of soil contamination, and in particular that produced by animal influences, as soil intake has been implicated in reducing dietary copper absorption by grazing sheep.

A description of six experimental sites was given in the 1984 Annual Report (p.188). They were chosen to have the same aspect (south facing slope) with the exception of Site 2 which was facing north and to yield herbage with relatively low predicted absorbable Cu (in grazing sheep). These three primary sites (1-3) all occur on Sourhope association soils with either contrasting aspect (Sites 1 and 2) or contrasting drainage characteristics with Site 1 of good drainage (Cowie series) and Site 3 with impeded drainage (Edgerston series). Automatic weather stations have been located only on Sites 1 and 2 although when equipment becomes available it is intended that a further station be established on Site 3.

Three further secondary sites have been included on deep peat (Site 4); mineral podsol with good drainage (Site 5; Hobkirk association, Harelaw series) and a brown earth with impeded drainage (Site 6; Balrownie association; Balrownie series). These secondary sites provide a wider range of soils which is necessary as soil association has been shown to be an important determinant of trace element uptake by reseeded pasture plants.

Compound NPK fertiliser (11:22:22) was applied to one 0.5 ha plot at each site in early spring at 200 Kg/ha and continuous sheep grazing regimes applied throughout the period April/November to maintain similar general sward conditions on all sites. Eight cages were placed with 10 m x 10 m randomly selected sub plots after pre-trimming to 1.5-2 cm sward height. Seven consecutive herbage harvests were made with the cages relocated after each harvest (Sites 1-3) but at Sites 4-6 harvests were made only after the growth periods 1, 3, 5 and 7. Herbages were cut from within the cages at the conclusion of each growing period using frame quadrats and cutting back to the same height (1.5-2 cm) as used previously for pre-trimming. As the effect of the cages on herbage growth increases progressively with time the length of the growth periods were selected to minimise this effect as well as to field plant material of a similar physiological state as measured by sward height (7-10 cm). Some variation in the length of growth period therefore occurred with those in early spring and late autumn being rather longer than those during June and July. The overall mean growth period was 29 d. At the end of each growth period all sites were harvested within 4-5 days. Soil samples (0-10 cm) were taken at the end of growth periods 1, 3, 5 and 7 at the points within the quadrants from which plant material was harvested. Neither the data from chemical analyses, except for soil pH, nor that from the automatic weather stations are yet available.

The soil pH results (H_2O), which are shown in Table 1, suggest that consistent differences occurred between sites, even though lime levels were adequate.

Due to a very high buffering capacity 0-10 cm soil samples from Site 4 (deep peat) were unsatisfactory and soils from this Site were sampled between 0 and 5 cm only. Nevertheless, Site 4 consistently gave the lowest pH values whereas those from Site 6 (brown earth) with the lowest loss on Ignition (organic matter) consistently gave the highest results. Site 2 (north facing) showed slightly lower values than Site 1 (facing south) even 'though in close proximity. There was little difference between Sites 1 and 3 suggesting that drainage characteristics have little effect, at least on this Sourhope soil. In general pH declines during the season and the lower values from samples taken in November could be anticipated.

TABLE 1
pH (in H_2O) of soil (0-10 cm) from reseeded pastures on six experimental sites.

Growth Period	SITE* 1	2	3	4	5	6	Mean
1 (22-24/5)	5.7	5.5	5.8	5.3 (0-5 cm)	5.4	6.1	5.6
3 (9-11/7)	5.7	5.6	5.8	5.1 "	5.3	5.8	5.6
5 (1-3/9)	5.7	5.4	5.8	5.2 "	5.4	6.0	5.6
7 (11-13/11)	5.5	5.3	5.4	5.1 "	5.2	5.9	5.4
Mean	5.7	5.4	5.7	5.1	5.3	5.9	5.5

* See text for description of sites

The experimental plots on all sites were surveyed for botanical composition in mid-October. A point quadrat procedure was adopted on 10 parallel line transects at each site. Cover-abundance for the more important sward components is shown in Table 2 and has been calculated from 500 individual points per site.

TABLE 2
Botannical survey of experimental sites

Specie	Site 1	2	3	4	5	6	Mean
	% Cover Abundance						
Perennial Rye-grass (Lolium perenue)	38(42)*	38(40)*	48(41)*	44(49)*	46(47)*	48(54)*	42(45)*
White clover (Trifolium repens)	25(27)	22(23)	16(17)	10(11)	16(16)	22(25)	19(21)
Meadow grasses (Poa spp.)	15(16)	20(21)	29(31)	10(11)	30(31)	10(11)	15(16)
Bent (Agrostis spp.)	10(11)	12(12)	5(13)	12(13)	5(5)	10(11)	9(10)
Sheeps fescue (Festuca Ovina)	-(-)	-(-)	-(-)	12(13)	-(-)	-(-)	-(-)
Broad leaved weeds	9(-)	4(-)	7(-)	10(-)	12(-)	11(-)	7(-)

* calculated after removal of broad leaved weeds

As expected, the introduced species, perennial ryegrass and white clover, together constituted the major sward cover at all sites. This varied from a maximum of 79% on the brown earth (Site 5) to a minimum of 58% on the poorly drained peaty podsol (Site 3) when adjusted for the removal of broad leaved weeds. Sheeps fescue was only recorded at Site 4 but significant amounts of reinvading grasses were recorded at all sites and in particular Agrostis and Poa spp with up to 30% cover of the latter at sites 3 and 5. The significance of this on the trace element concentration of the sward has yet to be determined.

Grass and clover growth rates (dry matter) are shown in Tables 3 and 4 respectively for the 3 primary Sites (1-3) together with statistically significant differences between the sites in adjacent columns.

TABLE 3
Grown rates of grasses on Sites 1-3

	Growth rate - KG DM/ha/d			
Harvest No.	Site 2		Site 1		Site 3
1 (28/5)	11.1	P<0.001	30.1	P<0.05	25.0
2 (17/6)	42.8	NS	46.1	NS	43.5
3 (11/7)	43.9	NS	43.7	NS	46.2
4 (7/8)	29.5	NS	29.5	NS	26.1
5 (3/9)	24.4	P<0.05	19.1	P<0.05	22.5
6 (11/10)	21.8	NS	20.1	P<0.05	14.2
7 (13/11)	7.7	NS	8.5	P<0.001	4.5

Maximum DM growth rates were recorded during June/July at these 3 Sites. The influence of aspect (Sites 1 and 2) is mainly shown in Harvest 1 where the growth rate on the south slope (Site 1) is almost 3 times greater than that on the adjacent north facing slope. This could be due to soil temperature effects. Drainage effects may have been strongly influenced by the above-average rainfall and low temperatures of the 1985 weather throughout most of the growing season. At Harvest 1 slightly lower growth rates were obtained on the poorly drained Site 3. However, at the last two harvests the influence of the cold wet autumn can be clearly ascertained with significantly lower growth rates on Site 3 when compared with the well drained Site 1.

TABLE 4
Growth rates of white clover on Sites 1-3

	Growth rate - Kg DM/ha/d				
Harvest No.	Site 2		Site 1		Site 3
1 (28/5)	2.0	P<0.05	6.3	NS	5.5
2 (17/6)	12.2	NS	13.3	NS	16.2
3 (11/7)	14.4	NS	12.9	NS	13.8
4 (7/8)	4.9	NS	6.4	NS	4.9
5 (8/9)	4.3	P<0.05	5.7	P<0.05	2.9
6 (11/10)	1.8	NS	2.1	P<0.001	0.5
7 (13/11)	0.04	P<0.05	0.30	P<0.05	0.03

Similar patterns of growth rate were obtained for white clover as for the grasses with lower growth rates at Harvest 1 at Site 2 (north facing). However there was a significant tendency for growth of white clover to slow down more quickly on Site 2 in autumn. The effect of poor drainage (Site 3) gave similar effects in autumn also. Growth rate reached maxima on south facing Sites (1 and 3) at Harvest 2 whereas on Site 2 (north facing) maximum growth rate was delayed until Harvest 3. Again this may be due to temperature effects, although the chemical and weather data are required before firm conclusions can be drawn.

Growth rates for Sites 4-6 for both grasses and white clover are shown in Table 5 for comparison. The maximum growth rate on the deep peat occurred during the first growth period for grasses, whereas for Sites 3 and 4 and for clover on all 3 Sites peak growth rates did not occur until Harvest 3. The reason for this is obscure. The high autumn rainfall produced almost waterlogged conditions on Site 4 (deep peat) restricting growth to non-measurable quantities at the last harvest.

TABLE 5
Growth rates of grasses and white clover on Sites 4-6

	Growth rate - Kg DM					
	Grasses			White clover		
Harvest No.	Site 4	Site 5	Site 6	Site 4	Site 5	Site 6
1 (28/5)	38.8	22.8	29.3	3.2	1.3	3.8
3 (11/7)	33.3	37.3	42.8	7.7	7.3	11.6
5 (3/9)	19.7	25.6	33.2	3.4	6.7	8.1
7 (13/11)	- *	9.0	9.3	- *	0.2	0.1

* No measurable growth

It is intended to continue these studies for at least a further growing season to assess possible year to year variability. This could be of particular importance if more normal weather patterns are re-established during 1986 to contrast with the very wet and cold conditions experienced during 1985.

PROGRAMME UNIT 7: SYSTEMS STUDIES IN RUMINANTS

Introduction

The purpose of the systems development programme is to test the principles which determine the integration of resources in improved systems of sheep production from the hills and uplands. In order to make extrapolation of the findings to other situations possible, field scale studies are being carried out in the widely different but limited range of environments represented by the three research stations where the essential biological monitoring and control over their management can be maintained.

The assessment of the worthwhileness of an animal production system within the context of a hill farm must be an economic one; system changes require capital investment and an assessment of the returns of such marginal capital is an important part of the evaluation process. Furthermore, the robustness of the system has to be tested which requires that stocking rates have to be increased at least to the point at which individual animal performance declines significantly.

Within the context of the present synthesis, responses to a wide range of alternative forms of input are required to provide a basis for assessing the outcome of these systems at the practical farm level. Land improvement, for example, can be brought about in a variety of ways; species composition, the presence or absence of clover, the use of fertiliser, will each have an effect on animal output responses and these require quantification. There is also the problem of examining the continuing flow of new information not only in the context of the present synthesis but also with respect to new systems possibilities. It is apparent that only a limited range of inputs can be tested using field scale studies because of the resources in land, animals and personnel that they require.

Systems modelling and the application of mathematical and computing techniques are being investigated as a means of extending the systems approach and examining the effect of the more comprehensive range of inputs. The approach has also been adopted to examine the effects of land allocation strategies as between agriculture and forestry on the economic viability of their integration.

The development programme also includes upland sheep systems experiments, designed to study the inter-relationships among stocking rate, date of lambing, levels of pasture production, individual animal performance and flock output.

1. HILL SHEEP: YEAR ROUND GRAZING SYSTEMS

Introduction

The basis of the year round grazing studies has been the integration of improved pasture with the open hill in such a way as to ensure the maximum impact of improved pasture on sheep performance. This has meant that improved pasture has been used for ewes from the time of lambing up to weaning (mid-August) and again, following the mid-season rest, during premating and mating period. During the remainder of the year the sheep stock has been kept on the open hill. This procedure represented a considerable change from the traditional year round set-stocked grazing systems.

Any attempt to improve sheep performance was expected to exacerbate under-nutrition in late pregnancy; it was therefore necessary to accompany land improvement with the provision of adequate supplementary feed during this period. Early and late lambing ewes have been identified by harnessing rams with crayon blocks and mating has taken place in enclosures. It was anticipated that this would lead to more efficient use of supplementary feed prior to lambing and better control over stock during lambing.

The main differences between the three studies reported derive from differences in their soil and vegetation, and consequently in the methods and level of expenditure that have been required for land improvement.

Research objective: **The evaluation of improved systems of sheep production from grassy hills (no. 001052)**

1.1 Low capital input on a grassy hill - Hairney Law/Auchope

Robin H. Armstrong, J. Eadie and T.J. Maxwell

Land Resources

There are 283 ha of mainly grassy pasture which has been subdivided in such a way as to enclose some 100 ha 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 (7.2 ha) 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 ha of the *Agrostis/Festuca* area was oversown following surface cultivation with a spiked bar rotovator. The seed mixture was applied at 28 kg/ha and 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 (N:P:K) compound fertiliser and heavy rolling. During 1976, 11.3 ha were sprayed with Asulox at a cost of £33.11 per hectare. In 1977 the more accessible 15 ha of the 18.2 ha in paddock 1 were treated with ground magnesium limestone at the rate of 7.5 tonnes per hectare. One hectare was enclosed and reseeded using a paraquat-rotovation technique on a trial basis.

