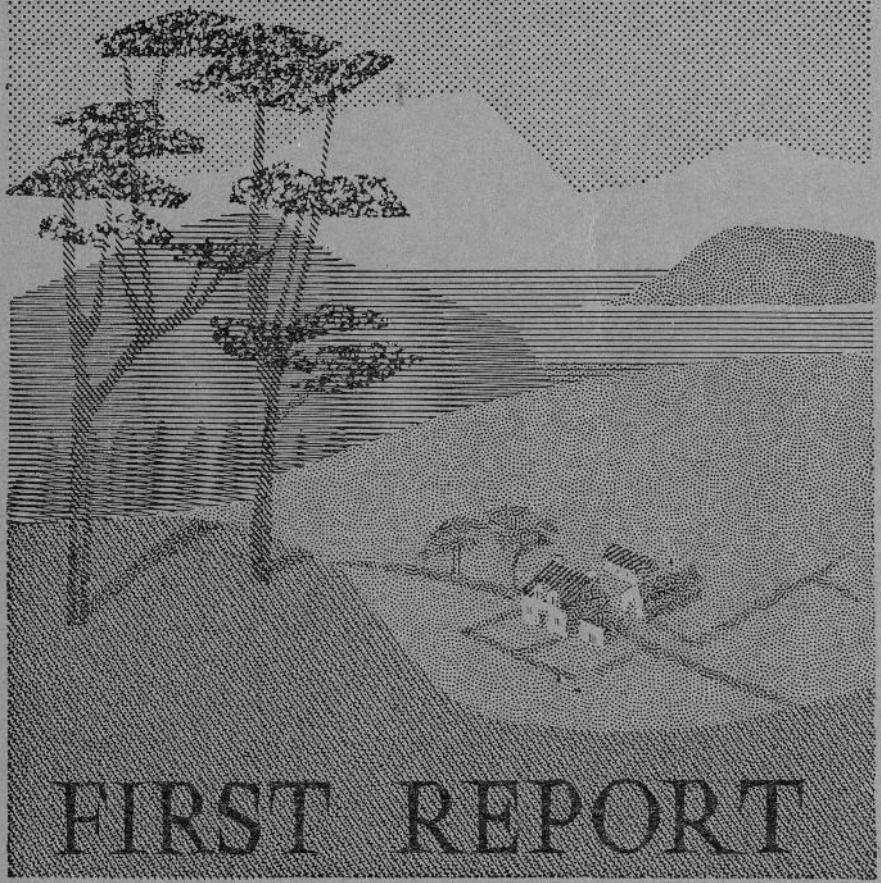
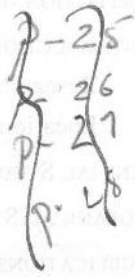
HILL FARMING RESEARCH ORGANISATION



FIRST REPORT

RFH

HILL FARMING RESEARCH ORGANISATION



FIRST REPORT

1954-58

48 PALMERSTON PLACE, EDINBURGH, 12

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DEFINITION OF TERMS

In this and all other publications of the Hill Farming Research Organisation the following terms, which are used locally, have the meanings indicated below—

Eild Ewe	Ewe which has not produced a lamb that season.
Gimmer	Female sheep from $1\frac{1}{2}$ to $2\frac{1}{2}$ years. Most hill ewes are mated and lamb for the first time as gimmers.
Heft	A group of sheep which habitually graze within the confines of a particular area of hill ground, and also the area of ground itself. Each heft of ewes is self-replenishing.
Hirsel	An area of hill with natural boundaries, which is shepherded by one man. A hirsel may contain several hefts.
Hogg	Sheep from 6 months to $1\frac{1}{2}$ years.
Mossing	An area on which *Eriophorum vaginatum* (drawmoss or cotton grass) occurs, providing valuable late winter and early spring food.
Muirburn	The practice of burning in winter or early spring, heather or the accumulated dead growth of *Molinia caerulea*, *Nardus stricta* and *Deschampsia caespitosa*.
Raking	The movement of a heft of ewes so that they graze the lower ground during the day and move to higher ground in the late afternoon and evening. Raking is partly instinctive, but is also induced by skilled shepherding.

INTRODUCTION

THE HILL FARMING RESEARCH ORGANISATION came into being as an independent grant-aided research institute on 1st April 1954, following the decision in 1953 of the Secretary of State for Scotland, in consultation with the Minister of Agriculture and Fisheries and the Agricultural Research Council, to create a body for the specific purpose of promoting research into hill farming problems. This step marked a further organisational stage in a development that gathered impetus subsequent to the second world war. The investigation of the problems of production from hill and upland farms is not, of course, new, having been pursued by many people since the start of this century and even earlier. But apart from the work of the Animal Diseases Research Association and other workers in the field of animal health, there had only been sporadic investigations and no systematic approach to the technical problems involved. Accordingly, when the Balfour of Burleigh Committee reported in 1944 on hill sheep farming in Scotland, it recommended an expansion of research on a large scale, with the creation of a Hill Farming Research Station. In England and Wales, the De la Warr Committee, which had undertaken a corresponding investigation, expressed similar views.

Subsequently, the Agricultural Improvement Council for Scotland was asked to consider these recommendations and appointed a Committee to suggest how they should be implemented. Its considered opinion was that there should be three experimental hill farms in Scotland, one in the area of each of the Colleges of Agriculture, and that a Hill Farm Research Committee be appointed to consider a national research programme and arrange for the delineation of work appropriate to each farm. The Colleges would be responsible for day to day management of the farms, which would also provide facilities for visiting workers from Research Institutes, Colleges and Universities.

These recommendations were gradually put into effect. A Hill Farm Research Committee was appointed in 1945. Already the North of Scotland College of Agriculture had obtained, in 1943, the farm of Glensaugh in Kincardineshire and this became the first experimental hill farm. In 1946 the East of Scotland College of Agriculture secured a lease of Sourhope in the Cheviot Hills, and in 1949 the West of Scotland Agricultural College entered into occupation of Lephinmore on Loch Fyne in Argyll. Thus the chain of stations recommended in 1944 became complete.

The first Hill Farm Research Committee completed its term of office and in 1949 issued a report entitled 'Hill Farm Research'. It was succeeded by a second Committee, which in 1952 issued 'Hill Farm Research—Second Report'. A major recommendation of this second Committee was that the time had arrived for a further development by the setting up of a central organisation to control the three research farms in Scotland and by the appointment to it of scientific staff devoting their whole time to hill farming problems. On the acceptance of this proposal by the Secretary of State for Scotland, the Hill Farming Research Organisation was established and the three research farms of Glensaugh, Lephinmore and Sourhope transferred to it on its inception. The Organisation is required 'to promote and implement a co-ordinated programme of work subject to the scientific oversight of the Agricultural Research Council on the problems arising from hill farming which require further research'.

The control of the Organisation rests with a Board of Management, appointed by the Secretary of State for Scotland, of scientists, agriculturalists and hill farmers in Scotland, England and Wales. For the first three years the Organisation was fortunate to have Professor R. G. White as Chairman of the Board. Professor White was Chairman of the second Hill Farm Research Committee, and a member of its predecessor. Moreover, he has been an outstanding authority on all aspects of sheep farming for nearly half a century, and his extensive knowledge and experience were of particular benefit in guiding the Organisation in its early days. Amongst the other members of the Board for its initial period were the late Professor T. J. Mackie and Dr J. Russell Greig. Both had long been concerned with research into animal health, were members of the Balfour of Burleigh Committee and of each of the Hill Farm Research Committees, and played a valuable part in formulating research programmes.

RESEARCH STATIONS

At the inception of the Organisation it was agreed that for an institute whose activities would cover hill farming throughout Great Britain it was appropriate to establish a headquarters in Edinburgh, comprising the necessary administrative offices with such laboratory facilities as would be necessary as a complement to actual research efforts in the field. From the beginning the primary function of the Organisation has been visualised as being field research with both animals and plants. Though plant research may prove feasible

on many farms where suitable facilities are available by arrangement with the farmers concerned, it is essential for animal research involving frequent sheep handlings to be carried out on farms under the complete control of the experimenter. The three hill research farms are therefore of prime importance to the scheme of research, and though they themselves are inadequate for investigating the multiplicity of subjects which demand attention, they have so far enabled a reasonable programme to be developed. Because of the variation in the terrain and environmental conditions, hill research does not permit the replication of experimental treatments that are possible with animals on uniform pasture land. Similarly, small areas are unsuitable for animal treatments since, if the results are to be valuable, hill sheep must follow normal grazing habits and movements up and down the hill. Thus, large numbers of sheep are necessary for an experiment and any one farm can only undertake a limited number of simultaneous trials.

The three research stations are:

Glensaugh, Fettercairn, Kincardineshire

Glensaugh is situated at the eastern end of the Grampians, immediately east of the Cairn o' Mount road between Fettercairn and Banchory. It consists of some 180 acres arable land worked in rotation, about 40 acres of unploughable grass, 80 acres pasture reseeded from the hill and nearly 2100 acres of rough hill grazings ranging in elevation from 450 to 1500 feet.

The hill ground is in two areas, one on each side of the South Highland Border Fault, and separated by the arable land. To the north-west lies the main hill of over 1500 acres overlying metamorphic rocks of the Dalradian series, while to the south-east there are some 500 acres of the Strathfinella Hill, which overlie Old Red Sandstone. These two hills are distinct geologically, in aspect and in grazing quality. The main hill vegetation consists of heather communities customarily found in lower rainfall areas, with some peat on the highest ground. Strathfinella only rises to 1100 feet, and though dominantly heather on the higher parts is drier and has more hill grasses on its lower slopes.

The regular sheep stock consists of 500 Blackface ewes with 160 ewe hoggs. This includes about 40 ewes and hoggs of each of the Lanark, Lewis and Newton Stewart types of Blackface. In addition there are about 40 Herdwick ewes and hoggs being maintained in connection with dentition studies.

The flock is in general managed in the manner prevalent in the

north-east counties of Aberdeen, Banff, Kincardine and Angus. In summer it has full range of the hill and is not hefted, and in winter it is only fed supplementary hay in periods of storm up to mid-February. Thereafter it is customary for the flock to be brought from the hill each morning to eat turnips and to return to the hill at mid-day. This applies to two-thirds of the Glensaugh flock, the remainder being fed alternative supplements. Another departure from normal practice is controlled tupping in the inbye fields in order that full breeding records can be maintained. Lambing also takes place in the inbye fields, the lambs going to the hill when from 7-10 days old.

Ewe hogg wintering has been the subject of experimental work at Glensaugh since 1944. As a result of a comparison of away wintering with home wintering on reseeded ground at the foot of the hill, it was concluded that under the circumstances prevailing at Glensaugh home wintering was satisfactory and more economical. In only one of the last four winters have any ewe hoggs been wintered away, but these gave in their first two lamb crops a significantly greater return in weight of lamb weaned per ewe. This may have been fortuitous, and it has not been possible to repeat away wintering. At present all ewe hoggs are home wintered.

An outwintering herd of 70 beef cows is maintained and over the last twelve years has permitted comparisons between cows of the Galloway and Highland breeds when mated to Shorthorn bulls and of Shorthorn × Galloway (Blue-Grey) and Shorthorn × Highland cows when mated to an Aberdeen-Angus bull. In respect of live weight at weaning, and when sold at eighteen months, there has been virtually no difference between calves of the two first crosses and between those of the two second crosses when reared under identical conditions. On the other hand, the Galloway cows have shown rather greater prolificacy than the Highland cows. Thus, since 1949, 146 matings of Galloway cows produced 78·1% calves born and 75·4% weaned, whereas 186 matings of Highland cows produced 66·7% calves born and 63·0% weaned. In the first cross cows, 143 matings of Blue-Grey cows gave 90·9% and 86·0% calves born and weaned, and 188 matings of Shorthorn × Highland cows gave 89·4% and 85·2% respectively.

Normally the breeding cows graze the outlying pastures and reseeded areas during summer, but in the summers of 1955, 1956 and 1957 the pure Galloway and Highland cows were on the main hill. Though in these three years the calves did not look so well as those of previous years when these cows grazed reseeded pastures, the weaning weights were almost as good and calving percentages

were normal. On the other hand the cows were too thin in the autumn, though this may have been partially due to advancing age. The Glensaugh hill has too much heather and too little grass to be a good hill for cows in summer and the best results are obtained if it is only used for cattle for short spells depending on the weather.

Lephinmore, Strathlachlan, Argyll

Lephinmore is situated on the east side of Loch Fyne in the Cowal peninsula. It consists of 33 acres arable, some 30 acres of enclosed pasture unsuitable for cultivation, and almost 4000 acres of rough grazing (1200 now planted) rising from sea-level to 1540 feet.

The farm is part of an estate which had been acquired for afforestation and on which a planting programme had been agreed before it became available for research. Originally the programme involved planting almost 1500 acres in three blocks rising to about 800 feet and leaving two downfalls for some winter grazing and for access. Two of the blocks were fenced off in 1950 and 1951 and almost 1200 acres were then planted. The Forestry Commission agreed to defer planting the third block for ten years. Thus there are available records of sheep performance on a hirsel at the south end of the farm on which all the low ground has been planted and on a hirsel at the north end which remains more or less as formerly. It is still too early to comment on the effects of afforestation, but it can be said that it is unfortunate that all the original scrub of oak and birch on the lower slopes was allocated to the forestry area. If a small portion of this had been retained near the arable land it would have provided valuable shelter into which the outwintering beef cows could have had access. As it is they have no such shelter and feeding costs in winter are correspondingly higher. Rainfall at Lephinmore averages 70 inches per annum, and high winds are common.

The hill ground of Lephinmore is varied. Most of the area remaining for sheep is covered with peat, and has a mixed herbage including heather, molinia, scirpus, juncus, and hill grasses. Heather comprises probably 50% of the plants. Though there are areas of deep peat, in others the underlying rocks of the Dalradian series outcrop. In recent years the hill has been improved for sheep by attention to drainage and to heather burning. Ticks are abundant and high counts for sheep are obtained at the periods of peak infestation. The arable ground has been managed since 1951 on a system of intensive grass production for making hay and silage and

for autumn and spring grazing. By systematic liming, manuring and reseeding it has been restored from its dirty and impoverished state in 1946 to one of high productivity whereby its production is now equivalent to carrying one mature cow per $1\frac{1}{3}$ acres per annum.

Before afforestation began, the Blackface sheep stock comprised 950 ewes and 290 ewe hoggs, but these have been progressively reduced to 560 ewes and 160 ewe hoggs. Further reductions will be necessary when the planting programme is completed. The original five hirsels have been reduced to three, of which one will ultimately have under 100 ewes. It is normal for the flock to stay continuously and to lamb on the hill, and winter feeding is not resorted to, even in storm, except for experimental work. The ewe hoggs are wintered away, usually in Bute.

An outwintering herd of 30 Highland cows has been built up by home breeding, but these are now being crossed with a Shorthorn bull. In the early stages of its development, the beef herd was used for 'complementary' grazing of the arable ground. For six weeks in spring before going completely to the hill for the summer, and again for six weeks in late autumn and early winter before the feeding of hay and silage began, the cows were brought from the hill each day to spend from a half to an hour grazing special swards on the arable ground. The latter were young leys of either ryegrass or cocksfoot plus clover and not more than three years old. They were specially prepared for grazing by resting periods and by seasonal nitrogenous manuring. Though it proved possible to produce the grass required, the cows did not respond either in condition or in satisfactory calf crops, the latter being particularly disappointing, and in due course the experiment was discontinued as a 'complementary' grazing trial. Had the arable fields been contiguous to the hill, results might have been otherwise, but in practice it was necessary to bring and return the cows through three gates from the hill to the grazing, and with the horns which Highland cattle possess, the aggressive cows inflicted punishment on the others. Older Highland cows have exceptionally strong horns and the veterinary surgeon was reluctant to dehorn them (all young animals are dehorned). When the herd is entirely dehorned it may be possible to resume the trial but, in the light of past experience, high protein grass used as complementary feed in spring needs supplementation by a starchy food if a satisfactory calf drop is to be secured from outwintering cows.

Sourhope, Yetholm, Roxburghshire

This farm lies fifteen miles south of Kelso, at the head of the Bowmont Water, and on the western slopes of the Cheviot Hill. Including the small farm of Auchope, which is part of the station, there are 70 acres of arable land and some 2750 acres of hill, rising from 600 feet to just under 2000 feet.

The underlying rocks are mainly andesitic lavas and tuffs, carrying a hill vegetation which is mainly grass, principally agrostis fescue, with some nardus and molinia. Heather is confined to very small areas on the highest land, and drawmoss occurs at only one spot. Bracken appears on some of the lower slopes but it is neither dense nor as extensive as on other farms in the Cheviot hills. Though there is some tick infestation it is relatively slight.

Sourhope is the Organisation's research station for work with Cheviot sheep, of which there are 950 ewes with 240 ewe hoggs. On the highest hirsel of the farm there are 330 Blackface ewes with 85 ewe hoggs. All the sheep are kept continuously on the hil, to which they are hefted, including both tupping and lambing. The ewe hoggs are also wintered on the hill on their own hirsels and are 'breeked' at tupping time. The hill is well fenced and the sheep hefted in the Border system. In all there are five hirsels, all but one being suitable for subdivision without interfering with normal sheep movement. Thus, of the three research stations, Sourhope permits the greatest number of comparative tests. Cheviots of the three types—Hawick type South Country, Lockerbie type South Country and North Country—are kept, there being 460, 360 and 130 ewes respectively.

An outwintering herd of nearly 60 beef cows is maintained, of which half are Galloway and half Blue-Greys. The latter are mated to an Aberdeen-Angus bull and it is hoped by using Galloway and White Shorthorn bulls alternately on the Galloway cows to make the herd fully self-replenishing. Most of the herd is concerned in a trial comparing mixed cattle and sheep grazing with sheep grazing alone. This began in 1951 and has shown quite conclusively that on the better grassy hills of the Cheviots cattle are highly beneficial in controlling the herbage to the advantage of the sheep. Supplementary hay feeding is necessary for the cows in winter, and to prevent the ewes on the mixed grazing heft from benefiting from this the cattle are removed for the winter. In view of this, the summer stocking of cattle (normally May to November) has been at the high rate of 26 cows plus suckling calves to 130 ewes plus hoggs and lambs, on a heft of about 250 acres. The sheep only heft has a

similar number of ewes on a comparable area. As a result of this treatment the mixed grazing areas has produced more and better lambs than the sheep only area and in addition almost 100% calf crop each year, the calves weaning at about 480 lb.

Meteorological Data

As will be seen in the records given below for the past five years there are not wide differences in the hours of sunshine at the research farms, but there are marked rainfall differences between Lephinmore in the west of the country and Glensaugh and Sourhope in the east. The records are given for flock management years, that is November to October inclusive, and are available since 1952.

	Rainfall (inches)			Sunshine (hours)		
	Glensaugh	Lephin-more	Sourhope	Glensaugh	Lephin-more	Sourhope
1952-53	32·1	57·5	44·3	1204	1169	1478
1953-54	42·5	86·7	39·9	1162	1164	1221
1954-55	27·8	67·2	26·9	1558	1542	1674
1955-56	43·6	59·8	37·0	1373	1321	1406
1956-57	42·3	75·8	32·8	1271	1301	1328

In addition to the annual variations in rainfall between the stations, the variation in seasonal incidence is also of interest. To illustrate this the rainfall is tabulated below for the four seasons:—

November to January—mating of the flock and early pregnancy.
February to April —late pregnancy and the greater part of lambing.
May to July —lactation and early lamb growth.
August to October —weaning, lamb sales and drafting of ewes.

Average Seasonal Rainfall (inches)
November 1952-October 1957

	Nov.-Jan.	Feb.-Apr.	May-July	Aug.-Oct.
Glensaugh	11·5	7·3	8·9	10·6
Lephinmore	24·4	11·8	11·2	20·3
Sourhope	9·3	5·3	9·2	12·2

At all farms the driest months during these five years have been March and April, while at both Glensaugh and Lephinmore the wettest month has been December. On the other hand the wettest month at Sourhope has been August, with 18% of the recorded rainfall for the five years. In this area August frequently experiences severe storms and flooding due to very heavy precipitation over short periods, on one occasion almost five inches falling in one day.

