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CONTENTS

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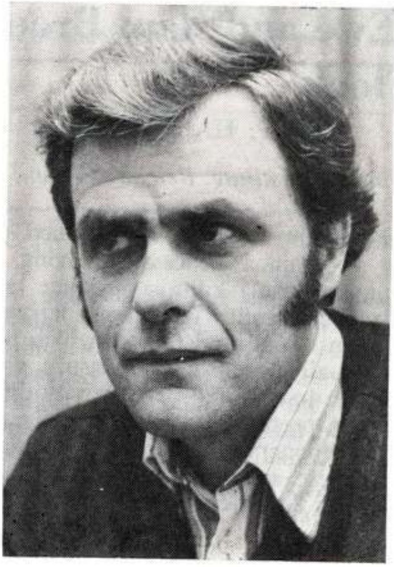

JOHN FLOOD

AN APPRECIATION

The untimely death of our President, John Flood, leaves a big void not only in the direction of the Association's activities but also in the drive for progress in Irish farming.

Until 1976 he was closely associated with the development of Premier Meat Packers, Sallins, after which he specialised in intensive beef production and winter cereals on his farm at Newhall, Co. Kildare. By quickly adopting new methods and technology he soon became an outstanding farmer with total commitment to development and progress.

He was a trend setter and always willing to share his deep knowledge of farming business with others. He spoke at several meetings of the Association and members benefited significantly from his analyses of farming problems and on how to overcome them. His advice, which he freely gave, was highly valued by all.

He was unanimously elected President of the Association at the Annual General Meeting at the Spring Show on May 1st, 1984.

John was a man of outstanding sincerity with a warm and kindly personality. As a sportsman he was very interested in rugby and was deeply involved in the training and development of the youth in his locality.

The Association extends its sympathy to his wife Maura, sons Fintan, Tadgh and Shane, to his parents and the other members of his family.

May he rest in peace.

Aidan Conway, Vice-President

Choice of Ewe and Ram Breed for Lowland Flock

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Lowland sheep farming in Ireland is concerned primarily with meat production and is a complex process involving the combination of animals, land and managerial skills to produce lamb for a variety of market outlets and make a profit. When considering the choice of breeds attention is focussed on the animal factors which influence profitability. Research does not usually attempt to measure profitability in animal experiments but argues that animal productivity differences are basic to long term differences in profitability. Accordingly, research has concentrated on the main components of variation in animal productivity and with information on these and their relative importance producers can make informed decisions about choice of breed.

In this paper discussion is confined to traits which are likely to influence animal productivity and to the evidence on breed differences. In the light of these differences present breeding policies and future prospects are examined in the context of how increased productivity can be achieved by rational breed choice and effective use of national breed resources.

EFFICIENCY

The efficiency of meat production can be considered as the fundamental component influencing choice of breed. It may be defined for an individual ewe or flock as

$$\frac{\text{Total carcass weight produced}}{\text{Food consumed by ewe(s)} + \text{food consumed by lamb(s)}}$$

Consideration of this definition shows that about 60% of the food input is required to maintain the ewe for twelve months. It is also evident that the more lambs produced per ewe per year the better the efficiency. Likewise lambs which grow faster will have a lower feed requirement and hence yield improved efficiency and, since heavier ewes have higher maintenance requirements, the size of the ewe also has an influence on the efficiency of production.

Litter size and efficiency. A summary of the relative efficiency for ewes of a given size that rear 1, 2, or 3 lambs is given in Table 1 and shows that prolificacy (litter size at birth) has a major impact on efficiency provided that the extra lambs are reared.

Table 1

Effect of number of lambs on relative efficiency of meat production

Ewes suckling	Relative efficiency
Singles	100
Twins	131
Triplets	156

Adapted from Large (1970)

Lamb growth rate and efficiency. Experimental evidence on the influence of growth rate on efficiency has shown a very small positive effect. Likewise the effect of carcass weight is quite small for a given carcass quality. Lamb growth weight is influenced by the milking ability of the dam as well as the growth potential of the off-spring. Breed differences in maternal ability may be summarised by saying that crossbred ewes from hill breeds are generally better than other types.

Ewe size and efficiency. The influence of ewe size on efficiency highlights the interaction between animal performance and other inputs and leads to the conclusion that ewe size per se is not a fundamental issue. Thus, research results in Britain have shown that matching ewe size and stocking rate gives similar gross margins per acre for small Welsh Mountain ewes producing one lamb and much larger Greyface ewes producing two lambs. However, when compared at the same litter size the smaller ewe type will give a higher efficiency. Experimental results are summarized in Table 2 and show that a ewe breed with a high bodyweight producing mostly single lambs represents the wrong choice.

Table 2

Effect of ewe size and number of lambs on relative efficiency of meat production

Ewe size (kg)	No. of lambs	
	Singles	Twins
58	124	158
78	100	138

Adapted from Large (1970)

Lambs reared per ewe joined. The foregoing discussion has shown that the number of lambs per ewe has a major impact on efficiency. What evidence can be produced to show that such experimental differences in efficiency can affect the profitability of the sheep enterprise ? There is now a considerable amount of data to answer this question. The evidence from one source is shown in Table 3 which summarises gross margins from The Agricultural Institute's Blindwell farm. Between 1977 and

1980 the ewe flock at Blindwell consisted of different ewe types of similar bodyweight but with different genetic potential for prolificacy. The results show that ewes with the highest prolificacy gave the highest gross margin per ewe. The average effect was that gross margin per ewe increased by approximately 13% for each increase of 0.1 in the number of lambs reared per ewe joined with the ram. Farm survey data from lowland flocks in Ireland have shown the same increase of 13% in gross margin for each increase of 0.1 in lambs reared per ewe (Fingleton, 1978). Results from recorded flocks in Britain yielded values between 11 and 13% for the increase in gross margin per ewe for each change of 0.1 in the number of lambs reared per ewe joined (MLC, 1975).

Thus, it is clear that increasing the number of lambs reared per ewe is a major source of increased profitability.

Table 3

Effect of litter size on the number of lambs reared and gross margin per ewe

Year of comparison	Breed of ewe	Ewe weight (kg)	Litter size	Lambs reared per ewe joined
1977 and	Galway	68	1.33	1.05
1978	Improved Galway	63	1.68	1.37
Extra Gross Margin earned by Improved Galway = 42%				
1979 and	Suffolk x Galway	72	1.66	1.30
1980	Improved Galway	67	1.87	1.59
Extra Gross Margin earned by Improved Galway = 40%				

Factors determining number of lambs reared per ewe

The number of lambs reared is expressed per ewe joined with the ram because it is the number of ewes joined which represents the investment in the flock for the years production and also accounts for most of the food costs. The number of lambs reared per ewe joined with the ram is determined by three components :

(a) the proportion of ewes which lamb
(b) litter size
(c) lamb survival

Proportion lambing. Ewes fail to lamb either because they are barren or they died between joining and lambing. While breed differences in the rate of ewe deaths have not been carefully studied the incidence is low and consequently there is little room for improvement by choice of breed. The rate of barrenness varies a little with breed but these differences are often negatively associated with breed differences in prolificacy. The breed of ram used for mating dces not have a significant effect on the incidence of barrenness except possibly in out-of-season matings. As a general rule 95% of ewes should be pregnant after a joining period of

six weeks. Prolific breeds usually give higher lambing proportions than less prolific breeds under the same conditions.

Litter size. There is plenty of evidence for breed differences in this trait and hence full attention should be devoted to these when choosing a ewe breed.

Lamb survival. The proportion of lambs which survive depends largely on management factors, litter size and ewe age. Breed differences in lamb survival are small when comparisons are made at the same litter size and age. Two experiments in the Institute, one conducted between 1961 and 1965 and the second from 1966 to 1972, used a variety of purebred and crossbred ewes and no significant differences in lamb survival were found. The average rate of survival to weaning for single, twin and triplet born lambs in the Institute's Blindwell flock between 1977 and 1982 were : singles 93%, twins 88%, triplets 78%. (In all cases lamb survival is expressed relative to the total number of lambs born, whether live or dead). From these figures it is evident that as flock average litter size increases the rate of lamb survival will decline somewhat.

BREED DIFFERENCES

Ewe breeds. Data from various breed comparisons in the Institute under lowland conditions, during the past 25 years are summarised in Table 4. This table shows average litter size and number of lambs reared per ewe joined with the ram. The breeds listed were not all in a single trial but litter size differences between breeds were assembled from various trials and used to construct the breed averages shown. The resulting mean litter sizes were then used to predict the number of lambs weaned per ewe joined. This was calculated by using information on litter size distribution as a function of average litter size and applying the average lamb survival data quoted earlier from the Blindwell flock. A value of 0.94 was assumed for the proportion of ewes lambing. It should be borne in mind that, for any given breed, litter size depends on ewe age, bodyweight and other management factors. (The means for Cheviot and Scottish Blackface ewes in Table 4 refer to flocks maintained under lowland conditions).

The data in Table 4 show that when the objective is 1.5 lambs reared per ewe joined then this requires a ewe breed with a genetic capacity to achieve an average litter size of at least 1.8 under average conditions.

Sire breeds. The term sire breed refers to the use of rams in a production system in which all lambs are destined for slaughter. The important criteria in making choices among breeds for this purpose include lamb survival, growth rate and the ability to produce carcases of a quality which is most suitable for the intended market. Carcass weight is also a consideration since it is generally more efficient to produce meat from heavy carcasses provided quality is not affected and other factors are also unchanged. The relative importance of these various criteria will depend on the production system. Thus, a farmer aiming to have all lambs sold for slaughter by the end of August and not in early lamb production

Table 4
Average litter size and number of lambs reared for different ewe breeds and crosses

Ewe breed type	Litter size	Lambs reared per ewe joined
Galway	1.45	1.21
Cheviot	1.60	1.31
Scottish Blackface	1.75	1.42
Belclare Improver	2.00	1.59
Suffolk x Galway	1.58	1.30
Suffolk x Cheviot	1.68	1.37
B. Leicester x Cheviot	1.70	1.39
B. Leicester x S. Blackface	1.70	1.39
Galway x Cheviot	1.56	1.29
Galway x S. Blackface	1.56	1.29
Improved Galway	1.80	1.45
Improved Cheviot	1.90	1.52

might need to use a sire breed whose progeny reach the appropriate level of finish at a light carcass weight. Regardless of the production system carcass quality is very important and must be judged with reference to export market requirements. In this context quality means a light to medium fat cover on a carcass with good conformation.

As a general rule breeds of small mature size (like the Southdown) reach a given level of carcass fatness at lower carcass weight than large breeds like the Suffolk or Oxford Down. However, breeds differ little in fatness if killed when they reach the same proportion of mature weight. Thus, given a particular breed the optimum carcass weight is determined.

Results from sire breed comparison on growth rate, carcass fatness and conformation will be summarized and the differences can be used in conjunction with individual production requirements in making breed choices.

From a number of studies in Ireland and Britain it is clear that the Suffolk and Oxford Down sired lambs grow faster than lambs sired by Texel rams and reach a fixed slaughter weight 1 to 2 weeks earlier. The differences among these breeds in carcass weight for a given level of fatness are rather small. These studies have also shown that Oxford Down cross carcasses have a poorer conformation than either Suffolk or Texel crosses with little difference between the latter breeds although the Texel is better than the Suffolk. Table 5 contains a summary of breed differences in growth rate and carcass traits. The major difference is the low fat content of Texel cross carcasses at a given carcass weight. This difference translates into an advantage of about 1 kg in favour of the Texel for carcass weight at a given level of fatness.

The difference between the Suffolk and Texel breeds for lamb growth rate may depend on the type of ewe with which rams from these breeds

Table 5

Relative performance of various breeds used as terminal sires

Breed	Relative performance for		
	Growth rate	Carcass fat	Carcass weight at fixed fatnes
Suffolk	100	115	95
Texel	96	100	100
Oxford Down	100	115	94
Dorset Horn	98	115	—
Galway	96	113	—

are mated. Thus, at Blindwell we have compared Suffolk and Texel rams on Galway type and Suffolk-cross ewes. The differences in lamb growth rate are summarized in Table 6 and show that for the progeny of Suffolk-cross ewes Texel sired lambs grew faster than lambs sired by Suffolk rams. In the case of Galway type ewes the Suffolk sired progeny grew significantly faster than those sired by Texel rams.

Table 6

Interaction between breed of sire and breed of dam for lamb growth rate

Sire breed	Dam breed	
	Suffolk cross	Galway type
Suffolk	100	100
Texel	101	95

In production systems where the objective is to finish all lambs off pasture, breed differences between the date at which lambs are suitable for slaughter may be the most important consideration. Results are shown in Table 7 which are taken from the study conducted in Britain

Table 7

Effect of ram breed on lamb marketing pattern †

Ram breed	Percent lambs sold by end of			
	June	July	August	September
Southdown	12	44	72	92
Suffolk	6	17	42	67
Texel	4	18	44	66
Oxford	2	10	26	54

† These data refer to twin lambs sold at the same subcutaneous fat grade from March lambing flocks (MLC, 1983)

by the Meat and Livestock Commission. The Southdown sires produced lambs which reached the appropriate level of finish at a carcass weight of 16 kg and were sold much earlier in the season than other breeds which produce carcasses weighing between 19 and 20 kg. The Oxford Down crosses produced the highest carcass weights and were the latest to reach slaughter condition. The differences between Texel and Suffolk were small.

No significant differences have been found between sire breeds for the survival rate of their crossbred offspring.

Table 8

Preliminary survey results on ewe and ram breeds in lowland flocks

Breed	1981	1982
	Ewe replacements (%)	
Suffolk-cross	61	66
Galway	28	24
Other	11	10
	Rams used (%)	
Suffolk		70
Galway		9
Oxford		5
Texel		3
Other		13

DISCUSSION

The foregoing results summarise the major differences in breed performance which influence productivity in the lowland sheep flock and indicate the choices which are available to producers. It is easy to change the sire breed used but changing the breed of ewe usually involves a planned programme over a number of years. This implies the need for planned production of ewe replacements since the range of ewe types listed in Table 4 is not readily available in the market place.

It has been shown earlier that ewe prolificacy has a major impact on flock productivity. However, the present structure of our sheep industry places very little emphasis on the production of ewe types with the necessary genetic capacity for high prolificacy. This is revealed by an examination of the breed composition of the lowland flock. Preliminary results of a survey of lowland sheep flocks are given in Table 8 and show that Suffolk crosses predominate in the ewe replacements presently being introduced into lowland flocks. There is little contribution from hill cross-breeds which are among the most prolific ewe breeds available (Table 4). This breed pattern differed only slightly when home bred hoggets (60% of total) were compared with purchased hoggets. Likewise, an examination of the survey results shows that 78% of all rams in use on lowland farms are either Suffolk, Oxford or Texel with the major fraction being Suffolk.

This breeding pattern means the terminal sire breeds are dominating sheep production and implies that very little planning is involved in the production of ewe replacements. Unless this process is changed our lowland sheep industry is destined to remain at an output level less than 1.3 lambs reared per ewe joined with the ram while our main competitor on the export market (Britain) is producing in excess of 1.4 lambs per ewe to the ram. The breed composition of our lowland flock needs to be changed by choosing ewe replacements with the genetic capacity to produce a litter size at birth of 1.8 under average conditions.

The execution of such a change requires planned allocation of flock resources since it can only be effected over a number of years. At individual farm level, replacement ewes can be homebred. With a ewe replacement rate for lowland flock of about 22% and at current levels of output, this requires mating of about 40% of the ewe flock to produce the necessary replacements. On a national scale cast hill ewes should be used to produce replacements for lowland flocks. Given current levels of lamb output and stock mortality in hill flocks and assuming that hill ewes can produce two lamb crops after being culled from the hill, then about 40% of the lowland ewe replacements could be crossbreds out of Scottish Blackface and Cheviot dams. With this level of contribution from hill ewes only 25% of lowland ewes need to be used to produce replacements, thus allowing the remainder to be mated with terminal sire breeds for prime lamb production. With a more prolific lowland ewe population an even smaller fraction would suffice. Increased productivity in hill flocks (lower mortality of ewes and lambs and better fertility) would enable cast hill ewes to provide a greater proportion of ewe replacements.

If the planning implied by these figures combined with the choice of ewe breeds discussed earlier were implemented then lamb output from lowland flocks could be rapidly increased to the target of 1.5 lambs per ewe.

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Mid-Season Lamb Production

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The size of our national ewe flock reached 1.80 million in December 1983, the highest since 1974 (C.S.O. Dublin). Sheep incomes in recent years have been very attractive (AFT Farm Management Survey 1981-1983) and the best incentive of all to encourage production is a good income per ewe and per hectare.

It is in the last three years or so that ewe numbers have increased. This strong revival of interest in sheep has occurred at a time of general recession all round and at a time when the financing of other livestock systems has become increasingly difficult. But there is enormous scope for further expansion as proven by the continuing difficulties of export factories to procure adequate supplies of quality lambs and by the continuing deficit in the EEC.

Re-Appraisal of the Role of Sheep Production

For a number of special reasons, therefore, it is now time for a national re-assessment of the role of sheep production in the agricultural economy, particularly on lowland farms.

1. In response to difficulties regarding CAP, it is necessary that we expand into products that are not in surplus. Sheep meat is such a case and in fact the EEC is only 74% self-sufficient in lamb — the present deficit is equivalent to 260,000 tonnes of sheep meat.
2. Lamb production enterprises are financially attractive and the top one-third of lowland sheep producers earned about £640 gross margin per ha (£260 per acre) in both 1982 and 1983 (AFT Farm Management Survey). These producers have shown that there is a way forward and clearly indicate that a landowner free to choose must consider sheep for high income from his farm.
3. Sheep farm development costs are moderate compared with other types of livestock. Most farms already have some buildings or a yard which can be converted for in-wintering a flock of ewes.
4. Sheep research information is now available to show how to produce 22 lambs sold per ha from 15 ewes stocked per ha.

Although these levels of productivity have been proven over many years at Creagh, Belclare and Blindwell, there appears to be a lack of conviction at farm level that high stocking rates are practicable in the case of sheep. While intensive lowland sheep units are common practice in Britain and New Zealand, sheep enterprises in this country have been very much subordinate to a predominantly cattle economy. This traditional role of sheep farming has resulted in lack of organisation and in lack of good management in many flocks.

We must, therefore, confront these issues by applying available information to develop specialised sheep enterprises and to achieve real growth in the industry. Such an approach must be based on the principles of intensification established by research. The purpose of this paper is to illustrate how sheep farm productivity can be significantly increased by translating research results into farm practice for spring lambing flocks.

Let us examine present levels of flock productivity and compare them with a sheep unit where the principles of intensification have been applied. Table 1 shows the average performance of lowland flocks in the Institute's Farm Management Survey and the performance of Improved Galway ewes at the Institute's farm at Blindwell. (This unit is used for the application of research results under commercial conditions). The survey shows that in lowland flocks both output per ewe and per ha are much lower than those achievable by using research information on ewe productivity and stocking rates. Methods of bridging this gap in productivity will now be discussed.

Table 1

Mid-season lamb production systems
(Farm Management Survey, The Agricultural Institute)

	No. flocks	No. lambs reared/ewe joined	No. ewes /ha
South Leinster 1978-1982	109	1.30	7.9
Galway/Roscommon/ So. Mayo 1978-1982	205	1.24	6.2
	No. ewes		
Blindwell 1977-1982 Improved Galway Flock	611	1.49	15.0

Output per ewe

The number of lambs reared per ewe joined with the ram is the main determinant of flock productivity. The immediate target in lowland fat lamb flocks is 1.5 lambs reared per ewe joined with the ram. To achieve this, an average litter size of 1.8 is required in order to allow for barrenness and mortality. The genetic resources available for improving average litter size are discussed elsewhere in this Journal.

Output per ha

Research results at Belclare clearly show that an annual stocking rate of 15 ewes per ha (6 ewes per acre) can be carried on dry land using suitable N fertiliser applications.

Nitrogen for grazing

The optimum amount of N for sheep grazing depends on the stocking rate and clover content of the sward. Dates of lambing and of turnout to grass in spring are also important in so far as they affect the demand for early grass.

Responses in sheep production to varying levels of N applications have been measured at Belclare. Table 2 shows the effect of N and stocking rate on average weaning weight of lambs in flocks with 1.4 lambs reared per ewe grazing. Duration of grazing was from April 1 to September 5 and lambs were weaned in early July.

Table 2

Effect of stocking rate and nitrogen on average weaning weight of lambs (kg) (Grennan, Belclare 1979-1981)

Ewes/ha	12	17	21	25
(Ewes/acre)	(5)	(7)	(8.5)	(10)
Nitrogen kg/ha				
67	31.5	30.5		
134		32.0	29.0	
201			31.3	29.0

The main conclusion from Table 2 is that increased use of N fertiliser allows higher stocking rates to be carried. Similar lamb weaning weights were obtained in 12 ewes/ha with low N, at 17 ewes/ha with medium N and at 21 ewes/ha with high N. At a fixed level of N, increases in stocking rate depressed average weaning weight.

The results in Table 2 relate to grazing only. Annual stocking rates will be lower because part of the grazing area must be closed for silage conservation in summer. Recommended annual stocking rates and the appropriate N dressings for free draining land are given in Table 3. These recommendations are based on farmlet system trials conducted by E. Grennan at Belclare.

Table 3

Nitrogen dressings for mid-season lamb production

	Annual stocking rate ewes/ha		
	10	12	15
Kg N/ha			
February 1	33	50	33
April (1st grazing)	—	30	33
May (2nd grazing)	—	—	—
August	—	—	33
Silage aftermaths reserved for grazing: 33 kg N/ha			

Silage

Silage is the most reliable and efficient form of grass conservation on highly stocked farms. Although hay continues to be an important winter feed on many sheep farms, it is difficult to make good quality hay consistently in our climate. Moreover, as stocking rates increase to 12 ewes per ha or higher, sufficient areas of pasture cannot be closed for hay without increasing the grazing pressure excessively. A two-cut system must be adopted and this necessitates making silage.

For a silage feeding period of about 100 days, requirements are estimated at 1 kg silage DM/ewe/day, equivalent to 0.6 tonnes per ewe of silage freshweight at 17% DM.

MANAGEMENT CALENDAR

Let us consider a grassland management programme which incorporates silage making at 15 ewes per ha. General guidelines for a 20 ha (50 acres) farm are given in Table 4 and these should be interpreted to

Table 4

Grassland Management Calendar for 300 ewes on 20 ha

	1.5 lambs reared/ewe joined 450 lambs reared 15 ewes/ha 0.6 tonnes silage/ewe December to March : Pasture rested		
March 15-April 15	April 15-June 21	June 21-Sept. 1	Sept. 1-Dec. 1
Flock turnout 15 ewes/ha 20 ha grazed	17 ewes/ha 16 ha grazed 4 ha silage (20%) Cut silage June 1 Wean June 21 Draft lambs for sale	42 lambs/ha Draft lambs for sale 44 ewes/ha 4 ha silage (20%)	Remaining lambs sold or removed Breeding season 15 ewes/ha 20 ha grazed

suit individual farm conditions. For example, in tillage areas, stubble grazing, beet tops, etc. from late November to early January reduce the silage feeding period to about 70 days or 0.4 tonnes silage per ewe. The main features of the calendar shown in Table 4 will now be described.

Spring grazing

At flock turnout the amount of pasture on offer for grazing at Belclare is normally about 550 kg DM per ha. Research by W. Sheehan at Creagh has shown that the daily feed requirements of the ewe in lactation are approximately double her requirements before lambing. In terms of pasture with 70% DMD a lactating ewe with twins needs to consume about 12 kg freshweight per day in order to satisfy her nutrient requirements for maintenance and milk production. This amounts to about 1.8 kg DM/ewe/day on spring grass with a moisture content of 85%.

Thus, with 550 kg pasture DM on offer per ha the carrying capacity is 16 ewes and their lambs per ha for about 3 weeks. Afterwards in April, grass growth accelerates.

After lambing, ewes and lambs are transferred to pasture which has been rested for the winter and they are grazed over the whole area in small groups initially to avoid mismothering, building up to 15 ewes per ha about April 1 when lambing is fully complete. After about 3 weeks ewes and lambs are grouped together in flocks not exceeding 150 ewes, for convenience in management up to weaning. Thus, there would be 2 groups of 150 ewes on the sheep unit described in Table 4.

Meal supplements are not normally required after flock turnout, when pasture has been rested and adequately fertilised with P and K in winter and with N as described in Table 3. But in a cold spring, grass growth will be poor and 1 kg meal supplement/ewe/day should be fed until grass supply is adequate.

Grazing method and number of paddocks

At high stocking rates, rotational paddock grazing is preferred to set stocking. The main advantages in a rotational paddock system are in better overall management and as an aid in allocating grass between the needs of ewes and lambs, and for conservation. Paddocks can be reserved for special needs, such as, early grass or flushing, and ewes can be confined to a small area after weaning when their feed requirements are low. A minimum of 6 paddocks is recommended and 8 to 9 paddocks provide greater flexibility when part of the farm is closed for silage, when ewes and lambs are grazed separately after weaning and when ewes in poor body condition require extra attention for flushing.

Grazing time per paddock varies from 3 to 6 days depending on the current supply of grass and the rapidity of re-growth.

Silage conservation

In mid-April decisions on silage conservation must be made. The amount of silage required for 300 ewes is 180 tonnes and this is conserved in 2 cuts as follows: The whole pasture area is grazed at 15 ewes per ha until mid-April. Then 4 ha are closed for silage and the remaining area is grazed at 17 ewes per ha until weaning in June using a rotational grazing system. The silage is cut about June 1 and, at an average yield of 25 tonnes per ha, about 100 tonnes are conserved. A further 4 ha are closed at weaning and cut in August which, at an average yield of 20 tonnes per ha, produces on additional 80 tonnes of silage. Hence, sufficient silage is conserved by closing 20% of the area for the early cut and 20% for the late cut.

Weaning

Lambs are weaned at 14 weeks of age and they are weighed and handled so that finished lambs can be identified for sale. Lambs are

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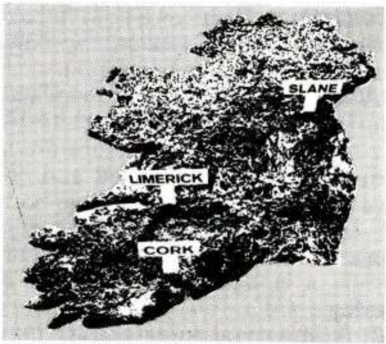

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After weaning, ewes are stocked at 44 ewes per ha until mid-August and lambs are stocked at 40-44 per ha initially, and declining to 12-15 per ha in September as lambs are sold out. In mid-August the ewe flock should be condition scored and ewes in poor body condition should be given extra grazing to improve bodyweight. It should be noted that after the late cut silage in August, 20% of the farm is released for grazing again.

Dosing

It is important to emphasise that growing good grass and maintaining a high stocking rate of 15 ewes per ha does **not** mean problems from worm parasites. There are now excellent drugs on the market which were not available in the distant past and sheep farmers should seek advice on dosing programmes for their flocks.

Breeding season

With a grazing intensity of 15 ewes per ha the whole pasture area is required from September onwards for the ewes. At Blindwell where the level of intensification is similar to that described here, the proportion of lambs which do not reach the target slaughter weight of 41 kg in autumn has been 24-30%. These lambs are either transferred to forage crops elsewhere for winter finishing or sold.

The importance of good ewe body condition at mating is well recognised. Research has shown that increased levels of feeding of the ewe before mating (flushing) increase the number of lambs born. The length of the flushing period depends on ewe body condition. A period of 3-4 weeks on good grass before ram turnout should be adequate to obtain the desired response. On average the gestation length in the sheep is 21 weeks and mating should be arranged for mid-October so that lambing begins in mid-March. Flushing should therefore begin about September 21. 2Rams (raddled) are turned out in mid-October and remain with the ewes for 5 to 6 weeks.

Winter management

After mating is completed, the ewes are flocked in one group, grazed for one rotation around the paddocks and transferred to the wintering area about December 1.

