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A Review of The Grass Growing Year 1989

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Efficient production and utilisation of grass were never so important for dairy farming as at the present. With the imposition of milk quotas and more recently the falling milk price, input costs must be minimised. Efficient use of grassland is the key. In this paper the grass growing season of 1989 and the management factors adopted at Moorepark to alleviate the effect of the mid-summer drought are outlilned. Results are also reported on two concentrate supplementation trials at pasture with different energy and protein sources.

Grass growth versus cow requirement

Figure 1 shows the average seasonal growth pattern of grass for 1982-7, 1988 and 1989. Figures 2 and 3 show seasonal growth patterns for 1988 versus the growth pattern required to supply a given level of DM intake. Cow requirement is based on a stocking rate of 0.85 acres/cow with 45 and 35 percent of the farm closed for first cut and second cut silage, respectively, with high level of nitrogen usage and concentrates taken out of the system by late April. The intake requirement is based on a cow of average bodyweight 550 kg. a January 1 calving date and an adjustment for stage of lactation (ARC, 1980). In 1988 seasonal growth pattern was greater than cow requirement until the end of September. In contrast there was a large deficit in cow requirement during late July and early August in 1989. A feature of 1989 was the poor growth rate during the April period and the very good grass growth in late August and September.

Silage yield and quality

Table 1 shows the silage analyses for the Dairymis II Discussion Group in Fermoy (28 farmers) for both 1988 and 1989. The first cut silages were on

Table 1
Dairymis II Silage Analyses 1988-89

		%DM	pH	%DMD
1st cut	1988	21.1	3.95	70.0
	1989	25.7	4.09	71.1
2nd cut	1988	22.1	3.80	65.4
	1989	32.0	4.26	69.9
3rd cut	1988	18.0	4.15	69.8
	1989	21.5	4.00	70.8

Table 2
Curtins Farm - Silage Yield 1989 (0.85 Ac/Cow)

Cut	%Farm Closed	Tonnes/Acre	Tonnes/Cow	DMD
1	45	10.7	4.0	72
2	35	4.1	1.1	72
3	20	9.8	2.0	71
Total			7.1	

average of a higher dry matter content, similar preservation and slightly higher digestibility for 1989 when compared to 1988. The second cut silages were also of higher dry matter content, with equally good preservation and much higher digestibility. The third cut silages had smilar analyses of equally good quality.

Table 2 shows the silage yield and digestibilities for Curtins farm at Moorepark. The notable feature is the very poor yield of second cut silage and the very large yield for the third cut. This shows the advantage of taking a third cut of silage in a year with severe drought conditions in mid-summer. This cut of silage was also taken without having a feed deficit on the grazing area (Figure 3).

Measures taken during the drought period

As we have seen in Figure 3 there was a large feed deficit period in the late July-August period. Figure 4 shows part of a lactation curve for a herd of cows

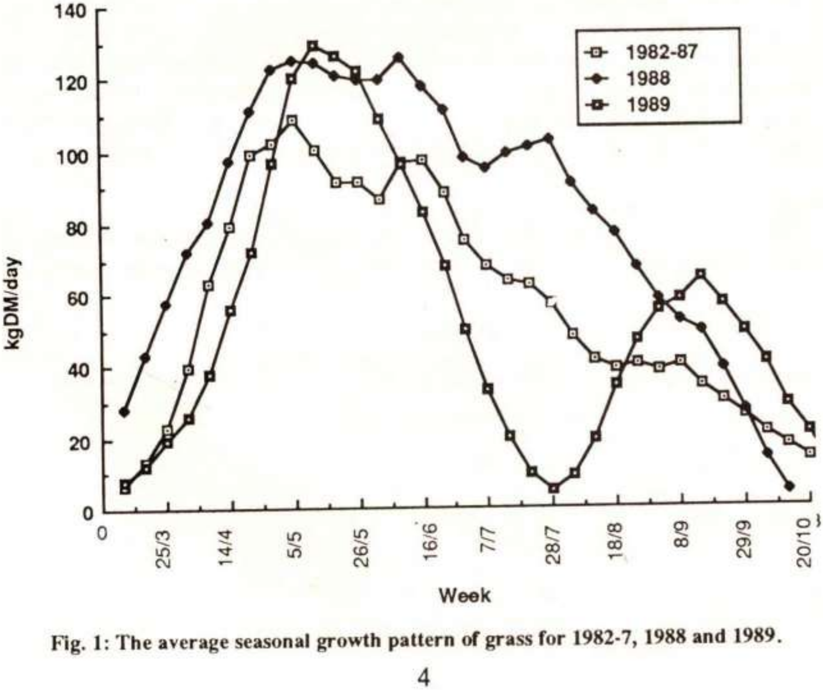

Fig. 1: The average seasonal growth pattern of grass for 1982-7, 1988 and 1989.

Table 3
Milk Concentrate Price Ratio

Year	Milk p/kg	Concentrate p/kg	Ratio (kg milk/kg conc)
1982	13.85	15.3	1.10
1983	15.20	16.4	1.08
1984	15.72	18.2	1.16
1985	16.36	16.0	0.98
1986	16.62	15.3	0.92
1987	17.46	14.3	0.82
1988	19.42	13.4	0.69
1989	22.01	15.0	0.68

at Moorepark. Daily milk yields were reduced by almost 0.7 gals/cow in the two weeks at the onset of the drought. During the following four weeks when grass growth was almost at zero the cows were supplemented with 5 kg. of hay plus 20 kg. of wet brewers grains. In this period it was estimated that the cows were being supplemented with 80% of their feed requirement. The supplements maintained milk yields at 14.5 kg./cow/day. It can be seen from Figure 4 that when grass growth recovered the milk yield of the cows partially recovered.

Supplementary feeding of grazing dairy cows

Supplementation of grazed pasture may be necessary in early spring after turn out due to poor grass growth, in mid-summer in the event of a drought and

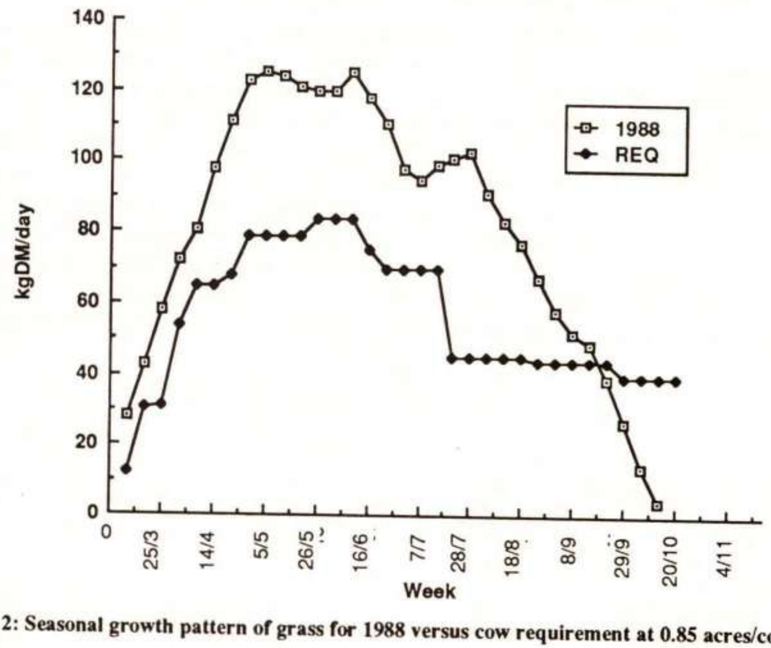

Fig. 2: Seasonal growth pattern of grass for 1988 versus cow requirement at 0.85 acres/cow

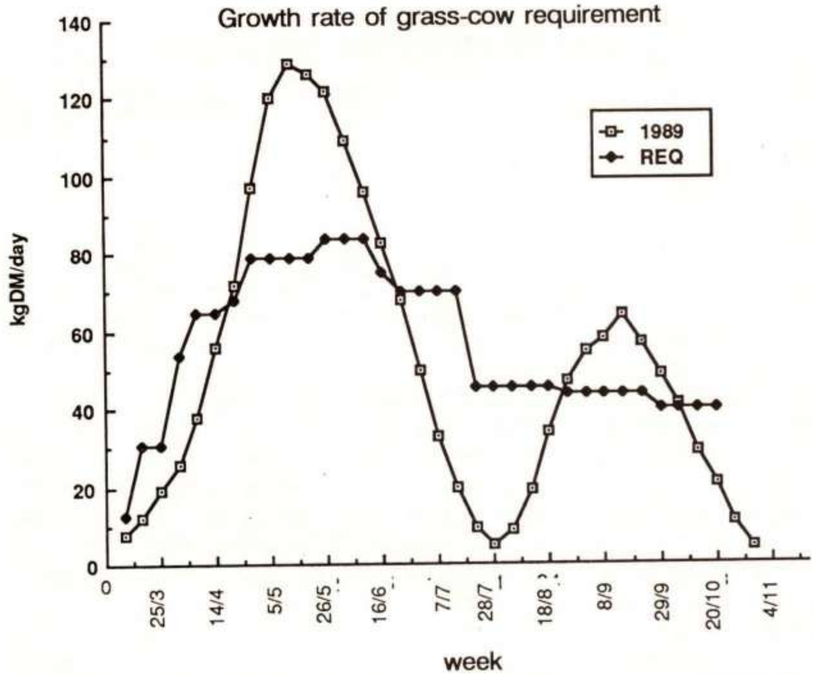

Fig. 3: Seasonal growth pattern for 1989 versus cow requirement at 0.85 acres/cow.

from September onwards due to declining growth rates of grass. The type of supplement fed can range from a forage, i.e. a high quality silage, to a concentrate. A concentrate can be either an energy and/or a protein source. Milk production responses to concentrate feeding have generally been poor and uneconomical. The major reason for the poor responses to concentrate feeding at pasture is the substitution of concentrate for grazed grass. This is defined as the decrease in grass intake per unit of concentrate fed. The most important factors that affect substitution rate are grass intake and digestibility. When intake or digestibility of grass is high substitution rate is also high. Many other factors affect substitution rate, such as concentrate type, lactation stage, cow genetic merit and level of concentrate feeding. Experiments at Moorepark from 1976-

Table 4
Chemical composition of the supplements (g/kg DM0

	Barley	Molassed Beet Pulp	Brewers Grains
Dry matter (g/kg as fed)	871	875	251
Ash	49	87	37
Crude fibre	43	139	177
Crude protein	137	109	266
Crude protein degradability (%)	80	80	60

Table 5

Milk production (kg/day) responses to barley, molassed beet pulp and brewers grains as supplements to grazing dairy cows

	Control	Barley	Molassed beet pulp	Brewers grains	SED
Milk production	10.5	12.7	13.9	14.0	0.56
Fat %	4.10	3.69	4.08	3.77	0.144
Protein %	3.68	3.80	3.81	3.64	0.084
Lactose %	4.20	4.26	4.25	4.20	0.073
Kg milk/kg conc.		0.44	0.68	0.69	

1987 under a wide range of grazing pressures, types of concentrates and at different times of the grazing season gave an average response of 0.50 kg. milk/kg. of concentrate. Table 3 shows the milk/concentrate price ratio from 1982-1989, taking the average milk and concentrate prices from the Dairymis II Discussion Group in Fermoy. Over that period the price of milk increased relative to the cost of concentrate. Therefore the break-even milk production response in 1989 was 0.68 kg. milk/kg. of concentrate fed when concentrate costs £140/tonne and milk was priced at 22p/kg.

Two experiments were carried out in Moorepark during the grazing season in 1989 with different energy and protein sources as supplements to grazing dairy cows.

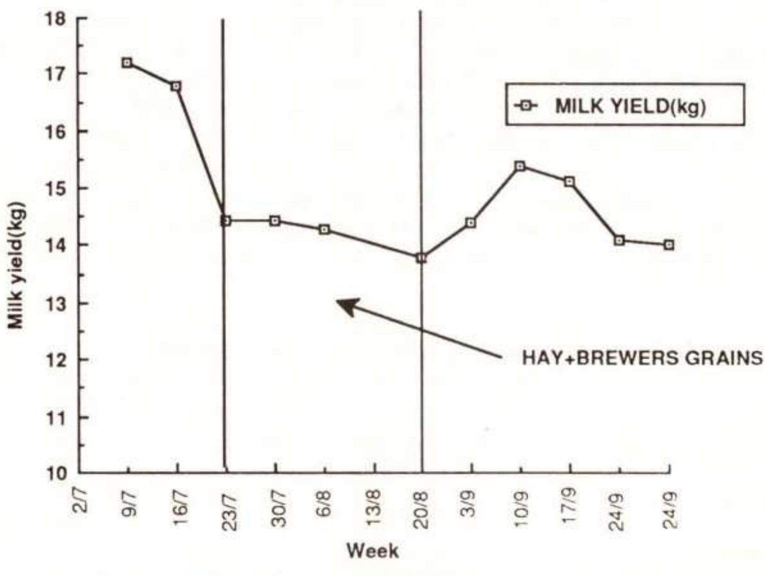

Fig. 4: Daily milk yields (kg/cow/day) during the drought of 1989.

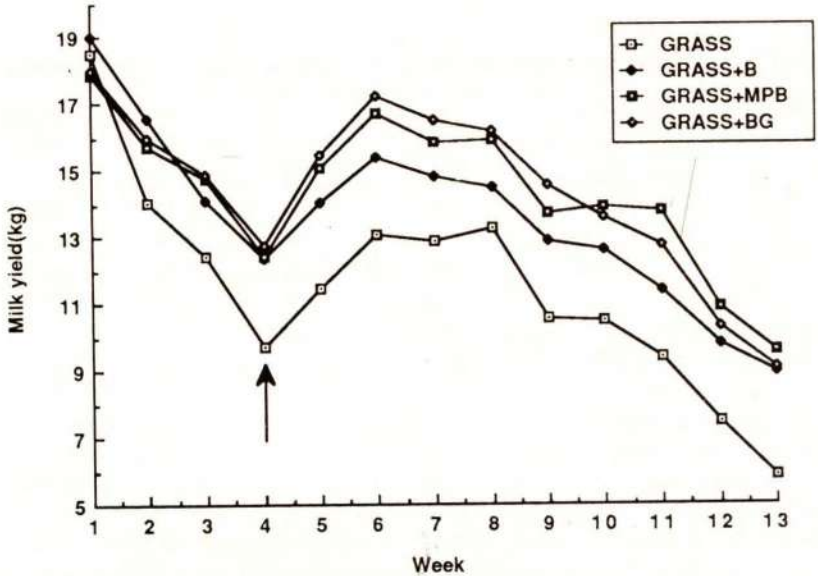

Fig. 5: Milk production patterns of cows supplemented with different energy sources.

Experiment A

High quality fibrous concentrates have been reported to give higher milk production responses and lower substitution rates compared to starchy concentrates when fed to grazing dairy cows (Meijs, 1985). Very large substitution rates with barley compared to both molassed beet pulp or beet pulp nuts were found with grazing dairy cows (Stakelum and Dillon 1988). The large substitution rate was associated with reduced pH and increased lactate concentration in rumen fluid shortly after feeding (Dillon, Stakelum and Murphy, 1989).

Four groups of 22 cows were assigned to four treatments, i.e. grass only, grass plus barley, grass plus molassed beet pulp and grass plus brewers grains. The experiment was conducted for 13 weeks from late July until late October. The supplements were fed immediately after morning milking. The barley and molassed beet pulp were fed at 4 kg. /cow/day for the first 4 weeks in conjunction

Table 6
Chemical composition of the supplement (g/kg DM)

	Barley	Soya	Sopralin
Dry matter (g/kg as fed)	896	900	892
Ash	49	88	76
Crude fibre	46	47	45
Crude protein	121	478	509
Crude protein degradability (%)	80	70	25

with 4 kg. of hay supplement. Thereafer, as grass growth returned to normal following the end of the drought, the cows were fed 5 kg./cow/day with no hay supplement. The brewers grains were fed at 15 kg./cow/day for the first 4 weeks and thereafter at 20 kg./cow/day. The chemical composition of the supplements are given in Table 4. Table 5 shows the milk yield, milk composition and milk yield response to the different supplements. All three supplements significantly increased milk yield over the control. The molassed beet pulp and brewers grains gave significantly higher milk yield than the barley supplement. Fat content was significantly decreased in the brewers grains and barley groups compared with the grass only treatment. Protein content was significantly increased for the barley and molassed beet pulp compared with the grass only treatment. Figure 5 outlines the milk production pattern of the four treatment groups. There appeared to be no difference in milk yield during the first four weeks when the hay supplement was fed. During the later part of the experiment after grass growth rate resumed the differences between the groups manifested themselves. The experiment supports previous work that higher milk yield responses are obtained with high quality fibrous concentrates compared to starchy concentrates when fed at pasture.

Experiment B

The crude protein fraction of grazed herbage is a complex mixture of proteins, peptides, amino acids and non-protein nitrogen. When herbage enters the rumen, the rumen microflora ferment the soluble and structural carbohydrates to yield a mixture of volatile fatty acids. In so doing they also digest the protein fraction in the herbage with the release of ammonia. Subsequently the microflora

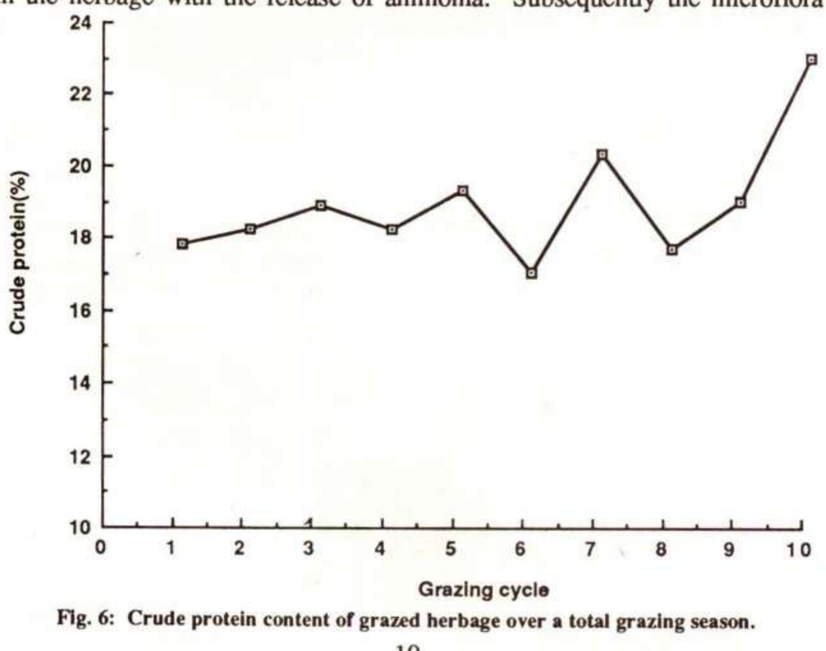

Fig. 6: Crude protein content of grazed herbage over a total grazing season.

synthesise their own protein and utilise the ammonia as a nitrogen source. The net result is that a major portion of the protein passing out of the rumen and into the small intestines is of microbial origin. Microbial protein is of average biological value, i.e. it could be deficient in certain essential amino acids. Therefore when higher quality unprotected protein is fed (high in biological value) it can be transformed into low quality by breakdown in the rumen. There is evidence in the literature that there is a positive response in milk production to feeding protected protein at pasture (Minson, 1981).

Figure 6 outlines the crude protein content of herbage across a full grazing season. More recent results at Moorepark show that the actual herbage selected by the grazing cow is of a still higher crude protein content. Experiments at Moorepark indicate that of the total herbage crude protein ingested, 75% is rapidly degraded in the rumen (RDP) and 25% is resistant to further breakdown and passes onto the small intestines as undegraded protein (UDP) (Stakelum, Dillon and Murphy, 1988; Dillon et al., 1989). An experiment was conducted in Curtins farm at Moorepark to evaluate milk production responses to different protein supplements compared to an energy source. Four groups of 18 cows were assigned to four treatments, i.e. a grass only group, grass plus 3.2 kg. of barley,

Table 7

Milk production (kg/day) responses to barley, soya bean meal and sopralin as supplement to grazing dairy cows

	Control	Barley	Soya	Sopralin	SED
Milk production	12.6	13.1	13.3	14.4	0.61
Fat %	3.74	3.65	3.67	3.44	0.096
Protein%	3.75	4.02	3.97	3.86	0.070
Lactose %	4.29	4.48	4.60	4.51	0.051
Kg. milk/kg conc.	-	0.16	0.24	0.58	

grass plus 3 kg. of soyabean meal and grass plus 3 kg. of sopralin. The experiment lasted nine weeks from early September until late November when cows were late in lactation. The supplements were fed immediately after the morning milking. The chemical composition of the feeds is given in Table 7. Table 8 shows the milk yield, milk composition and milk yield responses to the different supplements. The sopralin supplement significantly increased milk yield and decreased fat content over the grass only treatment. The barley and soya supplements significantly increased protein content. It is not possible to explain whether the much larger positive response to the sopralin was due to more amino acids reaching the small intestines or a dietary energy response. However, the response to sopralin is not an economic one due to the high price of the concentrate. The much lower response to the barley in this experiment compared to Experiment A was due to a higher supply of grass.

Conclusion

With falling milk prices and fixed quotas it is imperative that grassland management be excellent and that concentrate feeding on grass is eliminated where adequate grass is available. However, there can be periods during the grazing season when cows might be short of feed (i.e. drought of 1989) and a supplement would then need to be fed. There is clear evidence that a fibrous type concentrate gives much better milk yield responses than a starchy concentrate when fed as a supplement to grazing dairy cows. In the future, however, conserving extra silage in order to use it as a supplemnt during periods of grass shortage may be more economical. The surpluses which arise during the grazing season could be conserved as silage by the use of a flexible management system based on tight grazing to 6 cm in order to maximise quality of grass under grazing. At present it is not possible to define under what circumstances an economical response may be got from feeding undegradable protein. Where adequate grass was available, very poor responses were obtained from feeding degradable protein.

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Breeding Policies for the '90's

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The American economist Francis Fukuyama, viewing the collapse of communism in Eastern Europe, recently announced "This is the end of history". He exaggerates of course, but looking at the current and impending changes on the cattle breeding scene here in Ireland, and indeed throughout Europe, one can feel a similar sense that an old order is passing and that the future will be very different from what we have been used to.

- The decades of growth in output fuelled by expanding population, rising living standards and the sustaining hand of Brussels, have come to an end. In those days, the good, the mediocre and the bad could all survive. For the future, the uncompetitive will face declining fortunes. That applies to breeds, breeding programmes and breeders, as well as to farmers and farming systems.
- Governments everywhere are getting out of the breeding business, and nowhere faster than in Ireland.
- In its drive to "complete the internal market" by 1992, the EEC has ordained a deregulation of the AI industry. That industry in Ireland, as elsewhere, has developed as a protected monopoly; in future it will have to fight for its share of the market.
- The quota regime changes dairy farmers' breeding objectives; for some it intensifies the drive to more specialised dairy types, while for others it signals a return to dual purpose aims.
- The search for new breeds is finished; we have tried all the likely beef breeds, and the Holstein is the third and last foreign wave of dairy genetic material to hit our shores.
- Two elements of semen and embryo technology, at present showing promise in the laboratory, have the potential to change the cattle breeding scene beyond anything we would recognise.

The purpose of this paper is to discuss our options in the light of these developments.

AI

AI is the principal medium for genetic improvement in our cattle. Not alone are more than half the cows bred by AI, but most of the remainder are bred by sons of AI bulls. Furthermore, it is the sector in which policy decisions can have a big impact; several bulls here bred over 30,000 progeny each last year.

The percent of cows bred by AI in Ireland is rather low by European standards (Table 1). Our figure is 51%, the lowest in northern Europe. Elsewhere, with the exception of Britain and France, the norm is 90% or higher.

Table 1:
Cow populations, % beef cows, and AI use in some European countries (1988).

	Million cows	% Beef cows	% AI
France	9.0	38	57
U.K.	4.3	32	61
Ireland	1.9	28	51
Germany	5.1	2	97
Netherlands	2.0	1	88
Denmark	0.8	1	97
Norway	0.3	1	98
Sweden	0.6	2	88

Part of the reason for the low AI usage in Britain and France is the high proportion of beef cows in those countries. For obvious reasons, AI is both less convenient and less obviously valuable in suckler herds. In France, while AI usage is 80% in dairy herds, it is only 20% in suckler herds. Perhaps this is the reason for the low penetration rate here, though curiously, a survey of 600 suckler herds in 1985 by G. J. More O'Ferrall and colleagues showed a 60% AI usage level. At any rate, there seems to be no good reason why we should be so significantly behind the rest of northern Europe in AI usage levels, and one of the expectations for the future should be an increase in its use.

The structure of the AI business in Ireland has remained essentially unchanged for over 30 years, with two exceptions: Ballyhaise gave up their bull stud, and the five Munster centres set up a joint bull acquisition and testing programme. We can expect substantial changes in the near future. Elsewhere in Europe, AI organisations are amalgamating and consolidating to face the competition which will come with the EEC deregulation of 1992. The legislation for this is already in place, and its intention is to promote free trade in semen and embryos within the Community. Health regulations, which have isolated us from Continnetal imports in the past, will no longer be a problem. Among other things, the Commission proposes to eliminate Foot and Mouth vaccination throughout the Community.

Indeed, this competition is already here in a substantial way; this year at least 100,000 units of semen will be imported. This is almost all high performance Holstein semen, coming from Holland, Denmark, France, New Zealand, Canada and the US. We will pay out at least £1.5m. for it. While that is only sufficient to breed a quarter of our AI bred Friesian cows, it is, in financial terms, much more significant. All of the semen produced by the Irish AI organisations has a production cost of less than £1 a straw, and we could therefore say that the money spent on imported semen this year will be greater than the revenue to our own AI system for all of the semen it produces. Another way of putting it is that the import cost of this Holstein semen is about three times what we are currently spending on improving our own Friesians.

Our domestic AI industry is therefore under threat. The challenge is not so much on the technical side. The efficiency of the "arm service" seems to be good, to judge from published non-return rates. The pressure will come more on the quality of the genetic material on offer and on operational costs.

While half of Irish AI is with beef breed semen, the battle for survival will largely be fought out on dairy merit. There are a couple of reasons for this. The first is that the customer has a choice of about 10 beef breeds, so that most of his requirements are met by having reasonable bulls of these breeds available. Secondly, performance and progeny testing for beef, and calving surveys, are not so expensive as dairy testing, so that most AI centres can provide at least some documented merit in individual bulls within each breed. Thirdly, because of the wide variety of beef production systems, the internationally trading AI organisations have not found it worthwhile to make large investments in generating outstanding genetic merit in the beef breeds.

The Dairy Breeding Programme

In Ireland, as everywhere else, we have a fairly well defined system of progeny testing and selection of dairy bulls. Currently, we are testing 36 bulls per year, and selecting about 1 in 4 after the progeny test is complete. Along the way, these bulls are now mostly reared either in Bandon or in Sligo, so that some comparative growth and feed efficiency information is available on them, and most of them also have beef progeny tests based on 20 steers reared to slaughter. The whole exercise is a fairly costly one. The question is how cost effective it is, and how competitive it is likely to be in future.

The formal selection goal in most European dairy and dual purpose AI cattle selection programmes normally includes about 12 separate traits. These cover milk production (milk, fat and protein), beef production (growth, fatness and conformation), calving ease and mortality, and linear type traits indicating dairy utility. This is the list currently used in Ireland. In other countries, additional information is provided on milking speed, temperament, fertility and health (mastitis and ketosis). In all cases, including Ireland, ultimate selection is effectively exercised on a milk production index, which generally combines fat and protein yields with a higher weighting on protein

These selection objectives are not likely to change seriously in the future. If anything the concentration on milk production traits will increase. In particular, two developments are likely to reinforce this. The first is that as production per cow increases and as dairy farming becomes more specialised, the breeder's interest becomes more narrowly focused on dairy production. The second is that the higher the level of beef crossing in the dairy herd, the more the dairy farmer can concentrate his attention on dairy traits in the sires he uses to breed his replacement heifers. If and when sexed semen becomes available, this specialisation will be carried to the ultimate extent.

Cost benefit studies

I have conducted a number of cost benefit studies on AI related breeding programmes over the years and most recently one for the Munster Cattle

Breeding Society. The first stage of such a study is to define the breeding objective. I concentrated on three milk production traits (milk yield, fat yield and protein yield) and two beef traits (growth rate and carcass conformation). These determine most of the selection decisions that are made.

Milk volume has a negative value. Most of this is a transport charge of about 1p/kg. Adding on farm refrigeration costs, and making some allowance for inplant costs, we have taken a negative value of -1.25p/kg of milk volume.

Fat and protein are valued in relation to world prices. Both butter and skim milk powder had prices last autumn of about £1,300 per tonne. For SMP, this is not far off the intervention price, while for butter the intervention price is twice the world price. Translating the world prices back to values for milk protein and butterfat gives values of £1.61/kg of butterfat and £3.50/kg protein.

To arrive at net values for these, we have subtracted the marginal feed cost required. Assuming the feed input consists of grazed grass (64%), conserved grass (26%) and concentrates (10%), and that these have relative costs per unit of metabolisable energy (MJME) of 1 : 2 : 3, we can calculate the average cost of a unit of feed energy. This works out at 0.75p per MJME. A kilogram of butterfat requires about 69 MJME of feed input, while a kilogram of protein requires about 36 MJME. Feed costs are therefore 52p and 27p respectively.

For growth rate, we took a gross value of 250p/kg of carcass, and subtracted the cost of the 200 MJME of energy required to produce that. Improvements in carcass conformation require no additional energy but are quite complicated to calculate, because of the price differential on conformation varies over years and by type and weight of animal. Taking five years' data, we arrived at a value of aboutt 5p/kg. for one grade change. On a 330 kg. animal this is worth £16.50. These economic values are summarised in Table 2.

Table 2
Economic values in the selection objective

Trait	Gross Value	Feed Cost	Net Value
Milk volume (kg)	1.25	—	1.25
Butterfat (kg)	161	52	109
Protein (kg)	350	27	323
Carcass weight (kg)	250	125	125
Conformation (points)	1650	—	1650

High value of protein

The net values we have arrived at are substantially different from those that have been used in the breeding programme in recent years. In particular, they gave protein nearly three times the weighting per kilogram of butterfat, while the present RB182 weightings give protein 1.4 times the weighting of butterfat. The RB182 values are very much in line with those of progressive European breeding schemes in recent years. However, it is notable that late last year both the Dutch and the French have revised their weightings, in both cases to give several times the value to protein that they give to fat.

In carrying out these calculations, we used the discounted gene flow method and the computer programme SELIND, both of which were developed here and which are quite widely used for these purposes elsewhere.

Relative gains from different programmes

The present Irish programme aims to acquire about 80 young bulls each year, to progeny test 40 and to select 10. Three variants of the present (80-40-10) programme have been investigated. The first is a simple doubling of the number of bulls tested at each stage, with the number finally calculated held constant at five. This is represented at (160-80-10). Performance testing is cheaper than progeny testing, so we have looked at doubling this element along (160-40-10). Finally, since the performance test, while inexpensive, does not contribute a lot to ultimate gain, we have looked at keeping it constant and doubling the progeny testing stage (80-80-10).

The returns in each case will depend on whether a farmer retains his surplus calves or sells them (in which case he is presumed to keep a quarter of the genetic merit for beef traits). It is also of interest to compare the effect of the milk quota regime. We have assumed that the quota reduces the value of improvement in dairy traits by three quarters. The results in each case are therefore presented with and without quota, and with calves sold and reared. The results are given in Table 3.

Table 3

Genetic added value (£ per AI) from different programmes

	Prequota		**With Quota**	
	calves sold	calves reared	calves sold	calves reared
		£ per AI		
Present programme (80-40-10)	40	43	32	35
Double programme (160-80-10)	51	55	41	45
Double performance test (40-40-10)	43	46	34	39
Double progeny test (80-80-10	47	49	38	40

The most relevant case is with quota, calves sold, present programme. This shows a genetic added value per AI of £32. This is clearly very good value to the user. Assuming that the AI costs £14, and that about £10 of this would have been required to get a cow in calf, the genetic benefit from AI is worth close to £30.

- The quota regime reduces the benefits by an average of about £9 (range £7-£10) from the prequota system.
- A farmer who rears his calves gains on average an additional £3 from the genetic merit provided (range £2 - £4).
- Doubling the scale of the programme adds about £9 of benefit per AI (£11.00 before quotas).
- Doubling the performance test adds about £3. Doubling the progeny test adds about £6.

International comparisons

A couple of years ago, I published a comparison of 30 breeding programmes in Europe, the USA and New Zealand. I reduced the comparison to two structural statistics: the number of bulls tested per million AI and the lifetime usage of selected bulls. The results are shown in Figure 1. Briefly, this shows that the European programmes are testing large numbers of bulls but making relatively little use of the selected ones, while the American programmes tested much fewer bulls but used them more extensively. This difference in strategy can be easily rationalised. In Europe, each AI organisation has served a fairly small market on monopoly basis. In America, they all have access to huge markets and must compete with each other. The New Zealand Jersey and Friesian programmes were outstanding mainly because of their huge usage levels. The Irish and British programmes were making the lowest investments in bull testing of all the European schemes.