In the two years following the Organisation's assumption of responsibility for the three stations there were two contrasting

seasons. First came the abnormally wet season of 1954, during the summer and autumn of which rain fell almost every day for some months, retarding lamb growth and making the harvesting of hay, silage and cereals almost impossible. This was followed in 1955 by a very dry summer which had a most beneficial effect on sheep stocks, enabling them to recover from the moderately wet summers of 1952 and 1953 and the excessively wet one of 1954, as well as from snow storms in the first three months of both 1954 and 1955.

Equally contrasting have been the two most recent winters. That of 1956-57 was unusually mild at all three stations, and ewes came through the winter to lambing in very good condition, producing lambs above normal birth weights. In contrast the winter of 1957-58 was severe, being characterised in late winter and spring by cold east winds, which prevented growth, lowered the condition of the ewes and caused losses of lambs at birth due to lack of vigour in the lamb and lack of milk in the ewe. Glensaugh experienced the worst snowfalls, having almost a weekly snowstorm from mid-February to the beginning of April.

While snowstorms can be severe at both Glensaugh and Sourhope and may leave the whole hill covered with snow so that the ewes cannot fend for themselves, this does not happen at Lephinmore, where snowfalls are lighter and less frequent and the snow seldom covers the ground uniformly or persists more than one or two days.

RESEARCH PROGRAMME

Subsequent to its establishment in 1953 the Organisation had to recruit a research staff and formulate a programme of research appropriate to the facilities and resources available. Inevitably therefore, this report cannot record the result of research that is essentially long term in character. The following pages attempt to outline some of the work that has been initiated and to indicate the progress that has been made.


SITUATION
OF
RESEARCH STATIONS
SCOTLAND
ABERDEEN
GLENSAUGH
LEPHINMORE
EDINBURGH
GLASGOW
SOURHOPE
CARLISLE
NORTHERN
IRELAND
EIRE
ENGLAND
WALES
LONDON
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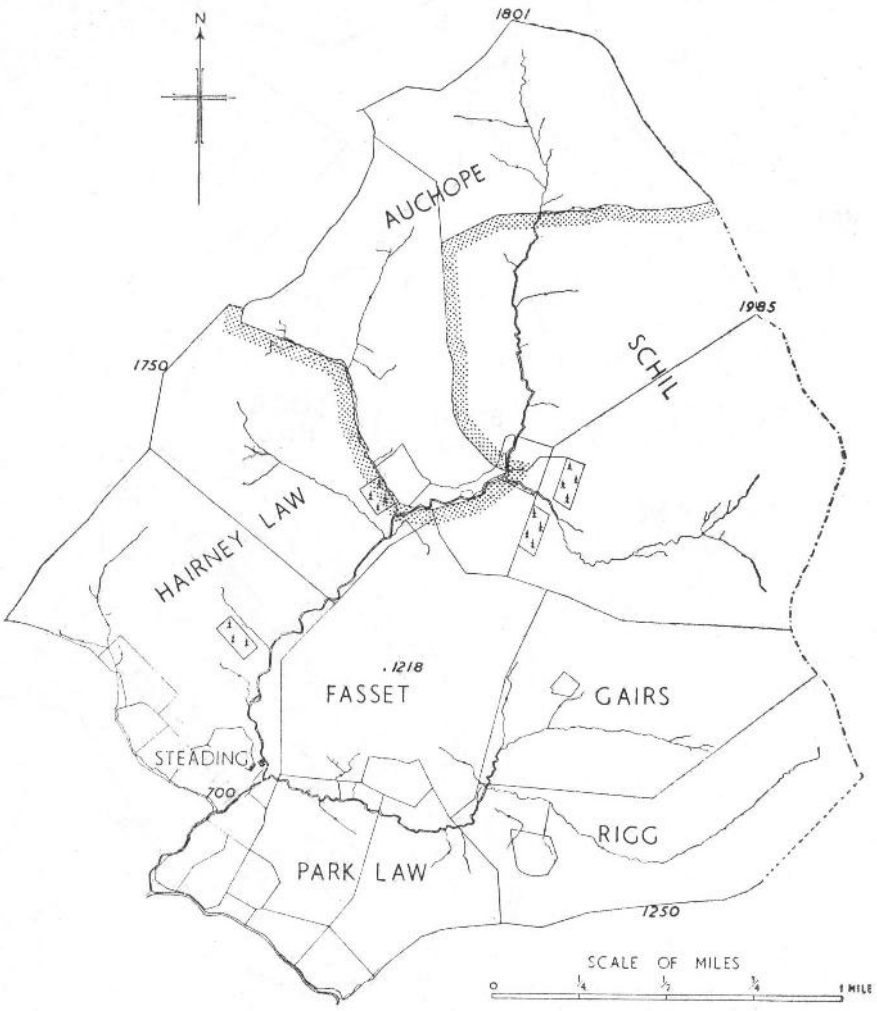
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AUCHOPE
1985
SCHIL
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HAIRNEY LAW
1218
FASSET
GAIRS
STEADING
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RIGG
PARK LAW
1250
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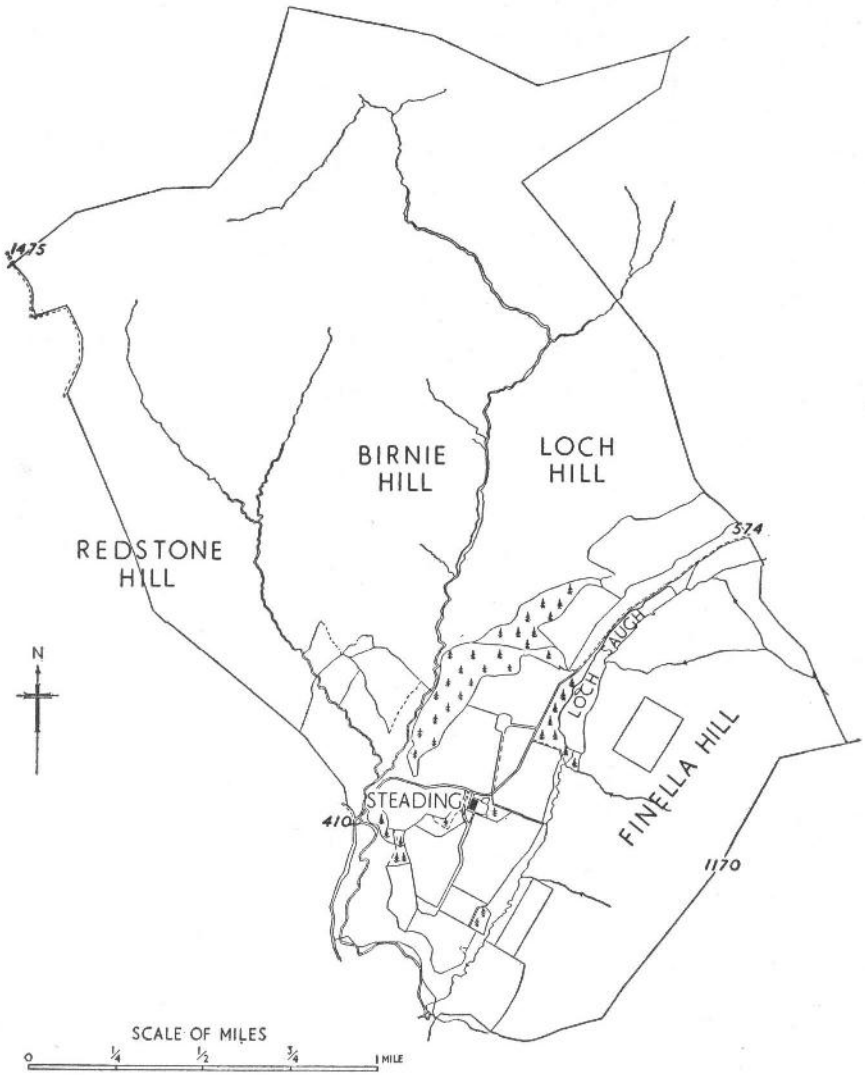
SOURHOPE

B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BIRNIE HILL
LOCH HILL
REDSTONE HILL
374
LOCH LAUGH
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STEADING
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FINELLA HILL
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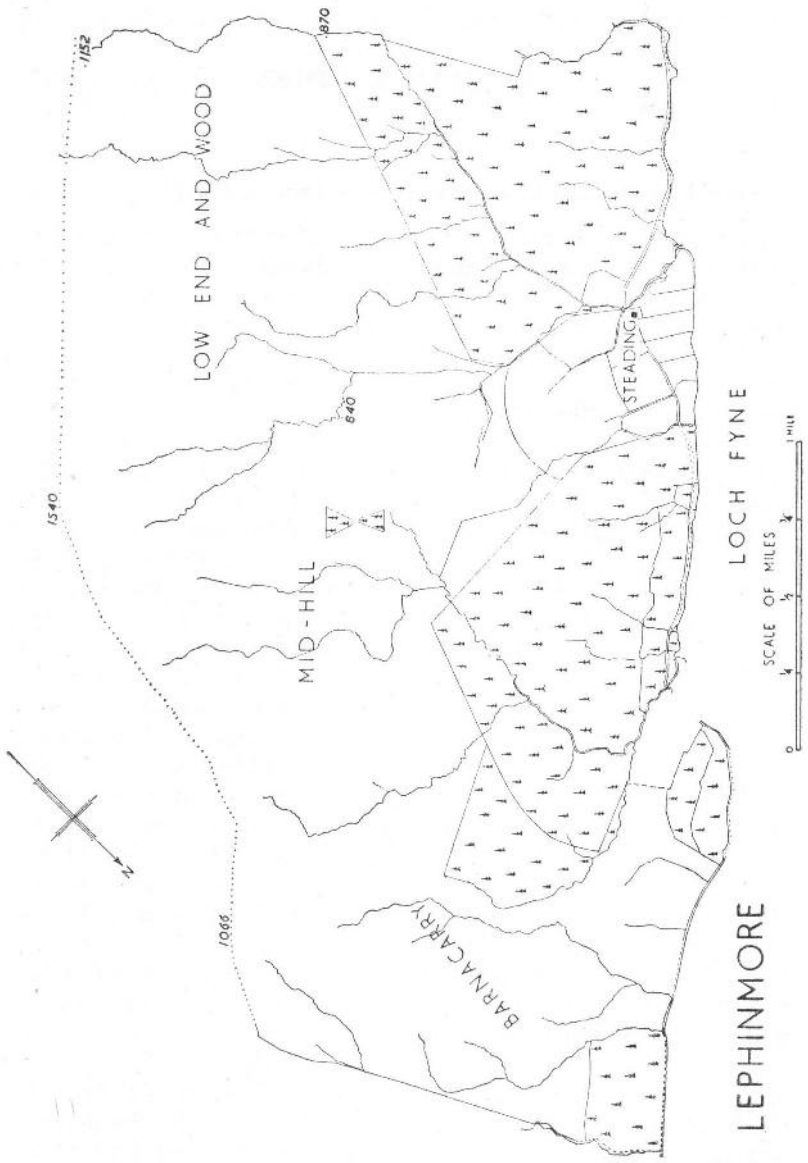
GLENSAUGH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MID-HILL
BARNACARRY
STEADING
LOCH FYNE
LEPHINMORE
SCALE OF MILES
1 MILE
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1540
1065
840
870
1152

ANIMAL STUDIES

BREEDING

Comparison of Scots Blackface and Cheviot Breed Types

1. *Introduction.* The hill sheep industry of Scotland is based almost entirely on the Blackface and Cheviot breeds. Both breeds have sub-types and it is pertinent to compare these in common enviroments. This is being done on the Organisation's farms by means of studies of the performance and adaptability characteristics of the different types and their role, through selective breeding, in the matching of the 'sheep' to the 'ground'.

Like other British breeds, the Blackface and the Cheviot have been improved along multi-purpose lines, and in consequence their evolution into different sub-types is marked by variations in such characteristics as breed-type, size, conformation, earliness of maturity and the like. Neither, for example, is so highly specialised as the Australian Merino which is adapted to a wide range of environments and requirements, principally by differentiation in the type of fleece. In both countries, however, the breeding policies and the responses achieved are governed by the environment or what is popularly termed the type of ground. Indeed, the interaction between genetic and environmental influences is so profound that it may be impossible to assess the extent to which breeding policy is being aided or defeated by the processes of natural selection, through the survival of the fittest. This problem has a special significance in hill sheep breeding because of the tendency for purchased rams to be bred in more favourable environments than those in which they are used. Thus, some light on the complexities of 'breed' and 'ground' effects should be forthcoming from the following comparisons which will serve also as a basis for the investigation of adaptability traits (or the components of hardiness) and their potentiality for genetic improvement.

2. *Scots Blackface.* A comparison of the Lanark, Newton Stewart and Lewis types of Blackface (about 30 ewes of each) with the home-bred flock, which is of the East Central Scotland type, was started at Glensaugh by the North of Scotland College of Agriculture in 1951. This trial is yielding useful information, but with the small numbers, the results are indicative rather than critical. The Glensaugh hill, being exposed and predominantly

of heather, supports a rather small type of ewe, as in the 'home-breds'. Contrary to expectations, the Lanarks have maintained their superiority in skeletal size and this may be linked with their slightly heavier losses, and the difficulty in maintaining their numbers. Though the differences in fertility are not very marked, the greater thriftiness of the Newton Stewart and Lewis types is reflected in their increased body-weights since their introduction to Glensaugh. Though of superior butchers' conformation, the Lanark wether lambs fail to fatten as readily as the Newton Stewarts or Lewis. Carcase examinations show that the thriftiness of the latter types is associated in some way with the heavier deposition of kidney-fat. Though detrimental to carcase quality, an excess of kidney-fat is characteristic of the unimproved mountain type, and such a trait in the ewes may be associated with adaptability to an adverse environment.

To some extent, the performance of these Blackface strains at Glensaugh demonstrates that there can be some compatability between on the one hand, improvement for conformation and earliness of maturity, fleece-weight and fertility, and on the other the ability to survive on hill ground. Thus, it may be an advantage that these trials are conducted under reasonably severe conditions which will help to expose the vulnerable points in the life cycle, should there be any breakdown in hardiness. Critical investigation, however, is rendered difficult by the complexity of factors and the lack of precise definition of simple concepts, such as 'earliness of maturity'. For example, the Blackface and the Cheviot equally, being short in the leg bones and compact of build, might be considered as early maturing. From the butchers' standpoint, 'condition' is also necessary. Thus, the superiority of the Blackface for raising the fittest weaned lamb is presumably a reflection both of its inherent conformation and the excellent milking qualities in the ewes.

As in other farm animals the greatest potential for growth in lambs occurs early in life, being partly coincident with the suckling period. Logically, therefore, if this early skeletal growth is substantially completed during the first summer—in the first 4 to 6 months of life—it may be that the suggested antagonism between earliness of maturity and hardiness is less real than is commonly supposed. In fact the converse might apply, namely that the thicker leg bones providing the necessary support for thicker muscles might improve these tissues as reservoirs of minerals and food reserves against the privation of winter.

At present, very little is known of the adaptability significance of

the different body forms to suit varying hill environments. Accordingly, the trial started at Glensaugh has been extended in modified form to Lephinmore and Sourhope in order to study the responses under conditions which differ from Glensaugh in respect of soil, herbage and rainfall.

3. *Scots (Blackface Strain Comparisons and Top-crossing Experiments.* The smaller lamb crops and heavier mortality associated with the poorer grazings and the higher rainfall of the west of Scotland are confirmed in Appendices VIII and IX of the Balfour of Burleigh Committee's Report 1944. Thus, the average lamb crops of 65-70% on Lephinmore and 90-100% on Sourhope are fairly representative of their areas. On these farms it was desired to avoid the complications that arise from the introduction of purchased ewes, and the slower method of up-grading by top-crossing with rams of the desired types was adopted. This method also had the advantage of providing useful ancillary information on the effects of hybrid vigour (heterosis) in raising productivity in the earlier generations of top-crossing.

At Lephinmore the experiment started in 1955 with the Mid-hill hirsel of about 200 home-bred Lanark type ewes. Of these, one group of 60 ewes are maintained as pure Lanark, two other groups of 60 ewes are top-crossed with Newton Stewart and Swaledale rams respectively and a fourth group of 30 ewes with a Lewis ram. These sub-flocks run together on the hill and are separated only for mating.

The investigation of as many as four breed types entails a limitation in the numbers of ewes assigned to each. Of the Organisation's farms, Lephinmore is in many respects the toughest environment and it was felt that a study of this variety of types would enhance the value of the investigation. The compatibility of the various characters of economic importance, and of the traits contributing to hardiness and survival, will be interpreted from the fully recorded performance of the respective types. It is expected that some interest will centre on the characters associated with the contrasting types of fleece. The variation in the weather and exposure on Scottish hills naturally results in conflicting opinions as to the most desirable type of fleece. The controversy is complicated by the dual function of the fleece in combining protection from the cold with waterproofing qualities. Moreover, the later age of drafting in Scotland ($5\frac{1}{2}$ and $6\frac{1}{2}$ years old) demands a moderately heavy fleece to safeguard against excessive bareness with increasing age.

On Sourhope the Schil hirsel of about 320 Lanark type Blackface ewes is involved in a comparison but, here, circumstances permit

of the comparison of only two types, the Lanark and Newton Stewart. The policy is to maintain half the flock as pure Lanarks and to use only Newton Stewart rams on the other half so that by continuous top-crossing this half is graded, in time, to the Newton Stewart. Thus, greater numbers are available at Sourhope for the investigation of the Blackface types native to the south of Scotland. Although there is much controversy as to their respective merits, many flockmasters do, in fact, regard them as complementary to each other. In the east of Scotland, as in areas of the east of England, the sheep are characterised by heavier fleeces than in the west, possibly as a protection against lower winter temperatures, and the comparison at Sourhope will permit observations on how the lighter coated Newton Stewarts will perform alongside the heavier coated Lanarks.

At both Sourhope and Lephinmore, the performance of the first and second generation crosses in these strain trials will give some measure of the effect of hybrid vigour on the viability of new born lambs. Indeed, any beneficial effects of crossing may be sustained throughout life, and thus add to the vigour and productivity of the sheep generally, so that these preliminary investigations may indicate whether heterosis is worthy of more critical study, notably from the standpoint of poor or problem grazings. In such situations there may be possibilities in the deployment of two or three breeds or types in a system of reciprocal or cyclical crossing in order to perpetuate the state of hybrid vigour, if it occurs.

4. *North and South Country Cheviots.* A comparison of the North and South Country (Border) Cheviots was started on the Hairney Law hirsel at Sourhope in 1952, with about 130 ewes plus hoggs of each breed.

The derivation of the North and South Country Cheviots from a common stock and evolved by the same race of flockmasters, though operating in geographic isolation, is of considerable historic and scientific interest. The greater size of the North Country Cheviot is, no doubt, partly a reflection of the lighter intensity of stocking in Sutherland and Caithness (1 sheep to 5-10 acres) and of the conscious selection for a larger framed animal. There has been a tendency in the south of Scotland for the North Country Cheviot to supplant the Half-bred on upland and semi-arable farms, and the South Country Cheviot on some low lying, kindlier hills. At Sourhope, therefore, the experiment has necessitated the introduction of North Country Cheviots to much harder hill ground than that to which they have usually been introduced in the south of Scotland. None of the original importation now remains, and though the North

Country sheep bred on Sourhope have suffered some reduction in size they remain the larger breed and will supply useful information on the merits of size in sheep and of its limitation by ground effects.

Unfortunately, this trial comparison is handicapped by the inclination of the two Cheviot types to graze in separate mobs. These habits have aroused much interest and are being systematically observed. The performance of the two breeds, therefore, will have to be assessed in the light of their distinctive grazing patterns.

