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Grass and Legume Cultivars to Maximise Production of High Quality Silage

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The scarcity of silage in Ireland is aggravated by its generally poor quality. The aim of this paper is to show how the use of bred cultivars of grass and legume herbage species when properly managed, can produce high yields of good quality silage and consequently improve animal performance.

Grasses

Ryegrasses are the mainstay of reseeded Irish pastures and therefore, this paper will be dealing only with cultivars of the three ryegrass species.

The quality assessment of the ensiled herbages is based on its *in vitro* digestibility. This is measured in terms of D-value, which is the percentage of *in vitro* digestible organic matter in the total dry matter.

It is well known that as grass grows during spring and early summer, the yield of dry matter increases but the digestibility falls. This fall is slow at first but reaches about 0.4 digestibility units per day as the grass matures. The increase in yield of dry matter during this period may be 100-200 kg per hectare per day. Consequently, a delay of one week in the time of cutting can produce a considerable deterioration of the silage quality. As greater emphasis is being placed on quality the right time for cutting is when the digestibility of the herbage reaches 67D value.

The average date of first cut of 67-D herbage varies with the ryegrass species and within perennial ryegrass with the maturity group of the cultivar. Thus, early and medium-early cultivars of perennial ryegrass should be harvested between 20 to 25 May, medium-late cultivars on the first days of June, late types on the second week in June and the very late, such as Endura and Angela, between 15 to 20 June. Cultivars of Italian and hybrid ryegrasses should be cut on 20-25 May. Regarding tetraploid perennial ryegrasses the fall in digestibility is slower than in the diploid cultivars and their digestibility at heading is higher than that of diploid cultivars with similar date of heading. Therefore, the inclusion of tetraploid cultivars in mixtures for conservation is advisable.

There are some situations in which a quality level other than 67-D has to be adopted. So, in dairy farms which aim at high milk production the herbage ensiled must have a D-value not lower than 70. There is also the case in which it suits a farmer best to cut a larger bulk of moderate quality silage and therefore the 63-D level should be more appropriate. The time of the first harvest is affected by weather conditions.

Spring grazing reduces the yield of the first silage cut and delays heading and the date at which a grass reaches a given D-value. The delay does not normally exceed a week and depends on the date when the sward is closed for silage. In areas of early spring grazing which can be closed at the end of March or first week of April the use of a mixture based on early or medium-early cultivars is recommended. This gives a first cut with a reasonably high yield of good quality silage at the end of May. When, on the other hand, a pasture cannot be closed until late April the use of medium-late or late cultivars is advisable.

Two large scale experiments in which ryegrass cultivars were assessed in terms of silage and beef production have been carried out at Oak Park and the results are given in Tables 1 to 3.

Both trials were undersown with barley, the first in the end of March 1970 and the second at the beginning of April 1975. In the first experiment an early and a medium-late cultivar of perennial ryegrass, Oriel and Spirit, together with Lemtal Italian ryegrass, were compared under a 3-cut silage management. In the second, Oriel was replaced by the medium-early cultivar, Oakpark, and the management consists of three cuts for the perennial cultivars and four cuts for Lemtal. Nitrogen inputs of 280-325 kg N/ha per annum were used in the first trial and 395 kg N/ha are being applied in the experiment in progress. Appropriate amounts of P and K per hectare were spread every year.

Table 1

Mean yields of dry matter (t/ha)—averaged over 3 years

	Cut 1		
Cultivars	Cutting date	DM yield (t/ha)	
Spirit	3-8 June	8.1-9.1	8.6
Lemtal	29 May - 3 June	6.1-7.5	6.9
Oriel	22-31 May	5.3-6.8	6.1
	Cut 2		
	Regrowth interval (weeks)		
Spirit	7.0	3.2-4.2	3.8
Lemtal	6.5-8.0	3.7-4.9	4.4
Oriel	7.0-8.0	3.0-3.9	3.5
	Cut 3		
Spirit	8.0-9.0	2.8-4.4	3.8
Lemtal	8.0-9.0	2.2-3.9	3.2
Oriel	8.0-9.0	2.7-3.3	3.1
	3-cut total		
Spirit	—	15.1-17.1	16.2
Lemtal	—	12.0-15.8	14.4
Oriel	—	11.0-13.6	12.6

Data on Tables 1 to 3 show how it is possible to obtain very high yields of good quality silage in the first harvest when this is made at the right time and under reasonable weather conditions. Thus, a delay of the harvest and unfavourable weather conditions caused a deterioration of quality of the first-cut silage of Spirit in 1976 (Table 3).

Table 2

Mean D-values of the herbages ensiled in 1971-73

Cultivars	Cut	D-values		
		1971	1972	1973
Spirit	1	73.7	67.3	69.2
	2	68.3	67.4	66.5
	3	65.6	70.7	62.6
Lemtal	1	69.9	64.4	63.9
	2	62.6	54.7	63.5
	3	53.7	64.0	50.4
Oriel	1	72.3	64.5	66.3
	2	63.7	63.0	64.3
	3	60.8	69.6	60.2

Regarding the subsequent cuts the quality of the silage produced depends on the length of the regrowth interval. For Italian ryegrass the regrowth periods should not exceed 4-5 weeks (Tables 1, 2 and 3). As a result of this shortening of the regrowth intervals the number of harvests has to be increased from 3 to 4 (Table 3). This reduces the total DM yield and in unfavourable years as 1975 and 1976 the amount of herbage collected in some cuts does not repay the high cost of harvest and ensiling. For perennial ryegrass, 6-7 week regrowth intervals are recommended to produce reasonable yields of high quality silage.

Early and medium-early and medium-late cultivars of perennial ryegrass are suitable for the 3-cut silage system of conservation. The results obtained with Spirit seem to indicate that medium-late cultivars are the most appropriate for this type of management, however, unusual hot dry summers can seriously affect the third harvest. Thus, in 1976 a third harvest of Spirit was not possible (Table 3).

The use of pure swards of Italian ryegrass for conservation does not seem advisable with a possible exception when a farmer wants to sow a very short ley of 12 to 18 months. The results of the experiments show also that when Lemtal is undersown with a cereal crop its DM yield in the first harvest season is lower than that obtained when it is directly sown in the autumn.

Table 3

Mean yield of dry matter and D-value of the herbages ensiled in 1976

	Cut	Cutting date	DM yield t/ha	D-value
Spritit	1	June 8	10.0	61.7
	2	July 27	4.5	65.7
	3	Sept. 14	0.0	—
Oakpark	1	May 24	7.3	69.5
	2	July 12	4.9	63.7
	3	Aug. 31	2.4	71.0
Lemtal	1	May 20	6.6	68.0
	2	June 24	4.2	65.0
	3	July 29	2.6	63.0
	4	Sept. 2	0.5	64.1

The 3-cut silage management has a depressing effect on the persistency of perennial cultivars and the yields drop substancially after four or five years.

The digestibility of herbages at the ensiling time is usually higher than that of the corresponding silages and the difference depends on the efficiency of the conservation process. Thus, in the Oak Park experiments the digestibility of the silage was on average 2-4 units lower but in badly preserved silages can be 10 units lower.

The overall mean of crude protein content for the first cut silages was 9.9% which is lower than the 12% requirement of most stock. Protein contents of subsequent cuts were higher than the 12% level.

The ryegrass silages produced in 1972 and 1973, and 1976 were tested in winter feeding trials in which Friesian steers, averaging 447 kg liveweight, were fed *ad libitum* without any supplementation. The mean daily liveweight gains obtained were as follows:

Trial 1

Silages	Liveweight gain kg/head/day	
	1972-73	1973-74
Spirit	0.613	0.456
Oriel	0.469	0.342
Lemtal	0.304	0.275

Trial 2

Only 1976-77 results. Silages	Liveweight gain kg/head/day
Spirit	0.498
Oakpark	0.641
Lemtal	0.592

Animals fed silages of higher digestibility performed better than those fed lower digestibility silages and the change of management of Lemtal swards in the second trial resulted, as expected, in a great improvement of the animal performance.

Legumes

White clover

Although white clover is less important as a herbage legume for conservation than red clover and lucerne, its role in grass/clover swards under a grazing and conservation management must not be underestimated. Apart from supplying nitrogen to the sward, this legume retains a very high digestibility of about 75-D over long periods and the fall in digestibility is much slower than for the other two legumes and for the ryegrasses. Its crude protein content is also very high, normally over 20%. Therefore, the quality of the silage harvested from a grass/clover sward will be improved in proportion to the amount of white clover present.

The best cultivars of white clover are Blanca and Kersey but sometimes it is difficult to obtain seed and its price is very high (£6.60 per kg). Cultivars Sabeda, Grasslands Huia and Milkanova can be used as alternatives.

Red clover

The dramatic increase in the cost of nitrogen caused by the oil crisis and the world shortage of protein have brought renewed interest in red clover as a special purpose crop. This red clover revival was helped by the fact that at this time plant breeders have introduced markedly improved new cultivars, mostly tetraploids, which are capable of giving high yields when grown pure or with a grass companion without use of fertiliser N for 2-3 years. On the other hand advances in the technology of silage making solved the problems of ensiling red clover.

The best cultivars presently available are the four tetraploid—Hungaropoly, Red Head, Teroba and Tetri. There is no significant difference in yield between these cultivars but Hungaropoly is possibly more persistent than the other three. These four cultivars are resistant to clover rot. In cases of seed scarcity tetraploid cultivars can be replaced by the diploid cultivars Violetta, Sabtoron and Kuhn which give good yields particularly in areas free of clover rot. Red clover has a high crude protein content (16-18%) and is also rich in minerals, but has a low water soluble carbohydrate content (8-12%).

High yields are dependent on a satisfactory crop establishment. In direct sowing a fine tilth, a firm weed free seed bed and a soil pH of 6 to 6.5 plus generous application of phosphorus and potassium are basic requisites for good, even establishment. Under Irish conditions red clover or red clover/grass mixtures can be sown from April to the first week in August. The pure-sward is very often open and susceptible to weed invasion, but in red clover/grass swards the invasion by weeds is reduced. A good establishment can be obtained from sowing red clover under a cereal crop which will be harvested as arable silage in July. A seed rate of 13-18 kg/ha should be used for a pure stand and for a red clover/grass sward 13 kg of clover mixed with 6 kg of grass per hectare should be sown. Annual fertiliser requirements are 40-60 kg of phosphorus and 200-300 kg of potassium per hectare.

Although yields of DM as high as 12 t/ha per annum can be obtained from pure stands cut three times for silage, the use of mixed red clover/grass swards is recommended. The main advantages of the mixed sward are: a DM yield of 20-30% higher than in the pure clover sward, the herbage is easier to ensile, the presence of a grass companion reduces annual weeds and minimizes the wheel damage to clover, and the herbage is better balanced nutritionally than in the pure sward.

Considering the companion grass, Italian ryegrass is not recommended and the best choice is a medium-late perennial ryegrass cultivar such as Spirit, Talbot, Barlenna, Combi and the tetraploids Taptoe and Barlatra.

The most appropriate management seems to be a first cut in early June followed by two subsequent cuts in early August and late September respectively.

The D-value of red clover at the time of the first silage harvest is 61-63D. This low D-value is acceptable because the intake of red clover silage by stock is 20-40 per cent higher than that of grasses of the same digestibility (Castle, 1975). Therefore, silages with 60-63D and a high protein content are considered of good quality. A 60D digestibility is obtained in second and third cuts made with 6-week regrowth intervals.

The dry matter content of red clover herbages is normally very low (12-14%) and therefore, they must be wilted to 23-25%. The use of an additive is essential and Add-F, containing 85% formic acid, has been used effectively at rates of 2.3-4.5 l/t lifted material.

Regarding the bloat hazard it is not important with red clover silage as it is when the herbage is grazed early in the growing season. However, no bloat problem was observed when red clover was grazed by store lambs or cattle from October to December. Autumn grazing is ideal for fattening store lambs.

Thompson (1975) reports that the oestrogenic level in red clover silage is enough to depress the reproductive rate of ewes. Therefore, ewes should not be fed silage prior to, and during mating. Braden *et al.* (1971) have demonstrated that cattle metabolize plant oestrogens more rapidly than sheep and thus may have a greater tolerance to oestrogenic effects.

The silage role of the red clover crop is mainly in arable farming systems where it makes an ideal break crop. Red clover improves the soil structure and promotes the replenishment of soil N. Spring barley after a 3-year tetraploid red clover ley yielded 5 t/ha with a N application of only 20 kg/ha (Mackie, 1975).

Lucerne

Little is known regarding this legume in Ireland although it has been grown in a very small scale for drying.