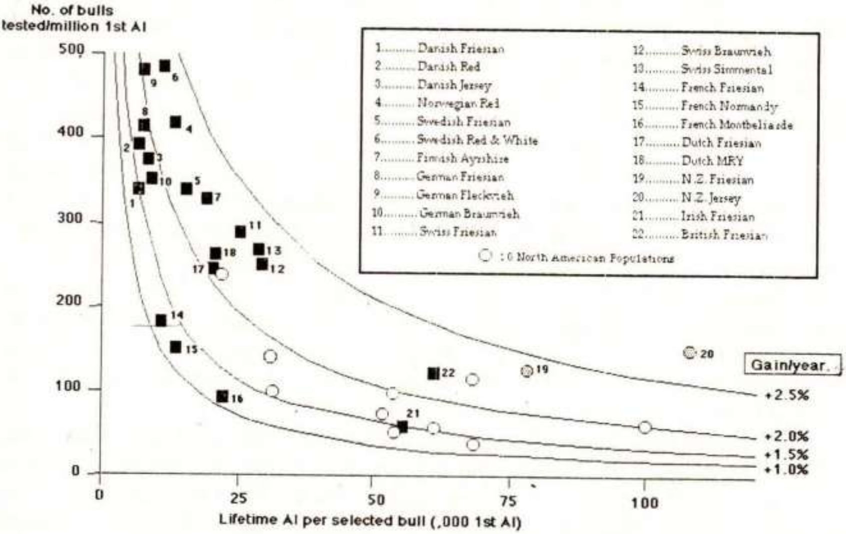

Fig. 1: Probable genetic gain as a function of
(a) No. of bulls tested/million AI and (b) AI usage per selected bull

I did the calculations again last year, and was surprised at how little had changed. In most European programmes they are still testing four times the number of bulls that we test per million inseminations. The one major improvement here has been the success of the fresh semen programme in the Munster group, which has pushed bull usage levels for the best selected bulls well beyond what most European organisations can achieve.

Since most AI organisations are now selecting for the same objectives, with the same basic stock, differences in level of investment will largely determine competitive ability. I calculate that our current Friesian testing and selection programme is costing about half a million pounds, or about £1.50/Friesian AI. This represents about 10% of the AI fee. In Denmark they claim the breeding programme cost 22.6% of the AI fee, in the Netherlands 38.8%, and in France at least 39%.

Holsteins

In 1973, I reviewed such evidence as then existed on the performance of American and Canadian Holsteins and their crosses in European countries. The data available were not the best: a mixture of small scale, well-controlled experiments and larger scale analyses of field data. However, a consistent picture emerged from the twelve reports I was able to assemble from several countries. This was that the US strain appeared to be about 5% higher in milk production than the Canadian, and more than 20% higher than the European. There was less information on the beef side, and what there was indicated no penalties on growth rate but some on carcass merit. These results were presented at a meeting of this Association in 1974.

In the same year, with encouragement from the editor of the Farmers' Journal, Waterford Co-op decided to finance an experimental importation. The original idea was to import from the US, and in preparation for this we did an interesting computer search of over half a million cows in the north-eastern United States to preselect heifers for import. We emphasised milk production, but also the improvement of butterfat percentage and the avoidance of the extremely large framed and angular models of the Holstein. In the event, because of blue tongue disease, the focus was shifted to Canada and 30 pedigree Holstein heifers were selected in Ontario in September 1974 for importation. Two of them survived the various quarantine stages and calved down in Coolnakilla in 1975. A matching group of 25 pedigree Irish Friesians was selected and a further group of comparable commercial Friesian heifers was assembled, partly from Moorepark replacement heifers. The three groups were run together during 1975 at Coolnakilla and in the subsequent three years at Waterford Co-op's farm at Castlelyons.

The trial was far from perfect, mainly because of the very different treatment of the Holsteins in the rearing and pre-calving period. However, the results confirmed our expectations. The pedigree and commercial groups were very similar, while the Holstein group gave 7%, 13%, 25% and 36% higher yields in their first four lactations. Though fat percentage was consistently lower, fat yields were 3%, 10%, 14% and 24% higher. The Holsteins were slightly faster

Table 4
Breed origin of 1989 beef cattle (1987 calvings)

Sex	Breed	%	
Male	Friesian	25	
	Hereford X	22	
	Continental X	14	
	Others	4	*66*
Female	Friesian	1	
	Hereford X	19	
	Continental X	10	
	Others	4	*34*

(Source: More O'Farrell et al.) 1987

growing and 6% larger in frame than the others.

Holsteins have moved more slowly here than elsewhere. Nevertheless, half of the genetic content of young bulls going into our testing programme in recent

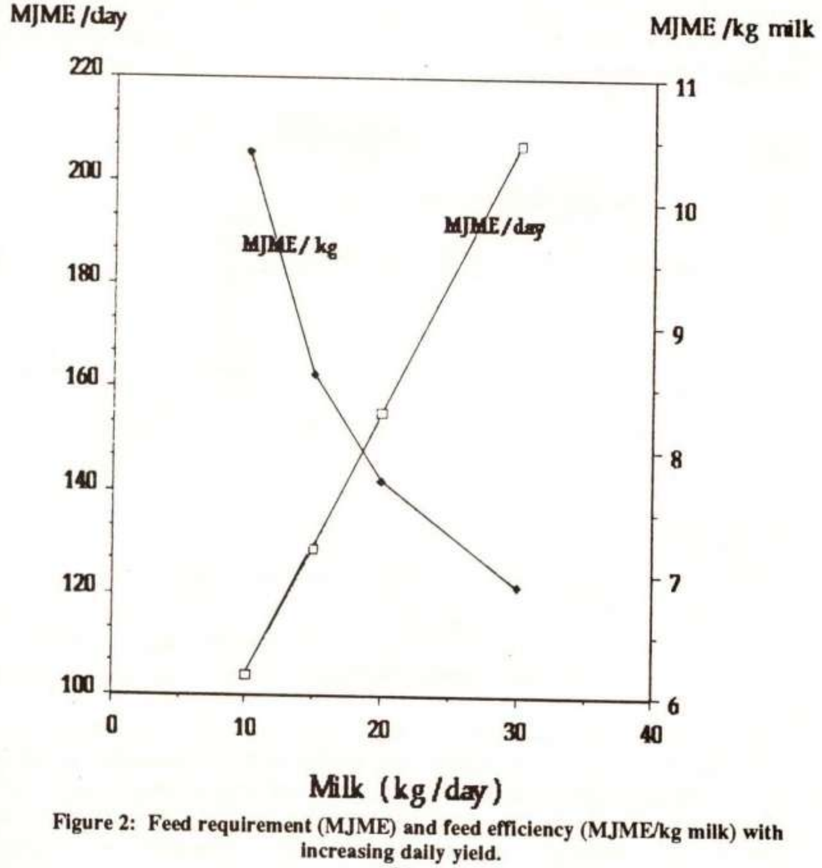

Figure 2: Feed requirement (MJME) and feed efficiency (MJME/kg milk) with increasing daily yield.

years has been Holstein and the Holstein content of the Approved Bull list is about 25% and climbing year by year. Everywhere else in Europe, they have essentially taken over at this stage. There is vehement opposition from those who have to rear the bull calves but the realities are, first, that they are generally different people from those who make the breeding decisions, and second, that because of the high level of beef crossing, the Friesian and Holstien bull calves make up only 25% of all our beef animals (Table 4). The movement to Holstein is simply part of the drive for higher biological efficiency and higher profitability in milk produciton (see Figure 2).

New technology

AI arrived on the scene 40 years ago and has transformed cattle breeding here and in other developed countries. Embryo technology was perfected about 10 years ago and it has also had major effects, though in a more restricted area. About 75% of all young bulls recruited for AI are now being produced by ET.

The new techniques now being developed include sexing of semen, sexing of embryos, mass production of embryos by IVF (in vitro fertilisation), and finally, cloning of embryos. In Figure 3, I have attempted to put these in perspective. The real question is not whether they are feasible, but whether they are likely to be competitive with the existing AI technology.

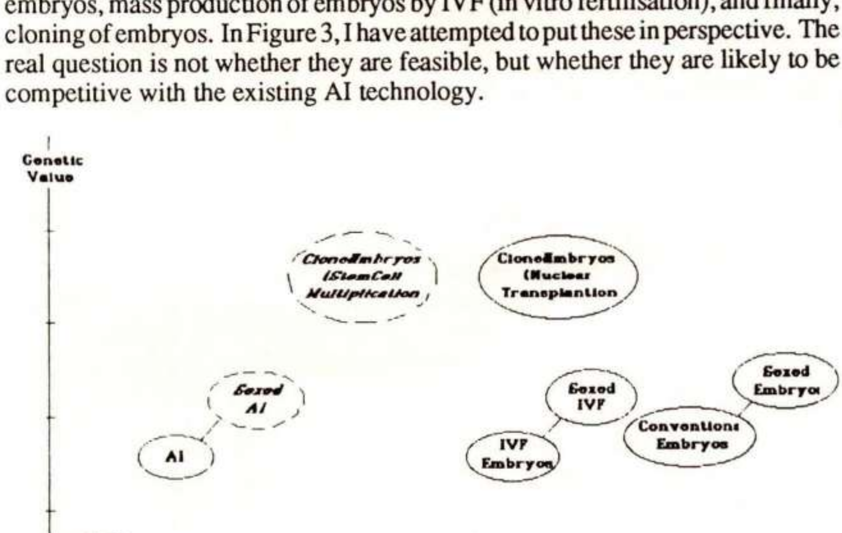

Figure 3: Schematic representation of different breeding techniques in terms of relative costs and genetic values

Sexed semen would clearly be a major benefit. It would put an end, once and for all , to the dual-purpose argument. Specialised replacement heifers would be Holstein or the equivalent, and all other calves would be beef cross and male. IVF embryos have been around for a year or two, but there is difficulty achieving acceptable success rates at reasonable cost. Pre-sexing of these is now becoming feasible and that will certianly add to their value, though whether it will be sufficient to make them competitive with AI is doubtful. For the specialised purposes now served by conventional embryo production, pre-sexing will undoubtedly be worth the extra effort.

Cloning of embryos (i.e. sub-division of embryos to make many identical copies of the individual) has now been achieved on an experiemental scale. If costs can be reduced and field success rates increase, it will undoubtedly replace a lot of the conventional AI business. A version of cloning, called Stem-Cell Multiplication, offers the prospect of achieving this, at least in theory. When this technology matures, it will give us the possibility of implanting a very specific genotype into each cow. I am confident that at that stage we will be looking beyond highly selected pure-bred genotypes to take advantage of some of the benefits in viability, performance and longevity which hybrid animals undoubtedly possess.

Crossbreeding in the Dairy Herd – Coping with Calving Problems

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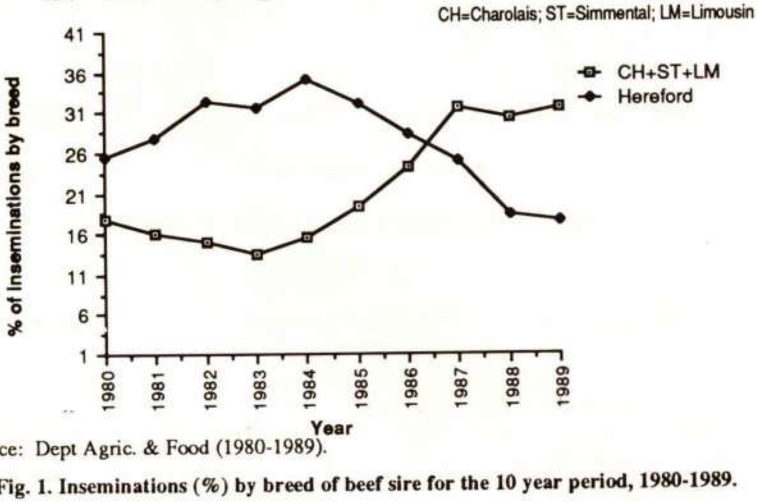
The increased use of specialised beef breeds as terminal sires in the dairy herd has accentuated farmers' awareness of the variation in calving problems both between and within beef breeds. However, the fear of increased calving problems is still the primary deterrent to more widespread usage of continental beef breeds in the national dairy herd. Traditionally, the Hereford was the dominant beef breed and remained so until the 1980's when a swing to the continental breeds took place (Fig. 1).

The effects of beef crossbreeding in the dairy heard on production and reproduction have recently been reviewed by More O'Ferrall and Ryan (1988, 1990). It was concluded that sire breed had no significant effect on mean lactation milk, fat or protein yield or lactation length, in the current or subsequent lactation. The calving to conception interval was significantly longer for Simmental sired calves compared with Charolais and Hereford sired calves which was in turn significantly longer than that of Friesian calves. The calving interval of Simmental and Limousin sired calves was significantly longer than that of Charolais and Hereford sired calves which was in turn longer than that of Friesian calves (More O'Ferrall, 1987).

The objective of this paper is to outline the nature and extent of the calving problems associated with beef crossing in the dairy herd and to examine how these problems may be ameliorated by good management.



Source: Dept Agric. & Food (1980-1989).

Fig. 1. Inseminations (%) by breed of beef sire for the 10 year period, 1980-1989.

Table 1

Foetal and maternal factors associated with calving difficulty

Foetal factors (75%)	Farmer/Vet (?)	Maternal factors (25%)
Oversize		Incomplete Dilation
Malpresentation		Inadequate pelvis
Anomalies		Uterine inertia
Dead in utero		Misc.

Calving problems

Recent calving surveys and crossbreeding trials in Ireland and the UK have quantified the current differences between breeds and between sires within breeds (More O'Ferrall, 1987; Anon., 1988/89; Anon., 1990; Mee & Dings, 1990). In general calving difficulty, gestation length and calf mortality increase as breed size increases except for the Limousin and Blonde D'Aquitaine breeds which tend to have a longer gestation length than expected from the sire breed size. Although the continental breeds generally have a higher rate of calving difficulty than traditional breeds, (approximatley two to three times greater), it is now possible to choose sires with lower calving difficulty figures than those of Hereford sires even though the continental sire breed average has not changed over the years.

The primary calving problems associated with crossbreeding are those related to increased calf birth weight, i.e. calving difficulty, calf mortality and prolonged gestation. Calving difficulty is mainly associated with relative foetal oversize and malpresentations but also with poor maternal preparation for calving and environmental factors (Table 1). Relative foetal oversize due to crossbreeding is inherently determined by hereditary factors such as breed, sire, sex and gestation length but is also modulated by environmental factors such as precalving nutrition, parity and season. Continental crossbred calves have a significantly higher prenatal growth rate than traditional British beef breeds but their birth weight has a relatively low correlation with postnatal growth rate. (Fig. 2).

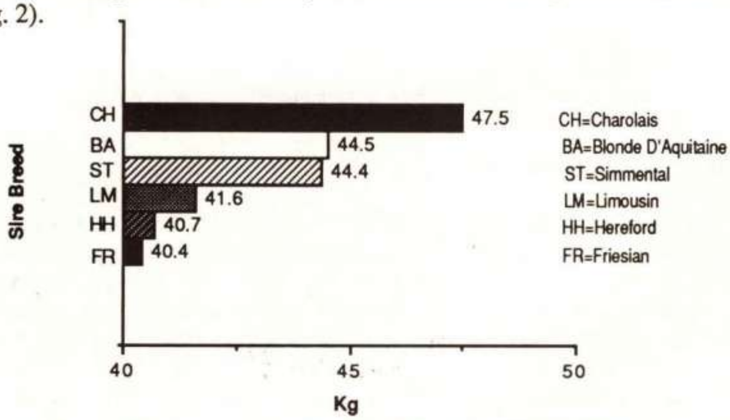


Fig. 2. Distribution of mean calf birth weights (Kg) by breed of sire

The consequence of this elevated birth weight is a higher rate of both assisted and difficult calvings (Tables 2 ,3). While the perinatal mortality rate is generally also higher for continental sires there is large variation within each breed (Table 4). Prolonged gestation can be a serious problem with certain sires causing foetal oversize and prolonging the calving interval.

Table 2
Distribution of calving assistance rates (%) by breed of sire

Sire Breed	Mean	Range*	Sire Breed	Mean	Range*
Friesian	10.6	1.1-22.5	Belgian Blue	18.8	11.4-26.8
A.Angus	12.4	3.2-28.1	Charolais	20.7	9.1-34.5
Hereford	12.4	1.3-24.2	Simmental	20.9	11.5-31.7
Limousin	18.2	6.3-27.3	Blonde D'Aquitane	21.8	20.0-25.3

Source: Dept Agric. & Food (1990), *Range of minimum and maximum means.

Table 3
Distribution of serious calving difficulty rates (%) by breed of sire

Sire Breed	Mean	Range*	Sire Breed	Mean	Range*
Friesian	1.9	0-8.1	Limousin	5.4	1.2-20.2
A. Angus	2.3	0-8.7	Belgian Blue	5.4	4.2-11.3
Hereford	2.5	0-6.9	Charolais	6.1	2.6-20.4
Simmental	4.9	1.8-17.7	Blonde D'Aquitaine	9.7	3.5-7.9

Table 4
Distribution of perinatal mortality rates (%) by breed of sire

Sire Breed	Mean	Range*	Sire Breed	Mean	Range*
A. Angus	1.5	0-4.9	Simmental	2.4	0.6-6.4
Friesian	1.7	0-6.0	Limousin	2.6	0.5-9.1
Hereford	1.8	0-3.5	Belgian Blue	2.6	1.3-3.0
Blonde D'Aquitaine	2.2	0.8-2.4	Charolais	2.8	1.1-6.1

Source: Dept. Agric. & Food (1990), * Range of minimum and maximum means.

Coping with calving problems.

1. Choice of sire

In choosing which breed and which sire to crossbreed a percentage of the dairy herd with, calving problems must rank as important selection criteria. To aid selection of sires from A.I. centres the Department of Agriculture and Food produce, each spring, a list of beef sires with below average calving difficulty rates (Anon., 1990). When comparing breeds a difference in serious calving difficulty rate of 1.5% or greater indicates a significant difference between breeds, while a difference of 3.0% or greater is required for a significant difference between sires within a breed. Studies conducted at Moorepark

indicate that this calving survey data needs to be used with caution but does act as a useful comparative guide to different sires (Table 5).

Table 5

Comparison of calving performance of three sires between three surveys (S1, S2 and S3)[a]

Sire	Number of Calvings			Serious Difficulty(%)			Perinatal Mortality (%)[b]		
Code	S1	S2	S3	S1	S2	S3	S1	S2	S3
CSB	345	521	442	13.3[c]	6.9	1.2	13.3[c]	4.3	1.3
JCE	402	521	1528	4.7	7.3	1.6	7.0	3.3	2.3
TET	667	555	1161	5.7	7.4	2.5	5.3	4.2	2.5

a S1 = Research herds, S2 = Dairymis II herds, S3 = Dept. Agric. & Food (1990).

b S1 and S3 from 0-48 hrs, S2 from 0-24 hrs,

c Heifers calvings

When purchasing a natural service sire one is dependent upon the grandsire's performance and the appearance of the bull before an assessment can be made on the herd. In order to avoid serious problems in the first year it is generally recommended that unproven sires be used selectively on only a few older, easy calving cows (Herron, 1989). Heifers, second calvers, smaller cows and cows with a history of calving problems should not be crossbred unless the calving results of the sire are below the breed average. With both A.I. and natural service sires it is essential to keep a record of service dates as such data may be needed if prolonged gestation is suspected and induction contemplated.

2. Precalving feeding.

Once a beef sire has been selected prevention of calving problems is now dependent upon the management of the cow during pregnancy and calving. The effect of precalving nutrition on calf birth weight and on calving difficulty has often been emphasized in preventing foetal oversize. Results from experiments in both dairy and beef cows suggest only a minor effect of precalving feeding level on calving performance (Drennan, 1979; Sejrsen & Neimann-Sorensen, 1979). Two thirds of foetal growth occurs during the last trimester of pregnancy while at term the rate of prenatal average daily gain slows down to 200-500 g/day. Results from Teagasc studies on beef cows have shown that unless the cow actually loses body condition during the latter stages of pregnancy the foetus will exercise preference for nutrients and grow at the expense of the cow. While problems of obesity at calving may occur with heifers the problem with cows

Table 6

Target optimum body condition scores for dairy heifers and cows (0-5 scale)

Parity	Mating	Drying off	Calving
Heifer	2.5-3.5	—	2.5-3.0
Cows	2.5	3.0-3.5	3.0-3.5

currently is more often one of poor body condition at calving as 'steaming up' precalving is not widely practised due ot milk quota restrictions. Achieving optimum body condition score at calving (Table 6) may necessitate restricting heifer's silage intake and providing supplementary concentrate feed for thin cows.

3. Calving induction

At term problems with cows 'going overtime' may be obviated by inducing calving at, or preterm. The commercial regimes currently available suffer from a high incidence of side effects such as poor udder distension, poor preparation for calving, retained placentae, and stillbirths. An alternative regime developed at Belclare Research Centre has shown promising results in trials but is not commercially available (Diskin, McEvoy & Sreenan, 1989). Ideally induction of calving should be practised on a planned basis with known service dates and initiation of the regime some 14 days before the predicted calving date in order to achieve a substantial reduction in birth weight. Problem with prematurity will arise if induction is practised more than one month preterm (O'Farrell & Crowley, 1974). It should be noted that while prolonged gestation may occur with individual matings within all breeds it is not a feature of the traditional British beef breeds nor of the Belgian Blue or MRi breeds (Table 7).

Table 7
Distribution of gestation lengths (days) by breed of sire

Sire Breed	Mean	Range*	Sire Breed	Mean	Range*
Friesian	281	277-283	Simmental	284	282-286
A. Angus	281	279-282	Charolais	285	283-287
Hereford	282	280-284	Limousin	286	284-290
Belgian Blue	283	281-284	Blonde D'Aquitaine	286	286-288

Source: Dept. Agric. & Food (1990), *Range of minimum and maximum means.

4. Calving supervision

At calving time it is recommended that all calvings be supervised, but not necessarily assisted, irrespective of the breed of sire selected. Being present at each calving enables one to monitor the course of the normal calving, correct an abnormal calving, revive a weak calf, disinfect the navel cord and feed colostrum promptly. Recently, calving aids have been introduced to make more efficient use of labour during the calving season both during the day and at night (Mee, 1988). Studies at Moorepark have shown no advantage of premature intervention during the calving process and in fact this leads to increased usage of the calving jack and more weak calves after calving. It is suggested that heifers be left to calve undistrubed for approximatley 2 to 3 hours and cows for approximatley 2 hours before intervention is contemplated. Implementation of this policy at Moorepark has reduced the incidence of unnecessary interference during normal calving. While comparable studies have not been conducted with crossbred calvings it is suggested that a similar approach to calving would reduce the incidence of calving difficulty.

5. Caesarean section

The question of whether or when to perform a caesarean section at a difficult calving is one that needs to be addressed by the attending veterinary surgeon based on the individual circumstances of the calving, and in some cases the breed of sire. While double muscling will not occur in crossbred calves it presents a problem with embryo-transfer calves and this needs to be borne in mind if attempting vaginal delivery by forced extraction. The caesarean section rate of double muscled breeds, when crossbred, is similar to that of other beef breeds. Current studies at Moorepark are attempting to predict the degree of calving difficulty based on the relationship between the size of the calf's legs and its body weight. It is hoped that this index may be used when deciding whether to perform surgery or deliver the calf per vaginum.

6. Calf resuscitation

Even before the calf is born stimulation of breathing is often necessary in cases of abnormal, prolonged or difficult calvings. Amniotic fluid can be evacuated manually or using suction devices during calving (Mee, 1988). Once the calf is born, brief suspension will drain excess fluid and establish a patent airway. Stimulation and maintenance of a regular respiratory rhythm may be effected by the traditional means of prodding a finger into the calf's nostrils, throwing cold water over the calf's head or ventilating the chest by raising and lowering the rib cage and upper limb. If successful, the calf is then placed sitting up with both fore legs stretched out in front to aid lung expansion. Recently, 'reviving drugs' and oxygen have been used to resuscitate calves. Respiratory stimulatnts are available to farmers as drops and gels (Dopram-V drops, Dallophylline gel) and oxygen (£80/5 year rent) in the form of industrial gas (Air Products Ltd. IIG Ltd.). Very few controlled trials have been conducted on these aids in calves but experience at Moorepark indicates oxygen may be suitable for use on larger farms.

The future

If current breeding trends continue there will be a further influx of exotic beef breeds into the Irish national herd and further growth in Holstein cross Friesian cow numbers. With the delay between the introduction and the completion of evaluation of imported breeds under Irish farm conditions the present problems will persist unless ongoing research is conducted and the information currently available is applied. Novel approaches to calving problems including induction of calving, prediction of problems and elective surgery, all require further research before widespread application of these techniques. Milk quotas are likely to limit production for the future and in this situation maintenance of income through achieving efficiencies in cost reduction and the use of cross-breeding, particularly specialist beef breeds, will be important.

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Automated Dairy Herd Management

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During the past decade microcomputer and videotest systems have had an increasing impact on dairy herd management. Major developments in process control systems have been made by milking machine manufacturers, initially, as an aid to milking parlour automation. More recently the trend has been to provide the farmer with a sophisticated management information and control system in which data are collected automatically and all feeding operations are controlled.

A comprehensive computerised dairy herd management system (Dairymis 5) has been developed at Moorepark. The data are presently entered via the keyboard of a personal computer. A measurement and control system has recently been developed at Moorepark for: (a) automatic cow identification, (b) automatic milk yield recording using electronic milk meters, (c) automatic control of the amount of concentrate fed in the milking parlour, (d) automatic printing of the code labels for individual cow milk samples. When milking is completed, the cow numbers and corresponding milk yields are entered automatically into the Dairymis II system.

Automatic cow identification

Electronic animal identification systems suitable for the reliable operation of concentrate dispensers for dairy cows are now readily available from multinational companies in most countries. Electronic identification for data acquisition in the milking parlour has developed at a much slower rate. Part of the problem with automatic data acquisition in the parlour has been the difficulty in developing a reliable milk meter and the time required to develop software but the main problem has been in the performance of animal identification systems themselves, placed in routine use in the milking parlour. Figure 1 shows the components of the transponder identification system used at Moorepark.

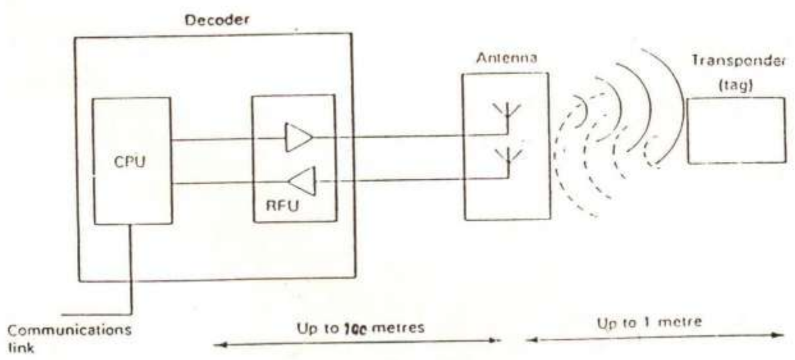

Figure 1:
Components of a transponder system.

The transponder is normally in an inactive or quiescent state but when it comes within range of the radio frequency field produced by the interrogating antenna, it is activated and transmits its data back to the antenna. The frequency used for data transmission is generally different from the activating frequency. The decoder (sometimes known as the interrogator or reader) contains a radio frequency unit (RFU) capable of generating the appropriate activating signal and converting the signal received from the tag into a logic level.

Moorepark system.

The components of the measurement and control system developed at Moorepark are:

1. A controlled (Micromac 6000 developed by Analog Devices, U.S.A.) linked to animal identification processing equipment located in the milking parlour. The controller manages the control devices for all automatic operations in the milking parlour and also measures and captures a wide range of associated data including animal identification and concentrate feeding (Figure 2).

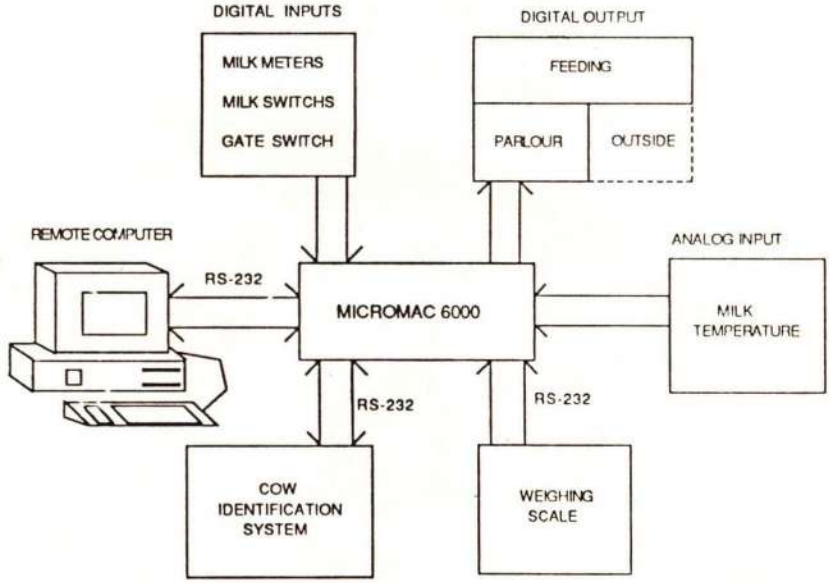

Figure 2.
System design of milking parlour automation.

2. Milk recording (using Afikim electronic milk meters - Model MM85) is fully automatic and is interfaced to the controller (Figure 3).
3. Eureka eartag transponders (Eureka Systems, Slough, England) are used in association with a walk through antenna at the parlour entrance. The layout of the walk-through system is shown in Figure 4. Antenna are also mounted

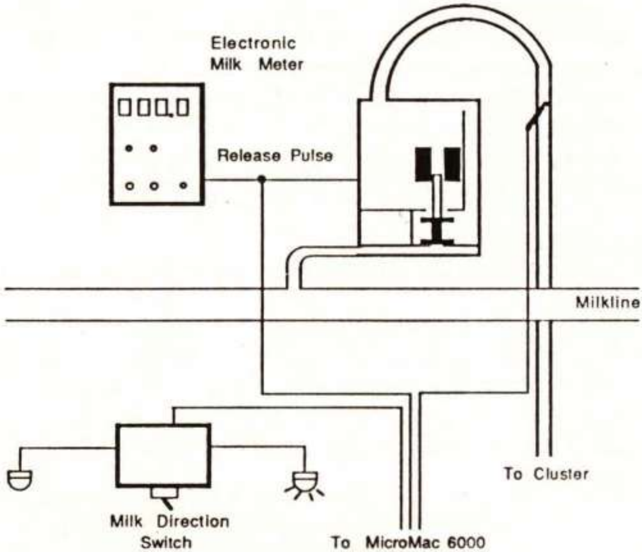

Figure 3:
Design of automatic milk recording.

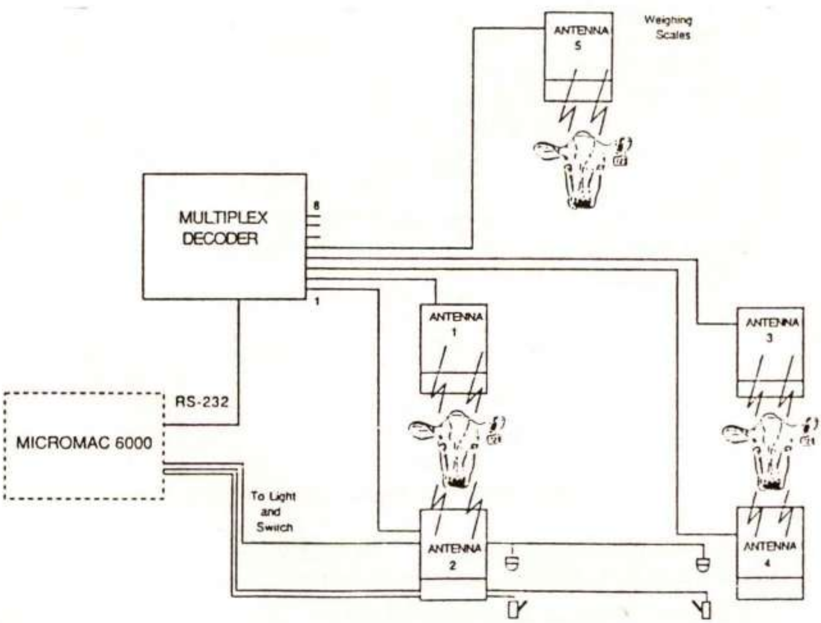

Figure 4.
Design of automatic cow identification system

over the head of the cow in each stall. The antennae are linked to a decoder which is linked to the controller.

4. The controller is linked to a remote computer (IBM compatible personal computer) located in an office. The data stored in the controller is communicated to the computer at selected intervals

Automation Programmes

The total programme is written in two different languages. One part is in Macbasic, the other part is written in Pascal. The micromac controls all actions in the milking shed and collects all data. The programme in the micromac is written in Macbasic and collects the following data:

1. The signal from the Eureka decoder which sends through the tag number of the cows.
2. The milk yield of each cow.
3. The milk temperature.
4. The row in which the cows are located.
5. The unit in which each cow is located.