As far as breeding policy is concerned, many of the larger Cheviot flocks are slightly line-bred, the practice of mating a specially selected purchased ram with picked ewes shed from the flock and the use of his sons cart-wheel fashion over different hefts being regular features both of Sutherland and Border sheep-farming. Flockmasters, therefore, must derive satisfaction from the success of their system in stamping the type and performance of two of our most characteristic and important breeds of sheep. Despite these achievements, however, there is still scope for improvement and the question arises as to which characters should be taken as the basis for genetic selection.

There is general unanimity of opinion that improvement for milk yield should receive priority, and a genetic selection experiment in collaboration with the Animal Breeding Research Organisation, taking lamb-growth at the 6-8 week stage as the criterion for selection, was started at Sourhope in 1954. This is being conducted with the Auchope hirsel of 200 South Country Cheviot ewes forming two closed sub-flocks which are run together, except at mating when one flock is bred to randomly selected rams and the other to rams selected for the excellence of their marking weights in June.

These two experiments, with the survey of breeding methods in South Country Cheviots by Mr J. N. Peart which occurs later in this report, provide some background information for the planning of future research on techniques of selection. Superficially at least, improvement for earliness of maturity on the conventional lines of body conformation and fleshing qualities offers another possibility. Such an approach, however, must be made with caution lest it should undermine the adaptability characteristics of the breed. For example, some element of lateness of maturity may be linked with the tendency for the Cheviot to lay down a little more subcutaneous fat and a little less internal fat than the Blackface, thus making it more suitable for the extreme of its environment—an excess of keep in summer as on the Cheviot hill generally, and fairly severe privation in winter, especially in the event of a late spring.

NUTRITION

Supplementary Feeding of Ewes in Winter

1. *Introduction.* Arising from the recommendations of the second Hill Farm Research Committee, the main theme of sheep research that has been developed is centred on the nutrition of hill ewes. In their report the problem was briefly expressed thus—'The hill sheep occupies a unique position among farm livestock in that it is required to survive during winter on a level of nutrition which is frequently insufficient to maintain body-weight, whilst its annual pregnancies coincide with this very period of semi-starvation'.

Trials on a field scale, involving supplementary feeding of concentrate cubes during pregnancy, were started on all three farms in winter 1955-46. The feed was intended as a routine supplement of readily digestible nutrients at a critical period at the end of pregnancy and was given from late February to the time of lambing in April. Some groups of ewes receive cubes while others receive hay or turnips or are left unfed to serve as controls. An open winter in 1955-56 was followed in 1956-57 by one of the mildest seasons on record, and both tended to minimise responses to the feeding. Such seasons are exceptional, and the experience in the much more severe winter and spring of 1957-58 has emphasised that a long term study requiring several years' experimentation is necessary before firm conclusions can be drawn.

Little authentic information is available on the effects of supplementary feeding under hill conditions, whilst the deep-rooted prejudice of many flockmasters against feeding, except in storm, tends to discourage those who do feed regularly from discussing their experiences. The following observations, therefore, are intended merely as a preliminary review of the Organisation's feeding trials from the standpoint of their general impact on practical systems of hill sheep management and as a guide to the problems requiring more intensive scientific enquiry.

As this early stage, despite the lack of defined feeding standards for hill sheep, the emphasis is concerned mainly with the amounts and timing of the supplementary feed under different systems of husbandry. The main objectives are to obtain a lead as to the critical thresholds of nutrition and of the physiological responses governing the performance of the ewes in different seasons and under different environmental conditions. The elucidation of the more fundamental aspects of these problems will require closer experimentation with small groups of sheep submitted to special regimes

of feeding under controlled conditions in sheds or small enclosures of rough land. Such facilities are only now being provided.

The scope of the present field trials is indicated in the following tabulation:

Farm	Sub-Flock/ Hirsel	Supplement Used	No. of Ewes
Glensaugh			
Blackface	Group A	Turnips	80
	,, B	Hay	80
	,, C	Cubes	80
Lephinmore			
Blackface	Mid-hill	Cubes	200
	Adjoining hirsels	Unfed	400
Sourhope			
Blackface	Schil	Cubes	160+hoggs
	,,	Unfed	160+hoggs
Cheviot	Hairney Law	Cubes	130+hoggs
	,,	Hay	130+hoggs

2. *Supplementary Feed.* At the outset of the trials it was decided that a cube was essential for feeding on the hill in order that the much needed digestible nutrients of energy and protein with the necessary mineral and vitamin additives could be available in a concentrated and easily transportable form, and that there would be a minimum of waste when scattered on the herbage. Moreover, it was considered that in the amounts offered (4 to 8 ounces per head daily) cubes would interfere little with the ewes' appetites for their natural grazing and their ability to rake the hill in the normal way. Although hay is an excellent feed in storm, it tends to be too bulky for regular use, and for experimental work it suffers from seasonal variation in its nutritive quality. Because of the lack of precise knowledge of the nutrients ingested by sheep from their natural pastures, it was decided to offer cubes of a medium protein content. In 1956 and 1957, the mixture contained a starch equivalent of 66 and a digestible crude protein of 14%, with added minerals and vitamins, but in 1958, cubes with a higher digestible crude protein content were used.

The hay and turnips fed to the control groups were rationed to provide theoretically similar intakes of digestible crude protein to that of the cubes, leaving the energy and minor nutrients to vary with the nature of the feed. Unfortunately, critical comparisons of feeds of such contrasting physical and chemical natures cannot be made. Some error is involved in the chemical estimation of the nutrients supplied in the hay and turnips, and bias arises from the feeding habits of the ewes which eat cubes and turnips regularly and readily but are inclined to refuse hay when any green herbage

is available. Despite this limitation, hay feeding was continued because it is the traditional feed. This has relevance to the husbandry at Glensaugh and in the north-east of Scotland generally where there is presumptive evidence that turnip feeding of hill ewes, a regular practice in the area, predisposes them to premature wear in the incisor teeth and the resultant early drafting of the ewes because of 'broken-mouths'. A survey of the husbandry implications of this problem in the north-east was made in 1956-57 and is reported by Mr D. Neil Jones later in this report.

3. *Feeding Habits.* In accordance with expectations, the ewes on Glensaugh and Sourhope, already accustomed to hand-feeding (turnips, hay-in-storm or minerals), took fairly readily to the cubes. At Lephinmore, in the absence of previous hand-feeding of any kind, the majority of the ewes were reluctant to feed in 1956, but did so regularly in 1957 and 1958. The cube feeding interfered little with the raking of the sheep. Some groups, like those on the hay and turnips at Glensaugh were waiting to be fed every morning, but most cube groups only came to the feeding centres on the appearance of the shepherd.

Unfortunately, the greatest difficulties in feeding arise on hills where the sheep are most in need of sustenance, namely on lightly stocked, hazardous ground, such as at Lephinmore. In these situations, unless the siting of the feed bins and the herding is skilfully planned, ewes may have to walk considerable distances to receive their meagre offering of cubes. At Lephinmore it was decided to feed the 220 ewes at three points so that there was a minimum of interference with the hefting of the ewes. The bins with the feed are placed well up the hill to avoid disturbance to the ewes when they rake out on to the valuable mossing in open weather. Again, the risks of lambs falling into burns, and of mismotherings, makes continuanation of feeding undesirable after lambing commences.

In order to reduce both the disturbance factor and the labour of feeding, the ewes at Lephinmore were fed only on alternate days in 1957 and 1958. The beneficial effects of feeding were apparent from the better developed vessels of the fed ewes at the pre-lambing gathering in March and subsequently from their increased lamb crop. In this connection it is of interest to note that in drought feeding experiments in Australia weekly or twice-weekly feeding gave better survival than the same amount rationed on a daily system.

Feeding does not greatly mitigate the hazards of an open hill lambing. Swift flowing streams and dangerous water holes take

their annual toll of young lambs and for these reasons the fed ewes at Lephinmore were brought into an enclosure below a cross-fence for lambing in 1957 and 1958. As a result there has been a marked increase in the lamb crop, a reflection of the combined effects of feeding and of more effective supervision at lambing. If the experience in these two seasons is any criterion, the merits of controlled lambing and the feeding are worth further trial.

At the outset troughs were used to accustom the ewes to the cubes but subsequently the cubes were scattered on the ground. This gives shy feeders a better chance of getting their share.

4. *Preliminary Review of Supplementary Feeding Trials.* There was no marked response to supplementary feeding in 1956 and 1957 which must be interpreted in the light of the exceptionally mild seasons and the variation in environment and husbandry background on the three farms. Although it is premature to draw any conclusions, a provisional examination of the records reveals some points worthy of comment.

The records show that in average to good seasons, hill ewes carrying single lambs have a natural tolerance of moderate weight losses during pregnancy. Only an excessive loss in weight whether brought about by hard winters, poverty grazings, or a combination of both, leads to low production and the prevention of this calls for skilled stockmanship in deciding the timing and regulation of any supplementary feed. As already indicated, some of the difficulties are operational rather than scientific or economic. For instance, labour saving methods of feeding are not easily devised on the hill where the flock and not the individual sheep is the unit of management. It can be said, however, that the records on our research farms support the time honoured custom of giving preferential grazing management to gimmers (the most vulnerable age), or to weakly ewes where there are hill enclosures to permit this.

It is difficult to assess what constitutes an excessive loss in weight. Obviously, the effects of the weight changes in pregnancy cannot be fairly assessed without regard to the ewes' condition at the commencement of winter, in November. Ewes full of condition may bear a loss of say 20 lb. weight more easily than lean ewes losing only 10 lb., while their subsequent recovery and nursing performance may be greatly modified by the character of the grazing. These facts serve to emphasise that feeding during pregnancy must be a supplement and not a substitute either for the natural grazing or for efficient husbandry management.

A point frequently overlooked in this type of experimentation is that the various hormone changes consequent on pregnancy and

parturition bring about a quickening of the ewe's appetite and body-metabolism, thus operating as invisible aids to the successful culmination of the reproductive process. The hormone changes at parturition, coincident as they normally are with the spring flush of herbage growth, are the more powerful, as shown by the quick recuperation in condition and milk yield of the newly lambed ewes. This form of cyclical thriving, involving the accumulation of body reserves in summer and autumn to be drawn on during the privation of winter, following by the rapid pick-up after lambing, appears to be an inherent adaptability mechanism in hill sheep. It is possible that we lose too much by over-dependence on these factors, because the generality of lamb crops is only 60 to 80.% Theoretically, these flocks offer the greater potential for improvement. An increase of about 25% in the lamb crop of the fed hirsel at Lephinmore in 1957 and 1958 and the absence of such a marked reponse at Sourhope are in keeping with these suppositions. Thus, in practice, flockmasters are concerned with the minimal thresholds of nutrition necessary to ensure economic returns through their influence on survival of ewes and lambs and the maintenance of a regular breeding performance.

5. *Responses in Lamb Growth.* In the good seasons of 1956 and 1957 the feeding of ewes in pregnancy produced only a slight response in the growth of their single lambs and this was almost obliterated by the time of weaning. In contrast, after the harder winter and spring of 1958, the lambs from the fed ewes were definitely heavier at marking (the weaning weights are not yet available). By inference, therefore, it would appear that in good seasons lambed ewes quickly adjust their milk flow according to the appetites of their young lambs and the nutritive quality of their grazings. Thus, beyond the minimal needs of pregnancy, it is possible that lamb-growth might be improved more efficiently by the improvement of hill pastures by heather burning and draining, or by liming and fertilising on suitable hills. On the other hand, in 1958 many of the under-fed ewes were punished too severely, as shown by both the lack of udder development and the slow growth of their lambs.

6. *Cubes as a Substitute for Turnips at Glensaugh.* The uniformly high lamb crops (fully 100%) at Glensaugh could not be attained without regular supplementation with turnips or other feed as is the custom in the north-east of Scotland. In 1957-58, the groups on cubes and hay performed similarly to the group on turnips whereas, in 1958, the turnip group was superior. In 1958 all three groups lambed singles satisfactorily, but there were heavier losses

of twin lambs in the hay and cube fed groups. Experience in this season, especially on bare lambing pastures, suggests that a combination of hay and cubes might be a better (and cheaper) substitute for turnips.

This flock is rather exceptional in that, consequent on the controlled tupping inbye, about 25% of the ewes lamb twins, a fair proportion of which are reared. The presence of small but statistically valid differences in the weaning weights of these twins (the turnip group heaviest, followed by the cube and then the hay group) but not in those of the singles, suggests that ewes nursing twins may be the more suitable material for assessing responses in nutrition experiments.

In 1957, the ewes were handled individually for condition at the March gathering, just before lambing. The turnip fed handled best, the cube fed not quite so well and the hay fed ewes least well, so reflecting the varying intake of energy on the three rations. Surprisingly, the hay-fed ewes have least trouble at lambing, there being easier parturition and fewer lambs in need of attention. This is further evidence that hill ewes are extremely versatile, though continued research will be necessary to observe how far these short-term responses link up to make a sustained life cycle of productivity over the good seasons and the bad.

7. *Losses of Young Lambs*. Over recent years on the Organisation's farms, the losses of young lambs between birth and marking, including stillbirths but not prematures, are in the order of 10 to 12%. This is possibly a normal wastage, the majority of losses occurring either at birth or within a few days of birth. Superficially, they seem to arise from what may be termed the natural hazards of hill lambing, possibly accentuated in the extremes of winter climate by a partial failure of the ewes to control fully the foetal growth of their lambs. Whilst there is an apparent constancy in the rate of these losses, an examination of the records denotes a variety of causes, springing from the complex interaction between 'food' and 'breed', which require detailed investigation.

Hitherto, the effects of supplementary feeding have exerted little effect on the incidence of lambing troubles whilst there is hardly any evidence of disease. In normal seasons, there are fewer losses of singles than of twins, reflecting the link between size and maturity of development in the lamb (and milk in the ewe) and the chances of survival. Some of the larger lambs, however, are lost through delayed parturition. Such losses were prevalent in 1957, and in many ways, imply an excess of nutrition. They occur also in normal pregnancies almost regardless of lamb size, when the ewes lack

condition and muscular fitness, especially in the event of dry weather or cold east winds at lambing time.

These troubles occur in the Blackfaces at Lephinmore, more particularly in the male lambs because of the increased resistance offered by their slightly larger size and strongly developed horn buds.

The 1956-57 winter was exceptional for the absence of any marked check either to the grazing or to the thriving of the sheep. Conditions were favourable even to twin pregnancies, and in certain instances ewes developed over-large singles, with the resultant complications at lambing. At Sourhope the season was marked by frequent cases of delayed parturition and loss of lambs on certain hefts, but the fact that there was more trouble in the South Country as compared with the North Country Cheviots or the Blackfaces, suggests the possible intrusion of conformation differences, such as the greater width of the head and shoulders in the South Country Cheviot.

Wintering of Ewe Hoggs

1. *Indoor Wintering.* The scarcity and rising costs of away-wintering in recent years have aroused interest in the possibilities of wintering ewe hoggs at home. One possibility is indoor wintering in sheds. At Glensaugh, indoor wintering is being compared with the normal home-wintering on grass, a random half of the Blackface hoggs (about 60) being assigned to each method.

This is not a new development since there are numerous instances of successful indoor wintering by private flockmasters. Indeed, partial indoor wintering with an outrun to grass is a traditional method of wintering Swaledales in the north of England. Where there is some clean rough ground to permit this, the method has the advantage of flexibility. Thus, the hoggs are kept fitter while the duration and amount of the feeding can be regulated according to the weather and the grazing available in the outrun, thereby reducing the costs of feed and labour.

At Glensaugh the object has been to obtain experience of indoor wintering, and to check the subsequent progress and breeding performance on the hill as adult sheep. Unfotunately, a suitable outrun from the shed available cannot be provided, and the provision of a full ration indoors is as costly as away-wintering.

2. *Plane of Nutrition Experiments.* There is very little information on the effects of different levels of wintering on the growth and development of hoggs. Data on growth are difficult to obtain from

comparisons of 'home' and 'away' wintering because of the great seasonal variation in the nutritive quality of grazings. These studies, however, furnish much useful information, especially their demonstration of the inherent capacity of the hoggs (including the hill wintered ones) to recuperate in condition quickly on the hill during the following summer. Whilst this response serves to confirm the operation of nature's nutritional priorities in favour of skeletal growth and the essential nervous and alimentary systems, it gives no criterion for the growth pattern of the skeleton which is the main determinant of size.

Since hogg-wintering is the only stage in the life of hill sheep when it is feasible to impose nutritional priorities, it is desirable to know more exactly what their effects are on the development of the main body tissues, bone, muscle and fat, and in particular on skeletal growth. For instance, flockmasters would like to know whether smaller hoggs would prove more responsive than larger ones to better wintering. Unfortunately, there may be physiological limitations in this direction since the hoggs may have passed the most responsive stages of their skeletal development before the commencement of the wintering. It is hoped that the plane of nutrition experiments that have been initiated at Sourhope and Glensaugh will help in the elucidation of some of these unknowns.

At Sourhope, the North and South Country Cheviot ewe hoggs on the Hairney Law hirsel were each scrambled into three groups in 1956-57 and 1957-58 and, except for one hill wintered group in 1957-58, were submitted to high, medium and low planes of nutrition in a shed. The progress of each group will be recorded by weights, measurements and records of performance during the wintering and throughout their complete life on the hill. In addition, representative individuals will be slaughtered for laboratory dissection as a check on the development of the main tissues, bone, muscle and fat.

In a less critical study with Blackfaces, which was commenced at Glensaugh in 1955-56, some specially selected large and small hoggs (30 of each) were wintered on high and medium levels of nutrition in a shed. A few of the larger hoggs were bred from and some of the smaller ones withheld from the ram as gimmers, in order to observe the effects of the first pregnancy at different ages (hogg, gimmer and $2\frac{1}{2}$ year old stages) on growth and subsequent performance. From the interim results there would appear to be little point in departing from custom in breeding first from the gimmer age.

MANAGEMENT

The character and performance of the British breeds of hill sheep are a testimony both to the breeders' art and to the background of efficient husbandry management. Topography and grazing facilities vary greatly between farms, so that management reflects the personal skills of flockmasters, evolved through long generations of experience. In the light of current knowledge, this subjective approach is generally effective in maximising output from the labour and resources available, despite the many problems which limit the proper utilisation of the ground.

Before the three hill research stations came under the control of the Organisation, a series of management studies had been initiated by the Colleges of Agriculture. These studies have been continued and elaborated and, as the following outline shows, they are in the nature of husbandry-management investigations of 'area' problems entailing long-term collaborative research.

Glensaugh

1. *Dentition.* As already noted, the predominantly heather hill at Glensaugh, with its exposure and liability to fairly severe snow cover in winter, is characteristic of the north-east of Scotland. By custom normal hill-going stocks of Blackface ewes in this area are given a supplementary feed of turnips on the break each morning from mid-February to lambing. This system predisposes to premature wear in the incisor teeth and the resultant early drafting of the ewes.

Thus, the supplementary feeding comparisons previously alluded to are intended both to investigate alternative forms of supplementation and to afford increased scope for X-ray examination of the dentition and skeletons of the sheep being carried out by the staff of the Rowett Research Institute. Clinical observations on the state of the teeth are made periodically. In furtherance of these studies, an exchange of a group of gimmers between Glensaugh and Sourhope was made in autumn 1956, with the object of investigating the significance of age and the interaction with ground effects on the problem of wear in the teeth. The presence of broken-mouths in the main flock and in all three Blackface strains at Glensaugh equally, more or less discounts causative factors of a genetic nature though, as a further check, a small group of Herdwick ewes, a breed noted for their longevity and the soundness of their teeth, was introduced to Glensaugh in autumn 1955 for observation on the dentition of their progeny.

2. *Winter Feeding*. At the moderately high levels of supplementation required at Glensaugh, all three feeds—turnips, hay and cubes—have their limitations. The turnips might be replaced more economically by hay and cubes in combination, or silage could be substituted. Dietetically, silage is suitable for the ewes, but a careful siting of the silage pit is necessary to minimise the labour of cartage and feeding.

