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ANNUAL REPORT for the Year 1971

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Introduction

This Report takes a new form in that the results of experiments are presented in an abbreviated abstract form as opposed to the full and detailed results given in previous years. The amount of experimental work has expanded and it was felt that the Report was becoming too large.

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The code numbers included in the contents list refers to the project classification shown under Appendix I.

The effects of climatic stress after mating on early embryonic wastage
(J. H. Doney and R. G. Gunn)

In a previous experiment, primarily concerned with the effect of external environmental factors on ovulation rate in Scottish Blackface ewes, there were clear indications that continued exposure to the stresses during the first 25 days after mating could cause an appreciable reduction in the number of corpora lutea represented by viable embryos at 25 - 30 days. An experiment was carried out in Autumn 1971 to substantiate this suggestion and to determine the relative importance to the successful establishment of an embryo of environmental stress in the immediate post mating period, covering fertilisation and the free blastocyst stage, and in a later period covering the early placental establishment. The experiment was also designed to provide information on a possible relationship between embryonic wastage and the adrenal response to weather stress.

After weaning 86 adult, home-bred Blackface ewes were brought first into convenient paddocks and later into the sheep-house. They were brought into a uniformly good body condition (grade $3 \pm \frac{1}{4}$) by differential group feeding and then maintained in that condition. Ewes were mated at the second oestrus after synchronisation by progestin sponges. Four ewes were discarded as unsuitable and the remainder were allocated to the following treatments:

- Group 1. Remain in sheep house till killed at 25 - 30 days (24 ewes)
- Group 2. Exposed to heavy rainfall outdoors from day 1 to 10 (24 ewes)
- Group 3. Similar exposure from day 11 - 20 (24 ewes)
- Group 4. Remain in sheep house but receive 60 i.u. ACTH/day (10 ewes)

Blood samples were collected 3 times each week until slaughter between day 25 - 30 or on return to service if earlier.

All the experimental treatments increased the rate of embryo wastage as compared with the housed control ewes. Ovulation rate ranged from 1 - 3 ova per ewe with a mean of 1.94. Treatment groups did not differ significantly. The results can be expressed either in terms of the proportion of ewes which lost one or more potential embryo, irrespective of the number of ova released (Groups 1 - 23%, group 2 - 48%, group 3 - 50% and group 4 - 50%) or in terms of the actual number of ova not represented by a viable embryo irrespective of whether the ova were released as single or multiples (Groups 1 - 12%, group 2 - 31%, group 3 - 30% and group 4 - 35%). Post-mating stress, imposed either days 1 - 10, days 11 - 20 or by ACTH injection increased the embryonic wastage significantly whether expressed on a ewe or individual ova basis. Results from the analyses of these samples for plasma progesterone and cortisol levels are not yet available.

The influence of body condition at mating on reproductive potential of North and South Country Cheviot ewes
(R. G. Gunn and J. H. Doney)

Studies on the reproductive potential of Scottish Blackface ewes have shown a highly positive relationship with body condition at mating. In the North and South Country Cheviot (NCC and SCC) breeds this relationship has yet to be demonstrated. Preliminary trials have shown that the potential of these breeds may be low in hill farm situations but they gave no information on any such relationship.

At weaning in August 1971, 48 NCC (7.5 and 6.5 yr) and 70 SCC (6.5 yr) hill ewes were allocated to two groups by breed, age and body condition. Between August and mid-December the groups were differentially fed to bring as many ewes as possible in one group into condition 3 and as many as possible in the other group into condition 1.5. Considerable difficulty was experienced in achieving an adequate loss of condition in the latter group. As the majority of these ewes dropped only to condition 2, they were maintained at that level throughout mating. Only ewes in the

condition ranges 3 ± 0.25 and 2 ± 0.25 at mating in December were accepted. From mating, maintenance feeding was carried out and the majority of ewes were killed either at return-to-service or after 25 ± 5 days for ovulation and viable embryo counts. Twelve ewes from each breed were involved in a carcass study which entailed their slaughter at a later date, ranging from 40 to 85 days post-mating.

The results of this experiment are summarised in the following Table:-

Live weight and potential reproductive performance of North and South Country Cheviot ewes in conditions 3 and 2 at mating

Breed	N.C.C.		S.C.C.	
	3	2	3	2
Body condition at mating	3	2	3	2
LW at mating (kg)	63.4 ^{66.1}	53.5 ^{52.2}	54.6 ^{55.1}	47.0 ^{46.3}
No. of ewes with				
1 - 2 ova	3 8	16 23	15 21	26 23
	2 20	5 4	20 10	6 3
	3 2			
Mean ovulation rate	1.83 ^{1.82}	1.24 ^{1.21}	1.57 ^{1.32}	1.19 ^{1.12}
Ova not represented	3 13	9 15	18 7	8 8
by viable embryos	9 24	35 44	33 17	18 28
			33 17	18 28
Mean potential lambing rate	1.67 ^{1.37}	0.81 ^{0.68}	1.06 ^{1.10}	0.94 ^{0.81}

In both breeds, an increase in body condition at mating resulted in a significantly higher ovulation rate. Although the NCC ewes in condition 3 had an apparently higher ovulation rate than the SCC ewes in similar condition, it was not possible to show this difference to be statistically significant ($\chi^2 = 2.81$) with the number of animals available. Embryo mortality in the SCC breed did not differ statistically ($\chi^2 < 1$) between the conditions of ewe but in the NCC breed the ewes in condition 2 lost significantly ($\chi^2 = 4.38$) more than did the condition 3 ewes. These results are, however, partly confounded by differences in the distributions and survival of single and twin shed ova.

At the high level of condition, neither breed came anywhere near the potential ovulation rates which have been obtained from Scottish Blackface ewes in similar body condition. This result may, however, be related to source differences such as described by Gunn, Doney and Russel (1972) and to differences in early growth pattern as are described elsewhere in this Report (Gunn and Doney).

Fecundity of Finn x Blackface ewes in relation to body condition at mating (J. M. Doney and R. G. Gunn)

Body condition at mating has been shown to have a very marked effect on both ovulation rate and early wastage in the Scottish Blackface breed. An effect has also been found in both North and South Country Cheviot ewes. In order to test a more general application of this static effect a small number of available Finn x Blackface ewes (a cross with fairly high potential fecundity) were used to make preliminary observations. The present results cover two years. In November 1970 the flock of 20 ewes was split into two groups and brought into body condition 1.5 - 2.0 or 2.75 - 3.25. Four were killed after mating for examination of ovary and uterus. The remainder continued to term as one flock given supplementary feed on grass. The results in terms of number of lambs are given - Table 1.

TABLE 1

Condition score	No. of lambs at term					Mean No. lambs/ewe
	4	3	2	1	0	
1.75	0	5	2	0	0	2.71
3	2	4	2	1	0	2.77

In 1971 only 14 ewes remained. These were again split into two groups to be brought into poor or good condition by mating. These ewes were then killed about 25 days after mating for examination of ovaries and uterus. The results, together with those of the 4 ewes killed in the previous year are shown in Table 2 as number of ovulations and number of viable embryos.

TABLE 2

Grade		No. of ovulations/embryos					Mean No. per ewe
		4	3	2	1	0	
1.75	Ovulations	1	4	3	0	0	2.75
	Embryo	1	3	4	0	0	2.63
3	Ovulations	2	4	4	0	0	2.80
	Embryos	2	2	5	0	1 *	2.40

In so far as the small number of sheep involved allows, it appears that body condition differences, over the range studied, had no effect on ovulation rate or embryonic wastage in this genotype. (The one ewe shown in Table 2 with no viable embryos at 25 days would in normal circumstances have returned to service later to bring the lambing/percentage close to that in the previous year).

The effect of early growth pattern on the reproductive potential of Scottish Blackface ewes
(R. G. Gunn and J. M. Doney)

In a previous experiment (Gunn, Doney and Russel, 1972), differential ovulation rate was reported in two sources of ewe at a given level of body condition. This was attributed to differences in adult size brought about by differential early growth patterns and not to differences in genetic potential *per se*, although the latter possibility could not be eliminated in this particular experiment.

At the conclusion of a study on lifetime production in two different adult nutritional environments (-H and -L) subsequent to two different levels of rearing from before birth to 12 mo (H- and L-), 157 ewes (6.5 and 5.5 yr) from one genetic source were brought into body condition 3 prior to mating in November 1971. This was achieved by transfer of ewes between groups and adjustment of group-feeding levels. After attainment of the required condition, ewes were maintained at that level till mating. Only ewes in the condition range 3 ± 0.25 at mating were accepted. From mating, above maintenance feeding was carried out and ewes were killed either at return-to-service or after 25 ± 5 days for ovulation and viable embryo counts.

The results of this experiment are summarised in the following Table:-

Live weight and potential reproductive performance
of Scottish Blackface ewes in condition 3
at mating

Rearing and adult treatment group		HH	LH	HL	LL
LW at mating (kg)		66.4	60.1	61.2	56.5
No. of ewes with 1 - 4 ova	1	3	5	1	8
	2	24	17	17	17
	3	9	5	8	0
	4	1	0	0	0
Mean ovulation rate		2.24	2.00	2.27	1.68
* Ova not represented by viable embryos on day 25 ± 5	No.	19	12	23	11
	%	26	23	45	26
Mean potential lambing rate		1.67	1.54	1.22	1.24

(* The numbers of ova on which embryo mortality is based do not tally with those on which ovulation rate is calculated, as some ewes were killed in error too early for accurate recovery of embryos).

The differences in live weight at mating, of ewes in the same body condition, indicate that early growth patterns have affected adult body size and, as this has been accompanied by differences in ovulation rate, it is concluded that reproductive potential can be influenced by the pattern of early growth. Of particular interest is the apparent importance of early rearing treatment from before birth to 12 mo in determining potential ovulation rate.

The effect on embryo mortality is less clear and the significantly ($P < 0.01$) higher loss from the HL group is difficult to explain. It does, however, result in a significantly ($P < 0.05$) lower potential lambing rate in those ewes which spent their adult life in a low plane environment (-L).