The Pescal programme is used to manipulate and print out the different files saved by the Macbasic Programme.

Performance of the electronic identification systems

The performance of the Eureka eartag identification system was measured with a walk-through overhead antenna at the entrance to the milking parlour and with an individual overhead antenna at each feed stall. The walk through antenna had an identification range of 1 meter, the range of the individual overhead antennae was 50 cm. The antennae were connected to three multiplex decoders. Commands for operating the decoders were incorporated into the operation programme for the data collection system. The performance of the two types of identification systems is summarised in Table 1.

Table 1
Performance of in-parlour electronic identification systems

	Individual antennae		Walk through – single antenna	
	am	pm	am	pm
Number of cows milked	70	70	70	70
% Identified	88	89	95	97

The primary reason for the low detection rate with individual antennae was inconsistent placement of the cows head and neck relative to the antenna. With the walk through system, some cows lowered their heads when walking under the antenna and the tag was outside the 1 meter detection range.

In a further experiment in which two antennae were used, one overhead and a corresponding antenna under the concrete floor at the entrance to the parlour, 99-100% of cows were consistently detected (Table 2).

Table 2
Performance of walk through identification systems

	Walk through antenna (Overhead)		Walk through antenna (overhead and under floor)	
	am	pm	am	pm
Number of cows milked	84	84	86	86
% Identified	95	98	99	100

Concentrate feeding and milk recording

After the cow has been identified with the walk through system concentrates are automatically dispensed. The controller can be linked to any make of concentrate dispenser and the quantity fed is programmable. It is proposed to develop an out-of-parlour concentrate feeding system.

Automatic milk recording is carried out by linking the release solenoids of the electronic milk meter to counters in the controller. Each release represents 0.2 kg of milk. When the clusters are transferred across the pit an overhead digital switch in the centre of the milkers pit is activated; the counter on the controller is automatically read and then zeroed for the next cow.

Future developments

A relatively cheap, reliable and accurate identification is the key to future developments such as:

(1) automatic mastitis detection
(2) automatic heat detection
(3) automatic alert of cows with digestive disorders or other illness
(4) automatic fault detection in milking machines.

Mastitis detection could be based on an in-line detector which measures the electrical conductivity of milk. A profile can be built up for each cow and by using "artificial intelligence", changes can be interpreted.

It is possible to use temperature sensor to measure changes in milk temperature which reflect changes in body temperature. When a cow is in heat both body and milk temperature rise by a small amount. A profile of each individual's milk temperature is drawn up and changes from this pattern are detected using artificial intelligence programmes. This can also be used to alert the milker that a cow has a severe infection requiring immediate attention. A similar system monitoring feed intake and linked to milk temperature could be used to detect digestive upsets or related illness.

Today in some of the more sophisticated cars, an automatic system checkout is carried out once the iginition key is inserted Since some components of a milking machine may be malfunctioning without any immediate noticeable effect, a similar automatic checkout system would be a decided advantage. This and the other elements of the automated package could be run through the one computerised system.

Beef Production from Silages Produced from Italian Ryegrass, Perennial Ryegrass and Permanent Grassland Swards.

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This paper presents one year's results (1987) from a three year (1987-1989) programme of research carried out at Grange Research Centre. Three sward types were compared under intensive silage conservation systems and subsequent annual beef carcass production per hectare was measured, when the silages were offered to finishing steers.

Grass accounts for 97% of ruminant feed in Ireland, with silage comprising one quarter of this total (Lee, 1988). The area under grass, including rough grazing, is 5.2 million hectares or 91% of the land area used for agricultural purposes (C.S.O., 1989). Most of the grassland (approx. 85%) consists of permanent swards and about 3% is reseeded annually (Collins and Murphy, 1978). Most of the permanent swards are of diverse botanical composition with relatively low levels of ryegrass species. The contribution of permanent grassland to the national silage crop is likely to be high, reflecting the overall predominance of these swards even though they may not be inherently suited for quality silage production. The main sown species is perennial ryegrass but some 10% of the total sown is Italian ryegrass, the latter being sown either in monoculture as a specialist silage crop or mixed with perennial ryegrass and sown as mixtures (Culleton and Murphy, 1987). Accordingly, an experiment was carried out at Grange to compare reseeded Italian ryegrass and perennial ryegrass swards with an old permanent grassland sward to determine the following:

1. annual grass yield and quality when each sward was managed in an intensive, unwilted, silage conservation system,
2. conservation losses and silage quality,
3. silage intake and animal performance by cattle offered these silages,
4 annual beef carcass output per unit area of grassland.

Swards

1. Italian ryegrass	(cv. Multimo)	(IR)
2. Perennial ryegrass	(cv. Talbot)	(PR)
3. Old permanent grassland		(PG)

Sward management and grass conservation

The OPG was an old permanent sward (over 40 years) of mixed botanical composition while the IR and PR swards were sown in the autumn previous to the experiment. The swards were in large replicated field plots with a total area of 3 ha. for each sward. The cutting schedule was designed to optimise production of high quality grass from each sward and was based on previous research findings at Grange. Consequently, there were 5 cuts of IR and 4 cuts each of PR and OPG, with all cuts ensiled separately (cutting dates given in Table 2). Grass was cut with a rotary mower and harvested without wilting. Formic acid was applied in all cases. Harvested grass was weighed into the silos and silage subsequently weighed out. Applications of P and K fertilizers were surplus to requirements and were based on soil analysis and estimates of P and K removal. The total annual nitrogen application was 430 kg N/ha on all swards, with applications spread between cuts as shown in Table 1.

Table 1
Nitrogen application rates (kg N/ha) for cuts of wards.

	N - rate (kg N/ha)		
Cut No.	IR	PR	OPG
1	120	140	140
2	100	120	120
3	80	100	100
4	70	70	70
5	60	-	-
	430	430	430

In December, after the harvesting season, seven sods (178 mm x 51 mm) were taken at random from each plot. Plant species were separated and tiller numbers per m^2 were calculated for each sward.

Animal production

Ninety-seven Friesian steers were used with 37, 31 and 29 steers being allocated to the IR, PR and OPG silages respectively. Silages were offered ad libitum together with 2 kg concentrates per head daily. The 4 or 5 cuts from each sward were fed in sequence over a period of 127 days. Steers were group penned in slated floor housing and individual intakes recorded for half the animals on each treatment. Carcass weights were recorded post-slaughter.

Results and discussion

Tiller numbers per m^2 for swards were 3336, 8331 amd 7365 for IR, PR and OPG respectivley. The IR and PR swards contained 80% and 93% Italian ryegrass and perennial ryegrass respectively, while the remaining tillers in each of the two swards were mostly annual meadowgrass. The OPG sward contained rough-stalked meadowgrass (33%), Bent sp. (31%), perennial ryegrass (15%), meadow foxtail (11%) and other species, including weeds, (10%).

The IR sward outyielded PR and OPG by 2.6 and 2.9 t grass DM/ha respectively in its first year after sowing (Table 2), while maintaining a similar overall digestibility. The mean yield and digestibility of PR and OPG were

Table 2
Grass cutting dates, yield and composition

Sward	Cut No.	Cutting date	DM yield (t/ha)	In-vitro DMD (g/kg DM)	WSC (g/kg juice)	LBC+
IR	1	13 May	5.1	790	32	28
	2	16 June	3.1	749	29	40
	3	22 July	3.6	700	25	38
	4	24 August	2.7	712	16	31
	5	23 October	2.4	786	29	-
		Total	16.9			
PR	1	26 May	5.5	744	36	36
	2	7 July	3.8	743	24	45
	3	20 August	3.3	715	17	49
	4	24 October	1.7	782	27	-
		Total	14.3			
OPG	1	27 May	5.7	744	29	38
	2	8 July	4.0	740	21	44
	3	22 August	3.3	710	13	39
	4	26 October	1.0	765	24	-
		Total	14.0			

+LBC = lactic buffering capacity (mg lactic acid required to lower pH of 1 g of grass DM to pH 4.0)

similar, indicating that within the systems chosen there was no apparent benefit in terms of grass production and quality to replacing the OPG with PR. Previous research on comparisons between a similar OPG sward and reseeded IR and PR swards showed that the relative dry matter yield per ha. per annum of IR compared to OPG can vary from 92 to 145% and that of PR compared to PPG from 94 to 113% (Collins, 1984 and 1985; O'Kiely and Flynn, 1986). Culleton, Murphy and McLoughlin (1989) at Johnstown Castle Research Centre, reported an increase in DM yield of 60% (9.3 to 14.9 to DM/ha) in the first year after reseeding, declining to a 36% and 13% yield advantage in the 2nd and 3rd year, respectivley. The results of Culleton (1989) indicate that the botanical composition of the old permanent grassland sward, and particularly the ryegrass content, will influence the response in DM yield to reseeding. The water soluble carbohydrate (WSC) levels in the grass juice varied considerably between swards and within cuts of swards. The PR sward consistently had higher WSC levels than the OPG on similar cutting dates. The lactic buffering capacity (LBC) and WSC are major factors influencing the ensilability of grass and the relationship between silage pH (Table 3) and grass LBC and WSC is described by the equation:

$$pH = 0.013\ LBC - 0.036\ WSC + 4.4$$

with correlation coefficient (r) = 0.78

Silage preservation was satisfactory for all cuts except third cuts of PR and

Table 3
Silage composition

Sward	Cut No.	DM (g/kg)	pH	In-vitro DMD (g/kg DM
IR	1	191	3.9	730
	2	186	3.7	687
	3	208	3.7	661
	4	177	4.0	677
	5	171	3.8	737
PR	1	200	3.7	744
	2	195	4.3	697
	3	160	4.5	699
	4	188	4.1	755
OPG	1	223	3.8	744
	2	209	4.0	707
	3	166	4.8	590
	4	200	4.1	771

OPG which preserved badly (Table 3). The badly preserved silages were associated with two levels of WSC in the harvested grass and in the case of PR, a particularly high LBC. Wilson and Collins (1980) reported that, over a 4 year period, 97% of IR silages had a pH of 4.2 or lower while only 72% and 28% of PR and PPG silages respectivley had a pH of 4.2 or lower. This indicates that ryegrass species, and particularly Italian ryegrass, are easier to preserve by ensilage than grass from old permanent grassland swards.

Similar animal performance was achieved by steers on each of the three sward treatments, with no differences being recorded for any of the carcass traits measured (Table 4).

Table 4
Silage intake and animal performance

	IR	PR	OPG	SE
Silage DM intake (kg/day	7.5	7.2	7.4	0.19
Initial liveweight (kg)	457	456	457	5.6
Final livewight (kg)	579	576	578	6.6
Liveweight gain (g/day)	960	950	950	40
Carcass weight (kg)	303	301	298	3.9
Kill-out rate (g/kg)	524	522	515	3.0
Kidney and channel fat (kg)	12.3	13.6	11.9	0.6
Conformation [a]	2.1	2.1	2.0	0.08
Fat score [b]	3.3	3.3	3.1	0.08

(a) Scale 1 to 5, with 5 indicating best conformation.

(b) Scale 1 to 5, with 5 indicating greatest fatness.

Carcass gain per ha (Table 5) for each sward was calculated using grass yields, in-silo losses, silage intakes and carcass gain data. The kill-out rate for steers at the start of the experiment was assumed to be 500g/kg. The IR and PR swards produced 125 and 41 kg more carcass per ha, respectively, than the OPG sward. However, even though individual animals received the same amount of concentrates daily, there was an additional 688 and 169 kg concentrates per ha fed to steers on the IR and PR swards, respectivley, than on OPG, because they carried more animals.

Table 5
Estimation of carcass gain per hectare

	Sward		
	IR	PR	OPG
Grass ensiled (t DM/ha	16.9	14.3	14.0
In-silo losses (t DM/ha) (% loss)	4.1(24)	2.8 (20)	2.1 (15)
Edible silage (t DM/ha)	12.8	11.5	11.9
Silage intake (kg DM/day)	7.5	7.2	7.4
Feeding days	1712	1589	1608
Carcass gain (g/day)	583	575	543
Carcass gain per hectare (kg)	998	914	873

If the relative carcass gain per ha were predicted from grass DM yields and quality, the benefits of the IR compared to the other two swards would be significantly over-estimated (Table 6). This supports the conclusion that the evaluation of cultivars of ryegrass should be assessed in terms of animal productivity (Ribeiro, 1984) and preferably in terms of carcass gain (Steen, 1984).

Table 6
Relative carcass gain per hectare - Predicted Vs Measured.

	Sward		
	IR	PR	OPG
Measured	114	105	100
Predicted	135	107	100

The margin over feed per ha was calculated for each sward and the costs and returns are given in Table 7. The relative differences between swards in returns per ha should be the same irrespective of the price per kg. carcass. However, the costs per ha may vary considerably between individual circumstances and thus influence the margin over feed.

Table 7
Margin over feed per hectare (£)

	Sward		
	IR	PR	OPG
Feed costs per ha			
Silage (fertilizer, cutting, etc)	966	809	809
Concentrates	481	456	451
Total (feed costs/ha)	1447	1265	1260
Returns per ha			
Carcass (£2.50/kg)	2495	2285	2182
Margin over Feed per ha	1048	1020	922

For example, the estimated costs of harvesting 1 tonne grass DM from each individual cut is given in Table 8. The 4th cuts of PR and OPG are particularly expensive, due to low DM yields, and it is unlikely that farmers would be prepared to incur these high harvest costs. The net result of omitting the final cuts of PR and OPG swards would be to reduce carcass output per ha (as less grass ensiled) when compared to the IR in the intensive silage conservation systems used, but the feed costs per ha would also be reduced (3 Vs 4 harvests). The grass used for cut 4 of PR and OPG in this experiement would more logically be used for grazing animals on farms at the latter end of the grass growing season.

Table 8
Cost* (£) of harvesting 1 tonne of grass DM for each cut of IR, PR and OPG swards

	Sward		
Cut No.	IR	PR	OPG
1	22	20	19
2	36	29	28
3	31	33	33
4	41	65	110
5	46	-	-

* Assumed contractor price £110/ha (precision chop)

The margin over feed for the IR and PR swards must also cover the cost of reseeding. This cost, in the case of IR, could be spread over three years (assuming it is necessary to reseed IR after three years), and in the case of PR could be spread over six to seven years.

Summary

* The IR sward had greater DM production than PR and OPG, but at the cost of an additional harvest.

* In-silo losses were highest for IR (24%) and lowest for OPG (15%) with PR (20%) intermediate.

*IR and PR swards produced 125 and 41 kg more carcass per ha respectively than OPG.

*For intensive silage production, resowing OPG with ryegrass is justified.

* Results of one year (1987) only. However, the 1988 results confirmed the benefits of reseeding.

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Enumeration of Lactic Acid Bacteria on Grass and the Effects of Added Bacteria on Silage Fermentation

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This paper summarises a research programme carried out by J. P. Moran while a recipient of the John Flood Memorial Scholarship. Within the programme various aspects of the microbiology and chemistry of ensiling grass were studied. The overall objective of the programme was to improve our understanding of the contribution of lactic acid bacteria (LAB) to silage fermentation under Irish conditions.

The enumeration of LAB on grass, silage and farm machinery.

a) A survey of LAB numbers on standing and harvested crops of grass between May and September 1988.

Grass grown for silage was sampled 19 times during a 20 week period between May and September 1988. The grass was sampled randomly from a variety of pastures immediately before harvesting (standing crop) and immediatley after harvesting (grass samples as it left the forage harvester). A rotary mower and precision chop harvester were used throughout the experiment. The silage additive (acid) applicator was switched off when grass for sampling was being harvested. Total counts of LAB on the standing crop as measured on MRS agar (Table 1) were generally quite high and ranged from 10^4 to 10^7 CFU/g grass.

Levels on the standing crop were similar to the harvested crop. The high counts of LAB detected on the standing crop are not in agreement with those found by Stirling and Whittenbury, (1963); Muck and O'Connor (1985) or Fenton, (1987). The high levels found may have been associated with Irish weather related factors (low UV radiation, high relative humidity, etc.), crop factors (dense high moisture crops), management factors (animal manures and silage effluent applied to silage ground; silage ground grazed late in the year) or may be due to a combination of all these factors.

Table 1.
LAB counts on grass pre-and post-harvesting

Crop	Mean LAB Count (Log 10 CFU/g grass)	SD
Standing crop	5.496	1.26
Harvested crop	5.525	1.13

The identification of a random selection of LAB colonies isolated from grass showed the homofermentative LAB to account for 54% of total isolates. Of the homofermentatives 87% belonged to the genus *Lactobacillus*. Heterofermentative LAB accounted for 32% of total isolates with *Leuconostoc* being the dominant species, accounting for 78% of heterofermentative isolates.

(b) The enumeration of LAB on different plant types.

Counts of LAB were carried out on different grass genera and one clover genus (Table 2). Counts of LAB on grasses and clover were high with Agrostis species giving rise to highest counts. The increased counts on particular genera of grass may be a genus only effect or it may be due to any one of a number of other effects such as plant growth stage, amount of dead material on the plant, local plant microenvironment, plant morphology, or some stimulatory or inhibitary conditions/substances on the plants.

(c) The enumeration of LAB on different plant parts.

LAB were enumerated on different plant parts (Table 2). Counts of LAB on all plant parts and on the entire plant were high ranging from 10^4 to 10^7 CFU/g grass. Highest counts were found on the decaying material at the base of the plant. This finding is in agreement with that of Stirling and Whittenbury (1963), who suggested that the presence of LAB were associated with the release of nutrients from damaged or decaying plant tissue. In addition it could be that the conditions prevailing at the base of the plant may encourage the growth of LAB i.e. reduced penetration by uv light, and a more moist and humid environment.

Stirling and Whittenbury (1963) found that no LAB colonies developed on the inflorescence, before or after seed formation. However in the experiment

Table 2

Mean counts of LAB (log_{10} CFU/g grass) on different plant types and different plant parts

Plant type	LAB Count	Plant part	LAB count
Italian ryegrass (Lolium multiflorum-cv Lemtal)	7.23(0.296)	Inflorescence	6.63 (0.66)
Perennial ryegrass (Lolium perenne-cv Talbot)	7.13 (0.100)	Stem upper[1]	5.33 (0.87)
Cocksfoot (Dactylis glomerata)	7.44 (0.068)	Leaf	4.80 (0.77)
Yorkshire fog (Holcus lanatus)	6.45(0.145)	Stem lower[1]	6.58(0.33)
Red fescue (Festuca rubra)	6.97 (0.022)	Dead material	7.39 (0.14)
Agrostis spp	7.56 (0.117)	Entire plant	6.39 (0.47)
Clover (Trifolium repens)	6.06(0.263)		
SEM	0.112	SEM	0.283
Sig	***	Sig	***
Error df	12	error df	15

[1] including leaf sheath

carried out here very high numbers were detected ranging from 10^5 to 10^7 CFU/g grass. These high numbers may be a result of the LAB locating in micro-environments among the seeds, thus protecting them from harsh environmental conditions. High counts of LAB have also been detected on corn seed (Miskovic and Rasovic, 1972; Koch, Moruarid and Kirchgessner 1973).

Lower numbers of LAB were detected on the leaves of the grass. This would be expected since leaves are usually orientated to achieve maximum interception of sunlight and hence *uv* radiation. For this reason the leaf provides very little protection for the LAB. These results are in agreement with Moon and Henk (1980) who found few bacteria on the surface or the interior of either wheat or alfalfa leaves.

(d) The enumeration of LAB on the cutting and harvesting equipment

Counts of LAB were enumerated on different parts of the cutting and harvesting equipment (Table 3) to determine the feasibility of an inoculation effect by the mower or harvester. The high counts of LAB recovered on some parts of new, previously unused machinery was not expected. The machinery was stored in an area adjacent to where silage was stored, fed and transported regularly. It may be that counts of LAB had been high in this general environment.

The same machinery was sampled again after being in regular use throughout the silage making season. Counts of LAB had increased on all machine parts except the harvester rollers. Highest counts were detected on the harvester chute. This was expected since this area was coated with a mat of plant fragments and debris which could be a medium for LAB survival and growth. Increases in LAB numbers on machinery after use have also been found by Fenton (1987) and Stirling and Whittenbury (1963) where plant sap collects as a result of chopping or laceration of the plant material.

Table 3

Counts of LAB (log_{10} CFU/cm2) on different machine parts

Machine part	LAB count	SD
Pre use[1]		
Mower blade	4.08	-
Harvester tines	0	-
" auger	2.64	-
" roller	3.08	-
" blade	3.78	
" Chute	2.66	-
Post use [2]		
Mower blade	5.32	-
Harvester tines	3.21	0.39
" auger	3.72	0.17
" roller	2.83	0.17
" blade	5.75	1.17
" chute	7.37	0.18

[1] = new machinery; 2 = machinery in use.

Several investigators have implicated the forage harvester as a major source of inoculation of grass (Gibson et al., 1961; Henderson, McDonald and Woolford 1972; McDonald, 1976; Muck and O'Connor, 1985; Fenton, 1987). Muck and O'Connor, (1985) working with alfalfa suggested that inoculation by the harvester would only be effective if the number on the unharvested crop was less than 104 CFU/g alfalfa

(e) The enumeration of LAB in large scale farm silos in the early stages of ensilage.

Numbers of LAB were enumerated in large scale farm silos during the first 48 hours of ensilage (Table 4). Overall, counts of LAB were found to increase in a similar manner and pattern to that seen in pipe and test tube silos. Treatment with formic acid was found to reduce the initial growth rate of LAB. This may be due to its ability to bring about a rapid reduction in pH and/or its antimicrobial properties (Saue and Breirem 1969; Woolford, 1975b). Treatment with L. plantarum resulted in a higher initial number of LAB on the harvested grass, however the numbers detected after forty eight hours were similar to those found on the untreated control.

Table 4

Mean counts of LAB ($\log_{10}$ CFU/g silage) in farm scale silages with different additive treatments.

Treatment	Time (hours		
	0	24	48
Harvested crop			
No treatment	5.68	7.98	9.13
Formic acid	5.61	7.28	8.73
Lactobacillus plantarum	6.00	8.87	9.04

NOTE: Standing crop had a count of 4.51

Effect on silage fermentation of bacterial inocula under varying levels of sucrose addition.

Perennial ryegrass (22g water soluble carbohydrate/kg grass juice) was harvested with a precision-chop harvester and ensiled in small plastic silos (6 kg treated grass per silo). It was treated with (1) no preservative (NP), (2) formic acid (850 g/kg) at 3.0 ml/kg (FA), (3) *Lactobacillus plantarum* at 10^6 colony forming units (CFU)/g grass (LP), (4) sucrose at 4 g/kg (S4), (5) sucrose at 8 g/kg (S8), (6) combination of LP and S4. Five silos per treatment were opened and sampled 3, 8, and 45 days after ensiling.

Forage from treatment NP and LP contained 6.5 (SE.07), 9.1 (SE.08), 9.1 (SE .03) and 8.6 (SE.06), and 6.8 (SE .09), 9.1 (SE .02), 9.1 (SE .03), and 8.6 (SE .04) lactic acid bacteria (LAB) Log_{10} CFU/g grass) on days 0, 3, 8, and 45, respectively. Formic acid reduced initial numbers of LAB but they recovered over time (Figure 1.). The lactic acid values for treatments 1 to 6 on day 45 were 96, 42, 85, 108, 97 and 109 g/kg dry matter (DM) (SE = 4) (Figure 2), respectively. The corresponding values for acetic acid, ethanol and ammonia-N were 17, 14, 14, 16, 15 and 12 g/kg DM (SE = 0.06), 15, 44, 16, 19, 10 and 13

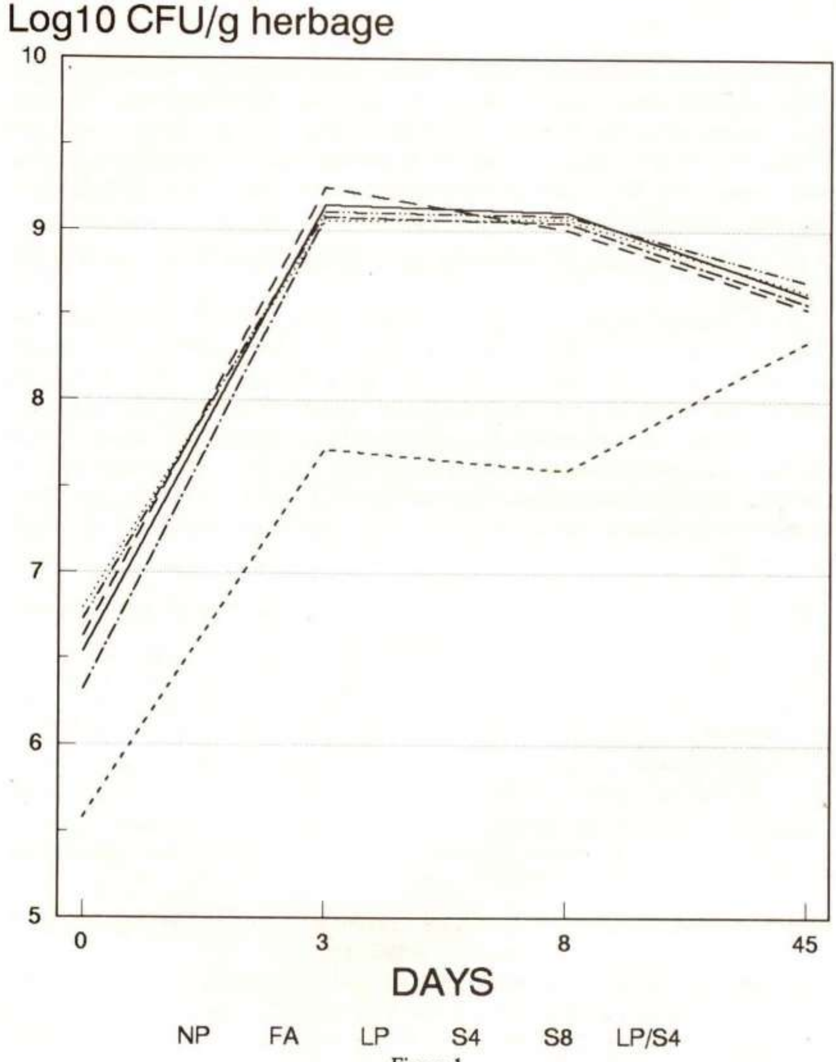

Figure 1
Lactic acid bacterial counts

g/kg DM (SE = 0.8) and 122, 72, 96, 95, 107 and 86 g/kg total N (SE = 3.9), respectively. LP (at 10^6 CFU/g grass) added to grass which had a high number of indigenous LAB had relatively little impact on total LAB numbers, or lactic or acetic acid levels. It did reduce ethanol production. Formic acid restricted the fermentation, reduced ammonia-N content and increased ethanol production. It also increased the initial flow rate of effluent.

Effect on silage fermentation of bacterial inocula from two sources

A lactic acid bacterium (LAB) which was identified as *Lactobacillus buchneri* was isolated from a well preserved silage and grown in de Man, Rogosa, and

Sharpe (MRS) broth. Italian ryegrass was cut using a precision-chop harvester and ensiled in test tube silos (90g treated grass/silo). Grass was treated with no additive (NA), *L. plantarum* at 10^6 colony forming units (CFU)/g grass (commercial strain) (LP) and *L. buchneri* (isolate) at 10^6 grass (LB). Four silos were opened per treatment after 1, 2, 4, 7, 14 21, 28 and 100 days ensiling.

Harvested grass contained 8 x 10^6 LAB/g grass. LAB numbers in the silage followed a similar pattern for NA and LP whereas LB gave rise to significantly

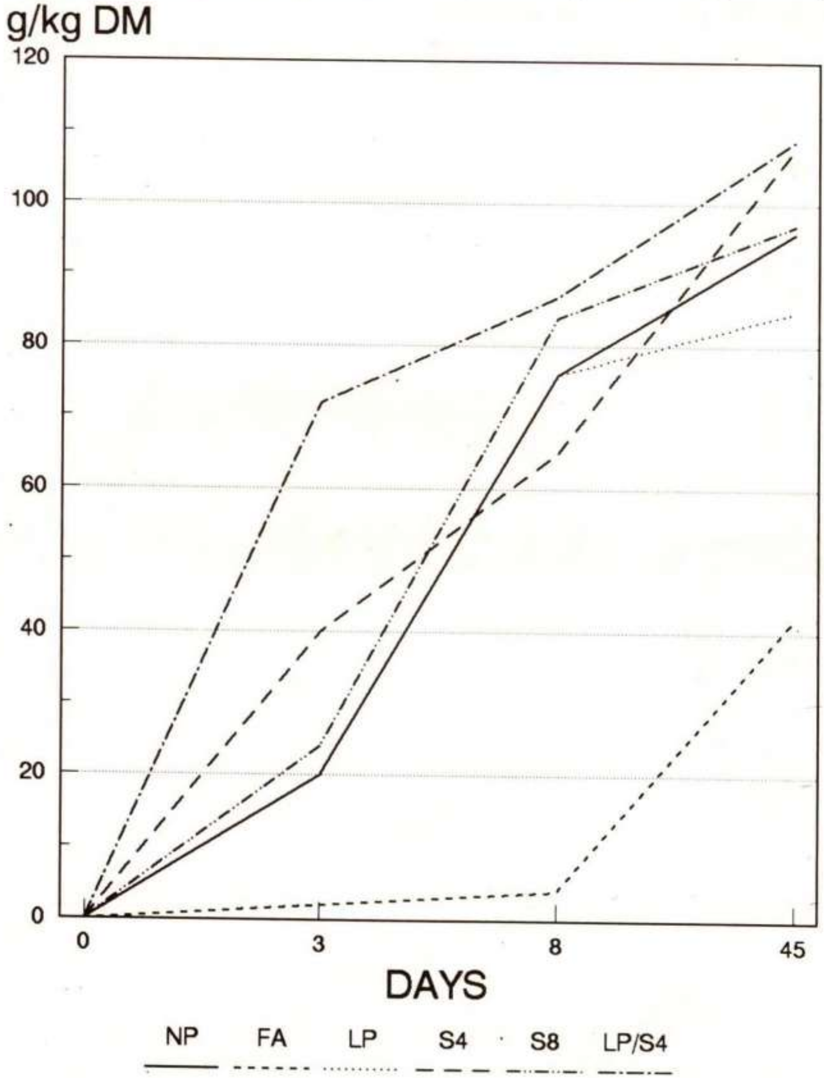

Figure 2
Lactic acid production

higher LAB numbers (Figure 3). Similar fermentation patterns occurred for NA and LP with lactic acid (25g/kg juice) (Figure 4), acetic acid (3 g/kg juice) and ethanol (1.5 g/kg juice) concentrations stabilising within 14 to 21 days. Final pH values for NA and LP were 3.70 and 3.69 respectively. For LB, pH, acetic acid, butyric acid, and NH_3-N (g/kg N) increased ($P < 0.01$) from day 28 and lactic acid decreased. Final pH, NH_3-N (g/kg N), lactic acid, acetic acid, butyric acid and

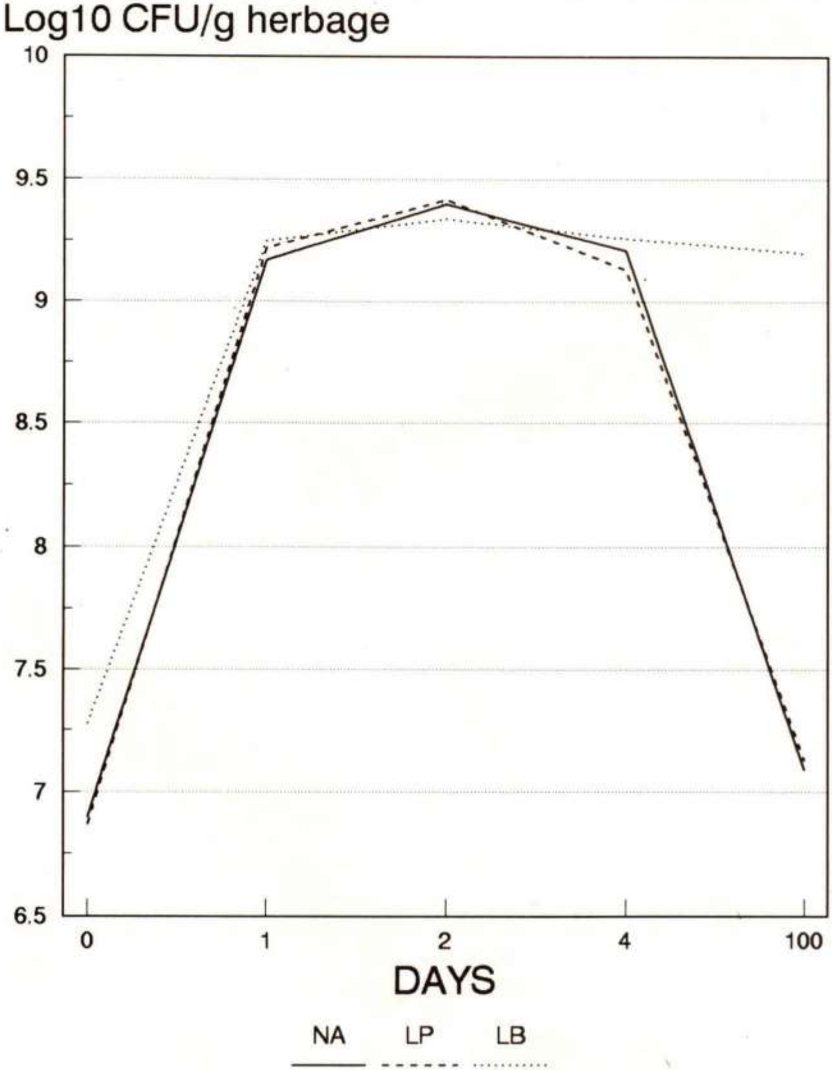

Fig. 3
Lactic acid bacteria counts

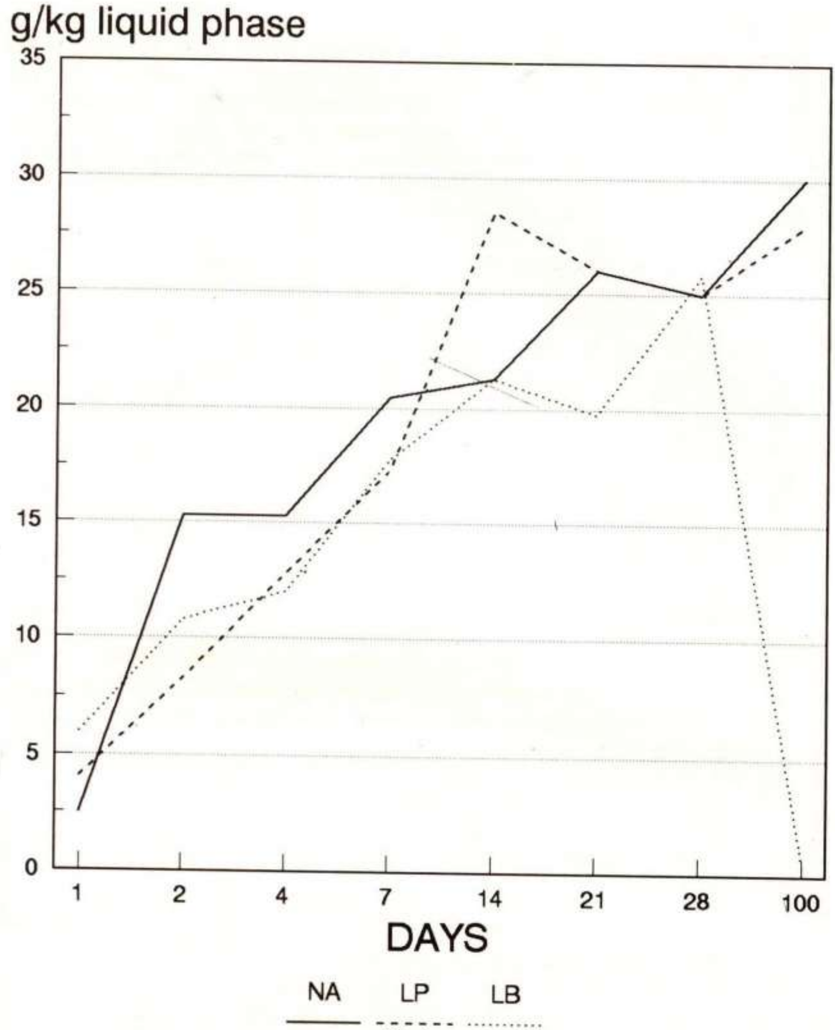

Fig 4
Lactic acid production

ethanol (g/kg juice) values were 4.64, 109, 0.6, 15, 5 and 2.6 respectively. These values were significantly different from the other two treatments. Treatment with *L. plantarum* had little effect on fermentation characteristics but *L. buchneri* addition had a deleterious effect and was associated with the development of a Clostridial fermentation.