In early pregnancy high levels of feeding are unnecessary and should be avoided. A moderate level of feeding, even giving a small loss of 7.8% of bodyweight, will suffice.

But in the final 6 weeks of pregnancy over 75% of foetal growth occurs and, consequently, to satisfy the high foetal requirements for nutrients at this time the level of feeding must be increased. Results show that silage will not be consumed in sufficient quantities by ewes in late pregnancy to give satisfactory lambing performance. It is necessary to supplement the silage in late pregnancy with concentrates commencing with 0.25 kg/ewe/day at six weeks before lambing and increasing to 0.75 kg/ewe/day in the final fortnight.

Details of feeding and flock management are given in Handbook Series No. 20, Sheep Production, published by the Agricultural Institute, 19, Sandymount Avenue, Dublin 4.

Synchronised breeding

In traditional practice, rams are joined with ewe flocks for 6 to 8 weeks during the breeding season. This results in a protracted lambing season. The progestagen-impregnated intravaginal sponge is a cheap, simple and effective method of synchronising oestrus during the breeding season. The sponges are placed in the vagina, using a speculum, for 12-16 days and practically all the ewes are in oestrus on the second day after sponge removal. The lambing pattern following synchronisation has two phases, with ewes lambing to the post-treatment oestrus (60-90%) over a period of about 9 days, then a period of about 7 days with very few ewes lambing; this is followed by the ewes that held to the second post-treatment oestrus lambing over a period of 8 days or so.

To illustrate this general pattern, a summary of the reproductive performance of the spring-lambing flock at Blindwell is shown in Table 5. In this flock the percentage of pregnant ewes which lambed to the synchronised mating was 82%. Of those, 90% lambed over a 1-week period with a mid-week peak. By planning the dates of insertion and removal of sponges, peak lambing at week-ends can be avoided.

Compact lambing is applicable mainly in flocks of 250 ewes or less; it is necessary to organise a 'ram pool', i.e. one ram per 10 ewes.

Table 5

Reproductive performance of Blindwell flock following oestrous synchronisation with vaginal sponges
(Data pooled for 1978-1982)

	No.	%
Ewes treated	1,036	
Ewes died	12	1.2
Ewes barren	46	4.4
Ewes aborted	23	2.2
Ewes lambed to synchronised mating	780	75.3
Ewes lambed subsequently	175	16.3
Ewes lambed to synchronised mating — as a % of all ewes lambed	82%	
Ewes lambed over a 7-day period — as a % of all ewes lambing to synchronised mating	90%	

Sheep Farm Production Targets and Income

Using the research results on sheep breeding efficiency and grassland management as described, the production targets for spring lambing flocks are shown in Table 6.

Table 6

Sheep farm production targets

1.	Ewes lambing %	95.0
2.	Litter size	1.8
3.	Lamb mortality %	13.0
4.	No. lambs reared/ewe joined	1.5
5.	N fertiliser kg/ha	150
6.	No. ewes/ha	15
7.	Average carcass wt kg	18
8.	No. lambs reared/ha	22.5
9.	Carcass output kg/ha	400

Let us now estimate the profit margin arising from this level of productivity. Assuming an average carcass price of 242p per kg and using current costs the gross margin per ha is estimated as follows :

	£/ha	
400 kg carcass @ 242p	968	
Wool @ £4/ewe	60	
Ewe premia @ £13.13	197	
	——	1225

Direct costs

1. Fertilisers for grazing		
5 bags 0.10.20 @ £146/tonne	36	
10 bags C.A.N. @ £125/tonne	63	
2. Silage 0.6 tonnes/ewe @ £12/tonne	108	
3. Meals* 50 kg/ewe @ £190/tonne	143	
4. Vet/medicine @ £1.60/ewe	24	
5. Ewe depreciation @ £8	120	
6. Casual help @ £1.50/ewe	23	
7. Shearing, transport	20	
	——	537
Gross margin per Ha		688

* Includes meals for ewes suckling triplets and for artificial rearing.

Facilities for labour productivity

To achieve the targets set out earlier, some basic flock management facilities are required. These are : wintering unit, stockproof fencing, water distribution around the farm and a good set of handling pens. Details on the construction of these facilities are available at Belclare.

Wintering arrangements vary from outdoor slatted platforms to enclosed straw bedded houses. Although outdoor units can be constructed cheaply and provide a basic 'off the land' wintering system, there has been a general preference for covered sheds. The main reason for this preference is that it provides a good working environment for the stockman, routine inspection of the flock can be carried out quickly and individual ewes which require attention can be treated promptly.

The cost of sheep housing varies widely depending on whether the work is done by the farmer or contractor, quality of materials, etc. Costs have ranged from £10 per ewe to £50 per ewe for straw bedded sheds. A concrete pad to accommodate a silage clamp, a power loader with fork grab for feeding silage and a transport box for sheep are also required.

Good fencing and water supply to the grazed paddocks are essential for effective grassland management and flock control. New electric fencing systems for sheep are now available and they can be installed under contract for 80-100p per metre depending on ground topography. To reduce the work load in sheep management a good sheep handling unit for collecting and sorting the flock, for drenching, vaccination and foot bathing means less man hours tied up with these routine jobs and allows more time for planning and general management of the farm.

The total cost of these developments for a modern 20 ha (50 acre) sheep farm with 300 ewes is shown in Table 7. This assumes that there are no existing facilities. The total net cost amounts to £16,290. Most sheep farms require some or all of these facilities. This will mean investment on most sheep farms to increase productivity per man, in addition to productivity per ewe and per ha.

Table 7

Facilities for 300 ewes (£)

	Cost	Grant	Value of Grant	Net Cost
1. Sheep house @ £40	12000	20%	2400	9600
2. Silage concrete pad @ £10/tonne	1800	20%	360	1440
3. Machinery	2250	—	—	2250
4. Fencing 1700 m @ 80p	1400	—	—	1400
5. Water distribution	500	20%	100	400
6. Handling pens	1500	20%	300	1200
TOTAL	£19450			£16290

SUMMARY

Although the introduction of wintering systems and improved management on some farms is encouraging, productivity in terms of the number of lambs reared per ewe and per ha has not changed for 30 years or more in lowland flocks. The two main constraints are firstly, the inherently low litter size of our existing ewe breeds and secondly, lack of grazing management technique for 12-15 ewes per ha.

Research results have shown clearly that the production targets for mid-season lamb production are 22 lambs sold per ha from 1.5 lambs reared per ewe stocked at 15 ewes to the acre. These targets involve a change to new ewe breeds not yet familiar to many traditional sheep farmers and the implementation of paddock grazing systems for high stocking rates.

Before it is decided to increase sheep stocking rates, existing deficiencies in flock management, e.g. high ewe barrenness rate, low litter size or high lamb mortality, should be rectified. In the process of sheep intensification, increases in stocking rate should be phased over 2-3 years in order to give adequate opportunity for the stockman to develop confidence in flock management procedures at high stocking rates.

Output per man is also an important feature of production efficiency. Obviously, facilities which reduce the work load in a sheep flock will result in more time for managing the farm generally and for managing other enterprises.

In conclusion, if we are to take advantage of the opportunities which the sheep market now provides, we must modify traditional practice on many sheep farms and move productivity into the modern era. Overseas markets are likely to become increasingly competitive and if we fail to modernise our production industry, the comfort derived from price rises in recent years may turn out to be transitory.

Sheep Farming in England: Specialist Sheep Units with Full Time Shepherds

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In recent years the Association organised two Sheep Farm Study Tours in England, initially in 1980 and again in 1984, in order to examine breeding and management skills underlying the high levels of flock productivity being achieved in top performance lowland flocks. This report describes the main features observed on the 1984 tour and their relevance to Irish conditions.

The flocks were specially selected by the U.K. Meat and Livestock Commission and they were located in Hereford, Hampshire and Wiltshire. The overall impression was one of high productivity based on prolific ewes rearing 170-200 lambs per 100 ewes joined and stocked at 6-8 ewes per acre over the grazing season. Flock size was generally of sufficient scale to justify the employment of a full-time shepherd. The main aspects of productivity are summarised here under the various headings.

Flock records

In order to discuss flock productivity in a meaningful way, it is first of all necessary to measure it by keeping basic flock records. On all farms visited it was clear that flock records were available and these provided a solid basis for discussing barrenness, mortality and profitability. Flock records on Irish farms are generally notable by their absence and in order to improve this situation the necessary records are listed in Table 1 together with current targets. It should be noted that the average performance in U.K. flocks is 143 lambs reared per 100 ewes joined which is lower than that seen on the tour.

Table 1

Records on components of output per ewe

		Target
1.	No. of ewes joined	100
2.	No. of ewes barren	3
3.	No. of ewes dead	2
4.	No. of ewes lambed	95
5.	Total no. of lambs born	175
6.	No. of lambs born dead	10
7.	No. of lambs reared	150

Prolific ewes

Mule ewes (the progeny of Blueface Leicester rams on Swaledale ewes) are used widely. Of the many breeds and crosses in the U.K. the Mule is the most prolific; the number of live lambs born per ewe lambed is 1.76 on average and 1.89 in the top ⅓ of flocks.

In clear recognition of the importance of prolificacy and particularly litter size, there has been rapid expansion of Mule flocks on lowland farms in England and unproductive breeds have been replaced. In response to the demand, hill farmers have produced them commercially in large numbers. Hill and lowland sheep farming in the U.K. are highly integrated, with mutual advantages to both hill and lowland producers.

Irish flocks on average produce 1.25 lambs reared per ewe joined compared with 1.43 in the U.K. Consequently, to remain competitive on export markets productivity per ewe needs to be improved substantially. This means organising a programme for the production of prolific ewes. The basis for immediate action already exists. Belclare Improver ewes have yielded a litter size of 2.0 at Blindwell over a number of years and rams have been located on commercial farms for upgrading our traditional ewe breeds. In hill areas the Department of Agriculture has introduced Blueface Leicester rams for crossing with hill ewes to produce fat lamb mothers for lowland farmers.

The Suffolk is the main ram breed used in England for fat lamb production but on some farms the Dorset Horn is preferred because of its earlier maturity.

Stocking rate and nitrogen use

Stocking rates are 6-8 ewes per grass acre using flexible systems of paddock grazing together with high quality fencing.

Nitrogen fertiliser is generally applied at rates of 200-220 units per acre through the grazing season. Under Irish conditions 6 ewes per acre can be maintained on dry land using 150 units N per acre.

Specialist sheep units

Unlike Ireland where sheep are very much subordinate to a predominant cattle economy, in England sheep have replaced cattle on many farms, mainly because of lower investment costs and higher net income.

The basic approach to flock management is considerably more specialised than in Ireland and sheep enterprises are practised on a scale which justifies the employment of a skilled shepherd full-time. Whilst there is a strong tradition of shepherding, two farms on the tour employed head shepherds from non-farming backgrounds.

Flock size on the farms visited varied widely from 300 ewes to 3000 ewes. There were many common features, however, on all farms. High quality fencing, paddock grazing, high stocking rates, low cost feeding and wintering systems and detailed care and attention to critical points of management are given priority.

In mixed tillage/sheep units, the grass 'break' consists of a 2-3 year ley which is heavily stocked at 6-8 ewes per acre over the grazing season and winter feeding is based on forage crops sown after winter barley is harvested. The double cropped area is then ploughed for spring barley.

Thus, sheep and arable crops are fully integrated with advantages for both; sheep grazing benefits the next crop in the rotation through better soil fertility and arable farming benefits the sheep by providing low cost winter feed. Another major advantage is that reseeded pasture is free from worm parasites. Also, on tillage farms sheep are the cheapest and quickest livestock enterprise to exploit short term leys through intensive grazing.

Fencing

Both permanent and temporary electric fencing systems for sheep are widely used. High tensile 5-strand electric fencing is now commercially available in Ireland costing 80-100p per metre erected by contract. Trials at Belclare and Blindwell have proved its effectiveness; not only is it stock proof for ewes and lambs but it is also a deterrent against marauding dogs.

An interesting semi-permanent fence was seen on Chilbolton Down Farms near Stockbridge. This is a 3-strand system costing 38p per metre. It is easy to erect by using a wheel barrow type machine geared for reeling out the wire and is capable of carrying up to 4 reels at a time.

Conventional sheep-wire fencing is common but wire quality is superior to ours. A 14-15 cm mesh is preferred in order to reduce the possibility of sheep becoming entangled in the wire. The contract charge for erecting this type of fence is £15 sterling per 50 metres.

Breeding management

Particular attention is devoted to the preparation of both ewes and rams for the breeding season. Although Mule ewes are inherently prolific they are also subject to management. It is worth noting again that although the average value for lambs born alive per ewe joined is 1.76, in the top $\frac{1}{3}$ of flocks it is 1.89 and this increase is very likely due to superior management.

After weaning, ewes are 'tubed' on some farms with long acting cow intramammary antibiotic (half a tube per teat).

Flushing of ewes before mating is given major priority in the management calendar. In addition, rams are fed meal supplements for a few weeks before joining with ewes and on one farm they were fed 120 g/ram/day for 3-4 weeks before mating and 450 g/ram/day during the mating season. If there are doubts about semen quality, it is tested.

On some farms with lambing in early spring, teaser rams are used for about 16 days before fertile rams are turned out, in order to get the rams to cycle and synchronise heat. On other farms where lambing is later in Spring, teaser rams are not used because ewes have entered their natural cycle at mating time.

For spring lambing flocks the benefit of using teaser rams in Irish conditions is very doubtful. To ensure an effect, ewes must be totally isolated from rams during the summer. It is in the August/early September period that the use of teaser rams would be of likely value.

Housing and winter shearing

Both indoor and outdoor ewe wintering systems are practised depending on individual farm conditions. On one farm waste ground with shelter was available and ewes were wintered there on hay and meals. In this case the cost of building a sheep house was considered uneconomic.

Three of the flocks visited were housed. The sheds varied in type from traditional barn type structures to purpose built sheep houses. Significantly, the flock with highest profitability and far exceeding the top ⅓ of of MLC recorded flocks was housed in an existing barn, cheaply constructed and modified to accommodate in-lamb ewes penned in groups of 50. Silage is block fed once a week on both sides of a central passage. The shed is straw bedded with 1 bale per pen every two days. About 23 kg concentrates per ewe were fed as supplements, generally in nut form with 14% crude protein content.

In this flock also, which technically and financially is very efficient, winter shearing has proved very satisfactory and in the words of the flock owner "you must shear if you house". Experience at Belclare shows that ewes shorn shortly after housing produce lambs with increased birth weights; they require less floor and trough space than unshorn ewes and were easier to manage Although no problems have been encountered on turn-out in spring to date, caution against turning out shorn ewes in bad weather is advised.

Forage roots

Outdoor wintering is practised in the largest sheep enterprise seen on this tour, nmely 3000 ewes grazing stubble turnips *in situ*. Average rainfall is 840 mm compared with 1175 at Belclare and the soil is predominantly light loam over chalk.

After tupping on new leys, the ewes are transferred to stubble turnips after Christmas and in late February ewes are transferred to lambing paddocks and fed hay and meals during lambing. The stubble turnips, 250 acres variety Toronda, are sown within one week of harvesting winter barley, using disc cultivation and 1.2 kg seed per acre broadcast with a fertiliser spinner together with 0.5 kg rape. Seed and fertiliser cost £24 per acre which is equivalent to £2 per ewe.

Shepherding at lambing

Since ewe wintering on roots is essentially an outdoor system, lambing down the flock is considered to be an outdoor operation also. However, a high degree of organisation in the preparations for lambing and in care and supervision is implemented.

After grazing stubble turnips, the 3000 ewe flock is transferred in groups of 300 to a series of 3 acre paddocks, equipped with individual pens along the fence line, for lambing. Each pen is constructed with 10 straw bales with one pen provided for every 10 ewes lambing i.e. 3000 bales for 3000 ewes.

Because lambing is concentrated into a 3-4 week period temporary helpers are hired to assist the three full-time shepherds. The temporary staff are students who report to the head shepherd a week prior to lambing and are given instructions and a short course on skills in lambing down ewes. Video and slide displays and practical demonstrations are used. Each temporary helper is given responsibility for lambing 300 ewes and work from 6 a.m. until darkness. Supervision during night-time is not considered necessary and any problems receive immediate attention in the morning.

To deal with individual ewes or lambs which require extra attention or nursing, each helper has access to a tractor and transport box to convey problem animals to a central nursing/fostering unit located in the main yard. An experienced shepherd supervises this unit and deals with weak lambs, fostering and other problems. Such a facility enables the helpers to return to the lambing paddocks without delay and continue their work without undue interruption.

It is this organisational approach which is largely responsible for the high levels of 170-200 lambs reared per 100 ewes in the top performance flocks. Fostering is a central feature of lambing husbandry with as many ewes as possible suckling twin lambs by taking one of triplets and cross fostering to single rearing ewes.

Success in fostering is more easily accomplished in large flocks where ewes are lambing rapidly and where fostering is done before the foster mother has adequate time to distinguish her own lamb from the fostered lamb.

In indoor lambing, ewes and lambs were held indoor for periods of up to two weeks in order to allow lambs to get strong before turnout. Ewes are lambed from group pens into individual pens where they remain for 24-48 hours and are then transferred to other buildings and group penned until turnout.

Triplets suckling ewes

On some farms triplets remain suckling on the ewes at pasture and in other cases, two lambs are left on the ewe and the extra lambs are artificially reared. The economics of artificial rearing are questionable and the rearing of triplets on the ewes is effective where meal supplements are fed to the ewe at pasture together with meal creep feed for the lambs. Triplet rearing ewes are grazed separately.

Lambing to weaning

Ewes are run in groups of 150 or so with their lambs on pasture, although the 3000 ewe flock was managed in groups of 600 on 100 acre blocks. Rotational grazing or creep grazing are not practised. The shepherd decides when it is time to change to a new field.

All the flocks visited were spring lambing and early marketing was not a priority in view of the extra costs which would be incurred. The objective is to achieve high output per acre at low cost and lambs are drafted for sale from June to Christmas.

On one all-grass farm meal supplements are fed to lambs after weaning at the rate of 120 g/lamb/day to prevent lambs entering a store phase. In the 3000 ewe flock lambs are not weaned until September and unsold lambs are finished on new leys and stubble turnips by December. On some farms weaning is delayed until August if grass is plentiful.

Lamb marketing

Lambs are weighed and sold as they become fit to produce 18 kg carcasses. To date there has been no incentive to produce early lambs. Indeed, late lambing in April, late weaning and selling in late autumn fits in better with the new U.K. seasonal target price for sheep meat.

Sheep and cattle

Where sheep and cattle enterprises are maintained on the same farm, the sheep and cattle are alternated on the pasture area and they are not co-grazed as in Ireland. One 450 ewe flock was grazed intensively behind 18 month beef cattle and by cleaning up the paddocks after the cattle the stock manager maintained that he maximised grassland utilisation while achieving 0.9 kg DLWG in the cattle over the grazing season.

Flock health

Proper timing in dealing with critical points of management together with attention to detail are clear priorities and are the responsibility of the shepherd. Extra lambs are saved and successfully reared using a series of lambing aids. This approach boosts the size of the lamb crop, 170-200 lambs alive and reared per 100 ewes joined as previously stated.

Mule ewes have proved to be very good mothers and they are readily available. After weaning, ewes are culled for mastitis and poor teeth, although on one farm poor teeth were tolerated to some extent because retention of such ewes lowered replacement costs. Replacements are purchased with great care; hog mouthed ewes and ewes with teeth protruding past the dental pad are avoided.

Crutching and foot trimming of ewes are done at flushing time and pre-lambing. In the 3000 ewe flock a rotary foot trimmer costing £800

Stg. is used and is economically justified in 1000 ewe flocks or particularly where joint ownership can be arranged.

Ewes are footbathed three times during the housing period and both ewes and lambs are footbathed regularly during the grazing season. In one case a footbath 1m x 3m was bedded with straw and filled with 5% formalin solution. There is a trend towards the use of Zinc sulphate solutions.

Ewes are dosed twice against fluke and worms: pre-mating and pre-lambing. Lambs are dosed firstly in mid-May and once monthly afterwards. The first dose is primarily against Nematodirus.

A wide variety of drugs are used to treat E. coli scours including Terramycin powder, Neomycin, Neftin, and Orojet. It is considered that the use of these drugs should be alternated rather than rely solely on a particular one. Adequate nutrition of the ewe, adequate intake of colostrum by the new born lamb and hygiene are the predominant management factors which reduce the problem of E.coli scours.

Other health problems such as Pasturella, orf and vaginal prolapses occur in individual cases. Generally, Pasturella vaccine is not used and in some flocks orf vaccines are used. Harnesses for rectifying vaginal prolapses are commercially available and are much more satisfactory than stitching or using plastic retainers.

Table 2

Financial results 1983 (£ Stg./ewe to ram)

	Bishops Frome flock	MLC Top Third
Ewes to ram	353	—
Lambs born alive	170	
Lamb sales	55.00	56.35
Wool sales	2.50	2.95
Ewe Premium	0.90	1.16
Flock maintenance	−5.20	6.75
Output	53.30	53.71
Ewe feed	2.50	6.44
Lamb feed	1.10	1.35
Grass and Forage costs	3.70	5.33
Vet and medicine	1.30	2.35
Other costs	2.60	0.94
Total variable costs	11.30	16.41
Gross margin/ewe	42.00	37.30
Grass margin/acre	357.00	250.00

To prevent grass tetany, high magnesium cake is fed at the rate of 120 g/ewe/day for 10 days after turnout in spring.

Profitability

In appraising the role of lowland sheep enterprises in England, it is felt that sheep are maintained as much for the way in which they fitted into the whole farm programme as for the income they generate. Incomes from sheep are nevertheless high and gross margins are about £42 per ewe and £250 to £357 per acre depending on stocking density. The financial results on cne award winning flock at Bishop Frome in Herefordshire are summarised in Table 2 together with the results on MLC top third of flocks. Sheep profits are comparable with winter wheat.

Winter Fattening of Cattle

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The objective of this paper is to discuss factors that influence economic returns from winter fattening. Like any farming enterprise there are a considerable number of factors involved but the most important are :

1. Weight gain achieved
2. Feed cost
3. Winter cattle price increase

The weight gain achieved is the most important of these factors and unlike the price increase it is directly under the control of the producer. To achieve high weight gains at reasonable costs the following factors must be considered :

1. High quality silage fed to appetite
2. Optimum level of concentrates (consider costs)
3. Minerals/vitamins
4. Implants
5. Feed additives
6. Control of internal (fluke) and external (lice) parasites

BARLEY SUPPLEMENTS WITH SILAGE

As the cost of grass silage is lower than barley a large proportion of the feed requirement for fattening cattle is usually provided as silage. However, because high rates of gain are required it is essential that the silage is properly preserved and of high digestibility.

The optimum level of barley for fattening cattle fed silage depends on a number of factors. To determine this level, a brief summary of feeding experiments carried out at Grange will be presented and economic returns then calculated using various winter cattle price increases and barley prices.

The data presented are the average results from a number of experiments in which cattle were fed grass silage alone or with different levels of supplementary barley. From these, the response from feeding 1.8 kg and 3.6 kg of barley per animal daily were calculated and adjusted to a 140-day feeding period. The average daily liveweight gain of animals fed silage alone was 0.57 kg. Over the 140-day period, animals fed 1.8 and 3.6 kg barley per day gained respectively 23 and 36 kg more carcass weight than those fed silage only (Table 1).

Feeding 1.8 and 3.6 kg of barley reduced silage intake by 10 and 19 percent respectively. A good response in terms of animal performance was obtained from feeding 1.8 kg of barley per head per day. This response declined when the level of supplementation was increased to 3.6 kg per day.

Table 1

Effect of feeding barley with silage on 140-day gains and silage intakes

	Barley fed (kg per day)		
	0	1.8	3.6
Liveweight gain (kg)	79	116	132
Carcass gain (kg)	41	64	77
Daily silage intake (kg)	7.3	6.5	5.9

Based on these results the economic returns from feeding different levels of barley were calculated. Implants or feed additives were not used in these experiments so the above gains were increased by a conservative figure of 20 kg liveweight (over 30 kg can be expected) to allow for the effects of growth promoters. Although there are inadequate data available to provide a precise figure, a better response to implants can be expected with the barley fed animals (have higher rates of gain) than those fed silage alone. Thus, using a standard figure for implants of 20 kg liveweight will tend to underestimate the level of barley which should be fed.

The adjusted gains and feed costs are given in Table 2. Adjustments in final liveweights are made to allow for the better killing-out percentages of those fed barley. Feed costs are shown when barley is charged at £150 or £180 per tonne and it is noteworthy that increasing concentrate costs by £30 per tonne increases total feed costs from £135 to £150 per animal when animals are fed 3.6 kg of concentrates daily.

Table 2

Adjusted daily gains and feed costs (£) per animal (400 kg initial livewt.)

	Barley fed (kg/day)		
	0	1.8	3.6
Daily gain (kg)	0.60	0.91	1.08
Feed costs			
Silage £12/t — Barley £150/t	72	103	135
Silage £12/t — Barley £180/t	72	111	150

The total non-feed cost of maintaining a fattening animal for a 140-day period will vary widely with circumstances but for the present discussion a figure of £68 is taken. Included in this cost are interest charges on the animal, overhead costs, transport, mortality, dosing and growth promoter costs. There is no labour charge or any allowance for repayments on buildings.

The economic returns per animal are shown in Tables 3 and 4.

Table 3

Effect of feeding barley (£150/t) with silage on returns per animal (£)

	Barley fed (kg/head/day)		
Winter price increase (£/100 kg)	0	1.8	3.6
6	−13	10	7
12	15	41	40
18	44	72	72
Purchase price = £118/100 kg			

Table 4

Effect of feeding barley (£180/t) with silage on returns per animal (£)

	Barley fed (kg/head/day)		
Winter price increase (£/100 kg)	0	1.8	3.6
6	−13	2	−8
12	15	33	25
18	44	64	57

When silage only is fed the cattle price increase required to break even is about £9 per 100 kg despite a daily gain of 0.6 kg and a feed cost of only £72 per animal. Feeding 1.8 kg of barley daily with silage improved economic returns in all circumstances. The optimum level of barley feeding depends on the cost of concentrates and the winter price increase of cattle. If concentrates are charged at £150 per tonne (Table 3), it is economical to feed 3.6 kg daily. However, if concentrates are charged at £180 per tonne the optimum level of barley feeding is reduced. The major point indicated by these calculations is that high levels of concentrates can be fed provided they are available at the right price. This generally means that the concentrate should be based on home stored barley, root crops and beet pulp.

CANE MOLASSES

Molasses is often available at reasonable prices on the world market and could be fed as an alternative to cereals. In two experiments with fattening cattle fed high quality silage to appetite, molasses was compared with barley as a supplementary feed. Molasses is low in protein content (about 4% crude protein) and in the comparisons soyabean meal was fed with molasses to provide similar supplementary protein from the barley and molasses based diets. In terms of energy, molasses was assumed to have 70 percent the value of barley. The diets fed and the results obtained from the two experiments are presented in Tables 5 and 6.

Table 5

Silage intakes (kg DM/day) and gains (g/day) of bulls (510 kg) fed barley or molasses/soyabean meal with silage for 100 days — Experiment 1

	Supplement (kg per head daily)			
	Barley (5.0)	Molasses (2.9) Soyabean meal (0.49)	Barley (2.5)	Molasses (5.7) Soyabean meal (0.9)
Silage	7.53	7.24	6.17	5.91
Liveweight gain	952	952	1056	981
Carcass weight gain	527	552	670	622

Table 6

Silage intakes (kg DM/day), weight gains (g/day) of steers (450 kg) fed barley or molasses/soyabean meal for 122 days — Experiment 2

	Supplement (kg per head daily)				
	None	Barley (2.5)	Molasses (2.3) Soyabean (0.45)	Barley (5.0)	Molasses (4.6) Soyabean (0.9)
Silage	6.70	6.04	6.17	5.55	5.93
Liveweight gain	502	785	880	1037	964
Carcass gain	287	460	526	632	616

In both experiments molasses/soyabean meal gave higher liveweight and carcass gains than barley when the comparison was at a low level of supplementation (2.5 kg barley per head daily). When the quantities fed daily were doubled, liveweight and carcass weight gains of the barley fed animals were greater than when molasses was given. This would suggest that the efficiency with which molasses is used declines as the level of molasses feeding is increased. Thus, when molasses is fed the inclusion rate in the diet should be in the region of 15 percent of total dry matter. For fattening cattle about 2 kg of molasses can be fed daily and to allow for the low protein content in molasses 0.25 kg of soyabean should also be given. At this low inclusion rate the molasses/soyabean would be equivalent to about 1.8 kg of barley and the remainder of the concentrate could be fed as barley or pulp.