This legume is associated with low rainfall areas and with light dry soils where summer drought frequently limits yield. It requires a deep well drained soil with a high pH (6.5-7.0). Its deep rooting system ensures the production of high yields of DM (12 -15 t/ha) in areas affected by drought. It can also be grown on heavy soils provided drainage is adequate as it is very intolerant of wet soil conditions.

A number of highly improved new cultivars which are able to persist fully productive for 4-5 years are available and the best are: Europe, Sabilt, Verneuil and Vertus. All these cultivars belong to the early group and provide three or four cuts per annum.

Europe outyields the other cultivars by 10-15% in the absence of Verticillium wilt. The other three cultivars are resistant to Verticillium wilt but Vertus has the additional advantage of being resistant to stem eelworm.

Cultivar Europe is being tested in a field scale experiment at Johnstown Castle, in pure and mixed swards. The total yields of dry matter obtained from three harvests in the first growing season were 12.8 t/ha in pure sward and 10.5 t/ha in mixed sward. This shows that, in contrast with red clover, there is no advantage in including a companion grass with lucerne.

Lucerne can be sown from April to the end of July but the April sowing normally gives a better establishment. As for red clover a good establishment can be obtained with a cereal cover crop which will be cut for silage in July.

Fertiliser requirements of lucerne are 40 kg of phosphorus and 200-300 kg of potassium per hectare per annum.

The most suitable management for lucerne is a first harvest in late May followed by two or three cuts with intervals of six weeks between cuts.

Lucerne silage is fairly low in digestibility and at the time of the first harvest has a 60D-value. However, its intake by stock is much higher than that of grass silages of the same digestibility. A 60D level of digestibility is obtained in the subsequent cuts when they are made with 6-week regrowth intervals. Lucerne silage has a high crude protein content (18-20%) and is rich in minerals.

Lucerne herbages have a very low sugar content and this made the production of good silages difficult before the new improved silage-making techniques were introduced. As for red clover the herbage should be wilted for 24-48 hours and an additive should be used. The amount of Add-F for a crop with 20-25% of DM should be 3 l/t lifted material.

There are no bloat problems with lucerne silage.

Conclusions

1. The use of seeds mixtures based on the ryegrass cultivars presently available and specially tailored to produce high yields of good quality silage would reduce significantly the deficit of animal winter fodder which exists in Ireland.

2. On many farms in the arable areas, where soil conditions and silage-making facilities are satisfactory, a greater use of red clover is recommended.

3. An attempt should be made to introduce lucerne as a reliable source of forage in areas with light soils, where poor summer growth of the grasses is always a limiting factor.

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The Relative Importance of Digestibility, Ensiling, Fermentation and Dry Matter Content in Limiting the Utilisation of Silage by Beef Cattle

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For reasons associated with climate and the mechanisation of farm operations, ensiling has become the first choice system of forage conservation on most intensive and modernised farms. Many problems have been associated with the ensiling process and with silage as a feed for ruminants over the years. The purpose of this paper is to examine the major factors which have been associated with the restriction of animal production from ensiled herbage and examine the relative importance of each of them in quantitative terms where possible. The factors which will be discussed are digestibility, preservation, dry matter content, ensiling *per se* and fine chopping. While factors like secondary heating during the feeding of silage (Zimmer, 1973; Wilkins, 1975) and the non-anaerobic storage of silage (Ruxton *et al,* 1975) can have a profound effect on silage preservation and consequently on the efficiency of animal production from silage, their effects are well understood and are not discussed here.

Silage Digestibility

While it has for long been recognised that digestibility of a forage is a factor of major importance determining its intake and nutritive value (McCullough, 1961; Balch and Campling, 1962; McCarrick, 1965; Castle and Watson, 1969) higher digestibility in a silage has not always been associated with higher production (Tayler and Aston, 1967) due to interaction of other factors (Wilkins, 1974; Wilkins, 1975). Because of these interactions the relationship between dry matter digestibility (DMD) and animal production has seldom been described in quantitative terms over a wide range of digestibility. In general, a change in silage quality has a considerably greater effect on the productivity of beef cattle than on the production of milk in short term experiments by dairy cows (Waldo, 1977). Thus it is of interest to examine the results of 40 feeding experiments at this station in which well preserved silages were offered as the sole feed to steers weighing 400 kg. In most experiments, pre-experiment slaughter groups were included to allow absolute measurement of carcase gain. The summary presented in Table 1 shows a clear relationship between DMD and animal performance in terms of daily liveweight gain and daily carcase gain. Silages which produced daily liveweight gains of

Table 1

Relationship between silage dry matter digestibility and production by beef cattle (summary of 40 feeding trials)

	Daily liveweight gain (kg)			
	<0.35	0.35-0.55	0.56-0.75	>0.75
Number of trials	6	10	16	8
Dry matter digestibility %	60.4	65.0	68.6	74.5
Mean liveweight gain kg/day	0.30	0.46	0.66	0.90
Mean carcase gain kg/day	0.23	0.33	0.41	0.51

less than 0.34 kg/day had mean DMD=60.4% while those which produced more than 0.75 kg/day had DMD=74.5%.

In these trials animals were fed in groups and mean silage dry matter intakes were recorded. There was a close association between daily dry matter intake and DMD. It ranged from 1.6% of mean liveweight at 60% DMD to over 1.9% at 74% DMD. This is in contrast with results of work with sheep (Wilkins *et al*, 1971; Demarquilly, 1973) in which the digestibility effect was masked by variation in preservation but is in agreement with the results of an experiment of Wilkins and Tetlow quoted by Wilkins (1974).

It is of interest to note the magnitude of the growth rate of cattle fed silages having DMD of 74%. Expressed either in terms of liveweight or carcase gain this is good production by cattle fed only conserved grass and approaches the production (0.57 - 0.60 kg carcase/day) expected of similar cattle on grazed grass over an entire grazing season. The difference between production from these good silages and the expected production from grass can be explained by difference in feed digestibility.

Similarly high levels of liveweight gain on grass silage only have occasionally been reported (Stewart, 1973; Demarquilly and Dulphy, 1976; McIlmoyle, 1976a) but other reports in terms of beef carcase production are not available.

Silage Preservation

It is generally appreciated that high quality wet herbage is difficult to ensile and is predisposed to clostridial fermentation. It is possible that imperfect preservation may be responsible for the infrequent reports of high production from silage. Table 2 illustrates how the quality of the preservation reduces the production potential of a high quality silage. In this experiment, the well preserved silage was treated with 2.3 1 85% formic acid per tonne grass at time of ensiling.

Table 2

Effect of bad preservation on the nutritive value of a high digestibility silage

	Preservation	
	Good	Bad
pH	4.2	4.8
D.M. digestibility %	73.5	70.7
D.M. intake % l.wt.	1.9	1.4
Liveweight gain g/day	895	472
Carcase gain g/day	508	344

Table 3 is a summary of the results of 14 experiments at this station (Flynn and Wilson, 1977) comparing untreated silage with silage made with the addition of 2.3 l of 85% formic acid per tonne of grass. The value of formic acid treatment in ensuring good preservation with low ammonia content in the silage is demonstrated and the improved preservation is reflected in animal production.

Table 3

Average results for 14 experiments comparing untreated and formic acid treated unwilted silages for young cattle

	Dry matter	pH	NH_3-N / Total N%	% in D.M. Lactic acid	% in D.M. Butyric acid	DMD %[1]	Livewt. gain kg/day
Untreated	17.7	4.52	25.4	3.1	1.7	61.1	0.31
Formic acid	19.5	3.86	8.9	6.6	0.2	64.4	0.42

[1] In vitro DMD results for only 5 experiments

Various reports (Forbes and Jackson, 1971; McIlmoyle, 1976b; Alder, McLeod and Gibbs, 1969; Dulphy and Demarquilly, 1977) indicate that the effect of imperfect preservation on silage nutritive value is reduced when supplementary energy is offered with the silage. The effect is not completely eliminated, however. Furthermore, imperfect preservation results in reduced efficiency of conservation of stored dry matter (Kaufmann and Zimmer, 1969; Waldo *et al*, 1971) and in reduced digestibility of dry matter fed out of storage (Waldo *et al*, 1971; Castle and Watson, 1970a). Thus for several reasons, the necessity for perfect preservation in the silo is demonstrated.

In farm practice, silage preservation can be influenced by grass species, content of fermentable carbohydrate and by ensilage techniques. Jones (1970) found that ryegrass (*Lolium perenne*) was easier to ensilage than cocksfoot (*Dactylis glomerata*) or timothy (*Phleum pratense*). We have confirmed this in many laboratory experiments.

The water soluble carbohydrate (WSC) content of the grass at time of ensiling is a major determinant of the course of silage fermentation in the absence of effective additive treatment. While fermentable carbohydrate levels as low as 6 to 8% of the dry matter have been suggested as adequate (Smith, 1962), it appears from a survey of 800 silages, mainly abstracted from published results, that a WSC content equivalent to 3% in the solution ensiled is required to give a 95% chance of the silage being well preserved without additive treatments (Wilson and Flynn, unpublished data). This 3% WSC solution corresponds to an average 14% WSC in the dry matter of samples in this survey.

Delayed sealing has a detrimental effect on silage preservation (Henderson and McDonald, 1975) and has a considerable modifying influence on the minimum WSC content required to ensure good preservation (Wilson, unpublished results).

The absence of a quick test which may be applied in the field to reliably estimate the WSC content of the herbage being ensiled means that farmers must adopt a policy of using formic acid or other effective additive on all high quality herbage ensiled without wilting.

Another problem often associated with wet silages is low nitrogen retention. While most studies as reviewed by Wilkins (1974) record low nitrogen retention on wet silages, it is of interest to note that Waldo *et al* (1969) and Waldo *et al* (1971) and Waldo *et al* (1973) found acceptably good nitrogen retention on wet silage in which ammonia nitrogen was less than 10% of total nitrogen in contrast with low nitrogen retention on poorly conserved silage with 14% of total N as ammonia. Low nitrogen retention may well be a specific characteristic of poorly preserved silage rather than a characteristic of wet silages in general.

Silage preservation is commonly accepted as being good if less than 14% of the nitrogen is present as ammonia. It appears from the results of nitrogen retention studies and animal production studies that a silage described as being well preserved should have less than 10% of its nitrogen present as ammonia.

Silage dry matter content

Raising the dry matter content of herbage before ensiling has for long been recognised as a means of ensuring good preservation in the silo and is very often regarded as essential in order to produce silage with a high nutritive value. Reports of experiments comparing forages of different dry matter content usually attribute any differences found to the difference in dry matter content even though in many instances the preservation of the wetter forage might have been quite imperfect by any standard. That is to say that differences have been attributed to dry matter content which could logically have been attributed to preservation.

Table 4 is a summary of reports comparing forages differing in dry matter content.

Table 4

Relationship between response to raising the dry matter content of silage and the quality of the preservation in the unwilted wet silage

Unwilted preservation					% response to wilting	
Class	D.M. %	pH	NH_3-N / Total N%*	Wilted % d.m.	D.M. intake	Production
Poor[1]	19.5	4.7	16.0	34.7	23.5	22.3
Good[2]	25.2	4.1	7.3	38.8	11.9	– 1.84

[1] References 1, 9, 26.
[2] References 4, 9, 14, 27, 32, 43, 48, 57.
* Not available for all silages.

They have been arbitarily segregated into 2 groups depending on whether the direct cut unwilted silage was poorly preserved or well preserved as indicated by ammonia (% total N) and/or pH. The response to wilting in terms of dry matter intake and animal production is given as the difference between unwilted and wilted expressed as a percent of the unwilted. This allows the results of experiments with dairy cows and with growing cattle to be summarised in one table. As expected, there is a considerable response to wilting in both dry matter intake and animal production when wilted silage is compared with poorly preserved unwilted silage. It is of considerable interest to note that despite an apparent increase in dry matter intake due to wilting, a production response is not normally recorded when wilted silage is compared with well preserved unwilted silage. Efficiency of conversion of forage dry matter to product appears to be reduced by wilting when wilted silage is compared with well preserved unwilted silage. The mean reduction in experiments reviewed in Table 4 was 10.8%. This aspect of forage dry matter content has been ignored in most reports though it has been noted and discussed by some (Waldo *et al*, 1969; Presthegge, 1959). It indicates that more highly fermented and/or wetter silage might be utilised more efficiently than the less fermented drier forage.

There have been several comparisons of unwilted and wilted silage for beef cattle at our Institute. The results of 3 experiments are summarized in Table 5.