Conclusions

New information elucidated in this work showed that LAB levels on a range of grasses in Ireland were greater than reported elsewhere (Stirling and Whittenbury, 1963; Muck and O'Connor, 1985; Fenton, 1987), that substrate availability in the early stages of fermentation can limit the ability of an added inoculum *(L. plantarum)* to make an obvious contribution to the silage fermentation pattern and that inoculation with other LAB *(L. buchneri)* could predispose a silage to a clostridial fermentation.

The information provided in the experiments reported here improves our understanding of the ensilage process. It demonstrated that:

- A poor fermentation should not usually occur under Irish conditions due to a shortage of LAB.
- Added inocula have a major challenge to overcome (i.e. high indigenous LAB numbers) if they are to dominate silage fermentation.
- Harvesting grass does not increase the count of LAB if the indigenous levels on the grass are high.
- Highest counts of LAB are found at the base of the plant (in the dead or decaying material) and are lowest on the leaf.
- Of the isolates identified, *Lactobacilli* were the dominant bacteria on the grass (64%) with the *Leuconostocs* accounting for 32% of isolates.
- LAB can survive on new unused, cutting and harvesting machinery and are increased following use, particularly in the harvester chute.
- Substrate availability can limit the ability of an added inoculant *(L. planta rum)* to make an obvious contribution to the fermentation pattern in the early stages.
- Added inocula tend to show improved fermentation when a readily utilisable form of substrate is supplied with an inoculum rather than relying on the grass having a high WSC content.
- Some LAB treatments can disimprove the fermentation.
- Clostridia can be active even at a pH of 3.9.

The research results in this paper have implications for recommendations for silage making.

- It has been proposed by Satter et al (1987) that inoculants need to be applied at a rate which adds ten times more LAB than the number of indigenous LAB, if they are to have the desired effect. If this is the case then most inoculants in Ireland need very high bacterial numbers (or more aggressive/active bacteria) and an excellent viability/shelf life.
- bacterial inoculants will frequently need a source of added fermentable carbohydrate if they are to have a noticeable effect on fermentation products.
- formic acid can significantly increase the effluent flow rate in the initial stages of ensilage.
- silages which reach a pH of 3.9 in the early stages of ensilage can, under unusual conditions, still undergo a clostridial fermentation.

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Factors Affecting the Optimum Level and Protein Content of Concentrates for Finishing Beef Cattle

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High quality silage is the cheapest source of winter feed for beef cattle. However, even with excellent silage, concentrate supplementation is still required during the finishing period to maintain sufficiently high levels of performance to exploit the growth potential of most types of cattle. It has now been clearly shown that as the level of concentrate feeding or the protein content of concentrates given to beef cattle are increased the responses in performance to each additional increment of energy or protein decline, giving a curvilinear response to additional inputs. Consequently a point is reached when the value of the extra weight gain is equivalent to the cost of the extra energy or protein required to produce it, and this determines the most economic input of energy and protein for any given type of animal.

In the past responses to additional concentrates or protein have been measured almost entirely in terms of the extra live-weight or carcass gain produced by additional inputs. However with increasing consumer demand for leaner beef it had become vitally important that the effects of varying the energy and protein intakes of beef cattle be assessed in terms of changes in carcass composition and the output of lean meat as well as the responses in live-weight and carcass gain. Consequently a series of experiments have been carried out at Hillsborough over the past few years to examine the effects of level of concentrate feeding and the protein content of the concentrates on the performance and carcass composition of finishing beef cattle.

Factors affecting the optimum level of concentrate feeding.

The optimum input of concentrates for finishing cattle is determined by a number of factors including the growth potential of the cattle, the quality of the basal silage diet and the overall economics of beef production.

Effect of the growth potential of the cattle

The potential of beef cattle for growth and lean meat deposition varies greatly depending on the breed and sex of the animal. In experiments at Hillsborough which have examined the effects of level of concentrate feeding on performance and carcass composition, heifers which were crosses of the continental beef breeds were used to represent cattle of low growth potential and continental cross Friesian bulls were used to represent animals of high growth potential. Ninety heifers which were initially about 13 months old and 360 kg. live weight were

Table 1

Effect of concentrate input on the performance and carcass composition of finishing heifers

(Robson and Steen, unpublished data)

	Concentrate input (kg/day)					
	0.6		2.4		4.2	SEM
Silage intake (kg DM/day)	5.8		5.1		4.3	0.10
Live-weight gain (kg/day)	0.70		0.85		0.95	0.025
Carcass gain (kg/day)	0.40		0.54		0.61	0.013
Response to concentrates (g carcass/kg concentrates)		78		39		
Carcass lean meat content (g/kg)	647		634		621	3.3
Lean meat gain (g/day)	247		314		336	
Response to concentrates (g lean meat/kg concentrates)		37		12		

given high digestibility (dry matter digestibility 722 g/kg), well preserved silages *ad libitum* and 0.6, 2.4 or 4.2 kg of barley-based concentrates per head daily for 150 days.

The effects of concentrate input on performance and carcass composition are given in Table 1. Increasing concentrate input from 0.6 to 2.4 kg/day produced relatively large responses in both live-weight and carcass gain, 150 and 140 g/day respectivley and approximately half of the extra carcass weight gain was in the form of lean meat. Consequently an extra 37 g of lean meat were produced for each extra kg of concentrates consumed, or 27 kg extra concentrates were required to produce one extra kg of lean meat. However when concentrate input was further increased from 2.4 to 4.2 kg/day responses in live-weight and carcass gain were much lower than those obtained from the first increment of concentrates and only 30% of the extra carcass weight was in the form of lean meat. Consequently over this range 26 kg of concentrates were required to produce one kg extra carcass weight and 82 kg extra concentrates were required to produce one extra kg of lean meat, which is a very poor response and would certainly be uneconomical if producers were paid for cattle on the basis of the lean meat content in the carcass.

In subsequent studies continental cross Friesian bulls which were initially 13 months old and 440 kg live weight were given similar high digestibility (dry matter digestibility 743 g/kg) well preserved silages as those given to the heifers. Silages were offered *ad libitum* and supplemented with 2.6, 3.8, 5.0 and 6.2 kg barley-based concentrates (90% barley/10% soyabean meal) for 150 days. The effects of increasing concentrate input on performance and carcass compositon are shown in Table 2. Again the responses in both live-weight and carcass gain to additional concentrates declined progressivley with each additional increment of concentrates. However responses were much greater than those obtained with heifers. For example, when bulls were given 2.6 to 5.0 kg

Table 2

Effect of concentrate input on the performance and carcass composition of bulls (Steen, unpublished data)

	Concentrate input (kg/day)						
	2.6		3.8		5.0		6.2
Silage intake (kg DM/day)	6.4		5.9		5.3		4.5
Live-weight gain (kg/day)	1.08		1.23		1.35		1.44
Carcass gain (kg/day)	0.69		0.79		0.84		0.86
Response to concentrates (g carcass/kg concentrates)		83		42		17	
Carcass lean meat content (g/kg)	658		659		656		654
Lean meat gain (g/day)	414		482		508		517
Response to concentrates (g lean meat/kg concentrates)		57		22		8	

concentrates/day the proportion of concentrate dry matter in the diet was similar to that when heifers were given 2.4 to 4.2 kg/day, yet the response in carcass weight gain to extra concentrates over these ranges was 40% greater for bulls than for heifers. Furthermore, a high proportion (61%) of the extra carcass weight produced in bulls when concentrate input was increased was in the form of lean meat. Consequently when the concentrate intake of bulls was increased from 2.6 to 5.0 kg/day the increase in the rate of lean meat production (40 g/kg. additional concentrates) was over three times greater than the increase obtain(12 g/kg additional concentrates) when the concentrate intake of heifers was increased form 2.4 to 4.2 kg/day (i.e. the same range of forage: concentrate ratios).

These results clearly show that in terms of both animal performance and carcass composition the optimum input of concentrates is much higher for animals of high growth potential than for those of low growth potential although the data for bulls and heifers have been obtained in different experiments. However, this important interaction between the effects of plane of nutrition and the growth potential of the animal has again been clearly demonstrated in subsequent studies at Hillsborough in which direct comparisons were made involving bulls, steers and heifers in the same experiment. In this case, Continental cross Friestian bulls, steers and heifers, all of which were initially 12 months old were given a complete diet containing two thirds high digestibility silage and one third barley-based concentrates on a dry matter basis. Half of the animals of each sex were given the diet *ad libitum* while the intake of the other half was restricted to 80% of *ad libitum* intake. The results are summarised in Table 3.

Responses in carcass gain to additional food were 169, 100 and 92 g per kg dry matter for bulls, steers and heifers respectively. Furthermore, the proportion of the extra carcass gain which was lean meat was 55% in bulls, 49% in steers and only 30% in heifers. Consequently, the responses in the production of lean meat to additional food were 90, 49 ad 28 g per kg dry matter for bulls, steers and heifers respectivley, the response in bulls being just over three times the response in heifers, as in the previous studies.

Effect of silage quality

The response in the performance of beef cattle to additional concentrates is also greatly influenced by the quality of the silage available to the cattle. The interaction between the quality of the basal silage diet and the response to

Table 3

Effect of plane of nutrition on the performance and carcass composition of bulls, steers and heifers

(Steen, unpublished data)

	Sex of animal					
	Bull		Steer		Heifer	
Plane of nutrition	High	Low	High	Low	High	Low
Dry matter (DM) intake (kg/day)	9.0	7.4	8.5	6.9	7.9	6.5
Carcass gain (kg/day)	0.90	0.63	0.63	0.47	0.55	0.42
Response to additional food (g carcass gain/kg DM)	169		100		92	
Lean meat gain (g/day)	540	392	342	263	258	219
Response to additional food (g lean meat/kg DM)	90		49		28	

supplementary concentrates has been examined in a number of experiments. The results of two of these are summarised in Table 4. In these experiments steers which were initially 580 kg live weight and had been implanted with hormonal growth promoters were given average (D-value 630 g digestible organic matter/kg DM) or high quality (D-value 707 g digestible organic matter/kg DM) silages *ad libitum* for 80 days. Each silage was supplemented with 2.5 or 5.0 kg per head daily of barley-based concentrates. The responses in carcass weight gain when concentrate input was increased from 2.5 to 5.0 kg were 95 and 65 g/kg concentrate for the average and high digestibility silages respectively. However a number of experiments have shown that responses to concentrates have been approximately 30% lower with non-implanted steers than with implanted steers. Consequently responses of 66 and 45 g carcass weight/kg concentrates would be expected over this range with average and high quality silages respectively. These are in close agreement with those obtained in other experiments. For example, Drennan (1984) obtained a response of 52 g carcass gain/kg concentrates when the concentrate intake of steers given fairly good quality silages was increased from 19 to 34% of total dry matter intake, and in the data given in Table 1 a response of 39 g carcass weight gain per kg concentrates was obtained when the concentrate intake of heifers was increased from 28 to 47% of total DM intake.

Table 4
Effect of silage quality on the response to concentrates
(Steen, unpublished data)

	Silage D-value (g DOM/kg DM)			
	630		707	
Concentrate input (kg/day)	2.5	5.0	2.5	5.0
Silage intake (kg DM/day)	7.3	6.6	8.1	7.4
Carcass gain (kg/day)	0.56	0.79	0.84	1.00
Response to concentrates (g carcass/kg concentrates)	92		64	

Taken together these results indicate that the optimum input of concentrates for non-implanted steers and heifers of average growth potential is likely to be of the order of 20 to 25% of total DM intake for high quality silages and 35 to 40% of total DM intake for medium quality silages. However, these levels are much lower than those currently used on many farms.

The interaction between silage quality and concentrate input on a total system basis has been further examined in a series of six experiments (Steen, 1988a). In these studies a traditional 2-cut system of silage making was compared with a more intensive 3-cut system using perennial ryegrass swards. Cutting dates, yields of grass and silage digestibilities are given in Table 5. The two systems were designed to provide equal quantities of aftermath grazing in the autumn. The silages were given to 380 finishing steers for a mean period of 150 days. When the silages from both systems were supplemented with 2.45 kg. concentrates/head daily, those given the 3-cut silage gained 0.22 kg/day or 41% more carcass gain than those given the 2-cut silage. Consequently, a concentrate input of 4.9 kg/head daily was required with the 2-cut silage to sustain the same level of carcass gain as that sustained by the 3-cut silage supplemented with 2.45 kg/head daily. However the higher intake of the 3-cut silage reduced the number of cattle finished/ha of grass ensiled by 25% compared to when the 2-cut silage was supplemented with the higher input of concentrates, but it reduced the quantity of concentrates required for the cattle finished on one hectare of silage by 62%.

With the current shortage of cattle for finishing in Ireland and the overall economics of beef production, finishing 9.4 cattle from a hectare of silage using 3.5 tonnes of concentrates is likely to be much more economical for the forseeable future than feeding 12.6 cattle from a hectare of silage using 9.3 tonnes of concentrates. Alternativley, the use of an extra 2.4 hectares of silage for every 100 cattle finished over the 150 day winter period would enable the high quality silage and low input of concentrates to be used rather than the average quality silage and the high input of concentrates, with a saving of 37 tonnes of concentrates, again the high quality silage system being much more economical.

Table 5
A comparison of 2-cut and 3-cut silage systems and interaction with concentrate input (Steen, 1988a)

	Silage system			
	2-cut		3-cut	SEM
Date of 1st harvest	10 June		23 May	
2nd harvest	16 August		5 July	
3rd harvest			25 August	
Yield of grass (t DM/ha)	12.5		12.1	
'D' value (g DOM/kg DM)	632		707	
Concentrate intake (kg/day)	2.45	4.9	2.45	
Silage DM intake (kg/day)	6.3	5.3	6.9	0.15
Live-weight gain (kg/day)	0.96	1.22	1.18	0.029
Carcass gain (kg/day)	0.54	0.76	0.76	0.023
Cattle finished for 150 days per ha silage	10.6	12.6	9.4	
Concentrates consumed by cattle finished on one ha silage (tonnes)	4.0	9.3	3.5	

Factors affecting the optimum protein content in concentrates

The use of high-protein concentrates, especially those of low degradability, to improve the performance of finishing cattle offered silage-based diets has been the subject of widespread research over the past few years especially in Great Britain. However, most of these experiments have involved implanted cattle which have a higher potential for growth and lean meat deposition than non-implanted animals. Consequently, the response to additional protein in the diet has been shown to be lower in non-implanted cattle than in implanted animals (Steen 1988b).

Effects with steers

In view of the current ban on the use of hormonal growth promoters a series of six experiments have been carried out to examine the effects of supplementing silage-based diets with protein for non-implanted steers. The silages were all well preserved with protein contents ranging from 112 to 173 g/kg DM and digestibilities from 656 to 734 g digestible organic matter/kg DM. In each experiment the silages were supplemented with 2.4 to 3.0 kg per head daily of either mineralised barley or with mixtures of barley and soyabean meal or barley and fish meal containing approximately 170 g crude protein/kg for periods of 98 to 155 days. Increasing protein intake did not affect silage intake or animal performance but significantly increased carcass fatness, these effects being consistent across the six experiments (Table 6). The significant increases in

Table 6

The effects of protein supplementation on the performance and carcass fatness of steers (Steen, 1989)

	Protein in concentrates (g/kg)		
	94	176	SEM
Silage DM intake (kg/day)	5.6	5.6	0.03
Live-weight gain (kg/day)	1.02	1.00	0.012
Carcass gain (kg/day)	0.61	0.60	0.006
Carcass fat classification+ 3	90%	60%	
4	10%	40%	
Subcutaneous fat depth mm)	6.6	7.4	0.14
Area of eye-muscle (cm2)	67	66	1.5
Marbling score#	2.8	3.5	0.11
Saleable meat content (g/kg)	697	688	6.4
Fat trim (g/kg)	93	103	4.2

+ 5 point scale, 1 = leanest, 5 = fattest

8 point scale, 1 = leanest, 8 = fattest

carcass fat classification, subcutaneous fat depth and marbling score (assessed in the cut surface of the eye-muscle at the 10th rib) with increasing protein intake are particularly important in view of the current demand for leaner beef.

Effects with heifers

A series of four experiments have been carried out to examine the effects of increasing the protein content of barley-based concentrates given with silage to continental cross finishing heifers. Well preserved silages of medium to high digestibility (642 to 734 g digestible organic matter/kg DM) were supplemented with 0.5 to 4.5 (mean 2.5) kg/head daily of either barley or mixtures of barley and soyabean meal (204 g crude protein/kg). The results are summarised in Table 7. Increasing the protein content of the concentrates from 96 to 204 g/kg did not affect the performance of the heifers or carcass fatness as indicated by fat classification, subcutaneous fat depth, marbling score or the contents of saleable meat and fat trim when the carcasses were boned out commercially. However, increasing the protein content of the concentrates significantly reduced the lean content and increased the fat content of the fore-rib joint as determined by total dissection into separable lean, fat and bone. Nevertheless, the detrimental effects of increasing protein intake on carcass fatness were less pronounced and were more variable in heifers than in steers, even though heifers would generally be considered to have a lower growth potential and consequently a lower requirement for protein than steers.

Effects with bulls

The ban on the use of hormonal growth promoters in the EC has resulted in renewed interest in Northern Ireland in the use of bull beef production as a method of producing lean beef efficiently. Consequently, two experiments have

Table 7

The effects of protein supplementation on the performance and carcass composition of finishing heifers (Steen, 1989)

		Protein in concentrates (g/kg)		
		96	204	SEM
Live-weight gain (kg/day)		0.97	0.96	0.020
Carcass gain (kg/day)		0.58	0.57	0.006
Carcass fat classification	3	70%	60%	
	4	30%	40%	
Subcutaneous fat depth (mm)		7.9	8.1	0.20
Marbling score		3.2	3.2	0.07
Saleable meat content (g/kg)		692	692	2.4
Fat trim (g/kg)		100	100	1.1
Lean content of fore-rib joint (g/kg)		605	594	2.5
Fat content of fore-rib joint (g/kg)		241	254	3.2

been carried out to compare mineralised barley and mixtures of barley and soyabean meal (800 g barley and 200 g soya/kg) as supplements to silage for finishing bulls. The silages used in both studies were well preserved and were of high digestibility (732 g digestible organic matter/kg DM). The bulls were Continental x Friesian and Friesian and were initially 12 months old and 409 kg live weight. Results are summarised in Table 8.

Increasing the protein content of concentrates did not affect performance in experiment 1 but increased carcass weight gain by 12% in experiment 2. Protein intake did not affect carcass composition in either experiment. The higher level

Table 8

Effect of protein supplementation on the performance and carcass compositon of bulls (Steen, 1989)

		Protein in concentrates (g/kg)		
		94	164	SEM
Live-weight	Expt. 1	1.00	0.99	0.051
gain (kg/day	Expt. 2	1.15	1.25	0.049
Carcass gain	Expt. 1	0.61	0.61	0.029
(kg/day)	Expt. 2	0.67	0.75	0.028
Carcass fat	2	30%	30%	
classification	3	70%	70%	
Subcutaneous fat depth (mm)		4.8	4.8	0.42
Marbling score		2.7	2.8	0.19
Carcass saleable meat content (g/kg)		720	717	5.1
Fat trim (g/kg)		72	79	3.6

of performance for bulls in experiment 2 than for those in experiment 1 is likely to have been due to the fact that in experiment 2 they were at pasture during the previous summer and had a lower level of performance and consequently would have exhibited compensatory growth during the experimental period while those used in experiment 1 were indoors throughout their lives and had a high level of performance prior to the experiment. Orskov et al (1976) found that sheep which were exhibiting compensatory growth had a higher requirement for additional protein than those which had previously been on a high plane of nutrition. Similar effects to those obtained with bulls have also been obtained previously with implanted steers (Steen 1988c). When soyabean meal was included in a diet of silage and barley there was no response in the performance of steers with a live-weight gain of 1.1 kg/day. It would therefore appear that for a given type of silage, responses in the performance of finishing cattle to additional protein are likely to be closely related to the growth potential of the cattle.

The experiments described so far have involved well preserved silages of medium to high digestibility. However, the protein in poorly preserved silages is not utilized as well by beef cattle as the protein in well preserved silages. Consequently, in a recent experiment involving young, growing cattle the response in performance when poorly preserved silage (204 g ammonia-N/kg total N) was supplemented with barley and soyabean meal rather than with barley was twice as large as the response obtained with a comparable well preserved silage (61 g ammonia-N/kg total N). There is also limited evidence to show that positive responses to additional protein may be obtained in the performance of non-implanted finishing steers and heifers when silages when a low digestibility and a low protein content are used.

Conclusions

The experimental evidence available would indicate that when finishing steers or heifers are given well preserved silages of medium to high digestibility, increasing the protein content of concentrates above 100g/kg will not improve animal performance and is likely to increase carcass fatness. However with young bulls or with steers with an exceptionally high growth rate, due to compensatory growth being exhibited, increasing protein intake is likely to produce some improvement in performance without affecting carcass composition. Similarly, when badly preserved silages or low digestibility silages with a low protein content are used a positive response in performance may be obtained to additional protein with most types of finishing cattle.

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Feeds and the Feeding of Finishing Cattle in Winter

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The importance of weight gain for economic success in winter finishing cannot be overemphasised. A daily liveweight gain increase of 0.1 kg amounts to 15 kg over a 5 month feeding period or 8 kg of additional carcass valued at about £20. Level and protein content of concentrates fed with silage to different breeds and sexes are discussed in the previous paper by R. Steen. The objective of the present article is to discuss concentrate feeds and feeding management for finishing animals

Accommodation and feeding

To avoid any reduction in animal performance it is important to provide suitable accommodation. In this respect points to be considered include: avoiding overstocking on slats, in cubicle sheds ensuring adequate cubicle size, and in straw bedded sheds the provision of adequate bedding. Maximum performance on any diet can only be achieved by providing unrestricted access to the diet. For concentrate feeding this involves the provision of adequate feeding space so that all animals can readily feed at the same time. The area where errors most often arise is that of providing unrestricted access to silage. This is almost impossible when complete reliance is on self feeding from the pit as it is very difficult to ensure unrestricted intake while at the same time attempting to avoid silage losses. Where self feeding is practised it is necessary to also provide a certain amount of easy feeding (e.g. round feeders). With easy feeding, edible silage should be available to the animal at all times. This means discarding inedible material prior to feeding and frequent removal (twice weekly) of deteriorated silage from the troughs.

Introduction to concentrates

A considerable quantity of home grown barley is now stored and fed on the farm. This practice makes good economic sense and will probably become more prevalent in the future. It is also likely that some of this barley will be replaced by wheat. Where high levels of concentrate (or roots) feeding is practised there is a danger of digestive upsets or acidosis (accumulation of lactic acid in the rumen and a drop in rumen pH accompanied by going off feed and scouring). This normally occurs during the introductory period and can be avoided by observing the following precautions :

1. Gradual introduction to concentrates (increase by one-third kg daily) .
2. Feed concentrates twice rather than once daily.
3. Use rolling or coarse grinding.
4. Ensure free availability of roughage during the introductory period.

If fed concentrates to appetite it is essential to ensure that once animals have reached the *ad libitum* feeding level following gradual introduction, concentrates are subsequently freely available at all times.

In practice, where mixing facilities are not available, different concentrate sources (also protein and mineral/vitamin supplements) can be satisfactorily fed by spreading them separately (and evenly) along the feeding trough. It is recommended to avoid sudden changes in the diet; if concentrates are changed during the feeding period this should be done gradually.

Method of feeding concentrates

Most winter cattle feeding operations in Ireland involve grass silage fed to appetite and the daily allowance of concentrates given in one of two feeds. Only a relatively small proportion of the larger units have facilities for feeding the silage and concentrates as complete diets. In one study, once daily feeding of a barley based concentrate with silage to appetite was compared with mixed diets at low and high concentrate feeding levels. No differences between the two feeding methods were evident at the low (2.7 kg per day) concentrate level (Table 1). However, at the high (5.2 kg per day) level of concentrates daily carcass gains were 0.08 kg per day higher where the mixed diet was fed compared with feeding concentrates once daily. In general, the results of studies show that the expected improvements in animal performance from mixed diets as opposed to separate feeding of concentrates and silage are less than obtained in this study. In further studies animals were fed grass silage to appetite plus 6 kg of a barley based concentrate daily in one of two feeds. There was no effect of treatment on silage intake but the daily carcass gains were 0.027 kg higher for those fed concentrates in twos as opposed to one feed daily (Table 2). This amounts to an improvement

Table 1

A comparison of once daily feeding of concentrates with complete diets for animals fed concentrates and silage.

	Concentrate feeding level			
	High		Low	
Concentrates feeds/day	One	Mixed Diet	One	Mixed Diet
Concentrates (kg/day)	2.7	2.7	5.2	5.2
Total feed DM (kg/day)	8.9	8.8	9.4	9.3
Liveweight gain (kg/day)	0.76	0.82	0.88	0.97
Carcass gain (kg/day)	0.44	0.46	0.52	0.60

Table 2

A comparison of once with twice daily feeding of concentrates for animals fed grass silage and concentrates (6 kg daily).

	Concentrate feeds per day	
	One	Two
Silage DM (kg/day)	4.1	4.4
Daily liveweight gain (kg)	0.91	0.94
Daily carcass gain (kg)	0.533	0.560

of about 4 kg of carcass over a 150 day winter period from feeding the concentrates in two rather than one feed daily. Prior to each of these studies concentrates were introduced gradually and during the introductory periods the daily concentrate allowances were given in two feeds. Thus, following careful introduction once daily feeding of concentrates is satisfactory for finishing cattle offered silage and up to 3 kg of concentrates daily. However, where 5 to 6 kg of concentrates are fed daily with silage, a small but consistent improvement is evident when twice rather than once daily feeding of concentrates is practised. Purchase of a complete diet feeder could not be justified in terms of expected improvements in animal weight gain even at high concentrate feeding levels when compared with twice daily feeding of concentrates,

Processing of grains

When home grown (or purchased) grains are used they are generally either rolled or ground prior to feeding. Irrespective of the processing method, it is important that the outer indigestible portion of each grain is damaged to ensure access by the rumen microbial population to the digestible inner portion. However, fine grinding is not necessary and is in fact undesirable due to increased losses of the finer particles and lack of the fibre characteristics which would be important particularly at high feeding levels. A comparison of rolled barley and wheat with the whole grains in grass silage based diets showed that the dry matter digestibility of the rolled and whole grains were 80.0% and 42.5% respectively (Table 3). These results clearly demonstrate that feeding barley or wheat (or oats) with even a small proportion of undamaged grains can result in an unacceptable reduction in grain digestibility and consequently in animal performance

Treating grain with sodium hydroxide

Treatment of whole grain with sodium hydroxide has been examined recently as an alternative to rolling or grinding. Sodium hydroxide treated grain has the advantage that it can be stored at a high moisture content without deterioration and thus drying is not necessary. In one study at Grange fresh barley was mixed in a Keenan Easi feeder with sodium hydroxide, following which it was deposited on a concrete floor. The grain was disturbed eight hours later and again after a couple of days to avoid setting in a solid mass. When compared in a digestibility study to diets consisting of approximately 50 percent grass silage the digestibility of the sodium hydroxide treated grain was 9 digestibility units lower than rolled barley (Table 4). Thus, based on this investigation sodium

Table 3

Dry matter digestibility (percent) of whole and rolled grains when fed with silage to cattle

	Whole grain	Rolled grain
Barley	45.3	79.2
Wheat	39.6	80.7

Table 4

Dry matter digestibility (percent) of rolled and sodium hydroxide treated barley when fed with silage.

	Barley fed with silage		
	None	Rolled	NaOH treated
Total diet	72.3	76.1	71.7
Grains only	–	79.9	71.0

hydroxide treatment could not be recommended as a satisfactory alternative to rolling.

ALTERNATIVES TO BARLEY

Quality of concentrates fed with silage

The standard energy source used as a supplement to grass silage at Grange has been barley (with added minerals/vitamins and if necessary protein). If barley is to be replaced in the feeding programme it is important particularly with finishing animals that the alternative is also of high quality. In three studies a high quality concentrate based on barley was compared with a low quality concentrate based on grain screenings. The concentrates were fed at 6 kg per animal daily (following gradual introduction) in two feeds with grass silage offered to appetite. To compensate for the lower quality of the concentrate, animals offered the grain screening consumed more silage (Table 5). However, daily liveweight gains were 0.2 kg greater for those offered barley and carcass gains were 0.17 higher. Thus, over a 150 day feeding period, carcass weight gain would be 25.5 kg higher for animals offered the concentrate based on barley as opposed to grain screenings. These results clearly demonstrate the importance of the quality of the concentrate fed as a supplement to grass silage.

Feeding molasses with silage

In two cases weaned continental cross suckler bulls were fed high quality grass silage to appetite and one of the following supplements per animal daily:

A. Barley 4.0 kg
B. Barley 3.6 kg + soyabean 0.4 kg
C. Barley 2.0 kg + molasses 2.0 kg + soyabean meal 0.3 kg
D. Barley 1.6 kg + molasses 2.0 kg + soyabean meal 0.7 kg

Table 5

Quality of concentrate fed with silage

	High quality concentrate	Low quality concentrate
	Barley	Grain screenings
Concentrate DM (kg /day)	4.8	5.0
Silage DM (kg/day)	4.5	5.1
Liveweight gain (kg/day)	0.90	0.70
Carcass gain (kg/day)	0.57	0.39

Thus, Supplements A and B had 2 kg of barley replaced by 2.0 kg of molasses and 0.3 kg of soyabean meal in Supplements C and D. There was no effect of supplement on silage intake (Table 6). Inclusion of soyabean with barley (Supplement B) did not improve weight gains over those offered barley alone (Supplement A). However, animals offered molasses and a low level of soyabean meal (Supplement C) had carcass weight gains of approximately 20 kg lower than those offered the entire supplement as barley. Inclusion of additional soyabean meal with molasses (Supplement D) improved carcass weight gains. In earlier studies molasses compared favourably with barley in silage based diets at low dietary inclusion rates but not at high rates of inclusion. It would appear from the present studies that even at low inclusion rates the protein content of the diet is more critical where molasses is fed as opposed to where barley is used.

