

CONFIDENTIAL

HILL FARMING RESEARCH ORGANISATION

ANNUAL REPORT for the Academic Year 1963-64

Headquarters

29 Lauder Road, Edinburgh, 9.

Research Farms

Glensaugh, Laurencekirk, Kincardineshire.

Lephinmore, Strathlachan, Argyll.

Sourhope, Yetholm, Kelso, Roxburghshire.

STAFF CHANGES

Appointment: R. L. Reid, B.Sc. Agr., Ph.D., - Associate Director D.C.S.O.,
as from 1.1.64.

Department of Agronomic Studies

Appointment: J. L. Smart - A.E.O. as from 24.8.64

Department of Botanical Studies

Appointment: C. C. Evans - A.E.O. as from 1.1.64.

A. R. Sibbald - A.E.O. as from 1.4.64.

D. C. Gwynne, B.Sc. Agr., - A.E.O. as from 18.5.64.

Resignation: D. C. Gwynne, B.Sc. Agr., - A.E.O. as from 30.9.64.

Research Farms

Promotion: R. Armstrong, B.Sc. Agr., - A.E.O. to E.O. as from 25.6.64
(Sourhope).

Resignation: E. G. Johnstone, S.D.A. - A.E.O. as from 25.6.64 (Sourhope).

G. F. Legge, B.Sc. Agr., - A.E.O. as from 30.9.64 (Glensaugh)

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ANIMAL PRODUCTION

Growth and Development

Early Growth and Lifetime Production (R. G. Gunn)

During the year, various aspects of this subject have continued to receive attention.

An experiment, started at Sourhope in 1956 to study the effects of different levels of feeding in their first winter on the growth, development and subsequent performance of North and South Country Cheviots, is now completed. High-plane and mid-plane rations were fed for comparison with low-plane rations. In 1956-57 the latter were achieved by shed-feeding and in 1957-58 by hill-wintering. In 1958-59 mid- and low-plane rations only were imposed by means of away- and hill-wintering. Full records of live-weight, lamb production, wool production, ewe survival and dental development and persistence have been taken over 5 productive years on the hill. In the first two age groups a sixth productive year has been recorded on inbye ground at Glensaugh. During the current year the second age group at Glensaugh and the third age group at Sourhope have been finally measured and dentition scored prior to drafting.

Because some of the treatments were insufficiently controlled and because there were other variables such as season both before and after treatment, the results are difficult to interpret. Nevertheless, they do suggest a reduction in level of lamb production and in ewe survival with increase in rate of early growth beyond a certain point. This is obviously a very complex situation, involving interactions amongst a very wide range of variables. The results also suggest only a limited effect, on growth, development and performance, of treatments imposed as late in the growth cycle as 6 months of age.

An experiment designed to impose treatments earlier in life was set up with Blackfaces at Sourhope in 1961. Closer control of growth rate was exercised from 3 months of age, with three nutritional treatments and a control. There were two treatment periods, 3-6 months and 6-12 months. The three treatments were high-plane feeding throughout, high-plane in the first period followed by unsupplemented hill-wintering, and hill-grazing followed by high-plane feeding. The control remained unsupplemented on the hill throughout. The effects of treatment on rate of growth to maturity and on long term productivity are being studied. Live-weight and a series of live measurements are being recorded at intervals, the latter to describe the cessation of growth. Lamb and wool production are also being recorded annually. This is only the second productive year of this experiment, but results suggest that animals given preferential treatment during the first period produce and rear more lambs in the first 2 years than those not given preferential treatment and regardless of the treatment over the winter.

This concept is being examined on a simple field scale on Finella at Glensaugh. Both last year and this, every second ewe lamb born has been summered with its dam on inbye reseeds until weaning. Every other ewe lamb has been returned to the hill within a week or two of birth. In spite of the good quality of Finella hill, the inbye lambs were 8-10 lb. heavier at weaning. Ewe lambs for flock replenishment were selected equally from both groups and from weaning onwards all received identical wintering treatment. In the first age group, the live-weight difference was maintained till 6 months and was still 7 lb. in June of this year. Performance of these animals will be closely recorded.

On hills where the hefting instinct is well developed and training by the dam is of importance, variations in sward types are associated with significant differences in performance between home ranges. This is the situation at Sourhope and it is possible to get uninterpretable results

from shed-wintering treatments due to the development of non-randomly by distributed social groups. This effect has been studied in an experiment by Mr. Griffiths on Hairney Law, designed to examine the intake of in-wintered North Country Cheviot hogs. Two distinct home range groups were identified and the hogs in them were split into three sub-groups, two for in-wintering treatments and the third to remain on the hill. Initially there were significant differences in live-weight and body size between the two home range groups. Considering the hill-wintered sub-groups only, there was a $4\frac{1}{2}$ lb. live-weight difference. This increased over the winter to 8 lb., the lighter animals actually losing almost twice as much as the heavier. This occurred in spite of the much reduced winter stocking on Hairney Law due to the rest of the hogs and one-third of the ewe stock being wintered off the hill. This suggests that the home range habit has an over-riding influence on the animals' performance and that these lighter animals were lighter because they grazed poorer swards and that they lost more weight because they were incapable of taking advantage of the extra feed available elsewhere.

The size of the animal is a function of its breeding and of its nutrition during growth. Subsequent performance is then a function of size, the environment and nutrition. The relationships between these components have not yet been clearly demonstrated. The differences in environment and nutrition between Lephimore and Sourhope are well known. Analysis of the records indicates greater production from the Lephimore gimmers than from the Sourhope Blackface gimmers. The away-wintering of the former in contrast to the hill-wintering of the latter could largely account for this. Performance subsequently is poorer at Lephimore. This suggests that away-wintering between two summer seasons of considerable growing potential is producing ewes of too large a size for the severe autumn and winter hill environment in which they have to live and produce at Lephimore. Measurement of last year's Blackface ewe lambs on both farms does confirm that the Lephimore hogs continue growing all the year round and are larger, and leaner, than those on the Schil at Sourhope. The large-framed ewes at Lephimore never put on much condition and it seems likely that the development of a smaller, fatter animal, might improve the overall production there.

Effect of Inbreeding of Blackface Sheep on Lifetime Production (J. M. Doney)

This experiment, which involved mating four flock Blackface rams to equal groups of their own daughters and unrelated ewes in 1959, 1960 and 1961, is in the final stages. All the surviving ewe lambs from these matings were retained unculled and records have been collected on their growth rates, wool production and lambing performance in the standard hill flock. These records will continue until all three age groups have been drafted from the flock after four lamb crops. The first group has now been mated for the last time whilst those ewes born in 1962 have been mated for the second time. Results to date have shown that inbred lambs are smaller at birth, grow more slowly to reach a lower adult mature size and produce less wool than their non-inbred half-sibs. The number of live lambs born to both inbred and non-inbred ewes has varied from year to year, but in each case the inbred sheep have been much poorer in all aspects of fertility and lamb production. There is some evidence that many of the ewes which are recorded as being barren might in fact have lost their lambs in the later stages of pregnancy. In the 1963-64 season the mean adult weight, taken at mating in November, was 89.8 and 97.1 lb. for inbred and non-inbred older ewes respectively, and 75.6 and 88.9 lb. for the $1\frac{1}{2}$ -year-old sheep. Mean fleece weight in 1964 was 3.4 lb. for inbred as against 4.1 lb. for non-inbred ewes. Of 49 inbred ewes surviving to lambing time, 36 were barren or had apparently aborted. Only four lambs survived the first few days after parturition. Of 62 non-inbred ewes, 16 were barren and 42 lambs survived. In this season the incidence of apparent abortion was slightly higher than usual in the rest of the flocks at Glensaugh.