ENSILED PRESSED BEET PULP

Pressed beet pulp (dry matter content 15-20 percent) is available from C.S.E. Teo and by using proper ensiling techniques (rapid and proper covering with polythene) this material can be successfully ensiled without an additive. The resulting silage was evaluated in two feeding experiments using fattening cattle. The treatments were :

1. Grass silage + 4 kg of rolled barley per head daily
2. Grass silage + pulp and 0.15 kg of soyabean (Experiment 1) or pulp alone (Experiment 2) providing the same supplement DM as treatment 1
3. Barley beef (barley soyabean meal to appetite)
4. Pressed pulp to appetite + soyabean meal (0.67 and 0.60 kg in Experiments 1 and 2 respectively)
5. Pressed pulp to appetite

Treatments 3, 4 and 5 were fed 2.5 kg of grass silage per head daily as a source of roughage. All treatment groups received a suitable mineral/vitamin supplement.

Good quality grass silage was fed in both experiments and high performance was obtained with all groups (Table 7). When compared with 4 kg of rolled barley as a supplement to silage, ensiled pressed pulp resulted in 54 g per day lower carcass gain in Experiment 1 but carcass gains were similar in Experiment 2. In both Experiments 1 and 2 animals fed barley or pressed beet pulp as a supplement to silage had the same feed conversion rates (kg feed DM/kg carcass gain). When animals were

Table 7

A comparison of ensiled pressed pulp and barley for fattening cattle

	Diet				
	Grass silage + barley	Grass silage + pulp	Barley/ soyabean	Pulp/ soyabean	Pulp
Experiment 1 (304 kg initially) — 152 day feeding period)					
Daily DM intake (kg)	8.32	7.77	9.40	7.90	
Daily liveweight gain (g)	1249	1163	1262	1132	
Daily carcass gain (g)	715	661	760	665	
kg DM/kg carcass gain	11.7	12.0	12.7	12.2	
Value of gain less feed costs (£)	119	134	19	94	
Experiment 2 (491 kg initially — 104 day feeding period)					
Daily DM intake (kg)	9.39	9.21	10.43	9.23	9.00
Daily liveweight gain (kg)	1039	1000	1267	1176	975
Daily carcass gain (kg)	646	648	882	693	553
kg DM/kg carcass gain	14.4	14.2	11.9	13.4	16.4
Value of gain less feed costs (£)	57	82	37	64	41

Barley=£150/t Soyabean=£270/t Silage=£72/t DM Pressed pulp=£110/t DM fed either rolled barley or beet pulp to appetite those receiving barley had greater feed intakes and higher carcass gains than animals receiving pulp. While the difference in feed conversion was small in Experiment 1 animals fed barley had superior conversions in Experiment 2 (11.9 vs. 13.4 kg feed DM per kg carcass gain). When pressed pulp was fed to appetite exclusion of soyabean meal (Experiment 2) reduced daily feed intake by 0.2 kg and carcass weight gain by 140 g per day. In terms of kg feed DM per kg carcass gain the pulp/soyabean meal and pulp only animals had figures of 13.4 and 16.4 respectively. In conclusion, the ensiled pressed pulp is a high quality feed but the protein quality is low which should be kept in mind particularly at high inclusion rates or when fed to young animals.

For both experiments, the value of carcass gain less feed costs was calculated using costs per tonne of dry matter of £176, £307, £72 and £110 for barley, soyabean meal, silage and pressed pulp respectively. Due to the lower cost of the ensiled pressed pulp, diets based on pulp gave better returns than those based on barley. The return from the barley beef treatment in Experiment 1 was particularly low due to higher intakes and lower gains than normally obtained with barley beef. Inclusion of soyabean in the pressed pulp diet in Experiment 2 shows the very good economic response which can be obtained from a protein supplement where protein is limiting. It should be noted that grass silage is charged at production costs only, whereas market prices are used for other feeds.

Supplementary protein

When barley is the supplement and the silage is of high quality, protein intake should be sufficient to meet the requirements of fattening cattle. However, when feeds such as molasses (low in protein) or fodder beet roots are used rather than barley, a protein supplement should be provided. It should also be considered with barley if the protein content of silage is low (less than 11% crude protein). Replacing 0.3 kg of barley daily by soyabean meal amounts to 45 kg over a 150 day winter and if the price difference between barley and soyabean is £120 per tonne this increases the feed costs per animal by £5.40. With a price of £2.42 per kg of carcass the additional carcass gain required to cover the cost of replacing the 45 kg of barley by soyabean meal is about 2.2 kg. Such a small difference could not be measured in a feeding experiment but when there is a doubt concerning protein adequacy such as in the cases mentioned above it is a good policy to include protein.

Supplementary minerals

Although grass silage is usually balanced for minerals a feed such as barley is low in calcium whereas pulp is low in phosphorus. Thus when reasonable levels of supplements are fed it is advisable to feed 60 g (2 ozs) per animal daily of supplementary minerals/vitamins.

Feed additives

Three feed additives (Romensin, Flavomycin and Avotan) are available, all of which act by altering fermentation in the rumen. As Romensin was the first product marketed most of the studies at Grange have been with this product. These and other studies would suggest that with fattening diets based on grass silage and concentrates the improvement expected from using a feed additive would be 7 to 15 kg of extra liveweight gain over a 5 month period. Where feeds such as barley and pulp are used the best method of giving the feed additive is by having it included in the mineral/vitamin mixture which can be spread over the concentrate at feeding time.

Type of animal

As animals become heavy and fat the rate of gain declines and the response to feeding decreases. Heavy, fat cattle should not be retained for further feeding. In most instances this is best overcome by purchasing the proper weight of animal, taking account of the possible selling time and the expected rate of gain.

As the overall quality of the winter diet improves it will be more economical to use animals of lower initial liveweight with higher growth potential. The results of a study with young fattening bulls ($\frac{3}{4}$ continental cross) fed moderate to high quality grass silage and concentrates are shown in Table 8.

Table 8

Performance of young bulls fed moderate to high quality silage — 218 days

	Supplement (kg/day)		
	Barley (4.3)	Barley (3.9) Soyabean (0.4)	Barley (4.1) (Fishmeal (0.22)
Initial liveweight (kg)	297	296	298
Final liveweight (kg)	563	560	559
Cold carcass weight (kg)	322.3	320.3	319.2
Killing-out percent	57.3	57.1	56.8
Liveweight gain (g/d)	1,211	1,219	1,200

The average daily intake of concentrates was 4.3 kg and feeding either soyabean meal or fishmeal with barley did not increase daily liveweight gain (1.2 kg). It should be noted that the killing-out percentage (57% using a full final liveweight) of these young continental cross animals is considerably greater than that of conventional breeds finished at two years of age. In addition to their potentially high growth rate and high killing-out percentages three-quarters of these animals had a score of U for conformation on the carcass classification scale. Thus, a price premium should be available for these compared with standard carcasses.

CONCLUSIONS

1. It is important to obtain high liveweight gains (over 1 kg/day).
2. If available at the right price (e.g. home grown barley) feed 4 kg of concentrates daily with silage.
3. If feeding molasses, include at about 15 percent of total dry matter, e.g. replace 1.8 kg of barley by 2 kg of molasses plus 0.25 kg of soyabean meal.
4. A high protein supplement is not necessary with high quality silage and barley (or pulp).
5. When using low protein feeds (e.g. molasses), fodder beet roots or silages of low protein content (under 11%) it is advisable to feed a high protein supplement.
6. When feeding 4 kg of concentrates daily it is preferable to provide it in two feeds.
7. Control parasites (fluke and lice), use implants and a suitable mineral /vitamin mixture containing a feed additive.


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Use of Implants for Beef Cattle

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Growth promoting implants are widely used in beef cattle in Ireland and the general principles of their use are well understood. This paper briefly reviews the information which has been widely publicised in the past, and expands on aspects which have received less attention heretofore. The growth promoters and feed additives at present available on the Irish market are shown in Table 1. Ralgro, Synovex-S and Compudose are oestrogenic type substances. They are substitutes for one another and in steers they are additive with Finaplix which is an androgenic type substance.

Table 1

Available growth promoters and feed additives

Growth Promoters		Feed Additives	
Trade Name	Active ingredients	Trade Name	Active ingredient
Ralgro (Ral)^T	Resorcyclic acid lactone	Rumensin	Monensin sodium
Finaplix (Fin)^T	Trenbolone acetate	Flavomycin	Bambermycin
*Synovex-S(Syn-S)	Progesterone + Oestradiol	Avotan	Avoparcin
*Synovex-H(Syn-H)	Progesterone + Oestradiol		
Compudose 365 (Comp 365)	Oestradiol 17 B		
Compudose 200 —	Oestradiol 17 B		

S* = Steer   H = Heifer ^{T} = Withdrawal period

Synovex-H is specifically for heifers and cull cows. Ralgro and Finaplix have withdrawal periods of 65 and 60 days respectively whereas the other products have no withdrawal period. All the growth promoters are ear implants and as the ear is discarded with the hide at slaughter, there is no risk of contamination of edible tissue. The duration of effectiveness of Ralgro, Synovex-S, Synovex-H and Finaplix is 3 to 4 months. Compudose 365 is effective for about one year and Compudose 200 is effective for 6-7 months.

General Efficacy

Numerous experiments have been carried out to determine the effectiveness of the various products and combinations of products now available. A summary of the results from one such experiment (Drennan et al, 1981) is shown in Table 2.

Table 2

Response to Ral and Ral + Fin in finishing steers (112 days)

	Control	Ral	Ral + Fin
Initial live wt. (kg)	416	426	418
Carcass gain (g/d)	417	499	578
% of control	100	120	139
Silage intake (kg/d)	5.00	5.31	5.22
% of control	100	106	104
% meat	67.7	—	69.4

The carcass gains of the finishing cattle in this experiment were increased 20% by Ralgro and 39% by Ralgro and Finaplix. This shows that the combination of Ralgro and Finaplix was superior to Ralgro alone. Treatment increased silage intake by 4.6% and practically all of the extra carcass gain obtained from implants was in the form of meat. Having demonstrated that growth promoters are effective, the most logical way of discussing their use is in the context of the different phases of a calf to beef production system.

Calves at Pasture

The response to Ralgro and Synovex-S in castrated male calves is shown in Table 3; both products increased liveweight gain by 11-16% over a 100 day period.

Table 3

Response to Ral and Syn-S in steer calves (100 d)

	Control	Ral	Syn-S
Initial live wt.	110	109	109
Gain (kg)	77.9	86.8	90.0
Gain (g/d)	779	868	900
% of control	100	111	116
			(Keane, 1982)

Similarly Ralgro administered three times at 90 day intervals and Compudose 365 increased liveweight gain by 16-17% (Table 4).

Table 4

Response to Ral and Comp 365 in steer calves (263 d)

	Control	Ral (X3)	Comp 365
Initial live wt.	105	106	105
Gain (kg)	145.9	168.5	170.5
Gain (g/d)	555	641	649
% of control	100	116	117

(Keane, 1982)

This shows that Ralgro, Synovex-S and Compudose improves the performance of castrated male calves by 11-17%. Finaplix however is not effective in steer calves (Table 5) and therefore no additional response would be expected from the inclusion of Finaplix with Ralgro, Synovex-S or Compudose 365 in calves.

Table 5

Response to Fin in steer calves (112 d)

	Control	Fin
Initial live wt.	90	86
Gain (kg)	92.2	94.4
Gain (g/d)	823	843
% of control	100	102

(Keane, 1982)

There has been less work with female than with male calves but the results in Table 6 show that female calves for beef production do respond to Ralgro.

Table 6

Response to Ral in heifer calves (180 d)

	Control	Ralgro (X 2)
Initial live wt. (kg)	86	87
Gain (kg)	123.3	139.0
Gain (g/d)	685	772
% of control	100	113

(Keane, 1983)

Weanlings in Winter

If calves respond to growth promoters then weanlings would be expected to respond also. However, spring born calves generally perform reasonably well at pasture whereas weanlings are fed for low to moderate performance only in winter. Therefore because of the low gains there may not be a worthwhile response to growth promoters in weanlings. This was investigated in an experiment where weanlings were grown at normal (300 g/d) or high (800 g/d) rates in winter (140 days) and implanted twice or not implanted with Ralgro. The results in Table 7 show that during the winter, the response to Ralgro was better in the animals on the high rate of gain (12.3 v 6.6 kg).

Table 7

Response to Ral in weanlings and yearlings (356 d)

Winter gains	300 g/d (silage only)			800 g/d (silage + concentrates)		
	No Ral	Ral	Diff	No Ral	Ral	Diff
Initial l. wt. (kg)	229	229	—	227	229	—
Winter gain (kg)	43.0	49.6	6.6	104.6	116.9	12.3
Summer gain (kg)	156.5	179.3	22.8	128.3	144.9	16.6
Total gain	199.5	228.9	29.4	232.9	261.9	29.0

(Keane, 1983)

At pasture, however, the animals with the low rate of gain in winter grew fastest and gave the best response to Ralgro. At the end of the grazing season the response to Ralgro was the same (29.6 v 29.4 kg) for both winter rates of growth but the proportion of the total response obtained in winter was much lower (22 v 42%) for the lower winter rate of gain. Based on these results the response to Ralgro in winter at different rates of gain was calculated (Table 8). It is clear that at low rates of winter gain there is not a worthwhile response to Ralgro (and presumably the other products) in weanlings.

Table 8

Response to Ral in relation to winter gain

Winter gain (g/d)	100	200	300	400	500	600	700
kg in 140 d winter	1.5	3.6	5.5	7.3	9.1	10.9	12.7

(Keane, 1983)

Yearlings at Pasture

In the early part of the grazing season animal performance is generally high and a good response to growth promoters would be expected. The data in Table 9 show that yearling steers at pasture responded better to a combination of two implants (Compudose 365 + Finaplix) than to a single implant (Compudose 365) and that there was also a response to a second implantation midway through the grazing season. It can be concluded from these results that yearling cattle at pasture should be implanted twice during the grazing season using a combination of two products (oestrogenic and androgenic) each time. In this particular experiment Compudose 365 alone increased liveweight gain by 18 kg (12%) over a 189 day grazing season. The corresponding increase for Compudose + Finaplix (twice) and Ralgro + Finaplix (both twice) was 39 kg (25%.)

Table 9

Response in yearling steers* at pasture to growth promoters (189 d)

	Control	Comp. 365	Comp. 365 + (Fin X 2)	Ral + Fin (X 2)
Gain to 1st implant (kg in 106 d)	106	111	129	131
% of Control	100	105	122	124
Gain to 2nd implant (kg in 83 d)	51	64	68	65
% of Control	100	125	133	127
Total gain (kg in 189 d)	157	175	196	196
% of Control	100	112	125	125

* Initial L.W. 310 kg (Keane, 1982)

Winter Fattening of Heifers and Cull Cows

Responses to growth promoters in heifers are lower and more variable than in steers. Treatment of heifers twice with Ralgro during a 163 day fattening period (Table 10) had a negligible effect on carcass gain, kidney and channel fat or carcass fat score. This suggests that Ralgro was not

Table 10

Response in fattening heifers* to Ral and Fin (163 d)

	Control	Ral (X 2)	Fin (X 2)
Carcass gain (kg)	68.4	70.8	74.8
% of Control	100	104	109
K & C* fat (kg)	10.7	10.8	9.2
Fat score	2.6	2.9	2.1

*Kidney and channel *Initial L.W. = 309 kg (Keane, 1982)

effective in increasing growth rate of fattening heifers (indicators of fatness are generally reduced when there is a growth promotion effect). Finaplix on the other hand increased carcass gain by 6.4 kg (9%). Since the animals were implanted twice the response per implant was only 3.2

kg carcass but the fattening period (163 d) was probably not sufficiently long to get the maximum response from two implants. Since Ralgro was not effective it is unlikely that there would be any advantage from including it with Finaplix for fattening heifers. A comparison of Finaplix and Synovex-H is shown in Table 11. Over the 116 day period Finaplix and Synovex-H increased carcass gain by 5.4 kg (13%) and 4.2 kg (10%) respectively. Finaplix had no effect on udder size but the Synovex-H caused substantial udder enlargement.

Table 11

Response in fattening heifers to Fin and Syn-H (116 d)

	Control	Fin	Syn-H
Initial live wt. (kg)	368	386	378
Carcass gain	42.2	47.6	46.4
Udder size*	0.6	0.4	1.5

*Scored 0=normal, 3=very enlarged (Keane, 1982)

The response in cull cows to Finaplix is shown in Table 12. Over a 90 day period carcass gain was increased by 7.7 kg (17%) and meat gain by 7.2 kg (30%). In cull cows, as in steers, practically all the carcass gain due to growth promoters was in the form of meat.

Table 12

Response to cull cows to Fin (90 d)

	Control	Fin
Initial live wt. (kg)	435	433
Carcass gain (kg)	46.0	53.7
% of Control	100	117
Meat gain	24.0	31.2

(Drennan et al., 1983)

Winter Fattening of Steers

Having shown earlier (Table 2) that growth promoters and combinations of growth promoters are effective in finishing steers, the additional questions that arise in respect of finishing cattle relate to the use of feed additives in conjunction with growth promoters and whether animals may respond to a second implantation during a normal winter finishing period. With regard to the use of growth promoters and feed additives together, the results of the experiments which have been conducted on this subject are not consistent. In 4 experiments animals implanted with Ralgro + Finaplix were either fed or not fed Rumensin (Table 13). In

Table 13

Response to Rumensin in finishing steers treated with Ral + Fin

Expt.		Ral + Fin	Ral + Fin + Rumensin
1	ADG (g/d)	1180	1150
2	,, ,,	1160	1200
3	,, ,,	1200	1300
4	,, ,,	1250	1350
Average		1198	1250
			(Drennan et al., 1981) (Drennan—unpublished

the first comparison there was a slight negative effect of Rumensin, in the second there was a small positive effect while in the third and fourth experiments there was the normally expected response to Rumensin. It is not clear why these different responses occurred and consequently it is not possible to give an unequivocal recommendation on the use of feed additives with growth promoters. However, as the average response over the 4 experiments was more than sufficient to cover the costs associated with using a feed additive and as there are results from elsewhere showing additivity between growth promoters and feed additives, it can be concluded that on balance the use of a feed additive in conjunction with growth promoters is worthwhile.

Whether or not cattle should be implanted once or twice during a normal finishing period depends on the duration of effectiveness of the products used. Attempts to define the response curves for the different products and combinations of products have not been successful. The results of an experiment in which Ralgro + Finaplix was given at the start, midway, and both at the start and midway of a 168 day fattening period are shown in Table 14.

Table 14

Repeated implantation of finishing steers* (168 d)

	Control	Ral + Fin (day 1)	Ral + Fin (day 84)	Ral + Fin (days 1 and 84)
Gain (days 1-84)	96	117	97	116
Response (days 1-84)	—	21	—	20
Gain (days 85-168)	62	67	89	88
Response (days 85-168)	—	4	27	26
Total gain (days 1-168)	159	184	186	204
Response (kg live wt.)	—	25	27	45
Response (kg carcass)	—	14	13	24
*Initial live wt. 369 kg				(Keane, 1982)

Treatment once only, increased carcass weight by 13-14 kg whereas treatment on two occasions increased carcass weight by 24 kg. This shows clearly that when the fattening period is as long at 168 days a second implantation is justified. Animals treated at the start of the experiment only gave a response of 21 kg liveweight over the first 84 days and an additional 4 kg over the second 84 days. This suggests an effective period of about 100 days. The carcass response to this treatment was 14 kg or 140 g/d if an effective period of 100 days is assumed. On this basis the expected carcass response of the animals implanted twice would be 23.5 kg. This is very close to the observed response of 24 kg. It can be concluded therefore from this experiment that the Ralgro + Finaplix combination is effective for about 100 days on average. It is likely, however, that effectiveness declines from about 80 days onwards but does not cease until perhaps 120 days. Another point of interest apparent from the data in Table 14 is that the response in animals treated for the second time was no different from that of animals treated for the first time. Over the second half of the experiment (days 84-168) animals treated for the first time on day 84 showed a response of 27 kg liveweight and 13 kg carcass weight. Corresponding values over the same period for animals treated on both days 1 and 84 were 26 kg liveweight and 11 kg carcass weight.

Even with fattening periods shorter than 168 days repeated implantation is also justified. The results of a trial in which Ralgro + Finaplix and Synovex + Finaplix were used once or twice during a 133 day finishing period are shown in Table 15. There was also a treatment in which Synovex-S was used the second time. As there was no untreated group, actual responses could not be measured but it is clear that the groups implanted twice performed substantially better than those implanted once only. Over the 133 day period the animals implanted twice with Ralgro + Finaplix gained 17 kg liveweight more than those implanted once. The improvement from the second Synovex-S + Finaplix implantation was 12 kg liveweight. Using Synovex-S alone at the second implantation was not as good as Synovex-S + Finaplix. It can be concluded from that data in Tables 14 and 15 that repeated implantation is worthwhile when the fattening period is of 133 days duration or greater.

Table 15

Repeated implantation in finishing steers (133 d)

	Ral + Fin (X 1)	Ral + Fin (X 2)	Syn-S + Fin (X 1)	Syn-S + Fin + Syn-S	Syn-S + Fin (X 2)
Initial live wt.	472	457	449	454	455
Gain (days 1-70)	86	83	92	89	92
Gain (70-133)	46	66	51	57	63
Total gain (1-133)	132	149	143	146	155

(Keane, 1982)

Total Lifetime Responses

While there have been numerous experiments in which different treatments were imposed over the lifetime of animals only on rare occasions have what would be considered optimal treatments been used throughout life. Some comparisons involving different lifetime treatments are shown in Table 16.

Table 16

Lifetime responses (kg carcass) to growth promoters

Carcass wt.		Response		Treatment	Reference
Control	Treated	kg	%		
283	320	37	13	Ral (X 6)	Roche et al, 1981
281	300	19	7	Ral (X 6)	Roche, 1982
281	304	23	8	Ral (X 4)	Roche, 1982
261	286	24	9	Ral (X 4)	Keane, 1983
281	304	23	8	Ral(X 4) + Fin(X 3)	Roche, 1982
300	321	21	7	Ral + Fin (X 3)	Roche, 1982
271	298	27	10	Comp. 365	Keane, 1983

The responses in this selection ranged from 19 to 37 kg (7-13%). The highest and lowest responses shown in this table were both obtained to 6 Ralgro implants over a two year period. This just emphasises the degree of variation encountered in response to growth promoters. In view of the results presented earlier on the response to implantation at various stages of the production cycle it is likely that a total lifetime response superior to any of those in Table 16 is possible.

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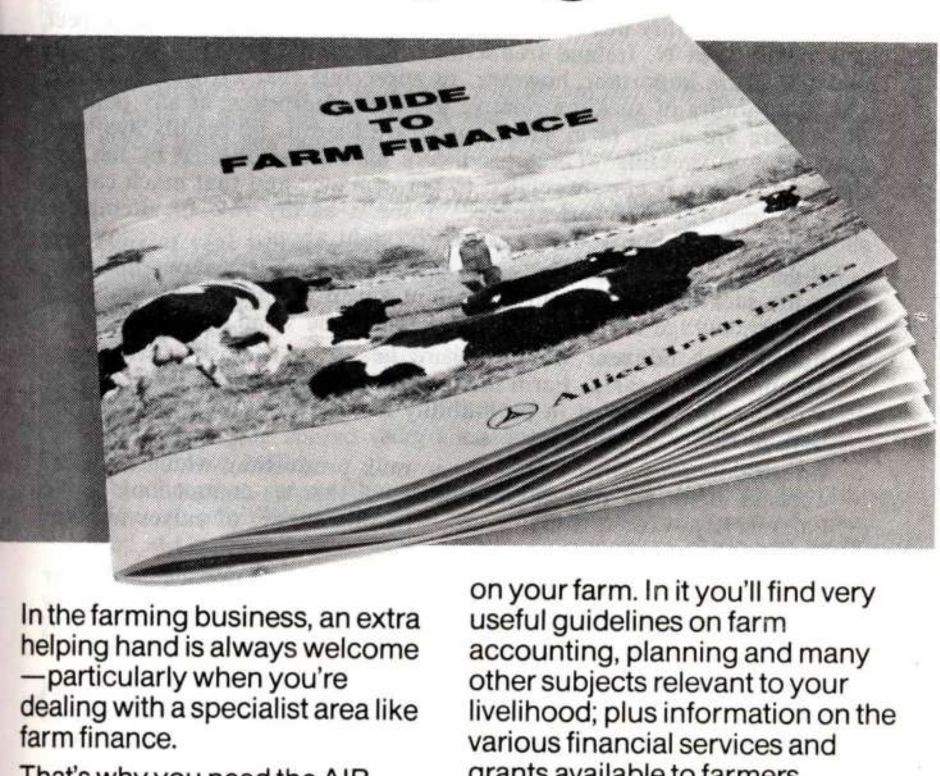

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Money from Grass through a Beef Breeding Herd

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Introduction

Lack of profitability has been a major factor in the rapid decline in beef cow numbers in N. Ireland (reduction from 339,000 in 1974 to 200,000 in 1983). It is important, however, to appreciate that irrespective of the low profitability of suckling relative to other enterprises, at any point in time, there are many farm situations where there is no readily available alternative to suckling. These producers should be consoled by the fact that profitability is closely related to performance and that much can be done to improve that performance. I see it as my role to attempt to show how these improvements can be brought about.

While it would be foolhardy for me to be eurphoric about the prospects for suckling in the light of present-day performance, a number of pointers encourage me to take a more optimistic stand for the future.

1. For the second year running there has been a brisk trade at the autumn suckler sales. Farm management results for the 1982/83 year show an improvement in profitability and suckling no longer fills the bottom slot of enterprise gross margins.
2. Constraints on further expansion in milk production, which the EEC appears intent on imposing, would mean that we cannot look to the dairy herd source to provide an increasing supply of calves for beef production.
3. There are now indications in N. Ireland that the decline in suckler cow numbers has been halted and that suckling is now being firmly consolidated into the Less Favoured Areas, where extra incentives and allowances are available.
4. In future dairy producers wishing to expand their farming activities may look to suckling as a possible alternative. Many milk producers have built up a high degree of expertise in their grassland management and are likely to bring their skills to bear on the suckler cow.

Since the only product of a beef cow is her weaned calf, the objective of suckling should be to regularly produce, as ECONOMICALLY as possible, a heavy calf at weaning which has further growth potential.

Financial results from MLC recorded suckler herds show that all round attention to detail is necessary to attain top-third performance. Compared to average herds, the top-third herds :

— sold bigger calves
— fed less concentrates to cows
— had lower total variable costs

— reared more calves per cow
— had similar or better calf daily gains
— had higher stocking rates (lowlands and uplands)

Detailed analyses of the contribution of different factors to the top-third superiority in gross margins show that the most important factors are :

* stocking rate
* weight of calf produced
* number of calves weaned/100 cows

I would like to consider my recommendations for suckling under two headings.

1. Animal performance aspects
2. Output from grass

The first category of topics is common to all suckler systems, while the second topic is more specific to lowland suckling and areas within the LFA where grass has potential for improvement.