The influence of intra-uterine nutrition on the post-natal growth of Blackface lambs
(J. N. Peart)

Two similar groups of multiparous Blackface ewes were fed either a high plane (HP) or low plane (LP) level of nutrition in late pregnancy. At parturition their mean liveweights were 70.1 and 54.0 kg and the mean birth weight of their lambs was 4.6 and 2.8 kg respectively. One lamb from each group of ewes was fostered at birth to a nurse ewe for rearing. After four weeks of lactation, either the HP or the LP lamb was removed from each nurse ewe and the remaining lambs subsequently reared as single-suckled. Milk and solid food intake of individual lambs were measured and the data indicate that the HP lambs had a higher efficiency of conversion of food into live-weight gain. From birth to 10 weeks of age the growth rate of lambs from HP ewes was 39 g/day greater than that of lambs from LP ewes. Wether lambs from each group were fattened and the mean number of days for each lamb to attain 40 kg liveweight was 116, 131, 124 and 155 for groups HP, LP, HPE, and LPE respectively (E = weaned at four weeks). The experiment is being repeated in 1972 and the data combined for full analysis.

The yield and composition of the milk of Finnish Landrace x Blackface ewes Part I Ewes and lambs maintained indoors, Part II Ewes and lambs maintained on pasture
(J. N. Peart)

These studies have been completed in collaboration with the Edinburgh College of Agriculture and a paper on Part I has been prepared for publication

in the Journal of Agricultural Science. In Part II, the ewes and lambs were maintained in pasture. Analysis of vegetation samples gave DOMD values of 76% in early lactation declining to 64% at the end of lactation. Detailed analyses of the data are not yet complete, but a preliminary examination indicates substantial differences between years particularly in respect of mean milk production, percentage fat in the milks and lamb growth.

	Mean total Milk production kg		Mean fat content %		Mean lamb growth rate g/day	
	Indoors	Pasture	Indoors	Pasture	Indoors	Pasture
Single	134	114	6.6	9.1	320	259
Twin	202	176	7.1	8.9	302	238
Triplet	207	193	7.7	9.0	251	211

Factors affecting the long-term intake of roughages by sheep
(Janet Z. Foot and A. J. F. Russel)

An experiment to assess long-term interactions between the animal and its roughage feed and to quantify as many as possible of the factors affecting intake has been in progress since mid-October 1971.

The approximate mean daily intakes of groups of 16 sheep during mid-February are shown below for three roughages of varying quality.

Roughage	Apparent D. M. Digesti- bility (%)	D.M.I. (g)	D.D.M.I. (g)	W (kg)	D.M.I. kg W (g)	D.D.M.I., Kg W (g)
A (hay)	59.5	900	536	51.5	17.5	10.4
B (hay)	61.5	1040	640	56.0	18.6	11.4
C (dried grass)	81.5	970	791	64.0	15.2	12.4

The mean liveweights at this stage are also shown; all three groups had an average liveweight of 49.5 kg at the beginning of the experiment. Some of the sheep in group C are still increasing in weight and in body condition.

Peak intakes were reached in the third week of the experiment by sheep offered dried grass (a mean of 1650 g D.M.) and a week or two later by sheep in groups A and B (means of 1300 g and 1500 g respectively). Intakes then declined rapidly until about the tenth week of the experiment and from that time to the present have shown signs of stabilising.

The fatness of the animals is being estimated every six weeks by tritiated water dilution techniques. Blood samples will be analysed to provide indices of metabolic rate. The results from these measurements should be available for inclusion in the next annual report together with further information on feed intake patterns and on the relationships between intake, diet quality, degree of fatness and indices of metabolic rate.

Studies on the nutritional physiology of pregnant gimmers
(Janet Z. Foot and A. J. F. Russel)

Half of a group of 60 Blackface gimmers were managed from tugging to six weeks before lambing to follow a weight pattern similar to that observed

in the field, i.e. a loss of 6 kg live weight (Treatment A). Over the same period the other 30 sheep were supplemented in an attempt to obtain a live-weight gain roughly equivalent to the weight of the gravid uterus at that stage, i.e. about 3 kg (Treatment B). In the event, a gain of no more than half this amount was achieved. During the last six weeks of pregnancy half the gimmers in each group were given a basic level of a complete diet plus a weekly increment of 30 g/day, similar to normal feeding patterns in the development projects (Groups AL and BL). The other gimmers were given the same basic level plus a weekly increment of 160 g/day (Groups AH and BH).

Effects of the nutritional treatments imposed up to six weeks pre-partum (A and B) were reflected in plasma non-esterified fatty acid (N.E.F.A.) concentrations, but during the final six weeks of pregnancy there were no apparent differences in nutritional state attributable to Treatments H and L; both were satisfactory by the criteria used in the development projects.

The weight change of the gimmers between mating and post-parturition was influenced by the level of nutrition both in mid- and late pregnancy:

AL*	BL	AH	BH	
0.10	2.98	1.52	3.36	kg

(* The nutrition of Group AL was similar to that which pertains in the field)

All the lambs were of a good size (singles over 4 kg) and there was no additional effect on lamb birthweight of the higher (H) level of feeding in late pregnancy. In contrast the average weight of the lambs from gimmers in the B group was 0.20 kg (H) to 0.50 kg (L) higher than those from gimmers in the A group, indicating that the weight loss normally encountered during early to mid-pregnancy in gimmers on the hill may have a deleterious effect on lamb birth weights.

Preliminary examination of field records suggests that the weight loss from mating to mid-pregnancy is largely independent of mating weight, and it is considered that body weight at first mating may therefore be of importance in respect of lamb birth weight and hence to incidences of lamb mortality.

The assessment of supplementary feeding requirements of grazing and housed ewes during late pregnancy.

(A. J. F. Russel and Janet Z. Foot)

The technique of regulating inputs of supplementary feeding during late pregnancy according to biochemical assessments of nutritional state was continued in three development projects in 1974.

Groups of 40 early lambing ewes and gimmers from the Sourhope Year Round Grazing System and from the Sourhope and Lephinmore In-wintering Systems were blood sampled at regular intervals during late pregnancy. In addition, a number of ewes from the joint Boghall development project with the Edinburgh School of Agriculture were sampled. As explained in a previous report, plasma ketone concentration has been found to be the most useful index of nutritional state in this type of large scale study and feed inputs were accordingly adjusted on the basis of actual mean ketone concentration. Consideration was also given to the change in ketone concentration resulting from the previous feed adjustment. Weekly increments in concentrate feeding ranged from 0 to 4 oz per head per day, and were generally implemented within 48 hours of blood sampling.

Results in terms of reproductive performance indicated that the technique was successful in providing an objective basis for determining inputs of concentrate feeding in both the grazing and housed situations.

Seasonal changes in the nutritive value of heather (*Calluna vulgaris*)
to sheep
(J. A. Milne)

The voluntary intake, digestibility and some measures of nitrogen metabolism of mechanically harvested heather, which contained between 78 and 85% of current season's growth, were determined with 6 wether sheep per harvest. Harvests were taken in July, September and November of heather in the 'building' phase. Harvests were also taken in July of heather in the pioneer and mature 'phases' and offered to 3 and 5 sheep per harvest respectively. All sheep were offered heather with a 40% refusal margin for a period of 4 weeks, the last 10 days of which were used as the measurement period. Mean values of voluntary intake and digestibility of organic matter, apparent nitrogen digestibility and nitrogen balance are given in the following table.

Seasonal changes in the nutritive value of heather

Harvest	O.M.I. (g/kg ^{0.75} /day)	OMD %	Apparent N Digestibility %	N balance (g/day)
July 'pioneer'	35.1	54.3	23.5	-1.3
July 'building'	32.7	50.0	23.0	-1.6
July 'mature'	35.0	54.5	39.9	-0.8
September 'building'	32.8	47.5	14.3	-4.1
November 'building'	34.9	47.2	24.9	-2.9

The effects of various levels of oat supplement on the voluntary
intake and digestibility of poor quality roughages
(C. S. Lamb)

Sixteen $3\frac{1}{2}$ year old NCC x SCC wethers, penned individually in metabolism crates, were used in four groups of four. Each group was allocated at random to receive one of four roughages. Each group of sheep formed a Latin Square comprising 4 twenty-eight day periods. Critical measurements of roughage intake were made over the last 9 days of each period and faeces and urine collections were made over the final 6 days. The roughages (3 hays and one straw) were chopped and offered to 20% in excess of the previous days' intake. Four levels of supplement were employed - 0, 270, 540 and 810 g. fresh weight/day. These were fed in two equal portions at 9.00 and 17.00 hrs. - prior to feeding half of the days' allocation of roughage. Liveweights, and subjective assessment of body condition were recorded weekly.

In the latter half of the experiment (i.e. Periods 3 and 4) an increasing number of sheep failed to consume the allocation of oats - particularly when 570 and 810 g. levels were offered.

(Four sheep actually lost weight over the period and one died some 2 weeks after the experiment was completed. A post-mortem examination of this sheep indicated that death was due to copper poisoning).

Consequently a detailed analysis of the results has not been possible and methods of abstracting detailed information by means of regression analyses is currently being studied. However, it does appear that intakes of roughage are not markedly affected by feeding up to 540 g. of oats per day and that DM digestibility of the ration increases noticeably when oats forms part of the ration.

Assessment of the nutritional state of beef cows throughout the annual cycle

(A. J. F. Russel, Janet Z. Foot and T. J. Macneil)

The programme of weighing and blood sampling the 25 Hereford and Shorthorn cows in the Hairney Law - Auchope development project has been continued during the past year to provide information on the nutritional state of breeding cows within a system of controlled grazing designed primarily to intensify production from sheep.