Growth and Development of the Fleece (J. M. Doney)

The series of observations on strain differences in adult fleece structure within the Blackface breed terminated this year. This completed the investigation in which wool samples were taken at Glensauagh at intervals of 4 months over a 3-year period from grazing ewes of the Lanark, Galloway and Lewis strains. The analysis of fleece structure from these samples is now proceeding slowly. So far those from the first year only have been processed and the results show that the apparent differences amongst the fleece types are reflected more in fibre morphology than in follicle density and follicle type ratio.

An investigation to study the inheritance of fleece structure in the Blackface breed has been started in conjunction with A.B.R.O. For several years they have carried out a selection experiment involving lines selected for body or fleece characters, using a large number of sires within each line. Wool samples have been taken from all the $1\frac{1}{2}$ -year-old ewes covering the summer growth period from August to October. These will be processed for fibre type and fibre morphology to provide estimates of the heritabilities of all the standard components of fleece structure within each line. The heritabilities in the lines selected on fleece character will be compared with those in lines which have been selected on body characters or which have been unselected.

Genetic Selection for Milk Yield (J. N. Peart)

The sires of the 1964 lamb crop from the "selected" line were mass-selected from the 1963 lamb crop of that line. The sires of the "control" line lambs continued to be provided from breeding groups as in previous years. At 8 weeks of age it was again found that the "selected" lambs had made slightly greater live-weight gains than those of the "control" line.

Nutrition, Climate and Production

Response to Climatic Exposure (J. M. Doney and J. G. Griffiths)

(a) Experiments designed to study the effect of differences in fleece cover and structure on heat loss in various climatic conditions have not progressed directly. Attention has been given to an examination of the techniques previously used. A wind tunnel has been built to provide a limited control of the environmental factors and has been calibrated. Some doubt has arisen on the meaning of surface temperature readings when the external environment surrounding the surface mounted probe is subject to change either by a drop in temperature or an increase in air movement. This will affect the validity of interpretations of changes in heat loss based on measurements of skin temperature and heat flow estimated by Hatfield discs. A guarded hotplate device has been constructed in the form of an artificial sheep and following calibration of the device itself we have started an examination of the effect of the external environment on surface measurements.

(b) Experiments on the gross effects of climatic exposure on sheep production have been continued at Glensauagh. Twenty-seven ewes were individually fed in the sheep house between mating and parturition whilst a further 27 were kept in outdoor pens, erected on an exposed site. Three nutritional treatments were imposed within each environment. One group were fed at a level expected to produce live-weight gain, a second to produce live-weight maintenance and a third to produce live-weight loss. All 18 ewes within any one nutritional group were offered the same amount of feed daily irrespective of their size or the environment in which

they were kept. There were individual differences in the amount consumed but no significant differences between the housed and exposed groups. At the lowest feed level the exposed sheep lost a significantly greater amount of live-weight over the period but there was no difference at the high level. There were no differences amongst the groups, differing in either feed level or exposure, in terms of the numbers of lambs born, birth-weights of the lambs, neo-natal mortality or subsequent live-weight gain of lambs. (All ewes were put out to the same pasture 10 days before lambing).

Control of Wool Growth (J. M. Doney)

A hypothesis has been developed from earlier observations to the effect that there are marked genetic differences in the physiological control of wool growth and that the environmental factors of nutrition and climate interact in different ways with different genotypes. At Lephinmore (using Blackface sheep) it was found that nutritional treatments during winter which had extreme effects on live-weight change (varying from a 15% increase to a 15% decrease in net maternal live-weight) had no apparent effect on rate of growth of wool, particularly between December and February. Irrespective of the rate of live-weight change all ewes were producing wool at a rate only 20% of that achieved during the late summer and autumn. It was of interest to record that, as at Glensaugh, the imposed treatments had no apparent effect on lamb performance.

An experiment was begun at Sourhope in which a group of North Country Cheviot and one of $\frac{3}{4}$ -bred Merino sheep are fed a constant annual offering. One-third are fed at a mean daily rate for the whole year, another third are fed on the basis of the expected seasonal levels of intake for hill-grazing ewes and the remaining third have this seasonal pattern reversed. All these sheep are individually fed in outdoor pens. Results to date have clearly shown that the Merino sheep can respond to variation in nutrient intake at any time of the year and that the daily rate of wool growth of those sheep fed at the high level in winter is about as high as that in the group which is fed at a maximum in summer. In contrast, the Cheviot sheep all showed a marked decline of production in the winter months with no differences amongst groups (the high level of feeding was almost 3 times as high as the low level). Plasma free fatty acid (FFA) levels were determined from blood samples taken at monthly intervals from these sheep. Despite this long interval between samples, the plasma FFA levels have followed the nutritional cycles remarkably closely. In a few instances, where meteorological records indicate unusually severe weather conditions prior to sampling, the levels were elevated in relation to those in adjacent periods, but the ranking of the treatments has always been preserved. The results to date suggest that climatic conditions and current nutrition act additively in their effect on the metabolism of fatty tissue. (In collaboration with A.J.F.R.)

Observations on the wool growth of wild Soay sheep, brought from St. Kilda and located in the Edinburgh Zoo, have shown that variation within the annual cycle of growth is much more marked than in the Blackface or Cheviot. The mean daily rate of growth in January and February was less than 5% of that in September. Twelve sheep of mixed age and sex have been sampled at monthly intervals since they were brought from the island. In six of these sheep it was impossible to obtain any wool from the sample site in either January or February and one ewe produced no growth at all in January, February or March. These results tend to suggest that the control of wool growth may have adaptive significance.

Further information relative to this hypothesis will be obtained from the experiments now in progress at Lephinmore and Glensaugh. At this stage we are reasonably confident in the basic conclusion that a gene/environment interaction exists in the control of wool growth. We may tentatively suggest that the control may operate through the relative sensitivity of

the breeds to some environmental factor which may be 'climatic stress', day-length cycle or even an inherent rhythm, but we cannot yet test this extension nor speculate adequately on the physiological mechanism involved in the control.

Effects of Cold Stress on Shorn Sheep at Different Levels of Nutrition

(J. G. Griffiths, J. M. Doney, A. J. F. Russel and J. Slee (Animal Breeding Research Organisation))

Sixteen Blackface wethers were confined in metabolism crates in the A.B.R.O. temperature-controlled chambers. Of the eight wethers in each chamber, four were fed ad libitum and four at a level of 23 gm./kg. body weight, the ration being a pelleted concentrate mixture (18% crude protein). The animals were close clipped at the start of the experiment and again after 27 days; they remained in the chambers for 35 days, after which they were removed to an adjoining sheep-house for a further 26 days. All were fed ad libitum after removal to the sheep-house. The temperature in both chambers was 20°C for the first 15 days. On the 16th day the temperature in one chamber was abruptly reduced to 1-3°C and remained at this level for the rest of the period. The temperature in the second chamber was kept at 20°C. The temperature in the sheep-house was between 12°C and 15°C. Measurements were made of daily feed intake, live-weight, skin (ear, foot and mid-side) and rectal temperatures, heart rates and respiration rates. Blood plasma samples were taken frequently throughout the experiment.

Stable ad libitum intakes were not reached for 10 days. Analysis of feed intake, body weight and body and rectal temperature data is not yet complete. Significant changes occurred in all parameters but the responses, although generally in the expected directions, were variable both between and within groups. Thus ad libitum feed intake tended to increase at low temperatures and after clipping. Body weight of animals on a restricted intake tended to decline irrespective of temperature.