1. ANIMAL PERFORMANCE ASPECTS

(A) Time of year to calve cows

Based on experience at Castle Archdale the main merits of early summer calving can be summarised as follows :

* Ideal environment.
* Favourable conditions at and after calving, simplified management and a good start in life for calves.
* Tight calving pattern.
* A 3-week calving spread (90%) has been achieved and maintained with minimum culling.
* High conception rate; although bulling was restricted to one month, on average only 7% of May/June cows proved barren over an 8-year period at Castle Archdale. It appears that plane of nutrition and good body condition of the cows post-calving and during the mating period, provide the correct conditions for high conception.
* Good growth rates; average weights of 300 kg can be achieved at weaning (9 months) without any concentrate feeding to the dams and little concentrate feeding to the calves.
* Few health problems; there have been no calf deaths by the common disease problems of scour and pneumonia. Mastitis is not a problem, and veterinary bills are small.
* High output from grass; finished cattle can be produced for sale at 14-15 months of age.
* Low labour requirement; labour needs are greatly reduced due to the near absence of disease problems and the excellent environmental conditions which occur at calving.
* Flexibility in sale date; disposal off the unit may take place at weaning or on turnout to grass. Alternatively weaned calves may be returned to pasture for sale off grass in the summer or autumn.
* Profitability; each year the highest gross margins were achieved with the summer calving herd. Experience with summer calving at Castle

Archdale has shown that the system has much to commend it for a wide range of farming situations.

However, housing of a summer calving herd is required and suitable accommodation must be provided for the cow and a strong calf. Summer calving has particular application on farms where adequate housing already exists and where sufficient quantities of good quality silage can be made.

It is recognised, however, that many producers in the LFA are spring calving at present and do not have sufficient suitable land for making adequate silage. My advice to these farmers is to continue to spring calve their herds but if possible calve earlier and consolidate the calving period by reducing the spread in calving. These actions will allow cows to make fuller use of the grass season and to produce heavier calves for disposal at the autumn sales.

(B) Breed of bull

It is now well established that sire breed has a major effect on calf weaning weight, much greater than that of cow type. The heavy late maturing breeds produce calves with the highest weaning weights (Table 1).

Table 1

Sire breed effect on calf 200-day weight (kg)

	Lowland	Upland
Charolais	240	227
Simmental	232	222
South Devon	231	221
Limousin	215	204
Hereford	208	194
Angus	194	182

(MLC)

For many years at Castle Archdale we have used Charolais and Simmental as our main top crossing sires. In recent years we have intrcduced Limousin on our first calving heifers. As well as benefiting from their extra size, surveys of suckled calf prices in recent years have shown that the continental crosses also command a price premium uer unit weight sold.

Finishers of suckled calves should be aware that while undoubtedly there are large differences between the crosses of different breeds in the duration of the feeding period, weight at slaughter and total feed consumption (Table 2), the differences in feed conversion efficiency are generally small. MLC found in their beef breed evaluation programme that when cattle were slaughtered at a fixed level of external fatness Charolais crosses had the highest slaughter weights and were oldest at slaughter. Simmental crosses were broadly similar to the Charolais in performance. Size and speed of maturity had significant effects on feed consumption. Big, late maturing crosses consumed much more feed in total than smaller early maturing crosses. For instance the Charolais crosses needed about 40% more feed in total than the Hereford crosses. Being bigger, they consumed more per day and being later maturing they had to be fed for longer. However, the extra feed was just about balanced by extra growth rate so differences in feed conversion efficiency were small.

Table 2

Winter finished suckled calves (slaughtered at fixed level of fatness)

Sire breed	Start wt. (kg)	Finishing period days	Daily gain (kg)	Slaughter wt. (kg)	Total feed (DM)	Kg feed DM per kg gain
Charolais	363	157	0.84	494	1.37	11.0
Simmental	359	153	0.86	490	1.34	10.7
Limousin	332	156	0.78	454	1.21	10.6
Hereford	322	113	0.78	410	0.96	10.2
Aberdeen Angus	319	97	0.77	393	0.83	10.5

(MLC)

(C) Choice of Cow

The factors of importance in the suckler dam are :

* regular breeding
* high calf weaning weights
* low mortality
* low feed costs
* some degree of hardiness

In our experience the Aberdeen Angus crossed with the dairy type animal—Friesian or Shorthorn—appear to produce a near ideal suckler dam which fulfils all the above requirements remarkably well.

A trial, carried out at our agricultural colleges in NI, provides us with some useful data on the performance of 3 dairy/beef crosses under local conditions. Calf 200-day weights over a 6-year period for 3 different sire breeds are summarised in Table 3.

Although all 3 cow types produced similar weight of calf at 200 days, the Angus crosses produced it more efficiently in relation to their body size.

Table 3

Comparison of weights (kg) of cross-bred suckler cows and of the calves from different sires at 200 days of age

Cow breed Dam / Sire	Breed of Calf Hereford	Charolais	Simmental	Cow wt.	kg calf 200 day wt. per 100 kg cow wt
Her X Fr	200	232	222	472	45
AA X Fr.	204	228	217	449	47
AA X Sh	208	227	219	450	47

(NI, 1970/76)

(D) Reduce calving spread

Compact calving is a key factor involved in improving profitability and simplifying management. The advantages of compact calving can be summarised as follows:

* heavy weaning weights and a more even batch of calves
* simplified management
* improved fertility due to a higher conception rate
* accurate feeding of cows
* less risk of scour and grass tetany
* saving in labour

There are a number of possible ways producers can reduce spread of calving. These include split calving, the culling of late calving cows and attention to management factors such as level of feeding, cow condition and bull potency. Improvement in management alone is usually not sufficient to reduce an existing wide spread. The culling of late calving cows and their replacement with early calving heifers may be the most appropriate action for the majority of producers. It is important that replacement heifers calve early in the calving period, preferably 2 - 3 weeks before the main herd as calving pattern is difficult to alter once established.

(E) Fertility

In order to maintain calving pattern and achieve satisfactory output each suckler cow should produce a weaned calf every year. A number of factors which influence fertility should be considered.

(i) Calving to service interval : It is well established that conception rates at second and subsequent oestruses are higher than with first oestrus.

(ii) Maturity : Farmers often observe that first calvers are more difficult to get into calf than mature cows. This may be partly due to the higher nutritional stress on a young animal in its first lactation. Of more importance is undoubtedly its slowness to cycle with the resulting fewer opportunities for service and the greater risk of service on first heat. Hence the importance of calving heifers early.

(iii) Late calvers : Researchers have found a general decline in fertility as cows calve later in the season.

(iv) Nutrition : There is evidence that very thin cows have an unacceptably high incidence of barrenness due to anoestrus. Selective feeding of these animals is necessary to stabilise liveweight loss, to get them cycling and achieve acceptable levels of fertility.

(v) A.I. versus natural mating : The major benefits of A.I,, namely the potential use of a wide selection of superior sires from a range of different breeds, must be apparent to almost all producers especially those with small herds where it is difficult to justify the purchase of a bull. Farmers are often deterred from using A.I. either because of inconvenience or fear of poor results. At Castle Archdale A.I. has been used very successfully for many years. A most important factor in determining the successful use of A.I. and one which is taken too much for granted is heat detection itself.

(F) **Feeding**

Since feed costs can account for 80% of total variable costs, feeding is an obvious area to focus attention on if we are going to reduce costs and improve efficiency of production.

(i) Cow feeding : Due to basic inefficiency of beef production from the suckler cow, and since a large proportion of feed costs occur during the winter period, all systems of suckled calf production should rely on mobilising the cow's body reserves of fat during winter feeding. These reserves can subsequently be cheaply replenished at grass. Our experience suggests that there is considerable scope for exploration of her reserves once the cow is in calf. There appears to be no overall adverse affects on dam performance and subsequent cost benefits to be achieved so long as cows are permitted to completely rebuild their reserves the following season at grass.

(ii) Creep feeding : Creep feeding calves at pasture is not normally justified and responses will only be obtained under conditions of severe pasture scarcity. Several trials at Castle Archdale have shown good responses to creep feeding indoors. However as the response to creep feeding is much greater when measured at turnout to grass than subsequently at weaning after a grazing period, the optimum feed rate will depend on disposal date and the relative prices of concentrates and beef. As our trials produced much poorer conversion rates at higher levels of creep feeding (dams feeding on silage only) we restrict creep feeding to a maximum of 1 kg head/day.

(G) **Housing**

Housing is important in relation to grass production rather than animal performance. Our experience with various housing systems including topless cublicles, kennels, indoor cubicles and totally slatted accommodation is that it is not necessary to provide elaborate housing (nor probably any housing) for suckler cows. In fact from an animal health point of view our experience with topless cubicles and kennel units would confirm that a well ventilated environment is highly desirable and that all that is required is a dry area for cows to lie down and some shelter for young calves. There are however, in our moist climate, very good reasons from a grass production viewpoint, to take stock off the land during the winter months. Unless an unproductive dry area or rock outcrop is available on the farm as a winter site, suckler stock should be yarded and provided with cheap and simple accommodation.

The effect of winter shelter on the performance of suckler cows and their autumn born calves has been evaluated in a major study, carried out over a 5-year period, at Craibstone in Aberdeen. Suckler cows were wintered from October to April on 4 sites. These were a slatted house, an exposed unroofed slatted pad, a sheltered paddock and an exposed paddock. The main findings on shelter were :

★ Suckler cows obtain little benefit from the provision of winter shelter in the British Isles.

★ The lower the level of feeding the more benefit the cows may gain from shelter. At most it could amount to the equivalent of saving 8 MJ ME per day over the winter which could be provided by 0.7 kg barley per day. However, at typical feed levels for autumn calving cows it is much less.

★ Calves benefit from shelter but a house is not economically justified. Where natural shelter is not available a simple windbreak will suffice. Although housed calves grow faster during the winter, outwintered calves compensate by faster growth at grass.

★ Confining cows during winter eases labour and management problems and controls the effects of poaching on crop and grass production.

★ Cows can be confined without shelter but should have a lying area free from surface water. Outwintering sites should have a frost-free water supply and good feeding handling facilities.

1. OUTPUT FROM GRASS

My discussion on breed and management factors have emphasised the need for :

— A live calf
— a cow capable of adequate milk production
— a calf capable of good growth rate
— avoidance of disease problems which inhibit performance.

In other words we provide an animal with the potential for very rapid growth and by making available sufficient grass (in the form of grazing or silage) of adequate quality we hope to exploit that potential. Accordingly the animal factors and grass production aspects are very much inter-related in the achievement of our goal, which is high output from our grassland.

I would like to make some points about the utilisation of our grass with sucklers as this is undoubtedly an area where there is great potential for improvement. If single suckling is to be made competitive with other grass using enterprises then stocking rate must be considered as the single most important task in our grassland management.

(A) **What stocking rate ?**

On average, 'good' lowland producers are achieving a stocking rate of 1.5 suckler cows per hectare. For many years at Castle Archdale (under LFA conditions) we have been stocking at 2 cows per hectare. What level of stocking rate should the prime lowland grass producer be aiming at ?

The total annual energy requirement for the maintenance of a 500 kg suckler cow and the production of 350 kg suckled calf is about 40,000 MJ. If we assume a pasture yield of 12,000 kg DM per hectare (approximately 5 tons per acre) and an energy concentration of just 10 MJ per kg, the energy output from a hectare of grass would be 120,000 MJ. On this basis it would be possible to produce 3 calves, with a combined weight exceeding 1 tonne per hectare.

This level of output is by no means theoretical, as targets based on research work at Hillsborough indicate (Table 4).

Table 4

Targets for lowland suckling

Calving season	Calf wt. (kg)	Stocking rate (cows/ha)	Calf output (kg/ha)
Autumn	300	2.8	840
Spring	270	3.3	890
Summer	330	3.1	1025
Summer*	450	2.5	1125

* Intensive finishing

Stocking rates given are based on well-managed, re-seeded lowland ryegrass pasture receiving 400 kg N per hectare (320 units per acre). There is no spring calving herd at Hillsborough but the performance targets quoted are being achieved with the summer and autumn herds at the Institute.

(B) **Some general guidelines on grassland management**

1. Stocking rate — singly the most important factor. Examination of individual farm results show a wide range of stocking rates at all levels of N use. Inadequate use of fertiliser N may not be the main cause of low stocking rates. Many producers could improve grassland

utilisation simply by increasing stock numbers on a given grass area and tightening up grassland management all round.

2. N usage — there are many suckler units where only low levels of nitrogen are applied. In these cases more N usage would greatly increase the potential for improvement in stocking rates. It is important to appreciate that the additional acreage created need not necessarily be occupied with more suckler cows. The farmer may wish to conserve a greater quantity of fodder and retain some of his suckled calves for finishing or sale at a later stage in production. This type of approach can help to protect him from the vagaries of the suckler calf sales.
3. Grass quality — suckled calves do not need as high quality grazing as dairy bred calves and are usually easier to manage because the cow shields the calf from the environment.
4. Leys versus permanent pasture — permanent pasture is capable of supporting similar stocking rates to leys up to about 150 kg N per hectare. Above this the response to N tails off on permanent pasture, and for really intensive grassland management the advantage lies with leys.
5. Grazing system — irrespective of cattle type stocking rate is more important than grazing system. At low levels of stocking grazing system has little or no effect on performance. At high stocking rates there are advantages in rotational grazing. A simple system, comprising 4 to 6 fields, whereby the herd rotates in a period of one month or less, is all that is required.
6. Creep grazing — where a paddock grazing system is adopted creep grazing can be easily arranged. Generally the benefits to be had from creep grazing are small but are likely to be more pronounced in high stocking rate situations or where grass availability is limited. In one comparison at Hillsborough creep grazed May born calves were 6 kg heavier at time of housing. At Castle Archdale 2 out of 3 trials gave a small (7 kg, 3 kg) advantage to creep grazing.
7. Clover — a really good clover sward has the capacity to produce the equivalent of 200 kg N per hectare. In practice there are probably few suckler producers who would exceed this level of N application on their grazing areas. Undoubtedly one looses flexibility with clover but there must be a good case for developing clover swards on at least part of the grazing area.

(C) **Output from permanent pasture**

Almost 70% (75% including rough grazing) of our grassland is permanent pasture (5 years old and over). Accordingly most of our ruminant production, especially that from suckler cows, comes from old pasture. A major study by the 'Joint Permanent Pasture Group' on the 'factors affecting the productivity of permanent grassland' was published in 1980. This document makes very interesting reading and I think the findings provide a challenge to grassland producers.

* The average annual UME output for dairy farms was some 44 GJ ha^{-1} compared with 40 GJ ha^{-1} for beef farms and 38 GJ ha^{-1} for suckler farms.
* On dairy farms ME derived from grass was only sufficient to supply Maintenance and about 5% of ME for milk production (i.e. 55% of total). On the average suckler farm grass supplied 81% of the total requirement (46% of production).
* The difference in output between dairy and suckler farms was smaller than would be expected from the differences in stocking rate and N use.

	Stocking rate (c.e. ha^{-1})	N (kg ha^{-1})	UME output GJ ha^{-1})
Dairy cows	1.8	154	44
Suckler cows	1.2	42	38

* Stocking rate was consistently the variable most strongly associated with output accounting for 51% of the variation in UME between dairy farms and 82% on suckler farms.
* Other variables consistently associated with output were fertiliser N and the manageability of land.
* Botanical composition was more important than the age of grass. Composition was of little consequence on high N farms.
* GRASS HAS POTENTIAL AS A PRODUCTION FEED, BUT MANY FARMERS USE IT LARGELY AS A MAINTENANCE FEED.

CONCLUSIONS

(1) Much can be done on the stock and management aspects to improve suckler output.

(2) Suckling is the one enterprise that obtains most of its production from grass.

(3) On many suckler units grass is not managed intensively and stocking rates could be greatly improved.

(4) Stocking rates can be improved without keeping more suckler cows.

(5) Silage quality is important for sucklers as, generally, little concentrate is used.

(6) A challenge faces suckler producers to get more "Money from Grass".

Breeding Strategy in High Producing Dairy Herds

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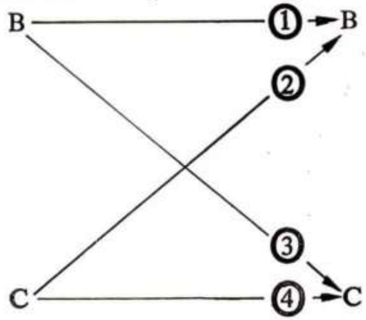
The average milk yield of a herd can be increased both through improved management and through a well planned breeding programme. While increased yields due to improved management (particularly at low levels of production) are usually more dramatic than those due to breeding, that does not mean the latter is any less important. Lifting the genetic merit of a herd is cheap and easy to do. It involves a planned approach to culling and breeding of replacements, activities which must occur anyhow. In addition, genetic improvement is permanent and, provided bulls of inferior merit are not used, cumulative. Relatively, genetic improvement is more important in high compared to low producing herds.

Dairy cattle breeding has made major advances in this country in recent years. The industry is rather well organised, through the AI structure, to make genetic progress though there are many improvements yet to be made. Larger dairy herds, with more attention being paid by farmers to breeding merit, together with improved sire and cow evaluation and more intense sire selection, will lead to an acceleration in the rate of genetic change for economic characters in dairy cattle over the next few years.

Genetic Improvement Pathways

Genetic progress in a dairy population can arise through four pathways. In a well organised progeny testing system the estimated genetic progress resulting from the four paths are approximately as follows:



			% Contribution
1. Bulls to breed bulls	—	BB	45%
2. Cows to breed bulls	—	CB	30%
3. Bulls to breed cows	—	BC	20%
4. Cows to breed cows	—	CC	5%

The contribution of each pathway will vary according to the intensity of selection. The reason that bull sires (BB) give a higher contribution than bull dams (CB) is solely attributable to the fact that sires are reliably progeny tested on the performance of many of their daughters. The information on the cow, on the other hand, is usually based on her own performance over 3 or 4 lactations, plus some information on her sire and dam. Thus the information on a cow can never be as reliable as a bull proof and so the contribution from the dam is lower. The above figures show the tremendous importance of sire selection — 75% of the genetic progress on average is made through the breeding of bulls — this is outside the scope of the commercial dairy farmer. Thus in the context of this paper we are only concerned with pathways 3 and 4 above.

Improving Herd Genetic Merit

There are 3 ways in which the diary farmer can improve the genetic merit of his herd :

1. By culling low yielding cows
2. By using only the best cows to breed replacements
3. By proper use of top sires to breed replacements

1. Culling low yielding cows

There is only limited scope for farmers to genetically improve yields through culling, largely because of the high rate of involuntary culling. Of the 20% or so cows culled by the farmers each year only 3 to 4% can be culled on yield. Table 1 lists the primary reasons for culling cows in Moorepark herds in 1970-72, 1980-81, and from 1970-81 and in 26 commercial herds in 1980-81. These show that while there has been

Table 1

Primary reasons for cow culling in Moorepark and 26 commercial herds (% of cows)

	Moorepark Herds			Commercial Herds
	1970-72	1980-81	1970-81	1980-81
Not in calf	8.4	4.9	6.8	3.7
Abortion (incl. Brucellosis)	1.8	1.4	3.2	5.3
T.B.	4.5	1.3	2.1	0.3
Udder disorders	0.8	1.9	1.6	2.1
Leg and foot disorders	0.0	1.4	0.8	0.8
Accidents	0.4	0.1	0.2	0.1
Calving difficulties	0.1	0.2	0.2	0.1
Late calving	0.3	0.2	0.2	0.2
Other reasons	0.9	6.2	2.9	0.6
Not recorded	1.4	0.0	0.6	1.6
Low production	1.7	3.7	3.1	4.7
TOTAL	20.3	21.3	21.6	19.5

an improvement from under 2% in 1970-72 to almost 4% in 1980-81 in Moorepark and almost 5% in commercial herds scope for improvement through culling low yields is limited. A recent study of MMB milk recorded herds by McClintock showed that culling low yielders would account for about 0.2% improvement per year of age.

2. **Using better cows to breed replacements**

This method of genetically improving one's herd also has limited scope especially for the majority of Irish dairy farmers. Firstly, in order to identify the genetically superior animals in a herd, cows have to be milk recorded and yields adjusted for age and date of calving. A cow's milk production increases until her 4th or 5th lactation so that age adjustment is necessary, while in a creamery milk situation every day later calving in the year can mean a drop of 2.2 gallons in milk yield.

Secondly, in order to have heifers calving down at 2 years of age they need to be born early in the calving season, so that in order to optimise this means of improvement the better cows need to be calving early. This would not be the same problem in a high producing or liquid milk herd when calving would occur throughout most of the year.

In the study mentioned above, McClintock retrospectively looked at the phenotypic superiority of the dams of herd replacements and found them on average to be only 1.37 phenotypic units above the average of all cows in the herds in which they were milked. He estimated that this average selection intensity among dams would only account for 0.02% genetic change per year. These are average figures over all herds and obviously individual breeders could do considerably better than this.

3. **Use good sires to breed replacements**

For most farmers, the simplest and most efficient way of improving the genetic merit of their herds is through the planned use of genetically superior bulls. This can best be done by AI, as the proven AI stud is a group of highly selected genetically superior bulls. Their merit for dairy and heifer conformation traits are reliably known, while beef merit and ease of calving are available on most.

a. **Sire evaluation :** Bulls are evaluated on the basis of the production of a sample of their progeny (usually 40 or more) and their proofs are expressed in terms of PREDICTED DIFFERENCES (PD) for milk, fat and protein yields and fat % and protein %. All PD's are expressed as deviations from a fixed base level of production. Predicted Difference is expressed as the difference that is expected between the average production of future daughters of the bull and the base level of production. The difference between the PD's of two bulls is the expected difference in the average production of their daughters when milked in the same herd and treated alike.

The RELATIVE BREEDING INDEX (RBI) quoted for each bull combines his PD's for **fat and protein yield** in a single figure. It is a breeding value for the bull and as such in twice the PD's. The RBI is expressed in terms of percent superiority above a mean base population yield of 188 kg of fat plus protein.

$$RBI = \frac{2\ (PD\ fat + PD\ protein)}{188} \times 100 + 100$$

The mean RBI for all the young bulls whose proofs became available this year was 122 or 22% above the base level. The minimum RBI for any bull approved for widespread use in 1984 is 121, while the mean of the proven stud is 127. The estimated mean RBI of all natural service bulls is 113 so that on average an approved AI bull is 14 points higher in Relative Breeding Index.

Furthermore, a weighting, which reflects the number of effective daughters on which the bull's proof is based, is also given. The higher the weighting the more accurate the proof. No bull is approved with a weighting of less than 20 — to achieve this figure approximately 40 daughters are recorded. The reliability of the proof is also given, this is merely the weighting expressed as a scale of 0.0 to 1.0. A weighting of 20 is equivalent to a reliability of 0.60. To have a reliability of about 0.8 a weighting of 60 and for 0.9 a weighting of 135 would be required.

b. **Value of AI :** The value of each unit on the RBI scale is estimated to be worth £1.60 at 1983 prices. In financial terms, the expected benefit to the farmer of using an average proven bull in preference to an average natural service bull, is about £22 (14 x £1.60). This represents the value to the farmer in today's money of the additional future production due to each insemination, net of production costs. Of course, if a farmer uses one of the top proven bulls, with say an RBI of 134, he stands to benefit even more : about £34.

c. **Choosing the right bull(s) for the herd :** Dairy farmers should not rely on RBI's alone in selecting bulls for their herds but rather should select bulls with acceptable RBI's which will largely compensate for weaknesses in particular cows. This can be done by referring to the bull's PDs for different production and conformation traits. For example, bulls with the same RBI can have quite different PD's for different traits as shown in Table 2.

Thus a bull such as KMK can have high milk yield at average fat %, compared to a bull such as TWB with high fat % at average milk yield.

Table 2

Comparison of PD's for production of two bulls with similar RBI

			PD				
Bull Code	RBI	Weighting	Milk (kg)	Fat (kg)	Protein (kg)	Fat %	Protein %
KMK	128	23	332	15	12	.09	.06
TWB	128	32	185	18	9	.35	.10

This can result in similar PD's for butterfat yield. The same can be true of protein. Therefore, if a farmer wants to improve his fat percentage he should use TWB, if he is a liquid milk producer he should use KMK. In addition KMK is strong on legs and feet and general appearance while TWB is particularly good on udders and teats.

Even if a farmer is not milk recording he will have a reasonable idea of his herd average milk yield and fat %; he should then be able to select a group of bulls suitable for use within the herd as a whole.

It is this type of approach that the farmer with high producing cows must take if he is to make continued genetic improvement in his herd. A word of warning should be sounded against trying to improve too many traits at one time. The higher the number of traits, many of which will have little economic value, the more difficult it will be to get a bull near the top in any of them; rather select bulls for just one or two economically important traits which have acceptable conformation or type.

The average genetic improvement in the population through the use of top sires can be as high as 1% per annum; in Ireland at present it is probably somewhere between 0.5% and 1.0%. McClintock in his study of MMB recorded herds estimated that in the UK the annual genetic improvement through this source is between 0.2% and 0.4%. However, individuals can do considerably better than average, particularly in the initial years of selection.

Genetic improvement is a slow but on-going process. For a farmer starting on a new breeding policy now, it will be 9 or 10 years before all the cows in his herd are top proven sires for continued genetic improvement. At the same time breeders share a responsibility to mate a proportion (20%) of their cows to young bulls in AI and milk some of their progeny in order to help the national progeny test programme. The average genetic merit of young bulls is improving annually, and this year at an RBI of 122 was 9 points above that of natural service bulls, so that the use of young bull semen on a portion of the herd will not impede genetic improvement.

Place of the Holstein

There has been considerable interest in the use of Holsteins to upgrade the dairy merit of our herds in the past number of years. The Holstein has been sweeping through most European Black and White populations but its impact here has been less dramatic. It is unfortunate that Holsteins appear to be regarded as a different breed than Friesians, rather than as a strain, highly selected for dairy merit, within the same breed. It would be better if we could look at bulls of both strains in terms of their individual genetic merit, namely their RBIs and PDs. Obviously the average genetic merit of Holsteins is considerably higher than that of Friesians so that it would be much easier to find outstanding Holstein bulls in terms of genetic merit, relative to our population, than among Friesian bulls. FSM was such a bull. The other proven Holstein bulls in AI here are all above average in RBI but there are a number of Friesian bulls of similar genetic merit in the AI stud.

Economic evaluation of Holstein

We have recently carried out an economic evaluation of the Holstein compared to Friesians in different production environments ranging from 600 to 1200 gallons. Holsteins are on average about 17% superior in milk yield, 12% in fat yield and 15% in protein yield. The increased output that would be expected from Holsteins over Friesians in the different production environments is shown in Table 3. The net value of the extra output from Holsteins ranged from £45 to £71 after deduction of feed costs. Feed costs were assumed to range from just over 20% in the lower production environment to almost 40% in the 1200 gallon environment.

Table 3

Increased output as a result of replacing Friesians by Holsteins in different production environments

	Production Environment							
	600 gal		800 gal		1000 gal		1200 gal	
	Fr.	Holst*	Fr.	Holst*	Fr.	Holst*	Fr.	Holst*
Fat yield (kg)	100	112	122	149	166	186	200	224
Prot. yield (kg	91	105	122	140	152	175	183	210
Total value (£)	426	483	568	643	709	803	854	966
Extra gross value (GV) due to Holstein (£)		57		75		94		112
Feed cost (FC) of extra output (output £)		12		19		31		41
Extra net value (£) (GV - FC)		45		56		63		71

* Assuming 12% increase in butterfat yield @ £2.56/kg **and**
15% increase in protein yield @ £1.87/kg

Holsteins would have other costs associated with them compared to Friesians. Much of these costs would be concerned with the lower beef merit of cull cows and poorer prices for calves; in addition Holsteins, because of their higher production, are assumed to have a higher replacement rate (25% vs 20%), this would result in only 4 lactations instead of 5 for Friesians, while in addition Holsteins have about 7 days longer calving intervals. The effect of cull cow price and calving interval is assumed to be less in the higher production environments because of higher level of concentrate feeding which would result in better body condition. These costs are listed in Table 4 and are deducted from the extra value of output in Table 4.