Table 6
Performance of bulls (307 kg) fed different supplements with silage (245 days)

	Supplement			
	A	B	C	D
Barley (kg/day)	4.0	3.6	2.0	1.6
Molasses (kg/day)	–	–	2.0	2.0
Soyabean (kg/day)	–	0.4	0.3	0.7
Silage DM (kg)	4.3	4.2	4.3	4.4
Liveweight gain (kg/day)	1.29	1.27	1.16	1.21
Carcass weight (kg)	366	361	343	356

Feeding roots with silage

Fodder beet roots are high in energy and have a protein content of 7 to 9 percent. In feeding experiments pulped fodder beet roots alone or with soyabean meal were compared with barley as a supplement to silage for finishing cattle. A summary of these experiments is presented in Table 7.

In the various studies, barley was fed at 2.5 or 3 kg per animal daily. Animals fed roots alone or roots plus soyabean meal were offered the same amount of supplement dry matter as the barley group. All animals were given a suitable mineral/vitamin mixture. Daily carcass gain of animals fed silage only was 0.35 kg. Feeding a barley supplement with silage increased carcass gain to 0.51 kg per day but feeding roots alone only increased gain to 0.44 kg daily. However, when soyabean was included with roots carcass gains were almost similar (0.50

Table 7
Feeding barley or fodder beet roots with silage

	Supplement fed wth silage			
	None	Barley	Roots	Roots/Soyabean meal
Silage DM (kg/day)	8.1	6.2	6.1	6.2
Liveweight gain (kg/day)	0.59	0.86	0.73	0.84
Carcass gain (kg/day)	0.35	0.51	0.44	0.50

kg per day) to those obtained from barley. Silage intakes from similar quantities of fodder beet and barley dry matter were the same.

In conclusion, the studies with fodder beet roots indicate the very good response that can be obtained from supplementary protein when protein is limiting. Thus, when preparing diets, the additional weight gain required to offset the cost of providing additional protein should be examined when using feeds marginal to low in protein content. To offset the low crude protein values in fodder beet (or potatoes) approximately 1 kg of soyabean meal (or its equialent) should be provided for each 8 kg of roots dry matter. Sugar beet roots contain only 4 to 5 percent crude protein and where fed, about 1 kg of soyabean meal should be given for each 4 kg of roots dry matter. This additional protein will provide a crude protein content of the mixture similar to that of barley.

Feed Additives

Feed additives that are available commercially include Romensin (Monensin), Avotan (Avoparcin) and Flavomycin. Most studies with feed additives at Grange using finishing animals in winter have been conducted with Romensin. In a summary of four experiments with animals fed silage and concentrates in winter, Romensin increased liveweight and carcass gains by 103 and 51 g per day respectively (Table 8). In these studies the effects of Romensin on voluntary silage intake were minimal. While the data are limited for other feed additives with finishing cattle, studies with weanlings were similar to those using Romensin (increased liveweight gain of 65 g per day).

Table 8

Effect of Romensin (200 mg of Monensin per head daily) on weight gains of finishing animals fed silage and concentrates

	Controls	Romensin	Differences
Daily liveweight gain (g)	821	924	103
Daily carcass gain (g)	475	526	51
Relative feed intakes	100	103	3

Supplementary minerals and vitamins

Although grass silage is usually balanced for minerals, feeds such as barley and other cereals are low in calcium whereas pulp, roots and molasses are low in phosphorus. Potatoes are also rather low in phosphorus and are very low in calcium. Thus, in silage/concentrate diets, 50 to 100 g per animal daily of a suitable mineral and vitamin mixture should be provided (i.e. about 20 g per kg of concentrates). Where home grown feeds are used and the silage and concentrates are fed separately then the mineral/vitamin (and protein if needed) supplement can be satisfactorily fed by spreading it evenly over the concentrates at feeding time.

Parasite control

With heavy animals, anthelmintics for the control of liver fluke are generally necessary. While treatment for the control of hoose and worms (effective against Ostertagia stage II) is always necessary with weanlings, there are circumstances

where control measures would also be required with older animals. Animals must also be treated for the control of lice.

Nutritive value of feeds

The metabolisable energy (ME) system is the system used in Ireland and the U.K. to describe the energy value of feeds. While this system effectively ranks the various feeds in order of nutritional value it does not directly allow calculation of relative monetary values. The reason is that the ME of higher energy feeds such as barley is used more effectively than is that of lower energy feeds. A more appropriate energy system is that used in the U.S. where, feeds assigned net energy for maintenance and net energy for gain values. Assuming that two-thirds of the feed energy is used for maintenence and one-third is used for weight gain, a single energy value for each feed has been calculated. These values relative to the comparable value for rolled barley are shown in Table 9.

Likewise, the protein value of feeds is generally shown as crude protein but because the crude protein values of two feeds are similar they are not necessarily equally effective sources of protein. The digestibility of protein in feeds such as roots is lower than that in barley and in the extent to which protein escapes breakdown in the rumen but is digested further along the digestive tract also varies between feeds. Within the above considerations relatively accurate monetary values can be calculated for feeds relative to one another. This is done in Table 9 using (A) the net energy value assuming two-thirds for maintenence and one-third for weight gain relative to barley except where protein content is lower than barley and (B) the net energy value and digestible crude protein as the basis of comparison. Barley and soyabean meal are used as standards for the purpose of comparison.

Cereal grains

Barley is the main cereal used for cattle feeding in Ireland and is used as a standard with which other feeds are compared. Both maize and wheat have higher energy values whereas oats has a lower value (1.16 kg of oats = 1 kg of barley). Although wheat is higher in feeding value than barley it is more likely to cause digestive upsets. Digestive upsets can be minimised by gradual introduction, using rolling or coarse grinding and feeding concentrates twice rather than once daily.

Molassed beet pulp and citrus pulp

These contain 90% to 95% the feeding value of barley. Compared with barley, they tend to be lower in phosphorus (which is high in barley) and thus a high phosphorus mineral/vitamin supplement should be used. This is also necessary where roots or molasses is fed. It is noteworthy that citrus pulp is a variable product and ME values lower than that presented can be obtained. The crude protein content is about 6.5%.

Tapioca

Although similar to barley in energy, it is very low in protein (2.7% protein).

Table 9

Guide to values of feeds relative to barley (£135/tonne) and soyabean meal (£200/tonne)

Feed	DM %	ME MJ/kg DM	CP % in DM	DCP % in DM	Energy equivalent to 1 kg barley	Value (£) [1]Energy	Value (£) Energy & Protein
Barley	86	12.9	12.0	9.0	1.00	135	135
Soyabean meal	88	13.2	50.0	45.0	0.96	140	200
Maize	86	13.6	10.0	7.0	0.94	139	139
Wheat	86	13.3	12.0	9.0	0.97	139	139
Oats	86	11.6	11.0	8.2	1.16	117	117
Beet pulp-molassed	88	12.0	10.0	6.3	1.09	121	121
Citrus pulp	88	12.4	6.6	2.8	1.04	120	120
Tapioca	88	12.8	2.7	1.3	0.99	124	124
Cane molasses	74	10.9	4.5	2.2	1.48	85	85
Corn gluten feed	88	12.4	20.0	16.0	1.04	130	142
Peas	86	13.2	25.3	20.0	0.99	137	155
Cotton seed	88	11.8	42.0	36.0	1.11	121	168
Corn distillers grains	88	13.0	25.0	17.5	0.98	138	152
Rape seed meal	88	10.5	40.0	33.0	1.33	102	146
Malt culms	88	11.2	27.1	22.2	1.19	113	138
Sunflower meal	88	9.8	42.3	38.1	1.46	93	146
Brewers grains	25	10.0	25.0	17.0	5.0	27	32
Whey-delactosed	30	12.0	25.0	23.0	3.2	42	51
Presed beet pulp	20	12.3	12.0	7.6	4.7	29	29
[2]Fodder beet	18	12.1	8.0	4.0	5.3	24	24
[2]Fodder beet	14	12.1	8.0	4.0	6.8	19	19
[2]Potatoes	21	12.3	9.0	4.7	4.4	29	29
Silage	20	10.4	14.0	10.0	5.9	23	24
Silage	20	9.2	12.0	7.8	7.1	19	20
Silage	20	8.0	10.0	5.8	9.3	15	15
Hay	82	8.0	8.0	4.6	2.3	60	60
Straw	82	6.1	4.0	2.0	4.7	29	29

ME = metabolisable energy. CP = crude protein. DCP = digestible crude protein.

[1]Energy only except where protein is lower than barley.

[2]Washed.

Molasses

Molasses is low in crude protein (and phosphorus) and the availability of the protein is also low. The energy value is about two-thirds that of barley. The dry matter content is about 74%. As a general rule the level of molasses should not exceed 15% of total dietary intake.

High protein/high energy feeds

The standard protein feed is soyabean meal which has an energy value similar to barley and contains 45-50% crude protein. However, feeds such as corn gluten feed, peas, cotton seed and corn distillers grains are often available at competitive prices and could be included in cattle rations. Corn distillers grains are similar to barley in energy terms and have a crude protein content of 25%. The energy value of corn gluten feed is somewhat lower than barley but like most by-products it is quite variable. In feeding studies at Grange, while weight gains of animals fed corn gluten were similar to those offered barley/soyabean meal, feed intakes were higher for those fed corn gluten. Overall the results showed that corn gluten had only about 90% the feeding value of barley/soyabean meal which gives it a somewhat lower value than that shown in Table 9.

High protein/low energy feeds

Feeds such as rape seed meal, malt culms, sunflower meal and brewers grains fall into this category. They are lower in energy than barley but are good sources of protein. Wet brewers grains can be satisfactorily ensiled and there is no need for preservative. Malt culms are variable and can be lower in quality than indicated. They are unpalatable because of their bitter taste and much of the crude protein is present in the form of non-protein nitrogen.

Whey

Delactosed whey contains about 30% dry matter, It is high in ash (20% of the dry matter) and crude protein (25/% of the dry matter). In feeding trials involving comparisons of whey with barley/soyabean meal on a similar dry matter basis as supplements to silage and straw, animal weight gains were the same. Thus, whey concentrate can contain up to 60% dry matter and is comparable to barley on a dry matter basis. However, the composition and particularly the dry matter content of whey can vary considerably and therefore the actual value of a particular batch will depend largely on its dry matter content.

Pressed beet pulp

Pressed beet pulp (dry matter content 20%) can be successfully ensiled without a preservative. The ensiled pressed pulp is a high quality feed but the protein quality is lower than barley. This should be kept in mind particularly at high dietary inclusion rates or when fed to young animals.

Roots and potatoes

Due to variable levels of soil contamination and likely greater storage losses it is very difficult to place monetary values on roots and potatoes relative to that of barley. In addition, handling of roots and potatoes is more difficult and equipment for chopping the roots is not available on most farms. It is also noteworthy that roots such as fodder beet can vary from about 12% to 18% in dry matter content depending on variety and this has a major influence on value per tonne of roots. Despite the above limitations it can be taken that in energy terms 1 kg of dry matter from roots or potatoes is equivalent to 1 kg of rolled barley. However, to allow for tare, roots and potatoes should be discounted a further 20% approximately. Sugar beet roots have a dry matter content of about 22% and a crude content of fodder beet roots used in Grange feeding trials was 8.6%. To allow for the lower crude protein values approximately 1 kg of soyabean meal, or the equivalent from other protein sources should be provided for each 8 and 4 kg of fodder beet (or potatoes) and sugar beet dry matter fed, respectively. This additional protein will provide a crude protein content of the mix similar to that of barley.

Roughages

Grass conserved as silage or hay forms a large proportion of winter feed requirements. The nutritive value of conserved grass is very variable. In common with roots the value per tonne of silage is influenced dramatically by dry matter content but for convenience a value of 20% is assumed. Because high levels of production are required with finishing animals only high quality conserved grass should be considered in those diets where roughage forms a high proportion of the total diet.

Productivity of Different Steer Breed Types for Beef Production

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Over 70% of all cows are dairy cows, predominantly Friesians. The remainder are suckler cows, predominantly beef breed x Friesians. Thus, the vast majority of cattle for beef production are the progeny of either Friesian or beef breed x Friesian cows. In 1988 and 1989, approximately 40% of inseminations were to Friesian, 30% were to traditional beef breed, and 30% were to continental beef breed bulls. To provide adequate dairy herd replacements, Friesian inseminations should be around 45%, so for the foreseeable future, the most numerous single breed type of beef cattle will be Friesian.

Because of the number of different breed types available, it is essential that producers understand clearly the differences betweeen them and how the desirable characteristics of each can best be exploited. To provide the necessary background information for this, a number of large scale experiments have been carried out at Grange in recent years. The overall approach has been to use the Friesian as a continuous standard and to compare two other breeds with the Friesian in individual experiments. Then, at the end of a series of experiments the data for all the breed types are ranked relative to the Friesian

Comparison of Friesians, Hereford x Friesians and Charolais x Friesians

The first comparison involved Friesian, (British) Hereford x Friesian and Charolais x Friesian steers. These breed types represent about two thirds of all male beef cattle originating in the dairy herd. The main results from this comparison are shown in Tables 1, 2 and 3. Corrected to the same slaughter date (750 days of age), Friesians and Hereford crosses had similar slaughter weights but Charolais crosses were 38 kg heavier than Friesians (Table 1). Hereford and Charolais crosses killed-out 1% and 2% units, respectively, higher than Friesians with the result that respective carcass weights were 10 kg and 32 kg heavier than

Table 1
Performance of Friesian, Hereford[a] x Friesian and Charolais x Friesian steers

Sire breed	Friesian	Hereford	Charolais
Slaughter weight (kg)[b]	571	578	609
Carcass weight (kg)[b]	304	314	336
Kill-out (%)	53.3	54.3	55.3
Conformation[c]	2.1	2.8	3.1
Fat score[d]	3.1	3.9	2.9

[a]British Hereford; [b]Corrected to 750 days of age; [c]Scale 1 (best) to 5 (poorest);
[d]Scale 1 (leanest) to 5 (fattest).

Table 2

Carcass composition of Friesian, Hereford x Friesian and Charolais x Friesian steers

Sire breed	Friesian	Hereford	Charolais
Bone (%)	16.9	15.4	16.7
Muscle (%)	59.5	57.1	62.8
Fat (%)	23.0	26.8	20.0
Subcutaneous fat (%)[a]	42	47	41

[a] % of total fat

Table 3

Feed intake and carcass traits of Friesian, Hereford x Friesian and Charolais x Friesian steers

Sire breed	Friesian	Hereford	Charolais
Feed intake (kg/d)	9.8	9.7	10.1
Feed intake (g/kg LW)[a]	20	20	20
LD[b] area (cm^2)	66	67	81
Muscle weight (kg)[c]	181	179	211
High value muscle (%)[d]	40.9	40.5	41.6

[a]g/kg mean liveweight during the measurement period
[b]*Longissimus dorsi;* [c]At 750 days of age; [d]Muscle in the pelvic limb loin

Friesians. Herefords had better conformation but had a higher fat score than Friesians. Charolais crosses had better conformation and a lower fat score than either of the other two breed types.

Herefords had least bone and Friesians and Charolais crosses had similar bone proportions (Table 2). Herefords had also least muscle and most fat while the Charolais crosses had most muscle and least fat. Herefords had a higher proportion of their fat subcutaneously than the other two breed types which were similar. This difference between breeds in fat distribution has implications for the visual grading of carcasses for fatness. Feed intake, measured during the finishing period showed (Table 3) that Charolais consumed more feed per day than the other two breed types. However, they were also heavier. Hence when feed intake was scaled for bodyweight no difference existed between the breed types. Friesians and Herefords had a similar muscle size (as indicated by *longissimus dorsi* area) and had similar proportions of higher value muscle. Thus, the superior conformation of the Herefords was not reflected in increased muscle proportion, muscle size or proportion of higher value muscle. Charolais crosses had a considerably larger muscle size and an increased proportion of higher value muscle.

Comparison of Friesians, Limousin x Friesians and Blonde d'Aquitaine x Friesians

The second comparison involved Friesian, Limousin x Friesian and Blonde d'Aquitaine x Friesian steers, and the main results are shown in Tables 4, 5 and 6. At slaughter, Limousin were 14 kg lighter and Blondes were 16 kg heavier

Table 4
Performance of Friesian, Limousin x Friesian and Charolais x Friesian steers

Sire breed	Friesian	Hereford	Blonde d'Aquitaine
Slaughter weight (kg)	653	639	669
Carcass weight (kg)	358	368	385
Kill-out (%)	54.7	57.5	57.4
Conformation	2.5	3.4	3.3
Fat score	3.4	3.5	3.1

Table 5
Carcass composition of Friesian, Limousin x Friesian and Blonde d'Aquitaine x Friesian steers

Sire breed	Friesian	Limousin	Blonde d'Aquitaine
Bone (%)	18.1	16.3	17.1
Muscle (%)	63.4	66.9	68.5
Fat (%)	18.5	16.8	14.4

Table 6
Feed intake and carcass traits of Friesian, Limousin x Friesian and Blonde d'Aquitaine x Friesian steers

Sire breed	Friesian	Limousin	Blonde d'Aquitaine
Silage intake (kg/d)[a]	6.4	6.0	6.3
Silage intake (g/kg LW)[a]	11	11	11
LD area (cm^2)	79	94	93
Muscle weight (kg)	221	240	255
High value muscle (%)[b]	35.2	36.1	36.1

[a]Supplementary concentrates also fed – finishing winter
[b]Muscle in silverside + inside round + knuckle + rump + fillet + strip-loin as g/kg total muscle

than Friesians (Table 4). Both Limousins and Blondes killed-out about 3% units higher than Friesians and as a result their carcasses were 10 kg and 27 kg, respectively, heavier than the Friesian carcasses. Both beef crosses had better conformation than Friesians and Blondes had a lower fat score.

Friesians had most bone, most fat and least muscle (Table 5). Limousins had less bone than Blondes but they also had less muscle and more fat. Silage intake during finishing was similar for the three breed types both in absolute terms and as a function of liveweight (Table 6). The two beef crosses had larger muscle sizes and higher proportions of their muscle in the higher value cuts than Friesians

Comparison of Friesians, Canadian Hereford x Friesians and Simmental x Friesians

The third comparison involved Friesian, Canadian Hereford x Friesian and Simmental x Friesian steers. The main results are in Tables 7, 8 and 9. The

Canadian Hereford was imported to improve the beef merit of Hereford cross cattle generally and it has been claimed that data obtained with the traditional British Hereford are not applicable to the progeny of Canadian Hereford sires. Canadian Herefords and Simmentals were 26 and 33 kg, respectively, heavier than Friesians at slaughter (Table 7). They also had 1% and 2% units, respectively higher killing-out proportions than Friesians and as a result carcasses were 21 and 27 kg heavier for Canadian Herefords and Simmentals respectively. Both beef crosses had better conformation than Friesians and Canadian Herefords had a higher fat score than the other two breed types which were similar.

Canadian Herefords had least bone but they also had least muscle and most fat (Table 8). Friesians had most bone while Simmentals had most muscle and least fat. As described previously for British Herefords Canadian Herefords had

Table 7

Performance of Friesian, Canadian Hereford x Friesian and Simmental x Friesian steers

Sire breed	Friesian	[a]C/Hereford	Simmental
Slaughter weight (kg)	575	601	608
Carcass weight (kg)	303	324	330
Kill-out (%)	52.2	53.2	54.3
Conformation	2.0	2.7	2.8
Fat score	3.2	3.9	3.3

[a]Canadian

Table 8

Carcass composition of Friesian, Canadian Hereford x Friesian and Simmental x Friesian steers

Sire breed	Friesian	C/Hereford	Simmental
Bone (%)	18.8	17.2	17.9
Muscle (%)	60.2	57.7	62.8
Fat (%)	20.0	24.1	18.3
Subcutaneous fat (%)[a]	45	49	45

[a]% of total fat

Table 9

Feed intake and carcass traits of Friesian, Canadian Hereford x Friesian and Simmental x Friesian steers

Sire breed	Friesian	C/Hereford	Simmental
Silage intake (kg/d)[a]	4.7	4.7	4.8
Silage intake (g/kg LW)[a]	14	13	13
LD area (cm^2)	67	68	79
Muscle weight (kg)	182	186	206
High value muscle (%)[b]	39.5	39.6	40.7

[a]Weanling winter

[b]As in Table 6 but includes also the cube-roll

a higher proportion of their fat in the subcutaneous depot than the other two breed types. Simmentals tended to have a higher silage intake than the other two breeds but there was no difference when silage intake was expressed as a function of liveweight (Table 9). Friesians and Canadian Herefords had similar muscle sizes and similar proportions of their muscle in the higher value cuts. Simmentals had a larger muscle size and more of their muscle in the higher value cuts.

Relative performance of breed types

The performance of all the breed types evaluated to date relative to Friesians is summarised in Tables 10 and 11. The value for the Friesians for each trait is set equal to 100 and the correspondng values for the other breeds are expressed relative to 100. Except for the Simmental and Charolais crosses which were heavier, the other breed types did not differ greatly in slaughter weight corrected to a constant age (Table 10). All the beef crosses had a higher kill-out ratio than Friesians and the continental beef crosses were higher than the Herefords. Because of the differences in kill-out, the ranking of the breed types for carcass weight for age was different than for slaughter weight for age. Compared with the Friesians, the beef crosses produced 3% to 11% more carcass weight for age. All beef crosses had considerably better conformation than Friesians with no major differences between the beef crosses themselves. Friesians, Limousins and Simmentals had similar fat scores, Herefords had higher fat scores than all others and Charolais and Blonde crosses had lower fat scores than all others.

Friesians and Herefords had similar muscle weights for age, similar muscle sizes and similar proportions of higher value muscle (Table 11). All continental crosses had considerably higher weights for age and muscle sizes than Friesians and Herefords. Higher value muscle proportion, although higher for the continentals, did not differ much between breed types. Other than Herefords

Table 10
Relative performance of breed types (FR = 100)

Sire breed	FR	HF	C/HF	LM	BL	SM	CH
Slaughter weight for age	100	101	104	98	102	106	107
Carcass weight for age	100	103	107	103	108	109	111
Kill-out	100	102	102	105	105	104	104
Conformation	100	133	135	136	132	140	148
Fat score	100	126	122	103	91	103	94

FR=Friesian, HF=Hereford, C/HF=Canadian Hereford, LM=Limousin, BL=Blonde d'Aquitaine, SM=Simmental, CH=Charolais.

Table 11
Relative carcass traits of breed types (FR = 100)

Sire breed	FR	HF	C/HF	LM	BL	SM	CH
Muscle weight for age	100	99	102	109	115	113	117
LD area	100	102	101	119	118	118	123
High value muscle	100	99	100	103	103	103	103
Subcutaneous fat %	100	112	108	—	—	100	98

which had higher values, the proportion of fat in the subcutaneous depot was similar for the other breed types.

The data in Tables 10 and 11 permit a comparison of the two strains of Hereford. Other than a difference in growth rate which resulted in the Canadian strain having a 3% higher slaughter weight for age and a 4% higher carcass weight for age, the two strains were similar.

Comparison of breed types at similar fatness

Because of the differences beween the breed types in carcass composition, animals from different breed types if slaughtered at the same age would have very different proportions of fat and muscle. Because of this, animals of different breed types are usually not slaughtered at the same age or weight – some account is taken of fatness or finish. The slaughter and carcass weights at which the different breed types would have the same proportion of carcass fat are shown in Table 12. Assuming that the optimum slaughter and carcass weights for Friesian steers is 600 kg and 320 kg respectively, Herefords (both strains) would have a similar carcass fat proportion at correspondng slaughter and carcass weights of 530 kg and 280 kg. Limousins can be taken to 50 kg liveweight and 40 kg carcass weight heavier than Friesians while the other continentals can be taken to 80-120 kg liveweight and 60-90 kg carcass weight heavier than Friesians at a similar level of carcass fatness. As kill-out proportion varies with weight for all breed types the kill-out values shown in Table 12 differ from those shown earlier where slaughter weights differ.

Table 12

Traits of breed types at similar carcass fat proportions

	FR	HF	C/HF	LM	BL	SM	CH
Slaughter weight (kg)	600	530	530	650	720	680	700
Carcass weight (kg)	320	280	280	360	410	380	400
Kill-out (%)	53.3	52.8	52.8	55.4	56.9	55.9	57.1
LW/KO (kg/1%)*	50	40	40	60	60	60	70

*kg liveweight change over 1% unit change in killout proportion

Comparison of international results

A number of breed comparisons have been carried out in other countries in recent years but it is often difficult to compare the results of experiments from different countries because the breeds used are not always the same, production systems vary and the methodology particularly for carcass assessments differs between countries and laboratories. Therefore, comparisons of international results must be treated with caution.

Dairy herd progeny

In Great Britain the Meat and Livestock Commission (MLC) have conducted a number of evaluations of the progeny of dairy cows and various sire breeds in recent years (Southgate, Cook and Kempster, 1982a, 1988; Kempster, Cook and Southgate, 1982a, 1988). The MLC values for carcass weight for age and muscle weight for age are shown with the corresponding Grange values in Tables 13 and

Table 13
Relative carcass weights for age from different comparisons (FR = 100)

Sire breed	FR	HF	LM	SM	CH
GRANGE[a]	100	103	103	109	111
MLC					
F 16M[b]	100	100	—	112	116
F 24M[b]	100	98	—	107	119
S 16M[c]	100	98	104	106	115
S 24M[c]	100	100	112	110	117

[a] From Table 10; [b] From Southgate *et al*, 1982a and Kempster *et al*, 1982a. [c] From Southgate *et al*, 1988 and Kempster *et al*, 1988.

14. Blonde d'Aquitaine crosses were not included in the MLC experiments and Limousin crosses were not included in two of their comparisons. Even with the four MLC comparisons, there was considerable variation in the magnitude of the differences between breed types in carcass weight for age (Table 13). Relative to Friesians at 100, Limousins were 104 and 112 in the two comparisons in which they were included, Simmentals ranged from 106 to 112 and Charolais ranged from 115 to 119. This indicates that the differences between breed types shown in any one experiment should be regarded as approximations and not absolutes. The Grange and MLC results are similar for Friesians, Herefords and Simmentals, but the superiority of the Charolais crosses was greater in all four MLC comparisons than in the Grange comparison. In the case of the Limousins, one of the MLC results was similar to the Grange result while the other MLC result was better. Notwithstanding these differences however, the overall pattern of the results was similar. In all five comparisons, the Charolais crosses were superior to all others. In four of five comparisons the Simmentals were superior to all others except the Charolais crosses. In two of three comparisons the Limousins were inferior to the Simmentals and in all three they were superior to the Friesians and Herefords which for all practical purposes were similar. Thus in five separate comparisons there is almost complete agreement in the ranking of the breeds for carcass weight for age.

Table 14 shows relative muscle weights for age for the Grange and four MLC comparisons. As with carcass weight for age, there are the differences between

Table 14
Relative muscle weight for age from different comparisons (FR = 100)

Sire breed	FR	HF	LM	SM	CH
GRANGE[a]	100	99	109	113	117
MLC					
F 16M[b]	100	101	—	114	118
F 24M[b]	100	98	—	107	121
S 16M[c]	100	100	109	109	118
S 24M[c]	100	101	118	110	119

[a] From Table 11; [b] From Southgate *et al*, 1982a and Kempster *et al*, 1982a. [c] From Southgate *et al*, 1988 and Kempster *et al*, 1988.

the breed types. However, the ranking of the breeds was virtually consistent across the five comparisons. As with carcass weight for age, there are some differences between the MLC experiments in the magnitude of the differences between the breed types. However, the ranking of the breeds was virtually consistent across the five comparisons. In all five comparisons, the charolais crosses ranked highest and in four of the five the Simmentals ranked next. In one comparison, the Limousin surpassed the Simmentals. There was a big difference between all of the continental crosses on the one hand and the Friesians and Herefords, which were similar, on the other.

Suckler herd progeny

Because the Grange comparisons were carried out using Friesians and Friesian crossses, it would be useful to know if the differences between sire breeds found with Friesian dairy cows would apply also with beef suckler cows. Because the Hereford is the predominant sire breed used in suckler herds, the Hereford was taken as the standard for this evaluation and the Hereford data from Grange were set equal to 100. In addition, the data from three other comparisons (Germ Plasma Evaluation Program, 1974; Southgate, Cook and Kempster, 1982b; Kempster, Cook and Southgate, 1982b) of the progeny from suckler cows were summarised. In carcass weight for age the Charolais crosses were superior to all other breed types (Table 15). Simmentals were superior to Herefords in all five comparisons and in four comparisons with Limousins the Simmentals were superior each time. In the two comparisons involving Blondes, they were superior to Limousins in both, and to Simmentals in one of the comparisons. Limousins were superior to Herefords in three of four comparisons and equal to them in the remaining comparison. In all comparisons, Blondes, Simmentals and Charolais crosses were superior to Limousins.

In muscle weight for age (Table 16), the pattern was similar to that for carcass weight for age except that the difference between Herefords and Limousins was much greater. In all five comparisons, the Charolais crosses were superior to all others. In the two comparisons in which they were included, the Blondes were superior to the Simmentals, the Simmentals were superior to the Limousins and as indicated the Limousins were much superior to the Herefords.

Table 15

Relative carcass weights for age from different comparisons (HF = 100)

Sire breed	HF	LM	BL	SM	CH
GRANGE[a]	100	100	105	106	108
MLC WINTER[b]	100	110	—	115	118
MLC SUMMER[b]	100	—	—	112	113
DENMARK[c]	100	105	113	107	110
USMARK[D]	100	102	—	107	110

[a] Calculated from Table 10; [b] From Southgate *et al*, 1982b and Kempster *et al*, 1982b. [c] From Bech Andersen *et al*, 1977. [d] From Germ Plasm Evaluation Program, 1974

Table 16
Relative muscle weight for age from different comparisons (HF = 100)

Sire breed	HF	LM	BL	SM	CH
GRANGE[a]	100	110	116	114	118
MLC WINTER[b]	100	112	—	115	120
MLC SUMMER[b]	100	—	—	112	114
DENMARK[c]	100	108	121	114	116
USMARC[D]	100	108	—	112	116

[a] Calculated from Table 11. [b] From Southgate *et al*, 1982b and Kempster *et al*, 1982b. [c] From Bech Andersen *et al*, 1977. [d] From Germ Plasm Evaluation Program, 1974

It is clear therefore that in different countries involving different production systems, foundation stock and slaughter weights, there is remarkable agreement on the ranking of the different breed types. In all nine separate comparisons of carcass weight for age involving Herefords, Simmentals and Charolais were at the top and the Herefords were at the bottom in all nine. In six comparisons involving Limousins, they were superior to Herefords in all six, they were never superior to Charolais and were superior to Simmentals only once. In two comparisons involving Blondes, they were superior to Limousins in both and superior to Simmentals in one. For all practical purposes, Friesians and Herefords can be considered similar. In terms of muscle weight for age (not shown) the trends were similar to carcass weight for age except that the differences were greater. All of the continental crosses were at least 8% superior to the Friesians and Herefords which were similar. Charolais crosses were superior to all others except the Blondes in one comparison. The Blondes were superior to the Simmentals in the two comparisons in which they were included and the Simmentals were superior to the Limousins in five of the six comparisons.

Conclusions

1. Approximately 40% of dairy-bred male cattle for beef production are Friesians, 30% are Angus and Hereford x Friesians and 30% are continental x Friesians.
2. Breeds differ in many characteristics but feed intake per unit liveweight is fairly similar for all breed types.
3. Carcasses of Friesian steers slaughtered at around two years of age following moderately intensive rearing weigh about 320 kg. If reared similarly and slaughtered at the same time, carcasses of Hereford, Canadian Hereford, Limousin, Blonde d'Aquitaine, Simmental and Charolais crosses would weigh 330, 342, 330 346, 349 and 355 kg respectively.
4. Carcass weights at similar levels of carcass fatness for Friesian, Hereford, Canadian Hereford, Limousin, Blonde d'Aquitaine, Simmental and Charolais crosses are 320, 280, 280 ,360, 410, 380 and 400 kg respectively.
5. All beef crosses have higher kill-out rates than Friesians and continental crosses have higher rates than Hereford.

6. All beef crosses have better conformation than Friesians but within the beef crosses, differences in conformation are small.
7. Continental crosses have larger muscle sizes and higher proportions of their muscle in the higher value cuts than Friesians and Herefords, between which there is little difference in these respects.
8. Herefords have a higher proportion of their carcass fat in the subcutaneous depot than other breed types which are similar.
9. Kill-out rate increased by about 1% unit for each 40 kg (Herefords), 50 kg (Friesians) and 60-70 kg (continentals) increase in slaughter weight.
10. Relative (Friesian=100) muscle weights for age for various breed crosses are: Hereford 99, Canadian Hereford 102, Limousin 109, Simmental 113, Blonde 115 and Charolais 117.
11. There is consistent agreement across a number of comparisons carried out in different countries that the Charolais is superior to all other breed types, it is followed by the Simmental or the Blonde and then by the Limousin. All continentals are superior to Herefords and Friesians which are broadly similar in productivity.

