Irish Grassland & Animal Production Association Journal 1982

Irish Grassland and Animal Production Association

JOURNAL

Vol. 17 1982

edited by

Sean Flanagan

Printed by Lithographic Universal, Dargle Vale, Bray

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Calf Rearing Principles and Standards

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Introduction

Calf rearing is primarily concerned with supervising and controlling successful transition from a non-ruminant digestive system dependent on a liquid diet to a ruminent digestive system where the calf is capable of utilising a roughage diet. At the same time the rearer must have satisfactory calf performance with a minimum of disease or mortality. This paper proposes to examine a number of important considerations in the rearing period to 12 weeks.

Growth

The amount of milk replacer fed and the total concentrate input will determine calf growth rate in the period to 12 weeks. The following growth pattern (Table 1) is suggested for calves reared within the frame work of a 24 month calf to beef system or for heifers calving down at 2 years.

Table 1

Growth pattern 0-12 weeks

Age in weeks	0	4	8	12
Liveweight in kg	40	51	68	91

A number of recent experiments from Grange indicate that any difference in calf liveweight present at 12 weeks due to different levels of feeding will remain subsequently when the calves are fed a common diet with little evidence of compensatory growth (Table 2).

Table 2

Effect of normal and high levels of feeding in the period to 12 weeks on subsequent liveweight (kg)

Level of feeding	Day 1	12 weeks	36 weeks	60 weeks
Normal	43	95	213	324
High	43	109	230	346
Difference	0	+14	+17	+22

Calf mortality

Colostrum feeding

With reference to calf mortality it is necessary to emphasise the importance of providing the new born calf with an adequate antibody defence against diseases by feeding colostrum which is rich in immunoglobulins (Ig) in the early hours of life. A survey conducted on purchased calves at Grange found that 45% had insufficient antibody protection when Ig values were determined on blood serum samples using the Zinc Sulphate Turbidity Test (ZST). It was found that mortality increased when the ZST value decreased and low blood serum Ig values resulted in a high incidence of mortality (Table 3).

Table 3

Effect of blood serum Ig status of purchased calves on mortality

Ig status	Poor	Fair	Good	Very good
ZST value	(0-7)	(8-14)	(15-21)	>21
Mortality %	12.5	6.8	4.0	3.0

Calf weight

Another study at Grange found a positive relationship between weight of calf at purchase and subsequent survival (Table 4)

Table 4

Effect of weight of purchased calf on mortality

Purchase weight (kg)	<36	36-40	41-45	>45
Mortality (%)	14	10.5	6.5	2

These results strongly suggest that in order to minimise losses in the rearing of purchased calves the stronger/heavier calf must be obtained. Such calves are also likely to be older.

Calf rearer

An extensive survey for calf rearing practices in the United States gave the following ranking to calf rearers (Table 5).

Table 5

Effect of calf rearer on calf mortality (U.S. Survey)

Ranking	Rearer	Mortality %
1st	Farmer's wife	6.5
2nd	Children	8.4
3rd	Owner or manager	8.9
4th	Hired help	12.5

This survey indicates the importance of individual attention for the young calf. In addition to transition of its digestive system, the calf develops its own active immunity system against pathogenic organisms.

Feeding programme

The feeding programme is concerned with ensuring satisfactory calf liveweight gain with the minimum disease risk during the transition phase from dependence on a liquid diet to a phase when the calf has capacity to utilise a concentrate and roughage diet. The calf's feeding programme may be divided into three phases:

Phase 1	Liquid	0 - 28 days
Phase 2	Liquid/Solid	28 - 56 days
Phase 3	Solid	56 - 84 days

In the selection of a feeding programme the rearer has little choice except to feed a concentrate ration *ad libitum* to 84 days. However, the rearer has considerable choice in the selection of a milk replacer feeding programme with respect to the quantity of milk replacer fed and the method of feeding. The final selection of a milk replacer feeding programme will depend on the availability of labour, housing facilities, age and type of calf available and the production system to which the calf is destined.

Bucket feeding system

Bucket feeding systems for milk replacers are concerned with feeding restricted quantities of milk replacer. The milk replacer is normally fed warm (38°C) in one or two feeds daily. The quantity and duration of feeding will depend on whether calves are to be weaned on the basis of age or early weaned based on concentrate intake. The milk replacer feeding programme for the two systems is detailed in Table 6.

Table 6

Milk replacer feeding schedule for bucket fed calves from 7 days of age

	Days		
	1-5	6-10	11 to weaning
Early weaning (gms/day)	250	375	375 wean after 35 days*
8 week weaning (gms/day)	250	375	500 wean after 49 days

* Concentrate intake 750 gms/day

In the feeding programme the milk replacer is reconstituted at the rate of 125 gms/litre and fed warm (38°C) in one feed daily. The above levels of milk replacer provide the calf with a diet slightly in excess of maintenance. It is essential therefore that the calves have *ad libitum* access to a palatable calf concentrate ration from the start. Clean fresh water should also be available.

A bucket feeding system based on the above feeding schedule gives the calf rearer very good control of fluid intake and minimises the risk of diarrhoea. Feeding limited quantities of milk replacer discourages solid food intake and results from Grange show the following concentrate intake pattern for calves fed milk replacer according to the 8 week weaning schedule.

Week	1	2	3	4	5	6	7	8	9	10
Concentrate (kg/day)	0.1	0.2	0.4	0.6	0.8	1.2	1.5	2.0	2.2	2.4

The 8 week weaning system is particularly suited to the rearer using group pens of 4 or 6 calves or the person with little experience in calf rearing. The early weaning system is appropriate for the specialist contract calf rearing where the calves are individually penned and where daily intakes of concentrates can be measured.

Automatic calf feeding system

A series of experiments over the past 6 to 7 years at Grange has examined various aspects of automatic feeder use. Two important aspects have emerged. Firstly, in the initial introduction of purchased calves to automatic feeders dispensing a warm 10% dry matter solution, it was found that 45% of the calves required veterinary treatment for diarrhoea within 14 days of arrival. Following a series of experiments it was found that the diarrhoea problem could be minimised by introducing the calves initially to a dilute solution and then gradually increasing the dry matter of the solution fed.

It was concluded that in order to minimise digestive upsets, purchased calves should be initially introduced to automatic calf feeders dispensing a 5% dry matter solution and the concentration should be increased by 1% unit every three days until a 10% dry matter solution is on offer after 15 days. Secondly, when calves have *ad libitum* access to warm milk replacer from an automatic feeder there is no pressure or urge on the calf to consume solid food. Lack of intake of solid food at weaning has resulted in severe losses in performance immediately after weaning. Results from experiments at Grange have found that successful weaning is dependent on having an average intake of 0.5 kg of concentrates per head daily in the week before weaning. The data presented in Table 7 shows that the mean daily concentrate intake for a group abruptly weaned after consuming 30 kg of milk replacer was only 0.45 kg daily in the week after weaning.

In summary it was found that automatic feeder use can result in substantial reductions in labour inputs, provide increased rates of daily liveweight gain and provide particular rearers with a successful calf rearing system. The success of the system is dependent on minimising

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Table 7

Effect of concentrate intake at weaning on calf performance

	Treatment	
	A	B
Milk intake to weaning (kg)	30	50
No. of days to weaning	33	50
Conc. intake (gms/day)		
7 days before weaning	100	450
7 days after weaning	450	1300
Initial wt. day 1 (kg)	44	44
Daily gain 1-70 days (gms/day)	490	690

the risk of digestive upsets initially by calibrating the feeder correctly, feeding the correct concentration and maintaining a high level of husbandry. It is also essential to ensure that the average daily concentrate intake is 0.5 kg per head daily in the 7 days before weaning in order to avoid a post-weaning check in calf performance. Increased concentrate intake in the 7 to 10 days period prior to weaning can be achieved by restricting the flow of milk replacer in the pipe line such that the amount of liquid diet consumed will not satisfy its appetite. When batch rearing with the automatic feeder an effective method of encouraging solid food intake is to reduce the temperature at which the milk replacer is dispensed from 38°C to ambient temperature and at the same time reduce the dry matter concentration from 10% to 5%.

When automatic feeders are operated efficiently it is expected that the average milk replacer consumption will be 50 kg per calf over a 49 day period and that calves reared on the automatic feeder will be on average 10 kg heavier at 84 days compared with calves reared by a bucket system feeding 25 kg of milk replacer over a 49 day period. The automatic feeding system is ideally suited to preparing male calves for sale off dairy farms at 4 to 6 weeks of age.

Acidified milk replacer feeding system

The cold acidified feeding system whereby acidified milk replacer is mixed cold and fed cold at ambient temperatures via a nipple and pipe line from a plastic container has generated considerable farmer interest in the past 3 to 4 years. Studies have included various aspects of acidified milk replacer feeding. Initial studies found that acidified and normal milk replacer fed by bucket gave similar calf performance. It was found that acidified cold (12.5% dry matter *ad libitum* from plastic containers) gave calf performance similar to normal milk replacer warm (5% dry matter increasing to 10% *ad libitum* from an automatic feeder).

Recent studies have examined two important aspects of acidified feeding. In experiments where we measured the effect of restricting the availability of acidified milk replacer between the ages of 3 and 6 weeks we found that by limiting the calf's access to the milk replacer, or by diluting the milk replacer, milk replacer intake was reduced without having any major effect on calf liveweight gain (Table 8).

Table 8

Effect of restricting the quantity of cold acidified milk replacer fed on calf performance

	Control	Limited access	Dilution
Initial wt. day 1 (kg)	43	44	43
Av. daily gain 1-84 days (gms/day)	640	580	640
Milk replacer 1-42 days (kg)	44.0	33.5	36.7
Concentrate 1-42 days (kg)	6.1	10.5	10.1

In the limited access treatments calves had 16 hours access in the fourth week, 12 hours in the fifth week and 6 hours in the sixth week to 12.5% dry matter solution. In the dilution treatment calves were offered 9.5% dry matter solution in the fourth week, 6.5% in the fifth week and 3.5% in the sixth week. Reducing the milk replacer intake in the period to 42 days had the desired effect of increasing solid food intake (Table 8).

Both methods can be used to restrict the total quantity of milk replacer consumed on the cold acidified system and allow the rearer to have an *ad libitum* system of milk replacer feeding without having to feed 50 kg of milk replacer to each calf.

A series of four experiments comparing acidified milk replacer and normal milk replacer fed *ad libitum* warm from automatic feeders found that in all four experiments the acidified milk replacer reduced the incidence of diarrhoea, increased average daily liveweight and improved feed conversion efficiency (Table 9).

Table 9

Effect of *ad libitum* feeding normal and acidified milk replacer warm on calf performance

	Normal	Acidified
Initial wt. day 1 (kg)	43	43
Av. daily gain 1-42 days (gms/day)	640	860
Incidence of diarrhoea (no.)	24	9
Milk replacer 1-42 days (kg)	44	50
Concentrate 1-42 days (kg)	3.1	3.0
F.C.E.	1.76	1.42

Acidified milk replacers fed cold from plastic containers via pipe line and nipple provide a suitable *ad libitum* system for small or large groups of calves. Initial training of the calves is an important aspect of the system. The acidified system provides the rearer with an *ad libitum* system to reduce labour, and provide accelerated gain in the early weeks of the calf's life without the expense of the automatic feeder. Reducing the quantity of milk replacer fed by restricting access and/or by dilution add an important dimension to the system, providing similar calf performance on reduced quantities of milk replacer.

Calf Housing

Calf requirements

The calf must be provided with:

1. A warm dry lying area. A three week old calf spends 80% of its time lying down. It is therefore necessary to avoid wet or draughty lying areas.
2. Draughts at calf level must be avoided. Air movement close to calf level, which can be felt on the back of the head, constitutes a draught.
3. Adequate air change—it is essential to remove moisture, pathogenic organisms and toxic gases rapidly out of the calf house and replace with clean fresh air. The temperature in naturally ventilated calf houses is often similar to the temperature in sheltered areas outside when the system is operating correctly.

Basic design requirements

* Reduce the risk of air borne infection by not allowing more than 50 calves to share a single air space.
* Widths greater than 40 ft reduce the effectiveness of natural ventilation.
* Cubic air space allowance of 250 cu.ft./calf—increasing the number of air changes/hour reduces the density of pathogenic organisms, therefore a large cubic air space reduces the number of air changes/hour and therefore the speed of air entering the building.
* Floor area allowance of 25 sq.ft./calf (including passage)—avoid over crowding and reduce the risk of disease build-up.
* Pen area allowance of 18 sq.ft./calf—comfortable for the calf, reduces area requiring bedding material and allows for a wide service passageway.
* Air inlet area of 0.8 sq.ft/calf when calf house is located on a sheltered site and 0.5 sq.ft./calf when the calf house is located on an exposed site.
* Air outlet area of 0.8 sq.ft./calf on an exposed site and 0.5 sq.ft./calf on a sheltered site.
* Height of building at eaves 8 ft. minimum—allows for outlet location at a suitable height above calf level and ensures adequate cubic air capacity in the house.
* A height difference of 5-8 ft. between the air inlet and air outlet provides ventilation on windless days.
* The calf house should be built with its long axis at right angles to the prevailing wind, so that ventilation will be mainly by the wind effect which is the predominant factor which governs natural ventilation in Ireland.

Nutritive Value of Feeds for Beef Production

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Since feed is the major cost in production much of the effort to improve efficiency in beef production must be directed to judicious feeding. Even when the best husbandry practices are applied to the grass crop, in terms of output, utilization and quality there may still be a need for supplementary feeding. The supplementary feeding may have the objective of correcting some specific nutrient deficiency in the grass (e.g. minerals, protein) but usually it will be provided to supply additional energy. If the overall feeding programme is to be approached on a rational basis, it is necessary to have reliable information on the nutritive value (feeding value) both of the basal diet (grass, silage, hay, straw) and of the supplementary feeds available.

Nutritive value

The nutritive value of a feed as a source of any nutrient is a measure of the extent to which the nutrient is available to the animal for maintenance or production. Nutritive value is therefore a biological response and it is not necessarily valid to equate nutritive value with the total amount of a nutrient in the feed : some nutrients may be apparently present in liberal amounts in the feed but completely unavailable to the animal.

Although nutritive value in the broad sense may refer to any nutrient, feeds are often compared on the basis of their energy content for the following reasons :

(i) Shortages of dietary energy are more important causes of low productivity than dietary deficiencies of other nutrients. This should not be taken to imply that we should not be concerned about providing a balanced diet; in fact it is only when a balanced diet is provided that optimum use is made of energy.

(ii) Energy is derived from protein, fat and carbohydrate—quantitatively the major part of the diet and also the most expensive.

(iii) With the range of feeds normally available for beef cattle, providing adequate energy often has the effect of also providing a balanced diet.

Thus the fractionation of dietary energy is considered in the following diagram.

Gross Energy (GE)
 ↓ — faecal energy
Digestible energy (DE)
 ↓ — urinary and methane energy
Metabolisable energy (ME)
 ↓ — heat increment
Net energy (NE)

GE = heat of combustion of the feed

Gross energy bears little or no relationship to the energy available to the animal. For example, wheat straw and maize grain yield similar values for gross energy although their nutritive values are vastly different.

DE = GE minus heat of combustion of the faeces

Digestible energy is usually a good indicator of nutritive value. It is relatively easily determined and in recent years the *in vitro* version of this, whereby the feed is subjected to fermentation under controlled conditions in the laboratory, has found wide acceptance as a reliable indicator of the nutritive value of roughages (O'Shea, 1970; Flynn, 1978). *In vitro* values are usually referred to as DMD (dry matter digestibility) or DOMD (digestible organic matter in the dry matter). The expected relationship between animal performance and silage DMD values under *ad libitum* feeding is given in Table 1. The values in Table 1 envisage good silage preservation—with poor preservation performance is often disappointing due to low intake and poor utilization.

Table 1

Relationship between in vitro DMD of well preserved silages and animal performance

% DMD	400 kg store kg/day	200 kg weanling kg/day
52	0.04	loss
62	0.38	0.13
72	0.72	0.48

Although the data on the evaluation of concentrates through *in vitro* fermentation are not as extensive as in the case of roughage, it appears that this method may give reliable results in the case of concentrates also (O'Shea, 1981).

ME = DE minus heat of combustion of urine and methane

Since the publication of Bulletin 33 (MAFF, 1975), metabolisable energy values for feeds have been widely quoted in Ireland. In the Irish context the ME system of evaluation suffers from the following limitations.

(i) Metabolisable energy is rarely if ever directly determined—the values quoted are usually computed from digestibility or chemical analysis data and are not subject to verification.

(ii) The prediction of ME from chemical analysis can have a large potential error; some materials with attractive analyses have low feeding values.

NE = what appears in animal products such as meat, milk, work and the heat of combustion of body substance which would be lost without feed.

Expressing the energy value of feeds in terms of net energy has the obvious advantages of :

(i) representing that portion of the feed which is completely available to the animal;

(ii) being open to verification (and revision if necessary) through comparative trials.

It is therefore not surprising that many countries have adopted net energy in their feeding standards and feed evaluation. The rationale behind the net energy standards recently adopted in the United States, The Netherlands, France and Switzerland have been reviewed elsewhere (Caffrey, 1981). In many countries barley is used as the standard with which other feeds are compared. In Table 2, feeds commonly available in Ireland are compared in terms of Barley Feed Units (BFU). One BFU is defined as the net energy value of one Kilogram of standard barley. The values quoted in Table 2 are in the writer's view likely to apply to the feeding situations which normally obtain in Ireland. The monetary values attributed to feeds in Table 2 relate to energy only and assume that barley costs £120 per tonne.

In the Netherlands the Feed Unit is set close to the net energy of 1 gram of barley.

FEEDINGSTUFFS

Grass and grass products

The importance of high quality grass and grass products—mainly hay and silage—in efficient beef production has been the subject of numerous communications to the Irish Grassland and Animal Production Association and will not be discussed in detail here. Instead feedingstuffs which are usually used to supplement or replace grass and grass products in feeding programmes will be briefly considered.

Straw

In the absence of winter fodder shortages little attention is paid to straw as a potential feed. It should, however, be appreciated that straw fed *ad libitum* plus about 2 kg of a suitably balanced concentrate (Caffrey, 1973) will provide a maintenance type diet for most classes of beef cattle. When high levels of performance are required, untreated straw can only make a minor contribution to the feeding programme.

In recent years there has been renewed interest in alkali treatment of straw as a means of increasing digestibility. Sodium hydroxide and ammonia have been the chemicals most widely tested and both have given consistent improvements in digestibility, when properly applied. Of the two, ammonia appears to have the greater potential since it not only improves digestibility but also increases the crude protein content and is unlikely to be associated with excessive output of urine which is a feature of animals fed sodium hydroxide treated material. The ammonia treatment may also have considerable application in improving hay quality.

Table 2

Feeding value in barley feed units (BFU)* and monetary value of selected feedstuffs assuming barley costs £120/ton

	BFU/kg feed	Value £/tonne
Barley	1.00	120
Wheat	1.00	120
Milo	1.00	120
Maize	1.06	127
Oats	0.90	108
Pollard (good quality)	1.00	120
Pollard (imported)	0.8 to 1.0	96-120
Molassed beet pulp	0.90	108
Molasses—cane	0.67	80
Brewers grain—20% DM	0.18	22
Distillers dark grains—90% DM	1.00	120
Fodder beet—16% DM	0.16	19
Swedes	0.12	14
Potatoes (sound)	0.25	30
Grassmeal (good quality)	0.80	96
Hay (excellent—65% DMD)	0.66	79
Hay (medium—58% DMD)	0.55	66
Hay (poor—50% DMD)	0.43	52
Silage (excellent—72% DMD, 20% DM)	0.19	23
Silage (medium—62% DMD, 20% DM)	0.15	18
Silage (poor—52% DMD, 20% DM)	0.11	13
Straw (good—45% DMD)	0.35	42

* One BFU is the net energy of 1 kg of standard barley (86% DM)

Cereal grains

Barley is the main cereal used for cattle feeding in Ireland—usually as a supplement to roughage. It is used as the 'yardstick' with which other feeds are compared in Table 2.

In general cereals have a crude protein content of 10 per cent and are highly digestible. They are low in calcium, sodium, some trace minerals and fat soluble vitamins. When used at low level as a supplement for high quality roughage these specific deficiencies in the cereal are often balanced by the basal diet. When used at high levels or with unbalanced roughages (e.g. straw) care should be taken that the overall diet is balanced.

Roots and potatoes

Swedes, fodder beet and potatoes are sometimes used as a replacement for cereals. Compared with cereals they tend to be lower in true protein and in the case of swedes and fodder beet the storage carbohydrate is present as sugar rather than starch. In feeding trials at Grange (Drennan, 1981) where fodder beet and barley were compared on a dry matter basis as silage supplements, animal performance from the fodder beet supplement was only 57% that obtained from barley in the absence of protein supplementation. However, when soyabean was included with the fodder beet (0.5 kg soyabean per 3.6 kg fodder beet dry matter) the value of fodder beet increased to 91% that of barley. Thus in the case of fodder beet, and probably also in the case of swedes and potatoes, the desirability of including supplementary protein is obvious.

Molasses

Molasses is often used to control dustiness and to improve the palatability of diets. In energy value it is about two thirds that of barley (Table 2) but it is low in protein and unbalanced in minerals. From work carried out at the Agricultural Institute 5 kg barley had roughly the same feeding value of 6 kg molasses plus 1 kg soyabean meal. Thus at current prices (barley £120 per tonne, soyabean meal £180 per tonne) the value of molasses as a roughage supplement is about £70 per tonne.

Cereal by-products

Included here are products from the flour milling industry (bran and pollard), brewing and distilling (brewer's and distiller's grains) and maize by-products such as corn gluten feed and corn gluten meal. In general they are lower in starch than the parent cereals and higher in virtually all other nutrients. They are potentially high quality feeds but can be variable and each batch should be considered on its merits. Apart from the contribution which they are likely to make on the energy side they are also useful sources of protein. In this respect, it is worth noting that brewer's and distiller's grains have always enjoyed a high reputation in dairy rations. The reason for this is not always clear but it is possible that the protein fraction may be involved. The protein in dried grains is fairly resistant to degradation in the rumen and theoretically at least might have advantages over readily degradable protein as a silage supplement. In view of the responses which are at times claimed for the use of fishmeal in ruminant diets (Pike, 1981) presumably because of the low degradability of fishmeal protein, it is possible that dried grains might have a similar effect.

Citrus pulp and molassed beet pulp

Citrus pulp and molassed beet pulp have about 90% of the feeding value of barley. Compared with barley they tend to be lower in phosphorus, protein — 1 percentage unit in the case of beet pulp and 4 percentage units in the case of citrus pulp—and higher in calcium. These differences in composition must obviously be considered when they are fed as a cereal replacement. In composition they tend to complement the composition of cereal by-products in nutrient make-up. At prices which normally obtain on the Irish market it would appear that a combination of citrus pulp, beet pulp and pollard could often form the basis of an economically priced supplement for beef cattle.

Vegetable proteins

Of the vegetable proteins, soyabean meal has been the most widely used in Ireland in recent years and enjoys a high reputation. It is usually a reliable material but in recent years considerable variation has been observed between different consignments. Therefore, vigilance is required to ensure that the particular batch meets the required specification.

Other vegetable proteins such as cotton seed, groundnut or sunflower may be used to replace soyabean meal in beef rations, depending on price and quality considerations. In the case of cotton seed and ground nut in particular it is important that they are free of aflatoxins.

Animal protein

Animal proteins, such as fish meal and meat-and-bone meal, can make a useful contribution to beef rations not only as sources of protein but also as sources of minerals. It is sometimes claimed that these proteins may have distinct advantages in providing 'by-pass protein': protein which escapes degradation in the rumen but is digested in the intestine. Theoretically at least the 'by-pass protein' concept would have more application in the case of the high yielding dairy cow where the requirements for protein are higher than in beef cattle feeding where protein requirements are moderate. It should be appreciated that both fishmeal and meat-and-bone meal are extremely variable in composition and quality. The fact that an economic response may be obtained from a specially prepared fishmeal product (Pike, 1981) does not mean that the results are applicable to all products.

Urea

In many parts of the world urea is a common constituent of beef cattle rations. Normally it should not be considered as a substitute for preformed protein except in situations where the feeds and feeding programme is conducive to the efficient utilization of urea. In the writer's view such feeding programmes rarely obtain in Ireland and the topic will not be discussed further.

PROTEIN SUPPLEMENTATION

Weanlings

The nutritive values attributed to feeds in Table 2 imply that the feeds are incorporated into adequately balanced diets. Because of cost considerations the level of protein in the diet requires specific mention. In a series of experiments involving weanlings carried out at Lyons Estate (Table 3), replacing part of the barley in the supplement by a protein concentrate resulted in a significant improvement in liveweight gain. From

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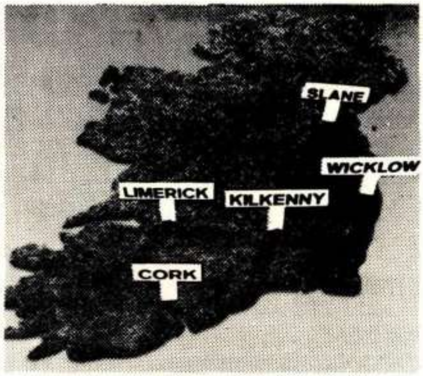

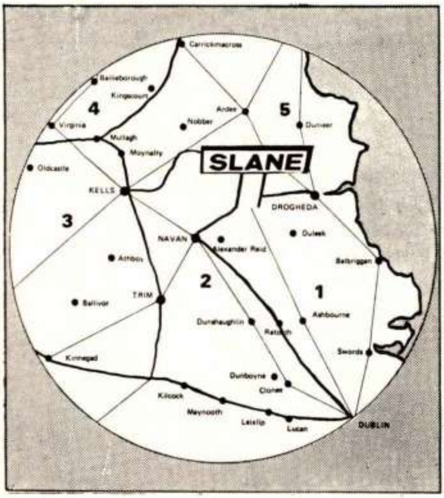

Grassland covers Ireland.