In March 1978 the same 15 ha were further treated with 1.8 tonnes of basic slag per hectare (excluding the one hectare which had been reseeded on a trial basis in 1977, and had received its slag at the time of reseeding).

Then in May 1978 a further 4.5 ha of the slagged ground were reseeded by the paraquat-rotovation technique which had proved successful the year before in the trial reseeding of 1977, and thus by the autumn of 1978 there was a total of 5.5 ha of reseeded ground within Paddock 1, i.e. one hectare reseeded in 1977, and 4.5 ha reseeded in 1978.

At this point the decision was taken to extend the fence erected around the trial reseed of 1977 to take in approximately 1.6 ha of non-reseeded ground in Paddock 1, and so in effect the original 18.2 ha of Paddock 1 was reduced by 2.6 ha, this new small enclosure now being referred to as Paddock 1A.

Thus the original Paddock 1 of 18.2 ha was split into a small paddock (1A) comprising 1 ha of reseeded ground and 1.6 ha of non-reseeded ground, and a much larger area (Paddock 1B) comprising 15.6 ha of which 4.5 ha had been reseeded.

In June 1979 the 1.6 ha of non-reseeded ground in Paddock 1A was oversown with 2.25 kg/ha of clover seed, and at the same time a further 1.6 ha of hill ground within Paddock 1B were fully reseeded using the paraquat-rotovation technique, to make a total of 6.1 ha of reseeded ground. It should be noted that the 4.5 ha of Paddock 1B which had been reseeded the previous year were successfully sprayed in June with MCPB/MCPA to control a bad infestation of boar thistles, and that all ground reseeded prior to 1979 received a top-dressing of 250 kg/ha of compound fertiliser (20:10:10) in early May.

In August 1979, 13.4 ha of ground within Paddock 2 was given 6.34 tonnes of ground magnesium limestone/ha and 943 kg of Phossac (20% P_2O_5) ha, the intention being to reseed the more accessible parts of this area over the next two years. To this end 3.4 ha of this ground, selected for reseeding in the spring of 1980, and lying to the north end of Paddock 2 was resprayed with Asulox to kill off a regrowth of bracken which was becoming increasingly evident after having been effectively suppressed as the result of an earlier spraying in autumn 1974.

In the spring of 1980 a 316 m extension to the high tension fence enclosing Paddock 2 was erected thus dividing the paddock in two. The 3.4 ha in the northernmost part which had been resprayed for bracken control in late 1979 was reseeded in early May using the paraquat-rotovation technique.

The 1.6 ha of hill ground within Paddock 1 which was reseeded in 1979 was sprayed with MCPB/MCPA in June to control boar thistles. Auchope hayfield and surrounds (3.6 ha) received a total of 11 tonnes of ground magnesium limestone, and 1.75 tonnes Phossac (20% P_2O_5).

During May 1984, ground magnesium limestone was applied on paddock 2, 4.32 tonnes per hectare on the 3.23 hectares of reseeded ground and 6.18 tonnes per hectare on the 4.05 hectares of upgraded pasture. (Cost per tonne £9.50). In June 1984 the one hectare of reseeded ground within paddock P1A received 494 kg of Scotphos G. (2:30:0) NPK. No special treatments were applied in 1985.

Cattle

As previously, 25 hill cattle were carried on the resource from May until December with short periods elsewhere.

Sheep Stocks and Livestock Reconciliation

Ewes & Gimmers Nov. 1984	Cast	Deaths	Gimmers brought into flock	Hoggs born 1984	Ewes & Gimmers Nov. 1985
667	146	14	158	160	671

Total stock numbers:

	1969	1970	1971	1972	1973	1974	1975
NCC	175	210	260	269	300	295	292
SCC	223	241	254	259	273	305	309
TOTAL	398	451	514	528	573	600	601

	1976	1977	1978	1979	1980	1981	1982
TOTAL	620	621	623	622	631	649	674

	1983	1984	1985	1986
TOTAL	683	662	667	671

Sheep Year 1984-85

a) Winter Feeding

N.E. Hairney Law (4 crop, 3 crop and 2 crop ewes)

9/1/85	Ewes started on feed blocks Also hay fed at 250 g/hd/day because of severe weather
16/1/85	Hay increased to 370 g/hd/day
22/1/85	Ewes started on S.B.P. cubes at 340 g/hd/day Hay reduced to 180 g
11/2/85	S.B.P. cubes increased to 410 g
5/3/85	Lean ewes identified and shed off. Fed hay at 300 g and gradually changed to ewebol pencils increasing to 450 g/hd/day
11/3/85	S.B.P. cubes increased to 560 g. Hay remaining at 180 g Ewebol pencils to lean ewes increased to 560 g. Hay remaining at 300 g.
23/3/85	Gradual change made to ewebol cobs to 560 g at which point S.B.P. feeding stopped. Hay remaining at 180 g
29/3/85	Hay increased to 360 g
10/4/85	All ewes back together. Fed cobs at 550 g and hay at 360 g Concentrate feeding continued throughout lambing, and super ewebol pencils fed to twin-nursing ewes at 450 g/hd/day until the end of May

		Jan.	Feb.	Mar.	April (1-14th inc)	April (15-30)/ May
Colborn blocks	(kg)	500	540	820	240	-
S.B.P. cubes	(kg)	1250	3950	4000	-	-
Hay	(kg)	2115	2092	2633	1687	675
Ewebol cobs (and pencils)	(kg)	-	-	1900	2900	4100
Super ewebol pencils	(kg)	-	-	-	-	1700

Auchope (1 crop ewes and gimmers)

9/1/85 Ewes started on feed blocks
Also hay fed at 300 g/hd/day because of severe weather

16/1/85 Hay increased to 370 g

22/1/85 Ewes started on S.B.P. cubes at 330 g
Hay redyced to 220 g

11/2/85 S.B.P. cubes increased to 410 g. Hay remaining at 220 g

4/3/85 Twin bearing ewes shed off to rested grazing area and gradually changed to ewebol pencils at 370 g. Hay fed at 220 g

Single bearing ewes fed S.B.P. at 340 g and hay at 300 g

18/3/85 S.B.P. to single bearing ewes increased to 400 g

23/3/85 Gradual change made to ewebol cobs to single bearing ewes and increased to maximum of 520 g at which point S.B.P. feeding stopped. Hay remaining at 300 g. Ewebol pencils to twin-bearing ewes increased to 420 g

7/4/85 Hay feeding stopped to single bearing ewes

Concentrate feeding continued through lambing and super ewebol pencils fed to all twin nursing ewes at 450 g/hd/day until the end of May

		Jan.	Feb.	Mar.	April (1-14th inc)	April (15-30)/ May
Colborn blocks	(kg)	440	440	540	200	80
S.B.P.	(kg)	1000	3250	2500	-	-
Hay	(kg)	1832	2160	2160	495	945
Ewebol cobs	(kg)	-	-	1225	2175	1975
Super ewebol pencils	(kg)	-	-	-	-	375

Hoggs (N.E. Hairney Law and Auchope)

4.12.84 Hoggs started on ewe and lamb mix (4-5 days) then on to Green Keil at an average of 250 g/hd/day. When hay is fed during periods of adverse weather or when grazing roughage is at a minimum, the amount does not exceed 225 g/head/day.

1.4.84 Hoggs finished on feed

	Dec.	Jan.	Feb.	March and April
Ewe and lamb mix (kg)	75	-	-	-
Green keil (kg)	550	1500	1400	1825
Hay (kg)	-	1103	1260	1485
Ewebol cobs (kg)	-	-	-	300

Total feed consumption (kg) and costs per head

	Ewes and Gimmers (667)	Hoggs (171)
Hay	25.2	22.5
Colborn blocks	5.7	-
S.B.P.	23.9	-
Ewebol cobs and pencils	21.4	1.8
Super ewebol pencils	3.1	-
Ewe and lamb mix	-	0.4
Green keil	-	30.8
Cost per head	£9.56	£6.58

The cost per head for feed in the above tables has been calcualted from the following list and prices of feed components.

	Cost per tonne 1984/85
Hay	£ 66.00
Green keil	153.95
Ewebol cobs	146.46
Ewebol pencils	143.83
Super ewebol pencils	152.13
Beet pulp cubes	130.21
Ewe and lamb food	198.00
Colborn blocks	208.60
Rumevite H.E. blocks	184.00

b) Lambing Performance

Ewes to tup	667	
Tup eild	32	
Kebs	6	
Ewe losses to lambing	5	
Total lambs born (alive & dead)	888	(133.1%)
" " marked	819	(122.8%)
" " weaned	806	(120.8%)

c) Lamb Weights (kg)

Birth Weights	Singles	4.3
	Twins	3.8
Marking Weights	Singles	10.8
	Twins	8.2
Weaning Weights	Singles	26.5
	Twins	26.3
	All lambs	26.4

d) Wool Production (kg)

Total 1305 kg (667 ewes & gimmers)
= 1.96 kg average fleece

e) Ewe Body Weights (kg) 1984/85

	Nos.	Pre-mating Nov.84	Pre-feeding	Pre-lambing	Marking	Weaning	Pre-mating Nov.85	Nos.
4 Crop	122	65.0	64.5	66.7	59.9	65.0	68.1	105
3 Crop	116	63.7	63.1	66.4	58.8	63.9	65.0	109
2 Crop	118	59.9	59.3	62.1	56.8	60.4	62.4	131
1 Crop	147	54.6	56.0	58.7	53.2	56.6	57.4	156
Gimmers	158	51.8	49.8	51.4	46.9	51.5	52.4	164
All Ages	667	58.4	57.9	60.6	54.3	58.9	60.1	671
5 Crop	6	60.9	57.7	60.7	56.3	61.1	-	-

Summary of Production and Performance 1968/85

f) Pre-mating ewe body weight (Nov.) (kg)

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

	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985
NCC x SCC	58.0	53.6	57.7	59.1	58.1	59.9	59.9	58.1	56.8	58.4	60.1

g) Production Data

	Stock Nos.	Weaning %	Total weight lamb weaned	Total weight wool wool (incl. hoggs)
1969	398	84.7	7786	850
1970	451	86.7	9188	1017
1971	518	102.5	14177	1253
1972	528	104.7	14046	1369
1973	573	99.5	14193	1561
1974	600	91.5	14329	1454
1975	601	102.7	16042	1535
1976	620	108.5	17902	1543
1977	621	106.9	17596	1503
1978	623	105.1	16470	1523
1979	622	113.3	17837	1601
1980	631	118.2	19471	1887
1981	649	104.0	17905	1610
1982	674	120.3	20149	1590
1983	683	110.5	19486	1723
1984	662	117.2	21020	1600
1985	667	120.8	21288	1645

1.2 High capital input on a grassy hill - Sourhope/Alderhope

Robin H. Armstrong, J. Eadie and T.J. Maxwell

This project is dependent for its improved pasture component on a high input of capital in a complete reseeding operation. The principles which have already been outlined and applied with regard to the use of improved pasture in relation to the open hill in year-round grazing systems are also being applied in this system.

At present further development of the project is postponed until the studies on copper deficiency, which has occurred in the flock, are complete.

Land Resources

The area of 130 ha is of mainly grassy pasture dominated by Molinia 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 units at Sourhope. During 1970, 3.2 ha of reseed were established with further reseeds established in 1972 (3 ha), 1973 (6.2 ha) and 1974 (3.2 ha). During 1970, 3.2 ha of reseed were established with further reseeds established in 1972 (3 ha), 1973 (6.2 ha) and 1974 (3.2 ha). During 1975 all reseeds were treated with 6.3 tonnes per ha of ground magnesium limestone and 880 kg of superslag (16% P_2O_5) per ha. During 1982, the following applications were made. Reseeds A1 and A4 received 125 kg of potassium muriate on 5th October, and A4 received 5 tonnes per hectare of ground magnesium limestone on May 19th.

In September 1984, reseeds A, A_2 and A_3 were treated with 5.0 tonnes per hectare of ground magnesium limestone. Reseed A_4 was not so treated. No special treatments were applied in 1985.