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Reproductive Management of Suckler Cows

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Introduction

The biological efficiency of suckler beef production is limited by the cow's reproductive rate, a maximum of one calf per cow per year, and by the rate of gain of the calf. These limitations are often compounded by late calving, extremely long calving intervals, and high culling rates because of barrenness. Because the suckler cow enterprise is largely a breeding enterprise, financial returns depend on getting the cow to calve at the optimum time each year. Reproductive performance is, therefore, very important. Because of the suckling effect of the calf, the cow is endocrinologically and physiologically different to the dairy cow in terms of onset of cyclicity and oestrous behaviour. Also, in attempts to further increase the econimic efficiency of the enterprise they are managed and fed differently. For example, they are allowed to accumulate body reserves over the grazing season, these reserves are then mobilized during the winter to supply part of their energy requirements. It is important to understand the implications of these differences for reproductive performance and how their effects can be minimized.

The objectives of a good breeding programme should include

1. 365 day calving interval.
2. Early compact calving with 90% of cows calving in 8 weeks.
3. A replacement rate of less than 20%.

Resumption of post-partum cyclicity

One of the major limitations to improvement of reproductive efficiency is the extended post-partum period which is longer in suckler than in dairy cows. Recent research has elucidated some of the endocrine events involved in the resumption of cyclicity post-partum and these are briefly summarised.

Endocrine events leading to first ovulation

During pregnancy the high circulating concentrations of progesterone and oestradiol result in prolonged negative feedback on the hypothalamic-hypophysial axis resulting in an inhibition of the synthesis of luteinizing hormone (LH) by the anterior pituitary gland. This in turn results in the depletion of pituitary stores of LH and in a reduction in basal release rates. After calving a two-phase recovery of the hypothalamic-hypophysial-gonadal axis occurs. The first phase lasting, two to five weeks, is characterised by relatively infrequent discharges of gonadotrophin releasing hormone (GnRH) into the hypothalamic-hypophysial portal circulation, about one pulse every 4-8 hours. This mode of GnRH secretion effectively stimulates the biosynthetic machinery in the gonadotrophs and the rate of synthesis of LH increases. The pulses of GnRH are sufficiently spaced that most of the newly synthesised LH is conserved rather than secreted into peripheral circulation. During this early post-partum period the pulses of LH are of insufficient magnitude to induce follicular maturation. When pituitary stores of LH have returned to normal, pulses of LH of sufficient amplitude and frequency are released into the circulation to stimulate follicular growth. This marks the beginning of the second phase of the recovery process. During the second phase, the increased circulating concentrations of LH stimulate growth of ovarian follicles and the resultant secretion of oestradiol. The increased oestradiol secretion increases the sensitivity of the hypothalamic and hypophysal tissues to the positive feedback effects of oestradiol. At this point, the frequency of discharges of GnRH increases, in turn, producing more frequent pulses of LH. These events lead to the final stages of follicular development and culminate in ovulation.

The first phase of this recovery process (events leading to increased pituitary stores of LH) are believed to be relatively independent of the suckling stimulus and of genetic and environmental factors. However, the second phase of the recovery (events leading to increased frequency of discharges of LH) appear to be tightly coupled to the suckling stimulus as well as to a variety of genetic and environmental factors. Some of the more important factors are discussed here.

Suckling effects

It is now well established that it is the suckling stimulus rather than lactation itself that increases the interval to the first oestrus. Suckling will suppress pulsatile secretion of LH for a longer period after parturition than milking (Peters et al, 1981), even when milking is increased to four times per day (Carruthers & Hafs, 1980). Evidence is emerging that the suckling induced inhibition of reproductive function is exerted through the release of endogenous opoid peptides which suppress the secretion of GnRH in turn suppressing the secretion of LH. The inhibitory effect(s) of the endogenous opioid peptides seem to be short-lived since cows must suckle more than four times per day before the post partum interval is extended. Therefore, the inhibition of LH secretion is observed in cows whose calves are allowed to suckle *ad libitum* but not in cows that are milked twice daily. Inhibition of this phase of recovery process persists until the suckling stimulus and/or environmental stressors are reduced to the point where more frequent discharges of GnRH begin to occur. The above information can be combined within a management strategy to overcome some of the consequences of the suckling effect.

There is emerging evidence that the physical presence of the calf has effects on both the interval from calving to first ovulation and also on the intensity of oestrus in suckler cows.

Nutrition and reproductive efficiency in suckler cows

Cow nutrition is the most important factor influencing suckler beef production. Feed costs alone account for approximately 75% of the variable costs involved. There is extensive evidence which links nutrition to the duration of the post-partum interval and to variations in subsequent calving rate. However the relationship is complex and involves interactions between nutrient intake, weight change, body condition, cow live weight and age, milk yield and suckling intensity. A further difficulty with suckler cows is that they differ in their response to a given level of nutrition due to differences in age, size, milk yield, stage of gestation, environment and body condition. To overcome these difficulties in describing the nutrient requirements of suckler cows a body condition scoring system has been developed. Condition scoring on a scale of 1 (very thin and emaciated) to 5 (grossly overfat) is a semi-objective measurement of the fat reserves of the cow. It has been shown to be a good indicator of the cow's nutritionl status and equally important, a good predictor of her likely future performance. This has led to the concept target body condition score at critical stages of production. Other aspects of using target condition scores are that they allow for the accumulation of body reserves in summer when feed costs are low, and the controlled mobilisation of body reserves during winter when feed costs are high.

Pre-partum nutrition

Frequently many producers are more concerned with the effects of pre-calving nutrition on calf weight and ease of calving rather than on other reproductive parameters. While the conceptus imposes huge nutritional demands on the cow particularly during the last trimester of gestation, it appears that maternal system will sacrifice body reserves to meet this demand. Therefore, birth weight of the calf will be only slightly reduced under severe nutrient restriction. In late pregnancy the cow will, in essence, lose weight proportional to the weight gain of the calf. However, severe under nutrition during late gestation has implications for calf vigour, survival and growth performance. However, energy restriction in late pregnancy results in cows calving in a thin body condition. A significant relationship has been shown between body condition at calving and subsequent pregnancy rate (Table 1). Only 72% of cows that were thin at calving were pregnant after an 80 day breeding period compared with 89% and 90% for cows in moderate and good condition at calving, respectively. There was, also a decrease in the proportion of cows pregnant early in the breeding period when they were thin at calving. The main reason for the lowered pregnancy rate in thin cows is the extended interval to first post-partum oestrus.

High levels of feeding in late gestation does result in over fat cows. Over fatness directly increases the incidence of calving difficulty (see Table 2). The

Table 1
Effect of body condition at calving on rebreeding performance

Condition at calving	% pregnant at 20 & 80 days after start of mating period	
	20 days	80 days
Thin	25	72
Moderate	35	89
Good	39	92

Table 2
Relationship between cow body condition and the incidence of assisted calvings

		Body condition score				
		2.0	2.5	3.0	3.5	4.0
Sire breed	Cow breed					
Charolais	Hereford X Friesian	6.7	7.7	8.0	10.1	14.3
Charolais	Blue Grey	4.0	5.9	6.3	7.0	10.1

consequences of excessive feeding are more pronounced in heifers than in mature cows.

For cows in good body condition it is recommended that they maintain their body weight up until calving. This means that they are losing some body condition when the growth of the conceptus is taken into consideration.

Post-partum nutrition

While it is important that cows calve down in good body condition the level of nutrition during lactation does have an effect on reproductive performance. After calving there is a dramatic increase in the nutrient requirement of the cow as well as a change in the ranking in which nutrients are utilized. After calving the priority for nutrients are for maintenance, milk production and lastly for reproduction. Reproduction will be the first function to suffer with poor nutrition. Almost inevitably there is some loss in body condition after calving. However, this loss should be minimised. Cows calving in a moderate to good body condition and receiving an adequate plane of nutrition post calving will generally resume cyclicity and can be successfully mated to calve down with 12 months. However, if weight loss after calving is severe, even cows calving in good body condition may not cycle or may initiate cyclicity and then become anoestrous. These effects are compounded if cows receive low levels of nutrition both before and after calving.

Nutritional management of suckler cows and the use of body condition scores

Target condition score at calving, mating and at weaning are presented in Table 3. For spring calving suckler cows the critical target is condition score at

Table 3
Target condition scores for spring and autumn calving suckler cows

	Spring	Autumn
Condition score at calving	2.5	3.0
Condition score at mating	2.0	2.5
Condition score at weaning	3.0	2.0

mating which is set at 2. This relatively low score at mating is compensated for by the high nutritive value of spring grass which allows the cows to be in positive energy balance throughout the mating period. On the other hand the target condition score at mating for autumn calving cows is 2.5 as cows are expected to rebreed while mobilising some body reserves.

Breeding management of heifers and first calvers

The extended calving season common in many suckler herds is often the result of poor management of heifers and first calvers. Date of first calving determines calving date in subsequent years as well as future calving spread for the herd. Once established, it is difficult to alter calving pattern. Ensuring that heifers calve compactly 2-3 weeks before the main herd will, over a 5-6 year period, help to reduce the calving spread of the herd. Because first calvers have a longer interval to resumption of cyclicity than older cows, calving them in advance of the main herd ensures that a higher proportion are cyclic at the start of the mating period. Furthermore, the longer the calving to service interval the higher will be the conception rates following mating. The mating period for heifers should be strictly confined to 6 weeks. Late calving heifers will be late calving cows in later years. While calved heifers have lower maintenance requirements and lower milk production than mature cows, they nevertheless, have an additional nutritional requirement for maternal growth. This results in a greater overall feed requirement compared to mature cows. If additional feed is not provided to meet this extra demand, the calved heifer will draw upon her body reserves, in other words essentially on her body condition. Nature dictates that first nutritional priority be given to nourishing the calf. Consequently, growth of the young cow may be slowed or stopped during this period. More seriously, reproduction is delayed if nutrition is inadequate. The net result is an increased calving interval and higher culling rates for barrenness.

To minimise rebreeding problems in first calvers it is critical that replacement heifers should calve 2 to 3 weeks in advance of the main herd. Also they are well grown at the time of mating(in excess of 330 kg at 15 months) and calving (500+ kg). This will, also ensure, that the replacement heifers are regularly cyclic at 15 months. Pregnancy rates are lower at the pubertal and first post pubertal heat than at subsequent heats. Heifers should always be mated to an easy calving sire.

Effect of heterosis on fertility in suckler cows

It is well recognised that crossbreeds are superior to purebreds as suckler cows. This phenomenon, known as hybrid vigour or heterosis, is one of the main reasons for using crossbred suckler cows. Crossbred cows survive and grow better, and attain puberty at an earlier age, have shorter calving to first ovulation intervals, have higher conception rates and their offspring survive and grow better. The cumulative advantage over purebreds is estimated to be about 23% in calf weaning weight per cow exposed to mating. To maximise heterosis the crossbred cow should in turn be crossed with a sire of a third breed, preferably a continental breed sire. The other reason for using crossbred cows for suckling is breed complementarity. This consists of the combining economically important traits from different breeds within the crossbred cow. For example, the milk production characteristics of the Friesian breed is combined with the beef characteristics of the Hereford in the Hereford X Friesian suckler cow. Recent studies at Grange recorded small differences between Hereford X Friesian and Limousin X Friesian genotypes regarding their suitability as suckler cows but with whatever differences that exist being in favour of the Limousin X Friesian.

Choice of terminal sire breed

Because the calf is the only saleable output from the suckler cow weaning weight is a major determinant of profitability. Sire breeds have a much greater effect on weaning weight than cow breeds. However, the advantage of faster growth rates and heavier weaning weights, must be offset by the increased birth weight which increases the incidence of difficult calvings and calf mortality. Also, gestation length is about one week longer in cows mated to continental sires. The larger continental breeds, Charolais, Simmental and Blonde d'Aquitaine should be used on the mature cows. Heifers should always be mated by an easy calving bull. For heifers calving at two years of age this invariably means either a Hereford or Aberdeen Angus bull. An easy calving Limousin bull could be used on two year old heifers or in situations where calving management is good. All bulls, however, are capable of giving rise to some degree of calving difficulty.

Bull fertility

In suckler herds the primary functions of a bull are to get cows pregnant and to produce live healthy calves, which have high growth potential, with minimal calving difficulty. In order to get cows pregnant a bull must have sufficient sex drive (libido) to seek out cows in heat, be capable of producing ample amounts of viable semen, be structurally sound and physically fit to deposit the semen to enable conception.

Frequently the role of the bull in herd reproductive performance of the herd is taken for granted. The fertility of the bull is several times more important than that of individual cows. A bull is usually expected to successfuly cover up to 45 cows while each cow is expected to wean only one calf each year. Subfertile bulls cause extended calving seasons, low calf crops and consequently low weaning weights. Therefore, on farms using natural service, bull fertility has a major impact on profitability. Unfortunatley, a bull's infertility or subfertility is not usually discovered until at least one repeat interval has elapsed after joining the herd. In Ireland there is no information on fertility of bulls in natural service. However, Scottish workers (Lowman et a, 1980) reported that 3-5% of bulls in natural service were completley infertile, while a further 30% were classified as unsatisfactory in terms of semen quality, penile abnormalities, and libido.

A bull may not remain fertile for all of its working life or indeed throughout a single mating season. For example, a bull that was ill and that had a raised body temperature for a number of days will be infertile for a period. However this period of infertility will not occur immediatley following the illness but 50 to 60 days later. Similarly, injury to the penis, sheath or prepuce while not affecting mounting behaviour, can prevent mating. Therefore, producers should constantly monitor bull performance.

In an attempt to reduce the extent of bull infertility a breeding soundness examination was developed in the United States. This involves a complete physical examination, rectal examination, scrotal circumference measurement, semen collection and evaluation. Scrotal circumference measurements are accurate predictors of sperm output. Bulls with large testes produce more spermatozoa. Scrotal circumference in young bulls is, also, positively correlated with fertility traits. As scrotal circumference increases sperm motility and percentage normal sperm also increase. The overall fertility classificaiton of a bull is based on the lowest classification obtained on any part of the examination. While this gives a good prediction of a bull's fertility there are other components which are equally important. Bull libido is vital and has little or no association with other fertility traits, such as semen quality or scrotal circumference. Difference in libido test scores of individual bulls have been associated with significant differences in actual pregnancy rate.

Because of the variability in fertility between bulls it is difficult to give precise guidelines regarding the maximum number or cows that should be allotted to a bull. The usual recommendations are 20 to 30 cows for young bulls and 40 to 50 cows for mature bulls.

While complete breeding soundness examinations of bulls are not carried out in Ireland, nevertheless, a veterinary examination of a bull combined with a semen evaluation taken one month before the start of the mating period will help to identify the majority of infertile bulls.

Use of A.I. in suckler herds

Between 30 and 40% of suckler cows in Ireland are bred by artificial insemination. Most of these cows are located in the smaller herds where close supervision for heat detection is possible and where herd size is too small to justify the purchase of a bull for natural service.

Advantages of using A. I.

Artificial insemination offers a wide range of genetically superior sires which are performance and/or progeny tested for growth rate, conformation, fatness, as well as surveyed for ease of calving. The range of breeds and sires within breeds allows producers to select a particular bull for an individual cow rather than having all cows mated by one bull in the case of natural service. In small herds the use of artificial insemination eliminates the need for keeping a bull while in larger herds it reduces the number of bulls required.

Disadvantages of using A.I.

The main disadvantage of using A.I. is that its success is almost totally dependent on the efficiency of heat detection achieved. Research has shown that heat detection efficiency is usually the weakest link in reproductive management. Heat detection is time consuming and requires total commitment for the duration of the breeding period.

To use A. I. successfully a number of critical management points must be understood and followed, particularly in relation to the occurrence, duration and behaviourial signs of heat.

Signs of heat

1. Standing to be mounted by herd mate or bull: This is the most definite sign.

2. Discharge of clear mucus: this originates in the uterus and is a good indication of imminent heat.

3. Restlessness and mounting behaviour: Signs of restlessness are often characteristic of individual cows that are either approaching or are in heat.

4. Swelling of vulva: Hormonal changes associated with heat cause an increased blood supply to the reproductive organs which in turn cause swelling and reddening of the vulva.

5. Hair loss and dirt marks: The hair on the tail head is usually removed by continuous mounting by herd mates and the skin on either side of the tail head is often scarred and dirty.

Duration and intensity of heat

It has generally been accepted that heat lasts for about 18 hours, but recent studies at Moorepark with Spring grazing dairy cows indicate that while some cows have a standing heat period of up to 30 hours, the average duration is only 9 hours. Also, over one third of all heat periods were less than 6 hours in duration and breaks in standing behaviour are common. It is likely that the duration of heat is of similar length in suckler cows. However, the intensity of heat behaviour is less in suckler cows due to the suckling stimulus and the physical presence of the calf. This lower intensity of behaviour makes heat detection more difficult.

Heat detection accuracy.

Failure to observe and record heat is one of the major factors reducing reproductive efficiency in A. I. programmes. Studies from many countries indicate that farmers frequently achieve a heat detection rate of 60 to 70% and that up to 20% of cows submitted for insemination are not in fact in heat. Careful checking in the early morning and late evening will detect at least 70% of cows in heat; three further checks during the day are required to detect 90% of cows in heat. The best time to observe cows is when they are at rest. Sometimes, judgement has to be made on a combination of and behavioural patterns rather than on an observed standing behaviour and consequently it is important to understand and recognise the signs of heat.

Timing of insemination

In the cow ovulation occurs at about 30 hours after onset of standing heat and is not influenced by duration of heat. Because the viable life of the ovum is less than 12 hours, and that of the sperm 24 to 36 hours, correct timing of insemination is important. The optimum time to inseminate is during the second half of the heat period and for a few hours after the end of heat. The best practical recommendation is that cows first observed in standing heat in the morning should be inseminated that evening, while cows first observed standing in the evening should be inseminated the following morning. Correct timing of insemination is critical if bulls of below average fertility are being used.

Fertility - Artificial insemination versus natural service

Artificial insemination is often criticised on the gounds that pregnancy rate is lower than following natural service. Apparent improvement in pregnancy rate often arises following the introduction of a bull. This apparent improvement is likely to be due to cows now being mated at a longer post-partum interval, and or because inaccuracies in heat detection are now eliminated. Where heat detection is accurate, and when insemination is timed and carried out correctly, pregnancy rate is similar following A. I. or natural service.

The combined effect of heat detection and pregnancy rates on calving spread

Accurate heat detection and correct timing of insemination will result in an overall herd pregnancy rate of 60% to each insemination. Under good management, a conception rate of 70% will be achieved over the first four weeks of the breeding season. During this first month of breeding, most cows presented for insemination are calved for about two months or more and are inseminated at their second or third heat. Conception rate falls during the second month of breeding because a higher proportion of cows presented are often at the first or second heat and have not had sufficient time for the completion of uterine involution and the re-establishment of normal cyclicity.

If the intensive heat checking required throughout the season to achieve good results with A. I. is difficult to implement, a combination of a shortened period (4 weeks) of heat detection, followed by the introduciton of a bull is a successful alternative where herd size allows. This will combine the use of A. I. on the early calving and more fertile cows and allow the later calving and repeat cows to be bred by a bull. This strategy will also help to ensure a compact calving pattern. While accurate heat detection is central to a high level of reproductive performance, it is the combination of heat detection and conception rate that determines the compactness of otherwise of the calving pattern. (Table 4).

Table 4

Cumulative calving pattern (%) as affected by different combinations of heat detection (HD) and conception rate (CR) assuming all the herd available from the first day of the breeding season.

Week of calving season	% H.D 70%. C. R. 50%	% H. D. 90% C. R. 60%
At 3 weeks	35	54
At 6 weeks	58	80
At 9 weeks	74	91
At 12 weeks	83	96

When heat detection and conception rates are high, most cows calve within a 12-week period. Otherwise, the breeding season and subsequent calving season must be extended in order to get an acceptable proportion of the herd in calf.

Techniques for improving heat detection efficiency

Many attempts, based on the cow's overt oestrous behaviour or on phsysiological changes associated with oestrus, have been made that would both reduce the labour and increase the efficiency of heat detection. However, to-date there have been few developments which are practical at farm level with the possible exception of tail-painting or the use of vasectomized teaser bulls.

Tail-painting

In dairy cows tail-painting has proved to be a useful aid to heat detection. However, its usefulness in suckler cows is more variable, primarily due to the lower intensity of behaviourial heat in suckler cows, resulting in less mounting activity and therefore less complete removal of the paint. The paint is applied as a strip of emulsion paint 5-8 cm wide and 20-25 cm long from the tail head forward. When a cow is mounted a number of times this strip of paint is either partially or totally removed by the mounting animals. The problem with suckler cows is that the intensity of mounting activity is often low and consequently removal of the strip of paint is incomplete. The paint needs to be applied every 7 to 10 days to a clipped and brushed tail-head and under dry conditions.

Teaser bulls

There are several methods of surgical altering bulls to render them either sterile or unable to successfully mate but capable of mounting. The most common is vasectomy whereby a part of the vas deferens is removed. This procedure does not affect their libido or ability to mate. However, it should be carried out 2-3 months prior to the mating season to allow the bull time to recover. The bull may then be fitted with a chin-ball marker device. The marker device involves a paint reservoir attached to a halter that holds it under the animal's chin. A ball on the lower side of this reservoir releases a marking paint when compressed. When the teaser mounts a female in heat his chin will strike her back, releasing the paint and marking the animal. Cows are checked twice daily for paint marks in conjuction with other signs of heat. The reservoir is refilled at fortnightly intervals. Such a bull can prove useful in detecting heat particularly in suckler cows where the intensity of heat is often low. However, like intact bulls considerable variation in libido, also, exists among teaser bulls. Bulls with a high libido generally prove to be the more efficient at detecting cows in heat. Teaser bulls require the same management as entire bulls.

Reducing the suckling stimulus

While the nutrient requirements to maintain lactation are large, this effect is further compounded by the suckling stimulus which delays the resumption of post partum cyclicity. Removing a portion of the suckling stimulus, by allowing calves to suckle only once or twice daily, will advance the onset of cyclicity. Where the use of this technique is planned commencement of separation should begin at 35 days post calving and should continue until the cow is inseminated. An added bonus of this technique is that it greatly facilitates heat detection because cows are penned twice daily. Furthermore, removal of the calf increases the intensity of oestrous behaviour thus facilitating easier identificaiton of cows in heat. Once or twice daily suckling seems to have no adverse effect on cow or calf health or on calf weaning weight. This strategy has applications in situations where calves are multiple suckled, in first calving cows which generally have a longer post partum interval, in late calving cows, or in cows where the suckling effect of the calf is likely to be compounded by poor pre and or post-partum nutrition. Complete calf removal for a period of 48 hours has also been frequently used but with more variable results.

Oestrous synchronization

Oestrous synchronisation involves gaining control, not simply over the time of heat onset, but, more importantly over time of ovulation. In the early post-partum period, cyclical activity is often not yet resumed and synchronisation here effectively means inducing oestrus and ovulation. Because progesterone, secreted by the corpus luteum, is the major hormone controlling the length of the oestrous cycle, gaining control over the lifespan of the corpus luteum is the basis for controlling or synchronising the cycle. There are two methods of control commercially available.

1. Prostaglandin treatment

This is based on the administration of either natural or synthetic prostaglandin, which induces rapid regression of the functional corpus luteum. Because only animals with a functional corpus luteum (between days 5 to 15 of the cycle) will respond a single administration will induce heat in only about 50% of treated females. However, by administering prostaglandin twice, at a 12 day interval, most of the animals will have a functional corpus luteum at the time of the second injection and 80 to 90% will show a synchronised heat on days 3 and 4 following the second administration. All treated animals may be checked for heat and inseminated on the basis of an observed heat. Alternatively, all animals may be inseminated at 72 and again at 96 hours after the second injection. The overall pregnancy rate is similar for both insemination regimens.

2. Short-term progestagen treatment

This is based on the administration of oestrogen, which causes regression of recently formed corpora lutea and endogenous progesterone to decline. At the same time natural progesterone is administered exogenously to simulate the function of the corpus luteum. All animals are then under the influence of progesterone in a simulated luteal phase. Following removal of the progesterone all animals enter the follicular phase together giving a synchronised heat and ovulation response. The above treatment is commercially available as progesterone releasing intravaginal devices PRIDs. For the standard synchronisation treatment the PRID is inserted for 12 days and the cows are inseminated twice at 48 and again at 72 hours following PRID removal. Alternatively, as with prostaglandin treatment, animals may be checked for heat and inseminated on the basis of an observed heat. The overall pregnancy rate is similar for both insemination regimens. More recently it has been demonstrated that by administering prostaglandin 24 hours before PRID removal that the duration of the treatment period can be reduced from 12 days to 7 to 9 days. Furthermore, the heat response is more synchronised thus leading to higher pregnancy rates to the fixed time insemination.

Choice of synchronization method

For cyclic heifers, the double prostaglandin regimen is probably the most convenient and cost effective method. For suckler cows the use of prostaglandin is not recommended because a high proportion of cows would not have a functional corpus luteum at the time of synchronization and, therefore, would not respond. While PRIDs are effective in synchronising heat in cyclic animals, their effectiveness for inducing heat in non-cyclic post-partum cows is somewhat variable. This variability is related to the interval post-partum and the depth of anoestrum. A combined progestagen and gonadotrophin (PMSG) treatment has been developed at Belclare, particularly for use in non-cyclic beef cows. This increases both the proportion of cows responding and the ovulation rate. The net effect is to increase the pregnancy rate by a further 10 to 15% and the twinning rate from 2% to 10%.

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Lamb Growth Rate on Pasture

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In the spring lambing flock, grass provides most of the feed requirements of ewes and lambs after lambing with little or no concentrates being fed unless grass supply is deemed to be very scarce. Where grass supply is adequate, lamb growth rate in April and May is generally satisfactory but tends to decline in June when lambs are at the 10 to 14 week age. Lamb growth rate post-weaning is known to vary widely depending on the type of the pasture on offer. The objective of grazing management is to provide grass in sufficient quantity and quality to promote high growth rate consistent with good stocking rate.

Pasture quantity

The quantity of grass on offer to grazing animals has been measured in different ways. Stocking rate is the method commonly used to match feed supply and demand but this method lacks any definition of the actual supply of grass on offer at any particular time. The pasture allowance method is popular in New Zealand. This involves measuring the yield of herbage in a paddock before grazing and offering a precise weight of grass dry matter per sheep per day. Fresh herbage is offered daily or less frequently. The residual dry matter method has been used in rotational grazing to decide when stock should be moved to the next paddock. This involves measuring the yield of herbage remaining after grazing a paddock.

In recent years the pasture height method has become popular as a way of judging the suitability of pasture for both set stocking and rotational grazing . It has the advantage at farm level that no yield measurement is required and with a little experience pasture height can be accurately gauged by eye. Pasture height and herbage allowance methods have been used in grazing studies at Belclare.

Lamb growth; birth to weaning

A high growth rate in lambs from birth to weaning is desirable, leading to heavier weaning weights and earlier drafting of lambs thereby reducing the dependence on selling in the peak months of July to September. Trials at Belclare over two years examined some factors that may affect lamb growth rate on pasture.

(a) pasture type: Three pastures were compared; old permanent pasture that was grazed by sheep only for many years (old pasture); A reseeded pasture, one year old and grazed by sheep in the sowing year (new pasture): and old permanent pasture grazed by cattle only in previous years (cattle pasture).

(b) pasture height: Each pasture was set stocked from lambing to weaning and grazed at each of three heights, low (3 to 4 cm), medium (5 to 6 cm) and high (8 to 9 cm).

(c) dosing: Two dosing frequencies were compared: In one replicate, lambs were dosed at 5 and 10 weeks while the second replicate received extra doses at $7^1/_2$ and 12 weeks. Mean lambing date was March 20 and ewes and lambs were put out to pasture when lambs were a few days old. The pastures were rested over winter and received 45 units of nitrogen per acre in February for early grass. There were 18 groups with 9 ewes and 14 to 15 lambs per group. No meals were fed after lambing. After turn-out the aim was to achieve target heights as soon as possible. Heights were maintained by using different size paddocks (approx. $^1/_2$, $^2/_3$ or 1 ha per group), adjusting paddock sizes using moveable electric fences, occasional use of non-experimental dry sheep, and topping of pastures as required.

Results

Pasture type: Lamb growth rate to weaning was similar on old and reseeded sheep pasture when grazed at the same height (Table 1). This confirms that good growth rates can be sustained on permanent pasture under intensive sheep grazing.

However, reseeded pasture may carry extra stock if grass production is higher. Growth rates on cattle pasture were higher than on the other two pastures. The advantage to cattle pasture was greatest in the first year of sheep grazing, amounting to about 10 percent better growth rate and about 3 kg heavier weaning weight. This higher weaning weight is of considerable advantage as it increases the number of lambs fit for drafting at weaning. It is interesting that growth rate on the 3 pastures was fairly similar up to 5 weeks. The advantage to cattle pasture was greatest from 5 to 10 weeks, and to a lesser extent from 10 to 14 weeks. The reason for the better performance on cattle pasture is not fully clear, but is likely to be due in part at least to the lower worm burden on the cattle pasture. Parasitological studies involving herbage larval counts, faecal egg counts, tracer sheep and examination of lambs sent to the factory indicated lower worm burdens on the cattle pasture in the first year.

The more intensive dosing of lambs (4 doses) was no better than the standard dosing (2 doses) even on pasture grazed by sheep every year.

The fact that there was no difference between pastures in the 0 to 5 week stage may not be surprising as lambs consume little grass at that age. This fact can be exploited in a clean-grazing situation where the aim would be to have clean grazing available from 5 weeks of age (about mid-April) with less concern for the 0 to 5 week stage.

Pasture height: Lamb growth rate increased with increasing pasture height on all pastures (Table 2). The response to increasing height was most evident up to 10 weeks of age (end of May), From 10 to 14 weeks (June) the effect of pasture height was less clear-cut, with a significant response only in year 2. In general the medium pasture height of about 6 cm gave near maximum (97%) growth rate and weaning weight. Grazing pasture of less than 4 cm restricted lamb growth rate to about 89% of their potential. However, grazing at a height of about 9 cm only improved growth rates by 3 to 4 % compared with the 6 cm and implied using a considerably lower stocking rate.

The period after turn out in spring is a time when grass is often scarce and the question arises as to whether supplementary feeding is needed. While no concentrates were fed in this experiment, they are not likely to be necessary if pasture is 5 to 6 cm high but may be required where the height is 3 to 4 cm.

Lamb growth rate from 10 to 14 weeks (June) was lower than from 0 to 10 weeks on all pastures and at all heights. This coincides with the time when ewe milk supply is low and pastures are getting stemmy if under-grazed in May. In this trial pasture quantity and quality may have affected growth rates in June. The short grass was leafy but scarce while the tall grass was plentiful but stemmy. Lax grazing (9cm) in April-May was no disadvantage while grass was leafy but it leads to a very stemmy pasture in June. Ideally the pasture should be maintained at about 6 cms pre-weaning. If grass is higher in May, a tight grazing (down to 3 to 4 cm) at the end of May would help to maintain the pasture in a leafy state in June.

The average weaning weights of lambs for 2 years on differnet pastures and at different heights are shown in Table 3. Normal 14 week weaning weight in similar flocks would be 31 to 32 kg. The results show the extent to which weights may be increased or decreased depending on the pasture type and height.

Table 1
Effect of pasture type on lamb weaning weight (kg) and growth rate (g/d)

	Pasture type		
	Old pasture	New pasture	Cattle pasture
Weaning wt.	31.5	31.3	33.2
0 to 5 wks.	295	289	299
5 to 10 wks.	288	284	318
10 to 14 wks.	243	247	259
0 to 14 wks.	275	273	292

Table 2
Effect of pasture height on lamb weaning weight (kg) and growth rate (g/d)

	Pasture height (cm)		
	3.6	5.8	8.7
Weaning wt.	29.8	32.6	33.6
0 to 5 wks.	271	302	310
5 to 10 wks.	263	309	319
10 to 14 wks.	245	245	258
0 to 14 wks	259	286	296

Table 3
Weaning weights of lambs

Pasture height	Old pasture	New pasture	Cattle pasture
Low	29.4	29.0	30.9
Medium	32.6	31.7	33.6
High	32.6	33.2	35.0

Lamb growth post-weaning

The effect of pasture height and herbage allowance on the liveweight gain of weaned lambs was measured over a number of years.

Pasture height-set stocking: Weaned lambs were set-stocked on old permanent sheep pasture maintained at different heights. Pastures contained very little clover. Lambs were dosed and treated with cobalt every 3 weeks. Table 4 shows the pasture heights and weight gains achieved. It is clear that highest growth rates were obtained on pastures grazed at 8 to 9 cm in the July to September period. Growth rates were lower in October/November but there was a similar response to increasing pasture height.

Pasture height – rotational grazing : In these experiments lambs were rotationally grazed on permanent or reseeded pastures of low clover content.