These cows are used mainly as an aid to pasture management, which means that during the grazing season their nutrition is of secondary consideration to that of the sheep stock. The amplitude of the annual live-weight curve was relatively small, being of the order of 50 kg or about 10% of maximum live weight. Most of the loss of weight occurred during early lactation (March to May), but measurements of nutritional state, based on concentrations of plasma non-esterified fatty acids and ketone bodies, indicated that the severity of undernourishment during this period was never more than moderate. Weight lost during early lactation was regained by late August or early September, and from that time until the following calving in February/March this year, live weight remained remarkably constant at about 550 kg. Nutritional states during the periods when the cattle were being used to "clean up" the production areas following the ewe stock, and throughout the autumn and winter months were very satisfactory and showed only very moderate degrees of undernourishment during late pregnancy.

The data available on these animals from their introduction as heifers in 1969 to the present time indicate a continuing improvement in live weight and nutritional state each year, although it is not possible at this point in time to apportion these results to effects of age, season, and the level of nutrition provided by the system of management.

This area of work has recently been extended by including cows from three privately owned commercial herds in the study. These comprise autumn calving Blue Grey and Friesian x Hereford cows and spring calving Luing cows. We are grateful to the owners of these herds for making their animals available to us and for their willing co-operation in this work.

The use of peripheral progesterone concentrations in the identification of twin-bearing ewes

(A. J. F. Russel and Janet Z. Foot)

The identification of single- and twin-bearing ewes some six weeks before lambing could aid management considerably by allowing attention to be focused on those ewes which require it most, and could also ensure that expensive supplementary feeding is used more effectively.

Preliminary studies (Annual Report 1970) on the use of peripheral progesterone concentration in the identification of foetal number indicated that the optimum time of sampling was around 100 to 105 days gestation. Samples were collected from 49 grazing ewes at Glensaugh in early March 1971 at which time all animals were between 99 and 106 days pregnant. Using a plasma progesterone concentration of 6 ng/ml to separate monotocous and ditocous ewes 12 of 18 ewes with single lambs and 25 of 29 ewes with twin lambs would have been correctly identified by this technique. Of 2 ewes which were barren, one would have been identified as such (progesterone = 1.9 ng/ml) but the other would have been diagnosed as carrying twins (progesterone = 6.2 ng/ml). This represents an overall accuracy of 78%.

In the previous year's work the level of progesterone used to discriminate between single- and twin-bearing ewes in the grazing situation was 15 ng/ml, as compared to a value of 6 ng/ml in previously well-nourished ewes in individual pens in the sheephouse. These housed ewes also provided evidence of an effect of current nutritional state on progesterone concentrations, and it was considered as at least possible

that adaptation to prolonged undernourishment might affect the rate of progesterone metabolism. The lower concentrations of progesterone (discriminatory level = 6 ng/ml) in grazing ewes in March 1971 following an exceptionally mild and open winter, as compared with the previous year, are at least consistent with this hypothesis, although they can scarcely be considered as strong supporting evidence.

It is concluded that although an accuracy of identification of foetal number of about 80% may be acceptable in certain situations, the use of peripheral progesterone concentration for this purpose is not regarded as a practicable technique, particularly in view of the development in Australia of a mass-radiography system which has a higher throughput than could be envisaged for most techniques based on analysis of blood metabolites, and which has the considerable advantage of providing an almost immediate estimate of the number of fetuses.

AGRONOMYLamb Growth Studies (J. Eadie)

In 1971 four herbage feeds were used. These were regrowths of Perennial Ryegrass and *Agrostis-festuca* and each of these with 30% clover. Each feed was given to 12 lambs ad lib. A fifth group of lambs was slaughtered at the beginning of the experiment when the lambs were approximately nine weeks of age. All lambs were slaughtered at the end of the experiment, for body composition determination. The experimental feeds were given for nine weeks.

Feed digestibilities, digestible organic matter intakes and liveweight gains are given in Table I.

Table I

Group	Digestibility (O.M.D.)	D.O.M.I/Kg ^{0.73} (g)	Gain/day(g)
Ryegrass	77.6	53.7	149
Ryegrass/Clover	78.5	62.4	183
<i>Agrostis/festuca</i>	73.2	39.5	59
<i>Agrostis/festuca/clover</i>	75.9	48.7	107

The presence of clover in the diet significantly enhanced the energy intakes and liveweight gains derived from both regrowth herbage.

Input/Output Studies (J. Eadie and J. S. Black)

This series of studies whose aims and objectives were outlined in the 1969 Annual Report, has continued.

Each experiment in the series has the following treatments

- A - control grazed
- B - lime applied
- C - lime and slag applied
- D - lime and slag applied and clover seeds sown
- E - lime and slag applied, clover and grass seeds sown

Experiment I

This was discontinued at the end of 1970. It was set up by a former staff member with rather different objectives. This area did, however, as intended, serve a useful purpose in the early stages of this programme and in 1971 it provided material for digestibility trials necessary to the current programme.

Experiment II

This is an *Agrostis-festuca* site on which the treatments were imposed in 1969.

Thus far only the complete treatment area (E) has performed significantly better than the control. Its carrying capacity is now some 50% greater than that of the remaining plots, and the evidence is that it is now somewhat superior in nutritive value.

Experiment III

This is a *Molinia* dominant site on a peaty podsollic soil. The treatments were applied in 1970, and are now beginning to take effect. Carrying capacity in 1971 increased across the range of treatments from A (620 grazing days per acre) to E (866 grazing days per acre).

The body weight change data indicate that treatments D and E, into which sown species were introduced, are nutritionally better than the remaining plots.

Experiment IV

This is a new addition to the series. The site is a *Nardus* dominant pasture on a peaty podsol. The range of treatments is identical to that of the earlier experiments, except that in the site preparation all parts were sprayed with Dalapon, to remove *Nardus stricta*. Experience of the site of Experiment I had shown that it was virtually impossible, except at the expense of an unacceptable nutritional penalty, to obtain the degree of defoliation necessary to control, and eventually remove, *Nardus stricta*.

Viable Seed Populations (J. Eadie)

This work, first reported in the 1970 Annual Report, has continued.

The viable seed populations counts from the sites of Experiments II and III were continued for a full year. The number of seeds germinating after nine months was very small.

In 1971 this study was expanded to include a similar examination of soil samples taken from the site of Experiment IV and seedling counts for the first four months are available. These indicate that the viable seed population of this site is much greater even than that of the *Molinia* site.

Changes in soil nutrient status of a *Nardus* dominant pasture as affected by grazing control and improvement treatments - Experiment II. (M. J. S. Floate, J. S. Black and A. G. Lowe)

Data were reported in 1970 (H.F.R.O. 187) on the soil properties expressed in concentration units. Few significant differences between the soils under different treatments were observed except for the higher pH of the plot receiving the full treatment. Density data have been used to convert results to weight per unit volume of soil and although there were only small differences between most treatments there were significant differences between the control and full treatments. Lime, NPK, surface seeding and grazing control (when compared with low intensity grazing) has resulted in significantly higher levels of total, organic and acid-soluble inorganic -P in the soil to a depth of 10 cm. The amount of increase is of the order of 200 kg/ha which compares with the amount added in treatments since improvement started in 1966. Some 46% of the added -P appears to have accumulated in organic forms, about 33% in acid-soluble inorganic forms, and 21% in acid-insoluble (fixed) inorganic forms in the soil.

Herbage and Faecal Sampling and Sample Preparation (J. Eadie and D. R. Campbell)

Three investigations were carried out in the Lourhope laboratory in 1971.

Experiment I

A series of drying and milling sample preparation treatments were applied to three roughage types. The samples were subsequently analysed for nitrogen, in vitro digestibility and various components of the Van Soest detergent scheme.

One hundred (^{degree}per cent) Centigrade drying significantly elevated the values for all Van Soest constituents in all herbage and significantly depressed the in vitro digestibility values of heather.

Experiment II

Sample preparation was investigated in faeces from three markedly different herbage types. The analyses included nitrogen, the Van Soest fractionation and a method of determining undigested nitrogen in faeces. The drying

treatments (45°C and 100°C) reduced faecal N values and significantly elevated all Van Soest constituents. Undigested dietary N estimates were greatly affected by the drying treatments.

Deep freeze storage of faeces for three months compared to one month had very little effect on any of the analyses.

Experiment III

An investigation was carried out into a range of procedures for sampling from a large bulk of fresh herbage. In addition the aggregation of small samples into a bulk, and its further subsampling were also examined.

The analytical and statistical results are now available but they have not yet been fully evaluated.

Plant growth in relation to soil aeration and moisture regions under field conditions.

(J. A. Rogers and G. E. Davies)

Four grass species, *Dactylis glomerata* (Cocksfoot), *Phleum pratense* (Timothy), *Festuca arundinacea* (Tall Fescue) and *Lolium perenne* (Perennial Ryegrass) were grown in eight sites on similar hill soils of varying moisture and aeration regimes. The same species were also grown in a single soil in a pot experiment in which well drained and a waterlogged treatment were imposed. In the field, the dry matter yield was measured over the growing season and related, using regression analysis to soil moisture and aeration conditions.

The yields of three sites, representing the range of moisture/aeration regimes, their mean soil moisture tension, oxygen and carbon dioxide concentrations and the regression coefficients of yield on these environmental factors is given in the table.

Mean Yields - 3 weeks' growth of 1 m row

Site	<i>Dactylis glomerata</i>	<i>Lolium perenne</i>	<i>Festuca arundinacea</i>	<i>Phleum pratense</i>	Soil moisture tension	% oxygen	% carbon dioxide
Waterlogged	7.1	20.7	24.4	22.0	0.6	9.1	8.0
Intermediate	32.9	48.5	43.7	37.3	4.7	15.5	3.1
Freely drained	54.3	56.4	49.3	46.0	13.1	18.2	1.1
Regression coefficient of yield on:							
Soil moisture tension			+ 3.5 **	2.5 *	1.5 *	1.4 *	
Soil O ₂ %			+ 4.8 ***	3.6 ***	2.3 **	2.1 **	
Soil CO ₂ %			- 6.7 **	5.0 **	3.3 **	3.0 **	

In addition, the herbage from some of the cuts was analysed for total calcium, magnesium, potassium, nitrogen, phosphorus and iron. It was found that, the yield of *D. glomerata* was the most severely restrained by waterlogged conditions. Potassium, nitrogen and magnesium were, in all cases positively correlated with soil oxygen content. Calcium content showed no relationships with soil moisture or aeration but in *D. glomerata* was related positively with soil calcium content; it is suggested that this may be due to damage to the roots or to the cell membranes in the roots of this species. Very high concentrations of iron were recorded for *Ph. pratense* under well aerated conditions.