Sheep Stocks and Livestock Reconciliation

Ewes and Gimmers Nov. 86	Cast	Deaths	Gimmers brought into flock	Hoggs born 1983	Ewes and Gimmers Nov. 85
293	63	1	68	73	297

Alderhope: Sheep Year 1984-85

a) Winter Feeding

Ewes and Gimmers

9/1/85 Ewes started on feed blocks
Also hay fed at 300 g/hd/day because of severe weather

23/1/85 Ewes started on S.B.P. cubes at 300 g/hd/day
Hay reduced to 150 g

11/2/85 S.B.P. cubes increased to 350 g/hd/day
Hay remaining at 150 g

18/3/85 S.B.P. cubes increased to 500 g/hd/day
Hay remaining at 150 g

27/3/85 S.B.P. feeding stopped. Commence feeding ewebol cobs at 500 g/hd/day

30/3/85 Cobs reduced to 430 g/hd/day
Hay remaining at 150 g

2/4/85 Hay feeding stopped, cobs remaining at 430 g

15/4/85 Cobs reduced to 260 g/hd/day. Hay re-introduced at 150 g

Concentrate feeding continued through lambing

26/4/85 Super ewebol pencils introduced to ewes nursing twins and increased to 450 g/hd/day

8/5/85 Feed to twin nursing ewes increased to 675 g because of lack of grass during the very cold weather

26/5/85 Twin nursing ewes changed from pencils to cobs

3/6/85 All feeding to ewes finished

	Jan.	Feb.	Mar.	April (1-14th inc)	April (15-30th inc)	May
S.B.P. (kg)	800	2675	2900	-	-	-
Feed blocks "	337	495	360	135	247	40
Ewebol cobs "	-	-	825	1625	500	450
Super ewebol pencils (kg)	-	-	-	-	900	1150
Hay "	1867	1665	1643	68	877	248
Ewebol pencils "	-	-	-	-	350	-

Hoggs

4.12.84 Hoggs started on ewe and lamb mix (4-5 days), then onto Green Keil at an average of 250 g/head/day.
Hay fed as required (approx. 80 days), both in periods of adverse weather conditions or in periods when grazing roughage was at a minimum, at an average of 225 gms/head/day

15.4.85 Hoggs finished on feed

Total Feed (kg)

Hay	1316
Ewe cobs	50
Green keil	2072
Ewe and lamb food	50

Total feed consumption per head for ewes and gimmers and for hoogs was as follows:-

	Ewes and Gimmers (283) (kg)	Hoggs (75) (kg)
Hay	21.7	18.8
Feed blocks	5.5	-
Beet pulp cubes	21.8	-
Ewebol cobs and pencils	12.8	0.7
Super ewebol pencils	7.0	-
Green keil	-	29.6
Ewe and lamb mix	-	0.7
Total cost per head	£8.16	£6.00

The cost per head for feed in the above tables has been calculated from the following list and prices for feed components.

	Cost per tonne 1984/85
Hay	£ 66.00
Green keil	153.95
Ewebol cobs	146.46
Ewebol pencils	143.83
Super ewebol pencils	152.13
Beet pulp cubes	130.21
Ewe and lamb food	198.00
Colborn blocks	208.60
Rumevite H.E. blocks	184.00

b) Lambing Performance

Ewes to tup	293	
Tup eild	6	
Kebs	10	
Ewe losses to lambing	0	
Total lambs born (alive & dead)	418	(142.7%)
" " marked	376	(128.3%)
" " weaned	370	(126.3%)

c) Lamb Weights (kg)

Birth Weights	Singles	4.1
	Twins	3.4
Marking Weights	Singles	10.9
	Twins	8.6
Weaning Weights	Singles	31.3
	Twins	25.7
	All lambs	28.1

d) Wool Production (kg)

Total 448 kg (293 ewes & gimmers)
= 1.53 kg average fleece

e) Ewe Body Weights (kg) 1984/85

	Nos.	Pre-mating Nov.84	Pre-feeding	Pre-lambing	Marking	Weaning	Pre-mating Nov.85	Nos.
4 Crop	41	62.7	60.4	63.6	52.3	61.1	63.8	44
3 Crop	50	63.2	61.2	65.2	54.7	61.6	63.5	55
2 Crop	59	61.1	60.3	63.8	53.7	60.6	59.1	67
1 Crop	73	53.4	52.8	54.8	47.7	56.7	55.0	63
Gimmers	70	52.8	48.6	49.4	42.5	51.7	54.1	63
All Ages	293	57.8	55.8	58.3	49.5	57.7	58.6	292

Summary of Production and Performance 1972/1985

f) Premating Ewe Body Weights (Nov.) (kg)

1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985
54.4	51.8	55.7	54.5	55.3	56.8	58.3	56.9	59.8	59.8	57.9	57.5	57.8	58.6

g) Production Data

	Stock Nos.	Weaning %	Total Weight Lamb Weaned	Total Weight Wool (inc. Hoggs)
1973	217	112.9	6615	493
1974	222	109.0	6534	490
1975	242	116.6	7981	560
1976	255	106.3	7751	542
1977	272	112.9	8934	536
1978	259	97.3	7056	501
1979	266	115.0	8325	469
1980	269	128.6	9394	586
1981	266	127.1	9878	610
1982	275	130.9	9892	590
1983	281	116.0	8709	569
1984	283	132.5	11320	595
1985	293	126.3	10393	593

Research objective: The evaluation of improved systems of sheep production from *Calluna* moorland (no. 001054)

1.3 On heather moor - Glensaugh, Cairn

T.J. Maxwell, J. Eadie, J.A. Milne and R.D.M. Agnew

From 1973 until 1978 the unit was managed in the context of the year round grazing system outlined in the Introduction as a prelude to the testing on a practical scale of ideas emerging from the heather research programme.

Land Resources

The Cairn lies on the north-eastern part of Glensaugh on land rising from 150m to 470 m, extending to 205 hectares, including 23 ha of permanent grassland and an enclosed area of the hill used for lambing.

During the summer of 1978, 17.2 hectares of the Redstone Hill were enclosed and divided into two approximately equal areas. In one of the areas (south) four half ha square reseeds and on the other (north) four half ha rectangle reseeds were created. In this way, artificial mosaics of reseeded grassland were set up within the callunetum. The reseeded areas were cleared of heather by brashing, given 7 tonnes lime/ha and 400 kg superphosphate/ha in July. They were then oversown with a grass/clover seed mixture with an application of 600 kg/ha of compound fertiliser and 600 kg/ha ground mineral phosphate in late July. The area was lightly grazed for the first time during the late summer and autumn with ewe hoggs.

In 1979, 15.7 hectares on Thorter hill were enclosed, using a similar strategy. Two enclosures of approximately equal area were created in which there were respectively four near-square, and three elongated strip reseeds.

A top dressing of 375 kg/ha (83 kg N/ha) of compound fertiliser (22:11:11) was applied to the Redstone Hill reseed in May 1979 and 125 kg/ha (32.5 kg N/ha) of Nitrochalk in July.

In 1980 and 1981 a similar dressing of compound fertiliser was applied to all the mosaic reseeds during May.

As a consequence of the investigations concerning the response to nitrogen fertiliser applications reported in the Annual Report (1982) nitrogen was applied on the mosaics at the rate of 125 kg/ha of Nitram (43 kg N/ha) on 18 April 1983 and again on 30 June using 200 kg/ha of Nitrochalk (42 kg N/ha). In early June 600 kg/ha of Potassic Super was applied to the mosaic reseeds providing 50 kg P and 95 kg K/ha.

Maintenance dressings of lime and phosphate were applied in 1983 to the Redstones Plot and Upper Redstones. On 23 June 1.25 t/ha of lime was applied and 50 kg P/ha were applied as Gramphos.

On 3 June 1983, 200 kg Nitram/ha (68 kg/ha) was applied on Redstones Plot and Upper Redstones.

A long term monitoring programme was initiated in September 1979 on the Redstone Hill reseed. This programme has been designed to assess botanical changes in the callunetum associated with the introduction of reseeded areas of differing configuration, and the effects of grazing on the indigenous and introduced vegetation.

During 1983, differential applications of nitrogen, lime, potassium, trace elements and Rhizobium were applied to randomly selected reseeded areas on an experimental basis in association with Dr Anne Rangeley.

During 1984 procedures were introduced to enhance the productivity of the unit. These involve increased levels of nitrogen application, the introduction of hill cattle as an aid to grazing management and the incorporation of further sown pasture to provide silage for winter cattle fodder.

The new regime was partially adopted in 1984, in that 15 Luing cows and calves summered on the Cairn hill and mosaics, and nitrogen input was increased. In 1985 and subsequently these developments were fully implemented as described below.

The 1985 fertiliser and reseeding programme was as follows:

The mosaic reseeds received a total of 90 kg N per hectare in the applications, 40 kg on May 6th, 25 kg on January 19th and on July 4th; with P and K each at an annual total of 25 kg per hectare.

The Redstones plot and Upper Redstones reseeds each received two applications, the first in mid April (40 kg N/ha) and the second in mid August (25 kg N/ha) amounting three annual totals of 65, 20 and 20 kg per hectare of N, P and K.

The Lower Redstones reseed was partially reseeded in early May when a heavy phosphate application was made (30 kg N, 60 kg P and 30 kg K per hectare). This reseed was used for silage making, so a heavy application of nitrogenous fertiliser was made on May 24th (100, 20 and 20 kg per hectare of N, P and K).

After the first silage cut in early July a further application of 75.15.15 kg/ha N, P, K was made on July 9th. There were no further applications, and after the second silage cut in early September light grazing by hoggs and for short periods by cattle was permitted.

Introduction of grazing management developments incorporating cattle and increased nitrogen applications

The conclusions reached from a recent analysis of the performance of the Cairn flock are that there is a need to provide a better balanced supply of feed from pasture to the sheep flock and that this will require to be done by manipulating nitrogen application and improve the utilisation of the hill area and the improved areas in the middle of the summer by the use of cattle. It was further concluded that there is a need, as far as possible, to control tick parasitism on the unit and to lamb ewes on lower fields than those previously used to reduce, if possible, lamb losses associated with severe exposure and climatic conditions at higher altitudes.

It follows from these conclusions that a radical change in the levels of inputs of annual expenditure for fertilisers is required and that in using a breeding herd of suckler cows provision for a supply of winter feed is necessary. The latter cannot be made from existing resources. It is also important that in using cattle to improve the efficiency of herbage utilisation that they should do this without competing significantly with sheep, particularly in the spring and autumn. Thus a further allocation of sown grassland has been made to the unit for the principal use of cattle and the supply of their winter fodder.

To be economically viable it follows that with increased annual expenditure, output from sheep will have to increase substantially above present levels. The actual level of fertilisers used is based on a judgement about the expected improved level of sheep performance that may arise from it.

Objective

Measure the effects of the integrated use of sown grassland, mosaic reseeds, (using 80 kg N/ha/annum on the improved grassland and reseeds) and heather dominant moorland, (which is also utilised by 15 Luing suckler cows and their calves), on the performance and output of a flock of Scottish Blackface ewes and overall economic performance of the unit.

Method

Grazing management: To achieve the objectives outlined above the following is the grazing allocation adopted. The Upper Redstones and Redstone Plot is used principally for sheep i.e. 'sheep reseeds'; also the reseeds in the enclosed hill paddocks (mosaics) are used principally for sheep in the early spring at a level of utilisation which aims to utilise grass only; as the summer progresses utilisation increases commensurate with satisfactory ewe and lamb performance, after weaning and during early autumn utilisation will be increased to achieve 40% utilisation of current season's shoots.

On the basis of the grazing regime outlined for cattle 5 ha of additional improved sown grassland has been allocated to the unit to provide all the bulk winter fodder for cattle; (5 ha yielding 18t/ha providing 90t - 6t/cow for 15 cows for winter through until late May). Lower Redstones is therefore allocated to the Cairn Unit - the cattle reseeds.

Four grazing areas are identified, the Hill, the mosaic reseeds, the sheep reseeds and the cattle reseeds. The table below outlines the allocation of stock throughout the year.

Cairn - grazing allocations, 1985

Adjustments to stock numbers and allocations on the sheep reseeds are made to maintain sward height between 3 to 4.5 cm on Redstones Plot and Upper Redstones through to weaning. The mosaic reseeds are controlled at a similar level until weaning and then reduced to between 2.5 to 3 cm during the late summer and autumn. The cattle reseed is grazed in the early spring until herbage is available on the hill and again in the late summer and autumn until calves are weaned on October 7 and removed from the unit. Hoggs graze the cattle reseed in the autumn.