Grassland Fertilizers Ltd. The Pound Road, Slane · Tel. (041) 24124 & 24160 the data presented it would appear that replacing part of the barley supplement by a protein concentrate is economically justified in most feeding situations where low levels of concentrates are fed to weanlings.

Table 3

Effect of supplementary protein on the performance of weanlings

A. Basal Diet : BARLEY STRAW

	Concentrate supplements		
Diets :	Barley	Barley/Soyabean	Barley/Soyabean
Straw	ad lib.	ad lib.	ad. lib.
% C.P. in concentrate	8.90	13.60	19.10
Concentrate (kg/head/day)	1.36	1.36	1.36
Performance :			
Number of animals	10	10	10
Initial weight (kg)	270	261	278
Days on trial	112	112	112
ADG (kg)	−0.23	+0.05	+0.05

B. Basal Diet : HAY . "Gool" 65% DMD, 10% CP
"Poor" 50% DMD, 6% CP

	Concentrate supplements			
Diets :	Barley	Barley/ Cotton	Barley	Barley/ Cotton
% CP in concentrate	10	16	10	16
Concentrate (kg/head/day)	1.36	1.36	1.36	1.36
Hay type	Good	Good	Poor	Poor
Performance :				
No. animals	12	12	12	12
Initial weight (kg)	199	200	197	196
Days on trial	126	126	126	126
Average daily gain (kg)	0.59	0.68	0.19	0.25

C. Basal Diet : WELL PRESERVED SILAGE 72% DMD, 12.2% CP

	Concentrate supplements	
Diets :	Barley	Barley/Soyabean
Silage	ad lib.	ad lib.
% CP in concentrate	9.5	14.0
Concentrate (kg/head/day)	1.6	1.6
Performance :		
Number of animals	24	24
Initial weight (kg)	218	226
Days on trial	126	126
ADG (kg)	0.56	0.64

Finishing cattle

The results of two experiments, in which part of the barley in the concentrate supplement of silage-fed finishing cattle was replaced by soyabean, are summarised in Table 4. In general, there was a tendency for the liveweight gain to be improved on the protein supplemented diets but the differences failed to reach significance.

Table 4

Effect of supplementary protein on the performance of finishing cattle

A. 15% soyabeans in supplement
Silage : DMD 72%, CP 12.2%

	Concentrate supplements	
Diets :	Barley	Barley/Soyabean
Silage	ad lib.	ad lib.
Concentrate (kg/head/day)	2.5	2.5
% CP in concentrate	9.5	14.0
Performance :		
Number of animals	24	24
Initial weight (kg)	401	408
Final weight (kg)	527	538
ADG (kg)	1.05	1.08
Carcase weight	271	275
K.O. %	51.4	51.1

B. 40% soyabeans in supplement
Silage : DMD 67.4%, CP 15.6%

	Concentrate supplements	
Diets :	Barley	Barley/Soyabean
Silage	ad lib.	ad lib.
Concentrates (kg/head/day)	2.5	2.5
% CP in concentrate	10.6	24.4
Performance :		
Number of animals	16	16
Initial weight (kg)	510	502
Final weight (kg)	608	610
ADG (kg)	0.87	0.96
Carcase wt. (kg)	317	315
K.O. %	52.1	51.7

It should be appreciated that the basal silage diets fed in these experiments were well preserved and this may have contributed to the apparently poor response from protein supplementation. A number of years ago (Murphy and Caffrey, 1972) we obtained a large and significant response from protein supplementation with a poorly preserved silage as the basal diet. In the writer's view the response to protein supplementation is more dependent of the quality of preservation of the silage than on the level of protein in the diet. Although experimental evidence on the topic is not convincing, it is probable that replacing some of the barley by protein in the concentrate supplement of silage-fed finishing cattle is economically justified in most feeding situations. In this context the ingredient cost of replacing 50 kg of barley by 50 kg of soyabean would amount to £3 which would be equivalent to the price of 1.5 kg of carcase. Differences in carcase gain of this magnitude are unlikely to show up as significant in conventional trials.

CONCLUSIONS

In this communication the rationale behind some of the systems of feed evaluation and nutritive value of selected feeds has been briefly considered. Although energy is the primary nutrient usually considered in feed evaluation, care must be taken to ensure that the diet as fed is adequately balanced with respect to all essential nutrients.

In practice if the feeding programme is to be approached on a rational basis, it is necessary to have realistic estimates of the nutritive value of available feedingstuffs. In the case of roughages (silage, hay, straw) the *in vitro* digestibility technique (Tilley and Terry, 1963) has proved to be a reliable laboratory method for the prediction of nutritive value. This technique has been extensively used in Ireland and close relationships have been observed between *in vitro* digestibility and animal performance (Flynn, 1978). To date similar developments have not taken place in the evaluation of concentrate feeds. In view of increasing importance of concentrate feeds in beef production—both in terms of cost and quantity—there is urgent need for the development of reliable laboratory methods for their evaluation. It is possible that the *in vitro* fermentation technique will prove reliable in this respect but further work is needed.

In conclusion, it is stressed that since nutritive value is essentially a biological response the merits of 'laboratory predictors' can only be assessed by animal feeding experiments.

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The Mineral Requirements of Cattle

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In this paper I will attempt to answer a two-fold question :

(a) How much of each mineral does the animal require, and

(b) How much does the standard ration supply.

The difference between these two is the amount which must be given as supplement, whether as a feed ingredient, a voluntary access lick, or block, or in some other way. The question is complicated by the fact that both during absorption and metabolism the minerals can interact with each other, sometimes beneficially and sometimes antagonistically. It is therefore desirable to know not only the actual quantity of a particular mineral but also what the rest of the diet is composed of. If high production is expected from a highly digestible, concentrate feed, then a more generous mineral supply will usually be required than for a maintenance store period.

Again, if one is dealing with young growing animals they will have particular requirements, for instance for calcium and phosphorus, to ensure good bone growth, whereas an adult lactating cow will have a much higher requirement for magnesium and sodium (related to milk production) than the young animals.

Classification of elements

Firstly, one should define a major element. It is a mineral which is required by the animal in considerable quantity in the diet, to an extent that it is usually expressed as a percentage of the feed dry matter. Major elements can be classified arbitrarily into structural or functional. Those that have a structural role include calcium and phosphorus as the major components of bone; sodium and potassium are required to maintain the structure of the soft tissues, while the functional elements would be magnesium (affecting nervous transmission and brain function), calcium with similar functions, possibly sulphur. Thus, it is seen that such classification contains overlaps.

Minor trace elements are essential for full health and production, but are required in very small amounts—so much so that they are expressed as parts per million of the feed. Their role is very much functional, acting as integral components in enzymes, hormones or even vitamins.

Major elements

There are seven well recognised essential major elements, viz, Calcium, Phosphorous, Magnesium, Sodium, Potassium, Sulphur and Chlorine. How are these elements supplied in usual foods ? Obviously we must consider grass as the basic food and whether it be in the form of grazing, silage, or hay, won't greatly affect the situation. Table 1 gives what could be typical values for major elements for an Irish pasture. These values are my 'norms' based on experience, not on any statistical survey or study.

Table 1

Typical Irish pasture (major elements)

Calcium	0.8%	Sodium	0.2%
Phosphorus	0.4%	Potassium	3.0%
Magnesium	0.25%	Chlorine	0.5%
Sulphur	0.3%		

How do these levels match up to actual requirement ? Again, we must consider the question in general terms, recognising that in both supply and demand there will be obvious exceptions to the general rule. Table 2 gives guideline figures for major element requirements for cattle. It is clear, that good quality pasture usually is adequate in major elements for all but very high production. What is the effect of ensiling ? The effect is not large if the process is good, and the same applies to hay. However, two points must be borne in mind. As a sward matures, there will be considerable change in mineral levels (both major and minor)

Table 2

Usual requirement for major elements (% of diet)

	Ca	P	Mg	Na
Calf	0.27	0.21	0.07	?
Fattening bullock	0.20	0.21	0.10	0.02
Pregnant cow	0.27	0.24	0.11	0.05
Lactating cow (1,200 gall)	0.60	0.45	0.23	0.16

and in most cases levels will be much lower in a sward at seed time than at an earlier stage. Thus, one should not expect to have as good a phosphorus value in hay cut in July as in a grazed sward. Also, there can be losses during conservation—in silage particularly as run-off from wet materials when soluble components such as magnesium and sodium can be lost.

What happens when concentrates are introduced. Firstly (Table 3), calcium is very low whilst magnesium and sodium are suboptimal. Thus, a significant amount of barley added to the diet will reduce calcium intake considerably.

Table 3

Typical Irish Barley (major elements)

Calcium	0.09%	Sodium	0.02%
Phosphorus	0.47%	Potassium	0.63%
	Magnesium	0.14%	

Soya tends to correct this situation (Table 4). It is a good source of phosphorus and adequate in other major elements. Some soya meals are very low in sodium.

Table 4

Major elements in other feeds

Soyabean meal	Ca	0.36%	P	0.75%		
Pollard	Ca	0.16%	P	1.01%	Na	0.02%
Beet pulp	Ca	0.75%	P	0.11%	Na	0.3%
Maize	Ca	0.02%	P	0.03%		

Table 4 also gives values for Pollard, Beet, Pulp and Maize. Pollard is low in calcium, high in phosphorus and low in sodium. Beet pulp is high in calcium, but very low in phosphorus. The level of magnesium in mollassed beet pulp can be quite variable depending on the industrial process used in the production of molasses. It can vary from adequate to very high. While the latter are contra-indicated for fattening lambs, they could be an advantage, for instance for lactating cows.

Minor elements

There is an increasing list of minor elements which are accepted as being essential, but of these the following are possibly of practical importance : Iron, Iodine, Zinc, Copper, Manganese, Cobalt and Selenium. Table 5 gives typical values for an Irish sward. In recent years it would appear that copper values are falling—8 ppm now seems much

Table 5

Typical Irish pasture (minor elements) ppm

Iron	250	Cobalt	0.10-0.20
Zinc	40	Iodine	0.10
Copper	8- 12	Selenium	0.12
Manganese	50-150	Molybdenum	0.2 -1.5

more usual than 12 ppm, and on peat soils 6 might be a more usual value. Molybdenum is included because of its interference with copper particularly at levels in excess of 5 ppm. Levels of minor elements are related both to the pasture species and to the soil conditions. The latter includes the influence of parent material and the effect of management and fertilizer use. Thus, the level of cobalt, given in the table as the optimum value, may on many soils of low cobalt or high pH or high manganese level fall far below this value. In Table 6 I have attempted to define trace element requirements for cattle. This is even more tentative than for major elements as the magnitude of interference from other minerals etc. is even larger.

Table 6

Trace element requirements for cattle (ppm)

Iron	30 (calf) 10 (adult)	Cobalt	0.07
		Iodine	0.05
Zinc	30	Selenium	0.10
Copper	10		
Manganese	10-25		

However, it is again seen that the supply usually meets the demand. Because plant minor element requirement can be very different from animal minor element requirement, it is common nowadays to see more serious minor element problems in cattle than major element problems. Copper deficiency, partly because of falling pasture values but principally because of molybdenum and possibly sulphur antagonisms, is now common. Cobalt too may be a problem, as may selenium. These are subjects large enough for a separate paper and cannot be fully discussed in this presentation.

Table 7 shows the minor element supply of barley. It should be noted that proprionic acid-treated wet storage of barley will destroy vitamin E, and therefore place a much higher dependence on adequate selenium. Manganese can be quite low.

Table 7

Minor elements in barley (ppm)

Iron	60	Manganese	18
Zinc	17	Cobalt	0.1
Copper	8	Zinc	20

Some of the minor interesting element levels in other foodstuffs are given in Table 8. The low values for copper and cobalt in maize and high copper value in soyabean meal should be noted especially.

Table 8

Other feedstuffs : minor elements (ppm)

Maize	Fe 20	Cu 2	Mn 6	Co 0.02
Pollard		Cu 24	Mn 132	Zn 50
Beet pulp	Fe 300	Cu 14		Zn 1
Soyabean		Cu 41 (±)		

Summary

In conclusion, I wish to summarise my attitude to supplementary minerals for animals. For lactating cows on pasture (yielding up to 800 or 900 gals), provided the sward is well fertilized and well managed, there should be very little need for additional minerals—possibly a salt lick. On silage and on hay, one has to recognise that cutting date and harvesting techniques will play a part and one would generally like to see a good quality mineral mix available, preferably as a feed supplement or alternatively some "free access" system. This should contain the essential major and minor elements in roughly the same proportions as the animal's requirements. The addition of concentrate should be matched by a suitable supplement, e.g. barley with a high calcium, beet pulp with a high phosphorus.

Obviously, one has to be aware of certain specific circumstances, e.g. grass tetany on spring swards, copper deficiency on shale soils, etc., but these should be diagnosed and treated as special farm problems requiring specific remedies.

One can justify a certain amount of extra mineral feeding in a sort of 'insurance' approach. But in my opinion, nearly as much damage to production is done by excessive use of mineral supplements as can result from possible shortage.

Intensive Beef Production from Conserved Grass in France

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Intensive beef production in France is based on the production of young bulls slaughtered at 15-18 months of age. Calves from the dairy herd are reared from 15 days to 3 or 4 months of age in a nursery, after which the fattening period commences. They are generally slaughtered at 15-17 months giving carcasses weighing 340 kg (Normand) or 360 kg (Montbeliard, Charolais crossbred cattle). Sucklers are weaned at 6 to 9 months of age and slaughtered at 18 months, giving carcases weighing 360-380 kg (Charolais, Limousin, Charolais crossbred).

The more usual feeding system is based on maize silage (80% of total dry matter intake) with 1 kg of soyabean cake, minerals and vitamins, and 1 or 2 kg of cereal depending on breed type and expected carcass weight. In recent years the production of maize silage, particularly in Bretagne and Normandie, has been questioned and interest in grass silage is increasing. Following the big expansion in maize silage recently, grass silage has exploited the techniques of direct harvesting with a precision chop machine.

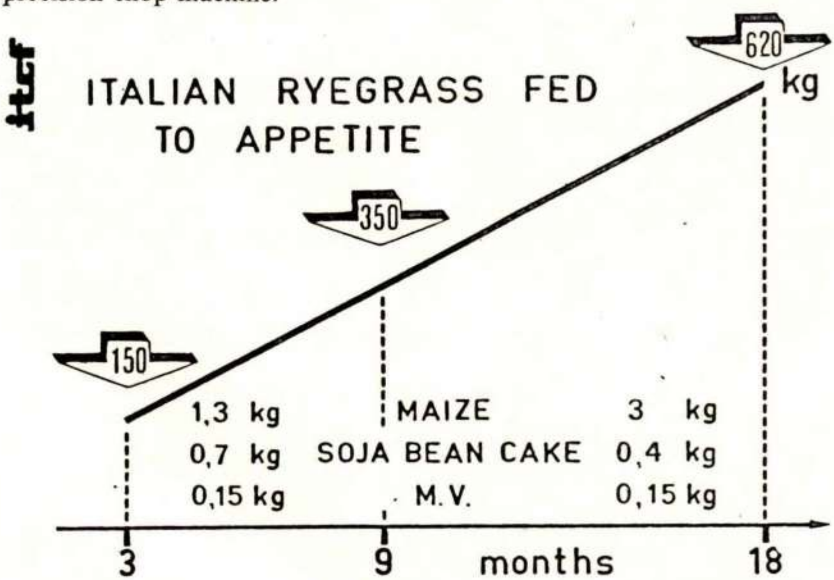

Figure 1

The most widespread diet using grass silage for young bulls is shown in Figure 1. Concentrates (cereal, soyabean cake and minerals) account for 40% of total dry matter intake (Table 1). It may be necessary to add 1 to 2 kg/d of additional cereal one or two months before slaughter depending on the degree of finish of the animals.

From a calf of 150 kg liveweight to a
carcass of 350 kg

LIVEWEIGHT GAIN → 1 kg per DAY

with

- 2600 kg of DM of grass silage
- 1100 kg of maize grain
  (or 1200 kg of barley)
- 250 kg of soja bean cake
- 70 kg of minerals and vitamins

Table 1

Another feeding system is the use of grass silage at the beginning of the fattening period (150 to 350 kg liveweight) and of maize silage from 350 kg liveweight to slaughter. In addition to maize silage during the fattening period 1-3 kg of maize, 0.7 kg of soyabean cake and 0.15 kg of minerals are fed daily per animal.

The choice between a full grass silage or a mixed grass-maize silage feeding system depends on the suitability of the area for maize production and the breed of animal. Late maturing breeds, such as the Charolais, need a higher level of energy particularly towards the end of the fattening period than earlier maturing breeds such as Normand or Charolais x Normand crossbred cattle.

Effect of level of energy supplementation of grass silage on the performance of young bulls

Several trials were carried out in France to study the effect of concentrate supplementation on the performance of young bulls fed grass silage.

Control diets were generally supplemented with 1 or 2 kg of maize (0.3 to 0.6% of liveweight) while experimental diets involved an additional 1 or 2 kg per day. The increment of cereal supplementation ranged from 0.15 to 0.4% of liveweight with an average of 0.3% of liveweight.

Responses in liveweight gain by growing (150 to 350 kg liveweight) and fattening cattle (after 350 kg liveweight) to concentrate supplementation of grass silage are illustrated in Figure 2. The extra daily gain used

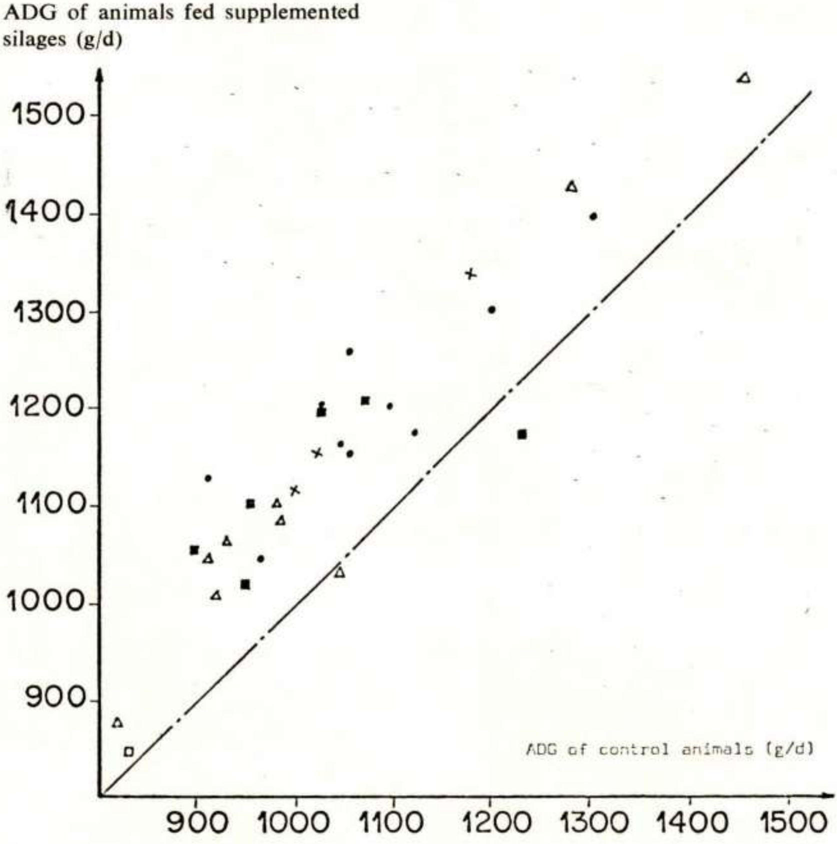

Figure 2 : Relation between average daily gain (ADG) of animals fed supplemented silages and that of control animals (grams/day).

● Growing bullocks fed direct cut silage
X Growing bullocks fed wilted cut silage
■ Fattening bullocks fed direct cut silage
□ Fattening bullocks fed wilted cut silage
Δ Sucklers fed wilted silage

to plot the points was calculated on the basis of a standard supplement of concentrate at 0.3% of liveweight (1 kg/d) in each trial. There was no significant effect of type of animal or type of silage on the response

in daily gain (ADG) to concentrate supplementation. The regression line which may be calculated is parallel to the diagonal, indicating that the average response was also independent of the level of ADG which ranged from 900 to 1400 g/day. The difference between the mean ADG of the control group (supplemented with 1 or 2 kg maize) and that of the experimental group (additional 1 kg of maize) is approximately 100 g/day as shown in Table 2.

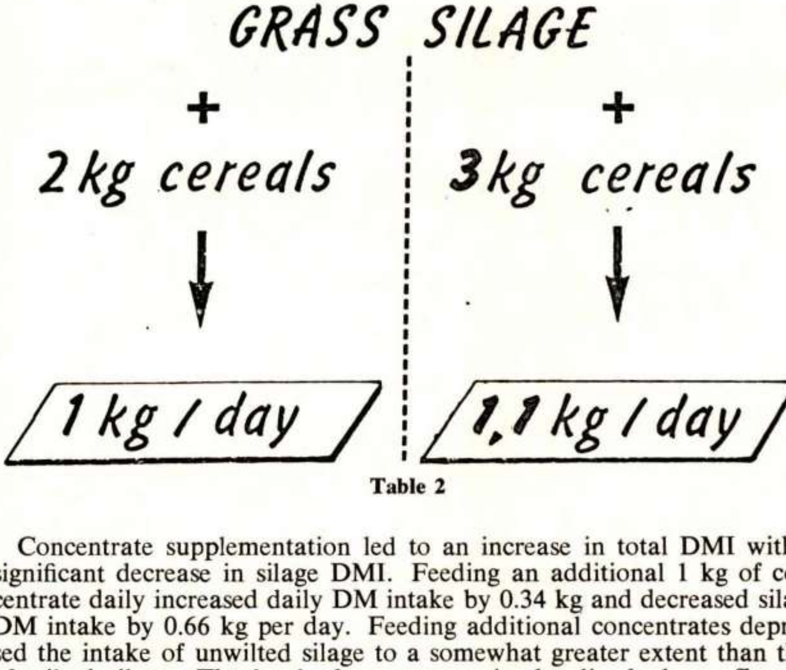

Table 2

Concentrate supplementation led to an increase in total DMI with a significant decrease in silage DMI. Feeding an additional 1 kg of concentrate daily increased daily DM intake by 0.34 kg and decreased silage DM intake by 0.66 kg per day. Feeding additional concentrates depressed the intake of unwilted silage to a somewhat greater extent than that of wilted silage. The level of concentrate in the diet had no effect on killing-out percentage. However, fat content of the 11th rib cut and kidney fat were greater for animals fed the higher level of concentrates.

Effect of additive treatment and wilting of grass silage for intensive bull beef production

Fourteen trials were carried out by the Technical Institute of Cereals and Forages and the Technical Institute of Bovine Husbandry to determine the effects of additives and wilting in silage making for bull beef production.

Preservatives used were mainly formic acid, sulphuric acid/formalin mixture (sylade) and a mixture containing malt and lactoserum (Acosil), all of which were applied at the rate of 3 l/t of fresh weight.

In the various trials wilting increased DM content by 4-14 percentage points. No investigation has been made of the interaction between preservative and wilting.

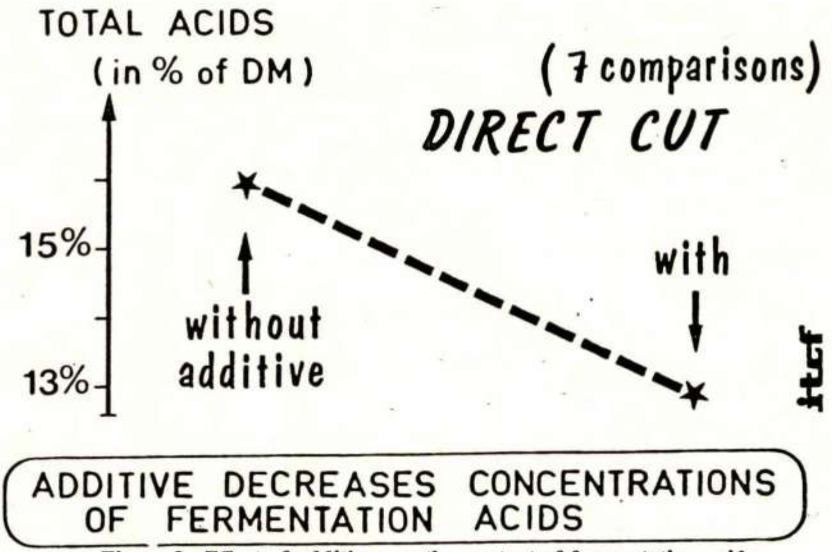

Figure 3 : Effect of additives on the content of fermentation acids.

Fermentation quality

Average pH values were 4.1 for both untreated and additive treated silages, and for both unwilted and wilted silages. The total content of fermentation acids was reduced by additive from 16% to 13% of DM (Figure 3). Wilting reduced the content of fermentation acids from 15% to 11% DM (Figure 4). However, lactic fermentation, expressed as a

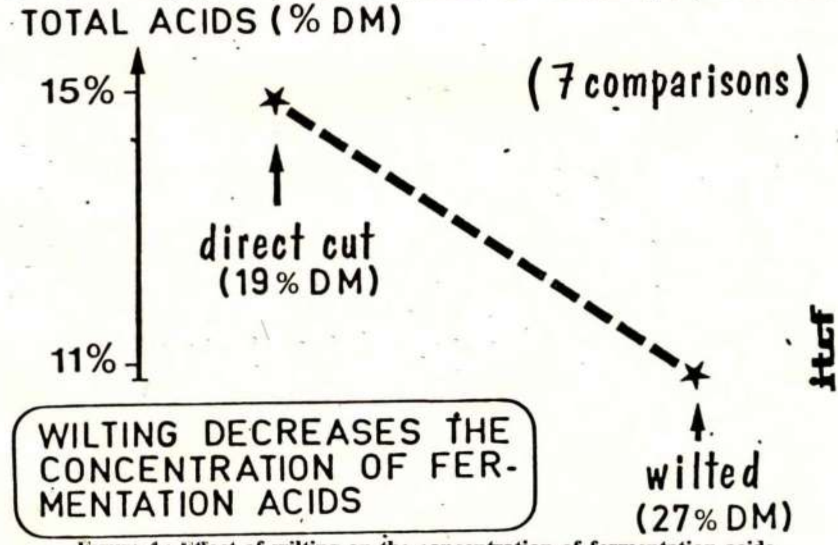

Figure 4 : Effect of wilting on the concentration of fermentation acids.

percentage of total acids, was increased to a greater extent by wilting than by additive treatment.