The results from the pot experiment agreed with those of the field trial and this indicated that the effects were not likely to be a result of soil factors other than those associated with soil moisture and aeration.

Oversowing of indigenous pasture: competition between Ryegrass seedlings and established *Agrostis tenuis* in simulated swards

(J. King)

The results of a previous experiment (J. Brit. Grassl. Soc. 26 1971) showed that when one grass species was sown in the presence of another already established, severe competition for nutrients took place and that as a result the response by the newly sown species to added nutrients was greatly reduced.

A further experiment was carried out in large pots using simulated swards of varying density to examine the effects and interactions of density and nutrient level on the growth of Ryegrass seedlings. *Agrostis tenuis* was the competitor species established before the Ryegrass was sown. Total plant density was held constant, competitor density being varied by sowing the two species in a replacement series.

The treatments were as follows:

<u>Agrostis</u>	<u>Lolium</u>	<u>Nutrient level</u>		
100	0	P ₁		N ₁
66	33			
33	66	X	2	X 2
0	100		3	

Eleven harvests were made over two seasons. The results show that as expected the response by Ryegrass to added nutrients was reduced as the proportion of Agrostis increased. A small increase in the proportion of Agrostis had a large effect, further increases giving lesser responses.

Interactions involving N, P and competitor ratio were also found to occur. An example affecting Ryegrass yields per plant is given in the following table.

		<u>DM yield/plant of Lolium</u>		
<u>Species ratio</u>		N1	N2	<u>Significance of N response</u>
100% Lolium	P ₃	112	212	**
	2	98	187	**
	1	92	109	NS
66% Lolium)	P ₃	46	121	**
33% Agrostis)	2	47	60	NS
	1	23	48	NS
33% Lolium)	P ₃	79	71	NS
66% Agrostis)	2	44	62	NS
	1	25	34	NS

Ryegrass yields were increased by additional N at both P₂ and P₃ when the species was growing in a pure stand without competition.

When 33% of the sward was established Agrostis a response was obtained only at the highest P level. With 66% Agrostis there was no significant response to N at any level of P.

Where the established competitor density is high, Ryegrass can be expected to have some difficulty in establishing itself even at quite high nutrient levels. At the highest Agrostis density used in this experiment the mortality amongst Ryegrass seedlings was low but higher Agrostis densities might well occur in the field and this would lead to low Ryegrass survival rates.

Where Ryegrass seedlings can survive the initial establishment phase, the ultimate ratio of Ryegrass to Agrostis in the sward will tend to reflect the nutrient level, Ryegrass being dominant only at high N and P levels and becoming a progressively lesser constituent at lower levels.

Heather moorland management: grazing and burning experiment
(Sheila A. Grant)

As a result of previous burning and grazing management a variety of heather stand types were produced adjacent to one another. The opportunity was thus provided, on re-firing, to study the effects of sward characteristics on burning and regeneration. The area was burned in late March 1970 and

the results in respect of burning efficiency were described in last year's Report.

Annual botanical analyses are carried out each September to record regeneration of the vegetation. In 1970 total vegetation cover varied from 20% to 60% and heather cover from less than 10% to just over 30%. By 1971 total vegetation cover had reached 60% on all plots and was over 80% on some; heather cover ranged from 20% to 50%. Initially both heather (more vigorous sprouting) and *Deschampsia flexuosa* (more present pre-burning) had higher average covers on younger compared with older sub-plots (for *Calluna* 24% compared with 15% and for *Deschampsia* 23% compared with 14%). By the autumn of 1971 however these differences had narrowed (*Calluna* 43% compared with 40% and *Deschampsia* 21% compared with 19%). As grazing affects the ageing of heather, not unexpectedly sprouting was more vigorous on heavily compared with more lightly grazed plots (*Calluna* cover 23% compared with 14% in 1970; 41% compared with 36% in 1971). The cover due to grasses tends to be related to pre-burning variation.

Final records will be collected in autumn 1972 after which a report on this phase of the study will be prepared for publication.

Heather utilization: reaction of the heather plant to various levels of cutting at different times within the growing season
(Sheila A Grant)

It is known that, in free range grazing systems, particularly where burning is practised, localised heavy grazing pressures have led to the replacement of heath communities by grass heath. Overall utilization however is very low being of the order of 5-15% of the annual dry matter production. Before introducing alternative systems with increased efficiency of utilization and a greater measure of grazing control it is important to know the degree of tolerance of heather to differing levels of utilization and how this varies with season. An experiment with heather grown in boxes was designed to investigate the effects of differing levels and patterns of clipping on both dry matter output and various parameters of quality.

Seedlings, which had been raised during 1970, were transplanted in early April 1971 and cutting treatments begun in May 1971. There were three levels of utilization (0, 40% and 80% of current season's growth) at each of three phases of the annual growth cycle, viz: (i) the early phase of growth initiation (late spring, plants cut mid-May), (ii) during the phase of rapid extension growth of the current season's long shoots (June-July, plants cut early July), and (iii) during the post flowering phase when seed set, lignification and build up of carbohydrate reserves occur (August - end of season, plants cut mid-September). All permutations of level with season were employed thus there were 27 treatments in all. The dry weights of clippings were recorded at all harvests and material from the third harvest was analysed for nitrogen content, percentage cell wall constituents (C.W.C.) acid detergent fibre (A.D.F.) and lignin content.

The weight of material harvested varied from 0.7 g for plants in which 40% of the current seasons growth was removed during phase i, with no subsequent defoliation to 67.7g for plants in which 80% of the current seasons growth was removed in phase iii, no previous defoliations having occurred. Recovery growth following the third harvest period is delayed until the subsequent season thus it would be premature to attempt interpretation of the yield data. In 1972 some plants will continue to be cut according to schedule but others will be rested and removed as samples to assess the effects of the 1971 treatments on 1972 performance.

The quality analyses of material from the third harvest date enabled an assessment of nutritive value gradients within the shoot by comparing shoots where 40% and 80% of the length was removed; information on ageing and regrowth effects was also obtained. Such data can indicate the opportunity afforded for diet selection (Tables I and II.)

TABLE I Indices of nutritive value as affected by gradients within the shoot. All material harvested September-- results expressed as percentage of DM

	Top half of shoot (40% remove)	Whole shoot (80% remove)	% Diff.	Significance
Nitrogen	1.93	1.87	-3.11	**
C.W.C.	40.61	43.06	+6.03	***
A.D.F..	33.86	36.23	+7.00	***
Lignin.	17.56	17.54	-0.01	N.S.

TABLE II Indices of nutritive value as affected by period of re-growth. All material harvested September - results expressed as percentage of DM

	Previously uncut	Regrowth since May cut defoliation level in May		Regrowth since July cut defoliation level in July		Regrowth cut May and July defoliation level	
		40%	80%	40%	80%	40%	80%
Nitrogen	1.56	1.72	1.80	1.80	1.91	1.92	2.20
% increase compared with uncut		10.30	15.40	15.40	22.40	23.10	41.00
C.W.C.	45.33	45.17	43.00	40.88	41.35	40.73	40.03
% reduction compared with uncut		0.35	5.14	9.82	8.78	10.14	11.69
A.D.F.	40.84	38.80	37.35	36.39	32.20	32.73	32.96
% reduction compared with uncut		5.00	8.54	10.92	21.15	19.86	19.29
Lignin	20.41	20.06	18.73	18.01	16.46	16.38	16.11
% reduction compared with uncut		1.71	8.23	11.76	19.35	19.75	21.07

The effects of grazing on wet heaths
(Sheila A. Grant and J. Eadie)

Plots were set up on a wet and dry variant of bog vegetation on the hill at Lephinmore. The wet site had been burned in 1969 and occupied an area where average peat depth was over a metre. The vegetation was Calluna vulgaris, Erica tetralix and Eriophorum vaginatum co-dominant with frequent Eriophorum angustifolium, Tricophorum caespitosum and Molinia caerulea. Sphagnum cover varied from 30% - 60%. Standing crops varied from 2100 - 2600 kg/ha and the weight of green material (omitting dead and/or woody material) ranged from 1300 - 1700 kg/ha. The heather height averaged 10 cm and length of long shoots just over 7 cm.

The dry site carried a much older and taller vegetation type, the heather height averaging 27 cm. Lengths of long shoots averaged 5 cm.

Calluna vulgaris and Eriophorum vaginatum were co-dominant with frequent Erica tetralix, Empetrum nigrum and Eriophorum angustifolium. Sphagnum cover varied from 25% - 40%. Standing crops varied from 3500 - 4200 kg/ha and weights of green material from 1500 - 1800 kg/ha.

The grazing treatments were selected to assess the consequences of increases in grazing pressure on what are thought to be the more vulnerable types of western hill vegetation. Time of grazing was related to two of the grazing systems currently being investigated at Lephinmore, viz: the year round grazing system (grazed August - October, January - March and, more lightly, during May - July) and the offwintering system (grazed as for YRGS2 but omitting the January - March grazing). Plots related to both systems were set up on the wet site, but at the dry site it was only practicable to investigate the YRGS. Three grazing pressures were provided for each group of plots the lowest being selected to equate with that on the open hill at the start of the YRGS. This level was expected to result in utilisation of some 10%--15% of the annual dry matter production.

Little is known of intake levels on bog communities but using a figure of 2½ lbs d.m. per beast per day, numbers of sheep grazing days to achieve utilization levels of the order of 10% - 15% (low), 30% - 35% (intermediate) and 55% - 60% (high) were calculated. In practice three or four sheep grazed the plots at monthly intervals for periods varying from 24 to 72 hours. The sheep were always held for a week before the grazing treatment in a holding paddock adjacent to the plots and on a similar vegetation.