Table 5

Comparison of unwilted and wilted silage for beef cattle (mean of 3 experiments)

	Unwilted	Wilted
Dry matter intake kg/day	7.96	8.48
Daily liveweight gain kg	0.78	0.78
Daily carcase gain kg	0.45	0.43

In general, dry matter intake has been higher for the wilted silage. This difference has not, however, been reflected in carcase gain. In another experiment (Flynn, 1974), wilting increased liveweight gain but did not raise carcase weight. The discrepancy between liveweight gain and carcase gain in comparisons of forages of different dry matter content has been noted before and has been shown to be attributable to differences in rumen contents (McCarrick, 1967). Again there is the suggestion that the wilted dry matter is utilised less efficiently than the unwilted dry matter.

Since Ekern and Reid (1963) showed more efficient utilisation of the dry matter in a highly fermented forage there have been basic studies reviewed by Wilkins (1974) and Waldo (1977) indicating similar efficiency of utilisation of energy in wet and dry forages. These results are in conflict with the apparently better utilisation of wet silage in feeding trials but this may arise out of the fact that silage dry matter intake is often a biased estimate of energy intake (Waldo, 1977). It must, however, be of some relevence to note that in a comparison of hay and silage the carcases of silage fed cattle were at least as heavy as, and contained more fat than, carcases of hay fed cattle (McCarrick, 1967). There is a clear implication in these results that the silage energy is utilised more efficiently than the energy in the dry forage. This aspect of forage conservation has to date received too little research attention.

The results of a recent experiment (Flynn, 1976) comparing the feeding value of wilted silage (50% dry matter) and hay for beef heifers are summarised in Table 6. Carcase production on the two feeds were similar but again there was a difference in carcase fat content in favour of the wetter, fermented forage. These results require an explanation.

Table 6

Effect of conservation system on beef carcase fats

	Wilted silage	Hay
Carcase wt. kg	193.3	191.6
Kidney + channel fat kg	6.4	5.0
Fat trim in carcase kg	24.7	21.0

Whether the explanation might be found in the proportions of volatile fatty acids (VFA's) in the rumen is not clear. While the volume of literature on rumen VFA's and their nutritional significance is large, very little of it deals specifically with the effect of conservation system on rumen VFA pattern. What evidence there is in this area is conflicting. While some reports indicate lower acetic/higher propionic concentration on wetter and more highly fermented forages than on drier forages (Ekern and Reid, 1963; Hawkins *et al*, 1970; Rohr et al, 1974; Schaadt and Johnson, 1969; Dash *et al*, 1974) others have found the opposite (Zelter, 1969; Donaldson and Edwards, 1976). In the experiment referred to in Table 6 the rumen VFA's were determined on samples of rumen liquor taken soon after slaughter (Wilson and Flynn, 1976). Acetic/propionic ratio was 3.5 for the wilted silage compared with 4.0 for the hay. While the difference is small it is in the direction which is regarded as favouring more efficient production by meat animals (Ekern and Reid, 1963; Weiss *et al*, 1967) and is similar in magnitude to a difference between grass and silage reported by Donaldson and Edwards (1976) as being large enough to be of nutritional significance.

Effect of ensiling

While it is accepted that efficient ensiling has little adverse effect on herbage digestibility (Harris and Raymond, 1963; Demarquilly, 1973) it is generally accepted that ensiling reduces the nutritive value of herbage through reduction of voluntary intake. Reduced intake of silage relative to the grass from which the silage was made has been demonstrated (Demarquilly and Jarrige, 1970; Donaldson and Edwards, 1976; Lancaster, 1975; Bryant and Lancaster, 1970; Harris and Raymond, 1963) but others working with corn silage containing very low levels of ammonia have found little difference between fresh and ensiled material (Bergen *et al*, 1974; Dinius *et al*, 1968; Wilkinson *et al*, 1976). Donaldson and Edwards (1976) using sheep found that wilting the grass and ensiling it with formic acid raised silage intake to the level achieved on the grass. Most of the experiments quoted here were conducted with sheep. In general the intakes of silages by caged sheep tend to be rather low and one must question whether the results of many silage experiments conducted with sheep are really relevant to cattle.

Flynn (1976) using 350 kg cattle found little reduction in intake of grass silage made with formic acid relative to intake of fresh grass.

Results of B. Michalet (quoted by Demarquilly and Dulphy, 1976) showed reduced dry matter intake of fine chopped herbage by sheep due to ensiling but no reduction in intake by heifers. Flynn (1977) compared fresh grass and silage made with formic acid in a 106 day experiment using 430 kg steers. All silages were well preserved. Animal production results are summarised in Table 7.

Table 7

Dry matter intake and production by steers fed unwilted or wilted grass and silage

	Unwilted		Wilted	
	Grass	Silage	Grass	Silage
Daily dry matter intake g/kg 0.75	92.6	87.1	89.4	87.2
Daily liveweight gain kg	0.80	0.66	0.79	0.56
Daily carcase gain kg	0.42	0.43	0.43	0.36

While daily liveweight gains differed between the feeds dry matter intake and daily carcase gain were very similar. Incidentally, these results show once again how misleading it can be to assess treatment effect on beef production in terms of liveweight change only. The experiment was conducted to quantify the silage intake problem and its effect on beef production. This result, when viewed along with the high levels of production achieved with the highly digestible silages in Table 1, questions the existence of the problem for beef cattle fed on well preserved silage.

It is becoming apparent that an ensiling fermentation in which ammonia production is restricted will not reduce the nutritive value of herbage and will not present a feed intake problem of practical importance for beef cattle.

Fine chopping

Several reports have appeared recently showing an effect of fine chopping and comminution on intake of silage by sheep and cattle. Dulphy and Demarquilly (1973) and Demarquilly and Dulphy (1976) using sheep found a variable intake response to fine chopping. Where responses were large, the effect of chopping was confounded with a silage preservation effect and the increase tended to be due more to very low intake on long silage than to elevated intake on the finely chopped silage (Dulphy *et al,* 1975). Likewise, Deswysen (1978) found an increase in intake by sheep due to fine chopping of silage just before feeding. Demarquilly and Dulphy (1976) quote results of B. Michalet which show a considerable response to fine chopping by heifers. These results also show that differences observed with sheep may be much greater than differences observed with cattle on the same feeds and illustrate again the danger of applying the results of sheep experiments to cattle. Demarquilly and Dulphy (1975) showed a response in terms of intake and milk production by cows to fine chopping but the efficiency with which feed was converted to milk did not seem to be improved. Retter (1978) increased intake of cows progressively by chopping to 17 mm or 9 mm compared with 72 mm long silage. Chopping stemmy forage through a harvesting machine set to a theoretical chop length of 17 mm did not increase dry matter intake of steers whereas chopping of 6 mm theoretical chop length increased dry matter intake by 15% (Flynn, 1977). Mincing or pulping forage has been shown to increase intake (Thomas *et al,* 1976; Greenhalgh and Reid, 1975) and production by cattle (Houseman *et al,* 1975).

It appears that this area of silage research is worthy of more investigation but care must be taken to separate the effects of chopping and preservation. Perhaps we should expect that the effect of fine chopping of silage should be analogous to the effect of processing dry forage as summarised by Beardsley (1964). We should look on fine chopping of silage as a means to increase its nutritive value relative to that of the parent herbage rather than as a process necessary to maintain in silage the nutritive value of the parent herbage.

Summary

High levels of production by beef catle are achievable on grass silage if digestibility is high and preservation is very good. While silage dry matter content can influence preservation and through preservation, influence intake and animal production, low dry matter content *per se* is not a major constraint to the productivity of wet silage. Utilisation of the dry matter in drier and less fermented forages often appears lower than that in wetter and more highly fermented silages. Our rather limited knowledge of the influence of conservation system on rumen fermentation could be a constraint in this area. The specific effect of ensiling by the best available techniques on the energy intake and nutritive value of a forage needs to be firmly established. Failure in the past to define the magnitude of silage intake problem for cattle has possibly been a constraint to clear thinking in the whole area of forage conservation. We should not see degree of chopping as a constraint to the achievement of high production from silage but rather as a process to increase the nutritive value of feed above that of the fresh parent herbage. In these last two areas there is need for more work with cattle and cows as there is a danger that results obtained with sheep may apply only to sheep.

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The Interaction of Harvesting Machinery and Silage Quality

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The importance of high quality silage in beef or dairy production cannot be over-emphasised. This is especially true when we consider the high costs of alternative feeds. There is an increasing awareness throughout the country of this need but for one reason or another many farmers are finding it difficult to attain their targets. There are many factors associated with producing a high quality silage but the one which predominates is the stage of cutting. Grass which has been fertilized and closed up from early spring must be cut before June 1 if the high quality obtainable from such forage is to be preserved. Since over 60% of all silage made in the country is harvested by contractors many quality-conscious farmers will be relying on these contractors to complete work on time. As more farmers change to early cutting it is inevitable that a peak demand period will occur in the early stages of the season. Contractors will therefore not be able to cope with all the work on hands. Already the problem is acute in some areas and farmers must wait up to three weeks for a contractor. How can this problem be avoided ? A number of solutions are possible.

1. By selecting grass strains which reach maximum digestibility at a later stage than usual or strains which retain their peak digestibility for a longer period. Such grasses are available and it has been shown that their quality will not deteriorate to any extent until the latter part of June. Their use should give the farmer more scope to obtain a contractor while herbage quality is still high.
2. By adopting a multi-cut system the quantities of grass for harvesting in the early cut will be reduced and the work-load will be spread more evenly over the summer months. This would suit the contractors since mid-summer work is usually slack. The current method usually applied by contractors of charging by the acre militates strongly against the multi-cut system and an hourly or all-in charge is a more satisfactory method. In addition, the full impact of the multi-cut system can only be felt if a high proportion of farmers opt for the method. It would seem that this solution will be slow in alleviating a problem which is already acute.
3. Increase contractor capacity. This is a solution which has only very limited application since contractors would be unwise to invest heavily in equipment which would only be used for a short period. Should a contractor increase his harvesting capacity to cater for the early rush he may be forced to charge more than normal for this service to compensate for the short working season.

4. The one sure way of overcoming the early harvesting problem is for all those farmers who cannot get their work completed on time by contract to purchase their own equipment. While this is not possible in every instance there are many farmers and groups of farmers who should have their own equipment. They would benefit considerably. In making the choice as to whether or not one should have his own equipment the following points should be considered :

(a) The ability to own and operate machinery : many farmers have neither the ability nor the inclination to own and operate their own silage-making equipment. Such people are best advised to seek one of the other alternatives or to offer inducements to contractors to commence harvesting on a pre-arranged date.

(b) Can the silage making routine be fitted into the existing farming routine? This question must be carefully considered. If other equally important work must be delayed or omitted, the advantages can be eroded. If silage-making coincides with other important work the speed of operation is reduced below acceptable levels. It has been suggested that the minimum target should be 60 tonnes of silage harvested per day. If harvesting does not commence until mid-morning and must finish early, it may be difficult to achieve this target with the machines available. In any event slow harvesting makes it impossible to ensile all the crop when the quality is highest.

(c) Is ownership of silage machinery economically feasible ? In costing an operation such as this it is usual to consider what equipment already exists and to assume that it will be available at operating costs plus repairs only. Equipment specially purchased for the work must of course be fully costed to the operation. The total cost of the work is divided by the acreage harvested and a cost per acre calculated. The cost thus obtained can be compared with alternative methods and if all things are equal the cheapest harvesting method can be employed. For most small harvesting systems the break-down point with normal contractor charges is between 50 and 120 acres. This does not take into consideration the extra cash benefits accruing from a better quality silage as a result of early harvesting. A recent study reported in Great Britain[1] suggests that when this is added, the break-even points can be halved.

Further consideration will be given to operating costs and break-even points in the following paragraphs.

Forage harvesting systems for private ownership

There are many harvesting systems suitable for farmer ownership and the five most popular ones are presented in Table 1. It shows that the side mounted single chop with a cutting width of 50 inches can harvest between ½ and 1 acre per hour and can break-even with a contractor at 50 acres harvesting per year. At the other end of the scale the trailed precision chop has a much higher output but would need to harvest over 125 acres per year to justify itself. If, of course, an alternative harvesting

Table 1

Outputs, power requirements and break-even points for five forage harvesting systems suitable for private ownership.