Summering in this area does not constitute any special problem, although there is evidence that a greater admixture of the heather with grass would prove beneficial. This is readily apparent in the improvement of the sheep on Finella (the smaller of the two hills) following the effects of the feeding and trampling of the hill cattle on the lower slopes. So little is known about optimum ratios of heather and grass that experimentation on this problem might be worthwhile. An increase of grass, however, would not entirely mitigate the wintering problem because of the exposure and the frequency of prolonged cover with snow.

Sourhope

The Sourhope hills with their herbage of mixed grasses, inclined to rankness of growth in summer, are typical of the Cheviots, and present quite different problems to those of Glensaugh. The sheep are too highly selective in their grazing to control all the summer growth and in the absence of topping by cattle, the herbage progressively deteriorates. Periodic burning is effective merely as a palliative and is inclined to coarsen the quality of the grazing. There is an advantage in grazing with cattle, but though cattle are highly desirable for the sake of the sheep, the number required and their wintering needs vary greatly. Some farms, or even hefts, may not need cattle, while the conventional cow and calf to a score of ewes may be desirable on others.

There are limitations in the use of this excess of summer keep as foggage for winter and spring feed. In our hill climates there can be no reliance on natural preservation of plant nutrients, either by the baking effects of a hot sun, as in the tropics or by deep-freeze, as in certain alpine climates. Instead, the feeding value of the herbage quickly deteriorates with the succession of changing weather conditions. For these reasons, green hills such as the Cheviots can be vulnerable even to sheep, especially in a late spring, and cattle must be hand-fed from about December until May.

At Sourhope a long-term critical study of the mixed grazing of sheep and cattle has been in operation on the Southside hirsel,

and on the Park Law hirsel an attempt is being made to assess, by means of controlled grazing, the possibility of increasing the carry of sheep. After the stock have settled down to a reasonable stability of performance under these changed regimes consideration will be given to a programme of hill improvement, through the application of lime and fertilisers on an experimental basis. This latter approach requires caution, as an increase in the rate of stocking might endanger health, especially in the event of the lime tending to immobilise the meagre supply of minor elements (cobalt and copper) on this type of ground.

1. *Mixed Grazing.* The study of mixed cattle and sheep grazing on Southside was started in 1951. This hirsel comprises three hefts, Fasset, Rigg and Gairs, each of similar area and each carrying a stock of about 130 Border Cheviot ewes, plus hoggs. The hirsel is characterised by its vigorous agrostis-fescue-molinia type vegetation and by a long history of ill-thriving in the sheep associated with cobalt pine and relatively high worm burdens. The rankness of growth may be gauged from the fact that, since 1951, the Fasset heft has carried regularly in summer 26 suckler cows without detriment to the normal stock of sheep. Indeed, there has been a sustained improvement in the sheep whilst the sporadic ill-thriving of those on the Rigg and the Gairs has continued. However, in case this response was biased by ground or ecological advantages in consequence of the interference to the natural rake of the sheep by the fencing of the hefts, suckler cows were introduced also to the Rigg in 1955. In this manner it is hoped to obtain a repetition on the Rigg of the beneficial effects of the complementary grazing on the Fasset and already Rigg sheep are showing a slight improvement. The third heft, the Gairs, continues as the control without cattle.

2. *Controlled Grazing.* This experiment was initiated in 1954 by the erection of a dividing tence to separate the Park Law at Sourhope into two sub-flocks, each of about 70 ewes plus hoggs. On one side of the fence the sheep are allowed free grazing, while, on the other side, the grazing on the lower slopes (about one-quarter of the area) has been enclosed and is used only at special times such as tupping, lambing, or as a boost to the suckling ewes in June or July. Cattle are used to graze the enclosures in summer. The sheep stock will be increased gradually in the light of their performance and cattle used only to top the roughage left behind them. Parity on the free-grazing side is obtained by allowing the same number of cattle free range.

Controlled grazing of this kind alien to the conventional Border system of hefting, having greater resemblance to the Welsh ffridd

or the Perthshire system of management. Careful observation is being made of the reactions of both sheep and herbage.

3. *Cobalt Pine.* In 1957, a dosing trial confirmed the presence of cobalt pine on the Southside hirsel on Sourhope. To avoid complicating the grazing experiments, a random half of the sheep of all ages on all three hefts were dosed with cobalt. This consisted of massive single doses (1 gram of cobalt sulphate in 1 ounce of water) administered at all the routine gatherings. By September, the response to the dosing on the Rigg and Gairs was such that dosed and undosed sheep could be spotted quite easily without reference to their identity. There was also a slight response on the Fasset. These results appear to support local opinion that pine is more prevalent in wet seasons when grass grows more luxuriantly.

BOTANICAL STUDIES

INTRODUCTION

DURING the last few decades, pasture research has concerned itself mainly with lowland pasture problems, an outstanding exception being the work associated with the name of Sir R. G. Stapledon on the reseeding of hill pastures and cognate problems. It is not the intention of the Hill Farming Research Organisation either to duplicate what is being done on lowland pastures or to rediscover the technique of reseeding hill pastures, but rather to devote attention to finding ways of improving the utilisation and management of the hill vegetation itself. This is not to deny the value of reseeding, but even if all the suitable hill land were reseeded there would still remain over ten million acres in the most efficient utilisation of which problems would arise. It is the latter type of pasture which we regard as hill pasture in the full meaning of the term.

A most important feature of hill pastures is their most obvious one—diversity—and this is seen not only in the large numbers of species found on them but also in the number of different plant communities which they form. The vast majority of hill pastures present a patchwork of distinct plant communities of which those dominated by heather (*Calluna vulgaris*), molinia (*Molinia caerulea*), nardus (*Nardus stricta*), drawmoss (*Eriophorum vaginatum*), deer hair grass (~~*Scirpus caespitosa*~~ *Trichophorum caespitosum*), bracken (*Pteridium aquilinum*) and the common species of the general Festuca and Agrostis predominate.

If those communities differed only quantitatively the problem would be simpler, but they differ qualitatively in the seasonal distribution of their yield and its composition, in their agricultural potential and their response to treatment, and in the grazing preferences sheep show for them. The patchwork is not, therefore, one of different intensities of the same colour of cloth but is composed of patches of different material.

It is necessary, therefore, to study separately each of these plant communities, their ecology and response to treatment. Taking molinia as an example, we require to study the soil condition under which it it flourishes, its response to grazing, manuring and burning, its yield, the chemical composition of that yield and its seasonal distribution, the degree to which it is utilised under different management systems and the relative measure of improvement which can be

effected in molinia communities compared with other communities.

The separate study of each species and of the communities it forms is only the first step. The next step lies in understanding the management system in the context of which improvement takes place, for unless the system of improvement, based on a knowledge of the characteristics peculiar to each community, is keyed to the management system one's efforts may be wasted.

With this approach the work which has been initiated can be classified under the following headings:—

Studies of the effects of management practices on vegetation.

Ecological studies to gain a better understanding of how the pasture is utilised, the effect of the grazing animal on it and an understanding of the characteristics of the more important hill species.

A study of the utilisation of the inbye or arable land and how it may be used more effectively in conjunction with the hill.

Naturally, every problem cannot be investigated at once and the work referred to in this report as either completed or commenced is only a part of what should constitute a comprehensive research programme. What is omitted from our present programme is not thereby ignored, but is merely postponed until time and facilities are available.

STUDIES IN MANAGEMENT PRACTICE

Muirburn

Of the several lines of investigation required in a study of muirburn those which require a long period of continued observation have been a first consideration.

Previous studies of muirburn have considered the effects of a single burn and an obvious deficiency in our knowledge concerns the effects of a series of burns. Accordingly at various centres throughout the country plots have been sited on heather and molinia communities and these plots will be subjected to different frequencies of burning. This work is long-term and its value will lie in confirming or questioning conclusions arrived at in other ways.

Considerable interest has been raised by suggestions that muirburn leads to a general degrading in the fertility of hill soils. These long-term experiments will help towards an understanding of this problem since, in addition to the botanical observations, the Macaulay Institute for Soil Research is following the pedological changes which may result from the different frequencies of burning.

Heather has a wide ecological range, being found on different

soil types, as a constituent of a number of plant communities and under a variety of climatic conditions. So that information may be obtained on the effects of burning and the rate of regeneration of heather in this wide range of conditions, the sequence of events after a heather burn in at least 30 different sites will be followed. This work started in 1957 and to date 11 sites in Perthshire and Angus have been brought under observation.

Work of a more detailed nature has begun on the effects of burning molinia, of which there is an outstanding gap in our knowledge. The object of this work is to measure the weight of litter burnt, the chemical nature of the products of a burn and their subsequent history. This will help to determine whether they are retained or a proportion is washed out of the soil.

Observations of minor interest are that there is an increased flowering of molinia in the summer following a spring burn, and that the silica free ash content of molinia leaves is significantly increased consequent upon burning. (We are indebted to the Edinburgh and East of Scotland College of Agriculture for the chemical analyses in the work.)

Drainage

1. *Hill Drainage Survey.* A survey of hill drainage schemes was initiated in 1956 when 32 schemes, mainly in mid and west Scotland, were investigated. At 15 centres, detailed records of vegetation were made and peat samples taken for examination. The survey should be completed in 1958 and by repeating it after five years the effects of hill drainage and its value in hill pasture improvement should be indicated.

2. *The Agronomic Significance and Control of Water in Peat Soils.* In collaboration with the Macaulay Institute preliminary experiments have been established to determine the effects of different moisture regimes on the chemical and physical nature of peat, and on the regeneration of a natural plant community after burning. The development of a sown sward under these conditions is also being investigated. These experiments have been laid down on an area of raised bog in Lanarkshire.

Surface Seeding and Cultivation

A survey of the methods at present adopted in surface seeding and the degree of success achieved was undertaken in 1957 with visits to parts of the Scottish Highland and Islands. Much work of this character has been stimulated by the North of Scotland

College of Agriculture, covering schemes on crofting townships and on farms varying in size from about 20 acres arable with different amounts of rough ground to large hill holdings of many thousand acres. Conditions include skinned peat, deep peat and shallow peat overlying clay, rock or mineral soil.

Where possible, some surface cultivation is carried out with a pitchpole, or a grass or spiked harrow weighted with stones, or with discs or a heavy ripper. Lime and fertilisers are always applied in the form of shell sand or ground limestone, basic slag or ground mineral phosphate, and a dressing of 3-4 cwt. of a concentrated complete fertilizer is common. The seed mixtures used are invariably of the general purpose type, crested dogstail or rough-stalked meadow grass being sometimes included or 'cleanings' of wild white clover. The areas treated are fenced and the importance of stock control in securing effective improvement and utilisation is generally appreciated.

The problems in carrying out work of this character often resolve themselves to one or more of the following—excessive exposure, inaccessibility, extreme wetness, transport difficulties—while the degree of initial success depends on two main factors, moisture and the extent to which the soil is exposed.

The greatest initial success is achieved where the soil has been exposed by burning and/or ripping and the conditions are damp. The best take, particularly of clover, is often on waterlogged areas. A take of clover is seldom, and of grass never, seen on dry areas covered by a bent sward. A better, though certainly not a highly successful, take occurs on dry areas where the sward is less grassy and includes heather.

In the light of this survey, trials were begun in 1957 to investigate the value of strains of a number of species of grasses and of their ability to compete with regenerating natural vegetation when surface sown. Each trial comprises 20 treatments sown in 4 randomised blocks, and each treatment consists of a single grass strain plus S 184 wild white clover except one which has no sown seed and one which consists of S 184 sown alone.

The trials cover a wide range of conditions:—

Glensaugh, Kincardineshire—Heather on shallow, undecomposed humus; burned and lightly harrowed.

Lephinmore, Argyll—Heather-drawmoss on deep peat; burned but not harrowed.

Birkhill, Lanarkshire—Heather-drawmoss on deep peat; burned and rotovated.

Sourhope, Roxburghshire—Molinia with nardus on a peat podsol; burned and severely harrowed with a heavy ripper.

Nardus on a peat podsol; severely harrowed with a heavy ripper.

Bent-fescue on a well drained acid brown earth; severely harrowed with a heavy ripper.

Before the seed was sown, each area received 3-3½ tons per acre of ground limestone, 6 cwt. per acre of superphosphate (at Lephinmore this was replaced by basic slag) and 1 cwt. per acre of nitro-chalk.

The initial establishment in these trials emphasised the importance of surface moisture, the effect of exposure to cold winds and the proper preparation of the area to be seeded.

Yorkshire fog made an outstanding start on all sites and the perennial ryegrasses, S 24 and S 23, were also prominent. Cocksfoot, S. 143 and the Danish 'Trifolium', while showing more variation than ryegrass, had a similar initial establishment and development. Timothy was prominent at Lephinmore and on the molinia site at Sourhope, while at Birkhill, rough-stalked meadow grass and S 170 tall fescue were vigorous.

In the summer of 1958, despite a cold winter and late spring, the strains which had shown slow establishment and development have become prominent.

Sod-seeding

In Australia and New Zealand, an important advance in the improvement of some pastures has been the development of the practice of seeding grasses and clovers into established swards by a sod-seeding implement.

Some observations indicate that a technique of this nature might be of advantage in hill pastures in this country, especially if improved clovers could be sod-bedded into a pasture which has been manured. It appears possible that the indigenous clovers are unable, for genetical reasons, to respond as fully to the improved level of fertility as improved clovers might do.

The implements already in use for this work are not suitable for British conditions in which the turf is much thicker and denser, but a new implement is being developed which may prove effective. Meantime, work has started to determine the depth and width of furrow which needs to be cut in the turf to allow the clovers sown in it to establish themselves and spread, and ~~at the same time to study~~ the agronomic potential of the indigenous clovers.

Heather Grazing Trial

Burning is the most frequent management practice with heather, and it is not surprising that it has received greater attention from research workers than the other problems involved in getting the best utilisation of this plant. One of the main factors influencing the growth of heather and the development of the heather community is the intensity and seasonal incidence of grazing. A heather grazing trial was, therefore, commenced in 1957 in which the effects of winter, summer or continuous grazing at two levels of intensity will be compared. This trial cannot be concluded before 1967 at the earliest and no comment can be made on it at this stage.

Top Dressing on Hill Land

In co-operation with the Macaulay Institute, the Scottish Colleges of Agriculture and the National Agricultural Advisory Service laid down, in 1952, a series of preliminary trials at fourteen centres in England, Scotland and Wales to investigate the effects on hill grazings of relatively light dressings of lime and phosphate, as might be applied by aircraft. Treatments were applied as follows:—

$$\begin{matrix} Ca_0 \\ Ca_1 \\ Ca_2 \end{matrix} \quad \times \quad \begin{matrix} P_0 \\ P_1 \\ P_2 \end{matrix}$$

Ca_0—No lime
Ca_1—Ground limestone equivalent to 4 cwt. CaO per acre
Ca_2—Ground limestone equivalent to 30 cwt. CaO per acre
P_0 —No phosphate
P_1 —Superphosphate equivalent to 50 lb. P_2O_5 per acre
P_2 —Superphosphate equivalent to 150 lb. P_2O_5 per acre

The effects of these treatments in a wide range of conditions have been studied by the workers concerned. Some of the preliminary results have been encouraging, but it is obvious that further investigation is needed, especially of the interactions between fertiliser dressing and grazing intensity.

Bracken Control

Autecological studies of bracken have not yet found any vulnerable point in its development which would point to an improved method of control. Similarly, no herbicide has yet proved so successful that its use has become a commercial practice, though there are grounds for optimism that a suitable spray has now been developed. The development of suitable herbicides, as also of new bracken

cutting or bruising implements, is the responsibility of other research bodies but, in so far as our facilities permit, we are co-operating with these organisations. Meanwhile, machine cutting, where feasible, is regarded as the most economic means of control, but there is doubt as to the best cutting or bruising frequency to prevent a controlled area from again becoming bracken dominant. To throw some light on this problem, we are co-operating with the Scottish Station of the National Institute of Agricultural Engineering in studying the cutting frequency required to maintain control. A study is also proposed of the actual effects of a light bracken infestation which many hill farmers in the Cheviot hills regard as not a serious menace and on occasions as an advantage.

ECOLOGICAL STUDIES

Heft Ecology and Sheep Behaviour

The term 'heft' is used widely in Scotland and describes both a self-replenishing group of sheep which habitually graze within the confines of a particular area of hill ground and also the area of ground itself. A heft, therefore, is the basic unit for study and the grazing preferences among the various plant communities of the sheep composing one heft at Sourhope are being studied.

The Gairs is the heft used for this study and it extends to 250 acres, being grazed by 150 ewes and hoggs. It ranges in altitude from 800 to 1750 feet with a herbage of molinia, nardus, heather and bent-fescue communities. The comparative grazing intensity per unit area for each of the plant communities is ascertained and at the same time, the relative productivity of the communities and the manurial return to them is assessed.

While these studies are still at an early stage they make clear two broad conclusions, when considered with earlier work. First, there are wide differences among the grazing intensities of different communities and these differences are not directly proportional to the differences among them in yield of D.M. or in its seasonal distribution. Second, each community has a seasonal variation in its grazing intensity which, although circumstances may modify it, appears to be characteristic of the community wherever it occurs in association with others.

Nardus, molinia and heather communities are all grazed with an intensity below the average for the heft as a whole. Nardus communities are grazed with greatest intensity in winter while both heather and molinia communities have two seasonal periods of greater utilisation, one in winter occasioned by the general scarcity

of grazing, and another in summer which coincides with the period when they are at their most palatable stage of growth. The bent-fescue communities, including those infested with bracken, are grazed with an above-average intensity which reaches a peak in early spring.

It also appears that the location of any particular plant community on the heft plays an important role in deciding the intensity with which it will be grazed.

While it is obvious that sheep are selective grazers there is no clear understanding of what determines their choice. In 1956, sheep were allowed to graze a series of grass plots on which in the previous three years a manurial experiment had been conducted, resulting in the herbage on the plots differing in mineral composition. The selection of the sheep among the plots was observed and the results, although far from conclusive, give more support to the conception that the sheep's selection is based on a preference for herbage of low fibre and high moisture content rather than for herbage of a high phosphate and calcium content.

Rooting Depths of Plants in Peat

It is most probable that plants with different rooting systems will differ in their response to drainage, a point of importance in studying the need for and the effects of draining peat. Accordingly, using radioactive tracers P^{32} and Rb^{86}, the rooting systems of plants growing in peat were studied in 1956 and 1957 at three sites—Lephinmore, Sourhope and Birkhill. The measurement of the radioactivity of the plants was carried out by the Macaulay Institute.

delete these two lines

~~As far as we know, the method developed for the placement of radioactive solutions in peat is new and it has proved successful.~~ The radioactive materials in aqueous solution were placed at the required depth in the peat and were shown to remain at that depth for a considerable period. After placement of the radioactive solution at various depths, the vegetation growing above the placement site was collected, separated into its constituent species and the radioactivity of the plant ash measured. According to the level of this radioactivity the depth of penetration of the roots and a measure of their activity at different depths can be assessed.

A summary of the results of this work is given on p. 45 and it can be seen that the various species showed considerable differences in ~~both the depth to which their roots penetrate and in~~ the relative activity of the roots at different depths. At Lephinmore, all the species grew in one community.

Percentage absorption at different depths of species growing in deep peat

Species	Depth 0-6 in.	6-12 in.	12-24 in.
C. vulgaris	93·6	4·8	1·6
E. tetralix	88·2	6·9	4·9
N. ossifragum	89·5	8·5	2·0
M. cærulea	61·0	29·4	9·6
T. cæspitosum	37·0	40·8	22·2
E. vaginatum	26·8	44·8	28·4
E. angustifolium	14·1	40·8	45·1

In the course of this work very high values were observed for the radioactivity of vegetation growing in peat and this was found to be due to the fallout of radioactive products from hydrogen and atomic bomb tests. The opinion was formed that the high rainfall associated with peat areas and the low calcium status of peat soils would account for the high radioactivity found in plants growing in peat. The significance of this is that in the event of radioactive fallout reaching a dangerous level, it is likely to do so more quickly in areas where high rainfall is associated with soils of low calcium status—in brief, in hill pastures.