Table 4

Economic benefits of Holstein over Friesian cows at different production levels (£ per cow)

	Production Environment			
	600 gal	800 gal	1000 gal	1200 gal
Benefits				
Daily merit (O)	45	56	63	71
Costs				
Cull cow price	12	8	4	0
Calf price	20	20	20	20
Longevity	14	16	17	18
Calving interval	10	8	6	4
Veterinary, labour, mortality, insurance	5	5	5	5
Calving difficulty/stillbirths	2	2	2	2
Total costs (C)	63	59	54	49
Overall benefit (O-C) (£/cow)	−18	−3	9	22

As a result of these calculations the effect of a changing from Friesian to Holstein would range from a loss of £18 per cow in the low production environment to a gain of £22 per cow in a 1200 gallon environment. A farmer would need to be producing in excess of 800 gallons per cow before he would even break even from such a change. At present production levels this would mean that less than 20% of dairy farmers would gain from Holsteinisation. However, high producing herds in excess of 1000 gallons (about 5% of herds) would stand to gain by grading up to high genetic merit Holsteins.

Milk Composition

Considerable attention has been devoted recently to the fact that there has been no increase in the composition of Irish milk in the last 20 years compared to other European countries. To some extent this has to do with our breeding policy where selection has been for yield of fat and protein. The reason for this has been straight forward and has to do with the heritabilities and genetic correlations between the different production traits — milk yield and composition have a negative genetic correlation This is probably best illustrated by looking at Tables 5 and 6.

In Table 5 are shown the relative gains from selecting for fat and protein yield compared to milk yield plus fat % and protein % at different value ratios of fat to protein. The gains from selection are 20% to 16% greater when selection is for yield.

Table 5

Relative gains from selection for milk yield and composition compared to fat and protein yield*

Selection for	Value ratio (fat : protein)		
	60 : 40	50 : 50	40 : 60
Milk yield plus fat % & protein	100	100	100
Fat and protein yield	120	118	116

Table 6 shows the direct and correlated responses from selection of the best 20% of bulls for a single trait at a time. Selection for milk yield gives the greatest response in milk but gives rise to a decrease in fat and protein percent. Direct selection gives the greatest response in fat %, but only small responses in yields of milk, fat and protein. Thus as the price of milk is largely related to the yield of fat and in some cases protein also, greatest gains are achieved through selection of fat and protein yields.

Table 6

Direct and correlated responses from selection for a single trait in dairy cattle

Best 20% of bulls selected on :	Milk yield (kg)	Fat yield (kg)	Protein yield (kg)	Fat %	Protein %
Milk yield	159	5.0	4.1	−.04	−.02
Fat yield	132	6.4	4.5	+.02	+.01
Protein yield	146	5.9	5.0	+.01	0
Fat %	59	0.9	0.5	+.12	+.05
Protein %	−4.5	0.9	0.5	+.07	+.08

If we want to improve fat and protein yield and milk composition at the same time the quickest way this will happen is if creameries put a negative value on milk volume. We were told at this meeting last year that is the way the Dutch do it and we all know they have one of the highest fat percentages in Europe at 4.1%. If a negative value was put on milk volume by creameries then farmers would have to pay considerably more attention to the selection of bulls with high RBIs associated with high PD's for fat % and protein %, as for example, bull TWB referred to above.

Milk recording

Milk recording is expensive. The cost of the A4 type milk recording scheme is approximately £12.50 per cow, a cost which is borne almost equally by the Department of Agriculture, the dairy co-ops and individual farmers. In 1984, approximately 106,000 of 6.6% of our dairy cows will be recorded under this scheme. This is the scheme which should be providing the records for the national progeny testing programme, but unfortunately up to now a number of farmers have been using this scheme for their own benefit with little input to the national testing programme. In time it is envisaged that approximately 15% of cows would be recorded under such a scheme. However unless farmers provide records for the national progeny testing programme they may not continue to receive this service, or if they do, they could have to pay the full cost of it. The lack of milk recorded daughters of young bulls is one of the biggest obstacles to an expansion in the number of young bulls going on test each year, and hence increasing the intensity of selection among bulls.

While milk recording is important, its main advantage to a dairy farmer is in the day to day management of his herd. For this, the simpler and considerably less costly type of DIY recording as operated by many of the Co-ops is adequate and will provide sufficient information in helping to identify the better animals from which to breed replacements. The use of the A4 type recording scheme is a luxury for dairy farmers not involved in the progeny testing programme and if the full cost of the recording were to be borne by these farmers, economics would, I think, dictate that he utilises a less costly DIY type scheme.

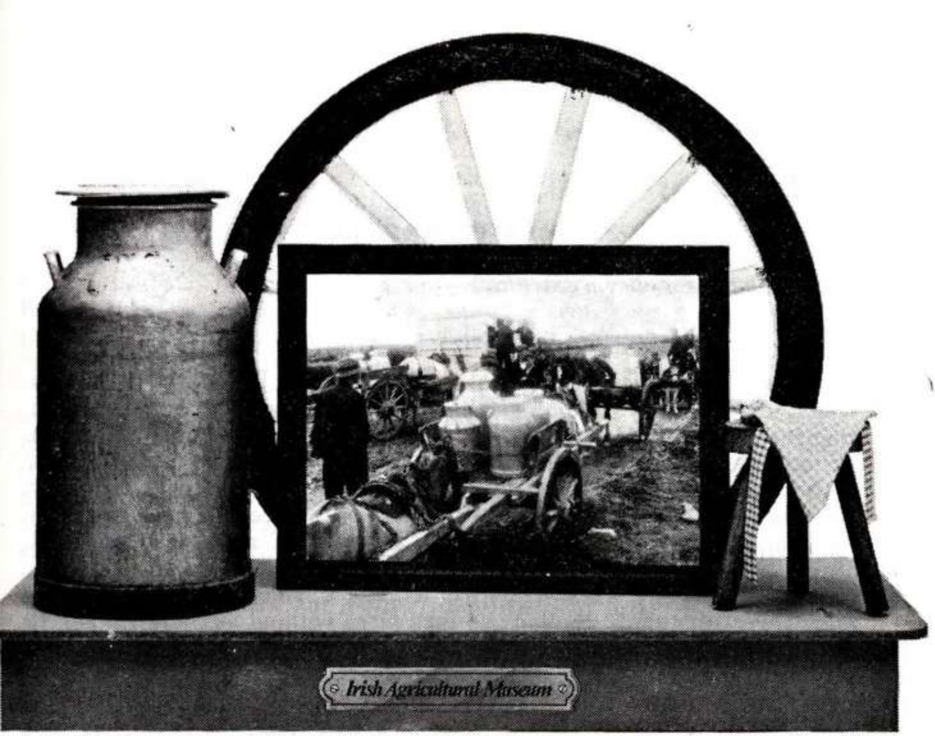
Summary

Herd yields can be improved through improved management and an improved breeding programme. Genetic improvement is relatively more important in higher producing herds.

Genetic improvement can be achieved through four pathways. Two of these, bulls to breed bulls and cows to breed bulls, account for 75% of the improvement, are concerned with the selection of bulls for AI and so are outside the scope of the dairy farmer. Of the other two, the selection of bulls to breed cows, and hence the sires selected by the farmer for use on his herd contributes considerably more to genetic improvement than the selection of cows to breed replacements. Culling of low yielders offers limited scope for genetic improvement. Farmers with high yielding herds should define their breeding goals in terms of improving economically valuable traits and then select bulls with the highest available PD's (or RBI) for these traits.

A change to Holstein would only have advantages for herds yielding 1000 gallons or more. Such a change should lead to an increase of about 17% in milk, 12% in fat and 15% in protein yields, but would lead to a considerable fall in the price of dropped calves and cull cows and lead to a higher replacement rate in the herd. In economic terms the advantages are estimated to be £9 per cow in a 1000 gallon herd and £22 per cow in a 1200 gallon environment. At 800 and 600 gallons there would be a loss of from £3 to £18 per cow from a change to Holstein.

Milk recording is important, firstly to provide records for the national progeny testing programme and secondly for the day to day management of the herd. If milk recording is primarily used for management purposes then the less costly DIY type service is sufficient and will also help in identifying the higher producing cows.



Ireland's dairy industry has come a long way since.

The days of dairymaids and horse-drawn creameries have passed. In their place has emerged one of the world's most modern and dynamic dairy industries. Today Ireland turns the greenest grass in Europe into a diverse range of the best-known dairy products in the world.

From Honduras to Hong Kong, from Trinidad to Tokyo you will find Irish cream, milk powder, chocolate crumb, cheese, casein and a great variety of other products, many of them sold under the Kerrygold brand name.

Irish dairy exports last year were worth over £700m. Which gives you some idea just how far the industry has come since the days of the dairymaid.

AN BORD BAINNE
IRISH DAIRY BOARD

Advances in Semen Technology in Ireland

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Introduction

Since the introduction of artificial insemination (A.I.) in 1940 as a fresh semen service, many technological advances have taken place. The main changes have centred on methods of processing and semen storage with particular emphasis on deep freezing of semen. Cryoprotective agents such as glycerol were added to allow deep freezing of semen in either ampoules or Continental (Cassau) straws. For the deep freezing of semen the exact rates of cooling from +5°C to −195°C are well defined. It appears that cooling should be at a slow rate especially through the critical temperature zone of −15°C to −25°C and once having passed this danger zone rapid cooling can take place without any adverse effects (Luyet and Keane, 1955).

Rate of thawing is one of the most important factors affecting post thaw spermatozoal viability (Robbins, Gerber and Saacke, 1972; Almquist, 1976). Rapid thawing rates of frozen semen packaged in Continental straws has been shown to significantly increase post thaw acrosomal maintenance and the percentage of motile spermatozoa (Almquist, 1976). Thawing in water at 35°C for 30 sec will give seminal temperatures of 32°C approximately and this is the conventional thawing practise adopted by A.I. Centres. However, there are divergent views as to the effect of raising seminal temperatures above 5°C during the initial thawing process. It has been suggested that thawing in warm water should be timed to prevent seminal temperatures from rising above 50°C and the thawed semen should be used immediately to avoid a drop in fertility (De Abreu, Berndtson, Smith and Pickett, 1979). It was suggested that keeping the temperature from rising above 5°C will prevent cold shock especially when external temperatures are zero or sub-zero. However, Almquist, Rosenberger and Branas (1979) recommended that seminal temperatures should be raised above 5°C especially during cold weather if maximum fertility rates are to be achieved. Other field studies found that non-return rates were similar for semen warmed to 5°C or to near body temperature in 35°C water (Forde and Gravir, 1973).

The effect of thawing procedure in most studies has been based on laboratory tests in which the percentage of motile spermatozoa and the amount of damage done to spermatazoa are assessed. Field trials in which the effect of thawing procedure on actual fertility are likely to be much more meaningful. Stewart (1969) at the Reading Cattle Breeding Centre found little effect on conception rate from conventional thawing procedures relative to thawing "in the gun". Similarly Davidovic, Borjanovic, Cvetkov and Knezevic (1972) obtained a non-return rate of 74% for 166 inseminations from conventionally thawed semen as compared to 72% for 392 inseminations with semen thawed "in the cow". In the U.S., Almquist et al (1979) obtained a 66 day non-return of 72% for semen thawed for thirty seconds in water at 35°C compared to 70% for that thawed to 0°C. An experiment by Rugg, Berndtson, Mortimer and Pickett (1977) showed that "in cow" thawing significantly depressed the pregnancy rate in 108 cows and concluded that thawing "in the cow" or "in the pocket" was unacceptable.

From the practical point of view "in cow" thawing would save a considerable amount of time since the straw could be directly loaded into the inseminating gun and used immediately. In addition many farmers feel that the thawing process needs to be exact and precise if maximum conception rates are to be obtained. Since both of these factors are very important the purpose of this trial was to compare the effect on conception rates of "in cow" thawing with conventional thawing procedures. For "in cow" thawing the end of each straw was rolled between the fore finger and thumb, until the semen at that end became fluid, before cutting with a scissors for insertion in the insemination gun. For conventional thawing the straw was placed in a container with water at 35°C for 30 sec. Animals were randomly allocated to "in cow" or conventional thawing based on similarity of lactation number and calving date. The trial was carried out for a two year period on four of the Moorepark herds using one A.I. operator and one semen ejaculate for each bull. Conception was verified by rectal pregnancy diagnosis 90 to 120 days after service.

Results and Discussion

The first service conception rates for semen thawed in the conventional manner and "in-cow" thawing are shown for 1981 in Table 1. There was no significant difference between farm or bull and overall the 90-120 day

Table 1

First service conception rate for semen thawed in water at 35°C for 30 sec. and "in cow" thawing (1981)

		"In cow"		35°C for 30 sec.		
Farm code	Bull code	No. served	No. conceived (%)	No. served	No. conceived (%)	X^2
CRT	BTL	45	28 (60)	34	24 (71)	NS
MPN	TET	37	21 (57)	43	32 (74)	NS
MPG	GOL	61	47 (77)	63	44 (70)	NS
BDR	TET	62	47 (76)	67	49 (73)	NS
TOTAL		205	142 (69)	207	149 (72)	NS

pregnancy rate for "in-cow" thawing was 69% and 72% for the conventional method. This difference was not significant. In 1982 (Table 2) seven bulls were used across the four farms. On the MPN farm "in-cow" thawing gave a significantly higher pregnancy rate than conventional thawing but this was largely due to a difference in conception rate for bull PRS. Overall the first service conception rate for "in-cow" thawing was 77% and 74% for the conventional method. These were not significantly different.

The overall results for the two years of experimentation indicate that there is no significant difference in conception rate for "in-cow" thawing versus the conventional method. This stands to reason since "in-cow" thawing is actually thawing the straw in an animal whose body temperature is approximately 37°C and therefore similar to thawing in water at 37°C. Since "in-cow" thawing offers considerable saving in time and no apparent effect on fertility, this method has been adopted as standard procedure in the Moorepark herds serviced by our own A.I. operator.

Table 2

First service conception rate for semen thawed in water at 35°C for 30 sec and "in cow" thawing (1982)

	"In cow"		35°C for 30 sec.		
Farm code	No. served	No. conceived (%)	No. served	No. conceived (%)	X^2
CRT	37	27 (73)	37	27 (73)	NS
BDR	70	51 (73)	71	52 (73)	NS
MPG	35	29 (8)	43	39 (91)	NS
MPN	54	43 (80)	53	32 (60)	4.7*
TOTAL	196	150 (77)	204	150 (74)	NS
Bull code					
GOL	54	44 (81)	51	41 (80)	NS
BTL	54	42 (78)	68	50 (73)	NS
BIR	18	11 (61)	21	14 (67)	NS
PRS	27	23 (85)	29	20 (70)	NS
BLC	20	13 (65)	14	9 (64)	NS
BTY	20	16 (80)	17	13 (76)	NS
AS6	3	1 (33)	4	3 (75)	NS
TOTAL	196	150 (77)	204	150 (74)	NS

Bull Usage

In the U.S. extensive dilution rate trials using egg yolk citrate diluent have shown that fertility progressively drops with increasing dilution and that this rate of decline is gradual down to 15 million total sperm and rapid as sperm levels are further decreased (Salisbury and Vandemark, 1961). In Ireland, frozen semen is processed to contain between 20-30 million spermatazoa and these sperm levels are maintained even when a fresh semen service is provided. As a result it is only possible to obtain between 25,000 and 40,000 doses of semen per annum from the top A.I. bulls. In addition, since 80% of Friesian inseminations occur in the months March, April and May, conditions are ideally suited to the use of a fresh semen service. However, bull usage could not be significantly improved unless sperm numbers per insemination could be dramatically reduced. In New Zealand, Caprogen diluent has been used with sperm numbers as low as 2.5 million without adversely affecting fertility. In this country by reducing sperm numbers to 10 million per dose it would be possible to meet the demand from the top dairy bulls during the peak breeding months and thereby greatly improve bull usage. In 1983 a study was set up to compare fertility of Caprogen diluent containing 10 million sperm per dose with a standard fresh semen diluent containing 30 million sperm per dose.

The Caprogen diluent was made up at Moorepark and distributed to the five Munster A.I. Centres. The standard diluent was made up at each centre in the usual manner. Semen dilutions were based on obtaining an equal number of inseminations from a split ejaculate from each bull under test. Estimates of sperm density were made based on colorimetric analysis. In addition to the diluent comparisons the non-return rates for the same day and day after collection were made. For the day of collection (same day) semen was collected from the bulls at 5.00 a.m., processed and delivered to the other four centres for bulls not standing at each centre. For the day after comparison semen was collected at the usual time (11.00 a.m.), processed and then used for inseminations on the following day. Semen was distributed in both diluents using the 0.25 ml Cassau straw. Both diluents were transported on ice at 5°C and the straws were coded as follows: (a) day after Caprogen diluent, (b) day after standard diluent, (c) same day Caprogen diluent, (d) same day standard diluent. The objective was to obtain approximately 9,000 inseminations per treatment in order to have an 80% chance of detecting a 2% difference which would be significant at the 5% level.

Results and Discussion

Non-return rates were standardised between all centres and the data were analysed on the basis of a three month non-return rate to first service only. During the trial a total of 27 bulls were used, but not all bulls were used across all centres or diluents. Thus, in an attempt to reduce the variation between bulls and centres the data were reduced to information from 8 bulls which were used across all centres and diluents. In Table 3 the total number of inseminations for each centre and each diluent are given. In Table 4 the 3-month non-return rate by bull and

Table 3

Reduced set data (8 bulls). Total number of cows inseminated

Treatment	Total (1) Day after		Same day		
Centre	CAP	STD	CAP	STD	Total
Galtee	1315	1203	812	758	4088
Ballyclough	1532	1440	565	603	4140
Bandon	769	679	503	501	2470
Castleisland	1151	1022	464	406	3043
Clarecastle	409	366	167	308	1250
TOTAL	5176	4728	2511	2576	14991

Caprogen Diluent containing 10m. sperm

Standard Diluent containing 30m. sperm

by centre are given. A bull by centre by diluent interaction was found, in that some bulls had a significantly higher non-return rate in some centres relative to others. In Table 5 the non-return rates for standard and Caprogen on same day and day after collection are given.

Table 4

Three month non-return rate (reduced data set) for each bull and Centre

Bull	Centre					
	Galtee	Ballycl	Bandon	Castleil	Clarecas	Total
BBT	75.04	76.25	77.25	78.25	74.52	76.19
COL	75.23	71.70	71.30	71.75	74.19	73.08
CCR	73.62	76.06	81.52	74.22	68.83	74.72
KMK	76.73	73.81	82.42	74.12	66.30	74.72
LBB	75.73	69.93	74.46	71.51	68.83	73.00
SAK	76.30	74.44	75.29	81.10	75.63	76.85
EJA	74.69	78.69	75.70	77.25	85.54	77.43
TET	73.30	74.65	72.90	71.43	76.38	73.37
TOTAL	75.17	74.81	75.51	75.45	75.28	75.19

Bull x Centre Interaction ($P<0.05$)

Table 5

3 month non-return rate (reduced data set) for Standard and Caprogen diluent on same day and day after collection

Diluent	Standard	Caprogen	Total
Day			
Same	76.24	75.15	75.70
After	75.78	74.15	74.93
TOTAL	75.94	74.48	75.19
Standard vs. Caprogen	1.44 (P<0.05)		
Same vs. After	N.S.		

The standard diluent was significantly better by 1.44% relative to the Caprogen diluent. However, this also depended on which centre and which bull was being considered. This interaction effect is illustrated in Table 6 where for example bull GOL at Bandon A.I. Centre had a significantly higher non-return rate for standard diluent than for Caprogen. However, this effect was not apparent in other centres.

Table 6

Interaction effects of bull, diluent, and centre, on 3-month non return rate

Bull		Standard	Caprogen
GOL	Bandon	80.4	65.1
CCR	Clarecastle	94.0	59.4
TET	Galtee	79.8	66.8
SAK	Bandon	67.0	81.2
LBB	Ballyclough	75.4	61.0
BRT	Castleil	74.5	82.3
On average		75.94	74.48
		Diff.	1.46 (P<0.05)

The low non-return rate with the Caprogen diluent in this particular trial is not consistent with the evidence from other countries. In New Zealand no differences were found between standard diluent and Caprogen diluent even with sperm numbers as low as five million (Shannon, 1968). Similar results were found in the U.K. using 5 million sperm in 0.5 ml Cassau straws (Anon., 1967/68). In our studies one of the factors which may have had an adverse effect on the Caprogen diluent was the fact that it was stored at 5°C when it is best suited to ambient temperature (13-24°C). In addition there is some suggestion that the nitrogen gas (an essential componnt of the Caprogen diluent) may escape through the PVC seals at the ends of the straw. A further experiment is currently underway taking these factors into account.

In conclusion, while the 1.44% drop in N.R.R. was found to be statistically significant in this trial, it must be weighed up against the greater utilisation of top quality bulls which can be achieved through using this diluent.

Acknowledgements

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Dairying — Where Now?

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The Irish dairying industry is examined in terms of its competitive strength and its suitability as a major focus of national industrial investment. The industry review is to a background of changing national and international business policies, an economy in continuing recession and a dairying industry with, among other factors, low income levels on many farms and great uncertainties about the future market arrangements for its present product range.

The milk production industry in Ireland is apparently becoming concentrated in a small number of dairy farms where increasing production efficiency is indicated by good technical performance, low costs of production, efficiency in the use of major production inputs and expansion despite milk prices that are lower than those in most competing European countries. Although the problem of low income remains on many dairy farms, the efficiency of many producers and the considerable financial incentives to increase technical improvement in milk production methods, suggests a considerable potential competitiveness in the milk production industry in Ireland.

This competitiveness is in contrast to the Telesis conclusion that "... Irish dairy farming ... is ... uncompetitive ... making the total dairy product uncompetitive", which if accepted in national industrial policy would greatly reduce the possibility of the dairying industry being a major focus of indigenous industry investment.

In milk processing, it is recognised that there is already considerable innovation in the process efficiency by which major milk commodity products are manufactured. However, experience in other industries suggests that there is an important distinction between the manufacturing focus of product as distinct from process innovation. Plants that are centred on process innovation find it exceedingly difficult, and generally inadvisable, to focus on both strategies at the same time within a single plant. It is suggested that there is a need for a re-direction of dairy industry investment, manufacturing structure, marketing and research and development, if attempts to steer the dairy industry towards product innovation are to be successful. Many recent studies have examined changes in the technical, social and demographic structures of dairy farming in Ireland and some have projected these into predictions of future changes. Also, especially in the past year, the future of Irish dairying has been discussed mainly in terms of the instabilities of E.E.C. marketing arrangements for dairy produce.

Continuing these themes, it is proposed here to examine in some detail the industrial policies of the Irish dairying industry. The proposed industrial strategy is that Ireland develop, within the dairying industry, a successful indigenous industry based on traded products that have competitive advantage over international competitors. Is national investment in the dairying industry worthwhile, and if so, how should the investment be directed ? The criteria used is an economic one. If competitive advantages in dairying do not exist, or cannot be created, then development of indigenous industry must pursue alternative strategies, both in its export businesses and in the capital investment used to support these businesses. Capital investment in dairying is thus seen as an aid to national economic development and such investment is seen as being worthwhile only if it can support export business on a continuing basis.

National Industrial Policy

The period since 1979 has been characterised by extreme environmental uncertainties and rapid structural changes in both the world and the Irish economies. New competitive strategies are being evolved with major re-alignment of previously held values in almost all of the economic structures of nations, especially in the western world. In Ireland, the continuing economic recession since the 1970's has brought many problems, including inflation, overseas borrowing, balance of payments difficulties, business failures and particularly, unemployment. In response, national priorities increasingly centre on the necessity to provide employment, especially for an expanding labour force of young people. These priorities emphasise especially the requirement for the establishment of new businesses in Ireland, especially where Ireland has competitive advantages. Economic difficulties have been felt especially in the industrial sectors in Ireland but within agriculture also there is a growing realisation that previous priorities in food production may be untenable in the future.

In February 1982, the Telesis Consultancy Group suggested the re-alignment of investment priorities in Ireland with a substantial reduction of average grant levels for many foreign owned firms located in Ireland and for indigenous companies in non-traded businesses. Additionally, it suggested "a substantial increase in funds devoted to the development of indigenous export buinessses". It was suggested that the proportion of funds allocated to indigenous export or skilled sub-supply firms be increased from a level of less than 40% over the past 10 years to 50% in 1985 and 75% in 1990. The Consultancy Group concluded that "new joint efforts should be undertaken to oversee the development of Ireland's resource-based industries". Although the Telesis Group did not study the agricultural industry directly, and did not propose the form of a co-ordinated effort, they concluded that "we are certain that a great opportunity will continue to be lost if nothing is done". However, they did suggest that "inefficient farming practices prevents the country from realising its full income potential in beef and dairy products. Since farm costs are between 70 and 90% of almost all traded products in dairying and beef, this penalty is particularly severe; it results in an uncompetitive final product and in low prices to farmers who cannot maintain a satisfactory standard of living".

Despite perceived difficulties, the dairying industry provides the greatest possibility for development of new indigenous business in Ireland based on natural resources and with considerable possibilities of competitive advantages in world markets. Thus, the Telesis Consultancy Group acknowledged that "the Irish dairy processing industry possesses facilities considered to be fully competitive in Europe . . . cheese . . . offers opportunities for price premium through product differentiation".

Milk Production

There are at present rapid changes in the structure and concentration of milk production on Irish dairy farms. Despite a 40% reduction in the number of milk suppliers between 1961 and 1981, the quantity of milk supplied to creameries increased almost 2.5-fold over 1961 values and the quantity of milk per supplier increased 4 times. In the period between 1972 and 1981, the land area devoted to dairying in Ireland decreased from 2.7 million acres to 2.6 million acres although milk production increased by nearly 50% in the same period. There has been a comparable change in the structure of milk supplies (Table 1). Whereas, in 1966, suppliers of less than 5,000 gallons comprised 76.8% of all suppliers and supplied 40.7% of all milk, the proportion of suppliers in this group in 1981 was estimated to be 36.8% and they supplied only 7% of the total manufacturing milk. Similarly, the number of suppliers

Table 1

Structure of milk supplies by level of supply

Supply (gallon)	1966 Suppliers	1966 Supply	1976 Suppliers	1976 Supply	1981 Suppliers	1981 Supply
	Per cent					
2,500 and less	53.6	18.7	27.9	3.7	18.9	1.9
2,501 - 5,000	23.2	22.0	21.5	9.4	17.9	5.1
5,001 - 10,000	16.1	31.1	22.6	19.3	22.3	12.6
10,001 - 15,000	4.7	15.5	11.3	15.8	12.5	11.9
15,001 - 20,000	1.5	7.4	6.5	13.1	8.6	11.7
20,001 - 25,000			3.8	10.2	5.3	9.3
25,001 - 30,000	0.9	5.3	2.2	7.3	4.1	8.6
30,001 - 40,000			2.4	9.4	4.5	12.4
40,000 +			1.8	11.8	5.8	26.6

Source : Kearney, B. "Potential, performance and constraints in Irish agriculture", Agricultural Science Association Conference, Sept. 16th, 1982.

producing over 20,000 gallons annually increased from less than 1% in 1966 to 19.7% in 1981. By 1981, it was estimated that 57% of Irish manufacturing milk supplied was produced by only 20% of milk suppliers, or about 13,000 dairy farmers. At the top of the production scale, the contrast is even more striking. It is estimated that, in 1981, 3,700 (or 5.8% of total) milk producers supplied 26.6% of all manufacturing milk supplies. In that year, there were a total of 64,400 suppliers in Ireland.