Fertiliser applications

Nitrogen is applied on all sheep reseeds and mosaics in spring and late summer. Forty kg N with 15 kg P_2O_5 and 15 kg k_2O per hectare is applied in late April when 10 cm temperature has reached 5.5°C. In the late summer (mid-July) a further 40 kg N is aplied with 15 kg P_2O_5 and 15 kg K_2O per hectare. This application is subject to an assessment of herbage availablity. If sward heights are in excess of 6 cm this application will be delayed but not later than the second week in August. Cows are removed from the reseeds and housed when sward height falls below 3.5 cm.

Sheep year 1984-85

Sheep stocks and livestock reconciliation

Ewes and Gimmers Nov. 84	Cast	Deaths	Gimmers brought into flock	Hoggs born 1984	Ewes and Gimmers Nov. 85
257	70	16	61	72	254

a) Winter feeding

Cairn ewes were fed concentrates during the mating period and again from mid-December through to the lambing period and until May 18th. Hay was fed from 4th January until 27th April.

	Hay			Concentrates		
	Dates fed		per head (kg/day)	Dates fed		per head (kg/day)
Ewes and Gimmers:	7/11/84	- 10/11/86	0.10	7/11/84	- 19/12/84	0.25
				20/12		0.34
	20/11	- 11/1/85	0.19			0.34
	12/1/86	- 20/1	0.68			0.34
	21/1	- 29/1	0.78			0.34
	30/1	- 3/2	0.49			0.34
	4/2	- 7/2	0.39			0.34
	8/2	- 20/2	0.68			0.34
	21/2	- 3/3	0.19			0.34
	4/3	- 15/3	0.39			0.34
	16/3	- 20/3	0.58			0.34
	21/3	- 25/3	0.78			0.34
	26/3	- 4/4	0.39		31/3	0.34
	5/3	- 13/4	0.19	1/4		0.39
						0.39
	20/4	- 21/4	0.39		30/4	0.39
	22/4	- 27/4	0.19	1/5		0.19
					18.5	0.19

Hoggs:	8/11/84 - 20/11/84	0.8		8/11/84 - 20/11/84	0.21
	21/11 - 6/1/85	0.7		21/11/84 - 6/1/85	0.20
	7/1/85	0.8		7/1/85 - 31/1	0.24
	17/4	0.8		1/2 - 17/4	0.27

Total feed and costs per head

	Ewes & Gimmers		Hoggs	
	kg	£	kg	£
Concentrates	64.6	8.86	37.4	5.12
Hay	53.1	3.98	118.9	8.92
Total	-	12.84	-	14.04

b) Lambing Performance

Ewes to tup	253
Tup eild	17
Kebs	13
Ewe losses to lambing	5
Total lambs born (alive & dead)	285 (112.6%)
Total lambs marked	237 (93.7%)
Total lambs weaned	224 (88.5%)

c) Lamb Weights (kg)

Birth weights,	singles	4.5
	twins	3.8
Marking weights,	singles	14.4
	twins	12.0
Weaning weights,	singles	29.4
	twins	26.0
All lambs		28.1

(d) Wool Production (kg)

N/A

e) Ewe Body Weights (kg) 1984/85

	Nos.	Pre-mating Nov.84	Pre-feeding	Pre-lambing	Marking	Weaning	Pre-mating Nov.84	Nos. 85
4 Crop	17	61.9	60.5	65.6	53.3	57.8	61.2	9
3 Crop	57	57.8	54.5	61.6	50.4	52.5	62.0	56
2 Crop	61	55.8	55.3	62.0	51.7	55.3	57.2	63
1 Crop	58	52.1	49.0	54.6	48.6	53.0	52.2	63
Gimmers	61	42.0	39.8	44.2	41.3	45.4	49.7	62
All Ages	257	52.4	50.3	56.1	48.2	51.9	55.3	254
5 Crop	3	59.7	59.7	70.0	54.0	63.0	61.0	1

Summary of production and performance (1972-85)

f) Premating Ewe Body Weight (Nov.) (kg)

1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985
52.8	51.8	55.8	50.0	47.5	51.3	54.0	56.7	57.5	51.6	49.1	48.2	52.4	55.3

g) Production Data

	Stock Nos.	Weaning %	Total weight lamb weaned	Total weight wool (incl. hoggs)
1973	234	97.9	5061	
1974	187	96.3	5078	
1975	190	111.6	5307	410
1976	204	99.0	4909	433
1977	196	67.3	3452	381
1978	176	86.4	4173	442
1979	187	101.6	5468	486
1980	178	105.6	4842	512
1981	200	100.0	5327	547
1982	263	90.9	5927	596
1983	262	61.5	3673	N/A
1984	262 + 6	63.7	3843	N/A
1985	257	88.5	6294	N/A

2. HILL SHEEP: OFF-WINTERING SYSTEMS

Research objective; **Evaluate improved systems of sheep production based on off-wintering with and without land improvement (no. 001055)**

2.1 On a grassy hill - Sourhope/Rigg and Gairs

Robin H. Armstrong, J. Eadie and T. J. Maxwell

Land Resources

The Rigg and Gairs are two similar units, each of 101 ha, 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. On the Gairs Unit a substantial area of improved pasture has been made available. An area of 15 ha 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 ha of *Molinia-Nardus* grass heath at 450m received 6.35 tonnes lime and 1.65 tonnes slag per ha. It was later sprayed with Paraquat, rotovated and direct reseeded in mid-July with 380 kg per ha 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 0.88 tonnes/ha was applied to the Gairs reseed. Gairs reseeds received applications of potassium muriate in November 1982 (EI 125 kg/ha, E2 187.5 kg/ha). In addition E1 received 7.5 tonnes/ha of ground magnesium limestone.

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.

Stocking Policy

The breed changeover from a South Country Cheviot to a Blackface ewe stock is complete. The change was achieved by September 1979.

The policy of grazing cattle on both Rigg and Gairs, thus enabling an equalisation of grazing days on each heft, became impracticable in 1977 due to inadequate pasture, and in that year cattle grazing took place only on the Gairs. It was decided that no cattle would be grazed on either the Rigg or the Gairs from 1978, and in the autumn of 1978 sheep stock numbers on both sides were reduced, the Rigg to 271 and the Gairs to 275.

Sheep Stocks and Livestock Reconciliation

Both the Rigg and Gairs have carried South Country Cheviots. Stocking rate increases were made equally on two units by purchase of ewe lambs in late summer which were then wintered with those hoggs retained from that season's flock. In 1974 Blackface hoggs were purchased to replace the Cheviot hoggs on both units. Cheviot ewe stocks were replaced progressively by Scottish Blackfaces. For this reason the flock data is presented separately for the two breeds.

	Ewes and Gimmers Nov. 84	Cast	Deaths	Gimmers brought into flock	Hoggs born 1983	Ewes and Gimmers Nov. 85
Rigg	269	54	6	66	75	275
Gairs	300	62	5	75	80	308
Total	569	116	11	141	155	583

Rigg and Gairs

Sheep Year 1984-85

a) Winter Feeding

During the autumn of 1984 ewes of Rigg and Gairs hefts were housed and allocated to an experiment investigating the reproductive response of ewes in different body condition to treatment with different levels of anti-testosterone serum. After mating the ewes were in such variable body condition that it was necessary to split them into four groups and feed accordingly, as shown in the following tables.

i) **Ewes in good body condition**

	From 9/1/85	19/2	8/3	13/3	21/3	28/3	3/4	10/4
Hay	680g	680	680	Change to super	680	680	680	680
S.B.P.	230g	280	280	ewebol pencils for	280	280	280	280
Conc.	120g	120	180	twin-bearing ewes	240	290	340	390

A high protein concentrate (18% Cd Ptn) was fed from 13th March to twin-bearing ewes at the same daily rate as the medium protein concentrate (14% Cd Ptn) being fed to the single bearing ewes.

ii) **Ewes in medium body condition**

Hay	1000g	900	900	680	Winter feed from 8/3 same as
S.B.P.	230g	230	280	280	ewes in good body condition
Conc.	130g	180	180	180	

iii) Ewes in low body condition

From 9/1/85		17/1	24/1	5/2	13/3	21/3	28/3	3/4	10/4
Hay	1000g	900	900	900	All* ewes changed	800	800	750	750
S.B.P.	230g	230	280	280	to super ewebol	280	280	280	330
Conc.	130g	180	180	230	pencils	280	340	390	450

iv) Ewes in very low body condition

From 9/1/85		17/1	24/1	29/1	5/2	13/3	21/3	28/3	10/4
Hay	1000g	900	900	900	900	All* ewes changed	800	800	750
S.B.P.	230g	230	280	280	280	to super ewebol	330	330	330
Conc.	130g	180	180	230	300	pencils	350	400	450

* All ewes irrespective of whether twin-bearing, or single bearing

Hoggs

4/12/84 Hoggs started on ewe and lamb feed (4-5 days), then onto Green keil.

11/ 1/85 Hoggs housed. DIET Hay - 600 gms/day
Green Keil - 250 gms/day

5/ 4/85 Hoggs out of shed.

Total Feed (kg) 142 hoggs.

Hay	7380	52.0
Green keil	3475	24.5
Ewe and lamb food	50	0.4

Total dry matter per head = 76.9 kg
Cost per head = £7.28

Total Feed (kg) 569 ewes and gimmers

	Pre-lambing	Post lambing	Total	Per Head
Hay	40500	5108	45608	80.2
S.P.B.	14775	2075	16850	29.6
Ewebol cobs and pencils	7725	3600	11325	19.9
Super ewebol pencils	3025	3550	6575	11.6

Total dry matter per head = 141.3 kg
Cost per head = £13.77

However, the range of dry matter intakes and costs varied from 123.1 kg and £11.61 for ewes in good body condition to 158.0 kg and £15.21 for ewes in very low body condition.

The cost per head for feed in the above tables has been calculated from the following list and prices of feed components.

	Cost per Tonne 1984/85
Hay	£ 66.00
Green keil	153.95
Ewebol cobs	146.46
Ewebol pencils	143.83
Super ewebol pencils	152.13
Beet pulp cubes	130.21
Ewe and lamb food	198.00
Colborn blocks	208.60
Rumevite H.E. blocks	184.00

b) Lambing Performance

	Rigg	Gairs
Ewes to tup	269	300
Tup eild	12	16
Kebs	0	0
Ewe losses to lambing	2	1
Total lambs born (alive & dead)	388 (144.2%)	421 (140.3%)
Total lambs marked	366 (136.1%)	392 (130.7%)
Total lambs weaned	356 (132.3%)	400 (133.3%)

c) Lamb Weights (kg)

		Rigg	Gairs
Birth weights,	singles	4.6	4.7
	twins	3.6	3.8
Marking weights,	singles	10.9	13.8
	twins	8.0	7.8
Weaning weights,	singles	30.4	31.1
	twins	27.4	29.6
All lambs		28.6	30.2

d) Wool Production (kg)

Rigg (274 ewes) total = 402.8 kg
Average fleece wt. = 1.5 kg
Gairs (283 ewes) total= 408.3 kg
Average fleece wt. = 1.4 kg

e) Ewe Body Weights (kg) 1984/85

	Nos.	Pre-mating Nov.86	Pre-feeding	Pre-lambing	Marking	Weaning	Pre-mating Nov.85	Nos.
RIGG								
4 Crop	43	57.5	59.6	62.8	55.6	59.7	58.2	48
3 Crop	55	54.9	58.7	62.8	54.8	58.7	61.0	52
2 Crop	54	55.5	59.7	64.5	56.6	69.2	56.3	49
1 Crop	52	50.5	54.9	59.4	53.1	57.1	52.1	66
Gimmers	65	49.0	51.5	56.0	49.7	52.8	54.0	66
All ages	269	53.1	56.6	60.8	53.7	57.4	56.0	275
GAIRS								
4 Crop	46	57.5	63.4	67.5	57.3	63.1	59.7	43
3 Crop	52	59.4	61.2	65.0	55.1	61.8	60.8	54
2 Crop	58	57.0	60.1	64.1	55.8	62.1	62.7	58
1 Crop	65	54.1	57.6	62.1	55.5	63.3	56.5	78
Gimmers	79	52.3	52.9	57.6	50.3	55.3	50.9	75
All ages	300	55.6	58.4	62.6	54.3	60.6	57.5	308