The grazing treatments were begun in August 1971. Twenty-four semi-permanent quadrats (to be re-sited at yearly intervals) were placed in each plot and these were visited after each period of grazing and records collected on the extent (% of cover) and degree (amount of shoot) of grazing. From these records mean percentage plants grazed and mean percentage utilization can be calculated for each species. Floristic records were collected in July prior to beginning the grazing treatments and will be collected annually at this time of year for the duration of the experiment.

Presentation of results for grazing behaviour is restricted to the autumn period as, at the time of writing, records for the winter period are incomplete. The data are summarized in Table I and clearly indicate the preferential grazing of certain species. Because of senescence, some of these preferred species are not available over the winter period (Molinia, Tricophorum and Narthecium).

Another aspect of grazing behaviour, of equal interest, is elucidated by more detailed examination of the data collected. This concerns diet selection within the species, i.e. whether mainly shoot tips or larger portions of the plant are eaten and whether the diet selected varies with season or grazing pressure. It is too early for comment on seasonal variation. Differences among plots, i.e. related to grazing pressure, were slight and inconsistent. Grazing patterns resulted in a mosaic of small grazed patches in an ungrazed background. It is thought that grazing pressure effects on diet selection are likely to be insignificant until such time as the grazed areas begin to coalesce when further grazing would necessarily mean, in the non-growing season, eating further down the shoot or stem.

TABLE I Summary of Grazing Records, Autumn 1971

Utilization levels at the close of the August to October grazing period

Plots Group 1 (Off-wintering wet site)	Grazing Pressure					
	Low		Intermediate		High	
	%G*	%U*	%G	%U	%G	%U
Calluna vulgaris	14.6	8.0	16.6	12.1	38.7	23.5
Erica tetralix	2.9	0.6	2.5	0.4	2.5	0.9
Eriophorum vaginatum	1.3	0.5	5.0	2.1	6.3	1.6
E. angustifolium	2.2	1.5	6.5	4.7	13.3	10.9
Molinia caerulea	insuff. cover		14.3	10.7	53.1	32.3
Tricophorum caespitosum	10.0	5.0	10.8	5.5	17.8	11.6
Narthecium ossifragum	2.8	0.7	23.4	15.7	30.0	13.6
Group 2 (YRGS - wet site)						
Calluna vulgaris	12.5	5.0	17.3	8.8	23.3	14.6
Erica tetralix	1.7	0.2	0.4	0.1	1.7	0.5
Eriophorum vaginatum	0.6	0.3	2.0	1.4	3.8	3.0
E. angustifolium	0	0	2.3	1.7	14.1	9.4
Molinia caerulea	12.2	6.1	34.8	22.9	49.2	31.2
Tricophorum caespitosum	insuff. cover		12.8	9.2	29.8	18.6
Narthecium ossifragum	6.8	2.8	16.4	11.4	31.3	20.3
Group 3 (YRGS - Dry site)						
Calluna vulgaris	5.8	3.3	7.5	4.0	8.8	6.1
Erica tetralix	0.9	0.3	0.8	0.4	1.7	0.7
Empetrum nigrum	0		0		0	
Eriophorum vaginatum	2.9	0.6	4.6	2.8	5.8	3.1
E. angustifolium	3.3	2.7	3.9	1.9	11.5	6.5

*%G = percentage of plants showing any signs of grazing

%U = percentage of possible edible material consumed, i.e. making allowance for tip, half or whole shoot eaten.

NUTRIENT CIRCULATION IN HILL PASTURE SOILS

Introduction:

Previously reported experiments, both in the laboratory and in the field have shown that increased amounts of "potentially available" plant nutrients may be mobilised when hill pastures are more intensively grazed. Recent experiments, and experiments currently in progress, are designed to assess the magnitude of production responses to increased nutrient re-circulation, and in collaboration with other sections, to assess the cost benefit of a range of improvement treatments on different soils.

1. Effects of sheep excreta upon herbage dry matter production
(M. J. S. Floate and J. S. Black)

Sheep faeces (F) and urine (U) were returned to Agrostis-Festuca pasture three times per growing season for three years. There were three rates of return and these were related to DM production per unit area by factor $\times \frac{1}{2}$, $\times 1$, and $\times 4$. Response data have been calculated from the yields produced from the three levels of urine and faeces alone and in combination. Co-variance analysis, using the first cut (pre-treatment) data as reference, shows that in the first season there was no significant response to urine or faeces alone, but that when applied together there was a significant response (5%) and production was increased from 2782 kg/ha ($U\frac{1}{2} F\frac{1}{2}$) to 3514 kg/ha ($U4 F4$). In subsequent seasons there was on no occasion a significant response to faeces alone but there was a highly significant response (0.1%) to urine in 1969, 1970 and 1971. Similarly the responses to urine and faeces applied together were highly significant (0.1%) for the same three years. After the first year, maximum yields were obtained from $U4 F4$ treatment:-
1969 - 6036 kg/ha, 1970 - 4499 kg/ha, 1971 (first cut only) - 3140 kg/ha. The data show little response to P in sheep faeces, but the response to N in urine was as high 15 kg DM/kg applied N in 1970. The mean for three years shows a response of at least 10 kg DM/kg applied N.

2. Comparison of herbage production response to sheep excreta and inorganic fertilisers
(M. J. S. Floate and J. S. Black)

In the three year experiment with the return of sheep excreta to Agrostis-Festuca pasture a parallel series of treatments was included in which nutrients were applied as inorganic N and P. The amounts of inorganic - N (applied in solution) were equal to the N content of urine and the amounts of inorganic - P were equal to the inorganic - P content of faeces. Thus the excreta treatments exceeded the inorganic treatments in amounts of nutrients returned, by amounts equal to the organic N and P content of the faeces. A comparison of the herbage DM yields between organic and inorganic pairs of treatments shows that the organic treatments were significantly superior (1% in 1970, 0.1% in 1971) to the inorganic treatments when urine and faeces were applied together. When the excreta were returned separately there were no significant differences in herbage DM production between inorganic and excreta treatments.

3. Effects of continued return of sheep excreta to Agrostis/Festuca pasture upon vegetation and soil fertility
(M. J. S. Floate, J. S. Black and A. G. Lowe)

A uniform area, with respect to soil and vegetation, was selected in 1968 for the experiment in which sheep excreta were returned in proportion to plant DM yield. A small area of clover was eradicated at the outset by spraying with CMPP. After three years of cut and return treatments a vegetation survey and soil analysis was carried out in 1971. On most of the treated plots there has been no significant change in vegetation from the original "Species-poor" Festuca-Agrostis pasture. The highest levels of urine, and urine and faeces return, increased the amount of Agrostis-tenius and Poa pratensis but decreased the proportion of Festuca ovina. There is some indication that Festuca rubra may also have been increased by these treatments.

Soil data are incomplete and to date only the following results are available. Soil pH (on samples taken 6 months after the last treatment) showed little variation between treatments. There were, however, indications that urine treatments, either alone or together with faeces, had increased soil pH by about 0.2 units above the control values of 4.9 and 5.2 in the litter and 0-5 cm layers respectively. Organic carbon analyses similarly showed little variation in soil organic matter contents between treatments. Here, however, there was a tendency for soil organic matter levels to be higher in 0-5 and 5-10 cm layers in those plots receiving excreta returns at the highest rates. Inorganic -N appeared to have had a similar effect. There were only minor variations in soil -N and C/N ratio.

Although the results are as yet incomplete it seems reasonable to conclude that the additional production obtained from the treated plots has not caused any run down in soil fertility, and there is in fact some indication of nutrient build up in the plots receiving the highest rates of excreta return.

Development of X-ray fluorescence analytical methods

(C. C. Evans and M. J. S. Floate)

Methods have been developed for the determination of Cu, Fe, Zn and Mn in plant and faecal samples. To compensate for inter-element effects the background count rate is used as an internal standard, and the ratio of peak to background is used to calculate elemental concentration. A single calibration curve is applicable to all matrices for Fe and Ca but for each distinct sample matrix a separate calibration is required for Zn and Mn.

Improved reproducibility and sensitivity were obtained by ashing samples at 450°C overnight for Cu determination. The ash is analysed in powder form on a "mylar" film support. Ashing was not necessary for the determination of Fe Mn or Zn. Because of the relatively low levels of these elements present in herbage no dilution with cellulose (binder) is employed in the preparation of sample discs.

Using these techniques the results from the X-ray fluorescence method compare well with results from other more widely used methods. Detection limits (measurable peak above background) and sensitivities (dependent on secondary X-ray yield for the element concerned) are given below:

	Lower limit of detection (ppm)	Sensitivity (counts sec ⁻¹ ppm ⁻¹)
Cu	0.1	6
Cu (in tap water)	0.06	8.5 (after concen- tration x 10)
Fe	0.5	7.5
Fe (in culture soln)	0.4	15
Zn	0.8	23
Mn	0.5	32

Methods for the analysis of Cu in tapwater and Fe in plant culture solutions have been developed. It was found necessary to increase the concentration of copper in tapwater by evaporation to obtain a measurable signal.

SYSTEMS DEVELOPMENT

(J. Eadie and T. J. Maxwell)

Introduction

For a detailed discussion and outline of the work carried out under Systems Development reference should be made to the Fifth Report 1967-70, p. 70 (Hill Sheep Production Systems Development).

YEAR ROUND GRAZING SYSTEMS

I. Sourhope - Hairney Law/Auchope (Y.R.G.S. 1) (R. H. Armstrong, Miss B. Rudd and H. B. Williams)

This resource consists of 283 hectares of mainly grassy pasture which has been subdivided in such a way as to enclose some 81 hectares of *Agrostis-fescue* pasture. It is stocked with North Country and South Country Cheviot ewes and from the 1st May to 31st December with 25 suckler cows.