System	Output ac/hr	Power required Hp	Break-even point ac/yr
Side-mounted single-chop	$\frac{1}{2}$ - 1	50 - 60	50
Side-mounted precision-chop	1 - $1\frac{1}{4}$	60 - 70	70
Double-chop	1 - $1\frac{1}{4}$	60 - 70	80 - 90
Precision-chop	$1\frac{1}{4}$ - $1\frac{3}{4}$	70+	125+
Pick-up wagon	$\frac{3}{4}$ - $1\frac{1}{4}$	40 - 50	80 - 100

method is not available, the break-even point is meaningless but a claim can be made for investing at a much lower acreage on the basis of an improved quality silage.

Table 2 attempts to summarise the main attributes of the different harvesting systems using a scoring system of 0 - 5 for the various headings. By combining the information contained in Tables 1 and 2 it should be possible to identify the system most suitable for many cases.

Table 2

Ratings for five forage harvesting systems suitable for private ownership (maximum and minimum scores 1 and 5 respectively)

	Manoeuv-rability	Speed	Chop and laceration	Wilt	Power	Sim-plicity	Price
Side mounted single-chop	5	2	3	2	4	5	5
Side mounted precision-chop	5	4	5	5	3	4	3
Trailed double-chop	2	3	4	2	3	4	4
Trailed precision-chop	2	5	5	5	2	3	2
Pick-up wagon	5	3	2	5	5	5	2

The pick-up wagon

The pick-up wagon forage harvesting system is comparatively new and merits some additional consideration. The system consists of a pick-up wagon, three tractors, a mower and a buckrake. Frequently the third tractor is omitted and the same tractor operates the mower and buckrake. Most pick-up wagons have the ability to take a grass swath off the ground at a rate exceeding two acres per hour. However, since the wagon must also transport its load to the silo it is off the field for some of the time and the overall harvesting rate is much slower than the picking up rate (Table 1). This is one of the basic drawbacks of the system. Farms on which the distance between the silo and the field exceeds 800-1000 yards are not suitable to the wagon system unless the machine is large or the access roads exceedingly good.

The power required by the wagon is less than 50 hp but it is recommended that at least a 60 hp tractor be used with the larger machines to tow full wagons up steep inclines and as an insurance against instability when transporting. Because of their low power requirement wagon systems need about 30% less fuel than a flail forage harvesting system with the same output. Since crops have to be pre-cut for the wagon the system lends itself to wilting.

Because of the high cost of the wagon and rotary mower the system has a high initial outlay but the running costs are low because of the small amount of men and machines involved. Table 3 gives a summary of operating costs for 50 to 100 hours annual use for a 5 and 7 year life span.

Table 3

Operating costs (£/acre) for a pick-up wagon forage harvesting system

Annual use acres/year	Life of machine 5 years	7 years
50	42.40	36.10
70	30.30	25.80
80	26.50	22.60
90	23.50	20.00
100	21.20	18.10

In using a pick-up wagon for the first time a number of points require special attention to ensure that the silage is properly made. Since the wagon only chops the grass coarsely (some machines have extra knives which can chop to a theoretical length of 1½") and does no laceration, the forage can be very spongy especially when wilted. In order that overheating does not occur the forage should be well rolled during ensiling. When the pits are full they should be covered immediately with two layers of 500g polythene and the edges thoroughly sealed.

Group ownership

Most of the systems already described are economically justifiable when the acreage harvested is in excess of 70 acres. There is however no reason why two farmers with half the acreage should not combine to purchase and operate the equipment between them and reap the same benefits. The concept of partnership or group ownershirp is not new although very few groups have been organised according to any recognized set of rules. Loose partnerships or instances where a machine is purchased between groups of farmers and passed from one to the other have a very slender chance of surviving unless the partners have very clear understandings. It has been shown both in this country and in England that where the partnership is established according to well recognised procedure with clearly defined rules to cater for every eventuality, the arrangements work very satisfactorily. Some properly-run groups are in existence for many years and have continued to expand their joint commitments.

Apart from the advantages of private ownership already mentioned, small farmers in partnership also have the advantage of a pooled labour force on the few occasions of the year when thy need them. If the ingrained opposition exhibited to the concept of group ownership could be overcome there is no reason why this pooling of resources could not contribute substantially to farming progress in the future. Indeed, smaller farmers may have very little alternative in the future if they are to continue to compete successfully with their larger neighbours.

Wilting

Much of the grass harvested in this country as wilted silage does not qualify for such a description. In most cases grass which is cut one day and picked up the following day without any intermediate treatment will not have wilted sufficiently especially if the crop is young and heavy. Crops cut in May are particularly difficult to wilt because dews are usually heavy and drying is slow. Wilting in inclement weather requires a particularly dedicated approach. In many European countries where a wilt to 40-45% is normal the early cut crops are frequently on the ground for 3-4 days and receive about 4 teddings or other treatments. Under Irish conditions where a wilt to 25-30% would be more common the early cut crop would have to be on the ground for two days and receive two teddings. At least one of these teddings could be eliminated by the use of a mower/conditioner. This is a mower with a special attachment which bruises or lacerates the crop during cutting and deposits it in a fluffy loose stage on the ground. Such swaths dry faster than untreated ones. Flail mowers also can be used and subsequent drying is very fast provided weather conditions are suitable. Using a flail mower in wet conditions can result in higher than average dry matter losses.

Feeding silage

The practice of cutting the silage from the clamp and trough feeding it to the animals is becoming increasingly popular. A number of systems are available for removing the silage and their selection depends on the feeding lay-out and the number of animals to be fed. Figure 1 shows how the common systems compare on costs and output for various numbers of animals. While these figures would indicate that the front loader, especially with an hydraulic tipping and grab attachment is the most economical and fastest system for units up to 400 animals it is not suit-

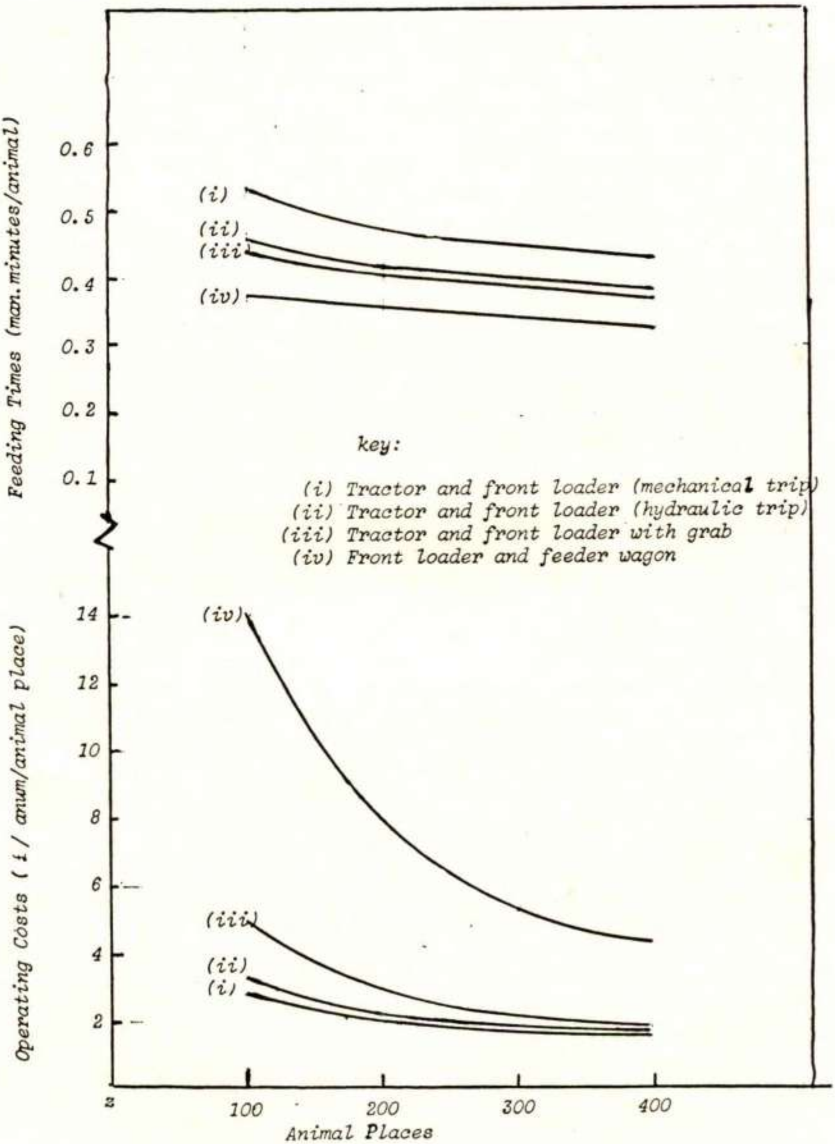

Fig. 1—Effect of animal numbers on operating costs and feeding times on four feeding systems.

able where the silo is a distance from the animals. This is particularly true for larger units where the feeder box is much more suitable.

Although the block cutter system was not covered in the above study later measurements indicate that it has an average feeding rate of about 0.5 minutes per animal for transport distances of up to 50 metres. The main advantage of the block feeder is the almost total absence of waste at the silo. In fact over a week's supply of blocks can be removed at the same time without any deterioration of the exposed silage surface. Some buildings, however, do not suit block feeders and even in the best lay-outs some hand forking is almost inevitable. This however should not deter the owners of houses with wide centre passages or peripheral feeding from stacking the blocks just outside the reach of the animals and giving them their daily ration by hand, off the top of the blocks.

Other systems using more elaborate silage cutting, transportation and feeding arrangements are also available. These have not become popular mainly because of their price and a high degree of specialization.

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Is there a Place for Irrigation on Dairy Farms?

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The drought years 1975 and 1976 have raised the question of whether or not there is a place for irrigation in Ireland. Even without the extreme drought of those two years, given time, the question would have arisen as our systems of land-use became more and more intensive.

There is no doubt that in every year all parts of this country suffer from drought—we have drought in summer whenever we have more than ten consecutive days without rain. This paper gives our best estimates of the yield losses in grassland caused by these droughts and indicates how the value of these losses relates to the cost of irrigation.

The response to water was measured at two sites in Co. Wexford—one site was on a coarse sandy-textured brown podzol (light Screen soil), the other on a loam-textured podzolic gley (heavy Rathangan soil)—in 1973, 1974 and 1975 (Table 1). Summer rainfall was 509, 465 and 295 mm (Apr-Sep inc) in 1973, 1974 and 1975 respectively, so that results were obtained in both wet and dry years. At each site in each year a total of 260 N kg/ha/annum was used in three applications (110, 70 and 60 N kg/ha in March and after each cut. Also 40 P kg/ha and 50 K kg/ha were applied in March, and 50 K kg/ha after the first cut. In 1974 and 1975 the nitrogen rate was increased to 400 N kg/ha to ensure that any losses by leaching would not affect yields (this was a safety precaution for experimental purposes only). Water was applied to the plots twice each week at a rate which varied with rainfall but which ensured that irrigation and rain equalled 3.3 mm/day since the last application. The greatest response was obtained in the driest year (1975), the least response in the wettest year (1973) (Table 2).

Table 1

Herbage dry matter response to irrigation (tonnes/ha in three cuts)

	Screen		Rathangan	
	−water	+water	−water	+water
1973	13.32	14.26	(8.15)	(8.23)
1974	13.32	14.10	14.76	16.50
1975	13.93	17.01	10.78	15.43

( ) two late cuts only

Table 2

Annual dry matter response to irrigation (t/ha) : August for two sites

1973	0.55
1974	1.33
1975	3.99

These results only indicate that grass yield in Wexford is normally restricted by water storage and that restrictions can be as great as 4 tonnes/ha/annum. In order to obtain a more general picture for the whole country over a long period of years, predictions of yield restrictions using meteorological records were estimated.

The meteorological records for Johnstown Castle for years 1973, 1974 and 1975 were used to calculate the expected loss of yield due to drought in those years, and these calculated values were compared with the losses found by experimentation in those years. This comparison was made in order to check that the method of prediction was reliable. Calculated annual yield losses are shown in Table 3.

Table 3

Calculated dry matter yield losses due to drought (tonnes/ha)

1973	1.03
1974	1.76
1975	5.85

The predictions were well correlated with the measured responses but the predictions tended to overestimate the response. On the basis of this trend all subsequent predictions were corrected accordingly.

From the meteorological records for selected sites potential annual yield and average yield loss due to water shortage were estimated (Table 4).

The results indicate that the yield loss due to drought is about 1 tonne/ha inland for the country as a whole with responses tending to increase towards the south east. Coastal areas generally show a higher response especially on the south and east coasts.

In a Dutch survey of European irrigation, this country is shown to have an average annual maximum water deficit less than 25 mm in the west and between 25 and 50 mm in the east (Table 5).