Table 4
Effect of pasture height on liveweight gain of weaned lambs under set stocking

Date				
July/Sept '88	Height (cm)	4.7	6.5	9.2
	LWG (g/d)	108	146	161
Aug/Sept '89	Height (cm)	5.5	7.3	8.3
	LWG (g.d)	121	135	163
Sept/Oct '89	Height	4.4	6.1	7.6
	LWG	4	76	122

Table 5
Effect of herbage allowance and post-grazing pasture height on liveweight gain of weaned lambs

Herbage allowance (kgDM/day)	1.5	3.0	5.0
*Post grazing height (cm)	4	5	6
Date	Liveweight gain (g/d)		
July/Sept 85-87	110	155	185
Sept/Oct 85-88	90	147	165
Oct/Nov 85-88	48	88	125

*Pre-grazing heights were 8 to 10 cm.

They were generally 8 to 10 cm high before grazing and grazed down to heights of about 4, 5 or 6 cm. Results show that highest growth rates were obtained with the highest herbage allowances (Table 5). Growth rates also declined in the late autumn period. The data reflect the wide range in growth rates that are obtained depending on the supply of grass and the time of year. The post-grazing heights indicate that highest gains were obtained where lambs did not have to graze down below about 6 cm on these pastures.

It is evident from these results that the optimum pasture height was higher than that required in spring. This is partly a reflection of the nature of the pasture at different times of the year. In spring the pasture is mostly green leaf and lambs can perform well on short grass. In summer and autumn, on aftermath or grazed pasture, the lower layer of the sward contains more stem and dead leaf and lamb growth rate is reduced if they are forced to graze down into this layer.

Clover : White clover is a valuable component of the sheep pasture. Intake and digestibility are generally higher for all-grass pastures, and this is reflected in higher lamb growth rates – up to 22 g per day in some trials.

Conclusions

From turn-out until weaning a pasture height of about 6 cm was suitable under set-stocking. Old and reseeded pastures gave similar growth rates in lambs. Growth rate was about 10% better on a cattle pasture not previously grazed by sheep. A pasture height of 8 to 9 cm was best for weaned lambs under set stocking, or grazing down to about 6 cm for rotational grazing.

Exploiting the Ram Effect for Early Breeding : Effects of Ewe Age and Breed

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Under appropriate conditions anestrous ewes can be stimulated to ovulate by the introduction of rams following a period of isolation from males (Pearce and Oldham, 1984). If such ewes are pretreated with a progesterone, oestrus will also be induced following ram introduction. Thus a synchronised mating can be induced in advance of the onset of the normal breeding season without the use of an exogenous gonadotrophin such as PMSG. There is a broad similarity between the events preceding puberty in ewe lambs and the onset of the breeding season in ewes and there is some evidence that ewe lambs can respond to the introduction of rams in the same way as adult ewes (Drymundsson and Lees, 1972).

Two experiments were conducted to examine the possible role of the ram effect in advancing the date of mating in ewes and in ewe lambs. The objective of the study with adult ewes was to test the utility of the ram effect for inducing a synchronised mating in ewes about 5 weeeks in advance of the expected date of onset of the breeding season. The study with ewe lambs was designed to examine the susceptibility of this age group to the ram effect and how this is influenced by the time of ram introduction relative to expected date of puberty.

Materials and Methods

Experiment 1: The adult ewes used in this experiment were from either the Belclare or Finn-Dorset breeds. The onset of the breeding season is known to be earlier in Finn-Dorset ewes (August 25th) than in the Belclare breed (September 15th (Hanrahan, 1986). The experiment was designed to compare the responses of these two breeds to ram introduction in mid-August and also to compare the performance of Belclare ewes given PMSG with those not given PMSG. All ewes had MAP sponges inserted on August 5th and these were removed on August 16th at which time fertile rams were introduced. The ram to ewe ratio was 1:9. Half of the Belclare ewes were given 750 i.u. PMSG at sponge removal. Matings were recorded daily and all ewes were subjected to laparoscopy on day 9 following ram introduction to measure ovulation rate. The rams were removed at this stage.

Experiment 2 : This study utilised Belclare and Belclare x Galway ewe lambs born in March/April. Previous studies with ewe lambs of these two breed types had shown that mean date of first ovulation is between mid- to late-October with first oestrus being observed about 3 weeks later in early November (Fitzsimons and Hanrahan, 1984; Hantrahan *et al.*, 1985). The experiment involved exposing ewe lambs, which had been isolated from contact with rams for at least one month, to fertile rams and recording the ovulation response, by endoscopy on day 6 following ram introduction. Ewe lambs were assigned to one of five groups on a within breed basis. Rams were introduced to Groups 1, 2, 3 and 4 on September 27th, October 4th, October 11th and October 18th, respectively. Group 5 was kept in isolation from rams until October 25th. Once rams were introduced to a group they remained with that group until all the rams were withdrawn on December 6th. The ewe lambs in the Control group were examined by endoscopy on the same day as each of the Groups 1 to 4. Date of first oestrus was recorded by daily checks for mating marks and ovulation rate was recorded within 10 days of first oestrus.

Results

Experiment 1 : The performance of ewes in each of the experimental groups is summarised in Table 1. All ewes had active corpora lutea at endoscopy. The difference among the groups was small except for ovulation rate which was increased significantly by PMSG administration. The differences in litter size reflected the ranking on ovulation rate but it is clear that the PMSG group showed only a small gain relative to the controls. The average number of lambs born per ewe joined showed an advantage of 0.16 for ewes treated with PMSG.

Table 1
Ewe performance – Experiment 1

Treatment group	No. of ewes	Percentage		Ovulation rate	Litter size per ewe	
		Mated	Lambed		Joined	Lambing
Belclare	40	92	75	2.17	1.42	1.90
Belclare + PMSG	40	100	78	2.60	1.58	2.03
Finn-Dorset	33	100	85	2.15	1.45	1.71
Approx. s.e.	—	—	7	0.11	0.15	0.12

Experiment 2 : The average bodyweight of the ewe lambs used was 42 kg in October and 44 kg at ram removal in early December. The effect of joining date on the proportion of ewe lambs which responded to ram introduction is shown in Table 2. The results show that ewe lambs failed to respond on September 27th but there was a clear effect of ram introduction on October 4th and October 11th. By October 18th ovarian activity had commenced in almost all the isolated ewe lambs. Aspects of the subsequent reproductive performance are summarised in

Table 2
Effect of joining date on the response of ewe lambs to rams

Joining date	No. joined	Percentage with Corpora lutea	
		Exposed	Isolated*
September 27	20	5	8
October 4	23	87	8
October 11	24	75	25
October 18	24	79	83

*Based on 12 ewe lambs on each occasion.

Table 3
Ovulation, conception rate and litter size in ewe lambs

Joining date	Date of 1st estrus	Ovulation rate	Conception rate (%) 1st estrus	Conception rate (%) overall	Litter size
Sept. 27	Nov. 3	1.65	65	85	1.47
Oct. 4	Oct. 26	1.63	61	83	1.32
Oct. 11	Nov. 4	1.62	79	88	1.33
Oct. 18	Nov. 6	1.77	70	91	1.41
Oct. 25*	Nov. 9	1.87	83	96	1.70
approx. s.e.	1.8	0.14	10	6	0.13

*Controls

Table 3. It is evident that date of first estrus was effected by the joining strategy adopted with estrus onset occurring significantly earlier in the group joined on October 4th than in the group first exposed to rams one week earlier on September 27th. It is not possible to estimate from this experiment the maximum advance in date of first estrus which could be obtained by exploiting the ram effect but it is suggested that an advance of 2 weeks is probable near the upper limit for the type of sheep used in this study.

An interesting feature of the experiment, which is apparent from an examination of date of first estrus in the ewe lamb which responded to the ram on October 4th and October 18th, is that they can be subdivided into two subgroups. One subgroup displayed first estrus about 17 days centered around 23 days post ram introduction. Out of 38 ewe lambs which could be assigned to the first subgroup (mean interval to estrus was 17.2 days, s.d. = 0.9), while 14 were assigned to the second subgroup (mean interval 23.2, s.d. = 0.80). A total of 8 ewe lambs had intervals to first estrus which were inconsistent with these two subgroups (6 with short intervals, 1 to 11 days, and 2 with long intervals, 28 to 36 days). These results are interpreted to mean that about 50% of ewe lambs which respond to ram introduction produce normal corpora lutea and display estrus when these regress after about 13 to 14 days. In the other subgroup the corpora lutea formed in response to ram introduction regress within 6 to 7 days of ram introduction followed by a second ovulatory event but without an associated estrus. First estrus then occurs 16-17 days later.

The ewe lambs exposed to rams on September 27th clearly did not respond, as judged by the incidence of ewes with corpora lutea at the endoscopy 6 days after ram introduction. However, there is evidence that these ewes exhibited a delayed response to rams. Thus the date of first estrus is the same as for the group first exposed to rams on October 11. Secondly, these ewe lambs were re-examined by endoscopy on October 12th together with their controls – on that occasion 35% had corpora lutea compared with 8% of the Control lambs ($P<0.10$).

The ovulation rate at first estrus was consistent with previous results for these breeds. There is a suggestion that the ovulation rate is lower in ewe lambs which responded to ram introduction but the differences were not significant. The conception rate at at first estrus averaged 70%. The average ovulation rate of these ewe lambs at conception was 1.68±0.06 and the resulting litter size was 1.42±0.06. The predicted litter size using ovulation rate and the average embryo survival in adult ewes (Hanrahan, 1982) is 1.49. Thus there is no indication of seriously impaired embryo survival in those ewe lambs which conceived at first estrus. The overall conception rate in this study was 89% which is quite satisfactory given the length of the joining period.

Conclusion

The ability of Belclare ewes to respond to ram introduction about 5 weeks prior to the normal date of onset of the breeding season is such that they can be successfully mated at this time without the use of PMSG. The overall productivity of such ewes was only slightly less than comparable ewes which were given 750 i.u. PMSG and did not differ from that of Finn-Dorset ewes despite the earlier onset of the breeding season in the latter breed.

Ewe lambs can respond to ram introduction within 5-6 weeks of expected date of first estrus. However, the transition between the state of not responding to ram introduction and responsiveness appears to occur very rapidly. The ram effect can be exploited to advance and synchronise first estrus in ewe lambs and thus ensure that parturition is at the same time as the adult ewes in seasonal production systems.

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Reseeding Grassland

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Grassland occupies some 89% of the arable land in Ireland and of this approximately 3% is reseeded annually (Culleton, 1989). Many of our permanent pastures have very poor botanical composition and Frame and Tilley (1988) pointed out that quantity and quality of secondary grass species are inferior to *Lolium perenne*. Nonetheless, there is evidence that permanent pastures have high animal production potential and that the large response to reseeding in the first harvest year is rapidly lost (Wilkins, Hopkins and Dibb, 1987).

Why Reseed?

The first part of this paper reports on an experiment conducted at Johnstown Castle which compared old pasture to a new reseed under both grazing and conservation conditions. The botanical composition of the old sward at the beginning of the trial is given in Table 1. The perennial ryegrass content was about 3.5%. The soil fertility was improved and perennial ryegrass cv. Vigor was sown in autumn. Both new and old pastures were rotationally grazed for each of 3 years. The results of the grazing trial are summarised in Table 2.

Table 1
Botanical composition of the old swards in year 1 and end of year 3

	Year 1	Year 3 Grazing	Year 3 Silage
Lolium perenne	3.5	31.5	5.0
Agrostis tenuis	40.0	26.3	18.0
Anthoxanthum	1.9	2.1	2.0
Cynosurus cristatis	3.3	0.5	3.0
Festuca rubra	2.3	0.8	3.4
Holcus lanatus	13.8	5.0	4.1
Poa annua	0.2	0.1	4.0
Poa trivialis	32.4	28.5	59.5
Poa pratensis	0.3	0.2	–
Trifolium repens	1.5	5.0	1.0

Table 2
Liveweight gains (kg/ha) at high stocking rates

	Year 1	Year 2	Year 3
New pasture	1145	1258	1205
Old pasture	850	1090	1118

In year 1, the old pasture gave 75% as much output in terms of liveweight gain/ha as the new pasture. However, by year 3 there were no significant differences between the new and the old pastures. The ryegrass content in the old pasture increased steadily and by the end of year 3, ryegrass accounted for almost 32% of the sward.

The results from the silage component of the trial are given in Table 3. In the first, second and third years the old sward produced 62%, 84%, 79% of the production from the new sward. Unlike the grazing sward the yield difference between the new and old pasture remained for the duration of the trial. In terms of digestibility, the old pasture was significantly poorer than the new pasture. Table 1 shows that the botanical composition of the old silage sward at the end of the silage trial did not significantly improve at all. This is in marked contrast to the grazing sward, where significant improvements in ryegrass content occurred.

Table 3

Silage yield (kg DM/ha) and quality (D values) from new and old pastures

	Year 1	Year 2	Year 3
New pasture – yield	14500	13600	12200
– 'D' value	78	75	69
Old pasture – yield	9300	11540	9670
– 'D' value	71	67	65

The structure of the grazing and the silage sward tended to be quite different from each other. Table 4 summarises the relevant data. At the end of the trial, 97% of the grass in the new sward was ryegrass under the grazing regime, while there was only 75% ryegrass in the silage regime. The grazing sward had more tillers/m^2 than the silage sward. It appears that ryegrasses prefer a grazing regime to a silage cutting regime. Even with good management silage swards deteriorate with time.

It can be concluded that the main niche for reseeding is in the conservation, rather than the grazing areas. Grazing areas should only be reseeded when there is no ryegrass present, or improvements in fertility in the existing sward have not already led to significant improvements in productivity.

Methodology of reseeding

Three aspects of reseeding are now discussed :

— Autumn reseeding
— Direct drilling
— Slurry seeding

Autumn reseeding

Ploughing and reseeding in autumn are becoming progressively more popular, with 40-45% of total reseeding being carried out from mid August to mid September. In general, autumn reseeding is a reliable method. Timing of sowing was the subject of a trial carried out at Johnstown Castle. There were two dates of sowing, September 3 and October 4. Seedling emergence and tiller counts/

Table 4
Effect of date of autumn sowing on establishment of perennial ryegrass

	September 3	October 4
Seeds sown/m^2	1030	1030
No. of seedlings 6 weeks after sowing	760	570
No of tillers in the following March	7190	3110
kg DM/ha in March	913	478

m^2 were monitored in the months after sowing and the results are summarised in Table 4

Some 73.6% of the seedlings emerged from the early autumn sown seeds, while only 55.3% emerged from the later sown seeds. The numbers of tillers in mid-March were significantly lower in the later sown crop than in the early one. The yield in mid-March was also significantly lower. This agrees with results of Culleton, Keane and Lemaire (1988) who showed that swards with high tiller numbers reached appreciate yield levels significantly earlier in spring than swards with low tiller numbers.

As shown earlier, silage swards tend to have lower tiller numbers than grazing swards mainly because, for much of the grazing season, tillering is restricted due to low levels of light reaching the sward base (Garwood, 1969). Culleton, Keane and Lemaire (1988) pointed out that persistency of silage swards is influenced by tiller numbers, in that swards with low tiller numbers allow an invasion of unsown species, thereby reducing overall persistency. It can be concluded that silage swards should have high tiller numbers at the onset of the growing season and therefore, when reseeding for silage, it is imperative that reseeding be carried out early in autumn, so that tillering can proceed during winter.

Generally, fields are ploughed because they are infested with docks and/or bent grasses. It is good practice to spray these fields with Round-Up. The Round-Up kills these persistent weeds and also benefits the reseed in other ways. Table 5 shows that spraying before ploughing can help to conserve moisture and thereby aid establisment. *Osciella Frit* control is also made less difficult by spraying.

Table 5
Effect of applying Round-Up before ploughing

Treatment	Soil moisture content at sowing (g water 100 g dry soil)	No of tillers/ m drill row	Herbage yield 80 days after sowing (t/ha)
Control	12.6	103	2.83
Round-Up 5*	13.1	105	2.91
Round-Up 20*	15.1	131	2.92
S.E.D.	0.65	5.91	0.13

* No. of days before ploughing

Source: Clements & Jackson, 1989

Autumn management

As already stated, one of the major problems with silage swards is the progressive reduction in tiller numbers over the years. This leads to weed ingress and sward deterioration. One method of slowing down this deterioration is through the autumn management of the sward. Table 6 summarises the effects of autumn grazing by sheep on the tiller density of the sward.

Table 6

Effects of autumn management on tiller numbers/m²

	Tiller No./m² on Oct. 1	Tiller No/m² on March 1	% unsown species on March 1
Cut for silage on Sept. 12	4300	5200	37
Cut for Silage on Sept. 12 Grazed until Dec. 20	4500	8700	14

By grazing the grass frequently throughout the autumn, light is allowed to penetrate into the base of the sward. This encourages tillering to occur. When the grass is not grazed the sward can enter the winter too tall (this has happened in 1988, 1989 and 1990 due to mild winters). This tall grass causes a reduction in light intensity reaching the sward base and tillering is restricted. By correct autumn management of the silage sward the cycle of sward deterioration leading to ploughing and reseeding can be slowed down significantly.

Direct drilling

In many situations it is not possible to plough. The land is too stoney, the soil is too shallow, or perhaps there is no tradition for ploughing. Nonetheless, the botanical composition of many silage swards in these areas is poor. Because ploughing was not an option, to date there has been no easy method for upgrading these pastures. The introduction of direct drilling has given the opportunity of introducing perennial ryegrasses into native swards without ploughing.

The management before, during and after drilling needs to be of a very high standard. Table 7 summarises the main points in the management package.

Table 7

Management strategy in direct drilling

Pre-sowing	—	adequate soil fertility
	—	bare pasture by cutting silage
	—	good soil conditions
During sowing	—	anti-slug pellets
	—	correct drill settings
	—	use of vigorous seed
	—	use of fertiliser
	—	Herbicides
Post sowing	—	tight grazing
	—	strategic use of nitrogen

Pre-sowing :- There is little point in drilling if soil fertility is low. Ryegrass seed does not thrive below a pH of 5.8, or a phosphorus level of below 3 ppm. Drilling is most successful after a heavy silage crop has been removed. The regrowth of the native sward after silage is significantly slower than that after tight grazing. The sown seedlings have a better chance to establish before competition from the native swards becomes intense.

During sowing :- Anti-slug pellets are essential. It is important to use vigorous seeds. Seeds with high germinability should be used. Large seeds tend to germinate and emerge more rapidly than small seeds. Table 8 summarises results on rate of seeding emergence among the different categories of ryegrasses.

Table 8
Rate of seeding emergence in ryegrasses

	1000 seed wt (mg)	No of days for 1st tiller to appear	Plant wt at 17 days (mg)	Leaf length (mm) after 17 days
Early perennials	2.3	30	1.6	83
Intermediate perennials	1.9	33	1.3	72
Late perennials	1.6	37	0.9	55
Tetraploids	3.2	33	2.2	96
Diploids	2.2	33	1.5	63

Herbicides can be used for complete kill of the native sward. The problem with this approach is that pest control in the new sward can be difficult. A further problem is that the row spacing of the current drilling machines is too wide for single pass operations. Suppression of the native sward by low rates of herbicide application is a useful technique to reduce competition from native sward and allow the seedlings to grow. If pre-sowing management has been correct, it is possible to drill successfully without the use of herbicides.

Post sowing :- It is very important to keep the native sward under control while the seedlings are establishing. This can be done by high stocking at 2-3 week intervals. Over the past few years, the main cause of failure has been the lack of adequate grazing post-drilling. Stock also have the effect of spreading the plants across the inter row spaces by trampling.

Results of trials carried out at Johnstown Castle are summarised in Table 9. It is clear that ploughing and reseeding in the conventional way give the best results but the direct drilling plots did give yields that were significantly greater than the control plots.

Table 9
Dry matter yields (kg/ha) from direct drilling

	Year 1	Year 2	Year 3
Plough and reseed	14,700	13,600	13,200
Direct drilling	13,800	12.200	12,500
Control	9,300	9,600	9,400

Slurry seeding

Trials on slurry seeding of Italian ryegrass into existing Italian ryegrass swards were carried out at Johnstown Castle from 1980 to 1988.

Table 10 shows typical Italian ryegrass yields in comparison to perennial ryegrass. In the years immediately after sowing yields are very high but by year 4-5 yields decline to those of perennial ryegrass. Because four cuts per year are necesary to maintain good quality, it is imperative that yields be maintained at high levels

Table 10

Yield of Italian and perennial ryegrass (t DM/ha)

	Year 1	Year 2	Year 3	Year 4	Year 5
Perennial ryegrass	13.0	12.0	11.5	11.4	11.5
Italian ryegrass	18.5	15.5	13.9	12.1	11.5

Normally, high yields are maintained by ploughing and reseeding every two to three years. This is becoming an expensive operation and work at Johnstown has been aimed at maintaining high productivity without ploughing and reseeding by slurry seeding. In September of each year, after the last cut of silage was taken, 15 kg seed/ha were sown using a fertiliser spinner. Cattle slurry at the rate of 35 m^3/ha (3000 gal/acre) was then spread. When the seedlings had established the sward was grazed lightly and frequently until the land was too wet for grazing in late autumn. The results are summarised in Table 11.

Table 11

Slurry seeding of Italian ryegrass (t DM/ha)

	Year 1	Year 2	Year 5	Year 6	Year 8
Control	18.4	15.5	12.1	11.1	10.8
Slurry seeding	18.4	16.7	14.8	13.7	12.8

The slurry seeding gave significantly higher yields throughout the trials. However, yields were always lower than the yields achieved in the early years of the trial. The technique is very weather dependent. A drought in the immediate aftermath of slurry seeding can cause complete failure. Table 12 shows that Italian ryegrass is a large seed and it is thus very vigorous in the establishment phase. The sward of Italian ryegrass is very open with a low tiller density. Thus, it is easy for the seed to come in contact with the soil and establish without undue interference from the native sward. Despite this, the technique was only moderately successful. The chances of success of slurry seeding perennial ryegrass into an old permanent pasture would be quite poor.

Table 12

Italian ryegrass parameters

	Tiller No. /m^2	1000 seed wt (mg)
Italian ryegrass	2000	3.2
Perennial ryegrass	5000	1.8

Grasses for reseeding

Table 13 shows the sales of the various types of ryegrass over the past number of years. There has been a significant swing away from the use of early perennial ryegrasses. The main reasons for this are the poor tillering ability of early grasses leading to open swards and the consistent steminess in mid-season.

Table 13
Trends in perennial ryegrass sales

	Early perennials %	Mid-season perennials %	Late perennials %
1979	41	21	38
1983	30	29	41
1985	16	32	52
1987	15	35	50
1989	11	38	51

In general terms, late perennials are typical grazing grasses. They are prostrate in growth habit, high tillering, giving a very dense sward and they tend to be leafy in mid-summer. They are also extremely persistent. Mid-season ryegrasses are upright and are reasonably persistent. They are described as typical silage grasses.

In designating mixtures it is important that the requirements of the mixture be matched against the characteristics of the maturity groups. If silage is required then the dominant component of the mixture should be made up of mid-seasons, with the minor component being made up of the late perennials, which fulfil the function of filling in the base of the sward. If the requirement is mainly grazing, late perennial ryegrasses should be used with some mid-seasons being included to make the mixture a little earlier growing in spring.

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Grazing Management Strategies for Beef Cattle

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One of the key ways of improving the profitability of beef production systems is to improve the efficiency of grassland utilization by good grazing management. The aim of grazing management is to convert pasture resources into animal product in the most efficient way possible. This requires a knowledge of the way in which animals respond to different sward conditions and the way in which swards respond to grazing by animals. Research work over the past 10 years has led to considerable progress in both these areas. The aim of this paper is to outline how this research can be used in a practical way to improve the efficiency of grazing systems for beef cattle.

Sward height

In general, the height of the surface of the sward is a good indicator of how much grass is present, although the relationship between sward height and herbage mass does vary with the density of the sward. A simple tool for measuring sward height known as the HFRO swardstick has been developed (Barthram, 1986). Using this device 30 to 50 measurements can be taken in a field relatively quickly.

Herbage intake and animal performance

Sward height has a large effect on the intake and performance of cattle. Under continuous grazing maximum herbage intakes by beef cows are obtained when the sward height is 9-10 cm or more (Table 1).

Table 1

The herbage intakes of lactating beef cows at different sward heights

Sward height (cm)	Herbage intake (kg organic matter/day)
4	11.1
6	12.5
8	13.3
10	13.6

Since sward height affects herbage intake, then not unexpectedly there is a close relationship between sward height and live-weight gain (Wright and Whyte, 1989). Figure 1 shows the live-weight gains of beef cows and their calves when grazed continuously on swards of different heights. On swards of less than 6 cm the cows lost considerable amounts of weight. At higher sward heights cow live-weight gain increased and reached a maximum at a sward height of 8-10 cm. Beyond that height the cow live-weight gain was reduced. Calf live-weight gain

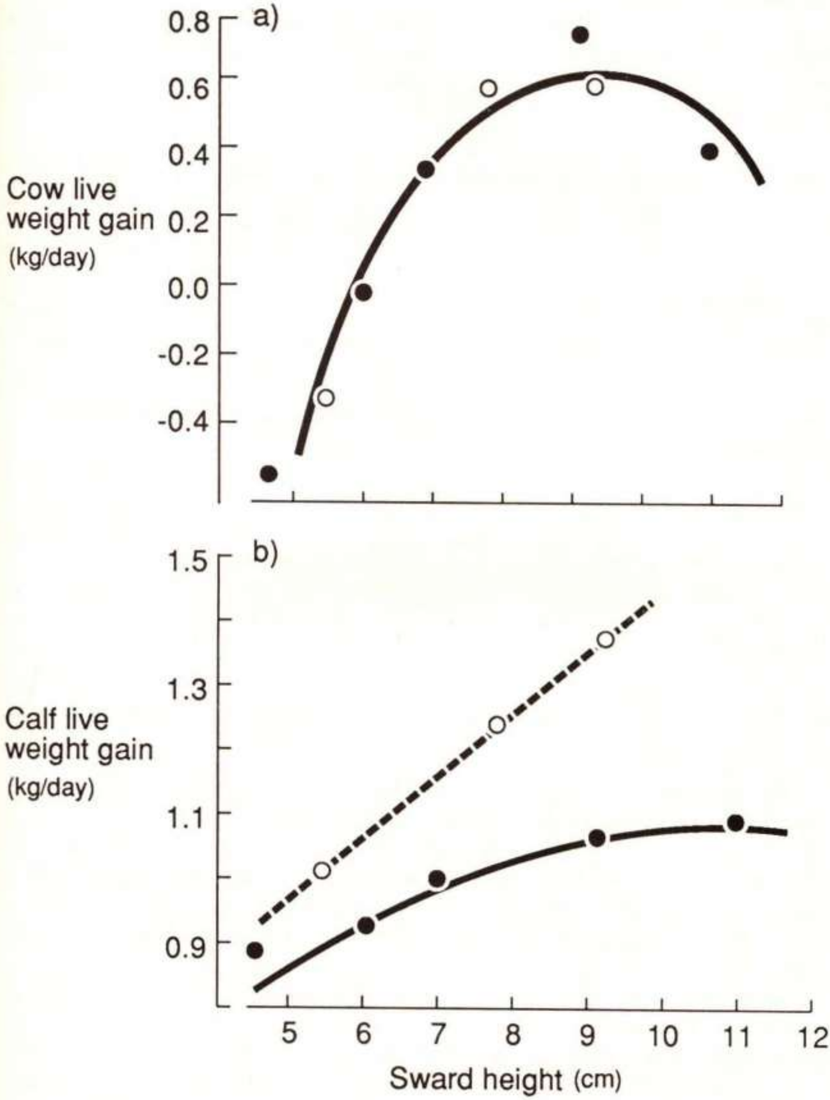

Fig. 1
The effect of sward height on a) cow and b) calf live-weight gain.
(● May-Aug; O Aug-Sept.)

showed a very similar pattern of response reaching a maximum at a sward height of about 10 cm. As the calves became older and less dependent on milk and more dependent on herbage, their growth rates became more sensitive to sward height, as indicated by the steeper slope of the curve for August-September, but maximum live weight gain still occurred at a sward height of 9-10 cm. Similar responses have been observed with autumn calving cows and their calves (Wright, Whyte and Osoro, 1990) (Table 2).

Table 2
The effect of sward height on the performance of autumn calving cows and their calves

	Sward height (cm)	
	4.6	7.6
Cow live-weight gain (kg/day)	0.30	1.19
Calf live-weight gain (kg/day)	0.43	1.21

With 14-18 month-old cattle a sward height of 4.3 cm depressed herbage intake by 21% and live-weight gain by 40% compared to that on a sward at 6.8 cm (Wright, Russel and Hunter, 1986) (Table 3).

Table 3
The effect of sward height on the intake and live-weight gain of 14-18 month-old cattle

	Sward height (cm)	
	4.3	6.8
Herbage intake (kg organic matter/day)	5.2	6.6
Live-weight gain (kg/day)	0.68	1.13

Herbage utilization

Grazing management also influences the way in which swards are utilised. Close grazing leads to a rapid increase in the number of tillers in the spring. It also results in high levels of herbage production with the elimination of reproductive tillers and seed heads. By maintaining a leafy sward with few seed heads the organic matter digestibility of the grazing herbage remains high, and on perennial ryegrass it can be maintained at between 75 and 80% for most of the grazing season.

When sward surface height increases beyond 8 cm, cattle do not graze uniformly. Instead they concentrate their grazing on some areas, rejecting others. These ungrazed areas go to seed and the digestibility declines dramatically. At a sward height of 8 cm the sward soon reaches a state where less than 10% of the area is rejected, but at 12 cm a large proportion of the area is rejected in the early part of the season (Wright and Whyte, 1989) and the sward becomes 'patchy' in appearance. The ungrazed patches go to seed and later in the season the cattle are forced to graze this material of poor quality and low digestibility and this is the reason for the decline in cow live-weight gain at swards in excess of 8 to 10 cm (Figure 1).

Sward height targets

Target sward heights for beef cattle are given in Table 4.

Table 4

Target sward heights for beef cattle

	Target sward height (cm)
Spring	6-8
Summer	8
Autumn	10-14

A sward height of 6-8 cm should be achieved as soon as possible in spring and the height should be maintained at no more than 8 cm until mid-summer to avoid seed head development. Once the risk of seed head development is past, sward height can be allowed to increase to 10-14 cm. These heights will ensure high levels of grassland utilization and high levels of animal performance. In autumn it is important to graze swards down to 4 cm to avoid 'winter kill'.

Control of swards height and forage conservation

Given a background of herbage growth rates that change not only seasonally, but vary within a season on a week-to-week basis as a result of climatic variation and fertilizer regime, some means of varying stocking rate needs to be found if sward height is to be controlled.

This can be achieved by integrating grazing and conservation. Instead of setting aside a fixed area of grassland for grazing and a separate area for fodder conservation, there is a need for a flexible approach. If on the area initially allocated to grazing sward heights are too high, then part of it can be closed off for conservation. Similarly, if sward heights are too low, then an extra area of grassland can be incorporated into the grazing area. Such an approach to grazing management has been tested at the Macaulay Land Use Research Institute. Sward heights are maintained by regular adjustment of the area available for grazing at least during the period of conservation (up until mid-August). The striking feature of this approach is the consistency of performance that can be achieved from year to year. Table 5 shows calf weaning weights over a three-year period when sward heights were maintained at 7-8 cm during the period of conservation and when overall stocking rate was 2.5 cows/ha. This stability over years was achieved in years which were considered to be both 'good' and 'bad' grazing seasons, and yet the variation is largely removed from individual animal performance and output.

Table 5

Calf weaning weights and percentage of area cut for silage when cows and calves were kept at an annual stocking rate of 2.5 cows/ha and sward height was maintained at 7-8 cm

Year	Calf weaning weight (kg)	Percentage of area cut for silage	
		1st cut	2nd cut
1	216	50	12
2	215	50	0
3	217	56	0

By controlling sward height in this way, rather than setting aside a fixed area for forage conservation, there will be some variation in the area cut and thus in winter fodder production. However the results in Table 5 indicate that over a three year period the total area cut (first plus second cut) varied from 56 to 62%. Thus the variation is not as great as might be expected and can if required be overcome by varying the level of supplementation in winter.

Conclusions

Sward height is a simple, easy way to make measurement that can be used as the basis on which to manage grazing systems. It provides an index of herbage production, pasture utilization and animal performance. Through the grazing season target sward heights for different types of livestock under different regimes can be achieved by integrating the grazing and conservation programmes on the farm. The results of adopting this approach are that levels of animal performance and output become very predictable and planning of the enterprise is much easier.

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Whole-Crop Fodder-Beet Silage: Research Results

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Fodder beet can produce 20 tonnes of dry matter/ha in one harvest compared with 13 tonnes of dry matter from four cuts of grass. Fodder beet silage is also highly digestible (80-85% DMD) when soil contamination is low. Consequently, even though production costs are high, it can be a cost effective "fodder concentrate". The research reported in this paper is the first stage of a programme to develop an integrated nutritional package based on whole crop fodder beet silage (WCFBS).

Fodder beet was harvested using a fodder beet silage harvester and ensiled in a conventional walled silo. The chemical composition of the silage is given in Table 1.

Table 1
Mean chemical composition[1] (and standard deviation) of whole-crop fodder-beet silage.