Heart rates were measured only at the end of the chamber experiment and during the period the animals were in the sheep-house. Differences in feeding level were reflected in differences in heart rates, mean rates for the two groups being 116 and 75 per minute. The differences between chambers were very small. Heart rates were similar when all animals were fed ad libitum in the animal house. Respiration rates varied with the level of feeding and with differences in environmental conditions. The ad libitum-fed animals showed rates of 164 at 20°C and 28 at 1-3°C. The restricted-fed animals showed lower levels in both chambers. The rates in both chambers declined after clipping, in the cold chamber the levels reached being similar in both groups. Respiration rates were similar in all animals after removal to the animal house.

Prefeeding blood samples for plasma free fatty acid (FFA) analyses were taken from all sheep at frequent intervals throughout the experiment. Diurnal variations in FFA levels were also studied. The mean values in the sheep fed ad libitum remained relatively constant at between 100 and 200 µeq./l. throughout the course of the experiment, and showed no response to a reduction in ambient temperature from 20°C to 1-3°C or to close shearing. Diurnal variations were also within the range of 100 to 200 µeq./l.

The mean FFA level in the sheep fed at a restricted level at 20°C fell steadily from approximately 1000 to 500 µeq./l. over the 20 days preceding shearing, rose sharply to 1100 µeq./l. after shearing, and declined to 600 µeq./l. in the next 2 days. During the 20 days prior to shearing the mean levels in the restricted-fed sheep which were exposed to cold ranged from 400 to 700 µeq./l. and showed no clear response attributable to the lowering of temperature from 20°C to 1-3°C 11 days before shearing. Diurnal variations in the low-temperature restricted group during the 48 hr. following the drop in temperature were within the

200 to 600 μ eq./l. range and closely followed the pattern of the 20°C restricted group. The morning after shearing the mean level had risen to almost 850 μ eq./l.; 4 days later it had fallen to 600 μ eq./l. On the day following the first ad libitum feeding (in the sheep-house) of the previously restricted groups the mean plasma FFA levels in both groups were below 200 μ eq./l. and indistinguishable from those of the groups fed ad libitum throughout the experiment.

The Effect of Environment on Voluntary Feed Intake and Wool Production in Hoggs (J. G. Griffiths)

Two groups, each of 12 North Country Cheviots, were individually penned, one group indoors, the other group outdoors. The remainder of the 38 animals available were returned to the hill and were wintered there in the normal way.

Differences in temperature between indoors and outdoors were of the order of only 2-3°C. The feed intake per unit of body weight was similar for both penned groups. The daily level fluctuated considerably and the pattern of variation was also similar in the two groups.

Wool growth in the hill group showed the usual pattern with minimum growth during February and March. Wool growth in the penned sheep was lower in the December/January period than in the February/March period. This low initial rate of growth is probably a consequence of an insufficient period of adaptation to the penned conditions rather than a difference arising from other experimental treatment.

The two groups of penned animals showed a similar pattern of body weight change. Body weight increased in November and declined during December. Throughout February and March body weights were almost constant. Body weights in the hill group showed a steady rise until the end of January, followed by a marked fall until the middle of March. The penned animals were returned to the hill at the end of March.

Microclimate Measurements and the Effects of Weather and Microclimate Variations on Sheep Behaviour (J. G. Griffiths)

A limited study was undertaken at Lephinmore during October 1963 to investigate the shelter needs and associated grazing patterns of a group of wether hoggs on inbye land. These results are presented in the Third Triennial Report (p.33).

A study has been initiated to investigate the totality of the weather and micro-variations on a heft at Sourhope and to look at effects of weather, exposure and shelter of grazings on the grazing behaviour of the flock. It is also hoped to investigate the effects of some short-term weather changes on body temperature responses.

Outer versus Indoor Wintering of Hill Ewes (J. N. Peart)

On 13th January 1964, 48 North Country Cheviot ewes were removed from their hill-grazing at Sourhope and divided into two similar groups of 24 each. One group was wintered and lambed indoors and the other wintered and lambed on a confined area (1 acre) out of doors. Both groups were group-fed and given a daily ration of 2½ lb. hay plus 1 oz. white fish meal per head. On 8th April the fish meal was increased to 2 oz. per head.

At the beginning the average live-weight of each group was 121 lb. These weights were maintained until mid-March and increased slightly as parturition approached. One ewe from the indoor group died suddenly shortly before it was due to lamb and one ewe from each group died from

tetany soon after lambing. The indoor group produced 18 single lambs, average birth-weight 10.3 lb., and 10 twin lambs, average birth-weight 8.4 lb. Comparable figures for the outdoor group were 19 of 10.7 lb. and 10 of 7.9 lb. There were no lamb deaths at birth or during the period to lamb marking.

Animal Health

Aetiology of Tick Pyaemia (W. N. M. Foster)

Field investigations into the aetiology of tick pyaemia were continued in the spring of 1964. Studies in the previous year suggested that ewes' milk might be the source of the haemolytic staphylococci. Bacteriological examination of further milk samples from ewes nursing pyaemic lambs demonstrated that although staphylococci were present in some samples, this was not invariably the case.

Studies have been initiated on the influence of colostral immunity based on determinations of serum gamma-globulin. In normal lambs gamma-globulin levels were highest in the first week of life and then declined steadily to reach the lowest level at 4 to 6 weeks of age. Occasional lambs exhibited very low levels after birth, demonstrating low colostrum intake or failure of absorption. There is at present no evidence that pyaemic lambs have low initial gamma-globulin levels. Following infection and abscess formation the gamma-globulin values rise to levels markedly above those expected in normal lambs of similar age. Utilising this technique it is possible to recognise lambs with chronic internal abscesses, but which appear outwardly normal. It is hoped to use a modification of this technique to carry out a more accurate survey of the incidence of pyaemia in the field, since the present figures for incidence are based largely on visible lameness. The overall incidence, which must include lambs with internal abscesses, may be considerably higher.

In 10 investigated cases of pyaemia, where precise information was available on the age of the lamb and the date of crippling, there was evidence, based on gamma-globulin values and post-mortem examination, that chronic abscesses already existed in six lambs before crippling occurred. Of the remaining four cases, two became crippled at 10 days of age and the remaining two at 39 and 42 days of age respectively. It is not yet proven, but it is thus possible that visible crippling in six of these lambs may have been due to secondary dissemination of bacteria from primary sites of infection. Moreover, although these six animals all exhibited an elevated serum gamma-globulin level due to the primary infection, this did not prevent the subsequent bacteraemia and lameness.

In the course of the field investigations it also became apparent that severe abscess formation in very young lambs is almost invariably associated with a severe anaemia. This is of interest since in tick-infested areas death of lambs is often popularly ascribed to "the lambs being sucked dry of blood". Although the explanation is inaccurate, the observed anaemia is real. In the absence of eperythrozoon, a blood parasite causing anaemia, it seems probable that the anaemia is a corollary of chronic abscess formation. Secondary anaemia associated with chronic infection is well documented, but the onset of such an anaemia is usually relatively slow. In the young lambs studied the onset was rapid. However, if the physiological change from foetal to mature erythrocytes in the first weeks of life is taken into consideration it is apparent that if erythropoiesis is inhibited and foetal erythrocyte destruction continues, a rapidly developing anaemia will ensue. This subject is still under investigation and it is not yet possible to determine how much the anaemia contributes to the overall mortality in pyaemia areas.

Prevention of Tick pyaemia (W. N. M. Foster)

Penidural LA, a long acting preparation of penicillin, was utilised in two field trials in an attempt to prevent pyaemia occurring.