Phytosociological Studies of Hill Vegetation

Information concerning the characteristics of the economically important plant communities of hill grazings is very scarce, and as these communities form a large part of the environment of the grazing sheep they become in consequence the basic material of many experiments. A systematic description and classification of these plant communities and their habitats is, therefore, essential and for this reason phytosociological studies are being carried out.

The field technique that has been adopted is that described by Poore (*J. Ecol.*, 43, 245), which is essentially that of Braun-Blanquet. In addition, use has been made of a point quadrat technique for obtaining more detailed information and for providing an objective standard against which to calibrate the estimates of cover/abundance of different workers.

Although the results are still incomplete, those obtained so far appear to support the conclusions of Gleason (*Amer. Midl. Nat.*, **21**, 92) and of Poore (*J. Ecol.*, **44**, 28) that variation in vegetation is continuous but that, within a region at least, areas exhibiting a certain degree of uniformity recur. These areas can be grouped together on the basis of constant species to form inter-related vegetation units (noda).

For practical purposes, it is desirable to have units with the highest possible degree of internal uniformity. This is so even though these units have validity only within a restricted region while less uniform units are desirable for purposes of general classification. It appears that when constancy is used as the sole criterion in forming vegetation units the highest possible degree of internal uniformity is not always obtained, and that it may be necessary to use as criteria both constancy and abundance. For example, it has been found that on gleyed soils within what might be regarded as a single vegetation unit a close positive correlation exists between the percentage area cover and pH for *Festuca rubra* and *Agrostis tenuis*. On the other hand, the abundance of *Agrostis canina* is negatively correlated with pH. Thus there might be considerable variation in the abundance of these species within a nodum in response to variation in soil base status, ~~a variation that might not be acceptable for some purposes.~~

The correlation between soil type and the type of plant community appears to be very close, at least in bent-fescue and molinia communities under present grazing conditions, and many noda can be identified by their associated soil profile types. Thus a number of noda have been distinguished in which Bent and Fescue species predominate. These range on the one hand from the type found on acid Brown Earth soils and related to the *Deschampsia flexuosa* nodum, through those of the eutrophic Brown Earths to noda characteristic of gley soils. The latter in turn have affinities with *Caretum*, *Juncetum articulatae*, or certain *Molinieta*. Associated with many of these bent-fescue noda are a series of *Nardeta* which appear to have arisen by nardus invasion of the bent-fescue. Similarly, two additional nardus types occur, which appear to have arisen respectively by invasion of the *D. flexuosa* nodum and of a certain type of heather community.

Molinieta, like the Nardeta, occupy a range of habitats which give the appearance of being very different ecologically, but unlike Nardeta, appear to occupy an intermediate position between certain other vegetation types. The Molinieta can be divided into four main noda each associated with a particular soil profile:

(i) The Fen type, which is to be found on deep mineral soil peat.
(ii) The Gley type.
(iii) The Peat Podsol type.
(iv) The Bog type, found on deep acid peat.

Floristically, the fen and gley types are basically very similar and show a relationship to the more base rich bent-fescue gleys. At the

other extreme, the Molinieta which is found on blanket peat and valley bogs, in addition to being closely related to the draw moss communities of similar habitats, demonstrates a strong affinity to the Molinieta of wetter peat podsols. Other peat podsol communities, however, are floristically more akin to some of the poorer bent-fescue and nardus noda.

Autecological Studies

1. *White Clover.* In most hill swards there is little white clover even in the best communities, while in many the species is completely absent. Since white clover is a valuable constituent of other grasslands, a series of experiments have been started to determine the factors limiting clover growth in hill soils.

There is generally a high lime requirement on hill soils and one series of experiments deals with the function of lime in relation to clover. No response to Molybdenum has been observed. Experiments are being made to determine the separate effects of Ca and pH on the clover plant itself, on the process of nitrogen fixation and on the free-living root-nodule organism. This work should enable the minimum lime requirements to be determined for vigorous clover growth and nitrogen fixation in the various soils being studied. Two other factors receiving attention are the ability of the indigenous Rhizobia to fix nitrogen and the productivity of the indigenous clover strains themselves. In co-operation with the Bacteriology Department of the Edinburgh and East of Scotland College of Agriculture, the indigenous Rhizobium strains of various habitats are being studied. The initial results indicate that strains of poor nitrogen fixing ability are relatively more abundant than efficient strains and that there may be differences between the Rhizobia populations of different habitats.

A collection has been made of clover plants from a range of habitats and these are being evaluated as spaced plants.

These studies are important since, if both the indigenous clover and the Rhizobia strains are poor and ineffective, a serious limitation is imposed on the response to fertilisers applied to hill land.

2. *Nardus stricta.* In the study of nardus communities, a range of different types has been distinguished. These occur on widely different soil conditions and most appear to have arisen by nardus invasion of other types of grassland community. In some of these communities apparent differences have been observed in the pattern of distribution of nardus which may be related to the relative competitive power of the other species present and to variations in

the grazing intensity. Work is in progress to discover more about these variations and their relation to the invasion process.

Nardus may also establish itself in heather communities and in some circumstances appears wholly to replace the heather. The seedlings, once established, are extremely drought resistant. On certain types of heather community in the first few years following a burn, nardus seedlings may establish themselves in patches having a suitable moisture level and surface stability. During this period older plants expand greatly in the absence of competition. Observations on this succession have been in progress since 1949, but a few more years are required before it can be seen how many of these young plants survive. The present indications are that nardus dominance is unlikely to occur as a result of a single heather burn unless some factor prevents or seriously delays the re-establishment of a complete cover of heather.

3. *Molinia caerulea.* Molinia is able to tolerate a wide range of edaphic and climatic conditions. Where a vigorous and dominant stand occurs, either in an acid or basic soil, it appears to have access to an independent ground water supply either from a high water table or in lateral seepage at the junction of the peat and mineral soil. It is possible that the nature of this water supply is a major factor in determining the vigour and success of molinia within a given plant community.

The effect of the ground water supply and its nutritional value on soil conditions, and the vigour of the plant, are factors which are being studied at selected sites in the field. A comparable series of ground water regimes under pot conditions has been established and the effect of this upon the growth of molinia is being observed. A feature which has emerged during the course of field investigations carried out during 1956 and 1957 and covering a wide area of North Britain, is the apparent inability of molinia to set seed in any quantity in many of the plant communities studied.

4. *Ecotypic Differentiation in Calluna vulgaris.* Very little is known about the extent to which findings from heather experiments can be generally applied, since we do not know the extent to which ecotypic differentiation occurs in heather. To investigate this it was decided to sample heather populations by collecting seed from different localities and raising the plants under a uniform environment.

In November 1956, heather seed was collected from 10 sites in Great Britain extending from Dartmoor to Shetland. The seed was sown in boxes and in the spring of 1958 some 50 plants from each group were transplanted into the field.

5. *The Effects of Various Cutting Regimes on Heather.* C. H. Gimmingham (*J. Ecol.*, **37**, 100) reported that the balance between regenerating *Calluna vulgaris* and *Erica cinerea* was affected by the intensity of grazing. His results could be explained in part by the morphological responses of the two plants to defoliation. At Glensaugh a grazing-burning experiment (see page 00) has been set up to investigate further the effects of intensity of grazing, though the main object is to study the balance between *C. vulgaris* and *E. cinerea.* An accompanying experiment has also been designed to be carried out on individual heather plants in boxes and it is hoped that the results will aid the interpretation of those of the field experiment. Little is known of the effect of defoliation on annual and total dry matter production.

Heather was raised from seed and the resultant seedlings thinned out and transplanted into boxes. There are seven treatments involving three frequencies of defoliation at two different times of the year and including uncut control plants. Treatments were commenced in winter 1957 and the duration of the experiment is expected to be four to six years.

6. *Ecological Survey—Glensaugh.* A soil and vegetation survey of the hill pastures of Glensaugh has been carried out in collaboration with the Macaulay Institute for Soil Research. The area was surveyed so that changes could be noted and the environment of any experimental work adequately described. Glensaugh hill is representative of the upland heath which extends over a wide area of north-east Scotland. The principal soil types have been described and an attempt made to relate vegetation to certain well-defined soil categories. As heather communities are of special interest in the area, particular attention has been paid to them. Four main types are recognised on the basis of floristic composition, and community structure and, while burning may result in their differentiation, a relationship with soil type is clearly recognised.

7. *Snow Mould on Upland Pasture.* The occurrence of several attacks of snow mould (*Fusarium novale*) at Glensaugh during the three years 1954-56 provided an opportunity to observe its effects on various grassland types and on different grass species. *Agrostis tenuis*, *Poa trivialis*, and *Lolium perenne* were most severely attacked while *Festuca rubra*, *Dactylis glomerata*, *Phleum pratense* and other species appear to be resistant. Widespread damage occurred on the bent-fescue grassland but only one case was recorded on temporary grass on arable land. Damage to this pasture, though extensive in March and April, was not permanent.

UTILISATION OF ARABLE LAND ON HILL FARMS

1. *Oat Hay.* Owing to the potential value of oat hay for feeding out-wintered hill cows, an investigation was undertaken into the yield and chemical composition of the oat crop at various stages of development and into losses in curing. The crop was cut at six stages, between and including the 'early milky' and the 'full ripe'. The principal results of a three-year study can be summarised thus:—

(*a*) The position of the peak yield in relation to stage of maturity varies from year to year but always lies between the 'late milky' and 'pre-ripe' stages.

(*b*) The percentage of crude protein is low, falling to a minimum after the 'early milky' stage and rising again to a maximum at the last cut. The yield of crude protein was highest at the last cut in one year and at the penultimate cut in two years.

(*c*) The percentage of crude fibre tends to decrease with increasing maturity, this being due to the low fibre content of the inflorescence, while the crude fibre yield is lowest at the beginning and the end of the cutting period.

(*d*) Chemical analyses at different stages of maturity showed the total ash content to be low. The content of calcium was especially poor.

(*e*) In one year, dry matter losses during curing ranged from 22 to 7% at the first and last cuts respectively, while corresponding figures for crude protein were 18 and 10%.

(*f*) In the absence of digestibility data and feeding trials, the conclusion is drawn that in the higher rainfall areas of the north and west, where the crop is most likely to be used, cutting between the 'late milky' and 'late cheesy' stages should give optimum results.

2. *Production and Utilisation of Autumn Grass.* The production and utilisation of autumn grass has been studied at Glensaugh over a period of years. The problems investigated included the value of various grass strains, the effect of manurial treatment and management on autumn growth and subsequent production, and the utilisation of autumn grass by weaned calves and older cattle. Various trials have shown that in the north of Scotland it is difficult to improve upon the general purpose type of seeds mixture, containing 8-10 lb. of cocksfoot, for extended autumn grazing. Where hay or silage is taken regularly, this tends to produce a cocksfoot dominant sward in the second and third years. Although this species has proved more suitable than others when sown alone with white clover, autumn production of the general purpose mixture

has not been found inferior. When other requirements of a sward on a hill farm are taken into account, the greater flexibility of this mixture has many advantages.

On hill farms where breeding cattle are kept there may be advantages in retaining until the following spring at least a proportion of the weaned calves. If they are over-wintered, a wider scope in choice of markets may be possible, while in addition to the dung produced a spring sale may provide a greater margin of profit if wintering costs are minimised. As a means to reducing the requirements of hay, silage and purchased concentrates, grass can play an effective part if used efficiently during the late autumn and early winter.

At Glensaugh, the calves are usually weaned at the beginning of October when they go into covered courts for the winter. In a three year study on land at approximately 550 feet, it has been shown that calves grazed for a period of 4-8 weeks after weaning compared favourably with those fed in courts immediately after weaning and throughout the entire winter period. Those on grass did, however, receive a slight set-back in liveweight gain when the change from outdoor to indoor conditions took place.

An experiment to investigate problems of grass production and utilisation by older cattle for a more extended period was also carried out for three seasons on an area of $3\frac{1}{2}$ acres. Management was intended to provide grass in October when summer pastures were getting bare. In each of the three years the area carried six or seven 6 cwt. $1\frac{1}{2}$ year old cattle for a period of nine weeks. Grass was rationed on a daily basis, sufficient being given to obtain an average liveweight gain of at least 1 lb. per day.

Attempts have been made to provide arable grass winter grazing for cattle after December, but under hill farming conditions it seems that the technique is too unreliable to be recommended in practice.

POPULATION STUDIES

The conditions under which hill sheep are kept are diverse, both in systems of management and in stocking intensities. If a research programme does not bear in mind the conditions under which the greatest number of sheep are kept, it is possible to devote too much attention to problems which may not be of importance to the industry as a whole.

The following Table gives the distribution of hill sheep in Scotland according to stocking intensity and shows that the major, though

not the exclusive concern of a research policy must be with these problems facing the farmer whose hill carries 1 ewe or hogg to 2-4 acres, conditions typical of the Blackface flocks on the better type of heather hill in Scotland.

Distribution of Hill Ewes and Hoggs in Scotland by Stocking Intensity (acres/sheep)
(Calculated from Hill Sheep Subsidy Parish returns for 1952)

Acres/sheep	0-1	1-2	2-3	3-4	4-5	5-6	6-7	7-8	8-9	9-10	>10
Percentage of total ewes and hoggs	0·6	6·2	34·7	20·6	11·6	10·2	5·8	1·8	3·6	1·1	3·8

The equivalent data for Wales and the north of England have not yet been examined. It is known that stocking intensities in Wales tend to be higher and it is probable that this fact—in addition to differences in systems of management, in the ratio of inbye to hill land and in the inherent fertility and potential of their respective hill soils—may tend to emphasise different features in a research programme for these regions from those we have assumed to be most important for Scotland.

PUBLICATIONS

(* Reprints not available)

ATTWOOD, P. R., and HUNTER, R. F. A method for studying the preferential grazing of hill sheep. *Brit. J. Anim, Behav.*, **5**, 149, 1957.

A description of a device used to record rapidly the location of sheep grazing over an extensive area of hill pasture.

BOGGIE, R., HUNTER, R. F., and KNIGHT, A. H. A study of the root development of plants in the field using radioactive tracers. *J. Ecol.*—in press.

Using radioactive tracers it has proved possible to determine the relative activity of the roots of different species at various depths in the soil. This is done without disturbing the plants in their natural habitat where they are found growing together. The results gained by this study are the understanding of the relationship between different species found growing in association.

COPEMAN, G. J. F., and NICHOLSON, I. A. Autumn and winter grazing in Northern districts. *Agric. Rev.* [*Lond.*], **3**, 22-30, March 1958.

A review article based primarily on the results of experimental work carried out in the North of Scotland on various aspects of the production of late autumn and winter grass under upland and low ground conditions.

GRAY, E. G., and NICHOLSON, I. A. Snow mould on upland pasture in North Scotland. *Trans. Bot. Soc. Edinb.*, **37**, 123-128, 1957.

Observations at Glensaugh showed that snow mould, caused by the fungus *Fusarium nivale*, was widespread in certain years, especially on the bent-fescue grassland dominating the lower hill slopes. In one year the disease caused extensive, though temporary damage to an inbye pasture in early spring.

Although a common disease of lawns and sports turf, snow mould has not been recognised previously as a disease of pasture in this country. Its significance is uncertain, but it may be an important factor in modifying semi-natural bent-fescue pasture and may have to be taken into account in surface seeding when certain seed mixtures are employed.

HUNTER, R. F. * The pasture-animal relationship on hill pastures. Paper read to the British Association, 1957.

The preference shown by sheep among the different plant communities composing a hill pasture is described and the relation of this to methods of pasture improvement discussed.

HUNTER, R. F. The direction and problems of research in hill pasture improvement. *J. Brit. Grassld. Soc.*, **13**, 121-125, 1958.

It is argued that ecological research is the essential basis of any research programme dealing with hill pasture improvement and the difficulties peculiar to experimental designs involving hill sheep are discussed.

KING, J. * The ecology of certain communities in the Cheviots with particular reference to *Nardus stricta*. (Ph.D. thesis, Edinburgh University—unpublished.

The edaphic and floristic characteristics of the predominant hill pasture communities is described. A classification of these is suggested and the role *N. stricta* plays as a competitor within each is discussed on the basis of data derived from field and laboratory observations.

MACLEOD, A. C. Heather in the seasonal dietary of sheep. *Proc. Brit. Soc. Anim. Prod.*, 13-17, 1955.

The slaughtering of sheep from Lephinmore fortnightly for helminthological investigations enabled rumen contents to be examined and an assessment made of the extent to which sheep graze heather throughout the year and of the parts of the plant eaten during the various seasons. *Calluna vulgaris* appeared to be a natural choice of hill sheep throughout the year. During winter and early spring, woody shoots up to two inches long were found, but in summer there was preference for the extreme tips of fresh growth. *Erica tetralix* appeared to be grazed in winter and early spring, but very little in summer.

NICHOLSON, I. A. The effect of stage of maturity on the yield and chemical composition of oats for haymaking. *J. Agric. Sci.*, **49**, 129-140, 1957.

Owing to an increasing interest in the use of oats in the sheaf for feeding to outwintered hill cattle, a study was made of the yield, chemical composition and losses on curing oats when cut at various stages of maturity after flowering. In the absence of digestibility data and feeding trials under Scottish conditions it was tentatively concluded that, in the higher rainfall areas, cutting between the 'late milky' and 'late cheesy' stages of grain development would give optimum results.

NICHOLSON, I. A., and SMITH, R. G. C. The use of autumn grass for weaned calves. *Proc. Brit. Soc. Anim. Prod.*, 33-40, 1957.

It was shown that late autumn grass could be used on a hill farm for grazing calves after weaning in the autumn. In two years of the trial, calves were grazed on foggage for four weeks and in one year for eight weeks, extending to the last week in November. Stocking rates were approximately two calves per acre. Comparison of the live weight gains showed that the foggage fed calves compared favourably with the court fed group while on grass, but suffered a set-back in daily weight gain on being housed. This resulted in the group fed inside continuously from weaning having a slight advantage in mean live weight in the following April. It is apparent that autumn grass can make a useful contribution to calf feeding, since it reduces consumption of purchased foods.

NICHOLSON, I. A., and ROBERTSON, R. A. Some observations on the ecology of an upland grazing in north-east Scotland with special reference to Callunetum. (Survey of Glensaugh.) *J. Ecol.*—in press.

An ecological survey of the hill grazings of Glensaugh was carried out to provide a background to future experimental work. The principal soil and vegetation types are described and their relationships discussed.

PEART, J. N., and RYDER, M. L. Some observations on different fleece types in Scottish Blackface sheep. *J. Text. Inst.* [*Manchr.*], **45**, 1821-1827, 1954.

Two groups of Scots Blackface sheep with different fleece types—'soft' and 'hard' coated were selected by visual inspection. Fibre counts indicated a greater mean number of fine fibres in the 'soft' group, which had both a higher mean follicle density and higher mean secondary to primary ratio. There was no difference in the proportions of different medulla types, and appeared to be no significant difference in the occurrence of pigmented fibres or in the incidence of fibre shedding in skin samples. It is considered that the more pronounced tendency to form staples in the 'soft' group is possibly related to the greater mean number of fine fibres in this group.

ROBINSON, J. F. Sheep husbandry in Iceland. *Scot. Agric.*, **35**, 132-135, 1955-56.

An account of sheep husbandry in Iceland, where remarkable progress has been made in recent years in developing greater production. Sheep graze communally on mountain pastures in

summer, but in winter are housed in sheds. Winter feeding includes artificially dried hay, sometimes silage, and from 1·5 to 2·5 oz. concentrates per day, the latter frequently being equal parts maize meal and herring meal. Lamb crops are about $1\frac{1}{4}$ lambs weaned per ewe and ewe lambs are mated.

WANNOP, A. R. The Hill Farming Research Organisation. *Scot. Agric.*, **34**, 177-180, 1954-55.