Dry matter (g/kg)	176	(9.1)	Calcium (g/kg)	14.2
pH	3.6	(0.11)	Phosphorus (g/kg)	2.3
Lactic acid (g/kg)	134	(33.4)	Potassium (g/kg)	24.3
Acetic acid (g/kg)	55	(4.2)	Magnesium (g/kg)	2.2
Propionic acid (g/kg)	2	(1.0)	Sodium (g/kg)	2.8
Butyric acid (g/kg)	8	(4.0)	Sulphur (g/kg)	1.8
Ethanol (g/kg)	45	(14.1)	Manganese (mg/kg)	148
WSC (g/kg)	43	(5.4)	Iodine (mg/kg)	0.78
Ammonia-N (g/kg N)	62	(11.8)	Selenium (mg/kg)	0.11
Crude protein (g/kg)	110	(13.2)	Zinc (mg/kg)	63.9
DMD *in vitro* (g/kg)	729	(16.1)	Copper (mg/kg)	13.8
NDF (g/kg)	235	(24.4)	Molybdenum (mg/kg)	0.60
Ash (g/kg)	263	(16.8)	Iron (mg/kg)	2000
Acid insoluble ash (g/kg)	138	(14.9)		
Buffering capacity	1162	(114.6) m. eq./kg DM		

[1]expressed on DM basis, except for pH and NH_3-N

Whole crop fodder beet underwent an extensive lactic acid fermentation in the silo. Ethanol production and residual levels of water soluble carbohydrates (WSC) were high. Crude protein and fibre levels were lower than would be expected from grass silage. Although the *in vitro* DMD value was lower than was anticipated, this is partly explained by the high levels of ash.

A large scale animal production experiment was carried out in which the following treatments were compared:

1. Grass silage (*ad libitum*) + 4 kg concentrates/day.
2. Whole crop fodder beet silage (*ad libitum*) + 1 kg barley/day.
3. Whole crop fodder beet silage (*ad libitum*) + 1 kg soyabean/day.
4. Concentrates (*ad libitum*) (i.e. barley beef).

The dietary regimes are described in more detail in Table 2. These regimes were intended to eliminate possible nutritional problems such as availability of a long fibre source, inadequate phosphorus or too rapid fermentation in the rumen.

Table 2

Quantities of various ingredients offered to each animal daily

	Grass silage + concentrates	Whole-crop fodder beet silage + Barley	Whole-crop fodder beet silage + Soya	Barley beef
Grass silage	Ad libitum	6 kg	6 kg	6.5 kg
Whole crop fodder beet silage	—	Ad libitum	Ad libitum	—
Barley	—	1 kg	—	—
Soyabean meal	—	—	1 kg	—
Concentrate mix	4 kg	—	—	Ad libitum
Sodium bicarbonate	—	100 g	100 g	—
Mineral vitamin mix				
– normal	100 g	—	—	100 g
– high P	—	100 g	100g	—

Feed intake and animal performance data are summarized in Table 3. The highest level of animal performance was attained by the barley beef group and the lowest level by the animals offered grass silage + concentrates. Both groups on the WCFBS diets were intermediate, with no apparent benefit attributable to protein supplementation.

Table 3

Intake and performance of Friesian steers offered whole-crop fodder beet silage (WCFBS)

	Grass silage + concentrates	Whole-crop fodder beet silage + Barley	Whole-crop fodder beet silage + Soya	Barley beef	SEM
Intake					
WCFBS DM (kg)	-	8.6	8.3	-	-
Grass silage DM (kg)	5.6	1.2	1.2	1.3	-
Concentrates	4	1	1	10.1	-
Initial liveweight (kg)	467.5	470.0	470.0	468.0	0.63
Final liveweight (kg)	570.8	597.0	589.7	611.1	9.62
Liveweight gain (kg/day)	0.91	1.12	1.10	1.26	0.084
Kill-out rate (g/kg)	536	532	533	534	3.09
Carcass weight (kg)	305.9	317.5	314.4	326.1	5.08
Est. carcass gain (kg/day)	0.69	0.79	0.76	0.87	0.044
KFC weight (kg)	14.3	14.0	14.1	13.8	0.91
Conformation score[1]	3.6	3.4	3.7	3.3	0.16
Fatness score[2]	3.3	3.5	3.1	3.7	0.13

[1]Conformation score : 1=best and 5=worst; [2]Fatness score : 1=leanest and 5=fattest

Table 4

Mean chemical composition[1] (and standard deviation) of effluent from fodder beet silage

Dry matter (g/kg)	85	(1.2)	Butyric acid (g/kg)	0	(0)
pH	3.82	(0.045)	Ethanol (g/kg)	137	(3.8)
Lactic acid (g/kg)	256	(30.0)	Ash (g/kg)	112	(10.8)
Acetic acid (g/kg)	46	(1.1)	Crude protein (g/kg)	86	(1.3)
Proprionic acid (g/kg)	2	(0.9)			

[1]expressed on DM basis, except for pH

At this stage the high nutritive value of whole crop fodder beet silage has been confirmed. Further experiments are required to determine the requirement for supplementary protein under a wider range of circumstances. In addition the need for a supplementary source of long fibre and the mineral and buffer requirements (if any) need to be clarified, as well as the effects on intake and performance of soil (ash) contamination.

Although the whole volume of effluent produced by fodder beet silage has not been properly quantified, it appears to be much higher than occurs with that produced by grass silage under normal conditions. In addition, fodder beet silage effluent has a high content of nutrients and is therefore too valuable a feedstuff to waste.

In a second experiment Friesian steers were offered unwilted grass silage *(ad libitum)*, fresh water and 1 kg rolled barley/head daily. Twenty animals had *ad libitum* access to the effluent from whole crop fodder beet silage (composition in Table 4) while a further 20 had not. Fodder beet silage effluent had a higher DM content and lower ash and crude protein levels than effluent from grass silage. The animal performance results, summarised in Table 5, show that liveweight gains, adjusted for differences in gut-fill between the two treatments, were improved by intake of effluent. The effluent from whole crop fodder beet silage clearly has a high nutritive value and should be used as a feedstuff rather than be spread on grassland. The next research objective is the incorporation of this effluent into a diet along with fodder beet silage.

Table 5

Intake and performance of steers offered effluent from whole crop fodder beet silage

	No effluent	Effluent
Intake (kg/day)		
Silage DM	5.7	4.1
Concentrates DM	0.9	0.9
Water	12.8	2.8
Effluent	–	34.2
Effluent DM	–	2.9
Total DM	6.6	7.9
Liveweight gain (g/day)	0.91	1.17

The major conclusions from the experiments reported here are :

(a) It is relatively easy to achieve good preservation of whole crop fodder beet silage, despite soil contamination.

(b) High intakes and good animal performance can be achieved where whole crop fodder beet silage is fed as the major component of the diet. The effects of reducing ash levels are, as yet, unproven.

(c) No response to protein supplementation was achieved when a crop with healthy leaves was ensiled.

(d) Fodder beet silage effluent has a high nutritive value and should be used as a feedstuff rather than as a fertiliser.

Crossbreeding of Friesian Dairy Cows

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According to Central Statistics Office data, total cow numbers were 2,088,300 in June 1990. Of these, 1,463,600 (70.1%) were dairy cows, predominantly Friesians. The Cattle Artificial Insemination (AI) Service carried out 1,069,482 inseminations in 1989. This represents about 52% of all cows but when account is taken of unrecorded "Do it Yourself" inseminations and of the fact that there is always a small proportion of cows which are not bred for various reasons, it seems that 55% to 60% of all matings are by AI. While there is no break-down of inseminations by type, it is widely accepted that it is very largely dairy cows which are inseminated.

Distribution of inseminations by breed

The distribution of inseminations by breed type, together with the incidence of serious calving difficulty, calf mortality within 48 hours of birth and gestation length are shown in Table 1. As would be expected because of the need to provide replacement heifers for the dairy herd, Friesian was the predominant sire breed, and represented 37% of all inseminations. After the Friesian, the early maturing breeds accounted for 27% of inseminations while the continental breeds accounted for 35%. The Charolais, Limousin and Simmental at 9-11% each made up the bulk of the continentals. Between them, Blonde d'Aquitaine and Belgian blue accounted for only 3% of inseminations. For the Friesian, Angus and Hereford breeds, serious calving difficulty was in the range 1.9% - 2.5%. Simmental, Limousin and Belgian blue breeds were in the range 4.8% - 5.4%, while the Charolais value was over 6%. The figure for the Blonde d'Aquitaine is abnormally high due to the inclusion of a small number of bulls with a very high incidence of calving difficulty initially. Since 1982 however, the serious calving incidence from 701 Blonde d'Aquitaine calving records is 4.4%. For Friesians,

Table 1
Percentage inseminations, calving difficulty, calf mortality and gestation length of different sire breeds

Breed	% Inseminations[a]	% Difficulty[b]	% Mortality[c]	Gestation (days)
Friesian	37.4	1.9	1.7	281
Angus	9.7	2.3	1.5	281
Hereford	17.8	2.5	1.8	282
Charolais	11.1	6.1	2.8	285
Simmental	9.3	4.9	2.4	284
Limousin	11.3	5.4	2.6	286
Blonde	1.5	9.7	2.2	286
Belgian blue	1.6	5.4	2.6	283

[a] % of total inseminations [b] serious calving difficulty [c] within 48 hours of birth
Source: Department of Agriculture and Food. Approved AI Bull List 1990.

Angus and Hereford, mortality ranged from 1.5% - 1.8% while for all the continentals it was in the range 2.2% - 2.8%. Gestation lengths for Simmental and Belgian Blue progeny were 2-3 days longer than for Friesians, while for Charolais, Limousin and Blonde d'Aquitaine progeny gestation lengths were 4-5 longer than for Friesians. In summary, therefore, the direct effects on calving of using a continental rather than a traditional breed of bull are an increase of 3-4 days in gestation length, 1% extra calf mortality and about 3% units more calving difficulty.

Effects of bull breed on cow performance

Some years ago a major survey of Irish dairy herds using two or more breeds of bull was undertaken. The comparison of Friesian, Hereford, Charolais and Simmental bull breeds is shown in Table 2. Heifer data are excluded. In this survey, breed of bull had no effect on lactation length or on current or subsequent lactation yield but all beef bulls extended the calving to calving interval. Charolais and Simmental sired calves were 5-8 kg heavier at birth than Friesian and Hereford sired calves.

Table 2
Effect of bull breed on cow performance

Sire breed	Friesian	Hereford	Charolais	Simmental
Lactation length (d)	266	267	267	267
Milk (kg) – current [a]	4425	4436	4404	4452
Milk (kg) – subsequent [a]	4239	4304	4206	4230
Calving interval (d)	360	371	370	391
Calf weight (kg)	41	39	46	47

[a]lactation

Source: Badi, More O'Ferrall and Cunningham, 1985

Because this survey gave inconclusive results on a number of important issues, a controlled experiment was undertaken to compare the effects of mating Friesian, Hereford and Charolais bulls to Friesian dairy cows. Although differences in milk yield were not significant, there was a tendency particularly for the Charolais bull to reduce milk yield by 1% - 2% in both the current and subsequent lactations (Table 3). This reduction can be attributed mainly to the fact that the Charolais sired calves were 4-5 kg heavier at birth than Friesian and Hereford sired calves. Surprisingly, the gestation length of Hereford sired calves was

Table 3
Comparison of bull breeds in repect of cow performance

Sire breed	Friesian	Hereford	Charolais
Lactation length (d)	262	261	258
Milk (kg) – current [a]	4179	4103	4065
Milk (kg) – subsequent [a]	4081	4064	4043
Calf birth weight (kg)	42	43	47

[a] lactation

Source: More O'Ferrall and Ryan, 1990

Table 4
Comparison of bull breeds in respect of cow production

Sire breed	Friesian	Hereford	Charolais
Gestation (d)	282.5	286.1	286.5
Calving – 1st service (d)	67.5	68.5	66.6
Calving – conception (d)	86.4	84.9	91.6
Services per conception (no.)	1.55	1.50	1.89

Source: More O'Ferrall and Ryan, 1990

similar to that for Charolais sired calves and the gestation lengths for all three bull breeds (Table 4) was longer than reported by the Department of Agriculture and Food (see Table 1). While there are large differences between bulls in gestation length of their progeny, there are data from Moorepark (Mee, 1989) showing that the gestation length for Friesians is about two days longer than indicated by the Department of Agriculture and Food (1990) figures and there are data from Grange with once-calved heifers showing that the gestation length for Herefords is 2-4 days longer than indicated by the Department of Agriculture and Food figures. These gestation lengths from Moorepark and Grange respectively agree with the values in Table 4. Sire breeds had no effect on calving to first service interval and there was no difference between Friesians and Herefords in calving to conception. Following the birth of a Charolais sired calf however, the calving to conception interval was increased by about 5 days and the number of services per conception was also increased.

In summary, there are no adverse economic effects on the dairy enterprise from the use of a Hereford bull compared with a Friesian, despite the fact that the gestation interval is slightly longer. Using bulls of the large continental breeds results in a reduction of 1-2% in milk yields due to the longer gestation and calving to conception intervals. It is also more difficult to maintain a 365 day calving interval. By way of compensation the continental cross calf is 5 kg heavier at birth.

Relationship between calving difficulty and calf growth rate

It is widely believed that there is a correlation between calving difficulty and subsequent performance of the calves. This is based on the hypothesis that calves which grow most rapidly before birth would also grow more rapidly afterwards and vice versa. This reasoning has led to a belief amongst producers that bulls with a low incidence of calving difficulties produce inferior calves or calves with a high incidence of calving difficulties. This may be the case if bulls were selected only on the basis of single traits, but bulls can and are selected for a number of traits simultaneously. Within the present approved A.I. Beef Bull List (1990) published by the Department of Agriculture and Food, there appears to be no association between the relative breeding value of a bull for growth rate and his calving difficulty value. This is illustrated in Table 5 which contains the mean values for 6 bulls (2 each Charolais, Limousin and Simmental) in each of four categories – highest relative growth rate, lowest relative growth rate, highest calving difficulty and lowest calving difficulty. (Individual bulls may have been

Table 5

Calving difficulty percentage (CDP) and relative growth rate (RGR) values for selected bulls

Highest growth rate bulls		Lowest growth rate bulls	
RGR	CDP	RGR	CDP
115	3.9	104	4.0
Highest calving difficulty bulls		Lowest calving difficulty bulls	
CDP	RGR	CDP	RGR
6.2	109	2.2	110

Means of 6 bulls (2 Charolais, 2 Simmental and 2 Limousin) per group

Source: Department of Agriculture and Food. Approved by AI Beef Bull List. Spring 1990.

included in more than one category). The mean data presented show no association between calving difficulty and growth rate. The sixth highest growth rate bulls had a mean relative growth rate value of 115 and a calving percentage of 3.9. The 6 lowest growth rate bulls had a mean relative growth rate value of 104 and had a calving difficulty percentage of 4.0. Thus, the 6 highest and 6 lowest growth rate bulls had similar mean calving difficulty percentages. Similarly, the 6 highest calving difficulty bulls had a calving difficulty percentage of 6.2 and a relative growth rate value of 109, while the 6 lowest calving difficulty bulls had a calving difficulty percentage of 2.2 and a relative growth rate value of 110. While there are bulls with both high calving difficulties and high relative growth rates and vice versa, the data in Table 5 show that there are bulls with high relative growth rate values and low calving difficulties. In fact, both the Charolais bull and the Simmental bull with the highest relative growth rate value had also the lowest calving difficulty percentage.

The absence of a relationship between calving difficulty and relative growth rate is further illustrated in Tables 6 and 7. In Table 6, the individual Charolais, Limousin and Simmental bulls with their respective relative growth rate difficulty had a somewhat higher relative growth rate value than the one with the lowest calving difficulty, this was not the case for the other two breed types. The two Limousin bulls with the highest (7.7%) and lowest (2.7%) calving difficulty had almost identical relative growth rate values while the Simmental bull with the highest (5.7) calving difficulty had a considerably lower relative growth rate

Table 6

Relative growth (RGR) of individual bulls with high and low calving difficulty percentages (CDP)

High calving difficulty bulls			Low calving difficulty bulls		
Name	CDP	RGR	Name	CDP	RGR
CF25 (C)	7.1	111	AC12 (C)	1.0	107
PAL (L)	7.7	106	CEB (L)	2.7	107
BRY (S)	5.7	109	SUE (S)	1.8	117

(C) = Charolais, (L) = Limousin, (S) = Simmental

Source: Department of Agriculture and Food. Approved AI Beef Bull List Spring 1990

Table 7

Calving difficulty percentage (CDP) of individual bulls with high and low relative growth rates (RGR)

High growth rate bulls			Low growth rate bulls		
Name	CDP	RGR	Name	CDP	RGR
BOA (C)	113	2.6	TOE (C)	104	4.3
DNB (L)	119	5.4	ACT (L)	104	3.4
SUE (S)	117	1.8	FRR (S)	103	3.6

(C) = Charolais, (L) = Limousin, (S) = Simmental

Source: Department of Agriculture and Food. Approved AI Beef Bull List Spring 1990

(109 v. 117) than the bull with the lowest (1.8%) calving difficulty. Similarly (Table 7), the Charolais bull with the highest relative growth rate value had a lower calving difficulty (2.6 v. 4.3%) than the bull with the lowest relative growth rate. For the Simmental also, the highest relative growth rate bull had only half the calving difficulty of the lowest relative growth rate bull. However, the highest relative growth rate Limousin bull had a somewhat higher calving difficulty than the lowest relative growth rate Limousin bull. These data show conclusively that while high relative growth rate bulls may have high calving difficulties and low calving difficulty bulls may produce calves of relative low growth rate, high growth rate bulls can be easy calving and easy calving bulls can have high relative growth rate values.

Productivity of less widely used breeds

Canadian Hereford : Hereford bulls from Canada were imported into Ireland with a view to improving the productivity of the Hereford breed. There has been little attempt to quantify this putative improvement particularly in respect of carcass characteristics. As part of the beef x dairy breed evaluation programme at Grange, Canadian Hereford x Friesians were compared directly with Friesians. Since traditional British Hereford x Friesians had earlier been compared with Friesians, it was possible to make a comparison (indirect) of the two Hereford strains. The results of this comparison are shown in Tables 8 and 9. The Friesian data were standardised to the norm for a two year old beef system (i.e. carcass weight of 320 kg) and the data for the two Hereford strains were adjusted accordingly. At the same age British Hereford crosses were 7 kg heavier and

Table 8

Performance of steers from Friesian cows and Friesian, British Hereford and Canadian Hereford sires.

Sire	Friesian	British Hereford	Canadian Hereford
Slaughter weight (kg)	600	607	627
Carcass weight (kg)	320	330	342
Kill-out %	53.3	54.4	54.5
Muscle weight (kg)	192	190	196

All data adjusted to basis of Friesian steer at two years of age

Table 9

Carcass traits of steers from Friesian cows and Friesian, British Hereford and Canadian Hereford sires.

Sire	Friesian	British Hereford	Canadian Hereford
Conformation[a]	2.2	2.9	3.0
Fat score [b]	3.3	4.1	4.0
Bone %	16.0	14.5	14.5
Muscle %	60.0	57.5	57.5
Fat %	24.0	28.0	28.0
Higher value muscle %[c]	40.9	40.5	40.9
Longissimus area (cm^2)	69	70	70
Subcutaneous fat %[d]	42	47	46

[a] Scale 1 (poorest) 0 to 5 (best); [b] Scale 1 (leanest) to 5 (fattest); [c] % TO total muscle; [d] % of total separable fat

Canadian Hereford crosses were 27 kg heavier than Friesians. Corresponding carcass weight superiorities were 10 kg and 22 kg respectively. Both Hereford strains had killing-out rates about 1% unit higher than Friesians. However, even though the Hereford cross strains produced 10 kg and 22 kg more carcass they produced 2 kg less and only 4 kg more muscle respectively than Friesians. This was because all or practically all of the extra carcass weight was fat. In summary therefore, compared with British Hereford crosses, Canadian Hereford crosses produced 20 kg more liveweight, 12 kg more carcass weight and 6 kg more muscle at about 2 years of age.

Carcass characteristics are shown in Table 9. Both Hereford cross strains had better conformation, higher fat scores, higher fat percentages and lower muscle and bone percentages than Friesians but there were no differences in any respect between the two Hereford cross strain themselves. The superior conformation of the Hereford crosses was not associated with increased muscle percentage (in fact it was lower), larger muscle size (as indicated by *longissimus* area) or more higher value muscle growth rate than the British Hereford but there were no differences between the two strains in carcass grades or composition.

Blonde d'Aquitaine : Blonde d'Aquitaine accounts for less than 2% of Irish inseminations but it is much more widely used elsewhere (Northern Ireland and

Table 10

Performance of steers from Friesian cows and Friesian, Limousin and Blonde d'Aquitaine sires

Sire	Friesian	Limousin	Blonde
Slaughter weight (kg)	600	590	615
Carcass weight (kg)	320	329	344
Kill-out %	53.3	55.8	55.9
Muscle weight (kg)	192	209	222

All data adjusted to basis of Friesian steer at two years of age

Holland for example). Its performance (when crossed on Friesians) compared with Friesians and Limousin x Friesians is shown in Table 10. At about 2 years of age Blonde crosses were 25 kg liveweight, 15 kg carcass weight and 13 kg muscle weight superior to Limousin crosses. Limousin crosses in turn were 9 kg carcass weight and 17 kg muscle weight superior to Friesians. Blonde crosses had similar conformation to, and a lower fat score than Limousin crosses (Table 11). They also had less fat, more muscle and more bone in the carcass. Both beef crosses had a slightly higher proportion of higher value muscle and a considerably greater muscle size than Friesians. In conclusion both beef crosses were considerably superior to Friesians in all important respects and at the same age Blonde crosses were superior to Limousin crosses in slaughter weight, muscle weight and muscle percentage.

Table 11
Carcass traits of steers from Friesian cows and Friesian, Limousin and Blonde d'Aquitaine sires

Sire	Friesian	Limousin	Blonde
Conformation[a]	2.2	3.0	2.9
Fat score [b]	3.3	3.4	3.0
Bone %	16.0	14.5	15.5
Muscle %	60.0	63.3	65.0
Fat %	24.0	22.5	19.5
Higher value muscle %[c]	40.9	41.8	41.8
Longissimus area (cm^2)	69	82	81

[a] Scale 1 (poorest) to 5 (best); [b] Scale 1 (leanest) to 5 (fattest); [c] % of total muscle;

Mouse-Rhine-Yssel (MRY) and Belgian Blue : The MRY is a Dutch dual purpose breed which is reported to be little behind the Friesian in milk production ability, but has better beef characteristics. With the introduction of milk quotas, a view emerged that in certain situations, crossing with the MRY might be appropriate as it would maintain milk production potential of the herd while improving beef merit.

Like other continentals, the Belgian Blue breed was imported to improve the overall growth rate and carcass characteristics of cattle from both the dairy and beef herd. Because both the MRY and Belgian Blue breeds were considered to

Table 12
Calving data for Friesian, MRY and Belgian Blue bulls

Sire	Friesian	MRY	Belgian Blue
Gestation (d)	282	283	284
Birth weight (kg)	39	43	43
Assistance (%)	28	38	43

have significant commercial potential in Ireland, they were included in the beef x dairy cattle evaluation programme at Grange. Interim results are given here.

Over two consecutive years, cows in Moorepark were bred by AI to Friesian,

Table 13
Performance of steers from Friesian cows and Friesian, MRY and Belgian Blue sires

Sire	Friesian	MRY	Belgian Blue
Slaughter weight (kg)	594	602	614
Carcass weight (kg)	317	328	341
Kill-out %	53.3	54.4	55.6
Muscle weight	191	195	225

Unadjusted data

MRY and Belgian Blue bulls. The calving data are shown in Table 12. MRY and Belgian Blue sired calves had gestation periods one and two days longer respectively than Friesians. Both MRY and Belgian Blue calves had similar birth weights (4 kg heavier than Friesians) and as would be expected, both exotics had somewhat greater calving difficulty with little difference between the MRY and Belgian Blue in this respect. Overall, calving difficulty was not serious.

Performance of the progeny is shown in Table 13. Compared with Friesian, MRY x Friesian steers were 8 kg liveweight heavier at slaughter, they had 1.1% units higher kill-out so they were 11 kg carcass weight heavier. However, they had only 4 kg extra muscle. Belgian Blue x Friesians were 20 kg heavier than Friesians at slaughter. They had 2.2% units higher kill-out so their carcass weight was 24 kg heavier and muscle weight was 34 kg heavier. Conformation was 0.4 units better for the MRY crosses than Friesians but fat score was slightly

Table 14
Carcass traits of steers from Friesian cows and Friesian, MRY and Belgian Blue sires

Sire	Friesian	MRY	Belgian Blue
Conformation[a]	2.3	2.7	3.1
Fat score [b]	3.4	3.6	3.1
Bone %	18.9	18.5	17.4
Muscle %	60.2	59.6	66.1
Fat %	20.9	21.9	16.5
Longissimus area (cm^2)	74	76	87

[a] Scale 1 (poorest) to 5 (best); [b] Scale 1 (leanest) to 5 (fattest)

higher (Table 14). Friesians and MRY crosses had similar bone proportions but the MRY crosses had about 1% units less muscle and 1% unit more fat.

Overall, MRY crosses were slightly more productive than Friesians, but they were not any leaner. Belgian Blue crosses were 0.8 units superior in conformation to Friesians and had 0.3 units lower fat score. They also had less bone, more muscle, less fat and a larger muscle size. In summary therefore, Belgian Blue crosses are vastly superior to Friesians in carcass weight, muscle size, muscle percentage and conformation.

Piedmontese : The Piedmontese breed originated in North West Italy. In terms of muscling, it is estimated that about 60% of the bulls are double muscled

Table 15

Beef breed inseminations in the Netherlands

	1975	1985	1988
Beef as % of total AI	0.7	3.8	12.4
Total beef AI ('000)	11	83	232
Distribution by breed (%)			
Piedmontese	4.6	67.9	68.9
Belgian Blue	2.8	7.3	9.2
Limousin	25.0	3.4	2.2
Charolais	24.1	1.2	2.1
Blonde d'Aquitaine	–	11.3	10.5

Source: Irish Piedmontese Cattle Society

and 40% are intermediate in muscling. Cows are predominantly intermediate. The only country in which Piedmontese is widely used seems to be the Netherlands (Table 15). In 1975 less than 1% of Netherland inseminations was to beef bulls and by 1985 it was less than 4%. In the following years to 1988 it trebled to over 12%. In 1975, the main beef breed was the Dutch Red and White with the Charolais and Limousin making up the rest. Ten years later those three breeds had virtually disappeared and the Piedmontese now accounted for almost 70% of inseminations with the Belgian Blue and Blonde d'Aquitaine being the only other breeds of significance. Thus by Irish standards, the Dutch beef breeds are all minority breeds.

The ranking for various traits of the progeny from a number of breeds including the Piedmontese relative to the Charolais is shown in Table 16. The Piedmontese had a growth rate lower than any other breed except the Limousin. However, it had the highest dressing percentage so its carcass weight ranking was above the Limousin, similar to that of the Blonde d'Aquitaine but below that of the Charolais and Belgian Blue. In muscle weight it exceeded everything except the Belgian blue. On the basis of these figures therefore, the Piedmontese is not exceptional in growth rate but has a high dressing percentage and good carcass characteristics. However, there is nothing to suggest that its overall productivity is better than the Charolais or Belgian Blue. From the United States a comparison of the Piedmontese and Gelbvieh (similar to the Simmental) has been reported (Table 17). The Gelbvieh had a better growth rate but a poorer

Table 16

Relative performance of different breed types (Char = 100)

	Char.	Pied.	B. Blue	Blonde	Lim.	Herf.
Liveweight	100	94	99	97	93	95
Dressing	100	104	103	101	101	97
Carcass weight	100	98	102	98	94	92
Muscle weight	100	102	104	100	93	88
Conformation	100	97	103	99	100	84

Source: Calculated from the data of Renand, 1988, cited by the Irish Piedmontese Cattle Society

Table 17
Comparison of Piedmontese, Gelbvieh and Red Angus progeny

Sire	Piedmontese	Gelbvieh	Red Angus
Slaughter weight (kg)	515	525	506
Dressing %	63.2	62.0	61.6
Carcass weight (kg)	312	313	299
Longissimus area (cm^2)	99	92	85
Fat depth (mm)	4.6	6.6	9.9
% Bone	16.1	17.4	16.8
% Fat	22.7	23.9	29.3
% Muscle	64.0	61.6	57.5
Muscle weight (kg)	200	193	172

Source: Tatum *et al.* (1990)

dressing percentage with the result that both breeds had similar carcass weights. However, the Piedmontese had less bone and fat and more muscle. Both sets of results are in agreement on the high dressing percentage and high muscle percentage of the Piedmontese but there is nothing to suggest that in overall productivity it is clearly superior to all the other common continentals.

Ranking of all breeds : Detailed comparisons of the main breeds have been reported recently (Keane and More O'Ferrall, 1987; More O'Ferrall, 1987; Keane, 1990). A summary of the ranking of all the breed types is contained in Tables 18 and 19. Friesians, Hereford (British), Limousin, Blonde d'Aquitaine and MRY crosses had similar slaughter weights for age (Table 18). Canadian Hereford, Simmental, Charolais and Belgian Blue crosses had higher slaughter weights for age. All beef crosses had higher carcass weights for age than Friesians. Hereford (British), Limousin (Canadian), Blonde d'Aquitaine and Belgian Blue cross values were higher, and Simmental and Charolais cross values were highest of all. In muscle weight for age, the Hereford crosses did not retain their relative carcass weight superiority over Friesians whereas all the

Table 18
Relative performance of different breed types (Friesian = 100)

	Slaughter weight for age	Carcass weight for age	Muscle weight for age	Carcass weight [a] at equal fatness
Friesian	100	100	100	320
Hereford (British)	101	103	99	290
Hereford (Canadian)	105	107	103	290
Limousin	98	103	108	360
Blonde	102	107	116	400
Simmental	107	111	116	380
Charolais	107	111	117	400
MRY[a]	102	104	103	320
Belgian Blue[b]	105	109	118	400

[a] At equal carcass fat percentage [b] Interim results

Table 19
Relative carcass traits of different breed types (Friesian = 100)

	Fat score	Conformation	*Longissimus* area	Higher value muscle
Friesian	100	100	100	100
Hereford (British)	126	133	102	99
Hereford (Canadian)	122	135	102	100
Limousin	103	136	119	103
Blonde	91	132	118	103
Simmental	103	140	118	103
Charolais	94	143	123	103
MRY[a]	106	117	103	NA
Belgian Blue[b]	91	135	119	NA

[a] Interim results. NA = not available yet

continental crosses extended their superiority relative to Friesians. Friesians, both Hereford crosses, and MRY crosses had low and similar muscle weights for age, Limousin crosses were intermediate while Blonde d'Aquitaine, Simmental, Charolais and Belgian Blue crosses had similar high muscle weights for age.

At the same age, Friesians, Limousin, Simmental and MRY crosses had similar carcass fat scores. Both Hereford crosses had higher scores and Blonde d'Aquitaine, Charolais and Belgian Blue crosses had lower fat score (Table 19). All beef crosses had better conformation than Friesians and there was little difference in conformation between the common beef crosses. MRY crosses were intermediate in conformation between Friesians and the beef crosses. *Longissimus* area is an indicator of muscle size and the breed types fell into two distinct groups for this characteristic. Friesians, both Hereford crosses and MRY crosses had similar and much larger *longissimus* areas. Despite the large differences in conformation there was relatively little difference between breed types in the proportion of total muscle in the higher value joints.

Conclusions

1. Using a continental rather than a traditional breed of bull increases gestation length by 2-4 days, increases calving difficulty incidence by about 3% units and increases calf mortality by about 1% unit.
2. Compared with a traditional breed of bull a continental bull increases the interval from calving to conception and the number of services per conception. This together with the longer gestation increases the calving to calving interval and milk yield is reduced by 1-2%. However, the continental cross calf is about 5 kg heavier at birth.
3. High relative growth rate continental bulls can be easy calving and easy calving continental bulls can have high relative growth rates.
4. Canadian Hereford x Friesians have about 3% units higher live and carcass growth rates than traditional British Hereford x Friesians but there are no differences between the strains in carcass characteristics.

5. At the same age, Blonde d'Aquitaine x Friesians produced 5% more carcass weight and 6% more muscle than Limousin x Friesians.
6. Compared with Friesians, Belgian Blue x Friesians produced 3% more liveweight, 8% more carcass weight and 18% more muscle weight. They also had 2.3% units better kill-out and 0.7 units better comformation.
7. The Peidmontese has a lower growth rate than other continentals except the Limousin. However, it has a very high dressing percentage and a high muscle percentage. Its overall productivity is not superior to the common continentals.
8. Overall, there is little difference in productivity between Friesians, Hereford (both strains) x Friesians and MRY x Friesians especially if muscle weight is included and conformation is excluded. All continental crosses are superior to these.
9. Carcass weights of Friesians and Friesian crosses at similar carcass fat proportions are : Friesians 320, Herefords (both strains) 290, MRY 320, Limousin 360, Simmental 380, Blonde d'Aquitaine 400, Belgian Blue 400 and Charolais 400.

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