Table 4

Potential dry matter yield and average yield loss due to drought (tonnes/ha) and number of years in 10 when yield loss exceeds 1.1 tonnes/ha (averages of 20 years to 1975)

Site	Pot yield	Average loss			Frequency of response >1.1 tonnes
		Season	Apr. June	Jul. Sept.	
Malin Head	15.4	1.1	0.3	0.8	5.0
Belmullet	15.3	1.1	0.3	0.8	4.5
Valentia	15.0	0.8	0.1	0.7	2.8
Claremorris	13.0	0.6	0.2	0.4	1.6
Shannon Airport	15.7	1.8	0.4	1.4	7.2
Mullingar	14.1	1.1	0.2	0.9	4.0
Cork Airport	15.1	1.1	0.2	0.9	6.7
Roches Point	16.3	2.6	0.6	2.0	8.5
Clones	13.5	0.9	0.3	0.6	4.0
Birr	14.0	1.1	0.1	1.0	5.0
Kilkenny	14.1	1.5	0.1	1.4	5.0
Dublin Airport	16.0	2.6	0.6	2.0	9.6
Rosslare	16.7	2.6	0.6	2.0	9.0

Table 5

The distribution of irrigation need in Ireland and yield response equivalents of various deficits

	West	East	South-East coast
Average annual max H_2O deficit	25mm	25-50mm	25-50mm
Frequency of deficit greater than 50 mm	1-3	3-5	5-7
Frequency of deficit greater than 100 mm	1	1-3	1-3
	Deficit	Response	
	25 mm	0.75 tonnes/ha	
	50 mm	1.50	
	100 mm	3.0	

Thus, an average annual response to water of about 1.5 tonnes in the south east, and less than 1.0 tonnes in the west is expected, and in the east this average is exceeded in more than five years of each 10 years.

There was no consistent difference in response between the light and heavy soils. Differences in root distribution could account for this. Table 6 shows that if the main body of roots at Rathangan were in the top 10 cm of the profile, then starting at field capacity, 30.2 mm of water would be available. This is equivalent to about 10 days' water loss by evapotranspiration in summer. At Screen, the same amount of water would be available if the main body of roots were in the top 15 cm of the profile (i.e. the roots at Screen would need to be only two inches deeper). It would appear from these data that soil type may be less important than rainfall in determining irrigation need for normal soils. In shallow soils, available water may be restricted by soil depth.

Table 6

Available water in profile

Depth	Screen	Rathangan
0-10 cm	19.2 mm	30.2 mm
0-15.6 cm	30.0 mm	
0-30 cm	57.7 mm	90.7 mm
0-46.8 cm	90.0 mm	
0-100 cm	192.2 mm	302.5 mm

Irrigation systems

Agricultural irrigation systems are generally mobile so that only part of the area is irrigated on each day. Commonly, the interval between irrigation in each part of the area is 10 days. Evaporation in summer is about 2-3 mm per day so that after a 10-day period without rain it is necessary to apply about 25 mm of water. Irrigation systems are designed to deliver this rate in a day's working. On heavier soils the infiltration rate of water is about 5 mm/hr; on light soils it is about 20 mm/hr, thus, even on heavy soils it is possible to apply 40 mm in an 8-hour day without flooding. A 10-day irrigation cycle is used because in this part of the world, with evaporation rates of about 2.5 mm/day, the deficit after 10 days is about 25 mm (one inch). It is generally agreed that, with a deficit between zero and 30 mm, plant growth is little affected. But above this deficit growth begins to be seriously affected. At 120 mm growth ceases.

The conventional rotary sprinkler on lateral pipes, moved by hand along a fixed main supply line, is relatively cheap, but has a high labour requirement. It is more appropriate for small horticultural systems.

The modern mobile irrigation systems are designed for larger acreages with reduced labour inputs. They require larger pumps and make greater demands on water supply; they also cost more. The systems vary widely in design and cost (Table 7).

Table 7

The irrigating capacity and water demands of some irrigation systems

Type		Area/10 days (ha)	H_2O rate m^3/hr	Pressure Psi
Mobile rotary sprinklers	Rainspray	25-32	54	70
	Baars	14-17	27	75
Rotating boom	Laureau	5	40-75	85
Rain guns (self-propelled)	Dolphin	20-80	14-110	95
	Rainamatic	8-36	9-42	97
Rain guns (sledge-mounted)	Perrot	20-110	25-110	130

The capital cost per hectare increases with the size of the system (Fig. 1). The annual cost/ha for running and maintenance decreases as the size of the system increases (Table 8). These costs are based on 1976 data for the United Kingdom. We have assumed that all costs are the same in Ireland except for the charge for abstraction of water from the mains. In Britain this cost is 4.2 p/4.5 m^3 for direct abstraction in summer and 1 p/4.5 m^3 for abstraction in winter for reservoir storage. In Ireland the water charge is 25p for 4.5 m^3. Hence the cost of water is a major item in the annual bill in Ireland.

Table 8

Costs of irrigation (£ sterling) as affected by size of the system and method of water supply

Area (ha)	31	31	35	37	48	51
Capital cost (inc. reservoir)	18200	17800	21700	21300	28200	27700
Annual cost/ha						
Direct abstr. (U.K.)	79	67	77	70	67	53
Reservoir abstr. (U.K.)	148	135	145	138	136	121
Direct abstr. (Ireland)	109	100	110	105	100	78
Private water (Ireland)	74	62	72	65	62	48
			Cost 4.5 m^3 (1000 gallons) water			
Ireland			25p			
U.K. direct abstr.			4p			
U.K. winter abstr.			1p			

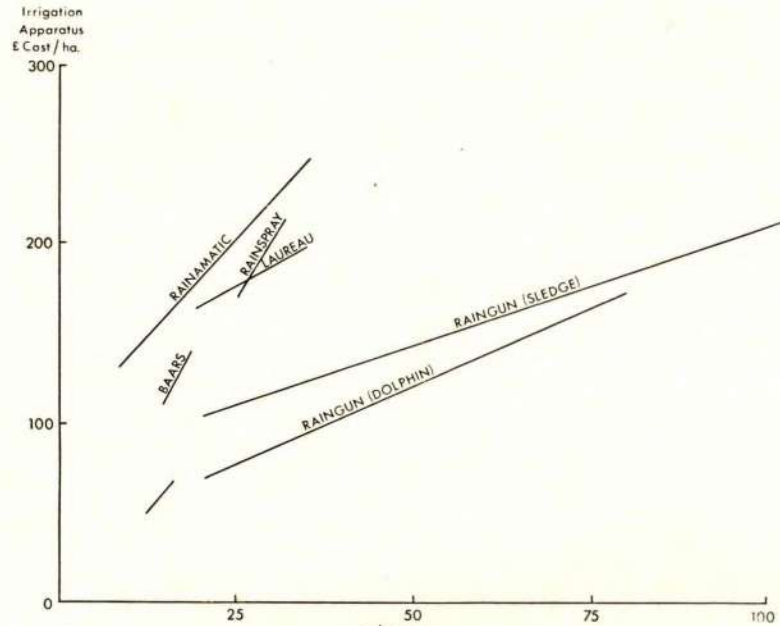

Fig. 1—Relationship between size of irrigation system and capital cost

The volumes of water involved in irrigation are large. In an average season six million gallons would be required. This is equivalent to a stored volume of 1 ha x 2.5 m deep.

If we calculate the value of grass dry matter as its Barley equivalent, then the grass dry matter response required to justify various levels of cost may be summarised as follows:

Irrigation system	Annual cost £/ha	minimum acceptable dm response (t/ha)
Private water supply	48	0.8
	74	1.3
Direct abstraction	78	1.3
at 25 p/4.5 m^3	110	1.9
Reservoir (Private	121	2.1
water supply)	148	2.6

At these cost levels it is clear that irrigation is only likely to be profitable in the south east and then only when a good private water supply is available. In the east and south coastal areas of high response even the most costly system could be justified.

Calf Housing—Design Considerations when Planning Housing for Home Reared and Bought In Calves

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The major objective in the design and planning of calf housing is to provide an environment which will encourage the production of healthy calves.

In this paper a brief outline of calf housing work carried out at the Scottish Farm Buildings Investigation Unit (SFBIU) will be followed by two commercial examples of calf houses designed on the basis of the results of the experimental studies.

General requirements

Calf housing should provide a suitable environment both climatic and structural for the calf and the stockman. It should also provide ample space for husbandry and management tasks and should be planned in detail to achieve these objectives at the lowest possible capital and with a low labour requirement.

Commencing in 1968, at the SFBIU, the feasibility of naturally ventilated uninsulated calf housing, termed climatic housing, was examined for rearing calves from approximately one to twelve weeks of age throughout the year. From the experiments it was established that climatic housing with good calf husbandry and an adequate plane of calf nutrition provides a very acceptable low cost alternative to the previously common fan ventilated insulated and often heated calf housing.

The main advantages of naturally ventilated calf housing are:

1. reduced capital cost;
2. low running costs (no fans, heaters or controls);
3. immunity from failure of electric power;
4. correct design—a reduced management requirement as no adjustments need be made to the ventilation system throughout the year.

Studies were also made on the design of natural ventilation systems. These enabled design data to be produced which will ensure a minimum ventilation rate of 20 cubic feet per minute per calf, with a minimum cubic air capacity of 200 cubic feet per calf in calf houses with different cross sections to the original experimental unit.

The results provided a design basis for naturally ventilated calf housing and buildings were designed and costed against a fan ventilated insulated calf house. The costings showed that naturally ventilated calf housing reduces the capital cost of calf housing when compared with fan ventilated insulated calf houses.

Overall, naturally ventilated calf housing was established as suitable for calf rearing and acceptable both environmentally and economically as an alternative to the fan ventilated insulated type of calf house (Mitchell, 1975).

Throughout the work the calf was considered as the designers client and an understanding of its requirements was put as a primary objective. In the past there had been a tendency for package deal manufacturers and farm buildings designers to use a similar structure for poultry, pigs and calves without first ensuring that it was suitable for calves. Each class of livestock requires different environmental conditions.

With the calf, a designer is basically aiming to provide: (1) a dry bed; (2) a well ventilated calf house; (3) a draught free environment during the winter months.

1. *A dry bed* is provided by attention to floor drainage beneath straw bedding and a minimum floor slope of 1 in 20 is required. The bedding will not move down this slope. The effects of flooring type on calculated critical temperatures for a 50 kg calf in calm air on full feed are given in Table 1.

Table 1

Calculated critical temperatures for a 50 kg calf in calm air on full feed (Bruce 1975)

Relationship to floor	Critical temperature* (°C)
Calf lying on dry straw	−13
Calf lying on wet straw	−10
Calf lying on wooden slats	−10
Calf lying on dry concrete	+2
Calf standing	−10

* It is important to remember that the lower the critical temperature, the better the calf is able to resist cold stress

It is often necessary to have close site supervision during construction to ensure adequate floor slopes and good internal layout of drainage. Water bowls, automatic feeders or feed buckets must be placed at the lower end of the sloped floors to ensure that bedding remains dry.

2. *Well ventilated calf house.* In a naturally ventilated calf house the minimum ventilation rate is calculated on the basis of the stack effect and the maximum rate on the wind effect. Ventilation should be designed to provide specific rates. It is a precise science and not 'a hole, a hole and a hope that it will work'. Design data given at the end of this paper will ensure an adequate minimum ventilation rate per calf. Ventilation should be designed to remove moisture vapour produced, disease organisms, dust and foul air, and replace them with fresh air. Ventilation should also remove by-products such as ammonia, hydrogen sulphide, carbon dioxide and methane.

3. *A draught free environment during the winter months.* Draught free conditions at calf level are achieved by attention to internal details and studies of internal airflow patterns. At the SFBIU we are fortunate in having both a water table and a wind tunnel for ventilation studies.

Model study airflow in two calf houses (Mitchell and Ross 1977)

Model studies were carried out to examine the effect of pen covers together with solid and open pen fronts on the air flow patterns in two naturally ventilated calf houses. One calf house was a model of the SFBIU experimental climatic calf house with two rows of pens and a central passage. Pen covers were first used over the rear of the pens in 1968 and continued in use throughout the work. The other had four rows with two passages and was a typical four-row naturally ventilated calf house. In both buildings air inlets were below eaves level and air outlets were open ridges.

The flow patterns were based on flow in the plane of a cross section from right to left. This flow represented the wind effect component of natural ventilation. The stack effect was ignored together with the effect of heat output from the calves.

Perspex models to a scale of 1 : 20 were used in the SFBIU watertable using an ink tracer and the general flow patterns were traced. There was a slight problem of stability with the flow patterns which meant that the repeatability of the patterns had to be checked to ensure that the dominant pattern was recorded.