There have been, apparently, equally dramatic changes in the technology of the milk supply pattern (Table 2). Herd size increases have been concurrent with dramatic changes in the efficiencies of milk production as measured by two important criteria; that is, milk yield per cow and stocking intensity. Similarly, there has been an increased specialisation in dairying in the farms holding the bigger herds. It is apparent that the adoption of new technology has effectively removed the limit to size in dairy farming (1). These changes in the milk production industry are similar to those which have dramatically altered the Irish pig production industry in recent years. Present indications in dairy farming, and the precedent afforded in the patterns of pig production, suggest a continuing concentration of the milk production industry into fewer and more efficient dairy farms with a concurrent emphasis by suppliers on technical information associated with profit maximisation.

Table 2
Relationships between dairy herd size and other variables in 1972/1973 and 1980/1981

Herd size	<10	10-20	20-30	30-40	40-50	50+
Farm size (acres):						
1972/1973	40	70	94	110	148	168
1980/1981	44	66	84	100	119	157
Milk yield (gal/cow):						
1972/1973	491	561	604	639	658	665
1980/1981	564	615	709	731	738	789
Stocking rate (ac/LU):						
1972/1973	2.41	2.03	1.74	1.55	1.67	1.40
1980/1981	2.26	1.95	1.72	1.56	1.46	1.30
Dairy output as % total:						
1972/1973	41	48	52	55	60	61
1980/1981	35	51	61	64	65	67
Cows—% of total grazing LU's:						
1972/1973	34	43	48	51	50	55
1980/1981	32	46	53	56	59	61

Source : Kearney, B. (as in Table 1).

Over the past 10 years, Irish agriculture has been characterised by an increasing division into two groups, one relatively prosperous (especially within the dairying sector) and one stagnating or even decreasing in family farm income (2). Numerically the latter group has predominated and it has been estimated that most of the growth in Irish agriculture that has occurred between 1976 and 1981, has come from no more than about 25% of farms.

Within the dairying industry also, there has been a wide disparity between farmers in income and in farm output. When specialist dairy farms in the 1981 Farm Management Survey of the Agricultural Institute were ranked in order according to their gross margin per acre, those in the top third of the rank produced nearly twice as much per man as farms ranked in the bottom third (3). This difference was found throughout the range of farm sizes from 30 to 150 acres. Farmers in the top third also produced more than twice as much milk per acre as those in the bottom third. Furthermore, in a study of low income farms (4), it is concluded that in a large proportion of farms, change is unlikely in the future. This was due to "the existence of some deeply entrenched obstacles to the generation of higher income among low income farmers".

Despite low income levels on many farms, there were, in 1983, still considerable financial rewards for increased milk production efficiency on those dairy farms where profit maximisation was an important objective. Present average dairy farm size is about 57 statute acres. Recent data (Table 3) showed a net margin of IR17,294 punts to service capital investment and reward labour on a 50-acre dairy farm using 1983 prices, a stocking rate of 1 cow/acre, and a milk yield per cow of 1,050 gallons; a technical value achieved on many farms in Ireland (5). This represents

Table 3

Estimated net margins at different levels of intensification on a 50 acre free-draining farm (£)

	2.0 ac/LU	1.5 ac/LU	1.0 ac/LU
Gallons/cow			
650	2,296	3,975	7,424
750	3,530	5,562	9,891
850	4,664	7,148	12,358
950	5,998	8,734	14,826
1050	7,231	10,320	17,294

Source : MacCarthy, D. (5). "Financial Returns from Dairying", Milk Production Seminar, Moorepark, May 24-26, 1983.

a net margin of IR412 punts per cow or a return to service labour of about IR300 per cow (or IR12,600 per 50 acre farm) after allowing for servicing of IR700 punts per cow space borrowed against working capital and other capital requirements. Similarly, Crosse (6) reported that the average dairy farm in his recording of Dairy Herd Management Information Schemes in 1983 had margins of IR479 punts per acre over feed and fertiliser costs (Table 4). These farms had average milk yields per cow of 991 gallons and each acre of the farm carried 1.02 livestock units. Since feed and fertilisers may be expected to account for about half of total dairy farm fixed and variable costs, the recorded profit margins amount to a net margin per acre of IR240 punts, to service capital and labour requirements. A total of 139 creamery milk herds recorded in the I.C.I. Dairymaid recording scheme (7) in 1982 had margins over meals and fertiliser of IR423 punts per acre, giving an expected total net margin of about IR10,600 punts on a 50-acre dairy farm. The data indicate considerable financial returns at attainable performance, even on relatively small farms.

Table 4

Performance and margins on 41 dairy farms (1983)

	Milk yield (gals/cow)	Stocking rate (LU/ac)	Margin over F & F[a] (£)
Mean all herds	991	1.02	479
— Range	819-1370	0.73-1.24	313-719
Curtins Farm (AFT)	1074	1.24	660

[a] Margin over feed and fertiliser costs

Source : S. Crosse, Moorepark (Dairymis Herds)

It is suggested that concepts of production efficiencies in a growing section of the dairying industry differs considerably from the Telesis conclusion that ". . . Irish dairy farming . . . is still generally uncompetitive and has a negative impact on processing costs, making the total dairy product uncompetitive". It is believed that estimates of milk production competitive advantage based on national average values are only an extremely limited measure of the potential competitive abilities of the industry. Average production efficiencies in dairy farming are, arguably, more demonstrative of the origins and history of Irish dairy farming practices and land tenure arrangements as well as market influences rather than as a measure of potential competitiveness. Perhaps a more realistic measure of competitiveness might be the extremely low cost of milk production in Ireland relative to the European competitors (Table 5), the considerable development of the production industry despite the lowest milk producer prices in the E.E.C. (5) or documented efficiency in the use of the major production inputs (9). Inefficiencies in milk production practices in Ireland are already reflected in a milk price that is only about 80 to 90% of that available to milk producers in most other E.E.C. countries and it is not correct to further project these inefficiencies (as the Telesis Report did) as a threat to the competitiveness of the whole dairying industry. Thus, for instance, Reardon (10) has contended that had the Telesis Consultants had the opportunities to see how productive some farms were relative to others in Ireland, they could well have concluded that growth of output depended on "giving highly productive farmers more opportunity to expand".

Table 5

Estimated production cost per kg of milk in the seven regions of the EEC studied 1977-1980, excluding family labour, interest charges and capital charges

	W. Germany DM	France FF	Netherlands	Belgium BF	UK £STG	Ireland £IR	Denmark KR
1977	0.122	0.086	0.122	0.077	0.098	0.055	0.122
1978	0.119	0.088	0.121	0.073	0.101	0.051	0.155
1979	0.121	0.092	0.129	0.076	0.116	0.063	0.125
1980	0.121	0.099	0.137	0.080	0.139	0.070	0.134

Source : Kelly, P. W. "Some developments in dairy farming in the EEC". Conference Economics and Rural Welfare Research Centre, An Foras Taluntais, Dublin, Dec. 1st, 1981.

In summary, the trends outlined suggest a continuing concentration of milk production on a decreasing number of dairy farms and an increasingly competitive milk production industry in Ireland. On these farms, profits will be maximised by increasing milk production efficiencies. The farms will parallel a further sector where social, structural, educational or other reasons prevent farm profit maximisation being a critical measure of success. It is suggested, however, that it was failure to measure the growing competitive strength of the milk production industry in Ireland that led the Telesis Group to erroneously conclude that there were not potential competitive structures in the Irish milk production industry.

Dairy Processing

The potential for efficiency in the processing of commodity milk products in Ireland and the progress made in diversification of commodity products is now recognised. The Telesis Consultancy Group saw competitive advantages for export marketing in the size, modernity and investment that has already taken place in Irish cooperative processing plants. Similarly, there has been considerable investment and apparent success in the research and technology servicing of process efficiency.

In contrast, there remains a critical need for product diversification programmes towards consumer products. The main dairy products manufactured in Ireland are butter, skim milk powder and cheese (Table 6). The product mix has not changed markedly in the past 5 years. The

Table 6

Production of major Irish dairy products (tonnes)

	Year				
	1978	1979	1980	1981	1982
Butter	118110	121650	111050	111591	132281
Butteroil	9762	8900	12091	8484	2454
Cheese	49640	57500	48942	52743	56325
Whole milk powder	28380	19152	34600	35840	38778
Chocolate crumb	40804	41400	33020	30651	36218
Cream	5295	6083	9638	12370	15919
Skim milk powder	122541	148000	140464	141298	149576
Casein	11416	13300	16918	14483	19350

Source : Annual Reports, An Bord Bainne

Table 7

Trends in whole milk utilisation[a] (percentage of total)

	1978	1979	1980	1981	1982
Butter	70.0	70.8	66.3	66.7	71.8
Butteroil	6.8	6.3	8.6	5.9	1.6
Cheese	12.9	15.1	12.9	13.9	13.2
WMP	5.4	3.1	6.6	7.0	6.7
Chocolate crumb	2.8	2.7	2.0	2.0	2.2
Cream	1.4	1.6	2.6	1.6	1.4
Others	0.7	0.4	1.0	2.9	3.1
	100	100	100	100	100

[a] Utilisation represents milk intake at creameries plus net transfer from the liquid sector

Source : An Bord Bainne, Annual Reports

longer term trends in utilisation of whole milk (Table 7) and skim milk (Table 8) indicate a continuing dependence on these products. The cheese manufactured has been almost exclusively of the cheddar variety.

The necessity for product diversification in the dairying industry was a major theme in the Telesis Report and it had been recognised also by cooperatives (11), Bord Bainne (12), and by dairy farmers (13). Prior to 1981, I.D.A. policies for the dairy industry were to encourage the establishment of process efficient plants. However, recognising the necessity for product development, IDA policy in 1983 stated (14) that ". . . dairy cooperatives will now have to commit resources to product

Table 8

Trends in skim milk utilisation (percentage of total)

Product	1979	1980	1981	1982
Skim milk powder	54.5	54.0	56.0	52.3
Casein	16.5	22.0	19.4	21.3
Animal feed	15.7	10.4	12.0	11.9
Human food	5.9	4.8	3.9	6.2
Pig feed	6.4	8.1	7.9	7.9
Standardisation	0.1	0.1	0.1	0.5

Source : Annual Reports, An Bord Bainne

development and marketing and we will assist them with financial and other aids . . . but we will not assist the development of increased capacity to produce commodity products". There was no novelty in these objectives since the necessity for product innovation had been advanced in the dairying industry since at least the mid-1970's. In early 1977, the Bord Bainne five year plan emphasised the necessity to reduce dependence of the dairying industry on butter. The McKinzie Report (15) stated that Ireland had to change from a commodity base to one of marketing.

The developments in the dairying industry in the 10 years since 1973 suggest a withdrawal from product innovation and product marketing rather than an active programme in this area as had been envisaged in 1973. Research on new products has been greatly reduced, and by 1983, new products that had contributed meaningfully to diversification of the dairying product portfolio were more notable for their rarity and because they had their origins in small or private firms or abroad.

An understanding of why Irish dairying did not successfully diversify its product portfolio is critical to the future investment strategies of the milk processing industry.

The Dairy Food Industry

Irish imports of food in 1982 (753 m. Irish punts) exceeded the value of all Irish dairy exports (IR 710 m. punts). The dairying industry, arguably the most important industry in the nation and certainly a major source of exports, was especially vulnerable to trading influences. By 1983, world markets for dairy produce were extremely difficult. Irish exports to the U.K., the major Irish market, had remained static, despite reduced market returns while the value of butter sales was expected to be somewhat less than half the sales in the mid-1970's (about 40,000 tonnes annually). Also, it was apparent that the Irish dairying industry's combined product mix and marketing arrangements might be approaching serious difficulties. In 1983, it was estimated that half of all skim milk powder and a third of all butter produced in Ireland would be sold into E.E.C. Intervention Stocks. Thus, Ireland is particularly vulnerable to those influences which, by mid-1983, increasingly threatened the value, if not the continued existence of the E.E.C. Intervention system. All E.E.C. countries, except Italy and the U.K., produced butter in excess of their requirements in the period to 1978. By mid-1983, it was apparent that the United Kingdom market for butter had become practically self-sufficient due to increased United Kingdom production, New Zealand imports and falling consumption. Thus, in summer 1983, it was increasingly apparent that considerable changes had occurred in the dairy food markets of the E.E.C. without apparent parallel changes in Ireland.

Organisational structure of the Irish milk processing industry

Although multi-national food companies are extremely big by Irish standards, the E.E.C. dairy food industry is characterised by a big number of small firms (16). The total number of dairy food firms in the E.E.C. in 1976 was 1,568 with 455 firms in France, 341 in Germany, 320 in the United Kingdom, 121 in the Netherlands and 64 in Ireland. As in Ireland, the number of dairy firms in the E.E.C. is decreasing. A total of 24% of firms ceased production between 1972 and 1976.

The size of milk processing plants in Ireland is big when compared with the dairying manufacturing units in other E.E.C. countries (17). Annual milk intake per dairy in Ireland (63,000 tonnes) is comparable to that in the Netherlands (75,000 tonnes) and greatly in excess of E.E.C. average values (12,300 tonnes). The number of creameries in Ireland decreased from 169 in 1960 to 82 in 1976. This figure had fallen still further by 1980 to 48 cooperative intake points representing 20 manufacturing companies. In 1970, the five largest cooperatives handled 27% of the total milk for manufacturing while in 1982, the largest seven cooperatives processed 75% of the total milk for manufacturing in Ireland.

Generally, in 1983, dairy cooperatives were engaged in conglomerates of unrelated businesses to a degree which was even more pronounced than that used by other large Irish companies. Cooperatives were involved in one dominant business, milk processing, with many other unrelated businesses. Most cooperatives had separate milk, animal feed, fertiliser, stores trading, farming, farm advice, artificial insemination and occasionally, construction and other operating divisions. The involvement in non-dairy business was considerable. Thus, in the 10 years to 1983 it was estimated (18) that dairy cooperatives had invested approximately IR45 m. punts in new animal feed manufacturing plants.

Within the milk processing units, it was apparent that the focus of the dairying industry was on innovation in process techniques and was, apparently, less concentrated on consumer product innovation and its distinctive market focus requirements. Manufacturing structures, together with their research and development, investment, and marketing structures, have been focussed essentially on the requirements for process efficiency. The particular focus of these activities are quite distinct from those which would be required if the primary attention of the industry had been towards consumer products as distinct from process innovation.

Studies (Fig. 1) on the rate of commercialisation of milk product and process innovations at Moorepark (1961 to 1974) showed that whereas there was a 48% success rate to a total of 81 innovations, only 35% of product innovations achieved commercial success while 74% of process innovations were successful.

Reasons for difficulties in product innovation in Irish dairying

In general, difficulties in product diversification in Irish dairying have been ascribed to E.E.C. market structures which favour commodity products (11) or to the seasonality of Irish dairy milk supply patterns (19). The former does not explain the very considerable product diversification that has occurred in other E.E.C. countries (20) whereas, arguably, the latter is a result rather than a cause of the limited industry product range. There are other less tangible factors such as the particular equity structures of Irish cooperatives, their already high risk profile (21) and low profitability (22). Despite these factors, it is considered that difficulties in dairy product innovation in Ireland may be understood primarily in terms of the present manufacturing focus of Irish dairy processing plants and the specific competitive strategies that have been adopted in large Irish cooperatives. It is suggested that the focus of large-scale dairy cooperatives in Ireland has been so firmly fixed on the process efficiency of large volume dairy products, as well as the problems of managing diverse businesses, that it would have been extremely difficult to undertake, without a major realignment of manufacturing structures and priorities, the additional management complexes of a programme of product diversification. While recognising the special complexities of the E.E.C. dairy food market, studies of industries abroad suggest the great difficulties and the general inadvisability of mixing priorities in product and process innovation within a single manufacturing plant.

Firms that are structured, for instance, towards continuous flow or assembly line process technologies in the production of high volume or commodity products find it extremely difficult to manage, in parallel, the job shop or batch flow systems that are usually used for standard low-volume products. The loss of production focus leads to basic structural inconsistencies and inadequacies with a series of severe internal problems. New product management is a totally different concept to mature product or commodity manufacturing and marketing.

The perceived difficulties of operating manufacturing units with multiple objectives and too many (sometimes conflicting) separate skills requirements has renewed attention, in many countries on the concept of "focussed" factories, that is production units concentrating on a limited range of production tasks. Typically, the focussed factory limits its number of process technologies and products. The focussed factory concept does not exclude new product development in a process-orientated manufacturing unit, but sees such products as being produced in a separate "Plant Within a Plant" (PWP), the new product manufacturing unit being separate both organisationally and physically from the existing facility. Each PWP can concentrate on its particular manufacturing tasks, using its own work force, management approaches, production control, organisation structure, etc. Quality and volume levels are not mixed, work training and incentives have a clear focus, the engineering, equipment and materials handling are specialised as needed. The segregation of manufacturing of various products is to recognise that there are important differences in the criteria by which manufacturing (and indeed labour skills, marketing and R and D) are measured for instance between new products, those in the mature stage of their cycle, and commodity/high volume processed products.

It is generally accepted now that the mixing of priorities towards new products and towards process efficiency in a single producton unit, creates a virtually impossible manufacturing task (23). Studies on innovation in the United States (24) concluded that "new products which require re-orientation of corporate goals or production facilities tend to originate outside organisations devoted to a 'specific' production system; or, if originated within, to be rejected by them".

Process and product innovation in the Irish Dairying Industry

Generally success in process innovation is measured by the degree by which savings are made in production costs. In large-scale Irish milk processing factories, these strategies have been characterised by high investment in fuel conversion schemes and an emphasis on efficient high-volume processing equipment. Experiences in other industries suggest that not only would it be unusual that product innovation would be a feature of such processing plants, but, in fact, it might have been unwise for the large processing units to undertake such innovation in plants already focussed on high volume commodity products. It may well be that product diversification has been sought in Ireland from industry structures that are unlikely, in reason, to be able to evolve innovative strategy from what are essentially mechanistic structures; and possibly necessarily so considering their size and the competitive environment in international commodity markets.

Difficulties of large dairy cooperatives in focussing on new product innovations must be expected to be further greatly increased by their already wide focus on diverse businesses. Certainly the diversity of skills required to manage present large cooperative structures must be so considerable as to make exceptionally difficult the inclusion of an additional focus on product development and export marketing and the very considerable addition of skills that are required. Factors outlined, and consideration of the special environmental conditions required for the management of new product innovation, suggest that an increasing product range in Irish dairying may be most likely to come now from other industry structures.

Manufacturing structures for product innovation

Consideration of factors affecting innovation do not suggest that large scale cooperatives cannot, per se, be involved in consumer product innovation. On the contrary, they provide some of the critical requirements in a product development programme, namely, competitive size, management expertise and technical skills. The special organisational features required for the innovative stage of new consumer product development however, and their inconsistencies with large-scale process manufacturing, suggest that new product development by large cooperatives should be done in separate manufacturing units and subject to a management and organisational structure that is, at least initially, quite independent of the base manufacturing complex. Apart from separate organisation, investment, marketing and R and D structures, product development subsidiaries would require an equity structure that would provide barriers against the instabilities often associated with present labour relations in large Irish cooperatives. This is to recognise that work stoppages in a plant producing commodities may be altogether less damaging than one in a plant producing a product of limited life cycle for international consumer markets. It is most likely that milk product diversification will come from small cooperatives or private firms or from separate plants within major milk processing factories and these trends are already apparent in the Irish dairying industry. Other options available to large processing plants might be some dis-aggregation of unrelated business so as to allow additional concentration on those technologies which Irish dairying plants know best; that is, the manufacturing of milk products.

Innovation and investment in dairying

The specific industrial structures that give rise to product innovation have been established now in the economies of most developing nations. In Ireland, this is apparent mainly in the IDA programme for the encouragement of small industrial firms. In the dairying industry it is apparent in present IDA policies which favour product diversification. To date, however, there has not been an investment in the dairying as distinct from other Irish industries in the skills and structures which will be likely to give rise to product innovation. Recognising the distinctive industrial structures that are likely to encourage innovation in consumer dairy products and earlier considerations of potential production efficiency on dairy farms, it is suggested that such investment would be worthwhile now.

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The IDA Policy for the Dairy Industry — A Programme for Diversification

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The IDA policy for the dairy industry is to encourage more diversification in the industry and help firms to undertake a greater degree of value added processing than is the case at present. Financial support will be particularly focussed on firms and projects which involve new products and new market development. In contrast aid will not be available for projects which merely involve increasing or replacing capacity for such products as bulk butter making, milk powders, casein or butteroil.

The breakdown of products produced by the dairy sector in 1980 together with the targets which IDA is seeking to achieve with the industry over the next decade are as follows:

	1980	1990 target
Commodity (butter, casein, powder)	83%	65%
Value Added Products	17%	35%

To encourage the achievement of these targets, IDA's financial aids will be directed at helping firms as follows:

— to check out the feasibility of new ideas and markets;
— to develop or to modify new products or processes;
— to build and equip plants to process and market new value added products.

This policy was set out as part of IDA's consultative document on a strategy for the food industry published in 1982. This paper is presented as a further contribution to the consultative process on the future of the dairy indusry.

International Trade

The future of the Irish dairy industry must be viewed against international trends including trends in milk supply and in the demands of the modern consumer, particularly the EEC consumer. Milk supplies have grown steadily in most advanced economies in recent years while at the same time demand for many dairy products has declined. A result of these trends has been increased Government stockpiles of dairy products.

In 1983 alone milk supplies increased substantially. The increase in the EEC was +3.8%, in the USA +2.0%, in Australia the increase was +5.0%, while in the USSR the increase in the first six months was +13.0%.

Consumption generally has declined in both the developed and the developing countries. The economic recession and changing dietary patterns have contributed to the consumption decline in the developed countries while such factors as foreign exchange restrictions and decline in oil revenues have helped in substantially reducing demand in developing countries.

World dairy stocks have increased rapidly as a result of these trends. In 1983 alone EEC and US stocks increased enormously.

EEC:	Butter	up	884,000	tonnes
	Skim Milk Powder	up	1,000,000	,,
US:	Butter	up	176,000	,,
	Cheese	up	406,000	,,

Most countries are actively seeking ways to competitively exploit whatever opportunities can be identified in the dairy sector. Competitiveness at all levels together with attention to consumer requirements will be necessary for success in what undoubtedly is and will remain for the foreseeable future a highly competitive sector. The Irish dairy industry must meet these challenges if it is to have a viable future. It is with this in view that the IDA has decided to concentrate its funds, expertise and facilities in helping dairy firms which seek out new product opportunities and new market outlets.

Ireland's Dairy Industry

The Irish dairy industry has 44 licensed dairy processing firms although 64% of milk is handled by the six largest co-operatives. Butter is the dominant product produced by these firms followed in a very poor second place by cheese (Table 1).

Table 1

Irish Whole Milk Use (1983)

	% of total milk
Butter (with S.M.P., Casein)	80
Cheese	11
Other	9

Total milk production has increased by over 90% since 1970. In contrast with most EEC members, Ireland's butter production has increased over this period while cheese production has declined. Sales of intervention products now dominate our exports.

Seasonality of production has remained a major problem with the increase in milk output, and processing plants now face a peak to valley ratio of 14:1. This compares with the normal European peak to valley ratio of 2:1.

Average milk yields in Ireland have increased rapidly over the past decade and are now at about 730 gallons per annum. This represents 84% of the average of other EEC member states as against 70% ten years ago.

The reliance on butter and on intervention sales together with the seasonality of production and relatively low average yields are among the main issues which the Irish dairy industry must address if it is to compete effectively and win consumer markets from other dairy producing countries.

The Need for Diversification

The existing product range of the Irish dairy industry must be viewed with concern on at least three counts, its mismatch with the overall demand of the EEC consumer, the declining trend in butter consumption, and the high dependence of the sector on intervention products.

In contrasting Ireland's dairy product range with the demands of the European consumer, as reflected by European production patterns, three facts stand out, our overdependence on butter, our low production of cheese, and our low diversification into other dairy products (Table 2).

Table 2

Whole Milk Utilisation in Europe

	Butter (S.M.P., Casein)	Cheese	Other
Ireland (1983)	80	11	9
EEC average (1982)	44	23	33
Netherlands (1982	44	26	30

In The Netherlands where the proportion of milk going for liquid consumption is lower than in Ireland and where exports are equally important, the industry has concentrated 26% of its manufacturing milk into cheese production and 30% into a range of other dairy products.

The consumption trends of butter in Europe and world-wide have been in decline for a considerable period. The US, for example, has halved its per capita consumption since 1960. The decline in Europe has been almost as rapid according to the GIRA Study of the markets in the UK, Germany and France. Since 1970 the annual per capita decline in these markets has been 1.8% and GIRA forecast this annual decline to continue at about 1.5% to 1990. Special actions by the UK Mik Marketing Board have aggravated the problem for Irish butter with the result of significantly reducing the opportunity for Irish butter exports to that market.

In contrast with butter the consumption of cheese is increasing steadily in Europe. GIRA estimate that the growth rates of the past decade should continue for the main types of cheese as follows:

Natural Cheeses	*Annual Growth Rate*	
	'70 -'78	'78 -'90
Hard	2.5%	2.0%
Semi Hard	2.9%	3.1%
Blue Vein	5.5%	0.3%
Soft	5.0%	5.8%
Fresh	2.8%	2.3%

Since 1980 cheese consumption in Europe has not been as buoyant as previously but the long term trends still point to the prospects of continued steady growth.

Ireland is the most directly dependent country on intervention products among all EEC members. This leaves our dairy industry increasingly dependent on EEC level decisions and also leaves it vulnerable to changes in the CAP.

Possible ways of undertaking Diversification

Any diversification drive must be based on a good understanding of the marketplace and on customer requirements. Given the huge dairy surpluses which exist internationally and with most countries actively pursuing diversification policies it is unlikely that highly profitable new product gaps will be easy to discover here. The decisions Boards are more likely to have to face are on product possibilities which involve risks and which show only modest profit margins. It is imperative however, that Co-Ops actively embark, albeit in a small way initially, on a product diversification strategy.

A first step which has obvious attractions, is to seek out joint ventures, or licensing arrangements with other firms, either domestic or overseas. There are several good examples of this approach in Ireland, e.g. Waterford and Sodema, Town of Monaghan and Mona. The IDA now has staff in its European and US offices whose sole function is to seek out joint venture and licensing possibilities for Irish firms. The IDA will work with Irish dairy firms who demonstrate a serious commitment to this diversification route and who have a clear idea of what they want and what they can contribute to such a partnership. Without such a serious commitment both the company and the IDA would be wasting time and resources.

The IDA would like to conclude up to five joint venture or licensing arrangements during 1984 in the dairy sector. Towards that end we are planning, in conjunction with dairy companies interested in joint ventures and licensing, to hold three major technology drives to selected overseas markets, and companies this year. One of the trips will be to the US and the other two will be to European countries.

In addition to seeking diversification through joint ventures and licensing, the larger dairy co-ops should seriously consider establishing their own research and product development capability. The IDA will provide grant aid towards the capital costs of any eligible buildings and equipment required and in addition will provide up to 50% of eligible operating expenses in the product development work carried out in the R & D facility. R & D units should be given clear responsibilities, targets and resources. To-date the level of R & D carried out by Irish dairy firms is far too low.

A central body should have prime responsibility for dairy processing research to support the product development work of individual firms. This body should be equipped as an operating production unit in the technologies considered most desirable for the Irish industry. The facilities available in such countries as The Netherlands and Denmark could be examined as possible models for Ireland.

A further method of diversification which has been little used to-date is the establishment of new enterprise companies to exploit new ideas in the dairy industry. The IDA believe that mechanisms should be provided to allow for the establishment of such companies in the dairy sector and plan to seek out such opportunities in future. Existing co-ops would have to provide milk to such projects and, in addition, could possibly take an equity participation. The IDA would be interested to hear from companies or individuals with new dairy product ideas for export markets or for new segments of the domestic market.

Ideas for Development

One major gap in our dairy processing sector is in cheese production. Cheese has the attraction of absorbing large quantities of milk and its consumption is generally increasing across Europe. Since 1970 cheese production and consumption have both increased by about 50% in the EEC but Ireland has not captured a share of this expanded market.