Ammonia content expressed as a percent of totaly nitrogen is markedly affected by additive (reduced from 12% to 9%), while wilting had no effect. This means that additive decreases rate of proteolysis to a greater extent than wilting. Additive decreases storage DM losses by about 2 percentage points only, while wilting decreases it by about 4 points (Figures 5 and 6). Cabon and Mosnier (unpublished results) have re-

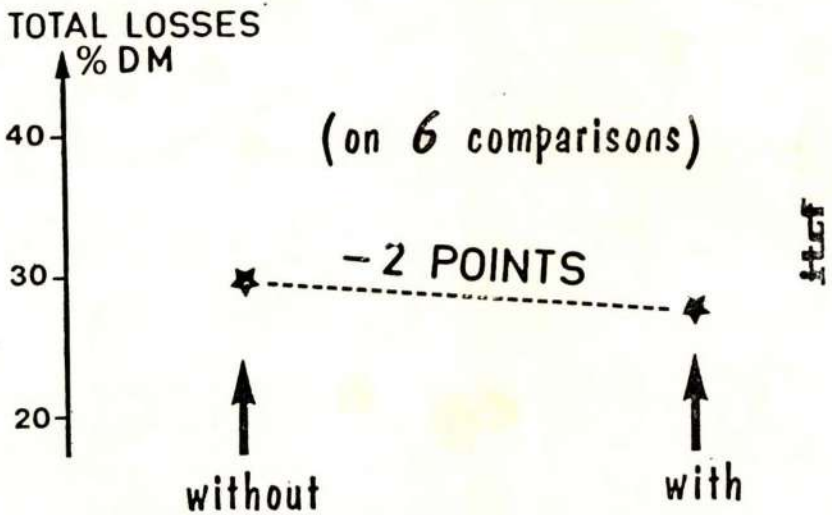

Figure 5 : Effect of additives on storage losses.

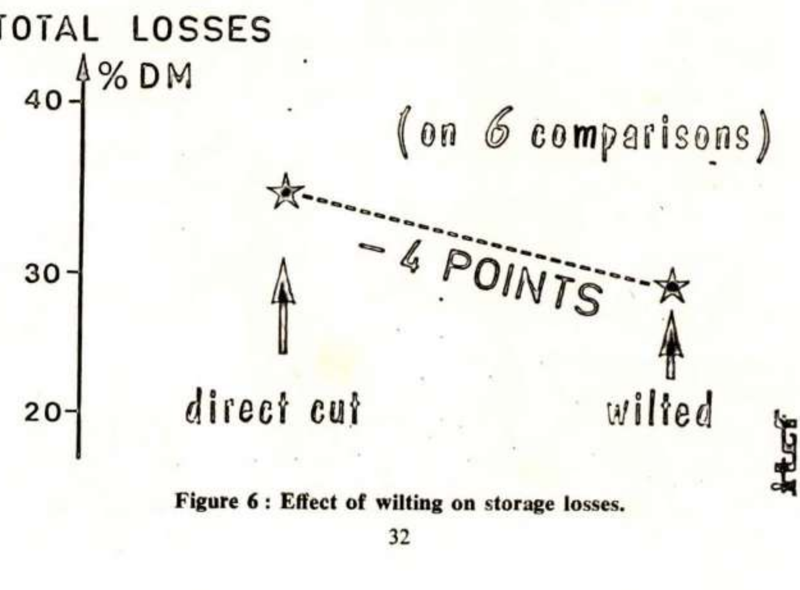

Figure 6 : Effect of wilting on storage losses.

corded under farm conditions (81 observations) that additives did not affect total DM losses during storage. The lower the DM content the greater the storage DM losses (Figure 7).

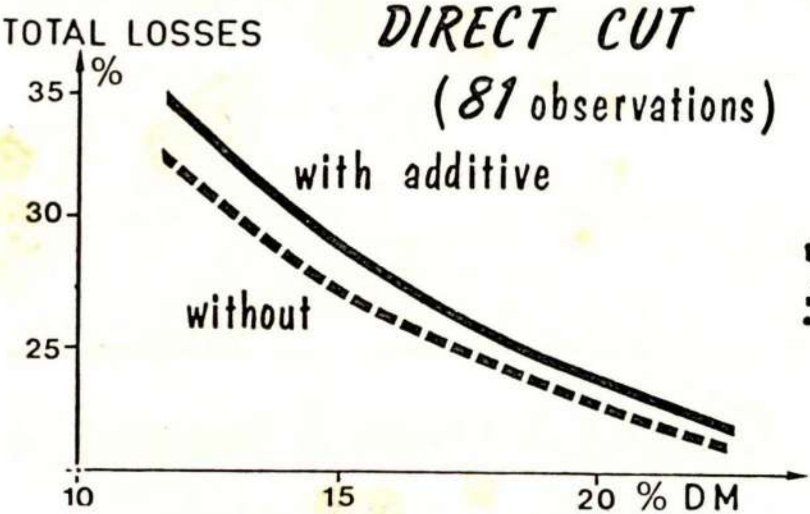

Figure 7 : Effect of additive on DM losses.

With silos opened in summer, DM losses of wilted silage increase dramatically as the duration of utilisation increases. With silos opened in winter, the most important factor affecting DM losses is the crude protein content. Losses decreased as crude protein content increased, although this is not a direct protein effect but a reflection of the type of material ensiled. The earlier the date of harvest, the greater the crude protein content and the better the compaction in the silo.

Animal performance

Additives tend to increase DMI (+3% on average) but the difference was not significant in our studies. Wilting had a marked effect on DMI (+ 7% on average in our studies). Only in three of the six trials reviewed did additive enhance average daily gain but the mean increment in ADG (+ 4%) was not significant. Wilting reduced mean ADG of animals by about 3%. This reduction occurred when ADG of control animals was greater than 1083 g/d.

With the exception of one of the six trials reviewed, the use of additives led to a feed conversion ratio equal to or slightly better than that obtained with the control silage. Wilting increased the DM required per kg ADG by 9% on average but this difference was not significant.

The poor response to additives in terms of DM intake and daily gain in the experiments reviewed is contrary to a number of studies. We must bear in mind that the control silages were generally well preserved. On the other hand, the level of concentrate in the diet may reduce the difference which would occur in lower energy diets. Growing heifers, for instance, respond fairly well to additives in grass silage.

The conclusions drawn on wilting are in full agreement with the review recently prepared by Wilkins and the Eurowilt group.

Possible Future Trends in Cattle Production and Marketing

F. MULCAHY

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County Westmeath is primarily a cattle county with :

3,000 beef farmers
1,200 dairy farmers
5% agricultural land in tillage.

Approximately 12,000 calves are brought into the county annually. In my area there are about 350 farmers with cattle production as the major enterprise. The scale of enterprise varies but a high proportion are engaged in intensive or semi-intensive wintering. Approximately 40 intensive beef producers sell most of their cattle in the January to June period. The output from these farms would be in the region of 10,000 cattle per annum.

The top producers are aware of the value of good performance and will always work and plan to achieve this aim. They must obtain high performance with an awareness of keeping costs to a minimum. The farmers achieve high performance by having :

1. **Top Quality Silage**—3 to 4 cuts per year of leafy material harvested mainly with their own equipment.
2. **High Throughput of Cattle**—Cattle are fed on a high plane of nutrition and the ration consists of silage/barley plus protein supplement. The target liveweight gain is 1 kg/day. Normally 2 batches of cattle are finished each winter and sold from January to June.
3. **High Stocking Rate**—Rate of stocking is 18 cwt. plus per st. acre from April/June, reducing to 12 cwt. later in the season. Fertilisers are applied according to standard recommendations.
5. **Careful Management of Cattle**—This includes the grouping of cattle on liveweight basis, lice control on two occasions, dosing if necessary, copper injection once if required, adequate feed and water and observing cattle in pens for lameness. Machinery for feeding requires careful consideration and reduction in feeding time allows more time for management. Feeder wagons or mixer wagons are used on these farms, e.g. Kidd Feeder Wagon, Movement Diet Feeder and Howard Mixer Wagon.
6. **Buying and Selling**—Purchases of cattle commence in June and they are sold out from January onwards. The large producers can usually obtain the top market price either as a bonus or commission.

Future developments

What is the next stage of development for these farmers ?

In my view, "group" participation is the next logical step. If a group is formed it will require a team effort on the part of ACOT, meat factories, research, veterinary personnel, Department of Agriculture and C.B.F. to promote and service the needs of the group. With such a group it will be necessary to monitor animal performance, feeding systems, class and type of animals. To service this demand, weighing scales and computer systems as an aid to management will be necessary. The commercial interests may have to provide these and the local adviser could interpret and select the clients who would use the various facilities. All the services will have to play vital roles in this development.

Other farmers will also have to consider group participation.

The group "idea" has existed in France for the past 20 years with rapid progress in the number of groups in the last 10 years especially in Brittany and Normandy. The aim of the group system is to organise groups of producers along certain lines of production, to co-ordinate the purchase and sale of animals and to provide technical advice to farmers on all aspects of production.

Production groups in Brittany and their members receive significant state and E.E.C. aid. In order to qualify for these aids, it is essential to be a member of a producer group.

All beef produced by group members must be on a basis of a written contract between the farmer and the group. This is the core of the producer group idea. The number, sex, breed and system of production is known and so marketing arrangements can be made in advance. Sellers from one group go to Italy to make contracts for young bulls.

Groups also operate a very useful and successful calf supply scheme, whereby calves from the dairy herd are purchased, transported and resold to members of their beef group. The co-optratives and S.I.C.A.S. have become associated with the whole development of the beef industry from the dropped calf to the marketing of the finished animal.

A typical French beef producer group comprises of 600-800 farmers pursuing a number of different systems of production such as bull beef, stores to beef, cull cow finishing, veal production and weaned calves (3-4 months age). There are very few groups specialising in one system of production and the majority of farmers have more than one system of production.

If groups are formed here the aim must be :

1. To improve income of beef farmers.
2. Promote better systems of production.
3. Improve quality of the animals.
4. Improve the supply of animals.

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 this year are expected to be worth well over £600m. Which gives you some idea just how far the industry has come since the days of the dairymaid.

AN BORD BAINNE
IRISH DAIRY BOARD

The Growth of Grasses and How it Responds to Management

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Stocking rate is the most important factor in determining the output of animal product per hectare in grazing systems. But the stocking rate that can be achieved, and consequently the levels of animal output per hectare, depends on the amount of feed available. A brief account is given in this paper of the weather factors, crop factors and management factors that determine the amount of feed available. But firstly, let us consider how animal output and dry matter are inter-related.

A diagrammatic illustration of the relationship between stocking rate and the level of output of animal product per hectare is given in Figure 1. The upper curve refers to a situation where grass is abundant. At low stocking rates, where the feed available per animal is greater than the amount required for maximum voluntary intake, an increase in stocking rate gives a proportional increase in output simply as a result of the increase in the number of production units (animals). Proportional increases in output with increasing stocking rate continue to the stocking rate where the amount of feed available per animal is only sufficient to give maximum voluntary intake. When stocking rate is increased beyond this (at B in Figure 1)—intake per head, and consequently output per head, decreases. At first this decrease in output per animal is more than offset by the accompanying increase in animal numbers and output per hectare continues to increase, though at a lower rate. When stocking rate is further increased the fall in output per animal increases to the extent that it is no longer offset by the increasing number of animals. As a result output per hectare increases to a maximum and then declines. The lower curve in Figure 1 shows how a similar curve applies when grass is less abundant. In this case, output per animal begins to decline at a lower stocking rate (at A). The maximum output per hectare is lower and the stocking rate at which it occurs is also lower.

In order to achieve maximum output per hectare in a grazing system, stocking rate must be progressively adjusted according to the amount of grass available. The amount of grass available shows a marked seasonal pattern. The pattern is determined by the seasonal pattern in temperature and radiation and by changes in the physiological state of the crop. The weather patterns and the changes in physiological state are predictable in a general way and in the same way the pattern of grass growth is predictable.

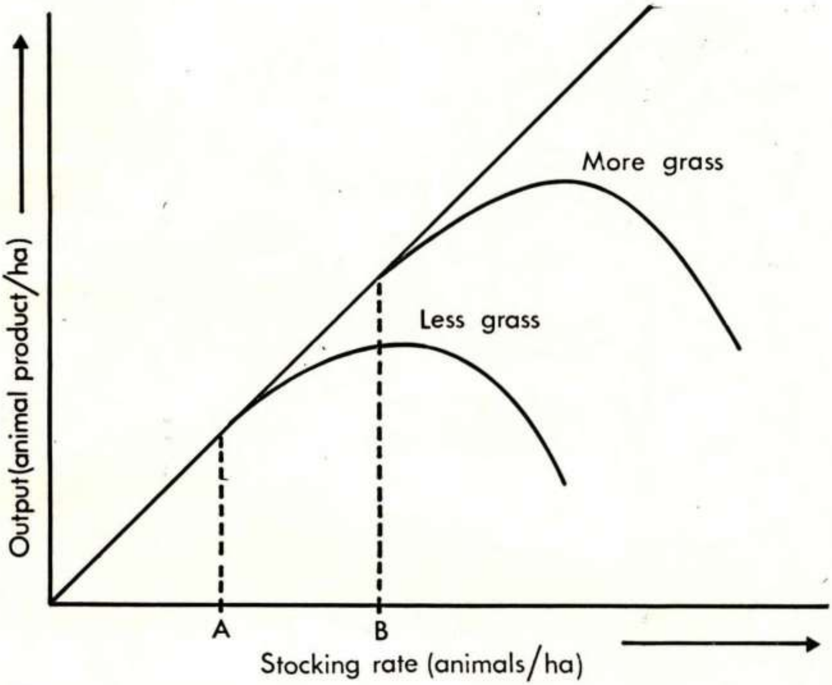

Fig. 1 : The relationship between animal output per hectare and stocking rate.

Physiological factor

In mid summer of each year there is a general replacement of the tiller population in the grass sward. The tillers which have become reproductive in spring die after flowering or are killed at grazing during May and June. These are replaced by a new crop of young vegetative tillers which form the flowering tillers of the following year. The growth potential of the vegetative tillers formed in mid-summer is about half that of the tillers they replace. As a result summer and autumn swards never achieve the growth rates of spring swards. The growth potential of the summer crop of vegetative tillers is approximately doubled after they have been subjected to low temperature during winter—this phenomenon is called vernalisation. Following vernalisation the tillers subsequently become reproductive when exposed to the appropriate day length in spring. Unvernalised tillers cannot respond to day length in this way. These population changes are illustrated diagrammatically with the parallel changes in sward growth potential in Figure 2. Growth potential is high from vernalisation in mid winter until after flowering in June, and for the remainder of the year growth potential is at least halved. The observed pattern of seasonal change in grass growth is quite different from this pattern of potential growth. This is mainly due to the fall in radiation levels and temperature in autumn, winter and spring.

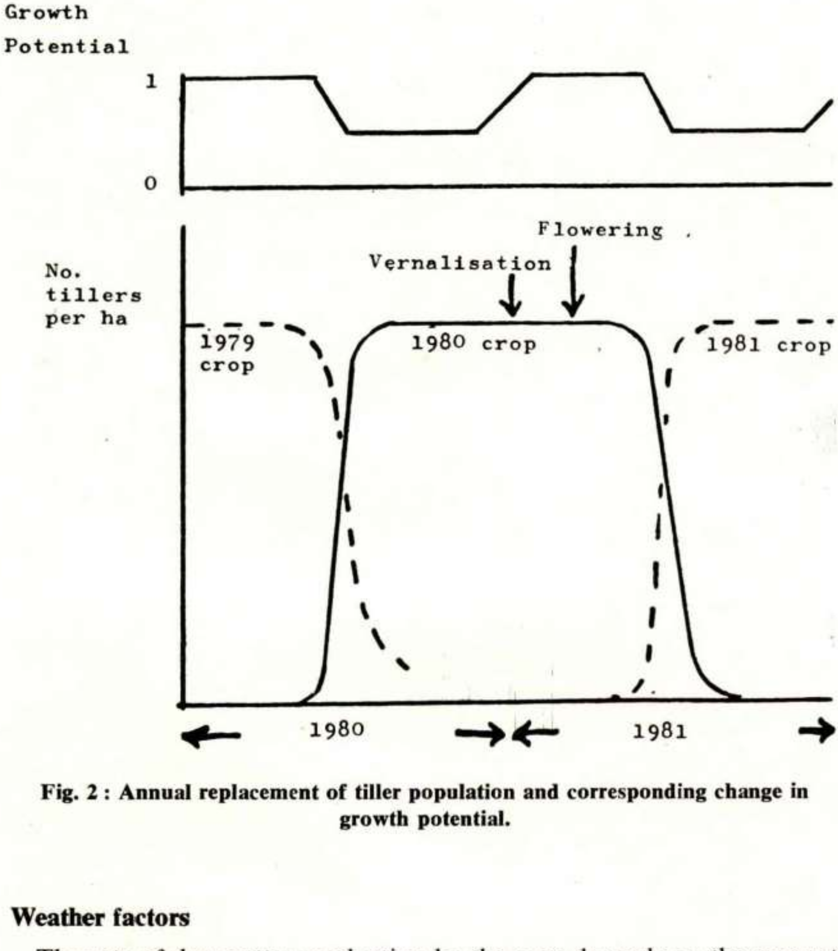

Fig. 2 : Annual replacement of tiller population and corresponding change in growth potential.

Weather factors

The rate of dry matter production by the crop depends on the amount of radiation energy received and on the efficiency of energy conversion to dry matter—which is controlled by temperature. The level of radiation varies with day length from about 200 Joules/cm²/day in December to about 2000 Joules/cm²/day in mid summer. Mean daily air temperature varies from about 5°C in mid winter to about 15°C in mid summer. The efficiency of conversion of radiation energy in the grass crop increases sharply in response to increasing temperature in the range 4.5-9.0°C (Figure 3). At higher temperatures the conversion is less sensitive to changes in temperature. In Figure 3, the upper curve refers to the vernalised crop in the period from mid-winter until flowering is complete. The lower curve refers to the summer crop of vegetative tillers in the period from June to mid-winter.

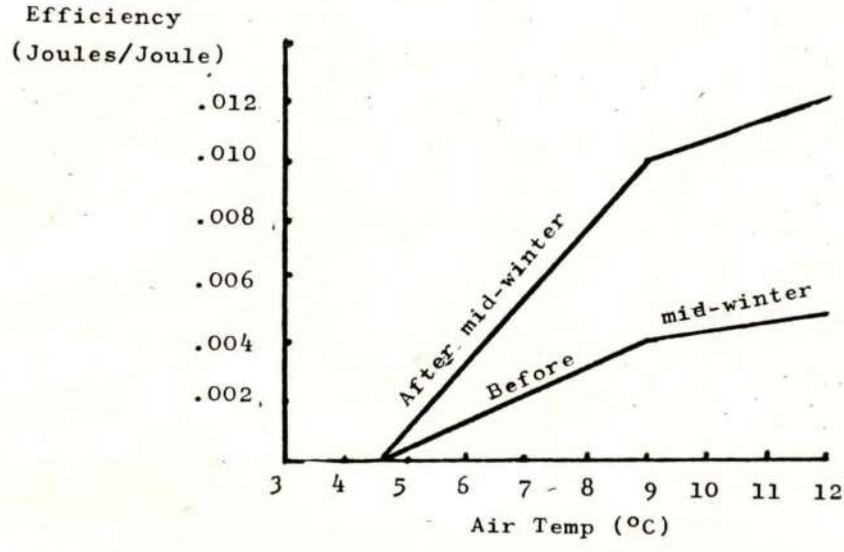

Fig 3 : Effect of air temperature on radiation use efficiency in grass swards.

Seasonal pattern of growth

From the published records of radiation and temperature we know how much radiation is available (on average) for growth in a particular period of the year. From the corresponding average temperature we know how efficiently the radiation is used and so we can calculate a rate of dry matter production for the period. Figure 4 shows the calculated pattern of grass growth rate across the year for the Wexford area. The pattern would be very similar for other areas.

Grass supply and demand

In Figure 4 the daily feed requirement of the grazing herd (at maximum voluntary intake) is superimposed on the grass growth curve. The feed requirement is that of the dairy herd at an overall stocking rate of 3.1 cows/ha. The diagram illustrates how the seasonal adjustments in stocking rate, associated with closing of paddocks for silage, change the feed requirement roughly in line with changes in grass growth. A more detailed picture of the balance between supply and demand is given in Figure 5. In this case the calculated amount of feed available day-by-day in successive 21-day rotations is compared with the amount required to give 90% of maximum voluntary intake. This level of feed requirement was chosen for the comparison because it seemed to give a good overall match between supply and demand for the season. At the start of the first rotation 400 kg/ha are available and over 800 kg/ha are required but at the end of the first rotation 1000 kg/ha are available when the feed required is still just over 800 kg/ha. On the first day of the

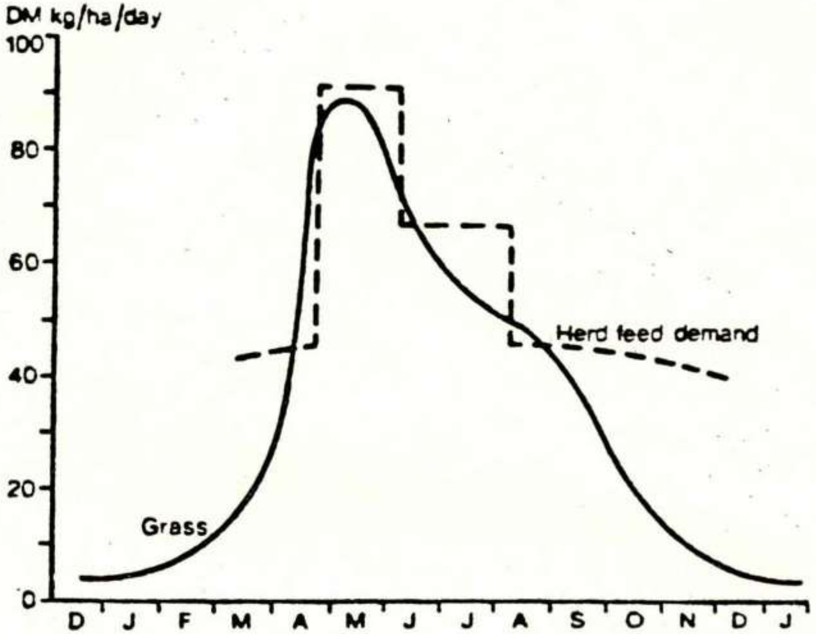

Fig. 4 : Seasonal pattern of grass growth compared with seasonally adjusted herd feed demand.

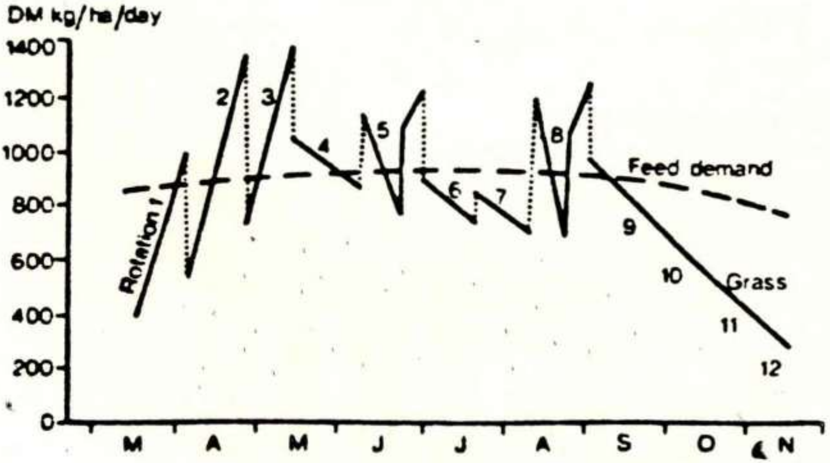

Fig. 5 : Daily availability of feed compared with demand during each rotation (21-day rotation).

rotation, regrowth since the last grazing amounts to about 500 kg/ha. This falls short of the feed required which is still over 800 kg/ha but again towards the end of the second rotation the available feed (1400 kg/ha) is greater than the amount required. This fluctuation in the balance between supply and demand occurs in each following rotation. In the last four rotations the feed demand is falling but the available feed falls more rapidly. The diagram is based on a 21 ha farm divided into 21 x 1 ha paddocks. The overall stocking rate is 3.12 cows/ha and management follows the recommendations given in the 1978 edition of Dairy Herd Management. The purpose of Figure 5 is to illustrate, in broad terms, the complexity of the task facing the grazing manager as he attempts to maintain a good balance between feed supply and demand. In preparing Figure 5 the effects of management on grass growth have not been taken into account (these effects will be discussed later). As a result the yield of grass available is overestimated for some parts of the season in Figure 5. Similarly there is an overestimate in mid-season because drought effects are not included. Even when growth rates are overestimated in this way, the diagram indicates that the system does not allow the herd to achieve maximum voluntary intake. This agrees with research at Moorepark which has shown that, at 3.1 cows/ha a high output of milk per hectare is accompanied by a reduction in output per cow. Throughout the season the wide variation in level of available feed per day suggests that there is a corresponding variation in the severity of grazing between paddocks but there is no indication that grass will accumulate to excess anywhere in the system. Between mid-April and mid-September the overall level of grass available is sufficient to feed the herd at about 90% of maximum voluntary intake. Outside of this period the feed situation is difficult.