Summary of Production and Performance 1969-1985)

f) Total Stock Number and pre-mating Ewe Body Weights

	RIGG				GAIRS			
	SCC		BF		SCC		BF	
	Nos.	Wts.	Nos.	Wts.	Nos.	Wts.	Nos.	Wts.
1969	205	48.3			209	49.9		
1970	205	49.7			207	50.5		
1971	238	51.5			233	51.9		
1972	278	51.2			260	53.5		
1973	279	50.6			279	52.9		
1974	298	50.0			297	54.1		
1975	234	51.8	65		240	53.8	65	
1976	152	53.8	128	48.5 (52.4)*	165	56.6	132	48.5 (54.7)
1977	93	55.6	191	52.1 (54.0)	111	56.7	199	51.5 (54.4)
1978	40	55.6	231	55.0 (55.1)	45	59.0	230	55.1 (55.7)
1979			264	56.9			271	58.0
1980			266	54.9			272	57.2
1981			260	56.7			281	57.0
1982			274	55.5			283	55.1
1983			268	55.3			286	57.3
1984			269	53.1			300	55.6
1985			275	56.0			308	57.5

* Nos. in brackets are mean weights of SCC and BF

g) Production Data

	Stock Nos.	Weaning %	Total weight lamb weaned	Total weight wool	Stock Nos.	Weaning %	Total weight lamb weaned	Total weight wool
1970	205	83.0	3706	402	209	83.0	3581	461
1971	205	87.0	4432	534	207	96.0	5246	524
1972	238	100.0	5712	641	233	91.4	5176	634
1973	278	87.8	5324	732	260	93.1	5675	752
1974	279	91.0	6155	680	279	87.0	6394	766
1975	311	89.6	6257	670	305	87.2	6381	732
1976	299	90.6	6640	674	305	99.0	7943	738
1977	290	105.2	8218	567	297	109.4	9248	643
1978	284	105.6	7920	525	310	111.9	9542	624
1979	271	121.0	8519	521	275	127.2	9956	512
1980	264	121.6	9020	530	271	129.9	10102	552
1981	266	118.4	9299	503	272	121	9962	531
1982	260	117.3	8996	519	281	112.1	9392	516
1983	274	125.9	9534	522	283	126.9	11118	575
1984	268	116.0	8822	523	286	130.8	11448	587
1985	269	132.3	10169	524	300	133.7	12114	548

3. UPLAND SYSTEMS

Research objective: Evaluate systems of upland sheep production (no. 001056)

3.1 Upland Sheep Systems - Hartwood

T.J. Maxwell, A.R. Sibbald, R.D.M. Agnew, A. Dalziel and E.V. Deans

Towards the end of 1982 a number of aspects of the management of upland sheep had become clearer as a result of component experimentation. For example, it was possible to draw some conclusions about the sward conditions necessary to achieve satisfactory levels of sheep performance during lactation consistent with maintaining optimum levels of herbage growth and utilisation; the type and level of supplement necessary to achieve satisfactory levels of performance in early lactation when grass is in short supply had also been clarified. Though more information was required for the period prior to and during mating it was possible to outline the tentative minimal sward conditions and a supplementation strategy capable of sustaining satisfactory levels of reproductive performance. The integration of this knowledge required to be evaluated in whole systems of production.

An experiment was therefore designed to examine the effect of maintaining sward grazing conditions at two levels, high (H) and low (L) in terms of height and herbage mass from as early as possible after lambing until weaning. Interest was focussed on the individual performance and total output of Border Leicester x Scottish Blackface (Greyface) ewes and their lambs, on the amount of winter fodder produced, and on subsequent lambing performance as a consequence of controlling sward conditions by closing areas for conservation. Two stocking rates, (h and l), 10 and 15 ewes per hectare, were used at one level of annual nitrogen application (150 kg N per hectare applied on four occasions). The treatments are replicated three times and the experiment ran for three complete production years 1983, 1984 and 1985.

The ewes were mated in late October to Dorset Down rams. Lambing commenced in each year around 20 March. Ewes were cast for age at five years old and replaced by bought-in two year olds. Once allocated to a treatment ewes remained on that treatment for the duration of their productive lives.

2.

The two sward condition treatments, measured in terms of herbage mass and height, were, in early lactation (L) a maximal herbage mass of 850 kg DM/ha with ewes fed 600 g cereal/protein supplement, and (H) where ewes were held on a 'sacrifice' area, and given cereal/protein concentrates and hay until the herbage mass on the grazed area had reached 1000 kg DM/ha (H). In mid and late lactation, the (L) treatment becomes 850 kg DM/ha and the (H) treatment 1350 kg DM/ha. Herbage mass was controlled by closing surplus areas for conservation but no control was attempted after weaning. Other decision rules controlled the amount and period during which supplementary feed was given in the spring and autumn, and the date on which ewes were removed from their grazed area and housed for the winter. In the autumn, around mating, 150 g per ewe of a 14% CP supplement was given when sward height was falling at 3.5 cm, 300 g at 3.0 cm and 300 g plus 1 kg of hay when sward height was 2.5 cm. Feeding was controlled during the winter in relation to ewe weight, condition score change, and foetal load. Fertiliser N application was made in relation to 10 cm soil temperature for the first application and thereafter by date.

A limited summary of the results is presented in this short report.

The average sward heights achieved over the three years in each part of the grazing cycle, are given in Table 1. For the most part treatment differences were maintained during the periods of sward manipulation up to weaning; thereafter differences were related to stocking rate.

TABLE 1
Mean Sward Height (cm) from Lambing

	Treatment Combinations				Main Effects			
Sward Conditions	L		H		L	H		
Stocking Rate	l	h	l	h			l	h
0-6 weeks	2.7_a	2.5_a	5.1_b	5.2_b	2.6_v	5.1_w	3.8	3.9
6-9 weeks	3.0_a	2.5_a	5.4_c	4.3_b	2.7_v	4.9_w	4.2_x	3.4y
9- weaning	3.5_b	3.1_a	4.7_c	3.5_{ab}	3.3_v	4.7_w	4.1_x	3.3_y
Weaning - 6 weeks premating	4.7_b	3.8_a	5.4_c	4.0_a	4.2_v	4.7_w	5.0_x	3.9_y
6 weeks premating - mating	5.1_b	3.9_a	5.5_b	3.9_a	4.5	4.7	5.3_x	3.9_y
Post-mating	3.3_b	2.5_a	3.5_b	2.6_a	2.9	3.1	3.4_x	2.6_y

Values with different subscripts within treatment and main effect comparisons (rows) are significantly different ($p<0.05$).

The production data (mean of three years) are given in Table 2. Output of weaned lamb was affected significantly by stocking rate ($p<0.001$) but not

TABLE 2
Production Data

	Treatment Combinations				Main Effects			
Sward Conditions	L		H		L	H		
Stocking Rate	l	h	l	h			l	h
Weaned Lamb (kg per hectare)	516_b	580_c	429_a	605_c	548	514	472_x	589_y
Weaning Weight (kg per lamb)	33.2_c	30.1_{ab}	30.4b	28.8_a	31.6_v	29.7_w	31.8_x	29.6_y
Lamb:Ewe Ratio	1.54_b	1.29_a	1.39_{ab}	1.40_{ab}	1.41	1.38	1.46	1.33
Lambs per Ewe (Scanned year following)	1.80	1.71	1.74	1.68	1.75	1.73	1.77	1.72
Proportion Area Conserved	0.26_b	0.06_a	0.33_b	0.13_a	0.16_v	0.23_w	0.29_x	0.09_y

Values with different subscripts within treatment and main effect comparisons (rows) are significantly different ($p<0.05$).

by sward height. Weight of lamb weaned per ewe was affected significantly by stocking rate ($p<0.01$) and also by sward height ($p<0.05$). In part the differences also arise from differences in lamb:ewe ratio which were significant at $p<0.10$ in relation to stocking rate. The proportion of the grazed area closed for conservation was affected by both sward height ($p<0.05$) and by stocking rate ($p<0.001$).

Ewe premating liveweights were affected by stocking rate ($p<0.001$) being 69.1 kg at 15 ewes per ha and 73.1 kg at 10 ewes per hectare. These differences persisted through the annual cycle of production. Only in mid-lactation were differences in ewe liveweight affected by sward height ($p<0.05$).

The growth rate of lambs from birth to six weeks of age of the ewes held off grazed pasture and given supplementary feed and a basal forage until target sward conditions had been reached in the spring (i.e. Hl and Hh) were significantly less ($p<0.001$) than those lambs of ewes immediately stocked onto their grazed pasture area and given 600 g supplement (i.e. Ll and Lh), (Table 3). From six to nine weeks the lamb growth rate of lambs of ewes at low sward height and high stocking rate (Lh) were significantly less than other treatments. From nine weeks until weaning lambs of ewes at low sward height (Ll and Lh) grew at a significantly greater rate ($p<0.05$) than those at high sward height.

TABLE 3
Lamb Growth (g/day)

	Treatment Combinations				Main Effects			
Sward Conditions	L		H		L	H		
Stocking Rate	l	h	l	h			l	h
Birth - 6 weeks	304_b	272_{ab}	241_a	237_a	288_v	230_w	272	255
6 weeks - 9 weeks	318_b	264_a	322_b	300_b	291	311	320_x	282_y
9 weeks - Weaning	236_b	220_{ab}	214_{ab}	197_a	228_v	206_w	225	209

Values with different subscripts within treatment and main effect comparisons (rows) are significantly different ($p<0.05$).

The reproductive performance of ewes as determined by scanning at 50-70 days into pregnancy (Table 2) was not significantly different between treatments despite differences in pre-mating bodyweight and condition score. Any differences in reproductive performance that might have been expected as a result of these differences in liveweight and condition appear to have been modified as a consequence of the supplementary feeding strategy adopted.

The broad conclusions of the experiment are that:-

i) there were no advantages to lamb growth rate as a consequence of holding stock off their grazed areas until target sward conditions had been achieved in the spring but this strategy did allow grazed areas to be closed earlier for conservation resulting in a higher proportion of the area being conserved.

ii) Sward heights within the range examined in this experiment gave rise to acceptable rates of lamb growth during lactation; the evidence would suggest, however, that growth rates were maintained at higher levels at the lower sward heights within the range except at the high stocking rate in mid-lactation.

iii) the reproductive performance of ewes (as at 50-70 days pregnant) consequent upon the management strategy used at mating suggests that control of reproductive rate can be achieved despite wide variation in stocking rate and sward height at the time..

iv) the proportion of each of the treatment areas conserved was affected by both stocking rate and the target sward heights for grazing. Too much conserved winter forage was obtained from low stocking rate treatments whereas too little was obtained from high stocking rate treatments. The results suggest that an adjustment to a stocking rate of 12 ewes/ ha at the annual nitrogen level used in this experiment would provide a more balanced system in terms of optimising summer grazing conditions and winter feed provision (in most years).

3.2 The effects of stocking rate and level of nitrogen use on the output per ewe and output per unit area : a comparison of the Brecon Cheviot and Beulah breeds

T.J. Maxwell, A.R. Sibbald, E. Morgan*, J.R. Jones* and E. James*
(*Welsh Plant Breeding Station)

The objectives of the 1985 experiment similar to those in experiment 1 1984 (reported in 1984 Annual Report, p.216) except that two treatments carried the Beulah breed with its greater reproductive potential.

The high stocking rate, high nitrogen treatment with a lamb:ewe ratio of 1.2:1 was repeated to compare results between seasons and was duplicated exactly in 1985 with Beulah stock. The third treatment also carried Beulahs and was identical to treatments 1 and 2 in terms of stocking rate and nitrogen applications but the lamb to ewe ratio was raised to 1.5:1.

Treatment four was in all respects identical to that in 1984 (low stocking rate, low nitrogen level with Brecon Cheviot stock at a lamb:ewe ratio of 1.2:1) again affording inter-seasonal comparisons.

Hence the four treatments were designated as follows:

$S_{20}N_{200}C_{1.2}$, $S_{20}N_{200}B_{1.2}$, $S_{20}N_{200}B_{1.5}$ and $S_{12}N_{100}C_{1.2}$

The swards were managed to maintain sward height between 3.75 and 5.25 cm from the commencement of the experiment until weaning; this was achieved by closing surplus areas for conservation.

The first application of N took place when 100 mm soil temperature reached 5.5^{o}C after 1st March (36 percent of total), the second on 10th May (28 percent in total), the third on 25th June (18 percent) and the final application on 10th August (18 percent).

Concentrate supplement was given in the spring at the rate of 600 g/ewe/day until sward height reached 3.5 cm. In the autumn, around mating, 150 g/ewe was given when sward height was falling at 3.5 cm, 300 g at 3.0 cm and 300 g plus 1 kg of hay at 2.5 cm.

The swards were managed in the same manner as the previous year and the same decision rules with respect to the timing of N application and supplementary feeding of ewes in the spring and autumn were used.