Ewe numbers have increased by 32% since the study began in 1969, with 398 ewes and gimmers. The combined effect of increased stock numbers and improvement in individual performance in terms of weaning percentage and weaning weight of lambs has given rise to an increase in the total weight of lamb weaned of almost 100% since 1969. Ewe body weight at mating has continued to increase from 54.8 kg in 1969 to 59.5 kg in 1971 for the NCC and 47.8 kg in 1969 to 55.8 kg in 1971 for the SCC.

	Production Data			
	1969	1970	1971	1972
Stock numbers (ewes and gimmers)	398	451	518	528
Weaning percentage	84.7	86.5	103.3	
Total weight of lamb weaned (kg)	7359	8893	14700	
Total weight of wool (kg)	787	1005	1273	

II. Lephinmore (Mid-Hill) (Y.R.G.S. 2) (D. C. Currie and C. D. Kerr)

The resource consists of 405 hectares of blanket bog. Improved pasture falls into two categories, some 18 hectares of grassy pasture, eight of which were reseeded several years ago, and two larger areas totalling 69 hectares of improved *Calluna Eriophorum* moorland within which some 20% of the area has been surface seeded to give a mosaic of improved grazing pasture throughout the whole. The remaining 324 hectares is open hill. It is stocked with 384 Blackface ewes, slightly more than prior to the initiation of this phase of the study.

There has been a substantial improvement in the weaning percentage during the three years this phase of the study has been in progress. This has resulted in a 42% increase in total weight of lamb weaned since 1969. Ewe body weights at mating have increased from 44.9 kg in 1968 to 51.2 kg in 1971. Much of this improvement can be attributed to the substantial improvement in the weight of gimmers at mating and the consequences of this on body weight in later life.

	Production Data			
	1969	1970	1971	1972
Stock numbers (ewes and gimmers)	339	361	373	384
Weaning percentage	85.0	92.5	103.5	
Total weight of lamb weaned (kg)	7207	8500	10268	
Total weight of wool (kg)	652	772	772	

OFFWINTERING (INWINTERING) SYSTEMS

I. Sourhope (Rigg and Gairs) (I.W.S. No. 1) (R. H. Armstrong, Miss B. Rudd and W. B. Williams)

This is a grassy pasture environment consisting of two similar units, the Rigg and Gairs, each of 101 hectares, the traditional stocking of which has been in the region of 130-140 ewes and gimmers. Both sheep stocks, which are South Country Cheviots, are inwintered for the same length of time (from January up to lambing) in the same wintering house, and the difference between the units is that in the Gairs a pasture improvement programme has begun. Fifteen hectares of *Agrostis-festuca* pasture has been enclosed, limed, slagged and oversown with clover. Further, 10 hectares of what was previously *Molinia/nardus* grass heath has been limed, slagged, sprayed with gramoxone, rotovated and direct reseeded.

Twenty-four suckler cows were grazed in such a way as to equate the number of grazing days per month spent on the Gairs with the number of days on the Rigg from the 1st May to 31st December.

Stocking rate increases have been made equally on the two units.

	Stock Numbers		
	1969	1970	1971
Rigg	205	202	238
Gairs	210	204	233

Winter feed has been based on hay, sugar beet pulp and a proprietary concentrate. Total feed cost per ewe in 1971 was £2.46. Total feed cost per hogg housed in 1971 was £1.49.

There has been a progressive improvement in the pre-mating body weights of both the Rigg and Gairs. The most significant difference between the two flocks in 1971 was in terms of the number of lambs weaned, the Gairs producing 9% more lambs. The mean weaning weights of the Gairs lambs was 2.5 kg less than that of the Rigg.

II. Lephinmore (Low End) (I.W.S. No. 2) (D. C. Currie and C. D. Kerr)

This is an area of *Calluna Eriophorum* moorland, consisting of two similar units, each of 162 hectares, traditionally carrying 100 Blackface ewes and gimmers both units having use of 14 hectares of 'common' enclosed grassy pasture. Both sheep stocks are inwintered in the same house for the same length of time, from January up to lambing. One of the units has a pasture improvement programme and is referred to as 'inwintering + land improvement'.

8 Hectares
 (Twenty acres) of blanket bog is enclosed and an oversown grass/clover pasture established. A further seven hectares will be established during 1971/72.

Stocking rate increases have been made equally on the 'inwintering' and 'inwintering + land improvement' sides.

	Stock Numbers		
	1969	1970	1971
Inwintered	106	114	143
Inwintered + land improvement	106	112	137

Winter feed has been based on hay and a proprietary concentrate. Total feed cost per ewe in 1971 was £1.80 and total feed cost per hogg housed was £2.88, the latter being greater due to the longer period of feeding.

No significant change in pre-mating body weights has been apparent. In 1971 the 'inwintered + land improvement' flock produced 9% more lambs at weaning and the mean weights of the single and twin lambs were 2.2 kg and 0.7 kg respectively greater than those of the 'inwintered' flock.

Records and Statistics (A. Sibbald)

The programme of analysis of sheep records from each of the projects has continued.

Appropriate methods of statistical analysis for some of the data are also being developed in consultation with the E.C.C. and Miss Phillips of A.R.C. Statistics.

Economic Appraisal

Methods of economic evaluation of the development projects have been investigated.

At present these studies are subjected to a marginal capital investment appraisal and the cash flows of each determined.

Computer programmes are currently being developed to handle the economic and production data to investigate the relationships between rate of investment, performance improvement, stocking rate build up and cash flow.

THE HUSBANDING OF RED DEER

(J. M. M. Cunningham, W. Hamilton, in collaboration
with K. L. Blaxter and Staff, R.R.I.)

Fencing of the hill area was completed during the year and approximately 550 acres are enclosed in three paddocks of 10, 30 and 40 acres and an open hill of 460 acres. Handling pens based on experience in handling deer in parks and developed on principles incorporated in sheep pens have been constructed and found to be satisfactory. This is associated with a small laboratory.

A large scale collection of calves was organised and 75 were captured.

Calves reared at Glensaugh received a commercial sheep-milk substitute from a multi-teat bucket and another group reared at the Rowett Research Institute were individually bottle fed on a commercial cow-milk substitute. Forty-nine hinds and seven stag calves were released on to the farm on 14th September. The liveweights at that time were nearly equivalent to those of yearlings and are shown in the Table.

Liveweights (Kg) of deer born in June 1971

	No	June 1971	July 1971	Aug. 1971	Sept 1971	Oct. 14th	Nov. 10th	Dec. 13th	Jan. 1972	Feb. 1972	Mar. 1972	April 1972
<u>Stags</u>	RRI	2	8.1	15.0	21.5	36.0	44.7	46.0	51.0	52.5	-	-
	HFRO	5	8.6	17.3	25.5	36.1	43.6	48.0	50.0	51.0	53.0	56.0
<u>Hinds</u>	RRI	17	7.6	12.0	17.4	27.7	33.0	38.3	40.3	41.6	42.1	44.0
	HFRO	32	7.5	15.0	23.0	31.3	37.6	42.2	43.5	44.5	45.0	46.5

Fourteen calves died, four with HFRO and ten at RRI during the rearing period. No animals have died since release on to the farm. Most of the calves born in 1970 were infected with warble larvae, before being caught, but they were successfully treated with an organo-phosphorus preparation.

As an exercise in semi-domestication the project has proved to be very successful up to date. The deer are very tame and will collect round visitors showing a great deal of curiosity.

Scientists from the RRI are undertaking haematological and other studies relating to nutritional status.

SUMMARY OF NEW WORKANIMAL PRODUCTIONPattern of live-weight change during recovery in relation to reproductive performance of Scottish Blackface ewes (R. G. Gunn and J. M. Doney)

Earlier work has shown that ovulation rate is related to body condition at mating and is not significantly influenced by the rate of live-weight change in the immediately preceding period. A comparison is therefore being made of the reproductive performance of Blackface ewes whose body condition has been raised from 2 to 3 in two different ways during the recovery period from August to November. All ewes were individually fed. In one group they were fed ad lib from weaning until they had achieved condition 3 after which they were maintained. In the other group they were maintained from weaning until early October after which they were fed ad lib to reach condition 3 before a synchronised mating took place at the end of November. During and after mating, all ewes were fed at 10% above maintenance. Mid- and late pregnancy management will be as commercial practice and lambing performance will be recorded.

Milk Production of Cross-bred Ewes (J. N. Peart)

Recording of the milk production of ewes is being undertaken as part of the programme of cross breeding hill sheep which has been initiated at Glensauigh. The possible increased growth rate of cross-bred lambs may be associated with a greater demand for milk by the suckling lambs. This possibility and its effect on the ewe is being investigated using Blackface ewes suckling Texel cross lambs compared with pure-bred Blackface ewes and lambs.

Performance of improved (crossbred) genotypes under improved hill conditions (J. M. Doney, R. G. Gunn and J. N. Peart)

It has been shown that, under conditions applicable to most unimproved hill management systems, the performance of the normal breeds of hill sheep falls well below their genetic potential in terms of fecundity and lamb growth rate. This has been shown to be largely due to the nutritional limitations imposed by the resource. With these limitations no significant overall improvement in animal output could be expected from improvement of the genetic capabilities. However, new systems are being developed which are capable of lifting some of these limitations and it is conceivable that the genetic potential of the native breeds could at some stage impose limitations to further advance in production. A cross-breeding project has been started at Glensauigh, initially in a small scale, to examine the consequences of utilizing an improved genotype in a hill system with some of the nutritional limitation removed.

Initially a newly formed flock of 130 ewes, located on the West Finella heft at Glensauigh has been used to provide the first stage. Half of the 2½-year-old and older ewes (50) were mated with rams of the Texel breed. This was chosen as being somewhat similar in adult body size to well-grown mature Blackface but with possibly a slightly higher potential reproductive rate, better growth rate and a different carcass conformation. Pure-bred and F₁ ewe lambs will be maintained in the environment for performance testing and eventually a second cross lamb will be produced. These sheep will be used in a number of off-location trials starting with a comparison of milk extraction, efficiency of utilisation and growth rate of pure and cross-bred lambs in 1972-73.