For both buildings the various combinations of pen covers and pen type were examined. From the range of combinations used, a selection has been made to illustrate the main points arising.

(1) *Pen covers.* Model tests were carried out for both the two-row and four-row calf house designs with and without pen covers over the rear of the calf pens. Omitting the pen cover results in a downcurrent on the opposite wall to the main air inlet and part of the primary air flow occurs at calf level (Fig. 1).

The presence of pen covers raises the lower limit of the primary air flow thereby effectively reducing the air speed at calf level. Secondary, slower flow occurs beneath the cover at calf level. In the full-scale calf house this secondary flow together with convection above the calves ensures adequate ventilation at calf level.

The pen cover has a similar effect when the air inlets are representing space boarding or when they represent openings between the pen cover and the eaves. The latter situation might be used under summer conditions if the ventilation panels can hinge downwards.

(2) *Solid versus open pen fronts.* Solid pen fronts also reduce air speeds at calf level but do not prevent down currents along the walls (Fig. 2).

(3) *Solid fronts with pen covers.* In model tests where both pen covers and solid fronts are used the pen cover tends to have the dominant effect as far as raising the primary flow and thereby reducing air speed at calf level is concerned (Fig. 3).

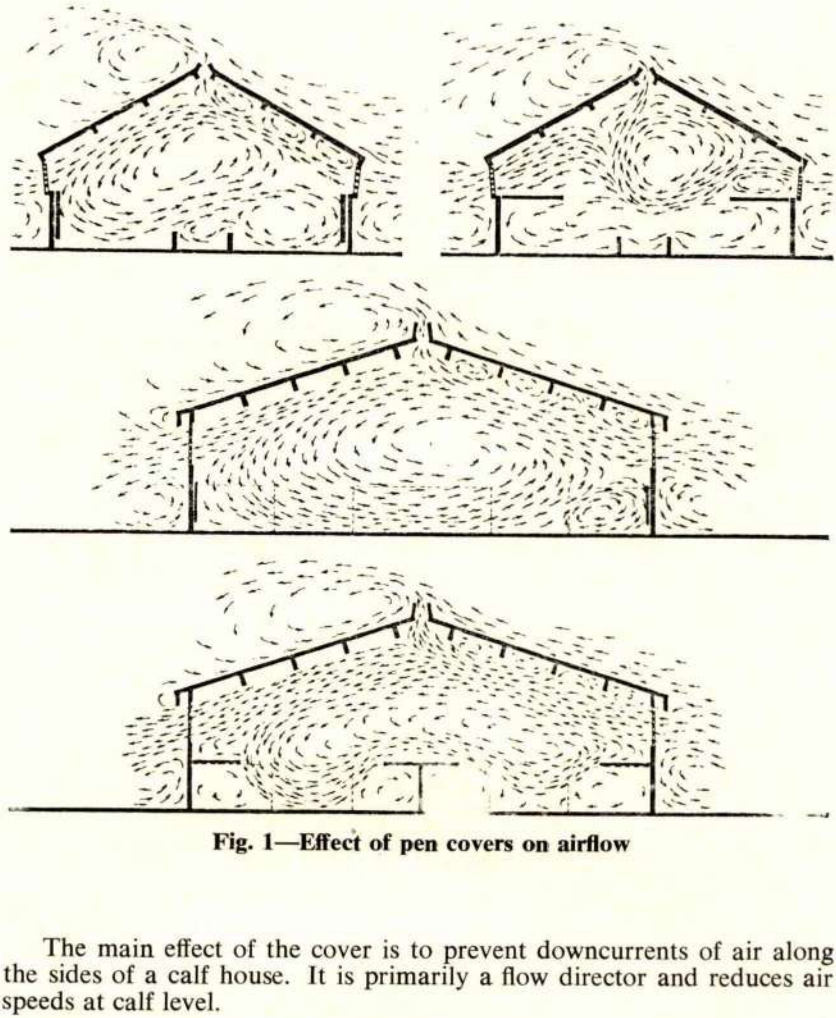

Fig. 1—Effect of pen covers on airflow

The main effect of the cover is to prevent downcurrents of air along the sides of a calf house. It is primarily a flow director and reduces air speeds at calf level.

There is no need to insulate pen covers. Erroneous statements regarding covers have implied heat conservation but the main aim of a cover is airflow direction. There is also no need to cover any more than the rear 800 mm of a pen.

Temperature patterns recorded from thermocouples in the SFBIU climatic calf house show that temperature lift beneath a cover is only slight in a well ventilated calf house (Table 2).

In the SFBIU climatic calf house, air speeds at calf level did not exceed 0.25 m/sec (50 ft/min) below the pen covers but speeds up to 1.25 m/sec (200 ft/min) were recorded above the pen covers.

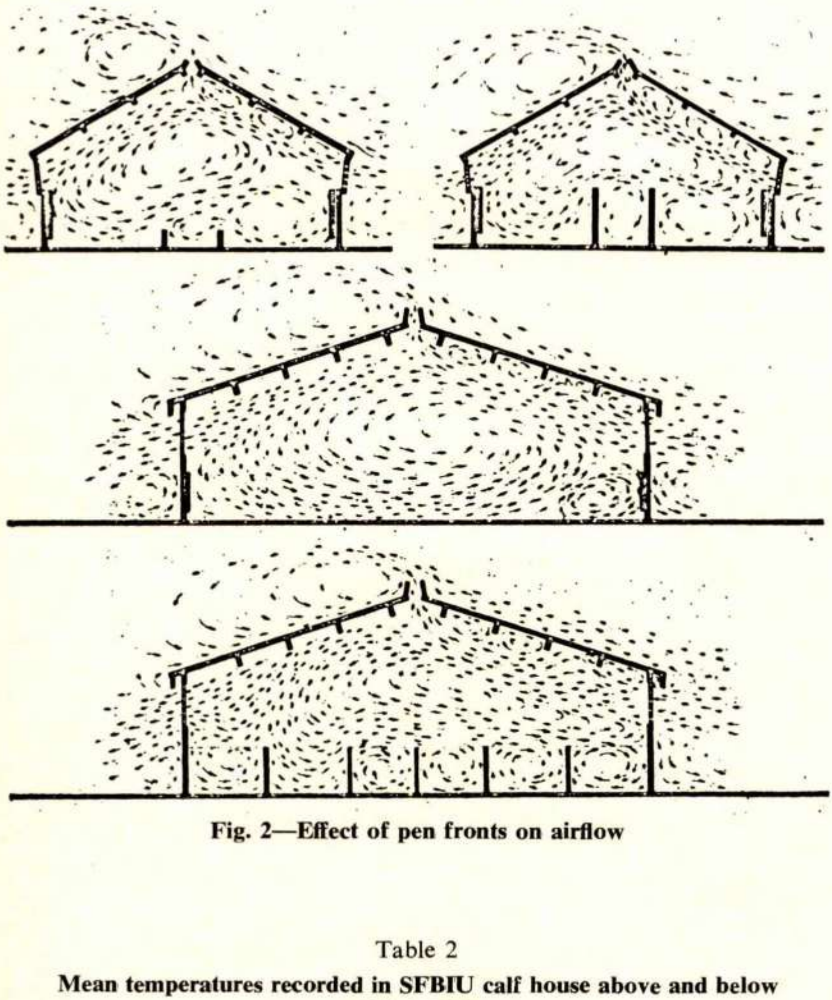

Fig. 2—Effect of pen fronts on airflow

Table 2

Mean temperatures recorded in SFBIU calf house above and below pen covers

Batch	Week	Temperature above pen cover (°C)	Temperature under pen cover (°C)
A	6	9.4	11.4
A	7	5.7	8.1
B	6	17.7	19.3
B	7	14.4	16.2
C	6	8.9	10.3
C	7	9.7	11.4

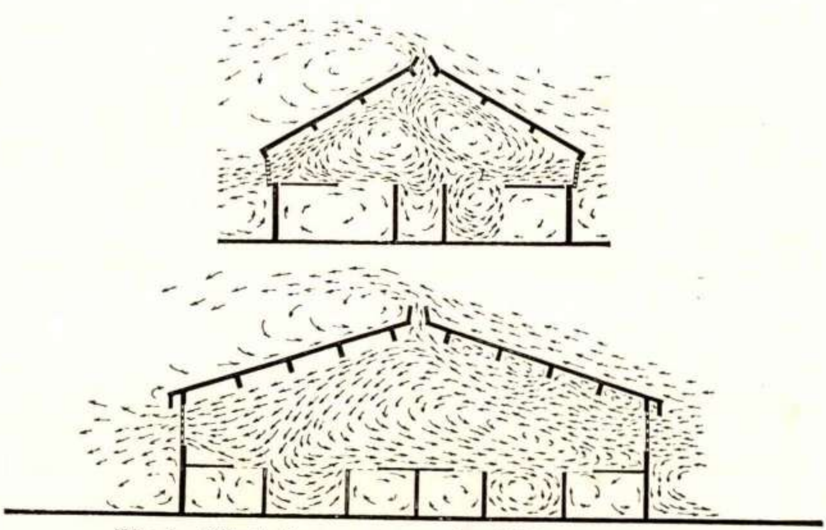

Fig. 3—Effect of pen covers and solid fronts on airflow

Discussion

Both pen covers and solid pen fronts have an effect on the flow pattern in calf houses and therefore an effect on the air speed at calf level. The pen cover has a more marked effect than solid pen fronts. It is also interesting to note the low air speeds recorded at calf level during the winter months in the SFBIU climatic calf house with pen covers, and with railed rather than solid pen fronts.

A completely solid pen front would have a serious disadvantage in practice as feed buckets would have to be inside the pen where they can easily be fouled. However partly solid pen fronts which allowed calves access to buckets outside the pen are possible.

If solid pen fronts and solid pen divisions were used, calves would not be able to see each other which is undesirable. In certain cases it might be useful to incorporate an occasional solid pen division, e.g. to prevent cold draughts in winter along the length of a calf house. The freedom of choice regarding solid and open pen fronts and divisions should be left to the discretion of the designer concerned. Simple model studies could be used to indicate the effect of different internal designs.

Let us now consider two examples of commercial naturally ventilated calf houses. Both were designed some years ago following interest by farmers and are typical of designs produced over the years.

Example A. A large scale naturally ventilated calf house for a farmer batch rearing bought-in calves.

Having had experience of rearing calves in controlled environment housing for many years, Mr. J. McFarlane decided to choose climatic housing for the calf unit at Earnslaw, Leitholm, Berwickshire. It has advantages for calf health and management and is less costly than controlled environment housing. The unit is in three sections: nursery, intermediate and follow-on. The buildings are straightforward but great attention has been paid to detail.

Nursery Building

The nursery is a long narrow building (Fig. 4) measuring 37.000 x 4.870 x 2.450 m to the eaves (121 x 16 x 8 ft) with traditional 0.610 m (2 ft) stone walls. It is divided into three sections by existing stone walls, and it accommodates 84 calves in three lots of 28 each. It used to be a cattle shelter attached to open yards. It was gutted, the openings were built up in salvaged stone to match the existing walls and the old low dilapidated slated roof was removed together with its timbers, and replaced by a new roof of coloured asbestos on timber trusses and purlins. Replacing the entire roof like this allowed the eaves height to be raised to 2.450 m (8 ft) and this in turn allowed 1.000 m (3 ft 3 in) deep slatted boarding to be fitted all round. This, together with the 'shelf' formed by the top of the 0.610 m (2 ft) stone walls, ensures draught-free inlet ventilation, and a 0.150 m (6 in) wide continuous open ridge with upstands takes care of the outlet ventilation. This ridge is fitted with protective wire mesh to keep out birds.

The individual pens are 1.520 x 0.910 m (5 x 3 ft) and the divisions are of the open sparred BOCM type (Fig. 4). There is a solid back to keep the calf off the wall and to prevent the wall being soiled. The pen floors have a relatively steep slope of 0.100 in 1.520 m (4 ins in 5 ft) from back to front. This ensures good drainage and a dry bed. The pens are bedded generously with straw twice a day. This makes for a comfortable lie, and also allows the calves to eat a certain amount of straw. They are fed once a day, in the morning.

The nursery building is based on the results of the experimental work on climatic calf housing carried out at the Scottish Farm Buildings Investigation Unit. The building is naturally ventilated, the roof is uninsulated and no heat is supplied. The idea is that if the calf has ample fresh air, free from draughts, and has a dry bed, it can stand normal winter temperatures without ill effect, and will in fact be a healthier and hardier calf. This has been proved in the unit at Earnslaw. The mortality rate over a period of seven years with 4,200 calves is below 1%.