A brief review of the development of research into hill farming and of the major problems associated with farming land of inherent fertility and with a harsh environment. Indications are given of the major items likely to be developed in the Hill Farming Research Organisation's programme.

WANNOP, A. R. Animal production from grass. A report of the fifth study meeting of the European Association for Animal Production 1955. *Proc. Brit. Soc. Anim. Prod.*, 115-119, 1955.

A review of contributions on the utilisation of the herbage of highly productive grasslands by farm animals and of some of the problems arising therefrom.

WANNOP, A. R. * The Hill Farming Research Organisation. *J. Blackface Sheep Breed. Assoc.*, 1955.

WANNOP, A. R. * The Hill Farming Research Organisation. *Edinb. Agric. Col. Former Stud. Assoc. J.*, 1957.

WANNOP, A. R. The weather of 1954 and the farmer. *Scot. Geo. Mag.*, April 1955.

WANNOP, A. R. * Hill Farming in New Zealand and in Britain. *New Zeal. Meat Prodr.*, July 1957.

WANNOP, A. R. * Agricultural Research in Scotland, 1857-1957. *Edinb. Agric. Col. Former Stud. Assoc. J.*, 1957.

WANNOP, A. R. * Progress on the hills. *Glasg. Herald*, 1957, Autumn Survey of Agriculture.

WANNOP, A. R. * Land reclamation is still worthwhile. *Esso Fmr.*, **9**, Winter, 1957.

WANNOP, A. R. * Sheep Farming in New Zealand. *Proc. Brit. Soc. Anim. Prod.*, 101-103, 1958.

WANNOP, A. R. * Hill Farming in New Zealand. *J. Black. Sheep Breed. Assoc.*, 1958.

A SURVEY OF MANAGEMENT SYSTEMS AND THE INCIDENCE OF 'BROKEN-MOUTHS' IN BLACKFACE SHEEP IN THE NORTH-EAST OF SCOTLAND

D. NEIL JONES

Introduction

The hills of the north-east of Scotland are predominantly heather and the style of farming is characterised by the fact that normal hill-going stocks of Blackfaces are regularly supplemented with turnips, or other feed, from about mid-February until lambing in April. There is strong presumptive evidence that this kind of management accentuates a problem which is endemic in the area, namely, the premature wear in the incisor teeth, and the resultant early drafting because of broken-mouths. This condition occurs at Glensaugh, the Organisation's hill farm in Kincardineshire where about half of the ewes are cast after rearing only three crops of lambs because of the breakdown in their teeth. At Glensaugh, the incidence of broken-mouths varies little between the breed types, Home-bred, Lanark, Newton Stewart and Lewis, which suggests that the causative factors are of environmental (or nutritional) rather than of genetic origin. The object of this survey, therefore, was to obtain more information on the prevalance of this broken-mouth condition, and of possible connections with the local systems of husbandry or any other environmental agencies, also to examine the repercussions on management policy as regards drafting, and replenishment of the flocks.

Survey Method

The survey was confined to hill flocks in the counties of Angus, Kincardine, Aberdeen and Banff, and visits were made to 36 flock-masters on the recommendations of the County Agricultural Advisory Officers. To ensure uniformity in the methods of recording, a questionnaire was completed on each visit and flockmasters were asked to express their personal views as to the factors predisposing to the early breakdown of the teeth. Everyone co-operated willingly but, unfortunately, there was a lack of continuous flock-records to corroborate or disprove the different opinions expressed. Furthermore, the interpretation of the information collected is rendered difficult by the apparent erratic variation between neighbouring farms, and occasionally between different seasons.

The distribution of the farms visited is shown on the map on page 60, 10 being in Angus, 5 in Kincardine, 12 in Aberdeen and 8 in Banff. The predominance of Blackface sheep on hill farms in this area is shown by the fact that of the 101,669 breeding ewes in these four counties qualifying for subsidy in 1949-50, 97% were of this breed, though these are merely 6% of the total Blackface ewes in Scotland.

Description of North-East Area

The hill land of all four counties lies north of the Highland Boundary Fault. At the east end of the Cairngorm massif, the summits range from 2000-3000 feet, but the foothills are more dissected and slope fairly steeply to cultivated or marginal land, farmed on a rotation with at least 50% grass. The hills are bleak and may be subject to prolonged snow cover in winter. These features, combined with the dominance of heather and the lack of variety in the grazings, necessitate the regular provision of supplementary feeding for the sheep in winter and spring (February to April). The system of turniping has no doubt evolved because of the proximity to the hill or rotationally farmed land, and the reliability of the turnip crop in this region producing as it does more animal nutriment per acre for winter use than any alternative crop. In consequence, the lamb crops are above normal with the intensity of production varying according to the amount of cross breeding and the complementary use made of the inbye land. In the majority of flocks, a substantial number of twin births is the rule rather than the exception.

Geologically, the rocks present in order of frequency of their occurrence are those of the Dalradian series (age uncertain but possibly pre-Cambrian), those of the Highland Border series (Cambro-Ordovician) and Old Red Sandstone (Middle). In addition to sedimentary rocks of these formations, a great variety of igneous rocks, both contemporaneous and intrusive, occur in in the Eastern Grampians. The soils of the hill grazings are thus derived from a wide variety of parent material but share in common a deficiency of lime, phosphate and other elements. With this complicated background, it is impracticable either to classify the survey data according to the geological or soil types or to gauge the influence of these factors on the incidence of the broken-mouth problem in the sheep. Certainly, the presence in varying degree of abnormal wear in the teeth of sheep in all the flocks surveyed appears to be consistent with ground or geological factors as the

primary causation. Superficially, all the evidence points to this but in an exploratory survey of this kind there is no ready means of proof or disproof. Even if this supposition was correct, the variety in the character of the soils would no doubt be expressed as a modifying rather than a constant influence on the problem of wear in different flocks. Whilst these hypotheses detract from the validity of classifying the flock data on the basis of breeding policy (and incidentally, by the intensity of production) there does not appear to be any other approach by which the records can be more usefully analysed.

Types of Sheep Farming

Despite the general similarities in the character of the hill ground, the types of sheep farming fall into three categories according to the breeding policies, which are largely conditioned by facilities for wintering or grazing on the inbye during critical periods such as tupping and lambing. The relevant information bearing on this classification is summaried in Table 1, the three categories being:—

(*a*) *Pure-bred Flocks.* These are normal self-replenishing stocks of Blackface sheep which predominate in the harder country in the south-west of the area, where the flocks are fairly large and the amount of enclosed land is limited (3% of the total). The majority of these farms are sited in the well known Angus glens of Glen Esk, Glen Prosen and Glen Isla, whilst others are on Deeside in Aberdeenshire. Many of the flockmasters engage in tup-breeding and a portion of the flock may receive preferential treatment at tupping or during winter.

(*b Mixed Flocks.* In these flocks a portion of the ewes, generally the younger ages, are mated pure whilst the remainder are crossed with Border Leicester rams to produce Greyface lambs for sale. As shown in Table 1, these flocks are smaller and there is a little more inbye land (about 10% of the total), but such a breeding policy necessitates the purchase of some additional hoggs (or gimmers) to maintain the flock.

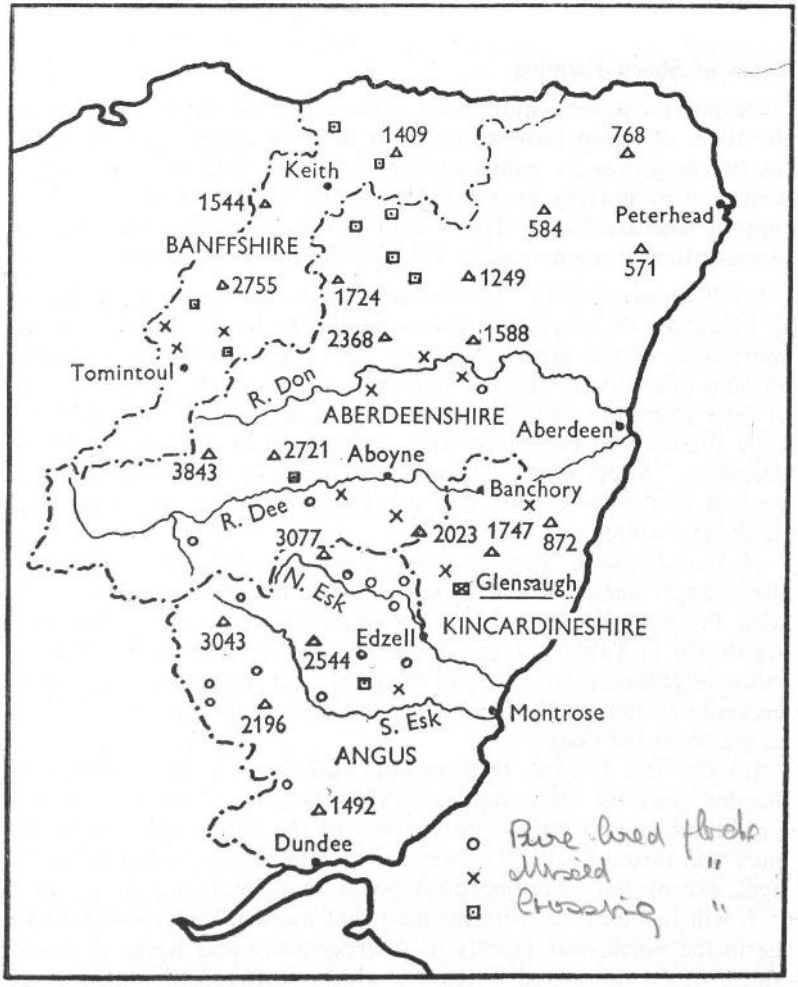
(*c*) *Crossing Flocks.* In these flocks all the ewes are crossed with Border Leicester rams and, naturally, there is greater dependence on the inbye land for wintering (16% of the total area). As in the pure and mixed flocks, the ewes are maintained in regular breeding ages, except that all replacement hoggs or gimmers are bought in.

It will be observed from the map that most of the crossing flocks lie in the north near Huntly in Aberdeenshire and Keith in Banffshire, whilst the mixed flocks are widely scattered, though for the

most part lying adjacent to the rivers Dee and Don and thus come in between the crossing flocks to the north and pure-bred to the south.

The data presented in the various tables are drawn from 15 pure-bred, 11 mixed and 10 crossing flocks, though not all flocks are included in all tables.

* MAP OF THE NORTH-EAST OF SCOTLAND SHOWING LOCATION OF FARMS VISITED



* Use same print as for the Dabell Readings ?

TABLE 1

Average Size of Flock, Rate of Stocking and Lambing Percentage

Type of flock	No. of flocks	No. of ewes	Acres of hill	Acres of arable and inbye	Inbye as % of total	Acres per ewe	Lambs weaned %
Pure-bred	13	754	3924	142	3·4	5·2	93
Mixed	10	406	2006	213	9·5	*	116
Crossing	9	435	1365	263	16·0	3·1	133

* Complicated by unknown areas of common grazing.

The greater intensity of production in the mixed and crossing flocks may be noted from the lambing percentages. The average of 93% of lambs weaned in the pure-bred flocks was exceeded in the mixed flocks by 23% and in the crossing flocks by 40%. Thus, assuming normal losses of lambs, it is apparent that the numbers at birth would vary from about 100% to 150%. Naturally, these heavy lamb crops could not be achieved without some measure of flushing and control at the time of mating. Many of the pure-bred flocks mate below a cross-fence, *i.e.* on the lower part of the hill, whilst in the mixed and crossing flocks most of the tupping takes place on the inbye fields, frequently with an out-run on to the hill at nights.

Because of the severity of the winter climate and the lack of inbye ground, the home wintering of hoggs is impracticable. Except for four farms grass-wintering at home, all the other hoggs were sent away for wintering. From the standpoint of this survey, the absence of hill-wintering is perhaps to be regretted, because there is no check of the effects of away-wintering on the development of the incisor teeth at a critical age. In the north-east, the away wintered hoggs may receive a few turnips, and in such cases the incisors are said to emerge a little earlier and to wear less satisfactorily. For this reason, one flockmaster who had experience of both methods of wintering stated that the teeth of hoggs grass-wintered at home were better at 5½ years than the teeth of away-wintered hoggs at 4½ years of age. This opinion is supported by the performance in the four flocks alluded to in which the hoggs are customarily grass-wintered at home.

In this area the ewes are usually drafted at 5½ years of age, after they have reared four crops of lambs. In other parts of Scotland Blackface ewes are frequently drafted a year later, after five crops. The earlier drafting in the north-east may be connected with the heavy lamb crops (and possibly with a better performance of the gimmers than is obtained in other areas) and the resultant wear in the ewes.

In short, the flockmasters would lose more than they would gain by retaining them for an extra year. Indeed, it is probable that the usual drafting at $5\frac{1}{2}$ years of age forestalls much of the dentition deterioration which would otherwise occur. Although drafting at $5\frac{1}{2}$ years of age is the normal, there are many flocks in which some of the ewes have to be cast a year earlier, so that the whole problem of broken-mouths is clearly one of degree as will be shown by reference to the details of husbandry-management and the severity of wear in the teeth.

Breakdown in the Teeth

Signs of the early breakdown of the incisors may be observed when the ewes are $4\frac{1}{2}$ or $5\frac{1}{2}$ years of age, and occasionally at $3\frac{1}{2}$ years. The typical symptoms are that the incisors become long and slack (and as if compressed laterally) are frequently accompanied by a recession of the gums and a pitting of the enamel at the base of the teeth. At this stage some of the teeth may be lost, though, should all the teeth be present, it is readily apparent that because of their 'piano-key' slackness they will not be retained for a further year. Naturally, the breakdown is accelerated mechanically by the stripping action of the teeth in biting heather and whole turnips.

Since it is unusual for any of the badly broken-mouthed ewes to be retained in the hill flocks, the incidence of premature wear may be gauged from the customary ages of casting and the estimated proportion of broken-mouths in the casts. This information is given in Table 2 for the three categories of flocks, pure-bred, mixed and crossing.

Table 2 on p. 63 denotes considerable variation both in the ages at drafting and in the incidence of broken-mouths. On the whole, it is apparent that in the majority of the pure-bred flocks casting takes place at $5\frac{1}{2}$ years old, whereas in the majority of the mixed and crossing flocks the ewes are cast in mixed ages, principally at $4\frac{1}{2}$ and $5\frac{1}{2}$ years old. In these latter flocks, the earlier drafting appears to be linked with a greater incidence of wear in the teeth at an earlier age. This situation would seem to reflect the greater strain from the cross-breeding and twinning compared with the pure-breeding. However, the possibility of premature wear being induced by twinning is not supported by the results at Glensaugh. In Table 3 the percentage of twin births from ewes born in 1950, 1951 and 1953 are stated separately for those cast after three lamb crops and those retained for a fourth crop. Thus, whilst there is no evidence of a connection between the frequency of twinning in itself

TABLE 2

Age at Casting and % Broken-Mouths, by Type of Flock

Type of flock	No. of flocks	Age at casting	Incidence of B.M.s graded *
Pure-bred	5	$5\frac{1}{2}$	1
	2	$5\frac{1}{2}$ and B.M. $4\frac{1}{2}$	1
	2	$5\frac{1}{2}$	3
	1	$5\frac{1}{2}$ and B.M. $4\frac{1}{2}$	3
	1	$5\frac{1}{2}$	5
	1	$5\frac{1}{2}$ and B.M. $4\frac{1}{2}$	5
	2	Mainly $4\frac{1}{2}$	7
	1	Mixed ages	7
Mixed	1	$4\frac{1}{2}$ and $5\frac{1}{2}$	1
	1	$5\frac{1}{2}$	3
	2	$5\frac{1}{2}$	5
	1	$4\frac{1}{2}$ and $5\frac{1}{2}$	5
	5	$4\frac{1}{2}$ and $5\frac{1}{2}$	7
Crossing	2	$5\frac{1}{2}$	5
	4	$4\frac{1}{2}$ and $5\frac{1}{2}$	5
	1	Mainly $4\frac{1}{2}$	7

* Grading of Incidence of Broken Mouths (B.M.)

Grade 1 = under 25% ewes B.M. at $5\frac{1}{2}$.
Grade 3 = 25-50% ewes B.M. at $5\frac{1}{2}$.
Grade 5 = 50-75% ewes B.M. at $5\frac{1}{2}$.
Grade 7 = 50-75% ewes B.M. at $4\frac{1}{2}$.

TABLE 3

Twin Births (%) from $4\frac{1}{2}$ Year Old Ewes, Cast and Retained at Glensaugh

Glensaugh	No. of ewes	Twin births in first three lamb crops: Total No. of Lambings	No. of twin births	% of twins
Ewes born 1950				
Cast 1954	41	123	27	22
Retained 1954	26	78	16	20
Ewes born 1951				
Cast 1955	21	63	10	16
Retained 1955	40	120	19	16
Ewes born 1953				
Cast 1957	40	120	29	24
Retained 1957	34	102	45	44

and the earliness of drafting at Glensaugh, there may be a relationship between a system of management which promotes a high twinning rate and premature wear in the teeth. The fact that there is a higher incidence of prematurely broken-mouthed ewes in the crossing and mixed flocks points to the systems of husbandry which are complementary to cross lamb production as the predisposing cause of the trouble.

More than half of the flockmasters visited thought that the feeding of turnips was mainly responsible for the broken-mouths, whilst there were frequent criticisms of the excessive forcing of ewes and the turniping of hoggs. Their views regarding the turniping of ewes are supported by the information collated in Table 5, whereas experiences of the different wintering treatment of hoggs are rather conflicting. The majority opinion was averse to the turniping of hoggs, especially towards the end of the winter when turnips might be frozen and the teeth more prone to damage. Yet the case histories vary. Three flockmasters stated that turnips were not detrimental, two of them reporting that over a period of years when their hoggs were grass-wintered the numbers of broken-mouths in the resultant casts were no lower, whilst the third said that only his gimmers were fed turnips and the numbers of broken-mouths were increasing. In another flock in which hoggs and gimmers only are turniped, 60-70% of the ewes are broken at $5\frac{1}{2}$ years old.

There was an almost equal body of opinion to the effect that the trouble was caused or at least accentuated in some way through the agency of rank heather, especially in hard winters. These views may not be soundly based because in other areas predominantly heather grazings are not necessarily associated with impaired dentition in the sheep although greater wear in the teeth may result from hard winters. Table 4 gives a general idea of the state of the dentition of sheep on grazings of broadly differing ecological types in this survey. For simplification, the incidence of broken-mouths is denoted by a grade (as in the last column of Table 2). The 'Heather' grazings are estimated to comprise 75% or more of heather, the 'Heather and Green' 50-75% of heather, whilst the 'Green' grazings are almost entirely of natural grasses.

The slightly better dentition on the 'Heather and green' grazings as compared with the 'Heather' is not sufficiently marked to deserve attention. A point of interest is that four out of the five 'Heather and green' grazings having sheep with a grade 1 (fairly good) dentition are associated with pure-bred flocks not receiving turnips in winter (and with lambing percentages below 100%). Unfortunately,

there are too few 'Green' grazings to obtain the much needed comparisons with the heather.

Genetic Influences

In view of the interchange of rams with outside areas (and the equal susceptibility of the strains at Glensaugh), the genetic influence can scarcely have relevance as a primary cause of broken-mouths. There were many references to the greater predisposition of ewes with over-shot jaws to the broken-mouth condition, whilst the importance to width and shortness of the incisors, especially at the younger ages, suggests that the genetic aspects of the dentition are all too frequently disregarded in the selection of breeding stock.

TABLE 4

Incidence of Broken-Mouths—Distribution of Flocks by Type of Hill Grazing

Type of grazing	Incidence of broken-mouths—graded *			
	1	3	5	7
Heather	3	4	6	5
Heather and green	5	1	4	2
Green	1	1	1	1

* 1 = 0-25% of cast ewes B.M. at 5½ years old
7 = 50-75% of cast ewes B.M. at 4½ years old } (see Table 2)

Winter Management

Flockmasters are reluctant to start routine supplementary feeding before mid-February, though hay is offered in periods of heavy snow or severe weather any time after the New Year. A few of the pure-bred flocks receive merely hay in storm, whilst in the mixed and crossing flocks, mild weather in January and February may effect economy in hand-feeding by the complementary use of hill and inbye grazings.