Fleece casting in Cheviot ewes (J. M. Doney)

This series of observations on South Country Cheviot ewes was started in 1971. The whole gimmer age group on one heft at Sourhope were sampled weekly from late January until two weeks before lambing. Only four ewes had more than 10% of all fibres with brush ends during this period when highest rate of brush formation is expected. There was negligible fleece loss before shearing in this group. The same ewes, together with a further 55 of the next age group are being sampled in 1972 and will be examined for fleece loss in July. The same procedure will be repeated annually on all surviving ewes of these two groups until they are finally culled for age.

The influence of changes in management on the occurrence of premature broken mouth (R. G. Gunn)

There is evidence to indicate an increase in the premature occurrence of broken mouth with changes in hill sheep management usually aimed at increased efficiency through a degree of intensification. This has been particularly noticeable on farms where the condition has previously been of little importance. For example, at Sourhope and Lephinmore, where broken mouth has traditionally seldom been seen, a variable incidence of between 20% and 60% of ewes with the condition at 6 yr of age can now be seen. This may be associated with such changes in management as in-wintering and the feeding of concentrated foods which have been introduced in the last decade.

It is suggested that the apparent regional or farm distribution of broken mouth is not so much due to differences in geology or inherent nutritional factors but to differences in ewe management and degree of animal exploitation. This implies that the condition may be brought about anywhere if the necessary limitations are present.

It is towards the determination and elimination of these limitations that research is being directed.

Further observations on protein and mineral status of ewes at Glensaugh (A. C. Field and A. R. Sykes, ADRA, and R. G. Gunn, HPRO)

Earlier studies at Glensaugh have shown that the concentrations of individual proteins in the blood plasma fall during gestation. These changes may reflect a reduced synthesis, an increased catabolism or loss of plasma protein, or an increase in plasma space. Possible causes are: a protein deficiency reducing plasma protein synthesis; an increased loss of plasma protein into the gastro-intestinal track due to internal parasites; or a dilution effect of the increase in plasma space which occurs in pregnancy.

Routine sampling of faeces at fortnightly and of blood at monthly intervals throughout the year September 1971 to August 1972, is being carried out on 12 free-grazing ewes, of which six are dosed monthly against internal parasites. This will enable the changes which occur throughout the year in plasma protein, in faecal N and mineral concentrations and in worm egg counts to be followed. Plasma volume is being estimated on three occasions.

The content, distribution and composition of body fat in different breeds of sheep (A. J. F. Russel in collaboration with the Animal Breeding Research Organisation and the Edinburgh School of Agriculture)

Previous work, now published, from HPRO, has contributed to knowledge on the content, distribution and utilization of body fat in Scottish Blackface and Finnish Landrace sheep. An experiment in the Animal Breeding Research Organisation, involving egg transfers among different genotypes, has provided material with which to study the growth, efficiency of food utilization and carcass characteristics of Finnish Landrace, South Down, Soay and Oxford Down sheep. At the invitation of ABRO, HPRO have agreed to undertake the responsibility for the body composition part of the study, with particular reference to the content, distribution and composition of the body fat in these different breeds.

Sixteen animals of each breed have now been slaughtered at stages of growth ranging from 40 to 76% of estimated mature weight, and the material now awaits dissection and chemical analysis.

The nutritive value of mixed diets of heather (*Calluna vulgaris*) and grass to sheep (J. A. Milne)

Under many circumstances on hill grazings sheep will be required to consume a mixed diet of heather and grass. In this experiment 5 levels of grass (0, 0.2, 0.4, 0.6 and 0.8 kg DM), are being offered, with heather

offered ad libitum to 5 wether sheep per level. The effects of inclusions of grass on the voluntary intake of heather, digestibility, rate of passage and nitrogen metabolism are being studied. In addition, to determine whether methods of estimating the proportion of heather to grass in the diet can be developed, measurements of the phenolic contents of feeds and urines are also being made.

The effects of age and nutrition on possible indices of metabolic rate
(A. J. F. Russel)

Evidence from work in the Organisation and elsewhere suggests that changes in metabolic rate in sheep may be of importance at various stages during the first years of life. Of particular interest and significance are a suggested decrease in metabolic rate during the period when lambs are generally fattened, and a possibly higher than adult rate at the gimmer age.

An experiment with 12 Blackface lambs is in progress in the Animal House at Bush to study the effects of age and plane of nutrition on the concentrations of blood metabolites which may be related to metabolic rate (viz. circulating thyroxine and protein-bound iodine concentrations). No analyses have yet been carried out.

Variation in the intake of individual pregnant ewes kept in group pens
(Janet Z. Foot, A. J. F. Russel and T. J. Maxwell)

Previous work on group-feeding of sheep indicated that the variation in intake between individuals within a group was high if the available feed was a concentrate which could be eaten quickly. In situations where nutrient requirements are high and high levels of concentrates are offered this might lead to severe under-nutrition in a few animals. Such a situation can occur during late pregnancy. An experiment is now in progress to measure the extent of the variation between the intakes of feed by individual ewes within groups during the last seven weeks of pregnancy.

The use of peripheral progesterone concentration as an index of ovulation rate
(A. J. F. Russel and Janet Z. Foot)

In a previous Report (1970) it was suggested that peripheral progesterone concentration might be used as an index of ovulation rate in sheep, but the results of the investigation designed to examine the relationship between these parameters were largely inconclusive because of an abnormal distribution of ovulation rate.

An experiment in the Animal Breeding Research Organisation, in which Dr Land was determining ovulation rate by endoscopy, provided an opportunity to examine further the usefulness of progesterone concentration as an index of ovulation rate without slaughtering the experimental animals. Jugular blood samples were collected from 30 Finn x Dorset ewes from the 8th to 12th days after ovulation, and at present samples from 12 ewes which each shed two eggs, 10 ewes which shed three eggs, and 1 ewe which shed four eggs are awaiting analysis.

Changes in live weight and body condition of rams throughout the year
(A. J. F. Russel, A. J. Macdonald, C. D. Kerr and Miss Brenda Ruad)

The patterns of change in live weight and body condition of hill ewes throughout the year are now relatively well defined for a number of situations, but there is no comparable information available with respect to the male. It is likely that the patterns of change in live weight and body condition in the male will be different to those in the female, and measurements are now being made to characterize these annual patterns.

Rams on the three research stations are being weighed and condition scored at approximately monthly intervals and the results will be collated and analysed during the coming year.

PLANTS AND SOILSSeed germination in relation to conditions of minimal cultivation in hill pastures (J. A. Rogers)

A programme of research is being developed to study problems of germination in reseeded. Economic and/or topographical factors generally militate against intensive cultivation and the preparation of an ideal seedbed. It is therefore proposed to study the conditions under which germination is expected to occur, and the effects of these on germination.

Effects of added calcium and aluminium upon the distribution of aluminium in soil (A. G. Lowe and M. J. S. Floate)

Following the study of the effects of Ca and Al addition to peat (reported in 1970 - HPRO, 187), a further pot experiment was conducted using Sourhope (Brown Forest Soil). A study is being made of the distribution of aluminium in the soil between various fractions separated using water, 1N.KCl, and buffered acetate extractants. Results are not yet available.

Effects of calcium and aluminium application on plant composition (A. G. Lowe and M. J. S. Floate)

Preliminary trials indicated that plant aluminium content was highest in plants grown at lowest soil pH when soil aluminium was most mobile. A number of factors, including pH, forms of Soil-Al, amount of Ca added, as well as amount of Al added, affect plant uptake as measured by Al content of grass leaves. High levels of soil-Al are known to interfere with P- uptake by immobilization within the root. Accordingly, analysis of both tops and roots are being conducted on materials grown in treated pots during 1971. Results are not yet available.

Effects of plant Al-content on decomposition rate (A. G. Lowe and M. J. S. Floate)

Preliminary studies have shown that the Biological Oxygen Monitor provides a technique for assessing decomposition (by measuring O₂ uptake rates over short periods) at intervals during a long period of organic matter decay. The technique is being employed to assess the possible influence of internal plant Al upon the overall decomposition rate of plant materials derived from pot experiments.

Assessment of the availability of phosphate to plants by radioactive tracer techniques (P. Newbould)

The loan of a laboratory from the Scottish Plant Breeding Station coupled with the completion of the glasshouse at Bush will enable work on this subject to start in 1972. The availability of phosphate to plants will be examined initially in soils from Glensaugh, Lephinmore and House o' Muir where experiments are to be set up to study the nutrient requirements of clover rich pastures.

Determine the economically optimum amounts of the major nutrients required to establish pastures rich in white clover (a) on the blanket bog at Lephinmore and (b) on the Calluna heath at Glensaugh (P. Newbould)

At Lephinmore site preparation has started and it is hoped to commence the experiment in 1972. The quantities of phosphate, calcium and potassium added to the soil will be related to the levels used in the input/output clover maintenance experiment (JE/MJSF) on the same site. At Glensaugh, a site has been selected and its initial characterisation and preparation will start later in 1972.

Investigate the effectiveness of rhizobia/clover interactions in hill soils (collaborative project with microbiology department - ESA)
(P. Newbould)

Considerable importance is attached to the introduction of clover into hill pastures both to improve their nitrogen status and to aid animal performance directly. The need for the inoculation of clover seed with rhizobia and if so with what strain is not clear particularly on soils with organic surface layers as at Lephimore and Glensaugh. Additional treatments to investigate this aspect will be added to the field experiments described in above and a linked series of pot experiments will be carried out in Edinburgh.

Investigate the practicability of improving hill land by the use of earthworms (collaboration with CSIRO-Division of Soils) (P. Newbould)

There is considerable controversy as to whether earthworms are primary soil improvers or whether they increase in number and activity following an improvement brought about by other means. Recent experience in Australia and New Zealand suggests that in some soils of types similar to those found in the Scottish hills the introduction of earthworms of the Megoscolex family has brought about marked improvements in soil conditions within 3-4 years. It is proposed to introduce a few earthworms of the Megoscolex spp. from Australia to replicate small areas (10 x 10 m) of the hill at Lephimore and to examine their influence on soil structure and fertility; for comparison, the effect of introducing Lumbricus terrestris, the larger of the native earthworm species not normally found in hill soils, will also be examined.