Pellets are on offer after the first few days and the calves stay in the nursery section until they are eating 2 lb per head per day (usually at age four or five weeks). Then they move as a batch into four pens to the intermediate building.

Intermediate building

This is 41.150 x 12.230 x 2.720 m to eaves (135 x 40 x 9 ft) and is a new building (Fig. 4) erected alongside the nursery building but spaced some 7.000 m (23 ft) away. It is of steel frame construction with 0.230 m (9 in) hollow block walls and slatted boarding all round, including the gables. The roof is of asbestos and there is a 0.230 (9 in) continuous open ridge with upstands, again protected with wire mesh against birds.

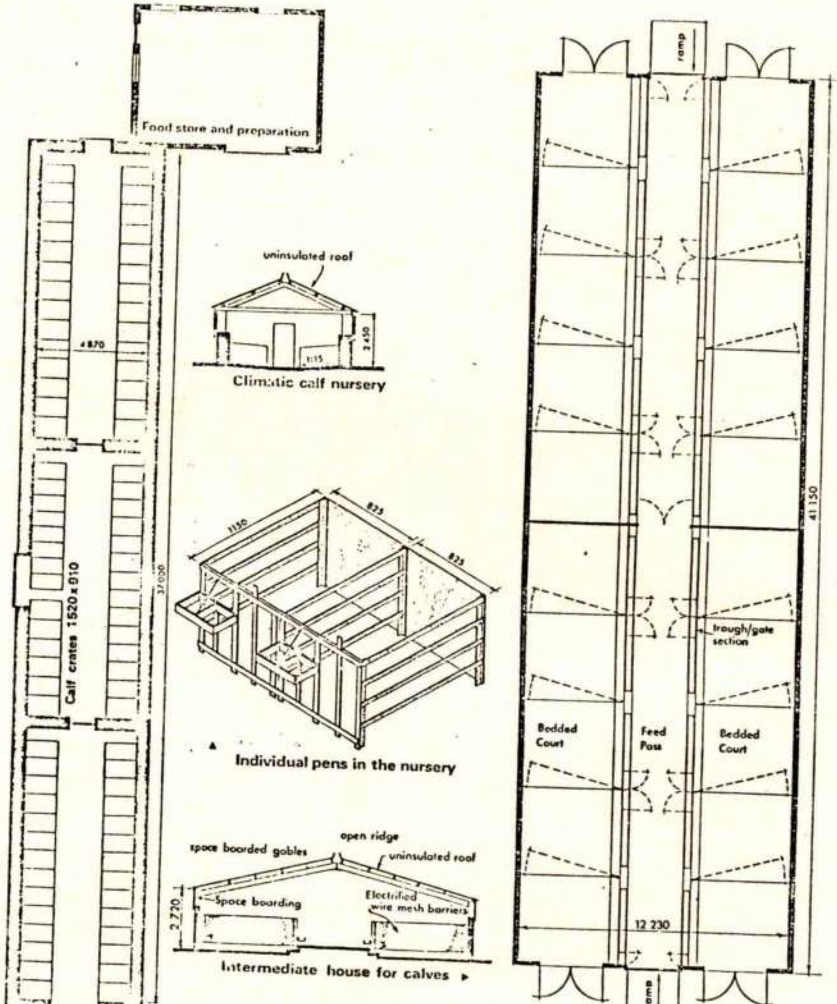

Fig. 4, Example A

The building is divided into two sections, each with ten pens of seven calves, giving a total capacity of 140 calves. A raised feed passage runs down the centre. The pen division fences are of electrified chain link adjustable for height. A good detail is that each fence is connected to the electric fencing circuit via its own plug and socket, so that when one fence has to be switched off (for moving etc.) the other fences are unaffected. Timber troughs and rails run alongside the raised centre feed passage, and part of the trough and rails is hinged so that it acts as a gate access to the pen.

The calves stay in the intermediate house until they are 12 weeks old, and then they move on to the follow-on section, which consists of traditional semi-open straw bedded courts.

Health. Health and hygiene are considered to be all-important. The walls are sprayed every fortnight against insects. The pen divisions are removed after every batch and cleaned, and they are re-creosoted after second batch. The house is rested for three weeks between each batch and is rested completely from August to October.

A very important role is played by the veterinary surgeon who sees every calf the day after arrival and there-after inspects them once a week.

Labour. The calf unit is run by one man.

Costs. The unit was erected in 1971 for a gross cost of £11,000, including demolition of old buildings, making up of site, hardcore roadways, and all fixtures and fittings.

Example B. A naturally ventilated calf house with monopitch roof for a farmer rearing home reared calves.

Accommodation was required by Thornton Farms Limited, Mains of Thornton, Laurencekirk, Kincardineshire for calves from the dairy herd up to four or six months of age. Cows were calved from October through to June mainly in existing boxes and at three days the calves would be moved to the calf house. After discussions between the estate factor, farm manager, farm building and veterinary specialists and advisers, the design was developed from the requirements which were formulated at this early stage. Visits were made to a number of calf houses on other farms, and full account was taken of current research and development work on calf housing in the UK.

Basic requirements

It was decided that the design must meet the following requirements:

1. Accommodation for 108 calves with ages ranging from three days to six months at any one time.
2. Individual penning for the first two weeks.
3. Potential for isolation of groups or individuals within the building.
4. Good ventilation.
5. A dry bed for all calves.
6. Good day lighting and maximum penetration of sunlight.
7. Unobstructed observation of all calves.
8. Good access for under-cover feeding and general management.
9. Easily cleaned internal surfaces at calf level.
10. Easy removal of muck by mechanical means.
11. Three additional loose boxes.
12. A feed storage and preparation area.

The building

A site was chosen for a new calf house separate from existing traditional buildings and from both foot and wheeled traffic associated with older cattle. It could thus be managed in isolation if required. The location was in close proximity to the manager's house to encourage both routine and casual visits for observation, and it was convenient for veterinary visits and treatment without passage through other buildings.

It was decided to use a tethered feed fence to provide individual accommodation for calves during the first two weeks in this building. The tethered feed fence was fitted with milk containers and rubber teats instead of buckets in order to ensure that the calves received milk through a teat before moving to group pens and automatic feeders. Access to calves for inspection and attention is much easier in a tethered feed fence than in individual pens and the veterinary practitioner supported this view. Details of the tethered feed fence were published (Mitchell, 1972) and are also available as a detailed drawing. Calves would then be transferred to group pens and fed by an automatic machine until weaning.

The building (Fig. 5) has a linear plan. The feed pass, which is 1.400 m wide, gives covered access to all sections and to the feed store and preparation area. A monopitch roof with the building facing south-west allows maximum penetration of sunlight, and rooflights give good daylighting to all parts of the building. Natural ventilation is provided by an opening beneath the eaves along the length of the passage at the back, space boarded to prevent strong through-draughts, and an open front which acts as both an air inlet and outlet. The sheeted front gates give good shelter to lying animals in the open-fronted sections. Again model studies were used to ensure a draught free internal environment.

Each section is divided off by a partition of cement rendered blockwork to a height of 1.5 m and flat asbestos on timber framing above. This prevents facial contact between calves in different sections. Initially it was planned to have doors in the passage between the separate sections

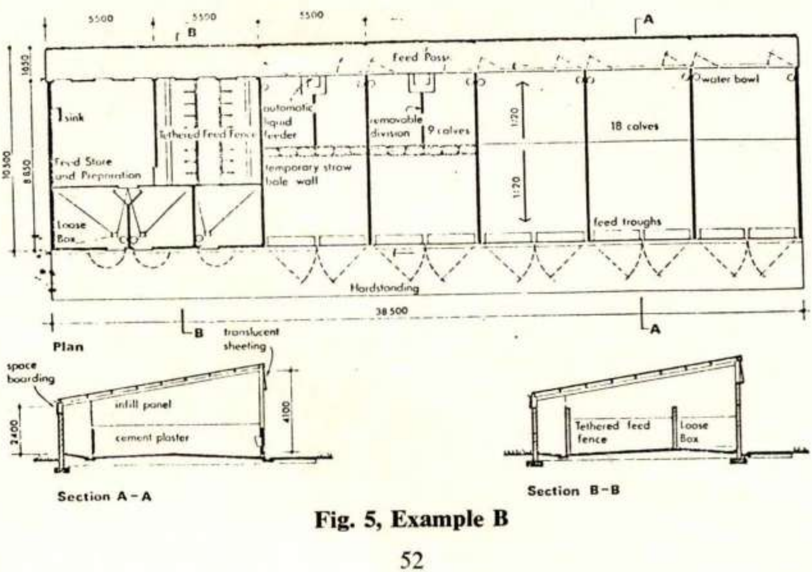

Fig. 5, Example B

to prevent through-draughts. Then it was felt that they would hinder movement between sections so it was decided to leave them out unless they proved necessary.

A dry bed was known to be very important in all types of calf housing. This is provided by straw bedding on 100 mm thick concrete floors, with a damp proof membrane, laid to falls of approximately 1:20 away from the centre of the pens. This ensures that any free liquid—urine or spillage from drinkers and feeders—drains quickly out of the pens. Straw usage is then minimised with maximum calf comfort. The loose boxes are drained separately from the rest of the building. The roof is corrugated asbestos cement sheeting on steel Z-purlins supported by a steel frame. No roof insulation is necessary in this type of freely ventilated building for calves. There is 3.4 m clear headroom at the front for mucking out by tractor.

Operation

(1) *Calf health and performance.* Approximately 324 calves have been reared in this building from three days of age to five months at the time of writing. Calf health and performance have been very good. Young calves settled in quickly and suffered no appreciable check on separation from their dams. There has been a complete absence of respiratory stress even at very low temperatures with high external winds. Observations by the veterinary adviser by day and night showed rectal temperatures, posture and behaviour to be normal under all conditions. General health and growth rates have been good and veterinary costs minimal. Only four calves have died to date.

Relative to external conditions the building gives protection from direct precipitation, provides a dry bed, and reduces air velocity at calf level. An open-fronted monopitch design is very unusual in the north-east of Scotland and it is interesting to observe its success under severe weather conditions.

(2) *Access.* The clear passage width of 1.400 m has been appreciated by the stockmen for ease of movement and feeding. Opening and closing of doors in the passage between sections would have been a nuisance. Experience to date and subsequent model studies in the SFBIU water table have shown that draughts were unlikely to be created by omitting the doors. Tractor access for muck removal is excellent.

(3) *Partitions.* Soft asbestos panels were used above the 1.5 m high cement plastered blockwork partitions between sections because they were cheaper than infilling completely with blockwork. It has been found that calves are able to reach up and damage the panels. An extra two courses of blocks, giving a blockwork height of 1.9 m would have prevented this.

(4) *Flexibility.* The building is extremely flexible in use and spare sections have been used for a variety of purposes including holding adult cows, barley beef animals during the summer months, and even machinery storage. All internal partitions are non-load-bearing and could be removed at a future date should a complete change of use be required.

In both examples given it is not necessary to adjust the building for summer or winter ventilation. Space boarding being fixed is better than a hinged inlet baffle which may require adjustment. In order to reduce labour requirement demountable pens are used and tractor access is provided to allow muck removal by tractor and foreloader.

Basic layout and design check list

Basic data for calves up to 12 weeks of age are given below together with a design check list.

Pen space

	Age	Minimum space required per calf
Individual pens	Up to 4 weeks	1.1 m^2 (1.5 x 0.75 m) 12.5 ft^2 (5 ft x 2 ft 6 in)
	Up to 8 weeks	1.8 m^2 (1.8 x 1.0 m) 19.5 ft^2 (6 ft x 3 ft 3 in)
Group pens	Up to 8 weeks	1.1 m^2 (12.5 ft^2)
	Up to 12 weeks	1.5 m^2 (16.5 ft^2)

Passage width. Two rows of pens—one on each side of a central passage 1.200 m (4 ft).

Single row of pens on one side of a passage 1.000 m (3 ft 3in).

Water. Individually penned—one water bucket for each pen.

Group penned—one water bowl for every 10-12 calves.

Trough frontage. Feeding space for individually fed calves—350 mm (1 ft 2 in) per calf.

Floor design. Beneath straw bedding provide concrete floors with a slope of at least 1 in 20. Passages should be domed and the floor slope in feed storage areas should be 1 in 40.