Information setting out the kinds of supplementary feeding, with the corresponding incidence of broken-mouths (graded) and the average lambing percentages for the three types of flocks is given in Table 5.

It will be observed that 9 of the 15 pure-bred, 9 out of the 10 mixed and the 8 crossing flocks received turnips, either with hay in storm, or concentrates as an addition. The rates of turnip feeding in the mixed and crossing flocks were very similar, averaging an acre of turnips for 35-40 ewes. Because of the difficulty of estimating yields

and the amount of waste, the rate of feeding cannot be accurately assessed, though it is probable that the daily intake of turnips will be in the region of 8-10 lb. per ewe (as at Glensaugh). In the pure-breds, there were only two flocks receiving such heavy turniping

TABLE 5

Kinds of Supplementary Food, Incidence of Broken-Mouths (graded) and Lambing Percentages (at Weaning)

Supplementary food	Incidence of B.M.s graded †	No. of flocks	% Lamb crop in each flock
Pure-bred flocks (15)			
Turnips and hay in storm	1	1	106
	3	1	100
	5	2	83, 111
	7	1	107
Turnips and concentrates *	1	1	100
	5	1	98
	7	2	90, 168
Hay (or oat-sheaves)	3	1	92
Hay (or oat-sheaves) in storm only	1	5	78, 80, 87, 90, 97
Mixed flocks (10)			
Turnips and hay in storm	5	1	92
	7	3	95, 100, 104
Turnips and concentrates *	3	1	107
	5	2	137, 152
	7	2	95, 100
Concentrates and hay	1	1	103
Crossing flocks (8)			
Turnips and concentrates *	3	1	150
	5	6	124, 125, 130 142, 143, 127
	7	1	125

* Inclusive of 2 flocks, in pure-bred, mixed and crossing respectively, to which concentrates are fed only to the poor ewes.

† 1 = 0-25% of cast ewes B.M. at $5\frac{1}{2}$
7 = 50-75% of cast ewes B.M. at $4\frac{1}{2}$ } (see Table 2)

and in these about 75% of the ewes were broken-mouthed at $4\frac{1}{2}$ years old. Most of the other pure-bred flocks received about half this quantity of turnips and with these is associated a much greater variation (between flocks) in the quality of the teeth than is characteristic of the mixed and crossing flocks. The majority of these latter flocks suffered a marked deterioration in the teeth and, together

with the two pure-bred flocks supplemented equally generously with turnips, they offer strong presumptive evidence of the turnips predisposing to the early breakdown of the teeth.

Except for one mixed flock supplemented with hay and concentrates, the main comparison with other kinds of feeding is obtained from the six pure-bred flocks receiving hay (or oat sheaves) as a routine supplement or in storm only. The superior dentition in these seven flocks is significant but unfortunately the lack of alternative supplementary feed to the turnip in the mixed and crossing flocks precludes comparisons in the three categories of flocks separately.

The average lambing percentages at weaning for each individual flock are given in the last column of Table 5. These percentages display considerable variation. The averages as a whole are high for hill going sheep and as might be expected from the differing intensity of the systems of husbandry, the lightest lamb crops are associated with pure-breds and the heaviest with the crossing flocks. Inspection of the data reveals an irregular correlation of the lambing percentages with the state of the dentition.

In the pure-breds, there appears to be a connection between the fairly sound mouths of the hay-fed flocks and the lamb crops, all of which are below 100%. If the flock with 168% of lambs is excluded, the remaining turnip-fed flocks average only 12% more lambs than the hay-fed so that this factor alone is unlikely to be responsible for the earlier breakdown in the sheep receiving turnips.

There is a general uniformity in the lamb crops in the mixed and crossing flocks. In the pure-bred portion of the mixed flocks the lambing percentage was similar to that in the lower producing pure-bred flocks. The overall percentage of pure and cross lambs in these flocks, if the 152% lamb crop is excluded, is only 5% more than in the turnip-fed pure-bred flocks yet the former suffered the greater wear in the teeth. Logically, therefore, it would seem that the breakdown in the teeth of the mixed flocks stems more from the heavier turnip feeding than from the crossing of a portion of the ewes with Border Leicester rams.

The crossing flocks produced about 30% more lambs than the mixed flocks and suffered lesser wear. This situation again appears to incriminate the turnip feeding rather than the greater intensity of cross lamb production.

There is no apparent connection between the method of turnip feeding and the breakdown in the teeth. As regards the methods, 8 flocks were reported to be fed on the break, 6 partly on the break and partly carted whole, 5 carted whole, and 6 carted and sliced.

Minerals were fed in approximately half of the flocks surveyed but without discernible effect in alleviating the deterioration in the teeth. The minerals were fed either as licks scattered on the hills or as powder mixed with the concentrate supplement.

Summer Management

The ewes were returned to the hill as soon as their lambs are properly 'roaded' though in some mixed and crossing flocks the ewes nursing twin lambs remain on the inbye whilst the remainder of the flock may be permitted the run of some inbye fields or hill reseed in conjunction with the hill grazing. Theoretically at least, the stresses arising from a ground deficiency or imbalance of minerals would be most severe in early lactation when the drain of minerals from the skeleton is greatest. Conceivably, it may be that the feeding of turnips—whatever is the precise nature of their dietary or mechanical effects predisposing to wear in the teeth—may render the ewes vulnerable to the change in diet imposed at a critical time when they return to the hill. Though in opposition to the frequently held views that turniping at the hogg stage is a major cause of deterioration in the teeth, the above line of reasoning is in accordance with the relative constancy of the broken-mouth problem in the mixed and crossing flocks, which draw their replacement hoggs and gimmers from a variety of sources within and without the area surveyed.

It would be interesting to have precise information on possible effects on the wear of teeth of retaining ewes nursing twins on the inbye. Experiments now in progress at Glensaugh should give a lead, within the next year or two, not only on this point but also on the long-term effects of turnip feeding in comparison with concentrates and hay feeding.

Drafting of Flock Replenishment

Contrary to expectations, there is little variation in the numbers of cast ewes or of young sheep introduced into the three categories of flocks. Some flockmasters reckoned their replacements in terms of hoggs, others in terms of gimmers, as shown in Table 6.

Surprisingly enough, the general pattern of replenishment in all these flocks deviates very little from that in other areas where five crops of lambs are taken before casting and flock mortality is fairly low (in the region of 5%). The number of casts may be slightly on the low side because no account has been taken of the occasional eild ewes sold in the fat market in early summer. Thus, apart from

TABLE 6

Numbers of Cast Ewes and Replacement Gimmers and Hoggs (per 100 Ewes)

Type of flock *	Cast ewes	Replacements	
		Gimmers	Hoggs
Pure-bred	21 (13)	27 (10)	29 (3)
Mixed	20 (10)	26 (5)	24 (5)
Crossing	21 (8)	29 (6)	26 (2)

* Numbers of flocks are shown in brackets.

the flocks most affected by broken-mouths having slightly higher through-put of ewes, the main economic consequence of the early breakdown of the teeth is the loss of revenue from the sale of broken-mouthed as opposed to whole mouthed ewes. The prevalence of broken-mouths in the southern fringe of the area surveyed may be gauged from the fact that at one of the cast ewe sales in the area surveyed in September 1956, only 47% of the crossed and uncrossed hill ewes on offer were warranted as whole-mouthed.

Almost all the cast ewes are sold for further breeding, regardless of the condition of the teeth, from which it may be inferred that after transfer to the kindlier environment on the low grounds they are not handicapped unduly by the impairment of their dentition. In the pure-bred flocks, it is to the flockmaster's advantage to draw the ewes for soundness of the teeth, because the whole-mouthed ewes may be worth about 20s. more per head than the broken-mouthed. The prices of crossed ewes are lower and, in consequence, it is not usually worth while in the crossing and mixed flocks to sort out a minority with whole-mouths. The method of presentng the cast ewes for sale in the flocks surveyed (Table 7) is consistent with the history of the dentition, discussed earlier in this report.

TABLE 7

Presentation of Cast Ewes for Sale by Soundness of Mouth

Type of flock	Number of Flocks		
	W.M. and B.M. * separately	W.M. and B.M. Mixed	All B.M.
Pure-bred	15	Nil	Nil
Mixed	1	6	4
Crossing	1	4	2

* W.M. whole mouth.
B.M. = broken mouth

There was remarkably little seasonal variation in the incidence of broken-mouthed ewes in individual flocks although in three of them the numbers had increased despite the constancy in the mode of husbandry-management.

Summary

The survey confirms a varying incidence of prematurely broken-mouths in Blackface hill-flocks in the north-east of Scotland. Whilst the presence of geological or ground association is inferred, the investigation supports the flockmasters' majority opinion that supplementary feeding with turnips is the main husbandry cause predisposing to the problem. The grazing of rank heather, especially in hard winters, was also advanced as a possible cause. This aspect could not be satisfactorily investigated because of the dominance of heather on practically all the grazings, though it is conceivable that such a diet accentuates the physiological stresses of the change when the ewes return to the hill in May.

As badly broken-mouthed ewes are not normally retained, the severity of the condition was gauged by reference to the ages and incidences of broken-mouths at casting. To facilitate the interpretation, this information was graded, as in Tables 2 and 5. In badly affected flocks, signs of the early breakdown of the incisors may be observed at $3\frac{1}{2}$ years old, and many of the ewes may be broken and are disposed of at $4\frac{1}{2}$ years old (as in the Organisation's flock at Glensaugh), whilst the proportion of broken-mouths at $5\frac{1}{2}$ years old, the normal time of drafting in the district, varies greatly between different farms.

All the flocks were run in regular ages of ewes though in the majority some or all of the ewes were crossed with Border Leicester rams, hence the classification into pure-bred, mixed and crossing flocks. With this classification (or indeed with any other), the difficulty was encountered of disassociating the many factors involved. The geology and soils were not specially investigated and, with reservations as to possible bias arising from these sources, the connection between turnip feeding and impared dentition in the pure-bred flocks appears to be reasonably certain. In the mixed and crossing flocks it would seem that the heavier turnip feeding takes precedence over the greater intensity of production through the crossing and twinning as a predisposing cause of the early breakdown of the teeth. Unfortunately, the turnip feeding cannot be incriminated categorically because of the absence (except for one flock with fairly sound teeth) of mixed and crossing flocks

receiving other forms of supplementation. However, the experiments now proceeding at Glensaugh should enable a more critical assessment of some of these points in a ~~farm~~ breeding flock.

Although there were a few flocks with relatively good dentition, these were pure-breeding (with one exception) and had the following features of management in common—no turnips were fed to hoggs or ewes, a low level of supplementary feeding, lamb crops in the region of 100% or less.

Practically all the cast ewes were sold for further breeding. The flock records showed that the only economic consequence of the broken-mouthed problem was a slightly greater through-put of ewes and the loss of revenue from the sale of broken-mouthed as opposed to whole-mouthed, ewes.

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A SURVEY OF BORDER CHEVIOT SHEEP

J. N. PEART

Introduction

The two principal breeds of hill sheep in Scotland are the Blackface and the Cheviot. Numerically, the Blackface exceeds the Cheviot by four to one and it is also more widely distributed throughout the country. There are two distinct types of Cheviot hill sheep—the North Country Cheviot, mainly found in the north of Scotland and the South Country or Border Cheviot, indigenous to the hill areas of the English/Scottish Border.

This survey is concerned with the Border Cheviot, the origin of which is obscure but which is believed to be native to the Cheviot hills. Originally, it was a small sheep, very light in bone and wool, with brownish head and legs and with a scraggy frame, bearing little resemblance to the improved Cheviot of to-day. The first recorded attempt to improve the Cheviot sheep was made at the end of the 18th century by Mr Robson of Belford, in Bowmont Water, who is reputed to have imported rams from a breed then existing in Lincolnshire. The cross was successful and improved the native Cheviot in every respect. Some authorities maintain that Robson's improvements were due to the use of Bakewell's Leicester, but there is some doubt about this. The impetus then given to breeding Cheviots was immense, and they quickly spread to other districts of Scotland and to Northern England. Under the influence of Sir John Sinclair and others, many improved Cheviots were taken to the north of Scotland about the year 1800 and from these the present North Country Cheviot has been bred. In many respects it closely resembles the improved Cheviot of the 19th century. Although many others were concerned with improving Border Cheviots, the next most noted breeder was Brydon of Moodlaw, who produced a very large type of Cheviot about 1850. Brydon's breeding methods are not fully known. It is believed that he selected from within the breed to secure size, but the possible introduction of some Leicester blood cannot be ruled out.

The severe winters and great snowstorms of 1869, 1884 and 1886 had a tremendous effect on the future of Cheviot sheep in the Border areas. In these storms many of the large improved Cheviots perished and, in consequence, hill farmers in the Borders started to breed a smaller type of sheep capable of withstanding such winters. It was

at this point that the differences between North Country and Border Cheviots began to appear. Within a comparatively short period the smaller type of Border Cheviot had been evolved. This suggests that there was a considerable degree of genetic variation within the breed and, therefore, selection towards a smaller sheep was not difficult. It is probable that during this trend towards a smaller sheep, differences in type arose within the Border Cheviot itself and produced the East and West types known to-day. During this evolution, the value of wool had dropped, and lamb production had become more profitable. Thus breeding policies were also directed towards meeting this new requirement and to meet changes in husbandry which were taking place at the same time.

The development of East and West type Border Cheviots is interesting in that, in meeting the changed conditions, the East breeders attempted to retain the character and fleece quality of the improved Cheviot whereas in the West the breeders appear to have concentrated on a smaller, blocky animal with less emphasis on fleece quality.

Border Cheviot breeders received a considerable setback to their efforts when, in 1910, a serious outbteak of Scrapie disease occurred in the breed and reached serious proportions by 1914. In their efforts to avoid or eliminate Scrapie, breeders were prevented from fulfilling their breeding policies.

For the production of the half-bred ewe, the sale of Cheviot cast ewes and ewe lambs was of considerable economic importance, and in the agricultural depression after the first World War, when lambs were of little value, the cast ewe trade was a particularly necessary source of income. This led to a concentration on 'style' and 'gay look' which attracted buyers. The influence of the show ring made itself felt in hill flocks and this is generally agreed to have had a detrimental effect on the breed. It seems probable that this emphasis on 'style' was more pronounced in East flocks and resulted in reduced production from the sheep under hill conditions. Following this there was a trend away from Border Cheviots and some hill farmers changed their flocks, or at least the higher lying hirsels, to Blackfaces. This change to Blackfaces was most active between 1940-45 but had almost ceased by 1949, and it is suggested that it was encouraged by marketing conditions imposed by wartime controls, which favoured the Blackfaced breed.

Object and Method of Survey

In carrying out a survey of the Border Cheviot breed, it was intended to record the present state of the breed with particular

reference to its productivity and current breeding methods. The flocks surveyed were selected throughout the area where the breed is maintained in appreciable numbers so as to give a representative sample. It is characteristic of Border Cheviots that nearly all flocks breed rams for use within the parent flock. Many, but not all of these are subsequently offered for sale. Thus, because all flocks surveyed breed rams, the survey is not, therefore, biased towards the more prominent ram breeding flocks.

Visits to sheep breeders commenced in December 1956 and terminated in March 1957. A total of 47 flockmasters were interviewed of which 39 were able to provide suitable date ~~and information~~. In determining the statistical data, average figures covering recent years have been used.

Area Surveyed and Type and Size of Farm

The farms surveyed are situated in the following districts:—

The Cheviot Hills, North Northumberland, Eskdalemuir, Ettrick Valley, Moffat, Lockerbie, Langholm, Nith Valley and West Linton.

The area covered is outlined on the map on page 75.

Of the 39 farms from which data were obtained, 33 are true hill farms with flocks almost entirely dependent on the natural hill grazings which range up to 2600 feet altitude. These hills are typically 'white' ground and generally only small areas of heather are encountered. Topographically, the hills are rounded and are very exposed, having little natural shelter and few plantations of trees. Except in severe snowstorms no winter feeding is practised although some farms, particularly in Eastern areas, may feed hay over a period in spring if necessary.

The remaining 6 flocks are on semi-lowland farms and are maintained in fields, some having an outrun to hill ground. They receive supplementary feeding in winter, but their main source of food is grass.

The farms vary greatly in size, the true hill farm varying from 300-6000 acres and the inbye farms from 310-995 acres. In total area the farms surveyed covered 68,436 acres.

Stocking Rates and Flock Size

On the true hill farms the stocking rates are a direct reflection of the winter carrying capacity of the hill grazings and the standard of husbandry practised. The average sheep stocking rate is 1·7 acres per sheep, with a range between farms of 1·2-2·5 acres per sheep.

A variation in stocking rate was found between hills on the same farm, the best hills having a stocking of 1 acre per sheep. The distribution of stocking rates on hill farms is given in Table 1 where the majority are shown to be within the range of 1·5-1·99 acres per sheep.

MAP SHOWING AREA CONTAINING FARMS SURVEYED

TABLE 1

Sheep Stocking Rates of Hill Farms

	Acres per sheep	No. of farms
	1·2-1·49	8
	1·5-1·99	18
	2·0-2·49	7
Average	1·7	33

The stocking rate of the inbye farms bears little relation to farm size but is influenced by the system of farming and the area of ground devoted to the sheep enterprise.

Excluding rams, the average size of hill flocks is 1001 ewes plus 246 ewe hoggs the size varying within the range of 160 ewes plus 40 ewe hoggs to 2700 ewes plus 700 ewe hoggs. In comparison with other breeds of sheep, particularly in England and Wales, the flock size is large. Thus in the average flock there are sufficient numbers to permit a considerable degree of selection towards breed improvement and no limitations are imposed in this respect. As these flocks are managed under the hefting system on the hill, this also is an aid to breed improvement in that each heft of ewes could be used as a breeding group for progeny testing.

Lamb Crops, Prolificacy and Fertility

The average percentages of lambs at marking, ewes producing twins and ewes barren are presented in Table 2. The percentages are based on the numbers of ewes and gimmers at tupping each year.

TABLE 2

Average Annual Percentages of Lambs at Marking, Ewes producing Twins and Ewes Barren

	Lambs marked %	Ewes producing twins %	Ewes barren %
Hill flocks	85·2	6·2	4·2
Inbye flocks	110·3	22·4	2·8

Twenty-five per cent. more lambs are reared from the inbye flocks than from the hill flocks, mainly due to the increased numbers of twins and fewer barren ewes. Some account must be taken of fewer losses in inbye flocks, but it is impossible to assess the difference with accuracy.

The twinning rate of the hill ewes is based on recorded information, but because these data are difficult to obtain by flockmasters it is possible that the actual twinning rate is rather higher than the figures given. It was reported in some flocks that fewer twins are born than formerly and it is suggested that in these flocks, twinning has been bred out. However, when considering individual flocks, there are many which produce well above the average number of twins. It seems, therefore, that by selection within the breed this deficiency of twins could be remedied. About one-third of the flockmasters

expressed a wish for more twinning but stipulated that only a small increase was desired. In hill flocks no attempt is being made to have twin-bearing ewes as general policy. Whilst it is appreciated that more twin lambs would increase production, the summer grazings are not considered good enough to support ewes nursing twin lambs. Therefore, any policy directed to produce appreciably more twins would have to be coupled with improvements in summer grazing, better nutrition of the pregnant ewe and changes in husbandry to cater for these new developments. The problems associated with increased twinning appear to be more economic than genetic.

Fertility of ewes and gimmers, as indicated by barrenness, is satisfactory under the conditions of management. There was little evidence of any veterinary problem associated with conception rates. In contrast with former years, it is now common practice to breed from gimmers and in considering the rate of lamb production it is apparent that the gimmers are producing their share of the lamb crop, indicating that they are sufficiently mature to do this.