In Trial 1 no result was obtained as the incidence of pyaemia was, unaccountably, very low in the spring of 1964. This is in contrast to previous years when the incidence was high on this farm and is one of the complicating features, both of the disease and of experimental field work.

Trial 2 was more successful, the incidence in 50 treated lambs being zero compared with 15 cases in 100 control lambs.

In both of these trials lambs were injected a few days prior to the expected outbreak of disease, but the latter cannot be accurately predicted and may occur at any time between mid-May and mid-June. Moreover, the possibility of secondary dissemination of bacteria from primary chronic abscesses may suggest that treatment would be more beneficial at an earlier stage, and the methods employed this year will require review.

The duration of prophylactic action of the penicillin also requires further study. In an experiment with 27 lambs, detectable serum levels of penicillin were maintained for 14 days post-injection. The decline in serum level does not, however, necessarily mean loss of protection for if the threshold concentration in the blood and tissues has been achieved and maintained for a proper length of time, clinical protection may persist even after the titre of the serum has fallen below demonstrable levels. It is hoped to obtain further information on this point by means of challenge experiments.

Tick-borne Fever (W. N. M. Foster)

Available evidence suggests that tick-borne fever plays a role, possibly the major role, in the aetiology of pyaemia, but confirmation awaits a greater understanding of the pathogenesis of tick-borne fever. It is known that the neutropaenia which follows the temperature reaction will reduce the resistance of lambs to experimental infection, and initial experiments have demonstrated that simultaneous infection with both tick-borne fever and staphylococci will lead to the establishment of chronic abscesses. The possibility of secondary spread of staphylococci from such abscesses is at present being investigated.

Pasture ManagementControlled Grazing - Park Law (J. N. Peart)

The management of this area was continued as in the previous year (see Triennial Report). By November 1963, both flocks had made a good recovery from the previous winter but their average live-weights were about 7 lb. below normal. Sheep born in 1962 and 1963 were most affected and it is possible that these sheep will remain sub-standard. In November 1963, the control-grazed ewes averaged 115 lb. and the free-grazed ewes 110 lb. Subsequently both flocks lost weight and in June 1964 their respective average weights were 110 lb. and 91 lb. This difference was reduced to 10 lb. (114 v 104 lb.) by August. Since then, the flocks have gained weight at the same rate, the differential of 10 lb. being maintained in favour of the control-grazed ewes.

Though lambs from the control-grazed flock were the heaviest at weaning, this was offset by there being fewer lambs weaned. Factors contributing

to this smaller lamb crop were the abnormally high number of barren ewes and also the depredation by foxes which resulted in the loss of six or seven lambs. The reason for the large number of barren ewes is not evident, but may be associated with an ineffective ram.

Agisted dairy cattle provided cattle grazing treatment according to programme, but this was considered to be inadequate for the season.

Sheep Production and Performance

	<u>Control-grazed</u>	<u>Free-grazed</u>
Ewes to Ram	100	100
Ewes Barren	11	4
Ewes Aborted	4	5
Lambs Born	91	95
Lambs Weaned	75	82
% Lamb death birth-weaning	18.5%	14.7%
Av. birth-wt. single lambs	8.1 lb.	7.5 lb.
Av. Weaning wt. single lambs	53.4 lb.	50.7 lb.
Total Prod'n. of weaned lamb	3914 lb.	3971 lb.
Wool*	500 lb.	500 lb.
Cast Ewes	2107 lb.	1720 lb.
Output per ewe mated	65.2 lb.	61.9 lb.
Output per acre	70.2 lb.	68.8 lb.

* These figures for wool are estimates

It will be noted that the net body weight change between November and June was -19 lb. in the free-grazed ewes, but only -5 lb. in the control-grazed ewes. It is clear that more detailed data are needed to find when this difference arises. Do the control-grazed ewes maintain their autumn (peak) weights longer or is their weight loss less in winter? Or do they gain weight more rapidly in spring? Likewise, what is the reason for the more rapid gain in weight of the free-grazed ewes between June and August (+13 lb. v +4 lb. in the control-grazed ewes). These detailed data will be sought in 1964-65.

Ewe Reactions to Different Grazing Management Procedures (J. N. Peart (in collaboration with Veterinary School, University of Glasgow))

This study was similar to that of 1963 when it was found that different grazing management treatments produced significant differences in blood calcium and magnesium levels in the ewes and highly significant differences in lamb growth rates, in favour of set-stocking.

In 1964 the grazing treatments were:-

1. Set-stocked; not moved (4 groups - 4 plots)
2. Set-stocked but moved twice per week (4 groups - 4 plots)
3. Rotationally grazed; moved twice per week (1 group - 4 plots)

The blood analyses for 1964 showed a similar pattern to 1963 in that mean serum calcium of the rotationally grazed group decreased immediately after each grazing change. After an initial fall associated with the change in grazing at the beginning of the experiment, calcium and magnesium values tended to increase in the other groups throughout the experimental period. The set-stocked moved group behaved in the same way as the set-stocked not-moved group. This indicates that the change in grazing, and not the movement per se, caused the reaction in serum levels.

Some individuals showed very low serum magnesium values, some of which were associated with low calcium values. Tetany might have been expected in these cases, but none occurred. However, the calcium values were not so low as in 1963, when four cases of tetany occurred.

Unlike 1963, the rates of growth of lambs were similar in all groups. No obvious reasons can be offered in explanation of the difference between years. The only field available for the study lacked uniformity in sward conditions. An attempt to distribute this variation between treatments was only partially successful. It was subsequently found that due to its cropping history there was a marked variation in fertility over the field.

Hill Pasture Improvement Study - Lephinmore (I. A. Nicholson)

This study is being continued (see Triennial Report). In 1964 it was hoped to have completed the improvement procedure in the second 100-acre enclosure. Lime and basic slag were applied to the areas selected for treatment but because of heavy rainfall the work was not finished early enough for the grass and clover seed to be sown. Nevertheless the area will make a significant contribution to the grazing next year and will enable a rotational system to be established, involving the integration of the two paddocks with the remainder of the hill.

The combined "standard grazing days" for sheep and cattle on the first 100-acre enclosure show the following trends since 1955-56.

1955-56	1407	1959-60	1249
1956-57	212	1960-61	3713
1957-58	1255	1961-62	4745
1958-59	1363	1962-63	3265

The grazing use of this area shows a marked upward trend in recent years. The current sheep stocking of 300 ewes on the whole of Mid-hill represents an increase of nearly 50% since 1956 and there is no evidence of a fall in individual performance.

In 1964 the enclosed area was mapped and the second vegetation survey was carried out on the first enclosure. The results are still being analysed.

The Nutrition of the Grazing Sheep

Prediction of Pasture Digestibility (J. Eadie, J. S. Black)

This series of trials carried out over the period spring 1962 - summer 1964 has now been completed.

A statistical analysis of the results has shown that it is possible, with an acceptable degree of accuracy, to predict O.M. digestibility from faeces N% in O.M., from regressions incorporating a wide range of hill herbage types. These regressions show a distinct seasonal bias and it has been found possible to avoid an arbitrary subdivision of the data into "summer" and "winter" regressions by the inclusion of "month-of-cutting" term. The inclusion of this third term significantly reduces the residual standard deviation in both "summer" and "winter" regressions and allows the incorporation of the data from all trials in one regression equation.

Annual Cycle of Nutrient Intake (J. Eadie, J.S. Black)

This project, which covered the period January 1961 - March 1964, has now been completed. The intake data have been calculated from faeces N% in O.M. using the regressions derived as outlined above.