The results (Table 1) show that at the same lamb:ewe ratio the Beulah produced a very similar level of total output of weaned lamb per hectare to that of the Cheviot. Treatment $S_{20}N_{200}B_{1.5}$ produced the highest level of lamb output and $S_{12}N_{100}C_{1.2}$ the least. Though lamb weaning weights were some 3 kg less than in the previous year there were no significant differences between treatments despite there being a higher proportion of twin lambs on treatment $S_{20}N_{200}B_{1.5}$; nor were there any significant differences in lamb growth rates from birth to weaning.

TABLE 1
Production Data

Treatment	$S_{20}N_{200}C_{1.2}$	$S_{20}N_{200}B_{1.2}$	$S_{20}N_{200}B_{1.5}$	$S_{12}N_{100}C_{1.2}$
Weaned lamb (kg per hectare)	630_a	635_a	722_b	398_c
Weaning weight (kg per lamb)	26.1	26.5	24.9	26.8
Lamb growth rate (g per day)	200	210	194	204
Lambs per ewe Scanned for following year	1.34_{ab}	1.56_b	1.82_c	1.43_{ab}
Proportion Area Conserved	0.20_{ab}*(0.19)	0.29_b	0.15_b	0.52_c*(0.40)

Values with different subscripts are significantly different ($p < 0.05$)
*Proportion conserved in 1984 in parenthesis

The proportion of the area closed for conservation in 1985 for treatment $S_{20}N_{200}C_{1.2}$ was similar to that in 1984 but 0.12 more for treatment $S_{12}N_{100}C_{1.2}$. A higher proportion was closed on treatment $S_{20}N_{200}B_{1.2}$ than on $S_{20}N_{200}C_{1.2}$ and almost twice as much as compared to $S_{20}N_{200}B_{1.5}$. These results suggest that not only does ewe stocking rate and level of N application affect the proportion closed for conservation but the lamb:ewe ratio also affects it, particularly later in the season.

Differences in pre-mating liveweight (October 1985) were small but significant, ranging from 46.6 kg for treatment $S_{20}N_{200}C_{1.2}$ to 50.2 kg for treatment $S_{12}N_{100}C_{1.2}$. The Beulah results lie between these values but it is clear that the Beulah ewes have a higher potential lambing rate than the Cheviots. The results for the Beulah at the higher lamb/ewe ratio treatment ($S_{20}N_{200}B_{1.5}$), however, may be confounded genetically since a higher proportion of twin-rearing ewes were selected at the outset to create this treatment.

The experiment will be repeated in 1986 but it can be tentatively concluded at this stage that higher levels of lamb output can be generated from these resources by using a ewe genotgype with a higher reproductive potential than the Brecon Cheviot without incurring any significant reduction in individual lamb performance.

Research objective: Evaluate systems of cattle production (no. 001057)

3.3 Systems of upland suckler cow production

T.J. Maxwell, I.A. Wright, A.J.F. Russel, A.R. Sibbald,
R.A. Hetherington and E.A. Hunter (AFRUS)

The objective of cattle systems research in the Organisation is to study the implications for total output, individual animal performance and the balance between grazing and fodder conservation, of choice of stocking rate, calving date and sward management criteria. Of central importance to these interrelationships is the choice of condition score at calving and turnout since relative to the cow's condition at the beginning of the winter, which is dependent upon choice of grazed sward criteria and stocking rate, it will determine the levels of feed inputs required during the winter.

Evidence suggests that cows should be in condition score 2.25 at calving but can fall to 1.75 by turnout without having adverse effects on calf birth weight or early lactation performance and without prejudicing subsequent production after turnout. This evidence provides an objective basis on which to compare and contrast different systems of beef cattle production.

If in each system cows are brought to the same condition score at calving and turnout, then variations in summer nutrition, whether brought about by grazing sown pastures of different sward heights or pastures of varying botanical and morphological composition, will be reflected in the body condition of the cows throughout the grazing cycle, their calf growth rates, and the level of winter feed inputs required to achieve the target condition scores at calving and turnout. Further, it is possible to examine objectively on sown pasture the interrelationships among the choice of summer grazing management (sward height), the consequent supply of conserved fodder, calf growth rate, weaned calf output, winter fodder requirement and stocking rate.

The objective of the current experiment at Hartwood is to examine the effect of choice of sward height for cows and calves from turnout to the beginning of July, at two stocking rates, on the performance of cows and calves and on the amount of winter feed required to bring spring calving (March/April) cows to condition score 2.25 at calving and 1.75 at turnout.

Two herbage heights, 4-5 cm (l) and 7-8 cm (h), and two stocking rates, 2.0 (L) and 2.5 (H) cows/ha, are being investigated using 40 Hereford x Friesian cows; the experiment is of a 2 x 2 factorial design replicated twice.

The experiment began at turnout (7 May) in 1984 and will continue for a period of 3-4 years. Some preliminary production data for the main treatment effects are presented in Table 1. There were no significant differences in calf weaning weights between treatments within years but there were differences between stocking rate treatments with respect to weaned calf output per hectare. The differences in the proportion of the areas closed for conservation in 1984 were not significant but differences in 1985 between stocking rate treatments were significant at p<0.10.

TABLE 1
Preliminary Production Data 1984 and 1985

	Sward Height				Stocking Rate			
	l		h		L		H	
	1984	1985	1984	1985	1984	1985	1984	1985
Calf Weaning Weight (kg)	237	214	226	208	237	218	226	204
Calf Weaned per Hectare (kg)	533	496	508	488	494	441	565	543
Proportion Area Conserved (ha)	0.42	0.38	0.36	0.32	0.42	0.41	0.36	0.29

In 1984, there was a failure to achieve the sward height treatment differences in the early summer. This explains, in part, the reasons why there was no significant difference in the proportions of areas closed for conservation in that year and also why no significant difference in calf growth rate (Table 2) during the periods of conservation occurred. In 1985, treatment sward height differences were quickly established and differences in calf growth in relation to sward height during the second period of conservation (July-August) were significant (p<0.10). Significant differences (p<0.05) between sward height treatments in cow live-weight change during this period in 1985 and the period following were also observed.

TABLE 2
Calf Growth Rates 1984 and 1985 (9 per day)

	Sward Height				Stocking Rate			
	l		h		L		H	
	1984	1985	1984	1985	1984	1985	1984	1985
Birth-Turnout	614	693	603	648	597	651	630	690
Turnout-late June*	1073	1210	1100	1283	1142	1270	1031	1223
Late June-August*	1278	815	1164	1136	1157	941	1286	1010
August-September	1060	909	1123	857	1203	960	980	805
September-Weaning	620	330	300	352	637	146	283	535

* Periods of Conservation

In both years calf growth rates declined very rapidly during the month prior to weaning. In 1984, all cows and calves remained outside during this period and calves of cows grazing swards previously held at 4-5 cm and those at high stocking rates grew significantly ($p<0.05$) better. In 1985, because of the very wet conditions during late July and August the herbage conserved in the second period could not be removed. From August onwards the conserved areas were strip grazed. By September, however, the ground was becoming severely poached particularly on the high stocking rate treatments. Cattle were progressively removed from their plots in relation to severity of poaching and sward height. All cows and calves were housed before weaning on 7 October except one replicate of treatment 2.0 cows/ha grazed previously at the low sward height. High stocking rate treatments were housed first. Thus in 1985, differences in calf growth rate during this period were significantly related only to stocking rate ($p<0.001$), the high stocking rate treatment being greatest.

While it is too early to draw firm conclusions from this 3-4 year experiment the decline in calf growth rates at this time of the year, observed in both years, does highlight the need to re-appraise the nutritional quality of pastures at this time and the sward conditions that may be necessary to sustain calf growth rates without resort to supplementary creep feeding. This will be necessary in order to quantitatively analyse the options for grassland allocation as between cows and calves, and ewes and lambs at this time of year. It is also apparent that on soils of this type severe poaching problems can be encountered during periods of persistent and heavy rainfall irrespective of the time of year. With cattle at high stocking rates in the autumn both operational management and the performance of stock are affected.

4. VETERINARY MONITORING

Research objective: **Develop disease preventive programmes for systems of hill and upland ruminant production (no. 001062)**

A.R. Fawcett and A.J. Macdonald

4.1 Research Stations:

HARTWOOD

Sheep. Respiratory diseases are still the main area of loss but only one case of Jaagsiekte was seen this year. Eight ewes died from exposure when the weather turned unexpectedly cold after clipping. Routine monitoring revealed the presence of fluke eggs in a ewe in August and in view of the very wet summer all stock on the farm were dosed. In April monitoring indicated that anthelmintic treatment of ewes was not being effective and investigations revealed worm burdens of *Ostertagia circumcincta* which were highly resistant to all benzimadazole anthelmintics. Treatment of all sheep has therefore been changed to a levamisole anthelmintic. A wide variety of losses with a miscellany of causes were recorded but with no particular disease entity responsible.

Cattle. Cattle health was generally good but 5 cows died from hypomagnesaemia during the inclement weather of the 1985 summer. Monitoring of calves again revealed copper and selenium deficiencies developing so treatment was quickly administered and a vaccination policy against lungworm initiated in response to a problem in 1984.

GLENSAUGH

Sheep. Lamb mortality was particularly high with chilling, starvation and watery mouth at lambing time followed by pneumonia and a variety of causes from marking onwards. Severe snow storms in April and the poor summer weather precipitated many of the deaths and future action involving housing of twin-bearing ewes better supervision at lambing, later lambing for hill ewes and extra vaccination cover against pasteurella pneumonia is being implemented. Treatment of all Cairn and Birnie lambs with cupric oxide wire in June was carried out in response to results of monitoring. Two cases of Jaagsiekte were recorded and an unfortunate incident with rhododendron poisoning resulted in the death of ten ewes.

Goats. The discovery of Johne's Disease in the herd in August prompted a screening exercise which found 10% of the adult flock were infected - these were all culled. Future control will include continued monitoring of the adult stock with culling of positives and a vaccination programme to include all kids born each year is to be implemented. Monitoring revealed hypocupraemia in the kids in May and adults in August and these were treated with cupric oxide wire. Coccidiosis caused problems in the kids in July and dipping of goats has been re-introduced owing to the emergence of *Dalmalinia caprae* - Ivomec injection previously was used with good results against suckling lice.

Deer. Three main problems overshadowed the previous good health record of the deer. An outbreak of Cryptosporidiosis accounted for the death of 39 calves average age 11 days - future control measures are being investigated. A mycobacterial infection, now identified as John's Disease, affected ten yearlings which have been culled. The infection appears to be restricted to the 1984 age group and further control involves isolation of the infected group with screening of the whole deer stock to be implemented in 1986. The feeding of poor hay to housed calves resulted in a prolonged outbreak of mycotic pneumonia.

Cattle. No serious problems were reported.

SOURHOPE

Sheep. There were no major problems, the contagious opthalmia of previous years abated with only a few cases which responded quickly to treatment with antibiotics.

Cattle. No particular problems were seen.

BRONYDD MAWR

Two ewes were confirmed as John's Disease and eight other poor ewes culled as suspect cases. Seven ewes were lost from exposure after clipping due to inclement weather and the remainder of losses were due to a variety of causes.

4.2 Veterinary monitoring samples

A.R. Fawcett and A.J. Macdonald

Samples taken in the course of monitoring and epidemiological studies.

		1983	1984	1985
1.	PARASITOLOGICAL			
@	Fluke and worm egg counts	3167	4283	5796
@	Pasture larval counts	85	73	204
@	Lungworm larvae (Baermann)	39	153	8
@	Total worm counts	13	16	17
*	Plasma pepsinogens	155	1475	805
@	Snail site surveys	34	36	101
2.	TRACE ELEMENTS AND MINERALS			
*	Plasma copper estimations	1809	1053	1958
*	Liver copper estimations	103	16	59
#	Serum vitamin B12 estimations	582	136	490
o	Glutathione peroxide (Selenium)	104	588	823
3.	MISCELLANEOUS			
@	Semen examinations	21	65	104
#o	Serology	1209	358	1046
@	Haematology	534	420	75
#@	Bacteriology, Virology etc.	594	526	458

@ Veterinary Section
* Biochemistry - E. Skedd, P. Moberly, J. Mackenzie
\# Veterinary Investigation Service
o ADRA, Moredun

SURGERY 1985	SHEEP	CATTLE
Oesophageal fistulation	30	6
Rumen cannulation	24	-
Rumen and abomasal cannulation	12	-
Laparoscopic inseminations	30	-

The surgical expertise of Miss L. Hay of the Animal Diseases Research Association and the help and advice of Mr A, Greig, Veterinary Investigation Officer of the Edinburgh Veterinary Investigation Centre has been much appreciated during the past year since the untimely death of the Organisation's Veterinary surgeon, Mr A. Whitelaw.