The IDA participated with An Bord Bainne in commissioning the Boston Consultancy Group to evaluate the Irish cheddar industry and make recommendations for its future. A draft of this study, which the IDA would not accept as final, has been extensively leaked and has been the subject of much comment. The IDA would not agree with its draft conclusions on diversification opportunities in cheese nor on some other fundamental issues contained in the leaked draft report.

The Irish dairy industry must carefully evaluate its position vis-a-vis the expanding cheese market. Specific product areas which merit examination include:

— Italian, Greek and Spanish cheeses;
— Processed and packaged cheeses

— A unique Irish cheese
— Natural sliced cheeses
— Farmhouse cheeses

Seasonality of production is a particular problem which will have to be reduced for a successful cheese industry.

Cheese consumption in Ireland is low, and at 3.3 kg./head is less than one-quarter the European average. New Zealand, which had a similar consumption level to Ireland, has succeeded in the last decade in doubling consumption. A similar target would appear to be feasible in Ireland for a good cheese and well orchestrated marketing programme.

Apart from cheese other dairy products which appear to offer attractive possibilities are :

— *Bulk Products*: industrial functional ingredients, flavoured milk powders, convenience foods, cheese flavour powders, whey products, consumer packaged whole milk or fat filled powders.

— *Health Products*: high protein balanced aids, supplements for hospital feeding, low sodium and high calcium cheeses, supplements for athletes, health snack products.

— *Fresh Dairy Products*: usually high margin and high distribution costs. Yoghurt and fresh dairy products are showing significant growth trends of 4% - 5% annually. Quark/cottage cheese with additives, protein enriched drinks, milk shakes, ice cream mixes, special desserts, frozen and fresh dairy cakes, whipped and frozen cream, mousses, soft frozen desserts.

The highly successful development of cream liqueurs and whey based alcohol in recent years gives room for optimism that new dairy based product opportunities can be developed and exploited profitably here.

Industry Structure

Most existing dairy co-ops are heavily focussed on collecting and processing large volumes of milk. There has been insufficient attention to product development and marketing within individual firms. A strengthening of the marketing and product development capability is equally essential for products sold through An Bord Bainne as for products sold directly to retailers or final consumers by the Co-Op.

Within individual firms which are setting up value added business there appears to be merit in separating the large scale processing of commodity products from the value added business so that the latter receives the clear priority it needs for success and allows it to build up the necessary skills it requires for efficient operation.

At a sectoral level there is a need to review existing structures. In Europe recent rationalizations in the industry have seen the emergence of larger business units than currently exist in Ireland. It may be opportune for the ICOS to review existing structures in Ireland and examine how effective they are against trends in Europe. Any such review would have to examine issues of scale, of duplication, the management of collection and of processing, and the accountability to suppliers.

Seasonality

Because of seasonality of production in Ireland the product range is limited to long shelf life products, mainly butter, skim milk powder and cheddar cheese.

The returns on these products will tend to decline over the forseeable future and so it is essential to diversify the range of products into areas which will at least maintain the current level of return.

To secure all year round milk production the supplier must receive a return over and above what he would get from producing milk on our current seasonal basis.

The industry should examine ways of altering prices over the year to encourage greater milk production during the normal valley period and by so doing to allow for greater product diversification.

Marketing

The dairy industry in Ireland, even with a highly successful product diversification programme over the next decade, will depend to a large degree on export sales of commodity products sold through An Bord Bainne. It is essential for the industry that these products continue to be delivered at a quality which meets customer requirements and are then marketed to best advantage. Individual co-ops must play an active role in this process to ensure the success of the marketing drive for these products.

In addition, co-ops need to build up their skills in the direct marketing of specialized dairy products to identified market niches. There may be a role for some centralized promotional work to support the marketing activities of individual co-ops in these specialized product areas, as is done in other countries.

Conclusions

Diversification in the dairy industry is no longer just a desirable option, it is a necessity for medium term survival. At present the industry is overdependent on butter and skim milk powder and overreliant on the intervention system for its income and for its sales.

Our product range is very much out of line with the product demands of the EEC consumer where demand for cheese and for various specialized dairy products is increasing while demand for butter is declining steadily.

The IDA has adopted the targets of reducing production of bulk commodities to 65% and of increasing the production of value added products to 35% by 1990. These targets could in turn be adopted by each of the individual large co-ops for their own diversification programme.

Joint ventures and licensing arrangements offer a first step of embarking on a diversification programme. The IDA has staff in the field for this purpose and will work with firms which demonstrate a serious commitment to this approach and know what they want and can give to such arrangements. The IDA want to conclude at least five joint venture/licensing arrangements in the dairy sector in 1984 and are organising three special overseas trips with dairy industry executives for this purpose.

In addition to work in joint ventures and licensing the larger dairy co-ops should examine setting up new product development units which are market oriented and which have clear objectives and their own resources. The IDA will provide financial aid towards the cost of any building and equipment necessary and also towards the operating costs of the product development work.

There is a need to encourage new entrepreneurs with good ideas in the dairy sector to set up in business here. The IDA is planning to undertake a programme in this area which would ideally be linked to existing co-ops for milk supplies and possibly equity participation.

Individual companies may have other ideas on how to embark on a diversification programme and the IDA would welcome such ideas. What is essential is that all companies become acutely aware that diversification from the existing product range is essential to the medium term survival of the industry. Companies should start their diversification programme initially in a modest way but with a strong commitment to act on indentified opportunities. The IDA for its part will support firms along this path with its funds, its facilities and with whatever expertise it has in the area.

TENTH EDWARD RICHARDS-ORPEN MEMORIAL LECTURE

Some Aspects of Pasture Utilization by the Grazing Animal

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Introduction

I wish to thank the trustees of the Edward Richards-Orpen Memorial Trust for inviting me to present the Tenth Memorial Lecture. Not only is it a great honour for me personally, but it is also an appreciation of the work carried out by the Agricultural Institute, particularly at Johnstown Castle, to develop Irish grassland.

It is a formidable task to deal with the subject of pasture utilization in a manner befitting the memory of such an outstanding man. He was a frequent visitor to Johnstown Castle in the early days of its establishment as a Research Centre and was appreciated because he was a scientifically minded yet practical farmer, who believed strongly in the role of research. Mr. Richards-Orpen was a close associate and friend of the then Minister for Agriculture, Mr. James Dillon, and his influence was given practical expression in the acquisition of up to date scientific equipment for Johnstown Castle. In view of his innovative capacity in many spheres and in particular his life long interest in improving grassland systems, it seems appropriate that the Tenth Memorial Lecture should be devoted to pasture utilization.

Pasture utilization is usually defined as the amount of herbage eaten by the animal, expressed as a percentage of either the total annual grass yield, or of the amount of herbage offered to the animal at each grazing. In either case, utilization is almost directly related to intake and is affected by factors that influence intake. It is possible however to broaden this definition by introducing an animal factor and define pasture utilization as the amount of animal product produced per unit of dry matter. This takes into account the varying efficiency with which animals on different grazing managements convert food into animal product.

The importance of pasture utilization is emphasised by the fact that 66% of the total area of 6.89 million hectares in Ireland is lowland grass with a further 20% classified as marginal land. Only 7.5% of the area is used for tillage. Maximum levels of dry matter production seem to vary from year to year and from one location to another, but production as high as 25 t dry matter per ha has been achieved in Britain (1). However, in grazing systems there are losses in both harvesting and conservation and the animal converts relatively little of the food into animal products. Consequently, even the maximal yield of 25 t dry matter per hectare would only provide 215 Giga Joules (GJ) of metabolisable energy and would only yield in animal products about 41 GJ of edible energy and 486 kg of protein if converted by dairy cattle. Alternatively, a cereal grain crop in similar conditions would yield 73 GJ of edible energy and 670 kg of protein. The relatively poor return from grassland emphasises the necessity for efficient utilization and conversion.

Grazing potential of Irish grassland

In order to put grassland utilization into perspective, it is interesting to look more closely at the potential for grazing in Ireland. An attempt was made to do this on the basis of the energy supplied by pasture from the different categories of soil (Table 1). The country's grasslands can be divided into three main soil groups, namely, a dry lowland mineral soil and two categories of wet mineral soil. The wet soil designated A (Table 1) is defined as one whose profile is wet within 70 cm depth for more than 180 days but, is not wet within 40 cm depth for more than 180 days in most years. Typical of this group of soils would be the Macamore and Rathangan soils in Co. Wexford, and indeed most of the wet limestone soils. Category B is a wetter group of soils whose profile is wet within 40 cm depth for more than 180 days and is usually wet with 70 cm for more than 335 days in most years. This group of soils would be represented by the Ballinamore drumlin soils and most of the West Clare and West Limerick wet soils.

Table 1

Grazing potential of Irish grassland

Soil Class	Area (Ha 10^6)	DM Prod.	% Utilization	Energy (GJ/Ha)	Potential (LU/Ha)	Potential Animal Population
Dry	2.83	12.000	80	105.6	2.78	7.87
Wet A	0.93	10,440	60	68.9	1.81	1.69
Wet B	0.81	9,000	44	43.56	1.15	0.93

1 LU requires 104 MJ/day or 37.96 GJ/year

1 kg DM = 11 MJ of metabolisable energy

Grazing potential for each soil category was calculated from the energy production per hectare divided by the energy requirement of a livestock unit (L.U.). Dry matter production and its utilization were calculated from experimental figures from Johnstown Castle and adjusted for the wetter soils according to Lee (2). The degree of dry matter utilization for the dry mineral soils was taken as 80% of that produced. Under wet conditions pastures are more easily poached and are consequently less utilized so the figures for utilization efficiency were reduced to 60% and 44% for the two wet categories of soil. Assuming that the metabolisable energy value of grass is equivalent to 11 MJ per kilo of dry matter, the different groups of soils will produce 105.6, 68.9, and 43.56 GJ of utilizable energy per hectare respectively.

A livestock unit (L.U.) was defined as 533 kg dairy cow milking 3,503 kg per year and requiring 104 MJ per day or 37.96 GJ per annum. Using this figure the grazing potential per hectare was calculated as 2.78, 1.81 and 1.15 L.U. ha^{-1} resulting in a total of 7.87, 1.69 and 0.93 million L.U. respectively for the three different groups of soil in the country. Thus, the potential livestock numbers that our lowland mineral soils can carry is 10.49 million L.U., without the input of extra energy in the form of concentrates. If milk yield was increased to 4671 kg per year then the potential livestock numbers would be reduced to 9.13 million L.U.

In 1983 concentrate feeding for dairy cows and drystock amounted to a total of 1.861 million t — 1.111 million t for dairy cows and 0.75 million t for drystock. This supplies sufficient energy to support more than 0.5 million L.U. When the estimated 0.7 million L.U. from hilland and marginal land (3) are added, the total potential at present levels of concentrate feeding, reaches nearly 12 million L.U.s, which is slightly higher than the figures of Lee and Diamond (3). This is nearly twice the actual number of L.Us of 6.074 million as reported for 1983.

This potential can vary greatly with fertiliser use and utilization efficiency. The postulated figures for dry matter production have been chosen assuming the use of relatively high dressings of fertilizer nitrogen, and a reduction in nitrogen usage will depress production figures accordingly. Variations in utilization efficiency will also affect the grazing potential of the country and the remainder of this paper will deal with factors that influence such utilization. Other than drainage, factors which influence utilization can be divided into three different general areas, viz. those of animal, sward, and management origin.

Factors of animal origin that affect utilization

The central control of feed intake in the brain is the hypothalmus, which when stimulated either electrically or chemically caused intake to be increased (4). Feedback to this central control system to limit food intake is governed by two types of stimulus, one allowing metabolic control arising from the metabolism of ingested food, and the other, physical control arising from the distension of the alimentary tract by the presence of food.

Metabolic feedback has been associated with the concentration of various chemicals in the alimentary tract (5), changes in environmental temperature (6) and the amount of body fat (7). Clear evidence for one or more of these has yet to be found. Two major factors govern physical control, one being the capacity of the alimentary tract and the other being the rate of passage of food through the reticulo rumen. A direct relationship between size and weight of the rumen and the voluntary intake of food has been found (8) and consequently intake is broadly related to liveweight.

The rate of disappearance of digesta from the rumen is a function of the combined action of microbial fermentation, and mechanical breakdown, including chewing during eating, rumination and muscular contractions of the gut. Presenting the animal with ground roughage that can readily pass the reticulo-omasal orifice usually leads to higher intakes than when the same roughage is presented in the long form (8).

The main animal factors affecting herbage intake are age, weight, pregnancy and lactation. Intake advances with increases in age and weight. The effect of pregnancy on intake is usually confounded with increased growth in heifers or the effects of lactation in cows, resulting in an increased intake up to mid pregnancy (9). There is a decline in voluntary food consumption in later pregnancy, the reason for which is not fully understood, but may be associated with the increasing size of the foetus in the abdominal cavity. Maximum milk yield in dairy cows, and accordingly maximum energy demand is reached 5 to 8 weeks after parturition, but maximum intake does not occur until sometime later, the period varying from 5 to 36 weeks depending largely on diet composition (16). It is suggested that part of the reason for this time-lag may be that fat deposited in the abdominal cavity before calving has to be mobilized before maximum rumen capacity can be obtained.

Factors of sward origin that affect utilization

It is accepted that grass is harvested less efficiently under grazing than under cutting systems, and that often the effect of the grazing animal can be deleterious to the quality of herbage. While both systems can cause injury to the plant, there are two effects peculiar to the grazing animals, namely, the fouling of pasture and the selectivity of the animal in grazing either individual plant parts or species.

Fouling

Studies have shown that during a day's grazing, a cow may deposit between 18 and 27 kg fresh weight of faeces (10). The area of individual patches varies from 0.05 to 0.09 m^2 and the number of separate defaecations from 10 to 16 per day (11, 12). Both dung and urine increase herbage yield, the dung for periods up to four cuts, and the urine for two cuts (13). While the urine patches are often grazed preferentially, the refusal of the animal to graze the immediate area surrounding the dung pat gives the impression of decreased utilization.

In an experiment at Johnstown Castle comparing continuous and rotational grazing it was found that 24% of the rotationally grazed area was rejected when measured after a day's grazing, while only 10% of the continuously grazed area was rejected (Table 2). This represented 49% and 23% respectively in terms of weight of rejected dry matter. The difference between the two systems could be explained by the fact that under continuous grazing the animals were under much greater pressure, and consequently eat more of the fouled areas. However, the effect of dunging on animal production appears to be small, as it has been shown that while fouling significantly depresses herbage intake it does not appear to alter either the milk yield, milk composition or liveweight change in cows (14).

Table 2

Details of rejected herbage due to dunging after a day's grazing in autumn on both a continuously and rotationally grazed pasture

	Extended height (cm) grazed area	clump	% of area covered	Wt DM rejected (%)
Continuous grazing	7.1	19.2	10	23
Rotational grazing	11.2	33.5	24	49

Diet selection and digestibility

Diet selection can be regarded as a two-phase process, involving firstly, the selection of an area to be grazed by the animal, and secondly, the preferential selection of species and plant parts from within that area (15). However, in temperate pastures under intensive management the animal is usually offered little opportunity to select different plant species. Other than a few species of grass, clover offers the only feasible diversion to the grazing animal.

Table 3

Digestibility of grass and amount of dead material at different heights in the sward over the grazing season (% OMD)

Dead material as % of total DM

cm. above ground level	8/5	30/5	22/6	Date 12/7	2/8	23/8	14/9
0-4	50.5	48.0	49.2	59.5	66.7	60.3	60.5
4-8	17.8	28.3	40.0	43.1	45.8	28.0	16.7
8-12	6.6	15.6	25.7	15.0	6.6	0	0
12-16	1.0	13.2	12.5	6.3	0	0	0
16-20	0	9.1	2.7	0		0	0
20-24	0	2.9					
24-28	0						
			Digestibility (% OMD)				
0-4	53.9	60.3	59.8	53.2	46.2	48.5	56.2
4-8	67.4	65.0	65.9	64.3	59.1	70.3	76.9
8-12	72.7	67.8	71.8	78.8	77.1	83.4	84.1
12-16	79.6	68.4	75.9	81.9	82.2	84.3	85.0
16-20	80.2	64.5	—*	—*		—*	83.4
20-24	82.9	71.9					
24-28	84.8						

* = Insufficient sample for analysis

There is now general agreement that animals select (a) more clover than grass fram grass-clover swards (17), (b) material that contains more leaf than stem (18) and (c) more green than dead material (19). The herbage eaten, when compared with that offered, is usually higher in nitrogen and gross energy, and lower in fibre. It is difficult to ascertain whether this selection by the animal is a deliberate exercise, or the natural consequence of the animal grazing down the sward in progressive layers. The distribution of green and dead material and the digestibility of the sward in 4 cm layers is shown in Table 3. Digestibility and the quantity of green material increase with height above ground level. It can be assumed therefore, that when animals are not compelled to graze the lower regions of the sward they will, by chance, select material of higher digestibility.

Early work showed a linear relationship between intake and digestibility up to a level of 67-75% OMD, with either a curvilinear or no relationship at higher digestibilities (20, 21). More recently however, linear relationships up to 83% OMD have been found (22, 23). The reason for this relationship was explained by Blaxter et al. (20) when they demonstrated that a decline in intake was related to the increased transit time of the food through the rumen. When feeding poor, medium and good quality hay, they showed that the amount of dry matter in the rumen at any one time was the same, irrespective of which hay was fed, and that intake was mainly controlled by rumen capacity.

Most particles greater than 1 mm are usually not allowed to leave the rumen, but are subsequently reduced in size by repeated rumination. This explains the increased intake of poor quality forage when it is ground pelleted, although its digestibility may have decreased in the process (24). A similar pattern has been found for the increased intake of leaf as opposed to stem with similar digestibilities. While studying the intake of various forages it was shown that the leaf fraction remained in the rumen for only 24.6 hours while the stem remained for 33.3 hours (25). The faster rate of passage of the leaf fraction enabled more of it to be ingested by the animal.

Climate and season

Climate can affect herbage intake by variations in either temperature or rainfall. In temperate climates, temperature does not affect intake even over a wide range of temperatures (26). Rainfall on the other hand has been shown by many researchers to decrease herbage intake. The effect seems to arise more from the increased amount of water ingested than from any unpleasantness in conditions caused by the rain. This is in agreement with indoor studies on dairy cows, where intake decreased by 0.337 kg of dry matter for each percentage drop in dry matter content below 18.1% (27).

It is widely accepted that cattle grow faster on spring than on autumn pasture. Many factors may contribute to this inferior late season growth. The herbage may differ in chemical composition and hence in digestibility and energy value. Pastures become more fouled as the season progresses, and dead and mould-infected herbage may accumulate. The animal loses its compensatory growth stimulus, and it increases in age and weight. Because of these simultaneous changes it is difficult to pinpoint a particular reason why spring pasture is more productive than autumn pasture.

Such a seasonal effect was experienced on a highly stocked rotationally grazed system of beef production at Johnstown Castle (Table 4). Both liveweight gain and intake decreased as grazing progressed throughout the season. The confounding effect of varying amounts of herbage on offer was avoided by expressing liveweight gain per unit of dry matter offered. Even then there was an appreciable advantage in spring pasture. The animal's efficiency of conversion was also greater in spring than autumn—requiring an intake of approximately 6 kg of digestible organic matter to put on 1 kg of liveweight gain in spring and nearly twice that amount in autumn. Spring herbage appears therefore to be able, not alone to produce more gain per animal, but is able also to support more grazing days per hectare over a similar time interval due to the greater yield. In terms of variable costs (e.g. N fertilizer) spring grass has on average over twice the value for beef production as autumn pasture (28).

Table 4

The liveweight gain, digestible organic matter intake and herbage offered over the grazing season on a highly stocked rotationally grazed system of beef production.

Cycle ending on	6/5	27/5	17/6	8/7	29/7	19/8	9/9	30/9
Kg LWG/animal/day	1.79	1.41	.92	.91	.49	.67	.46	.52
g DM offered/Kg LW/ day	47.8	44.5	44.7	56.2	44.6	40.7	18.7	36.7
g DOMI/Kg LW/day	45.3	29.7	19.4	22.2	16.5	17.5	15.7	13.8
g LWG/Kg DM offered	153	116	68	51	44	48	69	39
DOMI/LWG	6.1	5.8	6.4	7.8	8.5	9.0	12.2	9.7

Factors of management origin that affect utilization

The achievement of high animal production depends on three basic requirements :

(a) The production of large amounts of high quality food, the seasonal distribution of which must match the animals' requirements.

(b) Most of this forage must be harvested by the animal.

(c) The efficiency of conversion within the animal must be high.

It is apparent that grazing management influences these requirements and consequently efforts have been made down through the years to modify uncontrolled grazing so that land resources can be most efficiently utilized.

Stocking rate

Since the first results obtained by Hancock (29) in 1953 and further reported by McMeekan (30), increased stocking rates have led, almost always, to increased utilization with a concomitant increase in milk production or liveweight gain per hectare. This is usually at the expense of production per animal however, and the relationship between the two is shown in Fig. 1. As the stocking rate increases, production per animal decreases linearly. At the same time, production per hectare increases until a point is reached where production per animal decreased to such an extent that it cannot be compensated for by the increased stock numbers. At this point production per hectare also starts to decline.

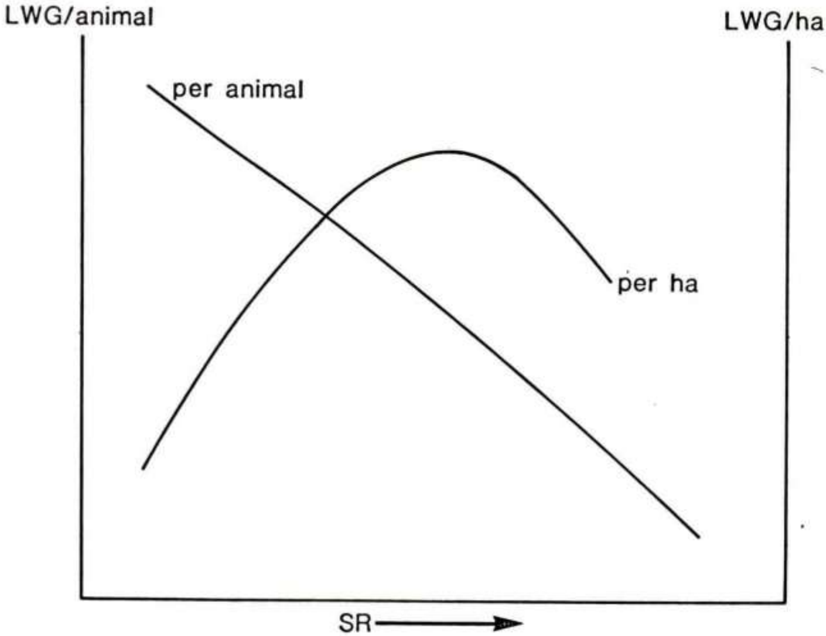


Fig.1 : Effect of stocking rate on production per animal and per hectare

An example of this can be seen in Table 5, where on increasing the stocking rate on a continuously grazed system, production per animal was depressed to such an extent (35%) that it also reduced production per hectare. On a rotationally grazed sward, the high stocking rate reduced animal performance by only 18% and this led to an increase in liveweight gain per hectare (48).

Table 5

Dry matter production and liveweight gain under continuous and rotational grazing systems (average 3 years)

	DM Production (kg/ha)	Total LWG (kg/ha)	LWG/Animal/Year (kg)
Continuous grazing			
LSR	9851	996	143
HSR	9115	940	92
Rotational grazing			
LSR	9997	1072	158
HSR	9244	1252	129
SE Mean and Significance	219.8*	33.9***	4.07***

LSR = Low Stocking Rate
HSR = High Stocking Rate
LWG = Liveweight gain

The level of production per hectare is vitally important with dairy cows and can be increased, without impairing the animal's health, by increasing the stocking rate. However, the accompanying reduction in animal performance may adversely affect the beef producer by interfering with the "degree of finish" of the animal. It was found that by reducing the stocking rate mid-way through the grazing season, output per hectare could be increased, while still maintaining an adequate performance (31). It is this system of management that we now use. It was later shown that maximum liveweight gains were obtained at stocking rates which were half those which produced zero liveweight gain (31).

The situation is more complex however, with dairy cows, where liveweight changes occur simultaneously with changes in milk production. In some situations a dairy cow may produce at a higher level than her intake could justify, by drawing on her body reserves. McMeekan and Walsh (33) concluded that the optimum stocking rate was one which reduced potential production per cow at a low stocking rate by 10% to 12%.

Grazing systems

One of the first efforts to control grazing was made as far back as 1777, according to Davies (34), when a Scottish agriculturalist described a 15-20 paddock system which was almost identical to the present one-day paddock system. Since then many different types of controlled grazing systems have been researched and used at farm level. The classical work of McMeekan in the 1950s demonstrated the importance of stocking rate in any form of grazing management. The results of his experiments showed that variation in stocking rates affected animal production to a greater extent than type of grazing system. Emanating from his work was the realisation that grazing systems could not be compared without the inclusion of two or more stocking rates, as there was a strong interaction between the two components.

In a recent appraisal summarising the results of nine different experiments (35) it was concluded that there was a benefit of 1.55% for dairy cows and 6% for beef cattle by grazing a paddock system. The value of such comparisons, where several experiments from different research workers are combined, is extremely doubtful. It is now accepted that there is an advantage to rotational grazing when the ratio between the amount of forage produced and the weight of animal grazing this forage is low. This ratio will vary widely with fertilizer use, type of pasture, stocking rate and possibly paddock number. In all assessments these parameters vary from experiment to experiment. With their inclusion into one assessment therefore, it would be most surprising if any difference was shown between the two systems of grazing management.

The first Irish work appeared in 1937 when Drew and Deasy (36) reported an increase of 27% in terms of liveweight gain per hectare, when store cattle were rotationally grazed. More recently, in a series of experiments with beef cattle, Conway (37) showed considerable advantages from rotational grazing. A similar advantage from rotational grazing has been found at Moorepark for dairy cows (38).

In view of the profusion of contradictions in the literature concerning the merits of different systems of grazing, it seems important to examine these systems in detail and to identify the criteria that lead to an advantage of one system over another. Only then will it be possible to provide objectively established guidelnes for the farmer.

Johnstown Castle results

With a view to the above, detailed measurements of dry matter production, liveweight gain, herbage intake, animal behaviour and other parameters were made on both a continuous and rotational system of grazing for intensive beef production at two stocking rates. The experiment was carried out for three years on a newly sown perennial ryegrass (v. Cropper) pasture at Johnstown Castle. Nitrogen was applied yearly at the rate of 350 kg N ha^{-1}.

The net herbage accumulation for the four treatments is shown in Table 6. At both stocking rates the rotationally grazed system produced more dry matter in 1979 but less in 1980. There was no difference however when the averages for the two years were compared. Stocking rate in fact had a greater effect on dry matter production than grazing system used—the high stocking rate caused a reduction of only 7.5% in both systems of grazing. This is in general agreement with the results from similar studies (35) and supports the conclusion drawn by Hodgson and Wade (39) that herbage accumulation is insensitive to variations in grazing management or variations in stocking rate.

Table 6

Net herbage accumulation from continuous and rotational grazing systems

	1979	Kg DM/Ha 1980	Mean
Continuous grazing			
Low SR	8,078	11,623	9,851
High SR	7,363	10,866	9,115
Rotational grazing			
Low SR	9,146	10,763	9,997
High SR	8,394	10,012	9,244
SE mean and significance	208.2*	386.0*	219.8*

Temperate swards adapt to changes in both stocking rate and grazing system, by making adjustments in tiller density, sward canopy and photosynthetic efficiency. Swards that are grazed severely tend to adapt a more prostrate growing habit, with a consequential increase in light interception. This, combined with an improvement in the ratio of young to old tissue, gives rise to an increased photosynthetic efficiency. Tiller population also tends to increase as the frequency of defoliation increases as in continuously grazed swards.