O.M. Digestibility of the intakes varied from 45-50% in February to around 75% in the May-June period. Intakes of digestible energy varied over the range 120 Kcals D.E. per Kg^{0.73} to 280 Kcals D.E. per Kg^{0.73}. The most striking feature of the intake pattern is the way in which digestible energy intake increases during the period which includes the last 4 weeks of pregnancy. The indications are that pre-partum levels of nutrition in the conditions of the investigation may not constitute such a serious impediment to levels of individual animal performance as is generally supposed.

When the intake data are corrected for differences in body size, a linear relationship exists between O.M. digestibility and O.M. intake. The relationship, quantitatively, is very similar to relationships observed by others between digestibility and voluntary intake of ranges of roughage diets (e.g. Blaxter, Wainman and Wilson etc.).

This work is currently being prepared for publication.

Factors Governing Herbage Intake (J. S. Black, J. Eadie)

For a proper understanding of animal/pasture relationships in pastoral systems, studies of the factors influencing herbage intake by grazing ruminants are important. It is convenient for the purposes of study to divide these factors into (a) those which are characteristics of herbage and (b) those which are characteristics of grazing animals.

(a) Herbage factors can be considered in two groups.

(i) Those intrinsic characteristics of roughage diets which influence the extent to which they are voluntarily consumed. It is proposed, when facilities become available, to look in the first place at digestibility/voluntary intake relationships in the produce from a range of hill pasture types. The data from the annual cycle study indicate a linear relationship between these parameters under the conditions of the study. But this general relationship may well mask important differences in the acceptability of different hill pasture types. From these studies we hope to learn to what extent those hill herbage comparatively neglected by grazing sheep under the current free-range grazing system could be

satisfactorily utilised by changes in the management system or whether their utilisation is limited by an inherently low acceptability.

(ii) Those characteristics of grazing situations which affect herbage intake. Evidence from the annual cycle study and elsewhere indicates that in some grazing situations herbage intakes are related to the quality of the herbage animals are able to select from the available pasturage. It is also known that intakes can be limited because of a lack of available herbage.

It seems reasonable on the basis of the available evidence to suggest that the first priority of the grazing animal is to eat to "constant fill" and that it selects from the available pasturage the highest quality diet consistent with the attainment of "constant fill". As a sward is grazed down the animal adjusts its selectivity and the quality of its diet on this basis. Other adjustments such as increases in grazing time, and changes in rate of ingestion are also doubtless important. At some point the animal is no longer able to satisfy "constant fill" and at this point it may be supposed that lack of available herbage limits herbage intake.

In an attempt to see to what extent the ideas very briefly outlined above provide a basis for further work, a small hill paddock on which there is a standing growth of some 3000 - 4000 lb. herbage D.M./acre is currently being grazed down by six wether sheep. Daily faeces collections are being made and will be continued until the grazing is completed, and intakes will be computed from faeces N - digestibility regressions.

In order that the intakes of the sheep can be reasonably related to the pastures from which that intake is derived, a more meaningful description of the available pasturage than those generally employed is being sought. The basis of this description is that it is not enough to describe the available pasturage in terms of its yield of available grazing to which is attached a mean digestibility value or some other index of quality. It is thought that it might be more useful to regard the available herbage as being composed of a population of grazing units, each having digestibility value, the whole being described as a frequency distribution of quantities of available dry matter about a range of digestibilities. As a starting point towards such a description 24 12" x 6" turves were dug from the peat before grazing began and the aerial parts of all the plant materials separated from the roots. The aerial plant material from each turf has been subdivided horizontally to give a total of some 240 herbage samples for "in vitro" digestibility determinations from which the frequency distribution will be produced. This procedure will be repeated at intervals during the grazing-down process and at the end of the experiment.

(b) Animal Factors (J. Eadie, J. S. Black, A. J. F. Russel)

It is generally accepted that the lactating ewe voluntarily consumes more of a given roughage diet than a non-lactating sheep of the same body size. The main objectives of an experiment carried out during the spring and summer of 1964 were to measure the extent to which increases in voluntary consumption take place in lactating ewes, and to see whether the quality of the ingested pasture modifies increases in voluntary intake. It was also hoped to look at the effect of energy demand on voluntary intake by including ewes with twins as well as ewes with single lambs in the experiment. For this purpose a pregnancy diagnosis was carried out on a group of ewes prior to the selection of ewes for the experiment. We were however, unable to get the number of twins necessary for this part of the experiment.

A group of 28 ewes was fed $2\frac{1}{4}$ lb. moderate quality hay + 6 ozs. concentrate per day for 5 weeks prior to parturition. As they lambed they were allocated at random to either an enclosed field of improved pasture or to a contiguous area of rough pasture, until each area had a complement of 10 ewes. To each area three wether sheep were added.

Intakes of all sheep were measured during the first 12 weeks of lactation by the chromium oxide/faeces N method and for the first 9 weeks of lactation milk yields were measured at weekly intervals by weighing lambs at 4-6 hr. intervals over 24 hours. All sheep and lambs were weighed each week.

The analytical work associated with this experiment is now being carried out. The performance records and that part of the analytical work so far completed indicate that the conditions necessary for the attainment of the objectives of the experiment, namely, substantial differences in the intakes of the two groups of sheep and in their levels of performance, have been achieved. It is hoped that in addition to the main objectives of the experiment some useful information on relationships between energy intake and performance under grazing conditions will be obtained.

Blood samples were taken from all ewes in this experiment from approximately 4 weeks pre-partum until about the 10th week of lactation. Although all ewes were run together until parturition, when they were randomly allocated to either the "field" or "hill" groups, pre-partum differences between groups in plasma free fatty acid (FFA) levels were apparent. Mean levels in the hill group increased from approximately 1250 μ eq./l. 30 days pre-partum to almost 1900 μ eq./l. 18 days pre-partum, before falling to 1300 μ eq./l. at the mean date of parturition. The corresponding levels in the field group were 1150, 1700, and 1200 μ eq./l. respectively. Lambs from the ewes which were allocated to the hill group were on average 0.3 lb. heavier at birth than those from the ewes subsequently assigned to the field group. This difference in lamb birth weights is not significant, but as there is a significant regression of pre-partum maternal plasma FFA level (y μ eq./l.) on lamb birth-weight (x lb.) ($y = 231x - 576$, $r = 0.70$; $p < 0.001$) there is some justification for attributing the pre-partum between-group differences in mean plasma FFA levels to the difference in foetal weights.

Mean plasma FFA levels fell in both groups after parturition. In the hill group this decline was relatively slow during the first 18 days of lactation (1300 to 1150 μ eq./l.) and thereafter accelerated, giving a mean level of approximately 250 μ eq./l. at 50 days post-partum. The initial post-partum decline in mean plasma FFA levels was more marked in the field group (1200 to 600 μ eq./l. in 18 days). Thereafter the rate of fall decreased until both groups showed virtually the same levels at around 50 days of lactation. The greatest difference in mean levels between the two groups was 550 μ eq./l.; this occurred at 18 days post-partum.

A considered interpretation of the results must await the completion of other chemical and of statistical analyses, but the data available to date indicate that the degree of "physiological" undernourishment in the field ewes was less severe than that in the hill ewes, and that this was reflected in the higher level of lactation and greater live-weight increase of these field ewes.

Digestibility of Hill Pasture Species - Winter (J. S. Black, J. Ladie)

The winter diet of the hill sheep is selected from herbage conserved 'in situ'. The available herbage at the beginning of winter is depleted by grazing and by plant senescence as winter advances. Plant senescence effects can in one sense be measured in terms of dry matter loss and reduction in digestibility. An attempt is being made to measure the relative senescence rates in Agrostis tenuis, Festuca rubra, Holcus mollis, Deschampsia flexuosa and Lolium perenne.