Grazing management effects

It is in such a context that grazing management work has been carried out at Johnstown Castle. The work has been directed towards quantifying the effect on grass production of grazing swards at the times when the available feed falls substantially short of requirement. We have therefore examined the effect of severe grazing compared to lenient at all stages of the season. We have examined the effect of grazing in autumn on overwinter regrowth. We have also examined the effect of early spring grazing on subsequent grass production in the period up to mid-June. Because early spring grazing is necessarily accompanied by grazing of the silage paddocks, we have examined the effect of early spring grazing on first cut silage production.

Grazing severity

In Table 1 dry matter production in spring in swards grazed at 21 day intervals to a height of less than 5 cm is compared with production where swards were grazed to about 8 cm. At the severe grazing about 66% of the total leaf per tiller was removed leaving approximately 8 cm per tiller after grazing. At the lenient grazing about 50% of the leaf was removed leaving about 12 cm per tiller. Dry matter production was consistently depressed by severe grazing. The effect was most pronounced where turnout was early.

Table 1

Effect of severity of grazing on cumulative herbage dry matter production (kg/ha) in spring 1979. Perennial ryegrass (cv. Vigor) grazed at 21-day intervals.

	Turnout 25/3			Turnout 15/4			
	Lenient	Severe	(%)	Lenient	Severe	(%)	LSD
25/3-15/4	666	443	(67)	—	—		303
25/3- 6/5	2241	1893	(84)	2590	2543	(98)	608
25/3-27/5	4203	3075	(73)	4463	4305	(96)	1058
25/3-17/6	6762	5252	(78)	7647	6453	(84)	1321

The same comparison is made in Table 2 for swards grazed in the summer/autumn period. These swards had previously been cut for silage. There was a 23% depression due to severe grazing (averaged for swards grazed at 14, 21 and 28 day intervals). The effect was consistent throughout the period mid-July to mid-October and there was no apparent effect of rest interval on the magnitude of the effect. In the summer/autumn experiment the post grazing leaf length per tiller in the severe and lenient grazed swards was about 5 cm and 15 cm and the proportion of leaf removed at grazing was 66% and 50% respectively.

Table 2

(a) Effect of grazing severity on dry matter production (kg/ha) in summer. Perennial ryegrass (cv. Vigor) average for swards grazed at 14, 21 and 28 day intervals.

(b) Ratio of dry matter production lenient/severe grazing in successive rest intervals from 15/7 to 9/10.

(a)

	Lenient	Severe	(%)
15/7 - 9/10	2897	2241	(77)

(b)

Length of rest interval	Intervals 1	2	3	4	5	6
14 days	0.71	1.81	1.54	1.28	1.79	0.95
21 days	1.44	1.37	0.67	1.67		
28 days	1.00	1.86	1.31			

Tillering rate was not affected by grazing severity in the spring experiments except at the end of the experimental period when the early turnout/severe grazed swards appeared to be tillering more actively than the other treatments. In the summer/autumn experiment severe grazing consistently stimulated tillering (at all rest intervals). The increased tillering did not appear to compensate for the depressing effect of severe grazing on production.

The analysis of the balance between feed supply and demand (Figure 5) has shown that supply falls substantially below demand at times throughout the season. The results here indicate that hard grazing at these times will depress production of grass significantly. Overall annual feed production will be maximised where over grazing is avoided.

Autumn management

There are two aspects of autumn management of grazed swards to be considered. Firstly, during October sward growth rates fall below the rate required to provide adequate feed for the grazing herd. From mid-October, growth rates are less than 20 kg/ha/day—providing at most 420 kg/ha after 21 days growth. This quantity is only sufficient to provide about 50% of the maximum voluntary intake of the herd. Secondly, grazing in autumn significantly affects the amount of grass available at turnout in the following spring. The effect of grazing in

Table 3

The effect of grazing in autumn on grass yield in following spring.

Autumn closing date	Yield after last grazing	Yield following spring 15/3	5/4
15 September	1160	2280	2840
	940	1720	2520
15 October	600	1240	2120
	308	1080	2120
15 November	440	1000	1860
	318	820	1760
15 December	460	800	1760
	315	600	1600

LSD between closing dates = 240

autumn until mid-September, mid-October, mid-November and mid-December on the yield of grass in the following spring is shown in Table 3. As the autumn closing date is delayed the grass available in spring is reduced. The September closing date gave the highest yields in spring but these swards contained a high proportion of dead material (from a visual observation). The effect of autumn closing date on turnout date in the following spring was calculated from the results for the hard grazed swards (Figure 6). Taking the herd feed requirement at maximum voluntary intake as 850 kg/ha/day and allowing that 1000 kg/ha of the grass present is not grazed, then the yield required at turnout is 1850 kg/ha in this case where the herd spends one day on each paddock. It is 2700 kg/ha in the case where the silage paddocks are not grazed and the herd spends 2 days on each paddock. In Figure 6 the turnout dates are given for the first paddock where the above yields are obtained on the 10th day of the 21-day rotation.

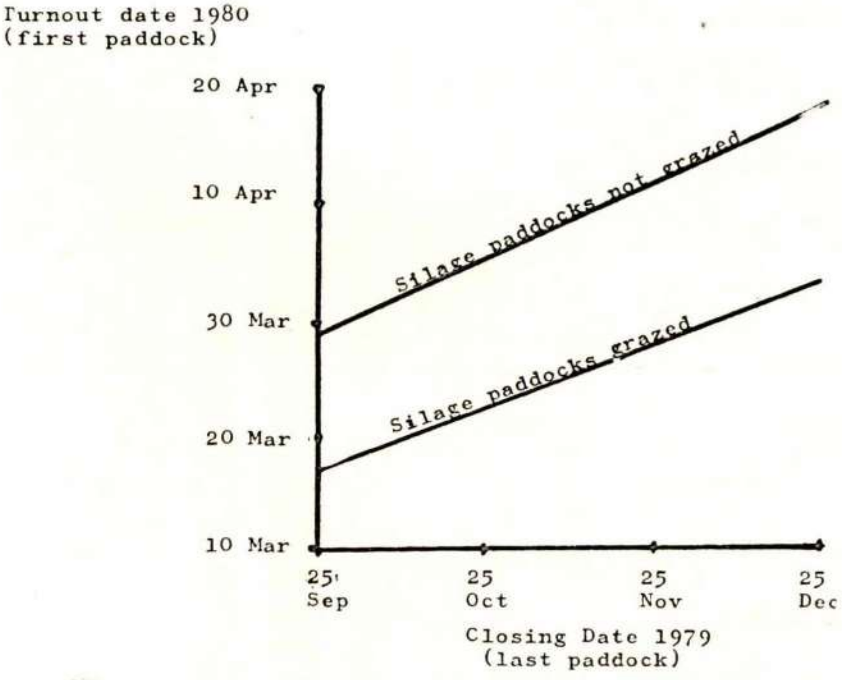

Fig. 6 : Effect of autumn closing date on turnout date following spring.

Where the silage paddocks are not grazed in early spring, turnout date is delayed by 2 weeks compared with the system where all paddocks are grazed. In both systems a delay of 5 days in closing in autumn results in 1 day's delay in turnout date in spring.

The main objectives in autumn should be to leave the sward clean grazed at closing and to close the last paddocks before the end of October. In this way the swards can recover before growth ceases in

winter but there is not an excessive accumulation which would suffer winter burn and lead to poor quality herbage in the following spring.

Turnout date

The effect of turnout date in spring on dry matter production in the following weeks was examined in 1979 (Table 4) and in 1980 (Table 5). In both years, dry matter production was greater where turnout was delayed. The effect was greatest under severe grazing in 1979 and at the shorter rest interval in 1980. The results indicate that potential production in the grazed sward may be reduced by over 1000 kg/ha where turnout is early. This reduction represents approximately 10% of total annual production.

Table 4

Effect of turnout date on dry matter production in spring 1979 (dm kg/ha). Perennial ryegrass (cv. Vigor) grazed at 21 day intervals.

	Lenient grazing			Severe grazing			
	25/3	15/4	(%)	25/3	15/4	(%)	LSD
25/3-15/4	666	907	(136)	444	907	(204)	303
25/3- 6/5	2241	2590	(116)	1893	2543	(134)	608
25/2-27/5	4203	4463	(106)	3075	4305	(140)	1058
25/3-17/6	6762	7648	(113)	5253	6453	(123)	1321

Table 5

Effect of turnout date on dry matter production in spring 1980 (dm kg/ha). Perennial ryegrass (cv. Vigor).

	7 day rest turnout date			21 day rest turnout date			LSD
	25/3	15/4	(%)	25/3	15/4	(%)	
25/3-15/4	663	1352	(204)	938	1563	(167)	371
25/3-27/5	2937	4734	(161)	3472	4564	(131)	1365

Silage

Where turnout is early it is necessary to graze the silage paddocks in early spring. This practice inevitably results in a reduction in first cut silage yield (Table 6 and Figure 7). The yield reduction is greater as the closing date is delayed and where the severity of grazing before closing is greater. When the amount of grass removed before closing is added to the silage yield there is still a significant loss in production.

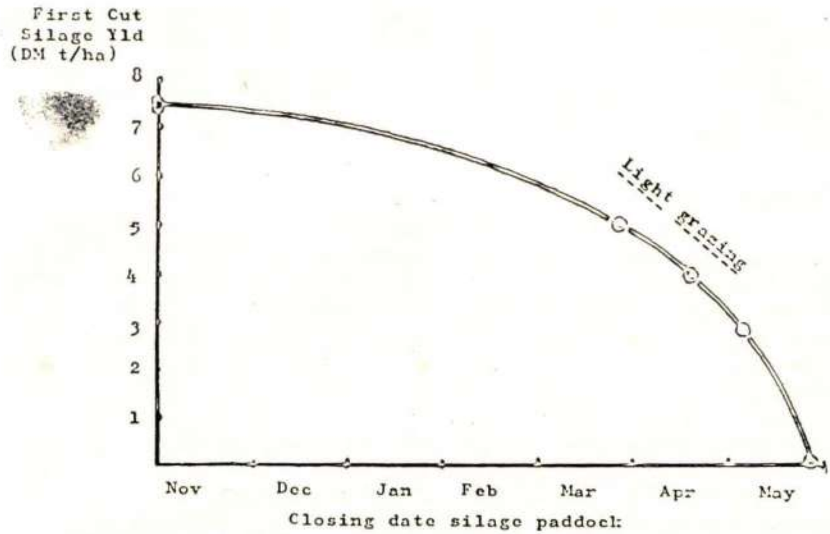

Fig. 7 : Effect of date of closing for silage on first cut silage yield.

Table 6

(a) Effect of closing date in spring on first cut silage yield (t/ac at 20% dm) on June 1st. Perennial ryegrass (cv. Vigor).

(b) Effect of closing date in spring on total recovery of herbage (t/ac at 20% dm) up to June 1st. Perennial ryegrass (cv. Vigor).

(a)

Closing date	Grazed lenient		Grazed severe
25/3	15.6		12.4
15/4	12.0		11.0
5/5	9.7		7.3
Ungrazed		17.6	

(b)

Closing date	Grazed lenient		Grazed severe
25/3	16.3		13.7
15/4	13.2		13.3
5/5	12.3		10.6
Ungrazed		17.6	

LSD between ungrazed control and all other treatments = 1.5.

In the system where the silage paddocks are grazed before closing and turnout is early, the winter indoor feeding period is shorter. Therefore less silage is required. A reduction in first cut silage yield from grazing in early spring is acceptable as long as the amount of silage produced is up to target.

Summary

The level of output of animal product per hectare is basically dependent on the amount of dry matter produced. The output/dry matter relationship interacts with stocking rate. In practice changes in stocking rate are used to adjust the balance between feed supply and demand. Seasonal variation in temperature, radiation, drought and crop physiology, cause continuous changes in the level of available dry matter. It is difficult to maintain a strict balance between feed supply and demand at all times because stocking rate cannot be adjusted continuously. In the rotational grazing system periodic adjustments in stocking rate are made which only succeed in giving a very general balance between feed supply and demand. The situation is further complicated by year-to-year weather variations. Whereas the seasonal pattern of change in growth is predictable for the average year, the year-to-year variation is much less predictable. In these circumstances output will depend on the adoption of a flexible approach to management.

This paper is primarily concerned with dry matter production. The results given show that, where the sole objective is to maximise grass production (at an overall high stocking rate), dry matter production will be increased where steps are taken to avoid grazing when the balance between supply and demand is low, early and late in the season, and to avoid overgrazing when the balance is low during the season.

Grassland Research and Development at Crichton Royal Farm

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Introduction

The Crichton Royal Farm was taken over by the West of Scotland Agricultural College in 1975 to study systems of dairying with particular reference to the efficient utilisation of grassland. It is a lowland farm of 253 ha situated in a moderate rainfall area (1052 mm per annum).

Between 1975 and 1978 a herd of 180 Friesian cattle was formed (Crichton herd) and this is used for trial work mainly concerned with winter and summer feeding management. In 1979 a new dairy unit was set up (Acrehead Unit) which is split into two herds of 90 and 70 cows to study the profitability of high and low concentrate systems.

The objectives of the work are to evaluate current developments in dairying under commercial farm conditions. This is important because many ideas which appear attractive in the narrow sense, e.g. when examined on an individual cow basis, subsequently are found to be unprofitable on a farm basis.

The importance of grassland utilisation

If the contribution of grassland to profitability is to be estimated, a suitable measure of grass utilisation has to be found. One measure which is being used increasingly is the utilised metabolisable energy per hectare (UME). The physical results obtained from any costed farm—the annual milk sales per cow, the annual concentrate input per cow and the annual stocking rate per hectare can be used to calculate the UME.

The UME value represents the amount of grass produced minus all the losses occurring in the field during the grazing season, and minus the additional losses in the silo and during feeding in the winter. To achieve high UME values therefore requires good management in growing, grazing, conserving and feeding the grass crop.

Table 1

Effect of UME (GJ/ha) on carrying capacity and relative margins *

UME	Stocking rate (cows/ha)	Relative margin over purchased feed/ha
60	1.54	100
80	2.05	133
100	2.56	166
120	3.08	200

* based on milk sales of 5000 litres/cow at 1.0 tonne concentrates/cow.

In Britain the average UME of costed farms is about 60 GJ/ha, with a range from under 40 to over 90. The UME of a farm relates closely to the margin per ha as illustrated in Table 1. At Crichton Royal Farm with nitrogen fertiliser inputs over 330 kg/ha, UME values of over 100 have been achieved.

Grass utilisation—grazing

Good grassland management during the grazing season involves optimising grass production, matching this with utilisation, whilst at the same time achieving satisfactory dairy cow performance.

As herd sizes increase in Britain, there is a tendency to separate the grazing area (particularly in early and mid season) from the conservation area, in order to keep the grazing close to the farm. Associated with this has been a trend towards set-stocking from rotational grazing. This system, whilst simple in concept (no intermediate fencing and less watering required), is very sensitive to changes in stocking rate.

It is essential to stock highly in early season with any grazing system to prevent heading and the subsequent development of rejected areas. This is shown in Table 2. In this trial, increasing the stocking rate in early season from 4.7 to 6.4 cows/ha, did not result in any reduced cow performance due to the increased utilisation of grass (UME).

Table 2

Stocking rate in early season for set-stocked dairy cows (Baker *et al*, 1980)

	Stocking rate (cows/ha)		
Early season	**4.7**	**5.5**	**6.4**
Grass height (cm)	7.3	5.9	4.8
Milk yield (kg/day)	25.0	25.5	25.0
Whole seaeon	**4.0**	**4.3**	**4.6**
Grass height (cm)	8.8	6.5	6.2
Milk yield (kg/day)	20.8	21.9	21.8
UME (GJ/ha)	80	86	94

Measurements of grazing time at Crichton Royal have shown that dairy cows are unlikely to graze for longer than 9 hours per day. The amount of grass eaten daily is therefore dependent on the rate of intake. As cows become more selective in their grazing habit as the season progresses, due to the increased treading, fouling and poor quality grass, the rate of intake declines. As a result, daily grass intake and the potential milk yield from grass declines as outlined in Table 3.

Table 3

Potential milk yield of grazed grass

Milk yield (kg/day)	DM intake required (kg/day)	Required grazing time (h/day) early	mid	late season
5	11	6	7	9*
15	14	8	9	11
25	17	9	11	14
35	20	11	13	16

* cows generally will not graze for longer than 9h/day

One method of maintaining intakes during the grazing season is to offer a buffer feed. This should be a feed with an energy value high enough to make a significant contribution to energy intake, but not high enough to be eaten in preference to grass. In the trial shown in Table 4, hay was offered as a buffer feed for 45 minutes in a feeding passage after the morning milking. When grass was in short supply and after adverse weather conditions, up to 3 kg of hay were eaten. The average milk yield response to hay over the season was economically worthwhile. This approach to buffer feeding at grass may be more beneficial than feeding concentrates as forages are approximately half the cost of concentrates per unit of metabolisable energy.

Table 4

Hay supplementation of set-stocked dairy cows (Phillips and Leaver, 1982)

	Control	Hay fed
Hay intake (kg/day)	0	2.0
Conc intake (kg/day)	3.3	3.3
Milk yield (kg/day)	19.5	20.7
Fat %	3.80	3.83
LW gain (kg/day)	0.3	0.3
UME (GJ/ha)	108	104

Grass utilisation—silage

Comparisons of different silage qualities tend to show that on an individual cow basis, higher quality silages are eaten in larger amounts and this gives an economic response in milk yield. However, a large amount of research work shows that earlier and more frequent cutting results in less silage produced per hectare. Also the greater intakes of high quality silage mean that greater amounts have to be conserved. For the production of high quality silage therefore, more hectares are required per cow, or there has to be an increase in grass production and utilisation (UME) through increased fertiliser usage. It is therefore important to measure the advantages of higher quality on a per hectare rather than on a per cow basis.

In Britain most dairy cow silage is taken from first cuts. The advantages of not cutting too early are illustrated in the trial work in Table 5. Cutting medium/late perennial ryegrasses 10 days later resulted in a 48% increase in cow feeding days per hectare, with no detrimental effect on cow performance. The extra silage produced by the late cutting system was not recovered in subsequent cuts on the early cut system, i.e. the UME over the whole season was lower on the early cut system.

Table 5

Early and late (plus 10 days) cutting of silages (Moisey and Leaver, 1980)

	Early	Late
Silage yield (tonnes, DM/ha)	4.2	6.0
D value	69	66
CP %	18	15
DM %	21	27
Silage DM intake (kg/day)	9.3	9.0
Conc DM intake (kg/day)	6.9	6.9
Milk yield (kg/day)	20.7	20.6
Cow feeding days/ha	384	567

The use of concentrates

The response in milk yield per cow to increasing concentrate levels is often shown to be uneconomic. Where good quality silage is offered *ad libitum* it normally requires at least 1 kg concentrates to produce an extra kg of milk. However, the energy requirement for 1 kg milk is provided by only 0.45 kg of concentrates. In judging the economic benefits of concentrates therefore, one must consider what happens to the 0.55 kg concentrates which is not converted to milk. Some of these additional concentrates go on to the cow's back which has an economic value, and the remainder substitutes for silage.

The short-term economic response to concentrates is therefore measured by : value of additional milk + value of additional liveweight + value of silage saved.

In the longer term a better measure of the response to concentrates is the margin per hectare, because the substitution of concentrates for silage allows more cows to be carried on the farm. This is illustrated in Table 6.

Table 6

Relationship of milk sales, purchased feed and stocking rate

Milk sales (litres/cow)	Conc per cow (tonnes)	Stocking rate (cows/ha)	Relative margins* (/cow)	(/ha)
5000	0.5	2.02	100	100
5500	1.0	2.17	99	106
6000	1.5	2.34	98	113
6500	2.0	2.54	96	121

* based on a UME of 90 GJ/ha and a milk : concentrate ratio of 0.9 : 1.0

At Crichton Royal a long-term study of two herds is being carried out on high or low concentrate systems. Each herd has a similar land area with the same grass varieties and fertiliser inputs, and both herds are looked after by the same man. The objective of the study is to examine over about 5 years, the profitability of the two approaches and to record the effects on cow health and culling rate. An outline of the study is shown in Table 7.

Table 7

Crichton Royal study of high and low concentrate systems

	High conc herd	Low conc herd
Land area (ha)	32	32
Average cow numbers	90	72
Concentrate input (tonnes/cow)	+ 2	1

Conclusions

The system of milk production practised in good grass growing areas must have as a primary objective high levels of grass utilisation. The

UME estimate for a farm gives a useful measure of the grass utilisation, and it relates closely to the profitability per hectare.

The amount of concentrates or other purchased foods used is a separate question and for a particular farm should be determined by the resources available to the farmer (land, labour and capital), because one of the most profitable aspects of any purchased feed is that it allows more cows to be kept on the farm. The full implication of this type of intensification must therefore be carefully considered.

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The Role of Embryo Transfer in Cattle Breeding

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While the cow normally produces an average of six calves per lifetime she has in fact an inherent potential to produce many more than this. The reproductive capacity of the cow is limited because normally only one egg is shed every cycle and if a pregnancy follows a successful breeding, gestation length is 280-290 days.

Embryo transfer is the term for a series of procedures that involve hormonally stimulating the cow to shed more than one egg at the end of each cycle and following breeding and fertilization in the normal way, these eggs are flushed from the uterus as one week old embryos and transferred into recipient cows that are at a similar stage of oestrous cycle. This allows an increase in the reproductive rate, firstly by increasing the ovulation rate in the donor cow and secondly in some situations by inducing a proportion of the recipient cows to carry twin calves. This procedure of course also allows the transfer of embryos from one breed to another or from pedigree or elite cows to commercial cows. Because the procedures used for flushing and collecting embryos from the donor cow's uterus are of a non-surgical nature, repeated treatments may be carried out on the same cows thus allowing for substantial increases in the number of calves produced per cow lifetime.

Current level of technology

1. **Production of embryos. Hormones,** Pregnant Mares Serum Gonadotrophin (PMSG) or Follicle Stimulating Hormone (FSH) are administered at mid-cycle to the donor cow followed 48 hours later by prostaglandin (PG). In 95% of cases the cow will stand in heat about 48 hours after the PG and will shed an average of 15 eggs. The main limitation to this part of the technology is the variation (0 - >20) in the number of eggs shed from individual donors. Because of this variation it is not possible to predict the response in the case of any individual cow.

2. **Collection of embryos.** The procedure is non-surgical and consists of introducing a flexible catheter into the uterus. Sterile physiological medium is flushed through and the flushings are examined under the microscope for the presence of embryos. About 60% of the shed eggs should be recovered.

3. **Storage of embryos.** Storage for periods of up to 24 hours is normally at 24-37°C. For periods exceeding this the embryos must be frozen and stored at −196°C (liquid nitrogen). At the present time storage in liquid nitrogen is quite successful but limited to embryos of specific age and developmental stage.

4. **Transfer of embryos.** Presently, there are two main transfer procedures, viz., Flank or Cervical. The flank transfer is carried out with minimal surgery under local anaesthesia with the recipient standing in a crush. It is a veterinary procedure and reserved for high priced donor cows. Non-surgical cervical transfers are similar to a normal A.I. and are used where the embryo cost is not high as in twinning.

Current overall success rates

On the basis of current technology the following data (Table 1) represents normal expectation in the case of fertile cyclic donor cows that have responded to superovulation and whose embryos have been flank transferred.

Table 1

Current success rates in cattle embryo transfer

Average no. of eggs collected per donor	10
Average no. of eggs fertilized per collection	7.5
Average no. of viable embryos per collection	6.0
Average no. of pregnancies per collection	4.0
No. of collections per donor per year	3
Range in pregnancies per collection	0-20

Role of embryo transfer

Perhaps the greatest role that the embryo transfer procedure has played to-date has been in a research context. This is true for all the farm species. Commercial application has so far been limited but the development of non-surgical procedures and the continued refinement of the procedures will no doubt see an expansion in it's use.

Both current and potential uses for embryo transfer are outlined in Table 2.

Table 2

Current and potential uses for embryo transfer in cattle

1. **Research Programmes :** Reproduction; Production; Breeding; Disease.
2. **Acceleration of Genetic Improvement :** Increasing the reproductive rate allows an increase in selection intensity.
3. **Breed Expansion :** Increasing the number of progeny from valuable animals.
4. **Increasing Litter Size :** Induction of twinning allows an increase in the biological efficiency of the cow.
5. **Import/Export of Cattle :** It is likely that there will be much international cattle movement in the future at the embryo stage.

Two of these uses are aimed at increasing production efficiency, viz., **acceleration of genetic improvement** and **increasing litter size** and these two are briefly discussed.

Acceleration of genetic improvement

Since the introduction of A.I., cattle breeders and in particular dairy cattle breeders, have realised that the use of progeny tested bulls will increase their production much faster than by using non-tested bulls. Because a bull in A.I. can breed large numbers of cows it means that only a small number of bulls are required thus allowing a high selection intensity.

On the female side, little selection is possible because,

a) each cow produces one calf per year,

b) half of all calves will be male, and

c) about 20% of the herd will need to be replaced in each year.

In the dairy herd where the emphasis for the most part is on milk yield, increasing the reproductive rate of the top 10% (based on yield) of the herd and breeding all replacements from these cows would give the maximum selection intensity possible through the use of embryo transfer. For a herd with an average yield of 1,000 gals, the top 10% would yield an average of about 1,400 gals. These cows with an average yield of 400 gals above the herd average would then be used as donor cows and embryos would be transferred from them to the rest of the herd. The expected increase in milk yield in the resulting female progeny can be calculated at 400 x 0.5 x 0.25 = 50 gals because such progeny will have received only half its genes (0.5) from the selected cow and because the heritability of milk yield is about 25% (0.25). This expected increase of 50 gals is measured against a zero rate of selection intensity. In the normal course of events, however, about two-thirds of the cows will be selected. If these top two-thirds produce on average 100 gals more than the herd average the expected increase in yield in their female progeny can be calculated at 100 x 0.5 x 0.25 = 12.5 gals. The net expected increase, therefore, from using embryo transfer on the top 10% of cows to produce all the replacements is 50−12.5 = 37.5 gals. In this calculation, it is assumed that the selection of the top 10% of cows is based on available milk records adjusted for calving date, cow age, lactation number and other production information. In addition, it must be remembered that nearly half of all the variation in milk yield is due to unknown factors as shown in Table 3.