Wool Crop

As shown in Table 3, considerable variation in average fleece weights was found between hill flocks, and it is interesting to note that this also occurred in the inbye flocks, where differences in nutrition might be expected to be less. This suggests that there is sufficient genetic variation of fleece growth character within the breed to permit selection for increased wool production, if this was deemed desirable.

TABLE 3

Average Fleece Weights of Ewes, Hoggs and Tup Hoggs

	Ewes		Ewe hoggs		Tup hoggs	
	Average weight lb.	Range lb.	Average weight lb.	Range lb.	Average weight lb.	Range lb.
Hill flocks	4·1	3·0-5·4	4·4	3·2-5·5	6·9†	5·0-10·0
Inbye flocks	4·8	3·8-6·5	5·1	4·0-6·5	5·8*	5·5-6·0

† Average of 13 farms only.
* Average of 3 farms only.

It is interesting that hill flocks which have above average ewe fleece weights also have higher lamb production, indicating that at these levels, the heavier fleece is not incompatible with lamb production and fertility. From an analysis of some data from the

Cheviot flock at Sourhope a high correlation has been found between the autumn ewe live weight and the succeeding wool crop. It has been found in a Cobalt dosing trial at Sourhope, that the dosed ewes produced heavier lambs at weaning but had lighter fleece weights than the undosed ewes. It is possible, therefore, that under some condition, maximum wool production may not be compatible with production of the heaviest lambs at weaning.

Authorities writing about 1875 quote fleece weights of Cheviots as being in the order of 2·5-3·0 lb. From the present average figure of 4·1 lb. for ewes it is apparent that fleece weights have been appreciably increased during the past 75 years. Although the object of most flockmasters is to produce a heavy fleece of good quality, quality in many flocks is now of secondary importance to quantity. This is partly due to the present market conditions in which the extra monetary return for higher quality does not compensate for the lower quantity. Some farmers associate kemp in the fleece with hardiness and maintain that if kemp is bred out the sheep will lose hardiness. The very dense fine fleece with a short staple is not favoured and preference is shown for a more open fleece of larger staple. This more open type fleece is claimed by many farmers to be a character of heavy milking ewes. It is also claimed to be a better protection for the sheep in areas of high rainfall.

In considering further increases in fleece weights, flockmasters were of the opinion that for average hill conditions an average weight of about 4·5 lb. would be the optimum It was suggested than an increase beyond this weight would encumber the sheep in snowstorms and might have serious consequences. Further, when a heavy fleece is saturated by rain it takes longer to dry out.

Flock Mortality

The data contained in Table 4 show that the annual mortality rates in both hill and inbye flocks are very similar. The mortality rate is reasonably low and under the conditions of management there seems little scope for reducing deaths. The figures quoted do not take account of losses which may occur in exceptionally severe winter storms such as in 1947.

Flock Wastage and Replenishment

Both hill and inbye flocks are maintained in regular ages and ewes are regularly cast when they reach casting age. However, ewes

TABLE 4

Average Annual Death Rate

	Ewes %	Hoggs %
Hill flocks	4·3	3·6
Inbye flocks	4·4	3·5

which have proved exceptional breeders may be retained in the flock beyond this. The vast majority of flocks now cast at $6\frac{1}{2}$ years old, although a few still cast ewes at $5\frac{1}{2}$ years.

A statement of average annual flock wastage and replenishment is contained in Table 5 in which the data has been classified according to type of flock and casting age.

TABLE 5

Average Annual Flock Wastage and Replenishment

	No. of flocks	Casting Age	Percentage of total flock			
			Ewe deaths	Cast ewes	Culls	Gimmers
Hill flocks	3	$5\frac{1}{2}$	5·1	21·2	2·2	28·5
	30	$6\frac{1}{2}$	4·2	17·5	3·1	24·9
Inbye flocks	2	$5\frac{1}{2}$	5·5	18·1	7·8	31·5
	4	$6\frac{1}{2}$	3·9	17·1	1·4	22·5

With the exception of those inbye flocks which cast at $5\frac{1}{2}$ years old, the average culling rate of young sheep is very small. This indicates that the quality of the ewe hogg intake each year is sufficiently high to warrant them being retained in the flock as adult sheep. The favourable lamb crops provide an average of 38% ewe lambs surplus to requirements for flock maintenance. This allows a high degree of selection at weaning, thus eliminating the necessity for heavy culling in subsequent years. Only one hill farm retained an abnormally high proportion of ewe hoggs which were subsequently heavily culled as gimmers.

From the evidence contained in Table 6 there is very little wastage due to broken mouths in ewes under $5\frac{1}{2}$ years old. However, at this age quite a high percentage of ewes in the inbye flocks are broken-mouthed at casting age, in contrast to the position in hill flocks.

TABLE 6

Average Percentage Broken-Mouthed Ewes at Casting

	No. of flocks	Casting age (yrs.)	Av. % broken mouths
Hill flocks	2	5½	1·5
	30	6½	3·0
Inbye flocks	2	5½	16·5
	4	6½	18·0

Selection of Ewe Lambs for Stock

The selection of ewe lambs to be retained for flock maintenance is made at weaning when they are about four months old. Lambs retained are mainly those which are the largest, conform to breed type and exhibit no obvious defects. Thus, within the limits imposed by breed type, ewe lambs which have made the greatest live weight increases since birth are inevitably retained. In the event of the crop of ewe lambs in any year not being up to normal standards, as few as possible are retained provided sufficient are kept to maintain flock numbers.

Breeding Policy

Seventeen flocks within the survey are pursuing a definite line breeding policy, two are being bred to a limited number of flocks rather than to any particular strain, and the remaining twenty flocks are being out-crossed.

Close inbreeding was generally condemned as being detrimental to the constitution of the sheep. Nevertheless, by the very nature of breeding methods, there must be in many flocks a close relationship between the sire and dams.

Methods of Tup Breeding

Unlike breeders of Blackface sheep, Cheviot flockmasters prefer to use home-bred tups. It is claimed that the progeny from home-bred tups are better suited to the local environment and therefore thrive better. It also preserves uniformity of type within the flock, which adds to the value of cast ewes and surplus ewe lambs. Except in small flocks where it is obviously impossible without close inbreeding, the great majority of tups used are home-bred. This is illustrated in Table 7 where it is shown that in hill flocks 72·4% of tups used are home-bred compared with only 22·3% in the smaller inbye flocks. The effect of flock size on the proportion of home-bred tups used is further emphasised when hill flocks of more than 600 ewes are compared with those of less than 600 ewes.

TABLE 7

Average Percentage of Home-Bred Tups used in Flocks

	Homebred tups %
All hill flocks	72·4
Inbye flocks	22·3
Hill flocks of more than 600 ewes	76·4
Hill flocks of less than 600 ewes	42·7

This demonstrates the greater scope of larger flocks for progeny testing and their greater potential for making genetic improvements within the breed. It is interesting to note, however, that four of the largest flocks in this survey are not at present offering tups for sale.

Depending upon requirements, exceptionally good tups are bought to mate with selected ewes and it is from these matings that tup lambs are selected for use as shearlings within the remainder of the flock, being subsequently sold at 2½ years old. The Cheviot Sheep Society maintains a flock book in which tups can be registered and, although not all tups offered for sale are registered, the pedigree of the sire is usually made known. Selection of stud tups is greatly influenced by breed type, pedigree, and reputation of the flock supplying the tup. It is impossible to classify these considerations in order of importance. Breeders who are breeding within a particular strain, are seeking the best sheep within that strain, those who are outcrossing pay particular attention to breed types and flock reputation.

Most stud rams are bought at 2½ years old and have been used as shearlings in the parent flock. It is often possible, therefore, to obtain information about a tup's progeny which can assist a prospective purchaser to assess the tup's breeding potential. Shearling tups are sometimes borrowed for the tupping season and then returned to their owners. In this way, a flockmaster can assess how well that tup might breed within his own flock.

Although most breeders are satisfied with the quality of tups for sale, a substantial number remarked on the scarcity of outstanding sheep available for flock improvement. This lack of outstanding tups is surprising considering the number of line bred tups available. In their endeavour to maintain breed type. which involves selection for several factors—often on a phenotypic basis, breeders may be limiting breed improvements in other directions. On the the other hand, in view of the history of the breed it may be that lines of

breeding are not sufficiently fixed to be prepotent and the selection of qualities from within breed type may not have reached fruition.

Written records of ewe flocks are very rare and within known breeding, the selection of ewes for tup breeding is mainly dependent on the knowledge and memory of flockmasters and shepherds. Selection of ewes is based on their performance under hill conditions. Pedigree and conformity to breed type are important factors but may be secondary to performance. Because of this emphasis on productivity, the vast majority of tup lambs retained for breeding are from older ewes. Gimmers are rarely selected for breeding tups and only occasionally are young ewes. This preference for breeding tups from older ewes also reduces the chance of close inbreeding on the hill, because the dams are often cast before their progeny reach service age. Therefore, this allows greater freedom of use of the progeny within the flock.

Tup lambs which are likely to be retained for breeding are often specially marked at birth, when they are easily identified with their dams. The first selection is made at marking when the lambs are about 6 weeks old. At this time about 80% are from tups and ewes of known breeding and which comprised the stud flocks. The remaining 20% are drawn from the main ewe flock and the pedigree of these may not be fully known. Whilst these latter may be of good conformation and representative of the breed, it was remarked that they were seldom as good breeders as those of known pedigree. The initial selection of tup lambs at 6 weeks old is at a time when the milking capacity of the ewes is reflected in the growth of the lambs. Therefore, by a first selection at this early age, a bias is given in favour of progeny from the heavy milking ewes.

Culling of Tup Lambs

The culling rate of tup lambs between initial selection and sale at 2½ years old is given in Table 8, from which it is seen that about 50% are culled.

TABLE 8

Culling Rate of Tups between 6 weeks and 2½ years old

	Average remaining of 100 tup lambs retained at 6 weeks				
	At 6 months	At 9 months	At 18 months	At 21months	Total Culls %
Hill flocks	79·0	65·0	51·0	46·0	54·1
Inbye flocks	75·4	62·0	58·0	50·0	50·0

The dominant feature of culling is phenotypic selection within known breeding. The greatest reduction is made by the time they are 9 months old, this weeding out being done to eliminate faulty lambs before wintering. Subsequent culling is also based on phenotypic selection and any sheep unlikely to repay the expenses of additional feed before sale are discarded.

Culling of Old Rams and Frequency of Outstanding Rams

Stud rams purchased to improve the flock are sometimes tested by being given a limited number of ewes in the first breeding season. But good tups are expensive to buy and not many flockmasters are prepared to limit their use in this way. If a tup breeds indifferent stock he will be withdrawn from the stud flock and used as a commercial tup or will be discarded. From the information obtained, it is considered that an average flock secures an outstanding ram once in 7 years. This amounts to about 4% of all tups used each year. Outstanding rams are usually retained for their entire breeding life. Sometimes, however, particularly in smaller flocks, they are resold for breeding elsewhere.

The average life of home-bred tups is 6·0 years and that of purchased tups, 5·6 years. It is not unusual to find tups still in use at 8 years old or even older. Some of the smaller flocks cannot use home-bred tups for their entire working life because of inbreeding, which emphasises the advantage of the large flock in progeny testing and breed improvement. The comparatively long breeding life of Cheviot tups makes possible the use of proven sires based on a progeny test.

Modern Breeding Objectives

Although the Cheviot is still classed as a late maturing breed there is evidence that it is now maturing earlier than formerly. Traditionally, Cheviot ewes were not mated until $2\frac{1}{2}$ years old but now it is common practice to mate them at $1\frac{1}{2}$ years. Nearly all breeders consider the present rate of maturing to be ideal for the breed. It was suggested that, if Cheviots were bred for earlier maturity, the breed would lose its position in providing lambs for spring fattening and the value of cast ewes would drop. At the same time, some emphasis is being placed on producing a fat lamb at weaning age and, with some breeders, this trend is taking precedence over the cast ewe trade. This is evident by the priority given to mutton conformation and the lack of attention paid to fancy points which used to attract buyers of cast ewes. To attain

the objective of fat lambs at weaning, the milking ability of ewes was stressed as being of great importance. About three-quarters of flockmasters credited their ewes with ample milking qualities. but the remainder were of the opinion that improvements were necessary. As the selection of both tup and ewe lambs for breeding purposes is based on retaining the best nursed lambs provided they conform to breed type, in general it is the progeny of the heavier milking ewes which are being retained in the flock. However, excessive adherence to breed type as the dominant factor in selection may preclude the retention of progeny from the heaviest milking ewes This practice must, therefore impose limitations to the advancement of the breed in respect of milking ability.

The influence of showing sheep and the introduction of show yard types to hill conditions was generally considered to have had a bad effect in the past. One-third of the flockmasters in this survey still considered that showing is having a bad effect on the breed in general. The majority, however, consider that awards made in the show yard have very small influence on the selection of tups for breeding on the hill and therefore no harm is being done at present.

Summary and Conclusions

1. From a survey of Border Cheviot sheep it appears that under their conditions of environment and management they attain a high standard of production.

2. The percentage of barren ewes is reasonably low and no veterinary problem of fertility appears to exist. In some hill flocks there is a shortage of twin-bearing ewes. However, all lowland and many hill flocks have ample twins and therefore the genetic capacity for twinning must be inherent in the breed.

3. Wool production is being increased, but there is a tendency to neglect wool quality.

4. Emphasis is now being placed on the production of fat lambs at weaning and less importance is attached to fancy points which enhanced the value of cast ewes.

5. The influence of the show yard type of sheep which had a detrimental effect in the past now appears to have little effect on the choice of sheep for hill conditions.

6. The dentition of sheep is very good and flock wastage from broken-mouths is small.

7. The comparatively good lamb crops permit a high degree of selection for ewe lambs for stock. This reduces the necessity for heavy culling as they mature.

8. Nearly all Cheviot breeders rear tups for use within the parent flock which are subsequently sold. Therefore, the future of the breed does not rest in the hands of a few specialist tup breeders. This may account for some diversity of type within the breed but should not prevent individual breeders making outstanding improvements.

9. There is evidence that the emphasis placed on breed type when selecting breeding stock may be a limiting factor to improvement in specific directions. This is particularly applicable to selection for milking qualities.

10. The hefting system of management and the method of tup breeding provides considerable scope for breed improvement by selection of tups based on a progeny test or on performance of their half sisters. Nearly all tups are sold at $2\frac{1}{2}$ years old, that is, before their half sisters can be assessed on a production basis. Under commercial conditions, this is an economic necessity which prevents breeders making full use of their breeding system.

11. Cheviot tups are comparatively long lived and this makes possible the use of proven sires.

12. The very high rate of culling within tup lambs retained for breeding suggests considerable genetic variation within individual flocks and indicates that in many flocks genetic lines are not well fixed in the parent stock. This lack of prepotency to breed true probably accounts for the scarcity of good rams for breed improvement.

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THE EFFECT OF SOME TREATMENTS IN AUGUST ON ON THE PERFORMANCE OF A PASTURE SWARD BETWEEN SEPTEMBER AND JANUARY AND THE SUBSEQUENT EFFECTS IN SPRING

I. A. NICHOLSON and M. R. SAMPFORD *

THE production of grass for consumption *in situ* by grazing animals in autumn has attracted considerable attention in recent years and, at Glensaugh this problem has been studied in relation to hill farming conditions. The earlier work was concerned with the use of reseeded hill pasture for wintering ewe hoggs while, more recently, attention has been paid to increasing the production of late autumn grass on inbye land and its more efficient use by cattle. In several trials, observation showed that certain manurial treatments in late summer, combined with grazing in late autumn and early winter, had marked beneficial effects on spring growth.

An experiment was therefore laid down in 1954 to determine the relationship between some late summer and autumn treatments and spring production, using a two year old cocksfoot dominant temporary pasture at an elevation of 550 feet. The experiment was originally laid down in four randomised blocks each of 20 plots, the 20 treatments applied comprising all combinations of four cutting dates (21st September, 26th October, 29th November, and 26th January) and five nitrogen treatments (no nitrogen, N_0, and the four combinations of two levels of nitrogen, N_1 = 15 lb. and N_2 = 40 lb. per acre, with two dates of application, T_1 = 6th August and T_2 = 27th August). To investigate the effect of nitrogen applied in spring on the responses to the previous year's treatment, nitrogen at the rate of 35 lb. per acre was applied on 1st April to ten plots in each block, so selected as to convert the original design into a partially confounded arrangement.

Autumn Yields

When no nitrogen was applied, the highest yield was obtained from those plots cut in October, the yield falling off thereafter. Application of nitrogen at the low level resulted in an increased yield at all cutting dates for both dates of application: there was, however, a marked interaction between date of application and cutting date

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in those plots receiving the lower level of nitrogen. With early application, the yield in October was only slightly greater than that for September while subsequently it fell off so that the January yield was well below that for September. With late application, on the other hand, the increase to October was considerable, and the subsequent falling off slight: yields were about the same for T_1 in September, and rather higher in later months. Application of nitrogen at the high level resulted in a further increase in yield at all cutting dates, with very little difference between dates of application: the maximum yield was brought forward to September, with a steady decline subsequently.

It is noteworthy that the percentage loss of dry matter from the peak yield was greatest when no nitrogen (22%, as compared with 18% and 7% for N_1 at T_1 and T_2, and 16% for N_2 at both times of application).

Mean Dry Matter Yields (1 lb. acre)

Cut	N_0	N_1T_1	N_1T_2	N_2T_1	N_2T_2	Mean
Sept.	1015	1344	1306	1834	1777	1455
Oct.	1222	1386	1453	1670	1657	1477
Nov.	1168	1210	1420	1560	1623	1396
Jan.	948	1131	1352	1548	1500	1296
Mean	1088	1268	1383	1653	1639	

Standard error of difference for { two means in body of table = 129·3. / two cuts = 57·8. / two treatments = 64·6.

Spring Yields

The plots were cut in mid-May, and again at intervals of six weeks until September.

The August nitrogen and autumn cutting treatments had a residual effect in May, and in subsequent cuts. The application of heavy nitrogen dressings in August increased the May yield by 23% when no nitrogen was applied in spring: when spring nitrogen was applied the increases were 7% for an early August dressing, and 16% for a late August dressing. A low August application had little effect, on the average, but peculiar results were obtained for early August application: these differences may be due to chance (they are not quite statistically significant), and they do not appear to be applicable in terms of botanical composition. Evidence from further experiments will be necessary to decide this point.

Mean Responses of August Treatments to Spring Nitrogen in terms of May Yield (lb./acre)

		N_0	N_1T_1	N_1T_2	N_2T_1	N_2T_2	Mean	
Spring Nitrogen	N_0	493	444	489	600	608	527	S.E. of difference = 30·1
	N_1	1227	1354	1220	1312	1427	1308	
Mean		860	899	854	956	1017		

S.E. of difference = 47·6

S.E. of difference of two means in body of table = 67·3

Late cutting in autumn increased the May yield: January defoliation gave increases over September defolitation of 63% in the absence and 19% in the presence of a spring nitrogen application. The general trend was similar for all the August nitrogen treatments.

Mean Effects on May Yield of August Treatments and Time of Defoliation in Autumn (lb./acre)

		N_0	N_1T_1	N_1T_2	N_2T_1	N_2T_2	Spring nitrogen N_0	Spring nitrogen N_1	Mean	
Autumn Cut	Sept.	722	920	749	821	902	440	1205	823	S.E. of difference = 42·6
	Oct.	894	818	754	895	947	404	1320	862	
	Nov.	915	854	924	847	1029	554	1274	914	
	Jan.	910	1004	990	1260	1192	716	1432	1071	

S.E. difference = 95·2

S.E. of diff. = 60·2

At the second cut, taken at the end of June, there was evidence that these trends were reversed.

It is clear that the interactions between late summer and autumn manuring and management and nitrogenous top dressing in spring require further study, but results from this experiment suggest that by adopting certain management techniques late in the season, a substantial increase in production may be obtained in practice at two periods of the year when pasture growth is limited.

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