The plots were planted out from tillers of each species. Each plot was made up of a rectangle of such tillers planted at spacings of 3 in.; each species was replicated 6 times. The intention was to cut part of each

plot at 4 dates throughout the winter, but the heavy snow cover during the winter 1962-63 prevented the collection of data between 26.11.1962 and 8.3.1963.

The amounts of dry matter present at the beginning of winter varied considerably between species as would be expected from the way in which the trial was established. Dry matter loss varied considerably between species.

Digestibility estimates were made using the "in vitro" digestibility procedure (Alexander and McGowan). The most striking feature of the digestibility data was the way in which Deschampsia flexuosa maintained digestibility over the winter.

Table I

Species	% D.M. Digestibility (in vitro)	
	26/11/62	8/3/63
<u>Deschampsia flexuosa</u>	72	62
<u>Lolium perenne</u>	71	43
<u>Festuca rubra</u>	65	48
<u>Holcus mollis</u>	65	42
<u>Agrostis tenuis</u>	65	35

There is however, an inverse relationship between reductions in digestibility and weight of dry matter present at 26/11/62. The appearance of the plots when the snow disappeared in early spring suggested that the species carrying the most herbage had suffered most. In other words a large part of the recorded digestibility differences between species could be accounted for in terms of the weight of herbage dry matter on the plots at the beginning of winter.

Digestibility of Hill Pasture Species - Summer (J. S. Black, J. Eadie)

Small plot experiments have been carried out during the summers of 1963 and 1964 with the object of investigating the variations in digestibility of Deschampsia flexuosa, Holcus mollis, Agrostis tenuis, and Festuca rubra under three management treatments, using the in vitro digestibility procedure.

Data so far available indicate no significant between-species differences in digestibility of herbage cut in the middle of May. But there is some evidence that as the plants grow towards maturity Holcus mollis, and to a lesser extent Agrostis tenuis, maintain their digestibility levels rather better than Festuca rubra and Deschampsia flexuosa. Digestibility assessments are continuing.

The Nutrition of Grazing Blackface Ewes (A. J. F. Russel)

As a preliminary to further and more detailed studies on the nutritional physiology of the Blackface ewe, 21 "hill" ewes and eight "inbye" ewes at Lephinmore were bled at weekly intervals from approximately 6 weeks pre-partum to 1 week post-partum. Blood samples were analysed for plasma FFA.

The "hill" group were run on the hill, where they received some supplementary feeding, until approximately 2 weeks before lambing when they were brought down to improved pasture. The "inbye" group comprised one

of the nutritional treatment groups from J. M. Doney's experiment (see "Control of Wool Growth").

It is difficult to make a critical appraisal of the results as changes in nutrition (supplementary feeding and introduction to improved pasture) were made for all hill ewes at the one time and not at the one stage of pregnancy. Lambing was spread over a period of some 3 weeks. Interpretation of the results is further made difficult by the fact that the spring growth of grass starts at around lambing time and it is therefore likely that early lambing ewes suffer relatively greater undernourishment in late pregnancy than do those which lamb later.

The mean plasma FFA levels of 11 mature "hill" ewes bearing single lambs were in the region of 600 μ Eq./l. 6 weeks before lambing, rising to 750 μ Eq./l. 2 weeks pre-partum and thereafter falling again to 600 μ Eq./l. before parturition, the fall being attributed to the ewes being brought on to improved pasture. Three barren ewes from the "hill" group showed a similar pattern to the single-bearing ewes, except that by the mean date of parturition their plasma FFA levels had fallen to around 500 μ Eq./l. The mean plasma FFA level of five "hill" gimmers bearing single lambs was maintained at a relatively constant level of between 900 and 1000 μ Eq./l. from 6 weeks pre-partum until 2 weeks pre-partum, when it fell to 700 μ Eq./l. Two mature "hill" ewes bearing twin lambs showed initial plasma FFA levels of the same order as those of the single-bearing mature "hill" ewes. This level began to increase at about 28 days pre-partum and reached 1150 μ Eq./l. 2 weeks pre-partum after which it fell to 750 μ Eq./l. 2 days before lambing.

The nutrition of the "inbye" group (all six-year old ewes) was designed to maintain net maternal body weight during pregnancy. Mean plasma FFA levels in these ewes showed less consistent trends than were found in the "hill" group, probably because of the necessary nutritional adjustments. Mean plasma FFA levels in the three ewes bearing single lambs varied between 400 and 600 μ Eq./l. in the 6 weeks before parturition, i.e. somewhat lower than the comparable ewes in the "hill" group. The four twin-bearing "inbye" ewes had mean plasma FFA levels ranging from 750 to 950 μ Eq./l. during this time - again somewhat lower than comparable ewes in the hill group, but probably indicating a certain degree of undernourishment.

All lactating ewes, with the exception of the two twin-bearing individuals in the "hill" group, showed elevated plasma FFA levels in early lactation. This increased mobilisation of body reserves was greatest and most striking in the four twin-bearing ewes of the "inbye" group, in which the mean plasma FFA levels reached a peak of 1450 μ Eq./l. 4 days after parturition. The decline in plasma FFA levels in one of the two twin-bearing "hill" ewes during early lactation was probably due to the removal of one lamb; plasma FFA levels fell from about 700 to 300 μ Eq./l. during the week in which the lamb was removed.

This preliminary study suggests that, under the prevailing system of management, mature ewes bearing single lambs are not subjected to undue nutritional stress during late pregnancy, but that gimmers and twin-bearing mature ewes on the hill do suffer a certain degree of undernourishment at this time. This stress is alleviated to a large extent by the practice of bringing the ewes off the hill on to improved pasture before lambing. Although sampling was not continued beyond the first week of lactation it would appear that undernourishment is more severe in early lactation than in late pregnancy, in spite of the continuing improvement in the level of nutrient intake as indicated by declining plasma FFA levels in barren ewes.

Experiments now under way are designed to study more closely the degree of undernourishment encountered by pregnant ewes under hill conditions, and to study the effect of various nutritional states during pregnancy, measured in physiological terms, on the performance of ewes and lambs.

Dentition and Mineral Status (R. G. Gunn)

Glensaugh has a history of premature broken-mouth in the ewe stock. Preliminary studies suggested that, with inbye lambing, withdrawal of minerals from the skeleton, and particularly the mandible, was considerable during lactation. This loss did not appear to be replaced on the heather hill. An experiment, started in 1961, was designed to study this and is continuing. Before and after lambing, four groups of 20 ewes each receive the same concentrate supplement with no mineral additives. One group remains on the hill throughout and the other three are brought off the hill on to reseeds before lambing. One of these receives no mineral supplement, one receives a dose of 13 gm. monosodium phosphate in solution 3X/week, and the third receives a dose of 12 gm. calcium carbonate in suspension, also 3X/week, from February to May, when all return to the heather.

Blood samples are taken periodically before each change of management and are analysed for P, Mg, and Ca by the A.D.R.A., Edinburgh. The teeth are examined twice yearly for eruption, mobility, periodontal pockets, wear, and the bite position on the pad. A photographic record is also taken of the teeth. Lamb production records are taken annually and only the hill group produce fewer lambs.

Preliminary examination of serum mineral levels shows large seasonal fluctuation in Ca and P but, as yet, little obvious relationship to, or variation with, treatment. Both show a tendency to increase the mode of their fluctuation with age. There is also a suggestion that the Ca level falls lower during lactation with each year and in the third year the inbye control group Ca level fell the lowest. In this autumn, at $4\frac{1}{2}$ years of age, over 20% of this control group are broken-mouthed, similar to previous results, compared with less than 5% in the other groups.