While the foregoing considerations are based on cow selection, it must be remembered that most of the genetic improvements either on a national or individual basis arises from the use of proven sires. The top proven dairy bulls in Ireland have a potential to increase milk yields by about 100 gals per lactation.

Increasing litter size—Twinning

Output and profitability in a beef cow enterprise is dependent solely on the weight of calf weaned or produced per cow. Twin-calving cows

Table 3

Variation in milk yield

Due to :	% of variation in milk yield
Calving date	10
Cow age	18
Cow breed	6
Sire	2
Herd	19
Other factors	45

would be biologically more efficient than single calving cows and provided the management and other inputs were not much greater than that required for single calving cows, they would be economically more efficient.

The potential effect of twin-calving on calf output per cow is shown in Table 4.

Table 4

The potential effect of twinning on calf production (100 cow herd, with 20% heifer replacements)

Current weaning rate	—	0.88 calves/cow calving
50% twinning + 12% overall calf loss	—	1.23 calves/cow calving (+.35)
50% twinning + 6% single calf loss 12% twin calf loss	—	1.28 calves/cow calving (+.40)

The currently achievable twinning rate of 50% combined with current calf loss of about 12% would still yield an extra 35% in calf output. Any reduction in calf mortality would of course increase this. From recent farm trials carried out from Belclare, the effect of embryo transfer on calf production is shown in Table 5. The result was an increase in weaning rate of 35%. Data from these trials relating to single and twin births are shown in Table 6.

Table 5

Embryo transfer effect on calf crops

	A.I. only	A.I. + embryo transfer
Nofl of cows	104	125
Twin calving rate	0%	45%
No. of calves/cow calving	1.0	1.45
Calves weaned/cow calving	0.9	1.25

Table 6

Single and twin-calf production data

	Single births	Twin births
Mean birth wt. (kg)	45 ± 3.2	32 ± 4.2
Calf wt/cow (kg)	45	64
Calf mortality	4%	18%
After birth retention	2%	6%
Gestation (days)	288 ± 1.6	277 ± 0.9
Calves weaned/cow calving	0.9	1.63

While the twin calf mortality in this first farm trial was high, most of this mortality was due to an absence of supervision at calving time. Even with this high mortality, output was nevertheless significantly increased. It has been calculated that induced twinning could increase the revenue in a dairy herd by about 12% and in a beef suckler herd by 60%.

Embryo transfer has already been of enormous economic benefit in research programmes, though this is difficult to quantify. In terms of breed expansion it has already been applied successfully in a commercial context. It seems very likely that in the future the economies to be made from international transportation of cattle as embryos will dictate a widespread use of the technique in this context.

Dairy Bull Selection for A.I.

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The basis of cattle breeding programmes throughout the world is the identification of superior individuals and their widespread use within the cattle population. This is a two stage operation in which the superior individuals are first identified and are then used as seed stock for future generations. Diagram 1 outlines the steps which are common to breeding programmes world wide. The first decision which must be made is to identify which traits are considered of most importance. The more traits one attempts to improve simultaneously the slower the rate of progress will be with any individual one. There may also be negative correlations between a number of different objectives which make simultaneous improvement in both extremely difficult.

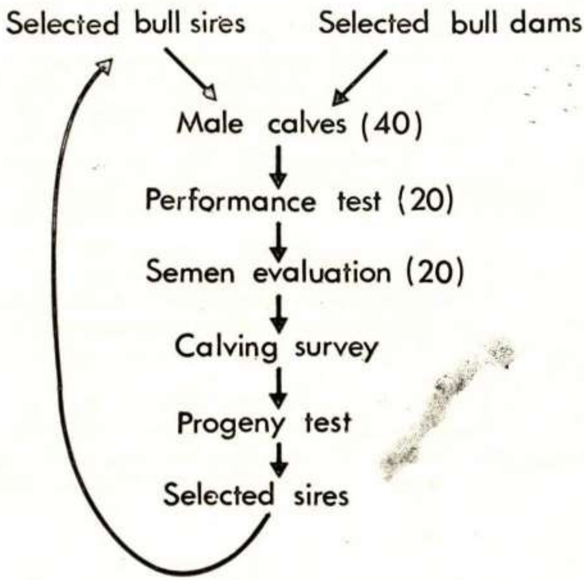

Diagram 1

Breeding objectives

Dairy cattle breeding in Ireland for the last number of years has mainly aimed at increasing the total fat and protein production of daughters of the bulls selected. This is an important point to bear in mind for instance, in relation to the recent report from An Foras Taluntais on the "Chemical Composition of Milk in Ireland". This report rightly points out that selection in the Irish breeding programme has been for total yield of fat rather than fat percentage but I think it has not been emphasised enough that this was a deliberate policy to breed, not for increased percentage of fat, but for total yield. As Table 1 shows, selection of bulls on the basis of fat and protein yield would only be expected to maintain present percentage levels of these constituents in the milk and this is in fact what

Table 1

Response to selection for a single trait

Trait	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 percentage	59	0.0	0.5	+.12	+.05
Protein percentage	−4.5	0.9	0.5	+.07	+.08

has happened, Within the group of bulls selected, the improvement in fat and protein yield may come from improvement in milk yield or in composition. There are many other important factors from the point of view of the commercial farmer and these relate to such things as udder quality, temperament and aspects of conformation which have economical importance. Table 2 shows the type of information which is made avail-

Table 2

Information normally given in relation to Friesian Sires

1. Name and code letters of bull.
2. Herd Book number.
3. Relative Breeding Index (R.B.I.). This is the estimated Breeding Value of the bull for yield of fat and protein as a percentage of a fixed base. This base is the average merit of Friesian bulls born in the mid-sixties with daughters in the herds used for Progeny Testing in the pre-1977 period. For example, a bull with an R.B.I. of 125 is estimated to be 25% better for fat and protein production than this base population.
4. Visual Assessment of Daughters. This is calculated in the same way as the R.B.I. and indicates the percentage by which the bull's daughters are superior for a particular trait such as height, udder conformation, etc., to the heifers in the base population.
5. Beef Merit. Bulls are ranked on both the growth rate and conformation of their progeny.
6. Calving Difficulty.

able to herdowners in relation to individual bulls and they can make a choice between different bulls of the same merit for fat and protein production but with different levels of merit for other traits.

Identification of superior dams

In the case of the selection of sires for future generations, however, most emphasis is placed on level of production, with all other factors being given a secondary importance. Our first problem arises in the accurate identification of superior dams for the production of young bulls. In Ireland a good identification programme of potential bull/dams has been virtually impossible to date for a number of reasons.

1. The small population of females in the country with a known pedigree.
2. The extremely low level of milk recording in herds with these females.
3. The absence of a milk recording programme which will permit the objective identification of cows with superior levels of production.
4. The tendency for pedigree breeders to concentrate on traits other than production in their breeding programmes.

It has been possible through the co-operation of the British Milk Marketing Board for a certain number of potential bull/dams to be identified in the U.K. and a limited contract mating programme has been operated by a number of the A.I. societies using this facility. To a very large extent, however, bull purchases by Irish A.I. centres have up to now been based on the information available on the sires and dams as they appear in sales catalogues or through individual contact with breeders rather than on a planned basis by the identification and contract mating of superior females. In practise, bulls entering the A.I. programme, particularly over the last few years are almost invariably from the very best sires available but the merit of the dams is less accurately quantified. The assessment of an individual breeder of the relative merits of his cows is not always an accurate guide to the identification of superior females. An objective measure of the animals' potential is essential. This is a weakness in the present programme of which all the A.I. centres are conscious and is one which we hope will be gradually overcome. In this context it is interesting to note that the bull which has come out in the test of young bulls for 1981 with the highest rating is a bull called "Ty-Deri Bird Griff" which was purchased in exactly this way by the identification of his dam through the British Milk Marketing Board records and his subsequent purchase directly off farm.

Performance tests

The next point in the process of dairy bull selection is the purchase of the bull calves resulting from the contract matings of top sires and top dams. A problem arises with regard to the number of these calves which are available because of the difficulty already mentioned in identifying suitable dams. In spite of this it has been the practise for the last few years in the Munster Group of A.I. centres to purchase approximately 20 calves each year for performance test at our unit in Bandon. The present intention is that a performance centre for 50-60 bulls is to be constructed this year for the use of the Munster centres and a similar unit will be built for the use of the centres in the northern half of the country.

Because of the difficulties in procuring adequate numbers of calves from this contract mating source, other bulls have been purchased at a later date to enter the third phase of the selection programme, namely, progeny testing.

Progeny tests

The total number of bulls which enter the progeny testing programme is another matter which has occasioned considerable discussion over the last few years. Ideally the larger the number that can be accommodated for progeny testing the better, since it will allow a greater selection differential in choosing the final sires to enter the proven stud. In practise, however, there are a number of factors which would restrict the number of bulls which can be accommodated. Firstly, there is the fact that from a purely economic point of view the law of diminishing returns puts an upper limit on the number of bulls which should be tested. The number of Friesian bulls entering the test programme each year is approximately 40. While there are difficulties of opinion regarding the optimum number to put under test there is general agreement that this number should be doubled, in order to make the Irish programme comparable with that in other major dairying countries and to allow for a selection ratio of 1 : 8 to 1 : 10. The reasons why this has not happened are largely as follows :

1. As already mentioned the difficulty in identifying suitable bull/dams limits to some extent the number of young bulls which become available for progeny testing. This, however, is not a major restriction and could be overcome if it were not for other constraints in the system.

2. There is reluctance on the part of herdowners, particularly herdowners who are interested in breeding and milk recording, to use the young bulls under test. This is in spite of incentive programmes of various types operated by the different centres. In this context it is important to note that most European countries have not only incentives for the use of young bulls but severe penalties for people who do not use young bulls and participate fully in the progeny testing programmes. This has not been adequately emphasised and it is essential that, if progeny testing is to be expanded, farmers must be prepared to play a more active role than in the past in assisting with the testing of young bulls.

3. The level of milk recording in this country is still at an abysmal level. Undoubtedly there are very strong arguments that other management practices can be much more important in raising the level of productivity on most farms, but the value of milk recording both to the individual herdowner and to the national breeding programme has not been adequately emphasised. It is simply not possible to test the optimum number of young bulls at the present level of milk recording in this country.

Use of selected sires

The next stage is the selection of a certain number of bulls from those under test to be used more widely in the proven stud. Here again there has been considerable discussion on the selection ratio which should apply. The basic criticism of the Irish programme at this level is that the number of bulls tested per year is too low, and consequently the selection ratio is not sufficiently intense (Table 3). On the other hand, a particularly strong point in the Irish A.I. service is the relatively high usage of proven bulls in the stud. This is running at an average of 50,000 inseminations per bull over the last few years but is gradually increasing and is considerably higher for the top sires. Prof. E. P. Cunningham, Agricultural Institute, Dublin, has shown that irrespective of the testing programmes the two most important factors determining the rate of genetic improvement are the selection ratio and the intensity of usage of the selected sires.

Table 3

Comparative data on dairy bull selection

	Ireland	U.K.	Denmark	Holland	N. Zealand
Total dairy cows ('000)	1600	3100	1000	2400	2000
Percentage milk recorded	4%	40%	70%	70%	35%
Percentage bred to A.I.	60%	65%	90%	80%	50%
No. of bulls tested/year	40	150	280	440	160
Selection ratio	1:4	1:7	1:7	1:7	1:7

Having examined the programme and pointed out the deficiencies in it, it is important to note that the genetic potential of black and white cattle in this country is not a limiting factor at present in level of production. The lack of individual milk recording within individual herds does mean that inferior cows are not being identified and are not being removed or avoided in the breeding of replacement heifers. The population as a whole, however, is genetically very similar to the British population.

There have been a number of comparative trials devoted to the relative genetic merit of different strains of Friesian cattle. The most comprehensive trial of this type is presently in progress in Poland. The experiment began in 1974 and will continue until 1984. Semen from Friesian strains in ten different countries was imported to Poland and used on Polish

Friesian cows. Thirty young A.I. bulls of each strain were used. Results on about 3,000 first generation heifers, milked through first lactation, and on about 6,000 first generation bulls reared to slaughter are available.

Dairy results

Average milk production of the 3,000 heifers completing first lactations was 3,762 kg at 4.06% fat, producing 153 kg of fat. The relative performance of the different strains is shown in Table 4. The results show that the American, Israeli and New Zealand strains are clearly superior to all others in terms of butter fat, with the American and Israeli strains achieving this on yield and the New Zealand strain on a combination of yield and high test.

Table 4

Friesian heifer comparisons

Country Strain	Milk Yield (relative)	Fat Yield (relative)	Fat % (relative)
U.S.A.	109	105	98
Poland	89	90	101
Canada	104	103	99
Denmark	96	97	101
Britain	100	100	100
Sweden	101	101	100
Germany	96	96	100
Holland	96	97	101
Israel	106	105	99
New Zealand	104	106	102
Mean (Actual)	3764 kg	153 kg	4.06%

The introduction of superior sires from these outside populations can thus be expected to produce an additional improvement over and above the progress being made through the normal breed improvement programme. There will also be some extra benefit associated with heterosis or hybrid vigour. This benefit will arise mainly in the first cross and will be reduced in future generations.

The rate of progress which has been made in improving the quality of the bulls available through Irish A.I. centres over the last few years is high, bearing in mind the deficiencies pointed out in the breeding programme. Table 5, which is taken from The Agricultural Institute's Report on the "Chemical Composition of Milk", shows the progress that has been made over the last few years. The information from the progeny testing programme on bulls imported from the U.K., together with the information on comparative trials carried out with New Zealand and Canadian semen would also indicate that the genetic merit of the bulls available in this country is as good as those available in the U.K.

Table 5

Daughter production of bulls approved for use in A.I.

	Milk (kg)	Fat (kg)	Protein (kg)	Fat %	Protein %
1975	2974	110	96.1	3.7	3.23
1976	2978	112.6	98.9	3.78	3.32
1977	3048	116.1	100	3.81	3.28
1978	3292	123.8	107.3	3.76	3.26
1979	3145	119.2	103.2	3.77	3.28
1980	3248	122.1	109.1	3.76	3.36

Any programme can be improved and there is certainly room for improvement in the Irish programme. Progress has been made, particularly in the last ten years. But in order to continue this progress in the future, those deficiencies in the programme which have been identified should be eliminated as soon as possible.

It is important to record that the biggest single step which could be made at present in improving the genetic merit of Irish cattle would be to increase the usage of A.I. from its present level to the level applying in the Netherlands or Scandinavian countries.

Establishing Net Income From Farming Systems

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What is net income ?

The simplest definition of net income is the sum available to provide for taxation, living expenses, capital repayments, investments, developments in that order. It is the single most important efficiency factor on the farm as it gives the complete picture. Other factors such as "gross margin", "margin over feed and fertilisers" are incomplete and can give a false impression of overall efficiency. Personally I have abandoned assessment and preparation of budgets using the gross margin or any other incomplete factor in favour of net margin calculations.

To explain this point, Table 1 shows the 1981 gross margin and net margin figures for 2 similar farming situations based on a 150 acre dairy

Table 1

Farm 150 acres—125 cows and followers

	(A) Owning machinery Hiring labour	(B) Hiring contractors Hiring labour
Gross Output		
Milk	59829	59829
Calves	6635	6635
Cull cows/bull	9059	9059
	75523	75523
Variable Costs		
V.C. other than Contractors charges	33777	33777
Contractors	—	5250
	33777	39027
Gross Margin	41746	36496
Fixed Costs		
F.C. other than Labour and Machinery	13313	13313
Hired Labour	7475	6540
Machinery and vehicle costs (incl. depr.)	10036	5333
	30824	25186
Net Income	10922	11310
GROSS MARGIN/ACRE	278	243
NET INCOME/ACRE	73	75

farm, 125 cows and 25 replacement units. In one case (A) the farmer owned the machinery to do the entire operation. In the second case (B) the farming situation was exactly similar except that the farmer hired machinery to make silage and spread slurry. While the gross margin per acre in Case (A) was £35 greater than in Case (B) the net margin per acre in case (B) was £2 per acre greater than Case (A) i.e. a difference equivalent to 50% of the net profit.

Relationship between output and net profit

There is not a direct relationship between gross output and net income. There are many dairy farms where fewer cows would give a greater net income. This is not to be interpreted as a case for reducing output. This situation can also be true for other farm enterprises. Many tillage farmers that make good money on a relatively small area can be very disappointed with profits when they expand into bigger areas.

It is not within the scope of this paper to explain how this happens. However, what is important to understand is that if farm profit is not satisfactory it does not follow automatically that more production units such as extra cows or acres of tillage is the solution.

Enterprise net incomes in 1981

The Consultants Association carried out a detailed review of the net incomes in 1981 from efficiently managed medium and large scale farms. To eliminate the effect of borrowing for fixed investments it was assumed that the farmer had no borrowings on land or buildings. Two separate situations were then examined for each enterprise (a) where livestock were financed by borrowing, (b) where livestock were not financed by borrowing. In each of these situations all interest on working capital was borrowed as this was believed to be the most efficient way to do business in the total agricultural context. The results of this review are presented in Table 2. The features worth reflecting on are as follows:

1. The low net income from all enterprises while the gross margins appear satisfactory.
2. In livestock systems the cost of financing the stock is large and except in cases where extremely high levels of performance can be assured (such as 1000 gallons per cow) it is difficult to justify borrowing money at present interest rates and repayment periods for the purpose of expanding livestock numbers.
3. When comparing dairying or breeding livestock systems with tillage systems it is not always advisable to directly compare the systems after charging the cost of financing the breeding livestock. In an inflationary situation the breeding stock will increase in value by approximately the level of interest on borrowed capital. While this "Profit" will never be reflected as cash in the bank until the day one goes out of business, it is nevertheless a real profit which does not apply in the non-livestock systems.

Table 2

Review of net incomes in 1981

Enterprise	Gross margin	Net margin	Cost of financing livestock	Net margin less cost of financing livestock	Key co-efficients
Creamery milk	£/acre 245	£/acre 86	£/acre 63	£/acre 23	850 gal/cow 1 L.U./acre 14 cwt. meals/cow Labour : Farmer plus hired
Liquid milk	274	100	69	31	900 gal/cow 1 L.U./acre 19 cwt. meals/cow Labour : Farmer plus hired
Pig breeding	210/sow	79/sow	21/sow	58/sow	18.5 bonhams sold/sow 1.1 tons feed/sow Labour : All hired
Sugar (1) excl. tops Beet (2) incl. tops	144 194	87 137		87 137	Yield 17 tons washed beet/acre
Calf to 2 year old beef	194	56	56	0	Sales : 1 animal at 11.25 cwt. Stocking rate : 1 L.U./acre Calf price : £124 Beef price : £52.5/cwt.
Cereals	136	75		75	Average : 2.7 tons/acre yield (all crops)

4. In calf to beef systems the interest on stock and working capital amounts to £120 per acre. This totally erodes what otherwise is a reasonable net income. This system is therefore only suitable for situations where finance does not have to be borrowed or where there is income from another source to provide living expenses and working capital.

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Table 3

Net income from creamery milk production

Sales	(£)	(£)
99450 gallons milk @ 60.16p/gallon	59,829	
87 calves @ £76.26	6,635	
25 cull cows @ £334.34	8,359	
1 bull	700	
		75,523
Expenses		
Variable :		
Livestock—Breeding bull	1,000	
Fertilisers	8,554	
Concentrate feed	16,152	
Vet, Medicine and A.I.	2,597	
Machinery hire	5,250	
Transport	100	
Silage additive and Polythene	1,394	
Bedding	300	
Deductions : Bord Bainne, Co-Responsibility, Institute, Disease eradication, Dairy inspection, IFA/ICMSA levy, Bulk tank hire, Cartage, Milk recording service	3,680	39,027
Fixed :		
Lime	465	
Pasture renewal	1,350	
Wages and Social Welfare	6,540	
Machinery running costs	2,400	
Rent and Rates	1,650	
Car, Telephone and E.S.B. (Share)	2,565	
Farm Insurance	300	
General maintenance and repairs	1,050	
Mortality (replacement)	720	
Interest on Working Capital	3,468	
Machinery and car depreciation	2,933	
Accounting services	450	
Miscellaneous	1,295	
		25,186
NET FARM INCOME		11,310
NET FARM INCOME PER ACRE		75

Preparation of net income budgets

To demonstrate the detail required in the preparation of a net income budget I propose to use the detoils in the example already used.

In Table 3 a sales and expenses statement for 1981 is presented. The herd average was 850 gallons per cow and meal feeding was 14 cwt/cow. Taking the conditions in 1981 into account this was good performance. With Table 3 I will try to explain why farmers seldom make as much money as they are supposed to. I will deal briefly with the items that are generally incorrectly treated in the preparation of projections and budgets.

1. **Milk sales**—To calculate the true figure the milk yield per cow should be multiplied by the average number of cows in the herd rather than the herd size. In practice the average number of cows in a herd is seldom greater than 93% of the herd size. This is because of in-calf heifers entering the herd in March/April and also cull cows being sold off towards the year end.
2. **Milk price**—This must be related to actual prices being obtained, not the Creamery quoted price for Grade I milk at 3.60% B.F. In practice farmers seldom average the standard butter fat test and seldom avoid quality penalties of some description. In the Consultants Assocation study the average gross price was 60.16p per gallon. The average basic price of milk at the Creameries concerned was 61.54, i.e. a difference of 1.38p
3. **Calf prices**—The number of calves that survive birth and at least one month of life is the relevant number. Allowance must be made for abortions, still births and calves that die within one month. In the Consultants study only 90% of cows and heifers ended up with live calves. Furthermore the value of all calves must be taken into account, ranging from the Aberdeen Angus heifer out of an incalf heifer to the good bull calves from the biggest cows.
4. **Cull cow prices**—The value of any in-calf heifer that has a difficult calving and is sent to the factory as a casualty must be taken into account. So also must the 10 year old cow with a poor kill-out percentage. It is not realistic to base prices always on good quality animals.
5. **Silage additive and polythene**—These are seldom reckoned in projections and they amount to almost £10 per acre.
6. **Deductions**—The list of levies etc. is large. Individually, they may appear insignificant but collectively they amount to almost £25 per acre.
7. **Pasture Renewal**—It is generally believed that reseeding is unnecessary. However, in practice most intensive dairy farmers reseed their grasslands at some stage and this is an expensive exercise where tillage equipment is now owned.
8. **Wages and Social Welfare**—The employers' share of Social Welfare contributions is often omitted. This amounts to 10.25% of the gross wage.
9. **Machinery, equipment and car depreciation** — Often omitted and

almost invariably underestimated. It is advisable to make a replacement provision each year when budgeting.

10. **Car, Telephone and E.S.B.** — Never omitted but invariably underestimated. The E.S.B. cost of milking a cow and refrigerating the milk is approximately £8 per cow per annum.
11. **Mortality (replacement)**—In a herd of 125 cows with 25 replacement units a farmer would be fortunate to lose only 1 cow and 1 weanling in a year. At to-day's prices this amounts to almost £6 per acre.
12. **Interest on working capital**—This is probably the most controversial item of all. It can only be accurately established by preparing a detailed cast flow statement. The reasons why it is underestimated are :

(a) Inputs are often not purchased at their most competitive price, e.g. concentrates and fertilisers are generally purchased as required without questioning the cost. The correct procedure is to negotiate the working capital requirement with the Bank or A.C.C. and armed with cheque book negotiate at the start of the season for the major inputs. In this way the overall cost will be minimised.
(b) Milk sales are not reflected as money in the bank for a considerable time after the milk is produced. At the extreme, the value of milk sold on January 1st will not be credited to the bank account until March 1st.
(c) Living expenses must be included in the cash flow unless the farmer has another source of income from which he can live. Similarly other outgoings such as loan repayments and investments must be included in the cash flow as they occur.
(d) Interest is charged to overdrafts in March and September. Unless the account comes into credit after the March charge there will be an element of compound interest.

A budget that miscalculates totally on all the above items would err by about £17,000 in the case of the farm referred to. In other words it would be wrong to the tune of 150%.

A Source and Application of Funds statement for this dairy farm is presented in Table 4. Using the Net Income statement and this Source

Table 4
Source and application of funds

Source	(£)	(£)
Net Income before depreciation	14,243	
Loan	5,000	
		19,243
Application		
Family Living Expenses	9,600	
Repayments—(Capital only)	1,528	
Machinery/Vehicle replacement	7,933	
Income Tax	1,000	
Interest accrued/not charged	(270)	
Deficit forward	(548)	
		19,243

and Application of Funds a monthly cash flow statement is drawn up, to show the working capital requirement and the cost for the year.

In Table 5 the Net Income from an area of 150 acres of sugar beet yielding 17 tons washed beet per acre is presented. As in the case of dairying the list of costs is much more comprehensive than one normally sees in a standard type budget. If the beet tops are fully utilised they could add £50 per acre to the profit.