4.3 A study of the clean grazing system at Hartwood

A.R. Fawcett and A.J. Macdonald

The difficulties of managing the clean grazing system within the constraints of the experiment programmes at Hartwood has necessitated a closer examination of the value of the system. Reductions in live-weight gains of lambs due to parasitism are now well established even in sub-clinical infections therefore a comparison of the performance of lambs grazing clean and contaminated pasture was carried out.

Three 0.96 hectare replicate plots were created in Thorntree which has been part of the clean grazing system since its creation. Three similar plots were also created in East Bing which is outwith the clean grazing system and has been continually stocked with sheep. Plots were stocked respectively with ewes and lambs from the Systems and Commercial flocks at 12½ ewes per hectare shortly after lambing until weaning on July 16th. Herbage mass was controlled by additional animals dosed onto and off the plots. Anthelmintic treatment followed the normal programmes i.e. all ewes dosed immediately post lambing, clean lambs no dosing and contaminated lambs dosed at the end of May and three weeks later. Pasture larval counts and herbage mass were measured weekly and lamb weights, worm egg counts and plasma pepsinogens were monitored every three weeks.

Pasture larval counts showed a clear distinction between clean and contaminated pastures (Fig. 1) exposing the lambs on contaminated pasture to moderate numbers of infective larvae from the end of May until weaning. This was reflected in the worm egg counts which showed negligible counts in the clean lambs until weaning. In contrast samples from contaminated lambs continually showed moderate egg counts despite anthelmintic treatment. Plasma pepsinogen levels showed no differences between the groups, indicating that the challenge to lambs on contaminated pasture was not of the order to produce severe parasitism. Never-the-less live-weight gains showed that clean grazed lambs gained an average of 3.51 kg ($P = < 0.001$) more than those lambs on contaminated pasture over the period from 30/5 to 16/7 when the larval challenge to contaminated lambs was of sufficient magnitude to produce an impairment of their potential performance.

4.4 Strategic dosing against fluke

A.R. Fawcett and A.J. Macdonald

The usefulness of a strategic dosing programme on a farm scale was demonstrated at Lephinmore. The aim of the programme was to kill the majority of liver flukes before reaching the adult egg-laying stage, thereby eliminating or considerably reducing the number of eggs passed onto the pasture. The flukicide rafoxanide (Flukanide: Merck, Sharp and Dohme) was used as it has been shown to be highly effective against Fasciola hepatica from four weeks after infection. A few flukicide triclabendazole (Fasinex: Ciba Geigy) has shown in trials a capacity for killing immature flukes at a very young age, down to two weeks and that the sexual maturity of surviving flukes following treatment is delayed by approximately two weeks. Using the principles of spaced dosing to prevent egg laying adopted with radoxanide the advantage of triclabendazole is that a strategy with less frequent dosing could be just as effective.

A farm in the Borders that had suffered extensive liver fluke disease in 1983 and 1984 offered an ideal test bed. An initial sampling in January 1985 demonstrated 49% of ewes to be passing fluke eggs and Fasinex was administered in February.

A four dose strategy starting in the second week of June and doses spaced ten weeks apart to coincide with the periods of greatest danger from pasture metacercaria has been adopted. This compared with a five dose strategy employed with rafoxanide. The dosage is at the commercial dosage rates and this differs from the use of rafoxanide where the dosage rate had to be increased from the commercial rate of 7.5 mg/kg to 12.5 mg/kg to achieve the required efficiency against four week old flukes.

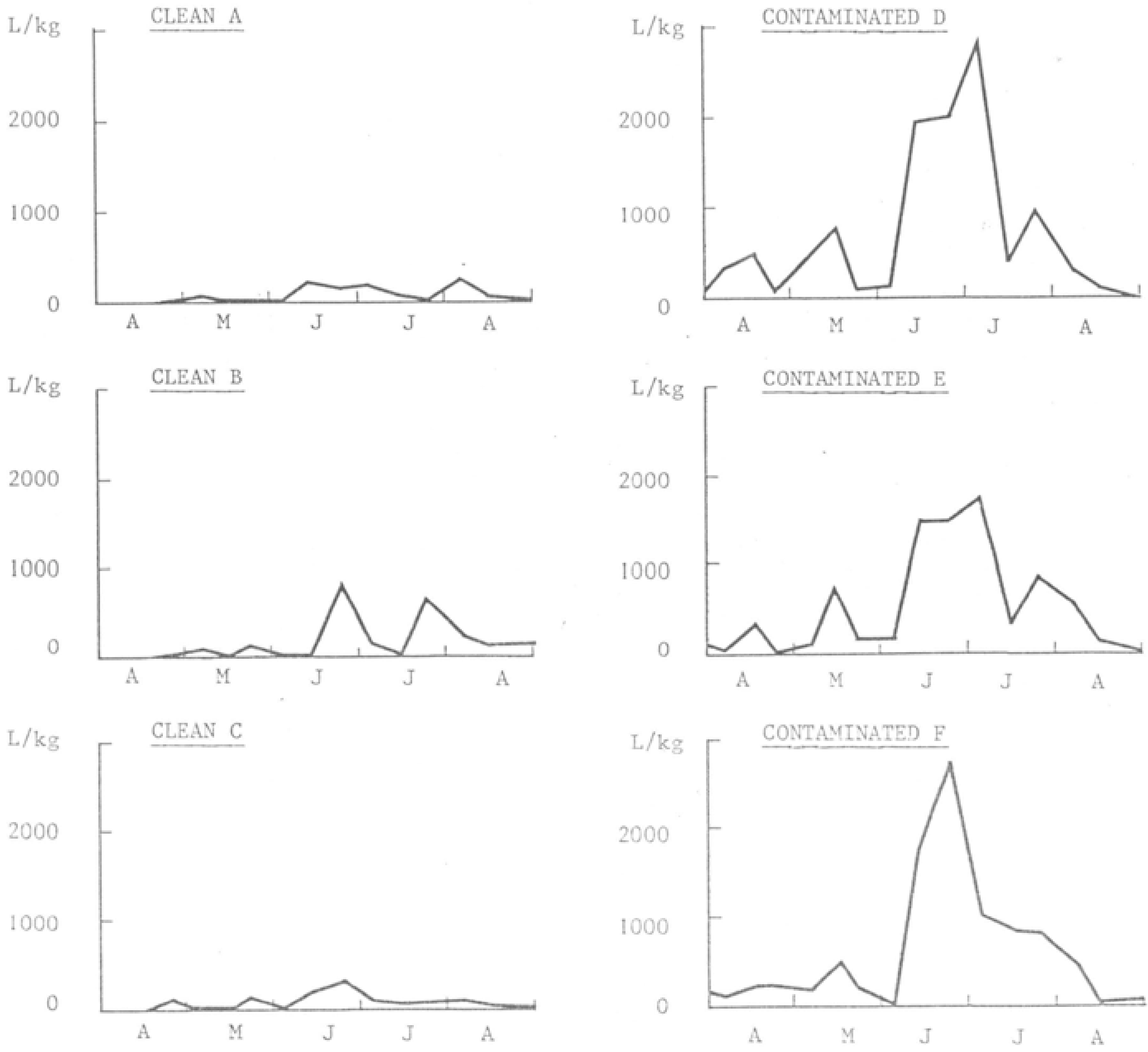
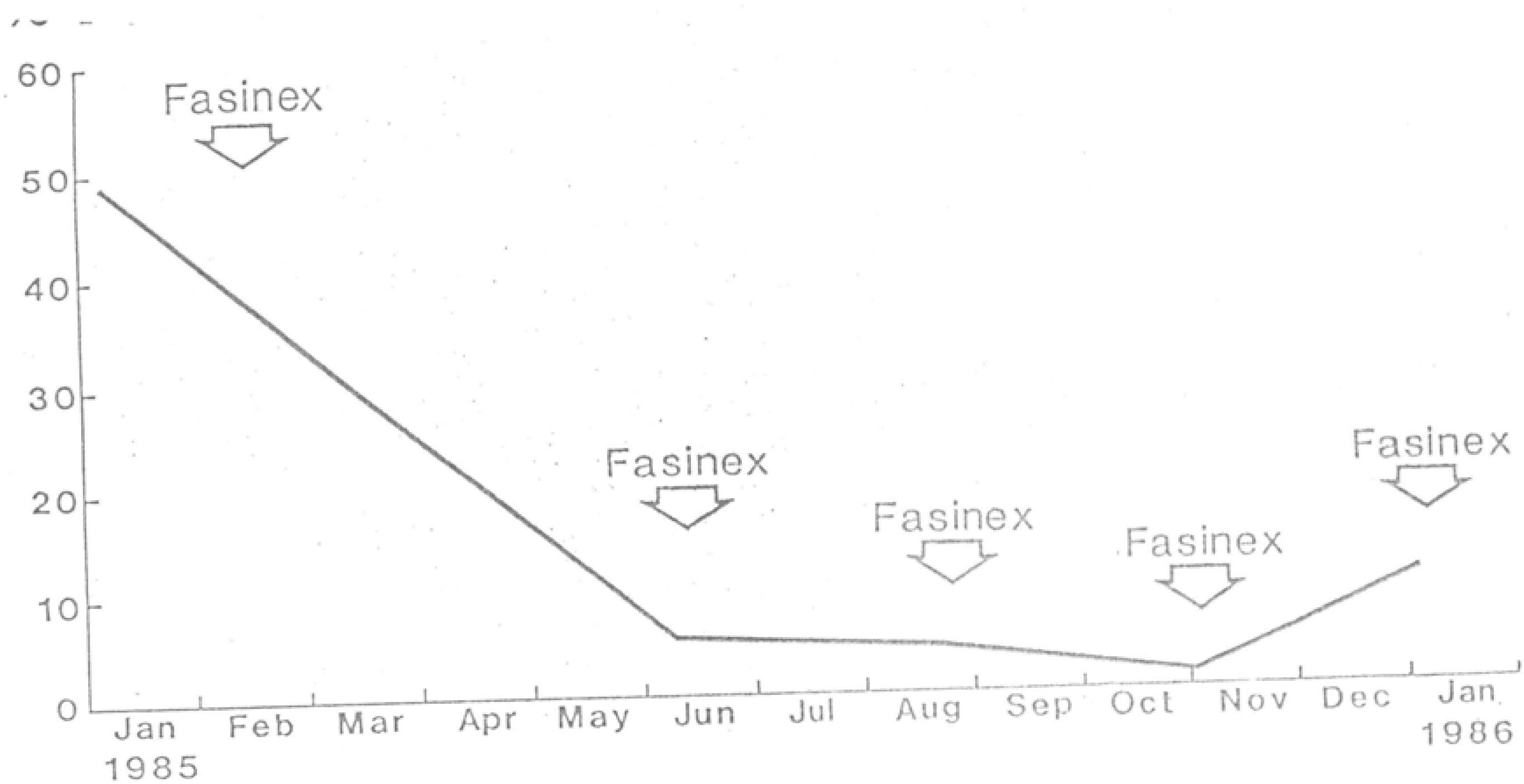


Figure 1. Pasture larval counts - Hartwood 1985

Fig.1. Strategic dosing trial - % ewes passing fluke eggs.



The results (Fig. 1) of the first year's work show a healthy reduction in the numbers of ewes passing fluke eggs, the slight rise in January 1986 follows the same pattern as observed in previous trials.

Research objective: Develop methods of preventing hypocuprosis and cobalt deficiency in sheep (no. 001029)

4.5 Assessment of slow release glass boluses for treatment of copper deficiency

The late A. Whitelaw, A.R. Fawcett, A.J. Macdonald and Robin H. Armstrong

Slow release glass boluses containing copper, cobalt and selenium are now on the market but circumstantial evidence suggests that as the bolus lodges in the rumen, the site of thiomolybdate formation, sufficient copper would not be released to combat the effects of high intakes of molybdenum. To determine if the bolus is capable of providing adequate copper in animals grazing herbage where the copper availability is severely restricted by elevated levels of molybdenum the following comparisons were made.

EWES. At mating time Alderhope ewes were randomly divided into three equal groups. Group one received a Cosecure* bolus (*Coopers Animal Health Ltd), group two 4 grams of cupric oxide wire and the third group no treatment. The commercial recommendation for animals grazing pasture with high molybden levels is two boluses but as ewes only graze the reseeds during lactation only one bolus was given. Plasma copper levels were monitored at major gathers throughout pregnancy followed by monthly monitoring of the twin ewes when grazing reseeds. At the end of the trial representative ewes were slaughtered to determine liver copper levels and state of boluses.