The importance of ground effect is now becoming clear. The first age group to stay permanently on Finella all the year round is still present at $5\frac{1}{2}$ years of age and have less broken-mouth than the $4\frac{1}{2}$ -year-old age group on Big Hill.

The importance of the ram in reducing the incidence of broken mouth through inheritance is being stressed and all rams for breeding are now receiving a careful dental examination.

The production of a group of ewes from a ram of known premature broken-mouth continues. The production of a group of ewes maintained permanently on an area of heather with access to and from a grass field also continues.

Preliminary analysis of records of broken-and whole-mouthed ewes at Glensaugh over 7 years, while only limited in their relevance, indicates a loss in weight and less milk for twin lambs in the broken-mouth ewes. This suggests the need for more critical examination of the influence of broken-mouth on efficiency of performance and of its mode of operation.

Plant-Environment Interactions

Plant Competition - *Agrostis Tenuis* and *Festuca rubra* (Sheila A. Grant)

A competition experiment in which *Festuca rubra* and *Agrostis tenuis* are growing in boxes in a replacement series has been established at the Scottish Plant Breeding Station. Two levels of fertility are provided and the original plantings were at two densities. The experiment was planted out in July 1963 and between then and October 1964 there have been seven harvests. At each harvest the vegetation is cut back to 1 in. above soil level. Differences in yield occasioned by the different planting densities had almost disappeared by the second harvest in October 1963 and had completely disappeared by the third harvest in March 1964.

For each harvest, yield curves may be plotted for the separate contribution of each species to the various mixes in the replacement series. If neither species affects the growth of the other these curves would be linear. This condition occurred until the third harvest when there was a suggestion of a departure from linearity at the higher fertility level. At the fourth harvest, at this same fertility level, there was a large negative curvi-linearity for *Agrostis tenuis*. Thus the yield of *Agrostis* was lower than expected if its growth was unaffected by the presence of *Festuca*. The corresponding positive curvi-linearity for the fescue did not appear until the next, the fifth harvest. Since then at all subsequent harvests, at the higher fertility level, there has been a positive departure from linearity on the part of the fescue and a negative departure from linearity on behalf of the *Agrostis*. At the lower fertility level both species have always yielded linear curves neither species being affected by the presence of the other, i.e., the yield of a tiller is similar whether it is surrounded by plants of its own or the other species.

The reason for this difference in result at the two fertility levels is thought to lie in competition for light. At the higher fertility level the taller growing fescue, which is also very dense, intercepts most of the light, and the growth of *Agrostis* becomes suppressed through inadequate quantities of light reaching its leaves. The longer the interval between harvests the more severe this effect would be. The fact that a reduced yield of *Agrostis* appeared earlier than the corresponding increase in yield of fescue supports the idea that competition for light rather than nutrients is the operative factor. The competition is a spatial one and the species winning most (or best in this case) space, as a result gets more nutrients. At the lower fertility level, though the fescue is still taller than *Agrostis* its growth is less dense than at the higher fertility level and its shading effects are reduced. Sufficient light is reaching the leaves of *Agrostis* for adequate growth.

The Relation between Plant Growth and Altitude in the Hill Environment
(R. F. Hunter, Sheila A. Grant, J. King and A. D. McKay)

The first study in this field (R.F.H. and S.A.G.) began in 1962 and will be completed in December 1964. It involves altitude transects situated near Glensaugh and at Sourhope and has been described in previous reports (Third Triennial Report, p.57). It is doubtful if useful comment can be made on the 1964 data as they have not yet been analysed.

A second experiment (J. K., A. D. McK.) is now in progress at Sourhope, in which the environment is more completely characterised than was possible in the first study. This will be continued for another 2 years and it is still too early for any useful results to be available.

It is intended to continue to develop the field of work and a further experiment is being planned in which the main objective will be to separate the effects of the principal components of altitude.

Relation between Plant Growth and Soil Moisture and Nutrients in the Hill Environment (J. King, J. A. Rogers and I. A. Nicholson)

(i) Plant growth in relation to natural moisture regimes
(J. A. Rogers and J. King)

In order to study the relationships between soil moisture and nutrient status and plant growth and vegetation composition, 27 sites have been selected on the Gairs and Rigg at Sourhope, such that they lie along gradients of varying soil moisture and pH. It has been necessary to include a range of different pH levels as, in the field, it is not possible to separate the effects due solely to moisture and pH. It is thus hoped that it will be possible to obtain two-dimensional regressions of plant response on these factors. The first phase is to investigate the present vegetation in relation to the moisture environment, by means of vegetational analyses and weekly measurements of soil moisture parameters - the latter over a minimum period of 2 years. The second will be to replace the existing plant cover with selected species and to study their reactions to these gradients. This will, of course, be a follow-up of plant/water relation studies carried out under laboratory conditions.

(ii) Plant growth under controlled moisture regimes (J. A. Rogers)

The series of large-scale box experiments at Glensaugh was continued. In previous experiments, it was found that drying-out of the soil was too slow. Since the main vehicle for achieving this end is the root/shoot system, it was decided to plant rapidly growing species of large dimensions. Also more fertile soil than has hitherto been used was employed. Thus the layout included three species:- Barley, Oats and Italian Rye Grass grown under six different moisture regimes. These were (1) continuously high water-table; (2) water-table alternatively at the soil surface (for 4 hours) and below the bottom of the soil "profile" (for 44 hours) (i.e. soil maintained at or near field capacity); (3) soil moisture tension maintained at 5 - 10 cm. Hg; (4) at 25-30 cm.; (5) at 35-40 cm. and (6) at tensions (rising) greater than 50 cm. Hg. Treatments 3 - 6 were maintained at the required levels by watering whenever the tension exceeded the upper limits. The soil moisture tensions in all boxes were kept at the same level for the first 4 weeks, in order to allow a good germination and establishment. After this, the treatments were commenced. Regular measurements were made to investigate the effect of these moisture treatments on the performance and internal water balance of the plants. Parameters recorded included tiller numbers, height of plant, final dry-matter yield and relative turgidity (of leaf segments). An attempt has been made to determine the point (R/T) at which stomatal closure occurred under different treatments. Soil moisture tension and temperature were both recorded throughout the experiment. As the results from this experiment are still being analysed it would be premature to discuss them in detail at this stage, although it would appear that tillering in Italian Rye Grass and Barley is more sensitive to soil moisture than it is in Oats.

It is proposed to continue this work on a more critical level using apparatus in which the moisture tension of small volumes of soil can be more accurately controlled.

Two further lines of laboratory investigation are being pursued. Firstly, the immediate response to rapid changes in the (accurately controlled) soil moisture stress by different species. This work will also include studies on the morphological effects of moisture stress on early growth. Secondly, competition between pairs of species (especially indigenous/non-indigenous pairs) under varying soil moisture stress will be investigated.

(iii) Soil Moisture Survey (J. A. Rogers and I. A. Nicholson)

In order to ascertain the magnitude and temporal changes in soil-moisture tensions in the field, tensiometers were placed in a variety of vegetation - soil types. Weekly readings of the tensions were made throughout the growing season and vegetational analyses and soil profiles are being made at each station.

(iv) The response of hill grass species to lime, phosphate and nitrogen (J. King)

Two experiments were carried out using a total of eight species grown in soil treated factorially with three levels of lime (L), phosphate and N. The results may be summarised as follows:-

(1) The species can be arranged in three groups on the basis of their overall yield.