Table 5

Net income from 150 acres of sugar beet in 1981

Sales	(£)	(£)
17 tonnes (15.6% sugar) @ £28.60 per tonne net	486.20	72,930
Expenses		
Scutch control	5.00	750
Ploughing	12.00	1,800
Lime	3.70	555
Fertiliser	84.60	12,690
Fertiliser spreading	6.00	900
Cultivation	20.00	3,000
Seed	10.00	1,500
Drilling and Sowing	15.00	2,250
Sprays	61.00	9,150
Spraying	7.00	1,050
Steerage Hoeing and Band Spraying	10.00	1,500
Insecticide	7.00	1,050
Transport	33.80	5,070
Machinery running costs	2.00	300
Interest on Working Capital	20.00	3,000
Farm Insurance	0.50	75
Harvesting	58.00	8,700
Car, Telephone and E.S.B. (share) excl. depr.	5.00	750
Rent and Rates	11.00	1,650
Miscellaneous (incl. general maintenance and repairs)	5.00	750
Accounting Services	2.00	300
Depreciation of machinery and motor vehicles	13.93	2,090
Casual labour	6.67	1,000
		59,880
NET CASH INCOME		13,050
NET CASH INCOME PER ACRE		87

Importance of efficiency

Efficiency is determined by output and cost of producing that output. Referring back to Table 2 it is obvious that performance levels which would be considered satisfactory by most standards are not good enough to yield satisfactory incomes. While not suggesting that farmers are not within their rights to demand more for their produce there is still need for improved efficiency at farm level. It is unlikely that pressure will bring about price rises that will give an adequate income at milk yields of 750 gallons per cow or cattle weights of 8 cwt at 2 years of age.

Summary

Net income is the only really reliable figure for assessing performance and for budgeting. Income projections and budgets are generally haphazardly prepared and overstate output, while understating expenses. This results in overborrowing and unwise investments. It is no longer always correct to say that what farmers need is one more cow, one more sow and one more acre under the plough. Before an extra cow is added to a herd the farmer must be sure that the net income earned by every cow already in the herd is satisfactory.

Financial Trends in British Dairying

S. CHURMS

Regional Consultant, Farm Management Services, Milk Marketing Board of England and Wales.

The word 'inflation' will occur repeatedly during the course of this paper. It is inevitabe that it will continue to influence agriculture both sides of the Irish Channel and we ignore it at our peril.

This paper is conveniently divided into three parts:

(a) Financial Trends in recent years
(b) Current Trends
(c) Services which Farm Management Services offer to dairy farmers to help them with financial problems.

Most of the information for farm profits comes from the MMB Information Unit. I would stress that these figures are not completely representative of the dairy industry for various reasons. However, the trends undoubtedly are similar and no assumptions have been made, whereas many 'official' statistics are years old and contain blatant assumptions.

Financial trends in recent years

Profit is only one aspect of the story. From profits we must pay for:

Private drawings
Income tax
Increase valuation (stock and stores)
Repayment of loans

Before examining the variation in profits, let us first consider what happened when the farmer paid for all his commitments.

In relation to profit over the period 1979-1981 there were very high levels of capital expenditure. In addition, personal drawings kept pace with inflation. Farmers already had loans to repay, so with high capital expenditure, increased private expenditure and loan repayments to meet, additional increase in borrowing was inevitable. In 1980 because there was very little inflation in stock values and none in land there was a decline in the net worth of some dairy farmers. In 1981 there was a recovery from that position albeit modest. There has been an increase in farmers' net worth but borrowing is still increasing, at a slower rate.

For 1982 estimates would suggest profit levels at or below 1981 levels. There are definite signs now however that investment has dropped, and while borrowing will increase yet again it has slowed down. Substantial increases in livestock values in recent months should mean an increase in net worth for 1982.

Why have profits declined?

Increases in milk price over 4 years have been between 5 and 10 per cent. All the signs are that 5-7 per cent is as much as can be expected in the foreseeable future. Calf prices have varied widely but recently there has been a good recovery. Cow prices have increased steadily except in 1980/81.

About 5m tonnes concentrates are used in England and Wales per year. Increases, except for 1979/80, have been very low. Had these kept up with inflation in other materials and had there been no change in milk prices considerable losses would have occurred.

Fixed costs, excluding interest charges between 1978 and 1981, increased at 16 - 25 per cent per year. Interest charges were a unique problem. A combination of soaring levels of borrowing and staggering increases in interest rates meant a 63 per cent increase in interest costs in 1979/80. However, with outputs inflating at under 10 per cent while most other costs inflated at 20 per cent for 3 years in a row, it is quite obvious that if there had been no technical improvements profit levels would have been far worse than actually occurred.

Table 1

Trend of technical performance of F.M.S. costed herds 1976-1981

	Milk yield per cow (1)	Concentrate use per cow (kg)	Fertiliser use Kg/Ha	Stocking rate cows/ha	Rate of cow nos. increase
1976	4692	1719	206	1.83	100
1977	4750	1868	180	1.92	104
1978	5155	1798	207	1.93	110
1979	5195	1872	214	1.95	114
1980	5243	1883	235	1.92	117
1981	5301	1783	243	1.95	120

The reason for any profit being achieved is because several technical improvements have taken place. As shown in Table 1, these are :

(a) Cow numbers have increased steadily

(b) Milk yield has also improved, from 1-7%

(c) Contrary to what some grass enthusiasts would like us to believe concentrate usage per litre has been steady. The only exceptions were the unprecedented drought years of 1975/76, 1976/77.

Current trends 1981/82

Inflation of most costs has steadied down. Bank overdrafts are now increasing less slowly. Had it not been for severe climatic factors a further improvement in profits would have been likely. Calves and cow prices have made a significant improvement.

Weather conditions in 1981 were exceptionally poor. The net result was ruined pastures and the worst silage for a very long time. The effects on yield per cow, concentrate usage and margin per cow were significant.

By next year there should be a recovery in production unless weather continues to be a major problem. Calf and cow prices are always erratic but there is nothing to suggest any major set backs. Inflation of most costs appears to be stabilising. If all this occurs then I think a modest recovery could be made. I do not think this is being too cautious. There is no way any major recovery to the position of repaying this amount of borrowed money can occur as long as milk price consistently increases much less than costs.

Current profit levels are hardly sufficient to maintain a stable dairy industry. On current trends investment and development is going to be minimal in the foreseeable future.

Approach within Farm Management Services

In order to undertake financial analyses on our clients' farms, detailed information about these farms is necessary for meaningful conclusions. Farm Management Services provide a full farm management costing service for 1100-1200 farmers. The management accounts provide —

a) Trading Account—how much profit ?
b) Annual Cash Flow—how much money was spent ?
c) Balance Sheet—levels of borrowing
d) Gross Margins—individual enterprise analysis.

Most of the farms are mixed farms. A high proportion will have cereals and some farms are very large on which cereals are by far the biggest enterprise. Our farm management accounts are specifically designed as a basis for forward budgeting on the individual farm. Determination of how much profit was made is only one aspect. The really important questions are :

What profit will be made next year
What are the commitments ?
Can these commitments be afforded ?

In effect we build up a forecast set of accounts using our best estimate of changes in costs that are going to occur. Until inflation accelerated in the late 1960's, past performance was a guide to likely future profits. When inflation of some commodities varies from 5 per cent to 30 per cent in two years, past experience is a poor guide for the future. Because of this, detailed forward budgets are becoming essential. Banks are now refusing to increase overdrafts unless these budgets are available to support a farmer's plan.

Where it is quite obvious that there is no margin for error these budgets are monitored monthly by our farm management consultants. This is usually done by preparing a monthly cash flow and at the end of the month adding up all expenses and receipts. If large discrepancies are occurring these are picked up sooner rather than later. If any prices change unexpectedly, adjustments are made to see whether the charges will cause major problems. Frequently the only alternative is to ring the bank manager and ask for his help. But the difference is WE ring him. We also explain why the problem has occurred and our proposals to overcome it.

Farmers are required to pay fees for our services. The cost of preparing management accounts is in the region of £400. A management consultant's time also has to be paid for. The accounting system is now fully computerised, and we are increasingly liaising with accountants to increase the overall value of the service.

Summary

1. Profits in British dairying have been in decline since the mid 1970's. There has been a modest improvement in 1981.
2. The main reason for the decline has been the very high level of cost inflation which has consistently been 5-10 per cent or more above the rate of income inflation for several years.
3. Climatic effects can have a severe effect at certain times—early spring being the most vulnerable.
4. Farm Management Services prepares full farm management accounts for 1200 clients. These are used to analyse the business and prepare a forward budget for the client.

NINTH EDWARD RICHARDS-ORPEN MEMORIAL LECTURE

The Potential for Production and Marketing of Irish Bull Beef

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At the outset we wish to thank the trustees of the Edward Richards-Orpen Memorial Trust for their invitation to present the Ninth Memorial Lecture.

This lecture differs to previous Orpen Memorial Lectures in at least two respects. Firstly, the authorship is shared between three people and each of us shall deliver our own specialised section of the lecture. Secondly, this lecture is not a comprehensive summary of experiments conducted over many years by the authors. Instead, it is a description of a production system which is as yet practiced by very few farmers in this country; it is an assessment of the place for such a system on Irish farms and an analyss of the market prospects for the output from the system.

The fact that the system in question is new to this country and is as yet practiced by only a small number of present day pioneer farmers makes it a suitable subject for a memorial lecture to a man who was himself a great pioneer farmer.

I. PRODUCTION SYSTEM

Practically all Irish beef is produced from grass and all production systems practiced in the country rely heavily on grazing as a feed source. An inadequate supply of low quality hay and more recently very moderate quality silage are features of traditional systems.

Many experiments at Grange and elsewhere have indicated that silage can be produced which will support production of cattle very close to that expected on grazed grass. A Grange experiment has shown that properly made, well preserved silage has feed value identical to the feed value of the grass from which it is made (Table 1). Numerous Grange experiments have shown that the major factor affecting the feed value of silage is its DMD. The relationships between DMD and production parameters for 450 kg cattle may be described as follows :

Liveweight gain (g/day) = 34.6 DMD - 1763
Carcase gain (g/day) = 23.8 DMD - 1275
Dry matter intake (% mean liveweight/day) = 0.019 DMD + 0.578

Table 1

Comparison of silage and grass as feed for beef cattle

	Grass	Silage
DM%	22.9	23.3
DMD%	71	71
Carcase gain kg/day	.42	.43 ± 29.8
Daily DM intake % L.wt.	1.98	1.87 ± .03

Silage NH_3-N = 6% TN

The effect of these relationships on the performance of 450 kg cattle fed silage having 20% dry matter and 3.9 pH is illustrated in Table 2. Clearly, high production can be expected from silage of high DMD and increasing DMD has only a minor effect on silage intake so that increasing DMD and increasing animal productivity has a major positive influence on the efficiency with which silage DM is converted to product. Any difference in production between silage of 75% DMD and production from grazed grass can be explained by difference in DMD. In farm practice, silage quality can be greatly improved and may be optimised by harvesting grass after six weeks growth intervals. The correct standard practice on many good farms in Ireland involves harvesting after 8-9 weeks growth. Results (Table 3) show a clear superiority for 6 weeks silage over 9 weeks silage in terms of carcase gain, even when silages are supplemented with 3 kg barley per animal daily.

Table 2

Silage DMD and beef production

DMD%	60	65	70	75
Carcase gain (kg/day)	0.15	0.27	0.39	0.51
LWG (kg/day)	0.27	0.45	0.64	0.82
DMI % L.wt.	1.66	1.75	1.85	1.94
Kg carcase/tonne Silage DM intake	22	36	47	57

Two year old system

With sufficient high quality silage, it is possible to maintain cattle growth at the same rate in winter as in the previous summer with moderate concentrate feed inputs. This is the basis for a 2-year-old beef

Table 3

Comparisons between six week and nine week silage cuts

	Carcase gain (kg/day)	
	6 weeks	9 weeks
	75%	70%
No barley	.57	.45
3 kg barley/day	.65	.58

system, the weight for age targets for which are set out in Table 4. These targets relate particularly to typical Irish spring born Friesian steers. Note that the average life time productivity for this system is only 0.73 kg liveweight gain per day. While this level of productivity is high by comparison with the average productivity of Irish cattle (about 0.5 kg gain per day) we must recognise that it is very modest by comparison with the current standard of 1 kg gain per day for male cattle born into the dairy herds of Europe. For example, all beef cattle produced in Holland, Denmark, Norway, Sweden and Finland are derived from dairy herds and are fed to grow at 1 kg/day over their lifetime. While maize silage is the major forage for this kind of beef production in Holland, France and Germany, it was not always so. Scandinavian countries cannot grow maize any more than we can and must operate the production system on a base of high quality grass silage supplemented with 2 kg concentrate per animal per day. Their standard lifetime gain is 1 kg/day.

Examination of the daily gain targets for the 2-year-old system (Table 4) shows that it is in the first year of the animal's life where the greatest opportunity exists to raise growth rate with a view to improving lifetime growth from 0.7 kg/day towards 1.0 kg/day.

Table 4

Target weights for beef at 2 years of age

90 kg	at	3 months	0.5 kg/day
200 kg	at	8 months	.65 ,,
285 kg	at	13 months	.55 ,,
455 kg	at	20 months	.85 ,,
575 kg	at	24 months	1.0 ,,

Lifetime gain = 0.75 kg/day; 300 kg carcase

We must recognise however that there is a limit to the production which may be readily achieved on a diet of grazed grass or high quality grass silage alone. For animals up to 9 months of age this limit is less than 1 kg liveweight gain/day. Accordingly, in order to increase animal performance during the first 12 months grass and grass silage must be supplemented with concentrate feed. Experience and practice abroad and here have shown that calves can grow at an average of 1 kg per day from 110 kg liveweight at 3 months of age to 380-390 kg at 12 months on a diet of high quality grass silage supplemented with 2 kg of concentrate feed per day. When animals are grown through the first year of life at a rate of 1 kg per day they must be continued at that rate to finish for biological and economic reasons. When this is practised Friesian males will reach finish conditions at 530 kg liveweight at about 16 months of age.

16 month system

With this knowledge, it was decided in 1979 to establish an intensive 16 month calf to beef system at Grange based on silage. At that time at least one member of this Association had already developed his calf-to-beef system to this level. Since then several other farmers have adopted the system.

Our feeding system is similar to the normal practice in Europe and the standards for the system are set out in Table 5. Bulls have a biological advantage over steers and the efficiency with which they convert feed to lean meat has been well demonstrated at Grange. This system, rather than the two-year-old system, is the appropriate kind of system within which to commercially exploit the biological advantage

Table 5

Standards 16 month beef

Months	Concentrate (kg/day)	Live gain (kg/day)	Weight (kg)
0 - 2	0.5	.65	80
12	2.0	1.0	390
12 - 13	2.0	1.1	430
13 - 16	4.0	1.1	530

High quality silage *ad lib* 265 kg carcase

Total feed : 1100 kg concentrate + 1850 kg silage

of the bull. In this context, however, it should be noted that the optimum combination of growth promoter treatment currently available for use in steer beef production can be expected to raise the productivity and efficiency of steers very close to the productivity and efficiency of bulls. The average of batches of animals in the 16 month system at Grange is given in Table 6. Levels of production are consistent with the targets for the system.

Table 6

Performance of animals on 16 month beef system at Grange

	Batch No.			
	1	2	3	4
Initial livewt. kg	297	103	124	126
Final livewt. kg	547	523	505	441*
Daily gain (kg/day)	1.13	0.99	0.93	0.99
Carcase wt. (kg)	286	282	275	

*Recent batch not yet finished

In these trials there has been no culling of animals and no selection for attributes such as colour marking or conformation at any time between purchase of the calf and slaughter. In commercial practice it is reasonable to exercise a certain degree of selection for conformation at purchase, and then at about 200 kg liveweight, to cull if necessary any animal with particularly poor performance. Considering the desirability to exercise some selection of animals for this system the standards set out here for animal performance and the standards achieved at Grange should be readily achievable in farm practice. Indeed they are being achieved by the small number of farmers practising the system already.

Type of farm

The place for this kind of intensive beef production system in Ireland is limited to those farms on which the necessary management decisions are taken to ensure that silage quality is excellent, i.e. dry matter DMD between 70 and 75%. There are too few farms in this category at the present time. However, there are a number of farms on which the targets for a two-year-old system are being achieved and surpassed and on which silage quality is of the standard required for a more intensive system. There are also a number of well organised grass farmers practising traditional systems of winter beef production on which silage and management standards are adequate to meet the requirements for this more intensive calf-to-beef system. An intensive 16 month calf-to-beef system is appropriate to such farms, provided that the farmers concerned have the necessary expertise in calf rearing and provided that the budget and projected income from the system are acceptable and competitive with their current beef system.

Feed budgets

A budget for a 16 month Friesian beef system, producing young bulls at about 16 months of age is set out in Table 7 together with an equivalent budget for a 2-year-old system. Total feed feed costs and non-feed costs vary considerably from farm to farm and calf prices and expected beef prices are figures that people will always debate. However, the figures in Table 7 provide a reasonable basis on which to compare the two systems and assess the potential commercial place for more intensive production systems in Ireland. There is a clear advantage of a 16 month old system in terms of margin over feed cost. This advantage is sufficiently large to ensure that when reasonable non-feed costs are deducted, there will be a decided profit advantage in favour of the more intensive system.

Table 7

Cost and income budget for 2-year-old and 16 month dairy beef systems

Sale price £/kg carcase	£1.85		£1.95	
	2-year-old	16 months	2-year-old	16 months
Carcase wt. kg	300	285	300	285
Per animal				
Sale of carcase	555	527	585	555
Less calf	100	100	100	100
GROSS OUTPUT	455	455	455	455
Less feed cost	224	267	224	267
Margin over feed	231	160	261	188
Per acre grass				
Margin over feed	231	320	261	376
Less non feed costs	120	160	120	160
RETURN TO LAND & LABOUR	111	160	141	216

Breed type

In this paper so far, only Friesian bulls have been considered for a 16-month system. But it should be fully understood that Friesian X Hereford cattle or Friesian X French Beef Breed cattle will perform at least as well and very likely better than pure Friesian cattle in such a system. The system is also flexible : it will accommodate steers instead of bulls by using approved growth promoters and feed additives. It is also possible to produce heifer beef through this kind of system; and several farmers are doing so. It is of interest to note that a variation of this management system is gaining popularity as a system for rearing dairy heifer replacements in France.

Summary

The place for systems producing intensively fed young beef in Ireland will be limited to grass farms on which the standard of grass management and silage production is very high.

Profit earning potential will depend on several factors, the most important of which are the quality and cost of silage, the cost of concentrate feed, the cost of the calf and the market outlets and value of the product. Because of the importance of silage quality, the making of silage must be under the farmer's control rather than a job dependent on the contractor. High calf prices undermine profit potential for any calf-to-beef system. Calf prices will moderate only if calf supplies increase or demand falls. From the beef industry point of view such change over the next few years would be best brought about by a large increase in the beef cow herd, preferably producing continental cross calves to be finished through an intensive feeding system as described here for Friesian cattle. Increasing the beef cow herd on traditional cattle farms would also have the effect of reducing the demand for dairy calves by traditional farmers. If these two factors would moderate calf price to a level where an average calf can be bought for the value of 75-100 kg of live beef, there would be a bright future for this system. This future would be secured by the development of marketing arrangements to ensure that the beef price available in Europe would be available to Irish farmers all year round.

II. THE PRODUCTION AND MARKETING OF BULL BEEF IN THE E.E.C.

As a proportion of total cattle slaughterings, bull slaughterings were 23.5% in 1979 and in tonnage terms bull beef amounted to 26.1% (Table 8). The difference arises because of the large number of calves in the

Table 8

Gross indigenous cattle production, cattle slaughterings and bull slaughterings in EEC Nine

	1975	1976	1977	1978	1979
Production (000 head)	29,254	27,840	27,000	26,992	28,078
Cattle slaughterings (000 head)	29,127	28,106	27,359	27,077	28,278
Bull slaughterings (000 head)	5,964	6,399	6,370	6,321	6,637
Bull slaughterings nos. as % cattle slaughtering nos.	20.5	22.8	23.3	23.3	23.5
Cattle slaughterings (000 tonnes)	6,619	6,546	6,383	6,427	6,827
Bull slaughterings (000 tonnes)	1,633	1,672	1,646	1,674	1.779
Bull slaughterings tonnes as % cattle slaughterings tonnes	24.7	25.6	25.8	26.0	26.1

Source : Eurostat "Animal Production" with personal correction of Italian data cattle figures. Whichever measure is used, bull beef production increased in importance in the period 1975-1979. It is most important in Italy, Germany, Denmark, Belgium and Luxembourg and it is least important in Ireland and U.K. (Table 9).

Table 9

Cattle and bull slaughterings by EEC country in 1979

	Cattle (000 tonnes)	Bull (000 tonnes)	Tonnes as % total tonnes
W. Germany	1517	785	52
France	1824	230	13
Italy	1105	710	64
Holland	403	54	13
Belgium	281	86	31
Luxembourg	8	3	38
UK	1051	19	1.8
Ireland	388	3	0.8
Denmark	252	116	46

Source : Eurostat "Animal Production" with personal correction of Italian data

With the exception of W. Germany and Denmark, bull slaughterings were more seasonal in 1978 than adult cattle slaughterings. Since bull numbers are also included in adult cattle numbers, the seasonality of bull slaughtering relative to adult cattle excluding bulls would be even more pronounced still. For all adult cattle the most common peak month is November and the most commonly low month is July. For bulls the most common peak months are June, July, August and the most commonly low months are November and February. Bull slaughterings therefore were quite opposite to total adult cattle slaughterings in their seasonal pattern, which no doubt suits the slaughter factories very much.

Beef consumption and self-sufficiency in EEC Nine

Total meat consumption and total beef consumption increased in the period 1975-1979. Meat consumption increased faster than beef consumption so that beef lost 2 percentage points of market share. It is predicted that there will be increased meat and beef consumption by 1985 but with beef having lost another 2 percentage points of market share. Figures are not available on bull beef consumption alone.

Table 10 shows that the EEC as a whole was self-sufficient in beef in 1979. The deficit areas are Italy, U.K. and Belgium/Luxembourg. It is expected that by 1985 Italy and U.K. will continue to be very substantial importers and Belgium/Luxembourg will remain small scale net importers. It has been forecast by the EEC Commission that W. Germany will be a net importer by 1985. However, it is difficult to accept this, given that W. Germany's self-sufficiency has now grown to 112% in 1981.

Table 10
Indigenous cattle production and self sufficiency by EEC country in 1979

	Production (000 tonnes)	Domestic use (000 tonnes)	Self-sufficiency
EEC-9	6791	6794	100
W. Germany	1515	1488	102
France	1957	1770	111
Italy	897	1413	62
Holland	412	307	134
Belgium/Luxembourg	284	289	98
U.K.	1060	1347	79
Ireland	428	87	493
Denmark	256	93	276

Trade

As can be seen in Table II the main EEC suppliers of beef and veal to Germany are France, Holland and Denmark. The main suppliers to

Table 11
Major intra-EEC flows in beef and veal % of total beef and veal imports

	W. Germany	France	Italy	Holland	Bel./Lux.	U.K.
W. Germany	—	27	26	8	—	
France	24	—	19	11	17	6
Italy	2	1	—	—	—	
Holland	21	11	14	—	20	
Bel./Lux.	3	2	—	29	—	—
U.K.	12	32	—	8	10	—
Ireland	8	23	1	31	37	68
Denmark	13	1	23	3	2	1
Non-EEC	17	3	17	10	14	25

France are UK, Germany and Ireland. German exports to France are mainly hindquarters and conversely French exports to Germany are mainly forequarters. French imports from the UK are also predominantly of hindquarters. This is also true of imports from Ireland, although to a much lesser extent. The main suppliers of Italy are West Germany, Denmark and France. For Ireland, Italy is still virtually virgin territory. Italy is by far the largest importer of live cattle in the EEC. Its predominant supplier is France. West Germany is also a substantial supplier of livestock to Italy. After Italy, Germany is the second largest importer of live cattle although only about 11% as large as Italy in that respect.

Prices

Let us now discuss the vital topic of producer prices and the question of whether or not there is a market for Irish bull beef in the EEC. There is a variety of determinants of producer prices and these are summarised in Table 12. The number of determinants of producer prices is greater for an exporting country than for a non-exporting country. The position of a country in which exports are moderately important relative to home consumption is more complex because the price received by the producer is

Table 12

Determinants of producer prices

	For a country serving only its own market	For a country with a large export orientation
Supply/Demand —	Wholesale prices	Wholesale prices
	Wholesale margins	Wholesale margins
	Transport costs	Transport costs
	Quality	Quality
	EEC/Government aid	Green exchange rates, MCA's
		Currency exchange rate
		EEC/Government aid

the result of interacting domestic market and export determinants; the effect of each is in accordance with its weighting or importance in the sale of the total output. It is necessary to make some simplifying assumptions if one is to draw any conclusions from an examination of producer prices. The assumptions made here are (1) that wholesale markins taken on Irish beef are similar to those taken in other beef; (2) that factory margins taken on Irish beef are similar to those taken on other beef; (3) that a given quality makes a given price irrespective of country of origin. The third assumption is the most crucial. The issue of whether or not there are reasons to believe that it might not be a valid assumption will be examined later for the German and French markets.

Currency exchange rates, green exchange rates/MCA's and differences in transport costs to market can all cause differences in prices at farm level. These effects are specific to the particular exporting and receiving country. As a general exercise, let us consider Italy as the receiving country and let us examine producer prices in Italy and in three other countries which export to Italy. The situation with regard to France is complicated by a price complement to producer groups which bridges the gap between the market price and 94% of the guide price. Since producer groups supply 65% of bull beef in France, the effect of this payment on average producer prices is taken as 65/100 times the relevant payment, which in October 1981 was roughly a 1Fr/kg deadweight (DW). The effective payment in Irish currency was approximately Ir£4.40/100 kg liveweight (LW). Prices and adjustment factors are shown in Table 13.