The aim of good sward management is the production of pastures with a good population of tillers and a high leaf area. While lax defoliation allows the production of large tillers with high leaf area, it also depresses tiller numbers and net herbage accumulation does not improve due to a simultaneous increase in senescence. Digestibility may also increase. Therefore the sward is well able to buffer itself against quite a wide variety of management systems. The production of large quantities of highly digestible material is a compromise between managements that produce a high tiller population with low levels of senescence and those which encourage a high leaf area index.

The seasonal pattern of dry matter production was also affected by stocking rate (Fig. 2). The lax defoliation at the low stocking rate allowed the grass to accumulate rapidly early in the season, resulting in an unevenly grazed tall open sward. The severe defoliation at the high stocking rate appeared to depress grass growth early in the season, while at the same time producing a low dense sward having a high percentage of leafy material with good photosynthetic potential. Consequently, the high stocking rate treatment out-yielded the low stocking rate treatment in the latter part of the season by 33.6%.

This phenomenon has a practical application at farm level in a rotationally grazed system, where it is difficult to match the amount of herbage on offer to the animal's requirement, for all paddocks. If the correct balance is reached in the first paddocks, then excess herbage will

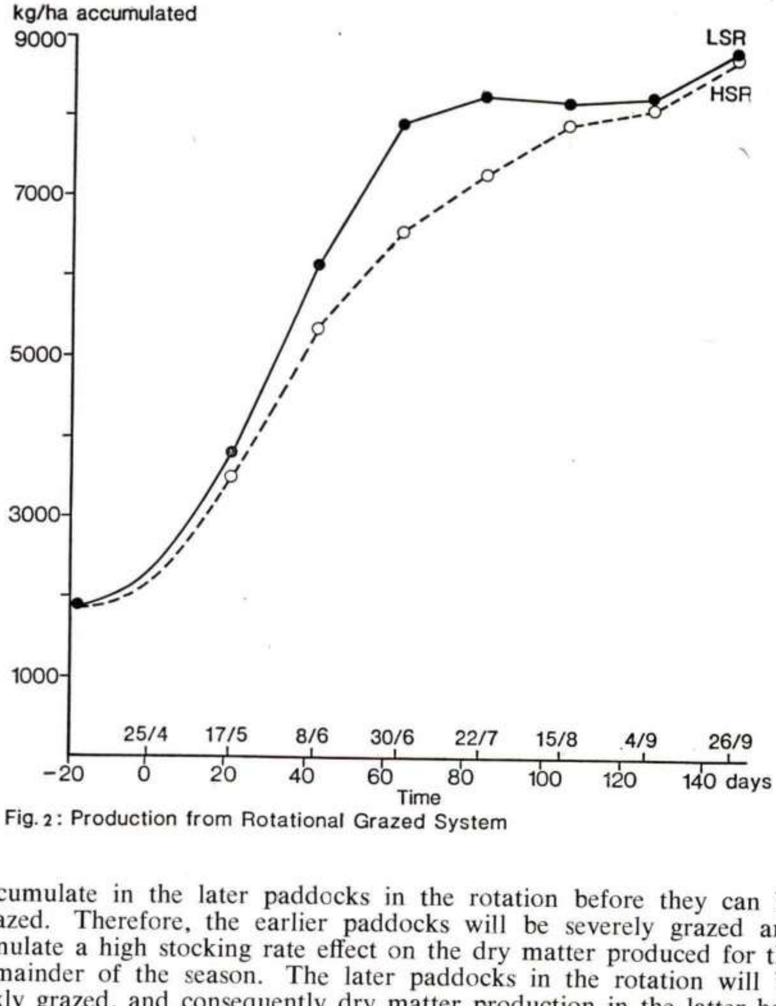


Fig. 2: Production from Rotational Grazed System

accumulate in the later paddocks in the rotation before they can be grazed. Therefore, the earlier paddocks will be severely grazed and simulate a high stocking rate effect on the dry matter produced for the remainder of the season. The later paddocks in the rotation will be laxly grazed, and consequently dry matter production in the latter half of the season will be impaired.

In the experiment reported, dry matter production was measured in 10 of the 20 paddocks and the herbage on offer for cycles 1, 5 and 9 are shown for the high stocking rate (Table 7). As expected, during Cycle 1 there was significantly more herbage on offer in the later paddocks (59%) when compared with the earlier ones. However, as the season progressed this trend was reversed so that in Cycle 9 the later paddocks had significantly less (35.8%) herbage on offer than the earlier ones, and it is obvious that adequate animal performance would not be achieved by offering animals less than 1000 kg DM ha^{-1}. One way to avoid an undesirable accumulation of dry matter early in the season, at farm level, would be to graze the more fertile paddocks in the system first. Alternatively, the time spent grazing each paddock might be varied at the start of the year, so that the later paddocks in the rotation would be grazed sooner, and thus prevent a build-up of dry matter.

Table 7

Herbage on offer (kg/ha)

	Paddock No.		
	1,2,3	7,8,9	14,15,16,17
Cycle 1	1647	1822	2620
Cycle 5	1282	1180	1474
Clycle 9	1432	1002	934

The continuously grazed pasture had significantly more perennial ryegrass tillers per unit area than the rotationally grazed pasture — 33% more at the low stocking rate and 75% more at the high stocking rate (Table 8). The severe grazing on the high stocking rate treatment caused a significant (P>.001) increase in tiller density on the continuously grazed paddocks. It is interesting to note however, that the treatment with the greatest number of tillers produced 7% less dry matter over the season. The point should be made at this stage, that although high tiller populations are desirable, they do not necessarily guarantee increased dry matter production, and unless tiller numbers fall below a very low level, production will not be impaired.

Table 8

Tiller density (Tillers x 1000/M^2)

	Ryegrass	AMG	Total
Continuous grazing			
LSR	9.8(b)	2.6(a)	12.4(b)
HSR	14.2(c)	3.1(a)	17.3(b)
Rotational grazing			
LSH	7.1(a)	2.2(a)	9.3(a)
HSR	7.6(a)	2.3(a)	9.9(a)

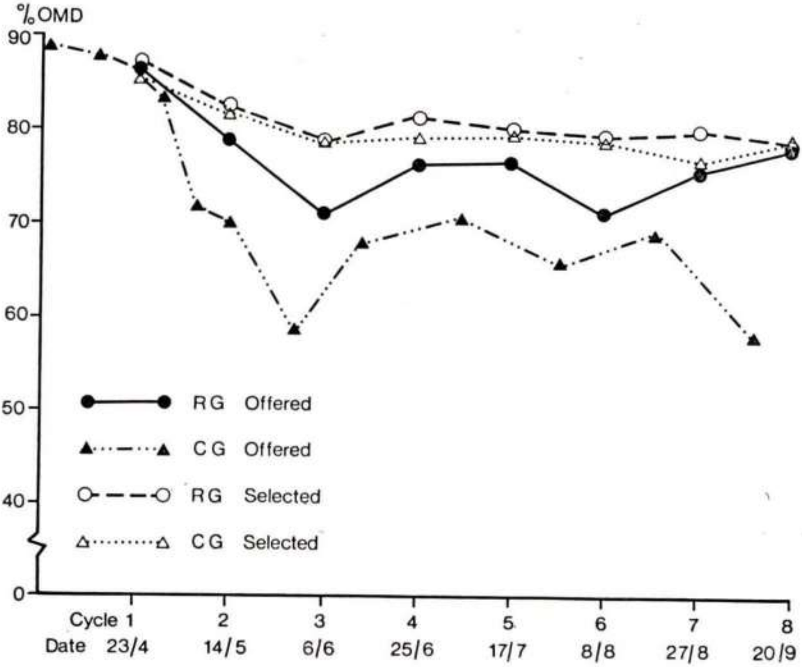
Values not having the same subscript are significantly different at P >.001

AMG = Annual Meadow Grass

At the high stocking rate there was an increase of 33% in terms of liveweight gain per hectare (Table 5) when animals were rotationally grazed rather than set stocked. At the lower stocking rate the advantage was only 7.6%, and one would expect that if the stocking rate was reduced still further, no difference would be obtained between the two systems. The effect of stocking rate varied with system of grazing. Increasing the stocking rate on the continuously grazed treatment caused a reduction in animal production per hectare, whereas on the rotationally grazed treatment the same high stocking rate caused a substantial increase in production per hectare. This was probably caused by the large reduction of 35% in liveweight gain per animal when the stocking rate on the continuously grazed system was raised, whereas there was a reduction of only 18% on the rotationally grazed treatment. Carcass weights showed the same trend as the liveweight gains, with a slightly higher percentage killout for the rotationally grazed animals (Table 9).

The digestibility of the herbage on offer followed similar trends for the three years of the experiment and the results for 1980 are shown in Fig. 3. The continuously grazed treatment averaged 69.3% OMD for the grazing season while the herbage on offer on the rotationally grazed treatment had a significantly higher digestibility of 76.6% OMD. There was no difference however in the digestibility of the material selected by the ani-

Fig 3 : Digestibility of Herbage Offered and Selected (1980)



mal from either treatment. Animals on the continuously grazed treatment selected herbage averaging 79.6% OMD and those on the rotationally grazed treatment selected material averaging 80.7% OMD. It must be assumed therefore that the greater degree of selectivity exercised by the continuously grazed animals probably involved longer hours of grazing.

Table 9
Carcass weights and percentage kill out

	Liveweight (kg)	Carcass weight (kg)	% Killout
Continuous grazing			
LSR	393	204	51.7
HSR	337	177	52.7
Rotational grazing			
LSR	402	217	53.9
HSR	379	203	53.4
Standard deviation	14.59***	17.47*	.997***

Grazing behaviour

Preliminary measurements of grazing behaviour (Table 10) show that the continuously grazed animals were active for longer periods than the rotationally grazed animals. The continuously grazed animals grazed for 10.9 hours on average and very often when herbage on offer was limited, grazing time increased to over 12 hours per day. The rotationally grazed animals grazed for only 8 hours per day and did not increase this time substantially, even when herbage on offer was very scarce. This is in agreement with most studies on animal behaviour where it is found that the normal rate of biting is between 40 and 70 bites per minute, the size of each bite depending on the availability of herbage (39). As herbage becomes limiting bite size decreases, and to compensate for this the animal usually increases its rate of biting, and if necessary its grazing time. However, the compensation may be limited as the number of bites per cow per day rarely exceeds 36,000. This then effectively sets the upper limit. Irrespective of biting rate, grazing time remains relatively

Table 10
Grazing time (minutes/day) and herbage offered (Kg/Ha)

	Grazing period			Herbage
	Afternoon	Morning	Total	on offer
Continuous grazing	341	313	654	1621
Rotational grazing	319	159	478	2940
Se mean and significance	6.5 NS	9.5***	11.9	137.3***

constant on strip-grazed or paddock grazed swards. This seems to be partly due to the animal becoming accustomed to the pattern of paddock change, and rather than continuing grazing when herbage becomes scarce he idles, anticipating a change to a new paddock.

The distance walked by animals while grazing showed the same pattern as the time spent grazing (Table 11). The continuously grazed animals walked approximately three miles per day, while the rotationally grazed animals only walked for approx. one mile per day. The distribution of only walked for approximately one mile per day. The distribution of distance walked between the afternoon and morning grazing periods also followed closely the pattern of grazing time during the same periods. There was no significant difference between the two systems, in the length of time the animals spent lying down, but rotationally grazed animals remained standing for more than twice the time of the continuously grazed ones.

Table 11
Distance walked (metres)

	Afternoon	Morning	Total
Continuous grazing	2475	2610	5085
Rotational grazing	1207	670	1876
SE mean and significance	93.3*	91.8**	156.1**

The energy cost of these activities has been calculated using the data of Graham (40, 41). Although these data refer to sheep rather than cattle, and consequently may not give absolute values of energy expenditure, it should nevertheless, allow a fair comparison to be made between the energy expenditure of the animals on the different treatments. As can be seen (Table 12) the continuously grazed animals expended 44% more energy on grazing activity than the rotationally grazed animals. It can be calculated that if this difference in energy could be used to increase weight gain, it would almost totally explain the 0.25 kg animal^{-1} day^{-1} difference between the two treatments.

Table 12
Grazing behaviour and its conversion into energy at high stocking rates

	Grazing (min)	Walking (metres)	Standing (min)	Lying (min)	Energy (KJ/Kg/day)
Continuous grazing	654	5085	94	691	39.4
Rotational grazing	478	1876	197	765	27.3
SE mean and significance	11.9***	156.1***			

A summary of the digestible organic matter intake (DOMI) and liveweight gain over the three years of the experiment is shown in Table 13. At the low stocking rate the continuously grazed animals ate 7.7% ($P > .001$) more digestible organic matter than the rotationally grazed animals, although they put on 7.1% ($P > .001$) less liveweight gain. At the high stocking rate, while the rotationally grazed animals ate 3.7% more, they put on 38.7% ($P > .001$) more weight. Obviously the rotationally grazed animals are more efficient at converting the food they ingest. The resultant figures for conversion efficiency show that this is so at both stocking rates the continuously grazed animals had to eat more to put on a unit of liveweight gain than did the rotationally grazed animals—13.6% more at the low stocking rate and 25.2% more at the high stocking rate.

Table 13

Digestible organic matter intake and liveweight gain (average of three years)

	DOMI (g/kg LW/day)	(g/kg LW/day) LWG	DOMI/LWG
Continuous grazing			
LSR	20.94	2.89	7.23
HSR	18.82	1.94	9.70
Rotational grazing			
LSR	19.44	3.11	6.25
HSR	19.52	0.69	7.26
SE mean and significance	.247***	.077***	.381***

There was quite a close correlation between intake and liveweight gain over the 1980 season on the rotationally grazed, high stocking rate treatment (Fig. 4). During that year there was very little drought and any soil moisture deficit that arose came very early in the season when adequate grass was available. The moist conditions of 1980 also led to the production of greater amounts of herbage (Table 6) than in other years, with the result that the animals always had an adequate supply of herbage available throughout the year. This was evident by comparing the amounts of herbage on offer during 1979 and 1980 on all treatments. On the rotationally grazed high stocking rate treatment, animals were offered 4.17% of body weight on average over the year, whereas in 1979 the average for the year was significantly less at 3.19%. Other treatments showed similar trends. Consequently in 1980, the animals did not have to expend large amounts of energy selecting material of high digestibility. This gave a high correlation between intake and liveweight gain, and 97% of the variation in liveweight gain could be explained by variations in intake.

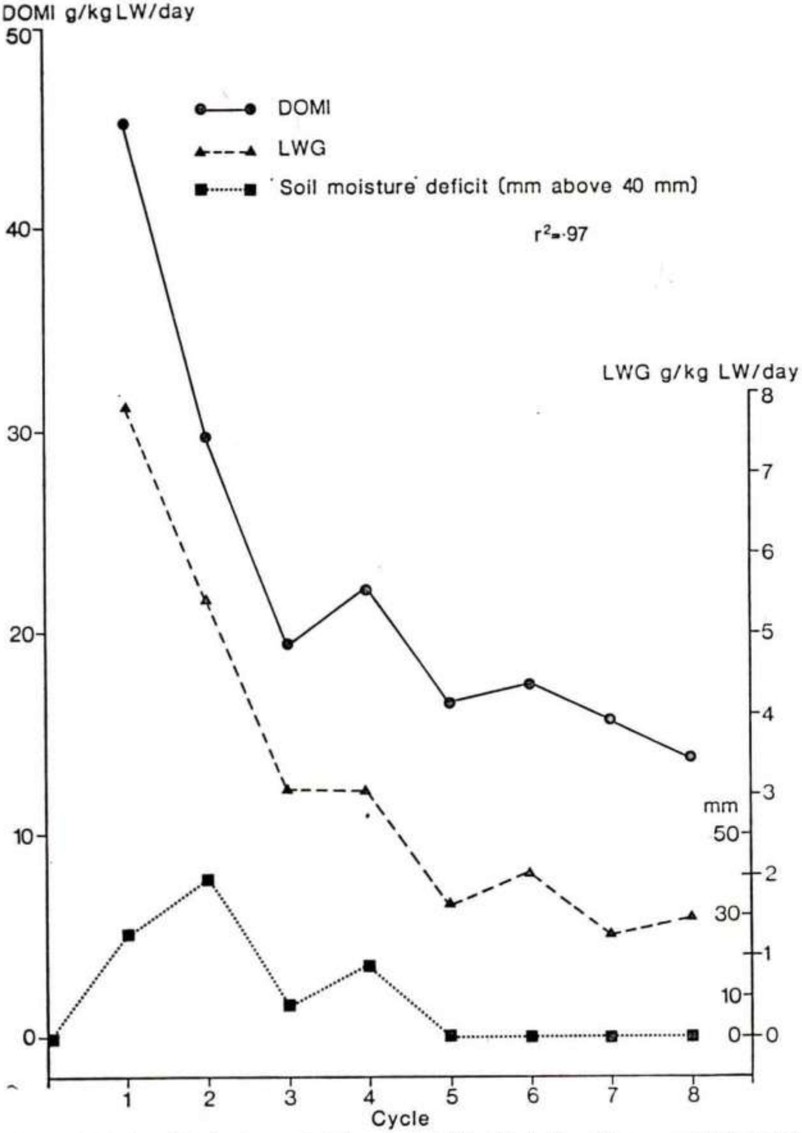
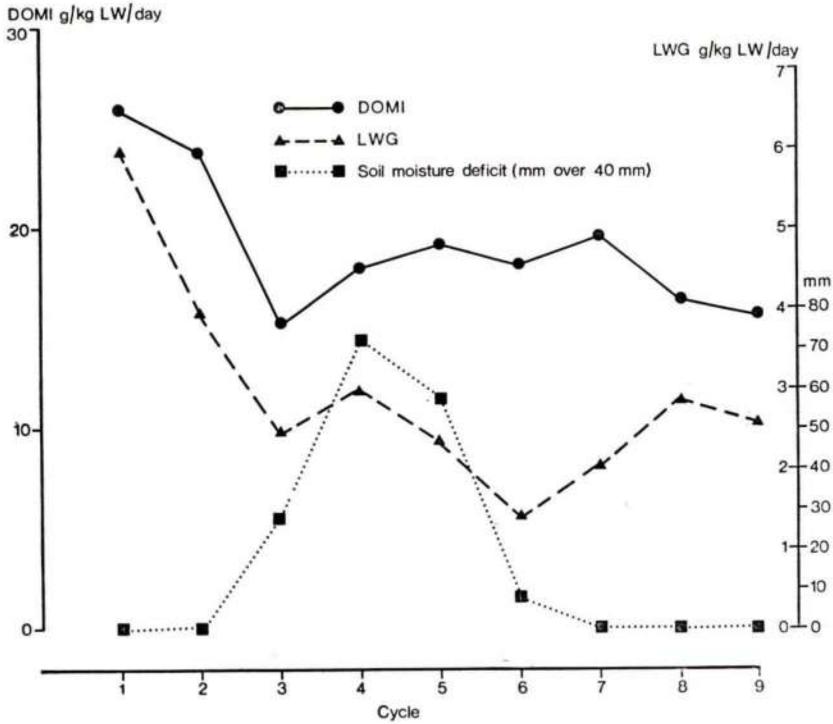


Fig. 4 : Relationship between Intake and LWG (Rotationally grazed HSR 1980)

In 1979 however, the pattern appeared to be quite different, in that very poor relationships were obtained between intake and liveweight gain. At best only 59.2% of the variation in liveweight gain could be explained by changes in intake (Fig. 5). When intake and liveweight gain were compared over the year, it was found that while there was a good correlation for the first four and the last cycle, there was a period in the middle of the grazing season where intake increased while the animals lost weight. It is difficult to find a rational explanation for this apparent contradiction, but a possible answer may be that the substantial soil moisture deficit during the middle of the grazing season led to sparse amounts of pasture with a high dry matter content. As the amount eaten is determined by the volume of what is ingested, then an animal could increase its intake while grazing such pasture. Grazing time may have to be increased however in order to achieve adequate intake. This increase in energy expenditure during the middle of the grazing season, when pasture height was only 5.6 cm may partially explain the decrease in liveweight gain at this time.

Correlation analysis showed that digestible organic matter intake, DM offered, green material offered and the digestibility of the material offered, were all significant factors affecting liveweight gain (Table 14). The

Fig 5 Relationship Between Intake and Liveweight Gain (Continuously Grazed Low Stocking Rate 1979)



amount of dry matter on offer had the least influence on the parameters presented, whereas the digestible organic matter intake had the greatest effect. However, at best, only 66% of the variation in liveweight gain could be explained by changes in intake. Multiple regression analysis involving the other parameters as well as digestible organic matter intake, did not significantly increase the correlation.

Table 14

The influence of intake and the amount and type of material offered on the liveweight gain of animals (R^2) (average of three years)

	Continuous grazing		Rotational grazing	
	LSR	HSR	LSR	HSR
DOMI	.637***	.662***	.545*	.565***
DM offered	.069 NS	.484***	.058 NS	.216 NS
Green offered	.466***	.500***	.245*	.268*
% DMD offered	.560***	.313*	.273*	.281*

LWG expressed as g LWG/kg LW/day
DOMI expressed as g DOM/kg LW/day
DM offered expressed as g DM/kg LW/day

The energy requirement for maintenance and activity was calculated by converting the digestible organic matter intake into total energy and subtracting from this the energy requirement for liveweight gain. In all years, at both stocking rates, the maintenance energy requirement was lower for the animals on the rotationally grazed treatment, by 18.2% at the low stocking rate and 11.4% at the high stocking rate (Table 15). Values for 1978 and 1979 were quite similar while those for 1980 were significantly higher. A possible explanation for this discrepancy may be

Table 15

Energy requirement for maintenance and activity

	MJ/animal/day			
	1978	1979	1980	Mean
Continuous grazing				
LSR	58.8	50.5	68.6	59.3
HSR	57.5	59.2	67.7	61.5
Rotational grazing				
LSR	45.4	46.2	54.1	48.5
HSR	50.3	51.2	62.1	54.5
SE mean and significance	2.20**	1.74**	2.38**	1.26***

that in 1980 the cattle had been doubly implanted with the growth hormones, Finaplix and Ralgro, and had subsequently displayed quite abnormal behaviour, which in turn required extra energy. The maintenance energy requirement for indoor fed cattle of the same weight would be 36 MJ/head. A review of the literature has shown that estimates of the energy requirement of the grazing animal have varied widely and values ranged from only slightly higher than those of housed animals (40), to those which were 2-3 times as great (41). The importance of the energy expenditure of grazing activity in animal production has been emphasised by the work of McGraham (42) who showed that a sheep 5 km from water, grazing sparse pasture would need to eat 2.2 times more than one grazing good pasture to maintain zero energy balance.

It is clear that pasture not utilized by the grazing animal will not yield animal products. Consequently in any grazing study, the ability to measure pasture utilization is almost as important as the ability to measure pasture production. The disappearance of grass, largely through animal consumption may be estimated by direct measurement *via* sample cuts before and after each grazing or from inside and outside exclosure cages. Utilization is expressed as the amount of dry matter utilized as a percentage of that produced (Table 16). Except in 1978, utilization was high in all treatments but it seemed to be mainly affected by stocking rate, higher utilization being obtained with higher stocking rates. Over the three years of the experiment, using this evaluation, it would appear that the best treatment was the high stocking rate of the continuously grazed system, with 93% utilization. This treatment, however, produced the lowest output per hectare in terms of liveweight gain (Table 5).

Table 16

Amount of grass utilised as a percentage of that produced

	1978	1979	1980	Mean	kg LWG/100 kg DM
Continuous grazing					
LSR	76.9	95.3	84.3	85.5	11.5
HSR	92.2	94.2	92.5	93.0	10.2
Rotational grazing					
LSR	67.9	73.5	83.7	75.0	12.0
HSR	75.8	81.4	90.0	82.4	14.5

Similarly higher utilization figures were obtained from both continuously grazed treatments although less liveweight gain was produced from both treatments. It appears therefore that this assessment of utilization gives a good indication of the amount of dry matter eaten by the animal but does not take into account his efficiency at converting it into animal products. Consequently, it can be a misleading figure in assessing the value of different grazing systems. A more meaningful figure is where liveweight gain is expressed per unit of DM produced (Table 16). From these figures it can be seen that the most efficient system was the rotationally grazed high stocking rate treatment where more than 1.4 kg of liveweight gain could be produced for every 10 kg of DM produced.

Future trends

Before one looks to the future it is often advisable to first look backwards and the following is an excerpt from a letter written by W. Dickinson to Lord Portman in London in 1847 (43).

"I had a new method of cultivating a peculiar plant — Italian ryegrass — the result of which was as startling as it was new, whereby nine or ten crops of excellent green food had been obtained between March and December; being cut in the former month and watered with liquid manure, consisting of one-thrid of pure horse urine and two-thirds of water, distributed from a London street water-cart passing once over the plant immediately after the grass was cut, one watering being sufficient for one crop".

Under these conditions Dickenson was still able to obtain a yearly production of up to 50 tons of grass per acre, which assuming a dry matter percentage of 15% would be equivalent to 18.8 t dry matter ha^{-1}.

In modern times, levels of 25.2 t ha^{-1} and 22.2 t ha^{-1} have been obtained in Wales (44) and in the Netherlands (45) respectively. Maximum recorded yields of 16.9 t ha^{-1} for permanent pasture (46) and 18.4 t ha^{-1} for Italian ryegrass (47) have been obtained in Ireland under high nitrogen fertilization and cutting conditions. There is however, a large fluctuation from year to year and from place to place. It would appear therefore, that no substantial increase in herbage dry matter production has been achieved in over a hundred years. This may not be so surprising as the maximum potential production for temperate grasses in Western Europe, assuming a conversion of up to 3% of the incoming light over the whole year is only somewhat over 20 t ha^{-1}.

One could not expect such high levels of production from grazed swards as from cut swards, and our yearly production under grazing in this country is still very much less than those figures. While there is little evidence to suggest that grazing management can influence annual rates of net herbage accumulation, it does affect sward structure which is closely involved in maintaining long-term sward stability, through the maintenance of high tiller populations. Further research is needed therefore to define management factors that affect tiller and leaf turnover combined with measurements on tiller populations, on sward structure and morphology and on leaf density.

While total annual production is important, its seasonal distribution is probably of equal importance, as fluctuations serve to limit stocking rates on a whole farm basis, and increased animal output might be achieved if the amplitude of these fluctuations could be reduced. There is now evidence to suggest that this could be achieved by timely applications of N fertiliser (47) or by the introduction of new grass varieties. This would allow greater adaptability for different grazing enterprises. Perhaps in this respect we should advocate the implementation of a definite reseeding policy at farm level, where for example, a small proportion of the farm would be reseeded annually.

To derive maximum benefit from our grasslands it is necessary that our soils be fertile. Consequently, farmers should have a definite policy on soil analysis. Again, a percentage of the farm could be analysed each year. Intensive grassland production has also led to some problems in animal health, due to shortages or imbalances in trace elements. In Ireland, while there are no recorded micronutrient deficiencies that affect grass growth on mineral soils, further research is needed to ensure that sufficient levels are available in the plant to meet the animal's requirements. For example, where sulphur is applied, care should be exercised that the copper level in the animal is not affected, particularly on light textured soils.

Further research must define accurately the nutritional requirement of the animal at all stages throughout the season, and in turn we must be able to modify management to meet those requirements. It would be an advantage therefore, if we could predict production in advance, so that the animal's requirements could be matched more accurately to the available herbage. In this respect, a definite policy on concentrate feeding during grazing at stress periods would be of benefit. We also need to be able to cut smaller quantities of silage. In this area one feels that good silage quality will not be consistently obtained until such time as the farmer has control of when the silage is cut, which ideally means having his own machinery.

It was not until recently that animal behaviour was regarded as being an important factor in animal production from grassland. While we have some preliminary results concerning the energy expenditure of animals on different grazing systems, it is desirable that more detailed measurements be made across the grazing season, so that a better picture is obtained of the animal's total energy requirement. Only then will it be possible to modify management so that these requirements can be adequately met.

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