High yields: Agrostis tenuis, A. canina
Festuca rubra, Poa pratensis

Middle yields: F. ovina, Cynosurus cristatus

Low yields: Deschampsia flexuosa, Nardus stricta

(2) There were large species x L and species x N interactions, but in general the species yielding most at low N or L levels tended also to yield the most at high levels.

The yield of all species increased with increasing L and N but for Nardus the response was very small indeed.

(3) Six of the eight species were grown at three P levels but there were no significant differences in their responses. The overall response was small and occurred only at the highest level of N.

These results are consistent with yield data from spaced plants in the field and also with the apparent success of the species in natural communities. The very small response to P suggests that this nutrient is unlikely to have a direct influence on yields or on the floristic composition of hill swards.

(v) Micro-variations within grazed swards (J. King)

The distribution pattern of species within a community and the relation of this to the pattern of environmental variation can be used to provide information on the mechanism of changes in pasture composition and on the factors affecting this. A small experiment is being carried out to see if this approach can yield useful results when used to study the effects on the pasture of the interactions between grazing intensity and micro-environmental variation.

Two sites on old sown pastures have been examined so far. Each is about 10 x 7 m. in size and records have been made of the variation in species composition, herbage height, micro-topography, and soil depth. Soil chemical composition will also be examined.

Hydrology and Nutrient Balance of Peat Catchments (I. A. Nicholson)

This experiment was begun in 1958. It was designed as a long term study to provide information in three phases on:-

(a) The natural water balance of a relatively undisturbed peat bog.

(b) The effect of draining on the nature of the water balance.

(c) The balance of water and of nutrients under different forms of pastoral use and the nature of erosion loss.

The run-off from the 17-acre experimental catchment, as a percentage of rainfall, for the first three-year period up to 1961 is shown in the table below:-

	J	F	M	A	M	J	J	A	S	O	N	D
1959	92.7	63.4	72.0	37.6	17.9	2.5	31.1	10.3	1.0	39.8	79.9	79.6
1960	83.2	88.9	80.9	34.1	20.6	0.6	1.1	7.0	41.7	40.2	77.2	95.7
1961	87.2	77.5	35.5	79.4	16.5	1.5	17.2	66.9	38.4	67.9	80.8	101.1

A survey of the subsoil underlying the peat indicates a basin structure bearing a relatively impermeable glacial deposit with no evidence of a serious "leak" in the catchment area. The actual evaporation loss is not readily obtainable by direct measurement, but measurements of the potential loss using an artificially irrigated lysimeter have been made throughout the experiment. Meteorological data have also been collected to enable this value to be calculated. This involves considerable computational work which will be relieved by the offer of computer facilities by the Hydraulics Research Station.

It was considered in 1963 that adequate data on meteorological factors, run-off and water table fluctuations had been accumulated for a satisfactory hydrological characterisation of the peat bog. Preparations were therefore begun for the second and third* stages involving an increase in the drain frequency and establishment of a series of small independently metered catchments within the large one. Preparations are now practically completed and it is hoped to begin the pre-treatment characterisation of the small catchments in November.

The construction of this field layout has involved considerable effort and several difficulties in water flow measurement have had to be overcome. Fortunately the N.I.A.E. has taken an interest in this problem and has been of great assistance in developing suitable instrumentation.

In the second phase it is intended to characterise the small catchments simultaneously with studies on the effects of additional drainage on the water balance of the entire catchment area. Some of the necessary records have already been collected.

The recording and tabulation of data from field charts is an extremely time-consuming process and it is only recently that we have been in a position to begin the necessary analytical studies. Current activity is directed towards completing the calculation of water balances for each year of the experiment and analysing the short term responses of run-off to rain storms of different intensities in relation to varying antecedent conditions. The Hydrological Research Unit of D.S.I.R., which has recently established a group working on hydrograph analysis, has offered advice on analytical procedures and is continuing to take a close interest in the work.

* There is a valid criticism which can be directed at the final phase of the programme. This is the use of adjacent catchment areas for the study of different forms of land use which might be expected to have some effect on the hydrological conditions of their respective catchments. As the peat is approximately 17 feet deep, the complete hydrological isolation of these catchments is impracticable and all we have been able to do is to minimise interference amongst them by the prevention of surface water contamination by suitably disposed open drains. As we cannot control ground water, the experiment contains an uncontrolled element, though it is capable of measurement. Ground water studies are therefore also being made, including the use of tritium to determine the extent and rate of ground water movement.

It has been suggested that this experiment should be incorporated as part of the British contribution to the Hydrological Decade.

Moorland Management (Sheila A. Grant, R. F. Hunter, J. King and G. E. Davies)

- (i) Long-term burning rotation experiment (Molinia) (Sheila A. Grant, R. F. Hunter and G. E. Davies)

The long-term burning rotation experiment at Sourhope is being continued. Burning is carried out in replicated plots at 2, 4 and 6-year intervals.

- (ii) Survey of heather regeneration after burning (Sheila A. Grant, R. F. Hunter and J. King)

In this study 30 areas of regenerating heather are being visited annually, a wide range of community types occurring on a variety of soils being included. As well as carrying out the standard botanical analysis and taking records of heather heights a start was made this year in the collection of soil samples for chemical analysis. On the basis of data on the community type in existence prior to burning and the soil data an attempt will be made to classify the site types. The data on the vegetation return will then be looked at in the light of this classification when any trends towards differential effects of burning may become apparent.

- (iii) The Finella grazing-burning experiment (Sheila A. Grant and R. F. Hunter)

Six grazing regimes are being practised on heather of four different ages. The different ages of heather were obtained by burning a quarter of each grazing paddock at intervals of two years, the last quarter being burned in the spring of 1963. The grazing regimes involve light or heavy grazing in summer only, in winter only or throughout the year. Botanical analyses and measurements of heather heights are made each year. Previously it has been reported that differences in the regenerating vegetation due to the year of burning were apparent, though no effects of grazing regime could be detected. This year, for the first time, the effects of the different grazing regimes are beginning to appear. Increase in vegetation cover is slower on the more heavily grazed plots and the indications are that, of the species present on the plots, Calluna vulgaris is the most sensitive to the heavy grazing pressure.

- (iv) Effect of frequency and time of defoliation on the chemical composition of heather (Sheila A. Grant)

The effects of frequency and time of defoliation on the heather plant are being studied in a box experiment sited at the Scottish Plant Breeding Station, Edinburgh. The effects on morphology and yield have been reported previously. Differences in the texture and colouring of the leaves of the heather plants undergoing different cutting treatments were apparent and this led to samples of leaf material being sent for chemical analysis. The first samples were collected in December 1962. The results of this analysis showed significant differences in silica-free ash, P, Mg, and N contents. There were no differences in Ca and total ash. It was not known whether these differences reflected a real difference in chemical composition of the leaves or merely differences in the rate of frost hardening associated with the various cutting regimes, the chemical composition of heather leaves being known to fluctuate seasonally. In December 1963 and April, July and October 1964 further samples of the current season's leaves were collected and sent for chemical analysis. Results are available for all except the last sampling date and confirm that there is a real difference in chemical composition associated with frequency of defoliation. The largest difference is in N which varies from 1.63% in the most frequently cut plants to 1.02% in the uncut controls (July figures).

Smaller but significant differences are present in P, K, Mg and silica-free ash. These differences in chemical composition are thought to be associated with the effects of defoliation on the process of ageing of the plant. The ratio of leaf (assimilating tissue) to stem (non-assimilating tissue) in woody perennials changes with age. Cutting or pruning maintains the ratio at a level characteristic of more juvenile stages of growth.