Table 13

Producer bull prices (IR£/100 kg LW) in those countries serving the Italian market, 2nd week Oct. 1981

	Denmark	France	Germany	Italy
Super	118.42	U 117.70	I 117.88	I 126.32
Extra	114.04	R 110.48	II 106.86	II 113.88
I	108.77	O 102.84		
II	102.63			
MCA paid to exporter into Italy	3.53	3.53	3.53	—
MCA paid to exporter out of Germany	—	—	8.67	—
French subsidy	—	4.40	—	—
Transport to Italy[1] (Milan) (P/kg DW)	6.93	5.63	5.49	2.64
Extent to which Irish transport costs exceed those quoted above (P/kg DW)	3.71	5.01	5.15	8.0

1. Source : A. Archer CBF

Inter-country comparisons of prices at producer level are hazardous given the multitude of price determinants operative at that level as discussed earlier. Italy is a large deficit country, France and Germany are in slight surplus and Denmark is a large surplus producer. Ireland's position would be quite similar in this respect to Denmark, fairly similar to France and Germany and quite different from Italy. Irish exporters to Italy also receive the Italian MCA of 3.53. In comparing Ireland with Denmark in terms of the data in Table 13, it is necessary to adjust only for the extra cost of transport from Ireland to Italy compared with Denmark. This excess is 3.70 p/kg (approximately 2.15 P/kg LW). If Irish producers were producing Danish quality bulls and selling them in Italy then they should receive Danish prices adjusted for the excess transport costs. These prices in October 1981 were :

Super	IR£116.27/100 kg LW
Extra	111.89
I	106.62
II	100.48

Compared with producer prices for Irish steers I in the same period these represent premia of IR£22.35/100 kg LW, 17.97, 12.70 and 6.56 respectively. The equivalent figures in carcase terms depend on killing out percentage. Using 58% for Super and Extra and 55% for I and II these amount to 17.5p/lb, 14.1p/lb 10.5p/lb and 5.4p/lb carcase. A similar exercise can be done with French prices which must also be adjusted for the French Government subsidy as well as excess transport. The results, in terms of premia relative to Irish steers I price, are shown in Table 14.

Table 14

Approximate estimate of premia relative to Irish steers I for bull beef. All prices adjusted for excess Irish transport cost, MCA's and subsidy where necessary (P/lb/DW)

	Denmark	France	Germany	Italy
Super	17.5	U 12.4	I 9.6	I 17.34
Extra	14.1	R 7.2	II 1.1	II 8.02
I	10.5	O 1.4		
II	5.4			

The data in Table 14 give a preliminary idea of the premia that are available to Irish producers for bull beef sold into Italy on the assumption that the effect of the other determinants of producer prices (i.e. intervention, domestic and other markets, quality and marketing effiic-iency) would be the same for Ireland as for the countries listed. This assumption would be least valid in the Italy-Ireland comparison. One expects that it should be most nearly valid for the Denmark-Ireland comparison. The Danish figures are interesting and encouraging. Carcase quality and breeds are very important and are discussed elsewhere in this paper, together with the efficiency with which Danish bull beef is marketed.

Let us now examine Western Germany and France in detail as possible markets for Irish bull beef.

W. Germany

Young bulls comprised 49.1 per cent of Germany cattle output in 1976 and 48.1 per cent in 1980. The production of young bulls in W. Germany has reached almost half their total output and this has been due to :

1) The greater production efficiency of bulls.
2) Availability of maize.
3) Proximity to the large deficit Italian market.
4) The equation of leaness with quality and value for money by consumers which was reinforced by a campaign in the 1970's against animal fats.
5) The traditionally high consumption of manufactured meat in Germany (50% of meat consumed in Germany is in manufactured form) which requires lean meat. The usage of bull beef in manufacturing also facilitates the acceptance of bull beef outside manufacturing.
6) Trade satisfaction arising from uniform quality of bull carcases and higher profits from greater yield.
7) EEC factors (a) an EEC scheme to reduce cow numbers in the late 1960's led to a decline in beef supply which in turn led to increased prices; (b) the introduction of intervention for bull beef in 1974 with favourable coefficients and consequently favourable intervention prices for bull beef; (Intervention took 8 per cent of German bull slaughterings in 1979).
8) The favourable effects on Germany producer prices of the movement of the German mark and the Italian lira relative to their respective green rate of exchange.

The grading distribution varies dramatically by region according to breed. Bavaria achieves a figure of 56% of its young bull beef in grade E because of its preponderance of Fleckvieh (German Simmental) cattle. However, in the dairy region of North Rhein Wesphalia where the German Black and White and Red and White predominate, only 4.5 per cent of young bulls are classed as grade E with 66 per cent classed as I and 28 per cent as II. As regards conformation standards in German and Irish classifications, the German class E covers slightly more than the top two Irish classes of I and R. In terms of fat cover, class E would approximate to about Irish fat class 2 and indeed very few of the German classes, except EF which is a special and very small "heavier fat" version of class E, would exceed Irish fat class 3.

Table 15 shows the percentage distribution by grade of Friesian bulls sold by The Agricultural Institute over 3 years. Virtually all these bulls graded as E and L and most of them were 2 and 3 in fat. As an approximation, Irish Friesian bulls would fall mid-way between German classes I and II; none would fall in the E class. Irish grades E and L of an acceptable fat level would be incorporated in the German live grade II. It is the price of German live grade II that we should use as a starting point in assessing the likely potential price that Irish Friesian bull beef would make if sold in Germany.

Table 15

Percentage distribution by grade of Friesian bulls (The Agricultural Institute)

	Conformation I	R	E	L	A
Fat 1			3	4	
2		1	15	7	1
3			19	29	
4			7	15	1

No. = 127 Av. carcase wt. 283 kg

The question of whether or not there are any reasons to believe that we would receive less than the German price for that quality must now be raised. Firstly, if we were selling bull beef on the German market now and assuming that we received the same price as the Germans, that price would be lower than the current price for both Germans and Irish alike. This would simply be due to the increase in supply which the Irish beef would entail. Of course, the operations of the intervention system would abate this to some degree. Secondly, if through successful marketing a special market segment could be created for Irish bull beef in Germany it would not necessarily have to compete with German bull beef. However, it is extremely unlikely that Irish bull beef in Germany could be successfully marketed as a premium priced product. The best that could be hoped for is that it would be viewed as being equivalent to German bull beef of similar quality and that it would receive an equivalent price. There are possible reasons however why even this might be unattainable.

The German market is more than self-sufficient in beef in general (112 per cent in 1981) and in bull beef in particular. Irish exporters would therefore be selling an undifferentiated product into an over-supplied market. In that situation buyer attention would centre on price competitiveness. This would be particularly true of the manufacturing sector which demands a highly specified product and is a very important user of bull beef. German manufacturers would buy our beef if we could supply the equivalent product as well as their German suppliers but only if we were more price competitive.

Regarding other marketing channels, it should be pointed out that German butchers tend to buy their bulls on a breed and tradition basis. Thus it is not merely bull beef that they buy but Bavarian Bull or Franconian Bull. Vac-packing for supermarkets or other outlets while technically possible requires special care. Bulls are susceptible to stress.

Stress raises their Ph (reduces the acidity of the meat) and makes the meat susceptible to the growth of spoilage organisms, thus reducing vac-packing potential. Also, because of light fat cover on the carcases, they do not travel well. Due to these problems bull beef gives the buyer less time flexibility in its sale than steer beef.

Taking account of the above issues, it appears that if we were selling bull beef into Germany now we would not be receiving the current German bull beef price because of :

(i) the pressure that would be put on price through the increased supply of Irish bull beef;
(ii) the probability that for a given quality level we would not receive the same price as German beef of the same quality.

The price reduction that would occur under (i) would be a function of how much the Irish beef would increase supply and of the price elasticity of demand. It is a matter of speculation as to what values these would have. It is also a matter of speculation as to what price penalty Irish beef would suffer under (ii). For this exercise I assume that if we were selling bull beef in Germany now we would be receiving 95 per cent of the current price.

As already stated, Irish Friesian bulls would fall into the second category on the German live classification scheme. The German producer price of class II young bulls in October 1981 was IR£106.86/100 kg LW. Ninety five per cent of this is £101.52. This is taken to be the price that Irish Friesian bull beef would have made in Germany in October 1981. The price that could be passed back to the Irish producer from this price would have been £101.52 less the MCA of IR£8.67/100 kg paid by the German importer, less the extent to which the transport cost of the Irish product exceeded that on the German product (taken here as 2.5p/lb DW). When adjusted for MCA and transport the Irish producer price works out at £101.52−(£8.67 + £3.03) = £89.82/100 kg LW. This compares with an Irish producer price for Steer I in the same week in October 1981 of IR£93.92/100 kg. Therefore, under the assumptions adopted in this exercise, the sale of Irish Friesian bull beef in Germany in October 1981 would have yielded a lower producer price (by 3.4p/lb DW) than was received by Irish producers of steers I at that time.

However, if we assume a German producer price for young bulls class I and following a similar procedure as before, the Irish product price is IR£100.30/100 kg which is higher than the price received by Irish producers of steers I at that time by IR£6.37/100 kg LW or about 5.3p/lb DW. This premium would be available only for high quality beef breeds equivalent to the German Simmental (Fleckvieh) and Charolais. Such animals would grade as I, 1,2,3 on the Irish beef classification scheme. In a classification exercise in autumn 1979[1] none of 57,000 Irish steers were classed as I and only 2.4 per cent were classed as R. That we can produce the high quality product is demonstrated by the classification

1. "Beef Carcase Classification and Market Requirements". P. O. Ryan. Paper read at Winter meeting of IGAPA, 1979.

results of the young bull reactors sold from Tully Performance Station (Table 16). The bulls were suckled as calves, weaned at 200 days and put on full test feed thereafter. The management was very good but not outside the reach of any specialised producer.

Table 16

Classification results of Tully bulls

Breed	Carcase wt. (kg)	Conformation	Fat	Age (months)	Number
Limousin	427	I^-	3^-	16.6	12
Simmental	439	R^+	3	16.7	27
Charolais	418	R^+	3	15.7	14
Blonde D'Aquitane	455	I^-	2^-	16.8	7

Source : Coleman, Department of Agriculture

France

Bull production is less important in France than in Germany. Whereas bulls account for about 50 per cent of production in Germany they account for only 20 per cent of production in France. However, in the last 10 years production of young bulls in France has more than doubled. Steers, which constitute only 2 per cent of production in Germany, amount to 23 per cent of production in France. The determinants of the growth of bull beef production in France were :

(i) Increased profitability arising from greater production efficiency.
(ii) Availability of maize.
(iii) Producer groups formation which now account for 65 per cent of production and qualify for Government aid.
(iv) Proximity to the Italian market.
(v) Support by the intervention system which currently takes 27 per cent of bull production.
(vi) Trade satisfaction arising from lower quality variation of bull carcases and higher profits from increased yield.

Of the total production of young bulls 36 per cent are consumed in France, 27 per cent are sold to intervention, 24 per cent are exported as beef and 23 per cent are exported live. It is estimated that about 80 per cent of live and dead exports are sent to Italy. It is expected that bull production will continue to expand in France and that the increased production will be consumed on export markets and not in France itself. Bull beef is not highly regarded in the quality conscious French market.

Appraisal of breed distribution of young French bulls by carcase class together with information from the Department of Agriculture, Dublin makes it possible to relate the French and Irish classification schemes and to conclude that Irish Friesian bulls would cross the R and O Grades of the Europe system.

As was seen in Table 15 Irish Friesian bulls are distributed evenly across Irish classes E and L. Thus, the price for Irish Friesian type carcases selling in France consists of about one third of the French price for French grade R and two thirds of the French price for the French grade O. This price must firstly be reduced by IR£4.40/100 kg which is the estimated value of the French Government subsidy in October 1981. The starting price for the 2nd week in October 1981 is therefore calculated as

$(110.48-4.40) \times 0.34 + (102.84-4.40) \times 0.66 = \text{IR£}101.04/100$ kg LW

The question arises again as to whether or not we could expect to receive this price (in France) if we were now exporting bull beef to France. As was the case with the German calculations, one must allow for the price depressing effect that an increase in bull beef from Ireland would have on French prices. Salient features in the marketing of bull beef in France are that catering outlets and supermarkets are currently the most important domestic market outlets, but butcher chains could be large outlets in the future. As in Germany, butchers tend to buy on a breed and traditional basis. Vac-packed bull beef is bought by French supermarkets. Bull beef is produced and marketed in a very disciplined and organised way in France and is mostly sold direct from abattoir to retail outlet. Wholesalers do not handle very much bull beef. This may be an important consideration for an exporting country in that direct abattoir-retail trade requires a high degree of discipline of supply and quality specification. Meat colour is very important and a problem with young bull beef is that it may be too light in colour for consumers. This may be overcome by including carrot pigmentation in the feedstuff.

The French market is not a deficit market and there is little possibility of further increases in French production being absorbed in the French market at realistic prices. Alternative export markets are being examined. As in the case of Germany, the Irish would be selling an undifferentiated product which has less selling time-flexibility than French bull beef or Irish steer beef on a fully supplied market. It is therefore reasonable to take 95 per cent of the previously mentioned starting point price as being a more accurate estimate of the price that Irish Friesian bull beef would receive if selling now in France. This works out as 95/100 x 101.04 = IR£95.99/100 kg LW. There are currently no MCA's on trade between Ireland and France. However, it is assumed that transport for the Irish exporter would be 2p/lb deadweight more than it would for the French supplier. This amounts to about IR£2.42/100 kg liveweight so that the price the Irish producer would receive for Friesian bulls sold in France in the 2nd week of October 1981 is estimated as IR£93.57/100 kg LW. This compares with an Irish producer price for steer I in the same week of IR£93.92/100 kg LW. There is therefore effectively no difference in price. It compares with a penalty in the case of Germany of about 3.4p/lb.

The message is fairly clear in both cases—bull beef production for the French and German markets using Friesian animals is not a realistic proposition. If one assumed that Irish bull beef was good enough to achieve gradings of E, U, R on the EUROPA scheme, then using the same procedure os outlined already the premia relative to Irish steers I in October 1981 would be 15.8p/lb DW, 8.8p/lb DW and 3.6p/lb DW respectively. The premia obtainable by producing German class I bulls was previously estimated at 5.3p/lb DW.

Summary

Solely from a marketing point of view, the sale of Irish Friesian bull beef in Germany and France would not offer much prospect of any premia in price. However, premia relative to Irish steer I prices are available for good quality beef derived from Continental beef breeds, the extent of the premia being dependent on the quality level.

The issues from the marketing point of view are :

1. What are these breeds ?
2. Can we produce beef from these breeds more efficiently than Continental competitors ?
3. What are the factors other than distance from the market which might prevent us from receiving the same price for a given quality as producers in Europe receive ?
4. Can we reduce or eliminate these factors ?
5. Can we create the other marketing determinants such as intervention, producer groups, guaranteed producer prices, some of which have been very important in the development of bull beef production abroad ?

III. MARKETING PRACTICES FOR YOUNG BULL BEEF IN DENMARK AND GREAT BRITAIN

Denmark and Great Britain have few similarities in the production and marketing of young bulls. Denmark is an important exporter of beef, and has been producing young beef for some time. Great Britain, by contrast, is the third largest beef importer in the EEC, has a relatively low level of young beef production and prospects for market growth are not bright.

(a) Denmark

An assessment of Danish experience in the marketing of young bull beef commences in the early 1960's. At that time the cattle sector in Denmark was not organised and was second in priority to the streamlined dairy sector. There was a combination of veal production and live cattle exports. Danish 'veal' however, was different from traditional European veal. Dutch, French and German veal is derived from calves fattened on milk products only, with meat that is white in colour and having a carcase weight of about 85 kg. Danish 'veal' was from calves fed on mixed rations of barley, beet, oilseed products, etc., to produce a carcase of about 140 kg.

Live cattle exports during the early 1960's were sent mainly to West German seaport towns with large public abattoirs. In 1962, 350,000 live cattle were shipped but with the formation of the EEC this trade was disrupted and other outlets had to be found. The Danes, however, with the same attitude which prompted them to develop the British bacon market, organised their veal production to produce young bull carcases for the Italian market.

Production

Young bulls currently account for about 43% by weight of total beef and veal production. The overall trend in Danish production during the 1970's has been downward, as indicated by a 9% decline in disposals from 1970 to 1980 (Table 17). There has been a corresponding gradual rate of decline in young beef production with the result that its share of total production has remained fairly constant. This currently amounts to about 500,000 young bulls per year. In common with the pattern in a number of continental EEC states, steer production in Denmark is relatively low and currently accounts for less than one per cent of total output.

Table 17

Slaughterings of cattle and calves in Denmark (000 head)

	1970	1975	1980
Cows		369.7	410.5
Heifers	482.1	130.3	100.6
Old bulls		21.0	25.7
Steers		10.7	5.3
Young bulls	575.8	537.4	509.0
Baby beef		23.9	8.4
Veal	29.0	14.6	11.0
Total slaughterings	1,086.9	1,107.6	1,070.5
Live exports	103.4	29.4	6.5
Total production	1,190.3	1,137.0	1,077.0

Source : Statistik 1980, Danish Meat Board

Breeds

The breeds of cattle on which young bull production is based are virtually all dual purpose or dairy type. In fact, 90% of all cows in Denmark are either Friesian, Danish Red or Jersey (Table 18). Pure beef breeds account for only 2.5% while the remaining animals are cross-breds. The major change that has occurred in the past 10 to 15 years has been the growth in the Friesian breed at the expense of Danish Red.

Table 18

Breeds of cows in Denmark

	1966	1978
Red Dane	47.8%	21.2%
Friesian	29.3%	52.0%
Jersey	16.4%	15.5%
Beef breeds	0.1%	2.5%
Crossbreeds	6.4%	8.8%

Source : Danish Meat Board

Slaughter weights and classification

Danish bulls are slaughtered at relatively light weights compared with young bulls in other Continental EEC countries. A survey carried out in 1980 showed that 85% of Danish young bulls have a carcase weight ranging from 163 to 275 kg. A weight of about 230 kg is preferred by the Danish meat export sector. The usual age at slaughter is 12 months and animals achieve a lifetime growth rate of about 1 kg per day.

The Danish classification system contains four principal classes, A1, A, B and C. Classes A, B and C are again divided into 3 sub-classes giving a total of 10 individual classes. Nearly two-thirds of animals are classified into the A1 class and the 3 sub-classes of A. Approximately one-third of animals fall into the B sub-classes with a small minority being further downgraded into the C area.

An approximate link up between the conformation standards of the Danish and Irish classification systems is as follows : the Danish classes of A1 and A roughly correspond to the top three Irish classes, I, R and E. Irish classes L and A broadly correspond to Danish B classes.

Seasonality of production

Production of young bulls in Denmark is spread evenly throughout the year and there is also a stable pattern of production from one year to the next. These two factors facilitate an orderly approach to both processing and marketing. The ratio of maximum weekly slaughterings is about 1.5 : 1. In actual throughput at meat plants, this means a change of about 2,500 cattle in weekly slaughterings above and below the average level of about 9,500 animals. The months of peak slaughter are March, May and June. Supplies are lowest in July, November and December. Year to year changes in production since 1975 have not at any time exceeded 10%, which in terms of annual throughput is a variation less than 36,000 animals (Table 19).

Market outlets

In 1980 two-thirds of all bull beef produced in Denmark was sold in Italy. The proportion consigned to Italy in earlier years was even higher.

Table 19

Production variations within year and between years

Annual slaughterings (000 head)		Average weekly slaughterings (head)	
1975	537.4	January	9,450
		February	9,600
1976	541.3	March	10,250
		April	9,500
1977	550.0	May	10,350
		June	11,800
1978	514.4	July	7,600
		August	9,850
1979	533.4	September	9,650
		October	9,400
1980	509.0	November	8,700
		December	8,000

Source : derived from Statistik (various issues)

Since the Danes rely so heavily on this market, it is obviously in their interests to maintain quality standards. There is a deliberate policy whereby bull carcases with the highest grades are exported to Italy; those with lower grades are sold for intervention storage and on the domestic market. Bull forequarters are sold to West Germany for manufacturing. The Danish meat export sector strongly maintains that it is very important not to allow bull carcase weights higher than 240 kg for export. The principal reason is that it permits them to maintain and service a particular market segment within the Italian market, without having to meet direct competition from other suppliers.

Italy is the major importer of chilled bull beef in Europe and is also a large market for veal. The total amount of bull beef imported has remained fairly constant at about 250,000 tonnes per year, which is largely imported as carcases and hindquarters. Within these requirements for bone-in bull beef, there would appear to be two separate market segments. The larger segment of the market consists of bulls weighing between 250 kg and 350 kg carcase weight and whose meat is darkish red in colour. This market segment is largely supplied by imports from West Germany and from France, both in carcase form and as live animals.

The smaller market segment is for carcase weighing from 220 kg to 250 kg, with meat that is light pink in colour. It is this latter market segment which is supplied almost exclusively by Denmark. The Danes maintain that the characteristic of a standard lean light carcase is more important than conformation because they can supply the requirements of a market segment in between the larger bull beef market and the separate market segment for white veal.

Danish bull beef sold in Italy is not identified at consumer level. The product is sold via the wholesaler trade to butcher shops. Little Danish bull beef is sold through Italian supermarkets. Sales are concentrated in three main regions : Florence, Milan and Genoa. Surprisingly, Denmark sells only small quantities of bull beef to the large population in the Rome area. Also, not only are Italian consumers unaware that the beef they purchase is Danish but, in the view of some Danish exporters, many consumers believe that it is Italian veal they are purchasing. If this is the case, it allows the trade in Italy to take a better margin on the Danish product and would partly explain why Italian importers express a preference for the Danish product.

Another interesting aspect of the Danish trade to Italy is that the majority of bull carcases are not broken down before export into quarters or cuts. About two-thirds of carcases are left unsplit and the remaining trade is hindquarters. Actual trade in bull meat from Denmark is directed by both co-operatives and private enterprise.

(b) Great Britain

Bull beef in Great Britain is produced and marketed on a relatively small scale and is estimated at the present time to account for less than 2% of all clean cattle slaughtered. This market share has remained constant in recent years and indications are that the prospects for significantly increasing its market are not bright. The majority of young bulls, about 70%, are produced in intensively fed cereal beef systems (barley beef) by producers who continue in the business from one year to the next. The remaining 30% are produced by farmers who change in and out of the system with changes in the levels of calf and feed prices. Cereal-fed bull beef, like cereal-fed steer beef, is extremely sensitive to changes in cereal and calf prices. Cereal-fed steer beef has declined considerably in Britain in recent years, as steers tend to become overfat on the high levels of nutrition, in addition to their disadvantages of slower growth rates compared with bulls. Young bulls are slaughtered at between 10 and 13 months of age ranging in liveweight between 220 and 260 kg. The breed of animal used is Friesian or Friesian cross.

Meat yield from bulls

Because of their superior lean-to-bone ratio, bulls contain more saleable meat than steers at the same level of fatness. However, the distribution of lean meat in bulls is slightly inferior because less of their saleable meat is in the higher priced cuts. According to the British Meat Research Institute bulls have more neck meat and less rump but the difference is small and is more than compensated by the higher yield of saleable meat.

Retail demand for young beef

Considering the relatively small level of production in Great Britain, it follows that the current size of the retail market for intensive fed beef is also limited. Nonetheless, it is an established market and the supermarket groups who market the product appear to be satisfied with it and they are prepared to pay a premium price. Rates of premium paid by the retailers vary at different times of the year but the most commonly quoted figure is about 4.4p/kg for a bone-in side price compared with high quality commercial beef. Also, there are no indications from the two supermarket groups currently selling intensively fed beef that their sales are not profitable. Incidentally, the term "bull" beef is not mentioned in any of their promotional literature.

Major criticisms of bull beef

In general, the attitudes to the product of meat traders not selling bull beef are adverse. Probably the most widely voiced criticisms are that it lacks flavour and taste, even though most traders admit that this is their own personal view, and not the result of any tests carried out with shoppers. Lack of colour is also mentioned as a problem. However, the real prejudice on the part of the British meat trade to bull beef may be that it commands a premium price. This would cost more and secondly, the trade appears to be concerned about possible supply problems.

On the price factor, the British are sceptical that the higher purchase price of the beef would be compensated by the higher saleable meat yields. They are not prepared to risk becoming uncompetitive in the market place. On the supply situation, it must be recognised that at the present time in Great Britain meat companies have no real problems in obtaining the quality of beef they currently specify and, if one supplier fails, they can usually change to another. With bull beef however, supplies are not so plentiful and a meat company could lose some of its flexibility as far as supply is concerned.

Organisation of marketing

There is little doubt that the two retail groups currently selling significant qualities of bull beef have devoted a large amount of effort into securing their supply by way of arrangements with meat plants and making contacts back to producer level. In fact, most bull beef production is carried out on the basis of an established market outlet. Many producers sell their animals to the same firms on a continuous basis, i.e. an "integrated" approach. An inherent benefit in this system of direct marketing is that it would appear to eliminate the incidence of "dark cutting" beef. Dark cutting beef, which is both unattractive to the consumer and highly susceptible to bacterial spoilage, can be produced in both steer and bull carcases by high levels of pre-slaughter stress and activity. Bulls are more sensitive than steers to stress and therefore more prone to produce dark cutting beef if they are not handled properly prior to slaughter.

The first example of a beef production line specifically designed to satisfy a particular retail need was in 1974 when the Aberdeen Beef and Calf group collaborated with Buchan Meat Producers (a co-operatively owned meat plant) to provide the Waitrose supermarket group with beef on a regular basis. That particular three-way link up is still in existence and it has led to the formation of others, but it does not conceal the fact that it is an undertaking which takes an amount of organisation. Incidentally, Waitrose buys all its beef from its suppliers in vacuum-packed form which is totally different to Denmark where carcases are left unsplit.

Conclusions

In assessing the potential market for Irish bull beef in the EEC there are two comments worth noting :

1. Solely from a distribution viewpoint, the marketing of bull beef requires a greater amount of co-ordination and organisation than conventionally fed beef.
2. The question of "why should we change" is likely to compound the marketing effort required in any development stage, given that doubts arise about the viability of the system and the availability of adequate and consistent supplies at competitive prices in this country.

GRAZING MANAGEMENT: ITS EFFECTS ON SWARD PRODUCTION AND PROCESSES

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The currently recommended system of grazing management for dairy cows (rotational paddock system) was examined in terms of the balance achieved between the supply of grass and herd feed requirement. Difficulties in balancing the feed budget arise at two levels. For most of the grazing season an overall balance between supply and demand can be achieved, but feed problems arise in early spring and late autumn. At any time during the season—although there is an overall balance between supply and demand—there is wide variation in the balance achieved in individual paddocks within each rotation. The effects of these disparities between supply and demand on total production were examined.