LAMBS. Twin lambs grazed exclusively on the reseeds were split on weight and sex into groups as shown:-

DAM'S GROUP	LAMB 1	LAMB 2
Cosecure	Cosecure	Control
	Cupric oxide	Control
	Cosecure	Cupric oxide
Cupric oxide	Cosecure	Control
	Cupric oxide	Control
	Cosecure	Cupric oxide
Control	Cosecure	Control
	Cupric oxide	Control
	Cosecure	Cupric oxide

The Cosecure treated lambs received two boluses each in line with the recommendation for lambs grazing pasture with high molybden levels and cupric oxide wire was given in 2 gram gelatine capsules. Both lamb treatments were administered on June 10th as the bolus cannot be given to lambs less than five weeks of age. Plasma copper levels and weights were monitored monthly and representative numbers of lambs slaughtered at weaning for determination of liver copper levels and state of boluses.

Gluthathione peroxidase and vitamin B_{12} levels were measured at all samplings in both ewes and lambs to determine selenium and cobalt status.

Results

EWES. Plasma copper levels (Fig. 1) show the superior longevity of action of Cosecure compared with cupric oxide wire in this trial. However, treatment of ewes in mid-pregnancy would perhaps be more favourable and prevent the onset of hypocupraemia observed in August. Liver copper levels are still awaited. Eleven ewes from the Cosecure group were slaughtered on October 10th and only one ewe retained a bolus (50% worn) indicating the claim of twelve months activity of the bolus to be optimistic.

LAMBS. Plasma copper levels (Fig. 2) show both methods of copper supplementation to be equally effective in providing adequate copper to growing lambs grazing pastures with elevated molybdenum levels. An additional benefit in terms of copper status to the lambs from Cosecure treated ewes is also demonstrated. Treatment of ewes had no significant effect on either lamb birth weight or gains from birth to June 10th. Lamb weight gains (Table 1) from June 10th (day of tratments) to September 17th (weaning) showed both treatments to be equally effective in restoration of normal growth.

TABLE 1

Ewe treatment	Lamb weight gain (kg) 10/6-17/9 by lamb treatment			Significance of differences		
	Cosecure (Cos)	Cupric oxide (CuO)	Control (Con)	Cos/Con	CuO/Con	Cos/CuO
Cosecure	15.77	16.43	14.16	*	***	NS
Cupric oxide	16.25	15.73	13.64	**	*	NS
Control	15.96	15.33	13.21	**	*	NS
All treatments	15.99	15.84	13.67	***	***	NS

Six Cosecure treated lambs were slaughtered at weaning with 3 lambs still retaining both boluses and 3 lambs only one bolus. Boluses showed little difference since their administration being only 20% lighter. Liver copper levels are awaited.

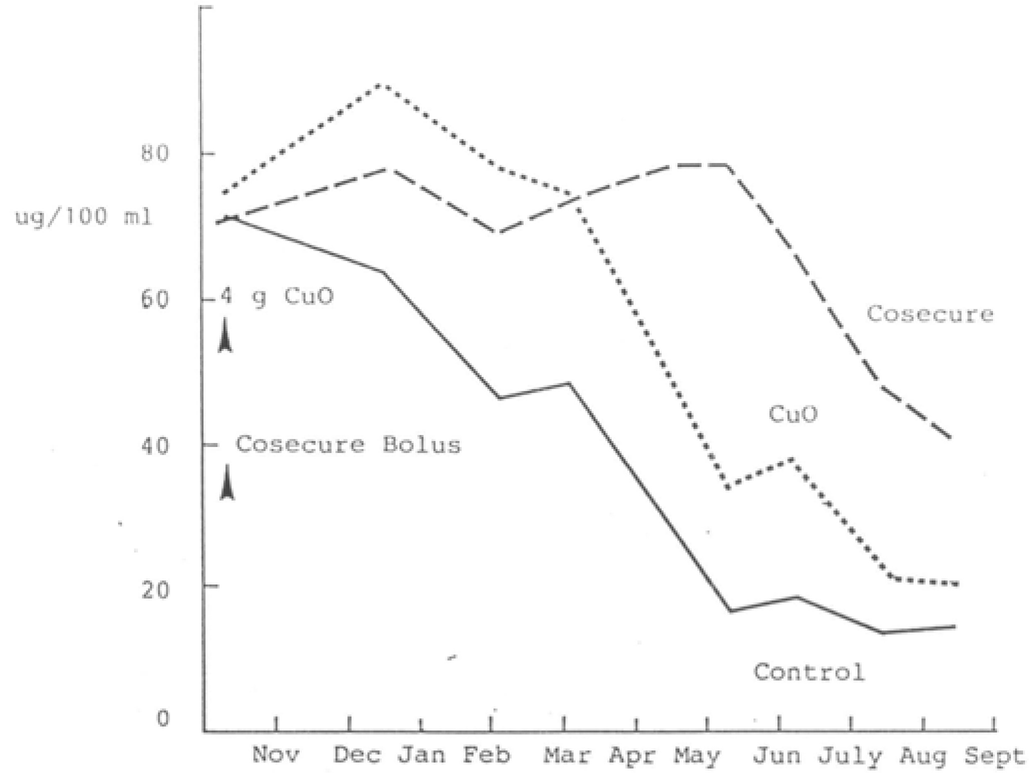


Figure 1. Plasma copper levels - twin ewes 1984-85

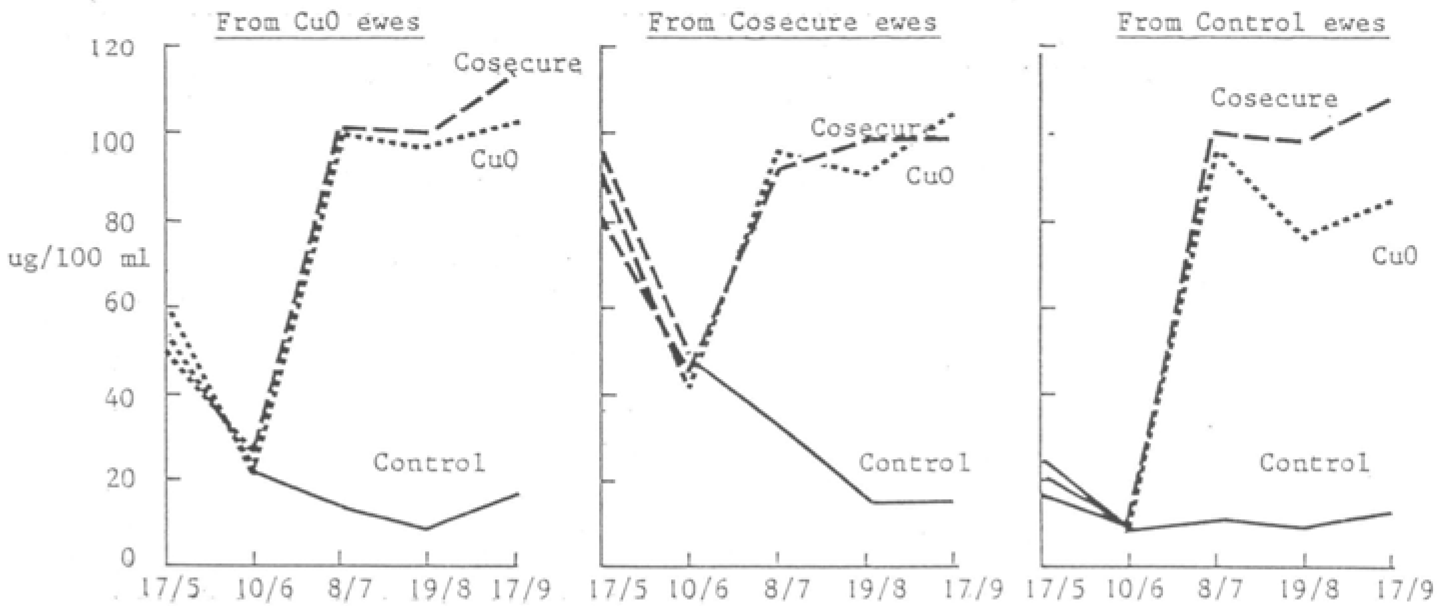


Figure 2. Plasma copper levels - twin lambs 1985

SERVICES

1. ANALYTICAL SERVICES

E. Skedd, J. Mackenzie, P.E. Moberly, A.D. Penman, E. Tierney, M.G. Hutchison, G.N. White, F. Hunter

1.1 In support of the research programme 60,000 analyses were carried out on approximately 32000 samples of plant tissues, soils, biological fluids, animal tissues and feeds.

1.2 Method development

1.2.1 Non-esterified fatty acid (NEFA) analyses: After an extensive trial plans to introduce an automated enzymic method for NEFA analysis were abandoned. This was because some samples, mainly sheep plasma, appeared to contain interfering substances.

1.2.2 Nitrogen: To meet the increasing need for nitrogen analyses a 40-place block digester was purchased. This allows 120 digestions to be undertaken each day. An examination of the block digester and the manual method was undertaken and good agreement between the two procedures was achieved for all materials used to date (Table 1).

TABLE 1
Nitrogen concentration (%) determined by two digestion techniques

Material	Block Digest Value		Previous or Quoted Result
n = 6 in all cases	Mean	S.D.	
Heather	0.79	0.02	0.78
Clover	3.09	0.10	3.04
Ryegrass	1.46	0.05	1.48
Nardus	1.73	0.06	1.70
Faeces	1.49	0.06	1.48
Orchard Leaves	2.74	0.11	2.76
Soil 1	2.75	0.06	2.73
Soil 2	0.52	0.02	0.41
Soil 3	2.82	0.02	2.85

1.2.3 Deuterium/Hydrogen Ratio: Few problems are encountered when analysing pure water for Deuterium/Hydrogen ratio (Coleman *et al*, 1982), however the same cannot be said when similar analyses are carried out on blood plasma.

This is due to the fact that plasma contains many components which interfere with the reduction part of the analysis. A method has been developed which, effectively separates water from blood plasma, gives greater than 95% yield and is reproducible.

Results for one such analysis are detailed in Table 2. The results come from one plasma sample which has been vacuum distilled six times and then reduced over hot zinc at 450^{o}C.

TABLE 2

Sample No.	Delta value	At% D
1	-335.163	0.040002
2	-334.037	0.040070
3	-339.305	0.039753
4	-335.388	0.039988
5	-335.634	0.039818
6	-338.221	0.039974
$\bar{x}$ =	336.291	
SD =	2.020	

Reference

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2. ELECTRONICS

A. Phillips

2.1 Sheep behavioural studies

Further developments have been carried out in the fabricating technique of the resistive bands at AGRI. A similar system has been set up here at HFRO.

The technique involves forcing a mixture of graphite flakes and carbon granules into an expanded silicon rubber tube by a vacuum pump. Two oxford medilog recorders were purchased this year bringing the total to eight recorders. The recorders were rewired to bring flexibility to the systems. The resistive bands can now be interchanged or replaced without difficulty.

The new bands were used at Hartwood by M. Beattie and E. Robertson. A playback machine, on loan from SIAE, was used to monitor the recorded grazing patterns. The new bands produced a more superior pattern than did previous bands.

2.2 Agroforestry

In October development work began on an Agroforestry project. Three environmental conditions in the field have to be monitored, namely solar radiation, moisture and environmental temperatures.

A number of Christie loggers were purchased. The loggers were modified to provide a switching supply to soil moisture AC/DC potential amplifiers. The loggers aare to be powered by two lead acid cells backed up by wind generators.

Two signal conditioning modules were developed. The first being a voltage to frequency covertor. The module is fed from a solarimeter with an input potential level that is proportional to the amount of solar radiation exposure. This is then amplified to a level required by the convertor. The V/F convertor then gives a frequency output proportional to the input. This frequency output is channelled to a counter on the logger via a driver.

The second module is a soil moisture AC/DC potential amplifier. The gypsum block soil moisture probe is in the feedback loop of an operational amplifier. To prevent polarisation of the poles, the sense of the poles is reversed at a frequency of 100 Hz. This is done by using a cmos quad analogue switch with a resistance of 75 ohms to provide interconnection reversals. The overall circuit gives a DC output proportional to the resistance of the probe. An oxillator with a divide by two circuit, drives the switch to provide an equal mark to space ratio to prevent polarisation. The output is then amplified by amplifying circuitry which then drives a level counter on the logger.

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*Not HFRO staff