Reaction of a heather community to various levels of grazing at different times within the growing season (Sheila A. Grant)

The site chosen for this experiment in 1970 was burned in February 1971. The fire resulted in a good clean burn and regeneration of the heather was excellent. A perimeter sheep proof fence was erected in spring and hare netting was added in the autumn as there was evidence of heavy grazing of the newly regenerating heather by hares.

The preliminary results from both Dr. Milne's work on the nutritive value of heather to the sheep and of the heather clipping experiment at Bush will influence final decisions about the range of grazing treatments to employ. Treatments, plot size and number will be finalized during 1972 after which the internal fencing will be erected. Grazing treatments will be commenced in 1973.

Regrowth and Carbo-hydrate reserves of heather (Calluna vulgaris)
(Sheila A. Grant)

To aid the interpretation of the effects of differing patterns and intensities of utilization on dry matter production, information is to be sought on carbohydrate reserves. Work to date has been confined to the search for a suitable technique for measuring such reserves in heather.

Effects of defoliation frequency on regrowth rate of pasture swards
(J. King)

More information is needed on the relationship between parameters of defoliation and the capacity of a pasture for regrowth. Work is being started in this field and it is hoped that among other things it will lead to a method for monitoring the regrowth capacity of grazed pastures.

Grazing management: effects of defoliation and nutrient level on pasture production in late autumn and early spring (J. King)

The new sheep management systems being developed by HPRO have specific requirements for pasture at various times of year. Two of these requirements are for pasture in the period October to December and again in early spring. Experiments are being started to investigate:

- (1) Factors affecting production and senescence of pasture crops in late autumn and early winter
- (2) The effect of autumn and spring defoliation on regrowth in early spring

Residual Effects of improvement treatments on blanket bog (M. J. S. Floate and G. Bolton)

Certain areas of the paddocks PI and PII (which now form part of the Development Systems at Lephinmore) were improved by fertilizer treatment and surface seeding in 1958/59. Other areas were similarly treated in 1964/65. Some of the original areas were re-treated with fertilizers in 1963 and 1968. Detailed records have been collected of the treatments applied, of the location of treated areas, and of vegetation changes. Some data are available from previous soil analysis and these indicate that in some cases residual fertility may be appreciable. Since the frequency of necessary maintenance treatments is an important aspect of soil and pasture improvement, an examination is being made of the current levels of soil nutrients within and outside the areas originally improved.

Response studies of improvement treatments applied to soils of the Sourhope Association (M. J. S. Floate, J. Eadie and J. S. Black)

A series of progressively more comprehensive improvement treatments including grazing control, lime and slag application and surface reseeded have been started on three sites:

- a) Sourhope (Brown Forest Soil) Festuca Agrostis (Experiment F-2)
- b) Cowie (Peaty podzol) Molinia Nardus (Experiment G-3)
- c) Frandy (Humus-iron podzol) Nardus Agrostis (Experiment F-4)

Responses will be assessed in terms of improved nutrient recirculation, herbage and livestock production, and through a cost effectiveness evaluation of each treatment. The soils of each site were sampled at the outset and some data were reported in the Annual Report 1970 (HPRO 187). Other results will be reported when these are available. Production data (available herbage and grazing days) have been recorded annually and full data on nutrient uptake and excreta return are usually collected at two-yearly intervals.

Assessment of nutrient recirculation, production responses, and maintenance requirements of reseeded pasture on blanket bog (M. J. S. Floate, J. Eadie and G. Bolton)

An experimental site on blanket bog at Lephinmore was established in 1971 and soil samples were taken from the whole area before any treatments were applied. It is intended to burn and reseed the area in 1972, lime (2 levels) and slag (2 levels) having been applied in 1971. Subsequently soil analysis will be carried out at regular intervals and maintenance treatments will be applied at intervals during the next five years. It is hoped that the first grazing of the reseeded pasture will take place during 1972.

Changes in soil properties under more intensive grazing in Development Systems on hill pasture (M. J. S. Floate and J. Eadie)

Year round grazing systems at Sourhope incorporate areas of pasture which are now much more intensively utilized than hitherto. Regular observations of litter layer thickness and surface soil pH are continuing. More comprehensive soil analysis may be required after four or five seasons under the changed management.

Effects of lime upon the mineralization of N and P from plant materials and sheep faeces (M. J. S. Floate and A. G. Lowe)

Lime application is an important element of the range of improvement techniques being evaluated in the Response Study Experiments. Laboratory incubation experiments are being conducted under controlled conditions to assess the contribution made, by various levels of lime application, in the mobilization of plant nutrients from organic sources. These sources may be either unconsumed plant material, sheep faeces or native soil organic matter. Plant and faecal materials from two Input/output-study sites have been collected from control - and lime-treated plots and these are being used in the first series of incubation experiments. Results are so far only available from the first plant material experiments and the indications are that lime, up to levels equivalent to 6.25 tonne/ha (2.5 t/ac), has no dramatic effects on nutrient mineralization from annually accumulated herbage. Experiments with sheep faeces collected from the same treatments are in progress.

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APPENDIX

PROJECTS 1972/73

<u>Project No.</u>	<u>Type</u>	<u>Subject</u>	<u>Key Titles</u>
<u>DIRECTOR</u>			
01E	(Applied)	The husbanding of red deer	RED DEER
<u>ANIMAL STUDIES DEPARTMENT</u>			
<u>ANIMAL PERFORMANCE SECTION</u>			
01A	(strat. a)	Environmental and genetic factors affecting reproductive rate in hill sheep	REPRODUCTION
02A	(strat. a)	Factors affecting lactation yield and its consequences in lamb growth	LACTATION
03A	(strat. a)	Lifetime performance of hill ewes in relation to early growth and annual cycles of body composition	LIFETIME PERFORMANCE
04A	(Applied)	Effectiveness of improved genotypes of hill sheep in utilising better hill resources	GENOTYPES
05A	(strat. a)	Factors which affect the regulation of wool growth rate, fleece structure and casting of fleece	WOOL
06A	(strat. a)	Influence of mineral balance on hill sheep dentition and performance associated with tooth decay	DENTITION

<u>Project No.</u>	<u>Type</u>	<u>Subject</u>	<u>Key Title</u>
<u>NUTRITION AND METABOLISM SECTION</u>			
01B	(strat. b)	Factors affecting voluntary intake of roughages by snoop	VOLUNTARY INTAKE
02B	(strat. b)	Studies on the nutritional physiology of the pregnant ewe	NUTRITION IN PREGNANCY
03B	(s+strat. b)	Studies of the interactions between nutrition and body composition in sheep	NUTRITION AND BODY COMPOSITION
04B	(strat. b)	Assessment of the nutritive value of heather to sheep	NUTRITION - HEATHER
05B	(strat. b)	Studies on the supplementation of low quality roughage diets for sheep	NUTRITION - SUPPLEMENTATION
06B	(strat. t)	Studies on the metabolism and nutritional physiology of immature and/or undernourished sheep	NUTRITION - METABOLISM
07B	(Applied)	Studies on the variation in intake of individual sheep kept in groups	GROUP NUTRITION
08B	(strat. b)	Beef cattle; characterization of nutritional state under different systems of management; studies on reproduction, lactation and calf growth	CATTLE

<u>Project No.</u>	<u>Type</u>	<u>Subject</u>	<u>Key Title</u>
<u>AGRONOMY DEPARTMENT</u>			
01C	(Applied)	Relations between nutrition and performance (especially lamb growth) in grazing sheep	LAMB GROWTH
02C	(strat. a)	Hill land improvement; the nutritional and productivity consequences of a range of improvement techniques applied to a range of hill pasture and soil types	INPUT/OUTPUT
03C	(strat. b)	Relations between pasture utilisation and nutrition by animals grazing hill and upland pastures	UTILISATION - NUTRITION
04C	(Applied)	The development of improved systems of animal production from hill pastoral resources; year round grazing systems	DEVELOPMENT - YRGS
05C	(Applied)	The development of improved systems of animal production from hill pastoral resources; off wintering systems	DEVELOPMENT - IWS
06C	(Applied)	The development of methods for the economic evaluation of hill farming production systems	DEVELOPMENT - ECONOMICS
07C	(Applied)	The development of improved systems of animal production from hill pastoral resources; in wintering at Boghall (Collaboration with E.S.A.)	DEVELOPMENT - BOGHALL

<u>Project No.</u>	<u>Type</u>	<u>Subject</u>	<u>Key Title</u>
<u>PLANTS AND SOILS DEPARTMENT</u>			
01D	(strat. c)	Studies of the mineralisation of plant nutrients from organic materials of plant and animal origin	MINERALISATION
02D	(strat. a)	Determine the soil physical conditions required to ensure optimum germination, establishment and growth of clover and selected grasses in hill soils	SOIL PHYSICAL CONDITIONS
03D	(strat. a)	Assess the economically optimum amounts of the major nutrients required to establish, grow and maintain clover rich pastures on hill soils	PLANT NUTRITION
04D	(strat. a)	Study the effects of competition between indigenous and sown plants (clover and selected grasses) and methods of adjusting the balance (including the use of herbicides) when forming improved pastures on hill soils	PASTURE FORMATION/ HERBICIDES
05D	(strat. b)	Study the growth of heather so as to assess the effects of seasonal patterns of utilisation and different grazing pressures on its potential productivity in both wet bogs and dry heaths	HEATHER
06D	(strat. a)	Study the growth of indigenous (<i>Agrostis/Festuca</i>) and improved (<i>Ryegrass/clover</i>) swards so as to assess the effects of seasonal patterns and different intensities of utilisation on regrowth and potential productivity	REGROWTH
07D	(strat. b)	Determine the quantities of the major nutrients circulating in soil-plant-animal systems on hill soils and identify factors which influence them	NUTRIENT CYCLING