Experimental results were presented showing the effect of differing grazing practices on herbage dry matter production. The results were used to present an integrated picture of the implications for production of different management strategies within the limits of the rotational system. Flexible options for overcoming the difficulties that arise in balancing the feed budget were considered.

An analysis of leaf and tiller dynamics (data from labelled tillers) indicate that the management effects evaluated in terms of dry matter may not be simply translated into effects on the animal. Results show that managements which increased leaf extension rates also increased leaf senescence rates. Therefore a management practice which increases dry matter production may not result in a corresponding increase in useful feed.

MICROBIOLOGICAL STUDIES ON SILAGE

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First and second cuts of *Poa trivialis* and *Festuca rubra* were ensiled in laboratory silos with the grass structure intact (long), partly destroyed (chopped) and more extensively destroyed (minced).

Total viable counts, coliform bacteria, clostridia, yeasts and moulds as well as DM, pH, VFA, lactic acid and VN/TN % were recorded on days 2, 4, 10, 30 and 60.

First cuts of both grasses made excellent silages in spite of low levels of WSC, 9.2 and 10.1% for *P. trivialis* and *F. rubra* respectively. Second cuts, although chemically similar to the first cuts gave a range of silages. pH values were 4.82 and 5.64 for the long silages and 3.80 and 3.99 for the minced silages at day 60. Chopped silages were intermediate. Apart from a highly significant ($p<0.01$) delay in growth of lactobacilli on long silage at day 2, the differences between grasses were small. Large counts of coliform and clostridia were present in long silages at day 60. Results suggest that a rapid release of nutrients by cell collapse is essential for good preservation. The number of lactobacilli may be less important. Total WSC, since it does not assess available WSC, is a poor indicator of the suitability of grass for silage.

PASTURE FINISHING OF CULL COWS

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A group of 30 cull cows were assembled in April that had calved since the previous December. They were divided into two groups on the basis of liveweight, body score and lactation number, and one group (C) was slaughtered as a control group on April 29th. The second group (G) was allowed a 54 day grazing period before being slaughtered on July 1st. The cows were grazed on a 2.8 ha area divided into six paddocks using an 18 d rotation.

The G group gained on average 44 kg liveweight and improved by 0.5 body score. They killed out 2.2 percentage points higher than the C group despite having heavier kidney-knob and channel fat. Estimated carcass gain of the G group cows was 32 kg while both factory grade and conformation classification of group G were improved compared to group C. Fat score was unchanged. Allowing for differences in initial weight, group G cows yielded 12.4 kg more saleable meat per side than group C cows, hence almost 78% of the estimated carcass gain was in the form of saleable meat.

THE EFFECT OF CUTTING FREQUENCY ON THE YIELD OF GRASS FOR SILAGE AND THE PERFORMANCE OF BEEF CATTLE

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Several experiments have been carried out to quantify the effects of cutting frequency and digestibility of grass for silage on the intake and performance of beef cattle. However there is little information available on the effects of cutting frequency on dry matter and digestible organic matter yields of grass over the range of cutting intervals relevant to silage making. A plot experiment has therefore been carried out to examine the effects of harvesting ryegrass swards at 5, 6, 7, 8, 9, 10, 11 and 12 week intervals throughout the growing season. Swards of both early and late-heading varieties of perennial ryegrass (Cropper and Talbot) respectively) were used over a three year period. Fertilizer was applied to all treatments at the rate of 420 kg nitrogen, 175 kg P_2O_5 and 210 kg K_2O per hectare per annum. Plots measured 2 m x 6 m and there were six replicates per treatment. Mean annual dry matter yields over the three years of the experiment for swards harvested at 5, 6, 7, 8, 9, 10, 11 and 12 week intervals were 12.80, 13.95, 14.72, 15.32, 16.07, 14.86, 15.63 and 15.65 $\pm$ 0.322 t/ha respectively for Cropper and 12.28, 12.91, 14.17, 14.52, 14.61, 14.29, 14.41, 14.74 $\pm$ 0.284 t/ha for Talbot. A series of eight feeding experiments have also been carried out over an eight year period to examine the effects of cutting interval of grass for silage on the intake and performance of finishing beef cattle. The silages were offered *ad libitum* to a total of 600 cattle (mean initial live weight 340 kg) for periods of 105 to 150 days. The results were presented.

SULPHURIC ACID AS A SILAGE PRESERVATIVE

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The efficacy of 45% sulphuric acid as a silage preservative was evaluated in a series of experiments during 1980 and 1981. In each trial 85% formic acid applied at 2.3-3.0 l/t was used as a positive control. In Experiment 1 (1980) three successive cuts of silage were harvested on May 22nd, July 1st and August 27th using a rotary mower and a pick-up wagon. Within each cut, grass was treated at ensiling with either 85% formic acid or 45% sulphuric acid, both applied at 2.3 l/t. A group of 16 Hereford cross heifers were allocated to each treatment and within each of these, first, second and third cut silages were fed in sequence to the same cattle. Silage was the sole feed and was offered *ad libitum* for 135 days. Daily liveweight gains for the finishing heifers fed the 85% formic and 45% sulphuric acid treated silages were 0.81 and 0.83 kg respectively and the corresponding figures for daily carcase gains were 0.47 and 0.45 kg.

In Experiment 2 (1981) grass was direct cut with a double chop harvester on 30th May and ensiled either without preservative or with 85% formic acid at 3.0 l/t, or with 45% sulphuric acid at 1.5, 3.0, 4.5 and 6.0 l/t. Four yearling Friesian steers per treatment were individually fed the silages *ad libitum*, without supplement for 35 days. Silage D.M. intake was recorded and was 2.0, 2.1, 1.9, 2.0, 2.0 and 2.0% of mean liveweight for the 6 treatments respectively.

In Experiment 3 the same treatments and harvesting system were applied as in Experiment 2, except it was carried out using the regrowth followng Experiment 2. It was cut on 30th July 1981 and was fed similarly to 4 weanling Friesian steers per treatment for 56 days. Silage preservation and digestibility was similar for the 6 silages and D.M. intakes (% liveweight) were 2.1%, 2.2%, 2.2%, 2.1%, 2.1% and 2.2%, in the same order as for Experiment 2.

For Experiment 4 (1981) three successive cuts of silage were harvested on 2nd June, 29th July and 6th October using a double chop harvester. Within each cut, grass was treated at ensiling with either (a) no preservative (3 tonne negative control clamp), (b) 2.3 l/t of 85% formic acid, (c) 2.3 l/t of 45% sulphuric acid or (d) 4.2 l/t of 45% sulphuric acid. A group of 16 heifers were allotted to each of (b), (c) and (d) and within each of these, first, second and third cut silages were fed in sequence. Within each group of 16 heifers, half were supplemented with 2.39 kg rolled barley daily. This feeding trial lasted 191 days. Preservative treatments (b), (c) and (d) resulted in similarly preserved silages and similar carcase gains (approximately 0.36 kg daily) and similar intakes of silage D.M. There was no interaction between supplement and preservative treatments.

The copper status of the animals in Experiments 2-4 and the copper, sulphur and molybdenum levels in the parent grass and the resultant silages were determined.

Based on all results accumulated to date, it may be concluded that sulphuric acid is an effective silage preservative treatment and may be used as an alternative to formic acid.

EFFECTS OF MODERATE AND HIGH LEVELS OF RELATIVE HUMIDITY AT 15°C and 7°C ON CALF HEALTH AND PERFORMANCE

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These experiments are part of current research in calf housing, involving comparisons of house types and model studies of basic designs.

Two expernments with purchased Friesian male calves (approximate age 7 days) were used to evaluate the effects of 75% versus 95% RH, at 15°C in Experiment 1 and at 7°C in Experiment 2. In each experiment the calves were blocked on a liveweight basis and allocated at random to one of two physchometric houses (20 calves per house). They were individually penned on wooden slats for a 42 day experimental period. The fresh air ventilation rate in each house for both experiments was 0.4 m^3/hour/kg liveweight with a recirculation rate of 26 air changes per hour. Calves were fed a milk replacer diet at 38°C twice daily by bucket in proportion to metabolic liveweight ($M^{0.75}$) and the amount fed was adjusted weekly. At 15°C the respective intakes of milk replacer (kg/calf) and average liveweight gains were 27.34 and 27.15 kg and 330 and 347 gms/day for 75% and 95% RH and at 7°C the corresponding values were 27.39 and 26.79 kg and 403 and 345 gms/day. The difference between the latter liveweight gain calves was statistically significant ($P < 0.05$) which suggests that damp conditions decreased calf performance in Experiment 2.

Health observations indicated that the incidence of respiratory infections decreased with increased RH. Radiological examinations conducted at 21 day intervals showed more apparent lung damage in calves housed at 75% compared with 95% RH.

The corresponding total viable bacterial counts per litre of air were 5.25 and 8.44 colony forming units at 15°C and 2.37 and 2.20 colony forming units at 7°C respectively, thus indicating that warm, damp conditions favoured the survival of airborn bacteria.

These two experiments suggest that the calves' tolerance of high humidities may be dependent on the temperature at which the calf is housed.

SUPPLEMENTATION OF GRASS FED CALVES

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Two experiments were described in which 14 week old calves were fed grass alone or supplemented with milk or concentrates. In absolute terms, all supplements depressed grass intake and increased total dry matter intake, the effects of concentrates being greater than those for milk. As a function of bodyweight however, there was little difference in total dry matter intake between the various treatments. All supplements improved calf performance, the response to milk being greater than that to concentrates regardless of the basis for comparison. The regressions of calf performance (Y in g/d) on supplement level (X in kg DM/d) were:

Milk: $Y = 668 + 463X, R^2 = 0.99$
Concentrates: $Y = 665 + 155X, R^2 = 0.98$

Efficiencies of utilization of milk DM, ME and NEg were 2.7, 2.0 and 1.5 times those for concentrates. The performance of milk supplemented calves was higher and that of concentrate supplemented calves was lower than predicted from their ME intakes. There was no response from treatment of the soyabean fraction of the concentrates with formaldehyde. When fed at the same net energy level, there was no difference between milk replacers of different ME concentrations.

PROCESSING OF CONCENTRATES FOR EARLY-WEANED CALVES

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Concentrate mixtures based on barley and soyabean meal have proved successful in the feeding of early-weaned calves over a number of years. It is claimed that the incidence of digestive problems, such as bloat and acidosis (potential hazards for ruminants on high-concentrate diets) is minimised by judicious processing of the concentrates and/or the provision of some long roughage. The work reported investigated the effect of (i) method of processing of concentrates and (ii) inclusion of 3.5% fat in concentrate mixture on calf performance in an early-weaning system of rearing.

The following concentrate treatments were compared :

A. Whole barley 62.5%, soyabean meal 25%, Cassava 3.5%, molasses 5.0%, and mineral/vitamins 3.0%, prepared as 8 mm pellet.
B. Composition as A but barley ground and concentrate prepared as 5 mm pencil.
C. Same as B except cassava replaced by 3½% tallow.

The three concentrate treatments were compared under *ad libitum* feeding with calves bedded on straw and having free access to hay (Trial 1) and with calves in crates without access to long roughage (Trial 2).

In Trial 1 concentrate treatment had no significance on liveweight gain or rumen pH and there were no digestive problems. In trial 2 liveweight gain, concentrate intake and rumen pH values were significantly higher on Treatment A than on Treatments B and C. Bloating was not apparent on Treatment A but calves on Treatment B suffered from persistent bloat. Thus, it appears that method of processing of concentrates can have a significant effect on the incidence of bloat and liveweight gain in calves and that there is likely to be an interaction between type of processing and the supply of long roughage. Long roughage intake accounted for less tharn 10% of total dry matter intake in Trial 1.

EFFECT OF MILK FEEDING REGIME AND METHOD OF PROCESSING OF CONCENTRATES FOR CALVES ON PERFORMANCE

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A 3 x 2 factorial design, involving 60 Friesian bull calves, was used in which two milk feeding regimes and three methods of processing the barley in the concentrate mixture were compared. The milk-feeding regimes were : (i) *ad libitum* feeding of acidified milk fed cold for 46 days (mean milk powder intake, 42 kg) and (ii) early weaning in which a restricted level of milk replacer was fed warm twice daily until weaning at 26 days (mean milk powder intake, 10.2 kg). The concentrate mixture (barley, soyabeans, minerals, vitamins) which was fed as a 9.5 mm pellet differed in method of processing the barley prior to pelleting as follows: (i) whole barley, (ii) whole barley treated with sodium hydroxide (28.2 g sodium hydroxide per kg barley) and (iii) ground barley.

The experimental period lasted 11 weeks during which time the calves were bedded on straw and had free access to hay, concentrates and water.

Mean daily liveweight gain was significantly higher on the *ad libitum* milk feeding regime than on the early weaning regime during the first four weeks (0.62 versus 0.45 kg) but there was no significant difference in daily gain (*ad libitum* milk : 0.81 kg, early weaning : 0.79 kg) over the 11-week period. The total mean concentrate intake was 58 kg higher on the early weaning system than on the *ad libitum* milk feeding system.

Calf performance was not significantly affected by method of processing of concentrate although calves on the "ground barley" tended to have the lowest concentrate intakes and liveweight gains.

Calf rearing regime did not have any significant effect on subsequent performance or on carcase weights at the two-year-old stage.

COMPARISON OF BEEF SIRE BREEDS FOR GROWTH AND CARCASS TRAITS

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Over 70% of our beef in Ireland originates in the dairy herd, either in the form of pure Friesian animals (36%) or Friesian x beef sire steers and heifers (36%). The remainder comes from the suckler herds. In 1978 about 20 herd owners agreed to cooperate in using a proportion of beef sire inseminations on a random sample of their cows. Progeny of these matings from six sire breeds (Charolais (CH), Simmental (S), Friesian (F), Hereford (H), and Angus (AA) were purchased the following spring and reared on a commercial basis to slaughter at 28 months (67 heifers) and 31 months (89 steers) of age. Heifers and steers were separated after their first winter; all breeds had steer and heifer progeny except Friesians (steers only).

On an age constant basis CHx and Sx steers had 6% and 5% heavier carcass weight and weight for age than Friesians, which were similar to the overall breed average; AA steers were 10% lighter. CH, H and S heigers were 5%, 4% and 3% above average carcass weight, and AA 10% below. Limousins had significantly better killing out percentage, while CH steers and heifers and S heifers had significantly better conformation, and F steers and AA heifers significantly poorer conformation than the overall mean. F steers and S steers and heifers had significantly greater carcass depth.

In a second trial of 57 intensively reared heifers (16 month old beef) of CH, F and H, Charolais had significantly better carcass weight (10%) carcass weight for age (9%) and killing out percentage (55.5 vs 51.9); than Friesians; they also had significantly better conformation and lower fat scores. Herefords had lower carcass weight and growth rate (3.4%), better killing out percentage (53 vs 51.9) and conformation, than Friesians.

In a third trial involving steers of the same three breeds fed at two feed levels and slaughtered at three different carcass weights, Charolais had significantly greater carcass weight for age (15%) conformation and killing out percentage than Friesians,, with Herefords being intermediate.

Killing out percentage and conformation scores improved as slaughter weight increased. Friesian had slightly longer and deeper carcasses than either Charolais or Hereford.

These trials confirm that Continental cattle have superior growth rate (av. about 10%) and conformation, than Friesians. In order to obtain the best results from continental crosses they should be fed more intensively than under our traditional extensive system.

THE EFFECT OF SODIUM HYDROXIDE TREATMENT OF WHOLE BARLEY ON ITS NUTRITIONAL VALUE FOR THE PIG WHEN PRESENTED IN THE MILLED AND UNMILLED FORMS

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Whole barley grain of 821 g DM/kg was treated with an aqueous solution of sodium hydroxide (270 g NaOH/kg) to give 33.8 g NaOH/kg DM. This treatment softened the seed coat of the barley so that it could be easily rubbed off by hand. Barleys both in the untreated state and treated with NaOH were then included at the rate of 800 g/kg in the ground and unground forms in the diets of 48 individually penned pigs from 31.6 kg until slaughter at 81.7 kg liveweight. The diets were fed to a scale which gave equal amounts of dry matter offered daily on all treatments.

Treatment of barley with NaOH did not affect the rate of growth or feed conversion ratio obtained with the diet containing whole barley but with ground grain there was a significant ($P < 0.001$) deterioration in both variables. For the diets with untreated ground and treated ground barley the liveweight gains were 571 and 445 $\pm$ 11.5 g/d respectively and the feed conversion ratios (DM basis) were 2.69 and 3.16 $\pm$ 0.071 respectively.

Grinding improved growth rates ($P < 0.001$) and feed conversion ratios ($P < 0.001$) with untreated barley. With the untreated whole and untreated ground diets the liveweight gains were 484 and 571 $\pm$ 11.5 g/d respectively while the feed conversion ratios (DM basis) were 2.69 and 3.16 $\pm$ 0.071 respectively. No improvement in performance resulted from grinding treated barley.

Grinding significantly increased the digestibility of energy and nitrogen. Treatment with NaOH improved the digestibility of energy from 441 to 582 $\pm$ 20.1 g/d ($P < 0.001$) in diets with whole barley. The digestibility of energy remained unaffected by treatment with NaOH.

Treatment of barley with NaOH did not improve nutritive value of either ground or whole barley but the apparent utilisation of digested energy for growth was severely depressed.

MICROMANIPULATION OF EMBRYOS

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This report described efforts to produce identical twins in cattle and sheep. Embryos were produced following the hormonal induction of superovulation. The *zona pellucida* of the embryos was opened and the blastomeres evacuated with a micromanipulator. The blastomeres were then grouped in two halves and replaced in previously evacuated *zonae pellucidae*. The rupture in the *zona pellucida* was sealed using a 1% agar solution in sodium chloride; the cylinders were transferred to the oviducts of synchronized ewes for 4-5 days. Overall 40% of split sheep embryos and 75% of split cow embryos continued development when recovered. Five of eight recipient cows were palpated pregnant at 90 days following transfer either surgically or non-surgically with micromanipulated embryos.

FREEZE-STORAGE OF CATTLE EMBRYOS

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The advantage of being able to successfully freeze embryos include the following: facilitate the wide scale application of embryo transfer, dispense with the requirement to maintain large recipient herds, genetic studies, immunological studies, breed preservation, help to overcome transport and quarantine restrictions in addition to numerous other potential uses. Applications such as these are dependent on obtaining a simple freezing method which will ensure high embryo survival rates following thawing. The freezing process consists of partial dehydration by the stepwise addition of a cryoprotective agent and freezing very slowly to temperatures between $-30^{\circ}C$ and $-60^{\circ}C$ prior to transfer to liquid N_2 at $-196^{\circ}C$.

Day 6 and Day 7 embryos were collected from superovulated donors and exposed to increasing concentrations of a cryoprotectant and cooled from $20 - 22^{\circ}C$ to $-7^{\circ}C$ at $1^{\circ}C\ min^{-1}$. Crystalization or seeding was induced at $-7^{\circ}C$. Following seeding, embryos were cooled to final temperatures of $-60^{\circ}C$ (Method 1), $-33^{\circ}C$ (Method 2), $-36^{\circ}C$ (Method 3) at varying rates between 0.1 and $0.3^{\circ}C\ min^{-1}$ before direct transfer to liquid N_2 for longterm storage.

Embryos frozen by Method 1 were slowly thawed by direct transfer from $-196^{\circ}C$ to $-50^{\circ}C$ and from $50^{\circ}C$ to $-10^{\circ}C$ at $10^{\circ}C\ min^{-1}$ and from $-10^{\circ}C$ to a waterbath at $20\text{-}22^{\circ}C$. Embryos frozen by Methods 2 and 3 were thawed by transferring directly from $-196^{\circ}C$ to a waterbath at $20\text{-}22^{\circ}C$. The cryoprotective agent was removed by exposing the embryos to a decreasing gradient of the cryoprotectant. Embryos undergoing normal development in culture, and expansion of the blastocoetic cavity and/or hatching from the zona pellucida were considered to have survived.

Embryo survival rates for Day 6 embryos following freezing by all three methods were 0. Embryo survival rates following freezing/thawing for Day 7 embryos were 14%, 75% and 74% for Methods 1, 2 and 3 respectively.

Following thawing and cultures, embryos showing normal development were transferred to recipients to determine pregnancy rate. Pregnancy rates of 87% and 63% ($P > 0.05$) were achieved following a single ipsilateral transfer of either a fresh or frozen embryos.

In a further experiment in order to simplify the de- and rehydration processes, direct and stepwise de- and rehydration were compared using the optimum freezing/thawing procedures. Embryo survival rates were high (80%) and similar for all four possible combinations.

RELATIONSHIP BETWEEN OVULATION RATE AND EMBRYO MORTALITY IN SHEEP, CATTLE AND PIGS

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The number of offspring born per conception depends on ovulation rate and embryo survival, since fertilisation is essentially an all-or-none process. Information on the relationship between ovulation rate and embryo mortality may be used to predict litter size, if a suitable model for the distribution of deaths can be formulated. From a study of an extensive set of sheep data from both natural matings and from egg-transfer experiments it appears reasonable to assume that the distribution of the number of surviving embryos for a given ovulation rate, is binomial. Consequently, embryo loss rate may be estimated from data on pregnant females only and such an analysis for published data on sheep shows that the probability of embryo loss increases linearly with increasing ovulation rate over the range 2-8 eggs shed. The resulting estimates combined with the binomial distribution model, yield the following curvilinear relationship between ovulation rate (X) and litter size (Y): $Y = 0.15 + 0.926X - 0.0763X^2$.

A survey of published literature on embryo mortality in multiple ovulating cows suggests the possibility that the distribution of twin ovulations between the unilateral and bilateral types may depart substantially from that expected under a model which assumes independent sampling of ovaries for the location of twin ovulation points. The observed distributions differer substantially among studies ($P < .01$) reported in the literature, with observed proportions of unilateral twin ovulations varying from 0.42 to 0.76. Published data on twin pregnancies and their associated ovulation counts revealed that 75 per cent of twin pregnancies (due to twin ovulations) were associated with bilateral ovulation points. This result together with the data on the distribution of twin ovulations indicates a substantial difference in embryo survival between bilateral and unilateral twin ovulating cows. Using the same model as for sheep the probability of embryo death was estimated to be 0.22 higher for unilateral twin ovulations than for bilateral twin ovulations. The rate of embryo loss in bilateral twin ovulations appeared to differ little from the loss in single ovulating cattle. Using a base value of 0.30 for embryo loss in cows with single bilateral twin ovulations the following relationship between ovulation rate and litter size was derived.

Ovulation rate	Predicted litter size
1.2	1.08
1.3	1.12
1.4	1.17
1.5	1.21

The relationship is essentially linear over the range of ovulation rates of likely interest for cattle. The predicted litter size was not very sensitive to changes in the proportion of unilateral twin ovulations but, as expected, depended critically on the level of embryo mortality in twin ovulations.

The relationship between ovulation rate and embryo loss in pigs also shows an increasing rate of embryo mortality as the number of eggs shed increases, with evidence of a curvilinear relationship between ovulation rate and litter size. Available data in the literature do not allow a detailed examination of the distribution of embryo survival in the pig as a function of ovulation rate. In contrast with sheep there is good evidence for considerable breed differences in embryo survival rate and also a suggestion that uterine capacity in the sow may be a function of age with gilts being least able to accommodate increases in ovulation rate.

The relationship between ovulation rate and litter size in sheep has been found to give accurate predictions of litter size from data on ovulation rate. Predictions for the cattle have not been tested while in the case of pigs there is likely to be a need for breed specific relationships.

HEAT DETECTION BY TIME-LAPSE VIDEO RECORDING

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The experimental technique of recording animal behaviour by time-lapse video recording has been used to study the changes which occur during oestrus in small groups of housed beef-type heifers exposed to low levels of artificial light during the hours of darkness. The conditions of these experiments are similar to that practised on normal dairy farms in Northern Ireland where 70% heifers are bred in winter and up to 90% of farms provide artificial light overnight during the winter months.

In the first experiment, 6 heifers were fed (hay and concentrate) at 8.30 am and were continuously observed throughout a total of 15 heats. Using this management system the mean duration of heat was 14.9±6.1 hours and the specific heat-associated activities were concentrated within the period 6 pm to 6 am. Proportionately fewer signs were shown during the period 6 am to noon. These observations confirmed those of previous workers (Hurnick, King and Robertson, 1975) that the maximum activity coincided with the period when the animals are least likely to be observed. Since the results of the experiment indicated that there was a fall in activity following feeding, this aspect was investigated in a second experiment.

In experiment II the feed was presented at 8.30 p.m. and the other experimental conditions were retained as previously. A total of 12 heats were observed with a mean duration of 18.1±3.5 hours. Heat activity was changed. The majority of activity occurred during the normal working day and 75% of all the events occurred between 7 am and 9 pm. The overall frequency of the heat signs also appeared to be increased. These differences were shown to be statistically significant (P less than .01) but in view of the small number of heats observed other factors, as yet undetermined, may have been involved. Further studies in this area are being carried out.

In the third experiment one heifer was removed from the group, replaced by a teaser bull, and feeding again occurred at 8.30 am as in experiment I. A total of 10 heats were observed with a mean duration of 16.1±4.1 hours. The investigatory behaviour of the bull, when no heifer was in oestrus or approaching oestrus, occurred mainly during the day, being distributed approximately in the ratio 3 : 1 (day : night). This pattern of behaviour resulted in the distribution of heat signs displayed by the oestrous heifers being similar to that in experiment II. This may explain why the inclusion of a bull is often claimed to enhance heat observation in heifers. The presence of the bull however reduced the frequency with which heat signs were displayed by the heifers.

Although the number of heats examined in each experiment was small the results suggest that heat detection may be improved by changes in management which could readily be applied by dairy farmers.