Environmental requirements

1. Cubic air capacity when fully stocked 6 m^3/calf (212 ft^3/calf).
2. Ventilation. With eaves level air inlets and ridge outlets allow an inlet area of 0.045 m^2/calf (0.5 ft^2/calf), an outlet area of 0.04 m^2/calf (0.4 ft^2/calf) and 1.5 - 2.5 m (5 - 8 ft) height difference between the two. If pens are arranged along the sides of a naturally ventilated building, then a cover should be placed over the rear part of the pen to prevent incoming air from dropping onto the calves. If fans have to be used design on a basis of 35-105 m^3/h (20 - 62 ft^3/min) per calf.
3. Air movement rate close to the calf, not more than 0.25 m/s (50 ft/min) in winter.
4. Relative humidity and temperature. No specific requirements under UK conditions. Satisfactory if similar to outside conditions.
5. Insulation not required.

Ensure that the following points have been clarified in the final design by checking with the design data above or by referring to Mitchell, 1976. The most common faults occur in these aspects.

Drainage. Are floor slopes adequate in pens, passages, feed storage and preparation area? Are liquids led out of the building without fouling working areas, without passing through calf pens?

Natural ventilation. Is the total air inlet area adequate? Is the total air outlet area adequate? Are the inlets well distributed? Will the calves be free from draughts?

Mechanical ventilation. Use manual NOT thermostatic fan controls. Is fan capacity adequate at the working back pressure? Is the air inlet area adequate? Are the inlets well distributed? Will the controls ensure that the ventilation rate will not go below the minimum required? Will the calves be free from draughts?

Materials handling. Is the size of the feed storage and preparation area adequate? Is it positioned well in relation to the calf pens? Can bedding and muck be easily brought in and removed from the building?

Details are given in the 'Calf Housing Handbook' by Dan Mitchell, available from the Scottish Farm Buildings Investigation Unit, Craibstone, Buckburn, Aberdeen. Price £2.00 paperback or £3.00 hardback (post paid).

Summary

In the design of calf housing it is essential to formulate a detailed outline of the housing requirements at the outset whether planning housing for home reared or bought-in calves. By consideration of the design requirement and currently available design data it is possible to produce low cost naturally ventilated calf houses which will ensure successful calf rearing provided management and nutrition are also adequate.

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The Influence of Management and Feeding Practices on Calf Performance

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Introduction

A calf rearing programme must contain a management and feeding system which minimises incidence of disease and the risk of calf deaths, and simultaneously provide satisfactory calf liveweight gain. In this paper, a number of factors which influence calf performance while it is dependent on a liquid diet are discussed.

Colostrum

A survey of 1,250 calves purchased direct from farms or from calf auction marts for Grange over the last four years showed that 40% had inadequate blood serum antibody levels when purchased. It was shown that low antibody levels were associated with increased rates of mortality (Table 1). Blood serum immunoglobulin (Ig) level of 15 - 20 ZST units provides moderate protection. However, levels in excess of 20 ZST units are more desirable.

Table 1
Immunoglobulin (Ig) status of 1,250 purchased calves and the effect of Ig level on calf mortality

	Immunoglobulin status (ZST units)						
	0-4	5-9	10-14	15-19	20-24	25-29	30+
No. of calves	75	166	285	250	237	112	125
Mortality %	18	8	6.5	5	3	3	3

The low immunoglobulin levels obtained could be due to:—

1. Weak calf unable to suckle sufficiently soon after birth.
2. Calf unable to suckle from a cow which has a pendulous udder.
3. Cow may not permit calf to suckle.
4. Farmer may not allow calf to suckle dam and may neglect to feed sufficient colostrum to the calf in the first 6 - 12 hrs of life.
5. Cow may be milked immediately after calving or have leaked milk before calving so that the colostrum available to the calf is low in immunoglobulins.

The calf's ability to injest sufficient immunoglobulin is dependent on:

(a) the amount fed—minimum of 4 kg for a 40 kg calf within 12 hrs of birth;

(b) the concentration of immunoglobulin in the colostrum fed—the mean immunoglobulin values for first, second and third milkings after calving are 11.5, 6.0 and 2.5 gms/100 ml respectively;

(c) time of feeding—the calf's ability to absorb the immunoglobulin fraction of colostrum has decreased by half between birth and 16 hrs and has practically stopped at 24 hrs after birth.

Ideally, the calf should be afforded the opportunity to injest its first feed of colostrum from its dam within 6 hrs of birth. This means that the calf should be assisted in suckling. However, it may be necessary to augment this suckling with artificial feeding of the colostrum in particular cases.

The alternative is to artificially feed the calf first milking colostrum in two feeds, the first feed 4 - 6 hrs after birth and the second 4 - 6 hrs later. The calf should be fed to appetite with colostrum that has been reheated to blood temperature. The calf's intake from two feeds is approximately 10% of calf body weight and this should provide most calves with adequate antibody protection (Table 2).

Table 2

Effect of two feeds of colostrum on bloodserum immunoglobulin levels

No. of calves	Intake in two feeds % of body weight	Mean Ig level (ZST units)	% of calves with Ig levels of 15 or less
67	10.2	22.2	3%

Calf type

Studies over a three year period at Grange have shown a positive relationship between weight of calf at purchase and subsequent survival (Table 3). These results indicate that in order to minimise loses, particularly when large numbers are being purchased, the stronger/heavier type of calf must be bought. This type is also likely to be older.

When the price paid for calves at auction markets is examined, it is found that the price paid is related to size of calf (Table 4).

Table 3

Effect of calf purchase weight on subsequent mortality at Grange for period 1973 to 1975

	Purchase weight (kg)				
	Over 45	41-44	40-37	35 or less	Total
No. of calves	267	320	211	57	855
% mortality	2	6.5	10.5	14	6.5

Table 4

Effect of liveweight on price paid for Friesian male calves at auction marts in spring 1976

	Liveweight (kg)					
	32	38	43	49	55	62
Mean price (£)	12	20	29	37	46	54
Price/kg (p)	35	50	65	75	85	90

The purchaser at the auction mart pays a higher price for the older heavier calf. Therefore it will be in the producer's interest to keep the calf on the home farm for the first 2 to 3 weeks so that it will be at least 45 kg at time of sale. Such a calf should present minimum rearing problems for the purchaser. A three week old calf should logically cost £10-£15 more than a calf less than one week old due to:

a) Saving to purchaser of three week old calf:

i) lower level of mortality (2% instead of 8%)	£3.50
ii) reduced milk replacer feed costs	
iii) reduced veterinary bill	
(18 kg instead of 25 kg)	£3.50
(£1 instead of £2)	£1.00
iv) added value of calf due to age	£5.00
	£13.00

b) Cost to rearer of three week old calf:

i) mortality 3%	£2.00
ii) milk feed costs	£4.50
iii) veterinary bill	£1.00
	£7.50

Production targets

The targets for calf growth in artificial rearing are given in Table 5. These targets are readily attainable and when they are not achieved the calf rearing system should be analysed with particular reference to feed inputs and incidence of disease. The calf, in order to attain these target weight gains (Table 5), will require 20 - 25 kg of milk replacer and 80 - 100 kg of calf concentrates.

Table 5

Growth pattern for calf in the period 0-12 weeks

	Cumulative wt. (kg)	ADG (kg)
Birth weight	40	
0-3 weeks	46	0.3
4-6 weeks	57	0.5
7-12 weeks	91	0.8

Calf feeding schedule

The feeding schedule in Table 6 will provide the necessary feed inputs to attain the above target weights.

Table 6

Feed inputs required to attain the above target weights

Age in days	Daily feed input (kg) Milk replacer	Concentrate
5-10	0.25	0.40
11-15	0.35	
16-22	0.45	
22-42	0.55	0.50
43-56	0.45	1.00
56-84	—	2.25

These feed inputs may be increased to provide greater initial liveweight gains. Table 7 shows the liveweight gains which were obtained when 25, 37 and 50 kg of milk replacer were fed over a 7 - 56 day period at Grange. However, the medium and high planes of nutrition in Table 7 have a number of disadvantages:

a) greater incidence of scour and risk of higher mortality;

b) higher inputs of milk replacer;

c) lower intakes of concentrates;

d) greater risk of over-feeding, namely a severe digestive upset occurring when calf is placed on the high feeding initially.

Table 7

Effect of level of milk replacer fed on calf daily liveweight gain (kg)

	Level of milk replacer fed 7-56 days		
	Low (25 kg)	Medium (37.5 kg)	High (50 kg)
Wt. at start—7 days	40.5	40.5	41
Av. daily liveweight for period			
7-28 days	0.25	0.57	0.75
7-42 days	0.53	0.73	0.80
7-84 days	0.62	0.77	0.78

The milk replacer and concentrate intakes of these calves are shown in Table 8.

Table 8

Mean daily milk replacer and concentrate intake (kg) for calves fed different levels of milk replacers—25 kg, 37 kg and 50 kg

	Low		Medium		High	
Days	Mllk	Conc.	Milk	Conc.	Milk	Conc.
7-28	0.45	0.2	0.80	0.10	1.05	0.05
29-42	0.55	0.5	0.90	0.35	1.20	0.20
43-56	0.55	0.8	0.95	0.65	1.25	0.45
57-70	—	1.6	—	1.60	—	1.60

Effect of management practices on calf performance on automatic feeders

Recent research on automatic calf feeders at Grange shows that different methods of introducing calves to the automatic feeder did not affect subsequent calf performance (Table 9).

Table 9

Effect of method of introduction to automatic feeder on caif performance

Treatment	Initial wt. (kg)	Av. daily liveweight gain 7-63 days
1) Pail feeding for 7 days, then to automatic feeder	41	0.40
2) Nipple feeding for 7 days, then to automatic feeder	42	0.43
3) Directly on to automatic feeder and assisted for 7 days	41	0.46
4) Directly on to automatic feeder and assisted for 1 day only	41	0.50

Preparing the calf for the automatic feeder by pail or nipple feeding for seven days prior to introduction on to feeder did not improve calf performance and would not be advocated as a routine practice.

A second experiment showed that by increasing the concentration of milk replacer fed from the feeder, when the calves were first introduced to the feeder, resulted in seven deaths out of 40 calves (Table 10).

When the calves were fed from an automatic feeder which dispersed a 20% solution of milk replacer (1 kg in 5 litres of water), the treatment had to be discontinued after three days because of illness and deaths. It was concluded that the initial concentration of 20% is unsuitable where bought-in calves were first introduced to the automatic feeder. It is therefore not recommended.

Table 10

Effect of concentration of liquid fed from automatic feeder on calf performance

	Treatment	
	1 10%	2 20%
No. of calves	40	40
No. of losses 7-35 days	1	7

Another experiment at Grange examined the effect of weaning calves abruptly off an automatic feeder when they had consumed either 30 kg or 50 kg milk replacer. Weaning off the feeder when the calves consumed 30 kg of milk replacer resulted in a severe check in growth rate after weaning (Table 11), due to low concentrate consumption before weaning. The average daily concentrate consumption for the seven days before weaning was only 0.1 kg per day for the calves weaned when fed 30 kg of milk replacer compared to 0.4 kg per day for the calves weaned when fed 50 kg of milk replacer.

Table 11

Effect of total amount of milk replacer fed on calf performance

	Amount of milk replacer fed to weaning	
	30 kg	50 kg
ADG 7-35 day (kg)	0.6	0.6
ADG 35-63 day (kg)	0.2	0.55
Age at weaning (days	37	52
Conc.—average daily intake		
7 days pre weaning	0.1	0.4
7 days post weaning	0.5	1.4

Automatic calf feeders reduce the labour inputs required in calf rearing and allow for redeployment of farm labour. However, the use of automatic calf feeders requires vigilant stockmanship by the operator.

Automatic feeder—critical management aspects

* Daily intake of milk replacer by the calf is not controlled.
* Bought-in calves are liable to overfeed when first introduced to the feeder.
* Avoid mixing very young calves with 4 - 5 week old calves, particularly on dairy farms.
* Calf fed on automatic feeder requires 40 - 50 kg of milk replacer.

* Calves on automatic feeders have a loose faeces due to high input of milk replacer.
* There is difficulty in getting some calves which are on *ad libitum* milk to eat sufficient concentrates before weaning.

Cost of calf rearing—7-84 days

Costs are summarised as follows:

System 1: Pail feeding 7-75 days—input of 25 kg of milk replacer and 95 kg of calf concentrate. Liveweight gain 0.60 kg/day.

System 2: Automatic feeding 7 - 63 days—input of 50 kg of milk replacer and 53 kg of calf concentrate. Liveweight gain 0.65 kg/day.

Table 12

Calf rearing costs 7-84 days

	System 1	System 2
Milk replacer @ £13.00/25 kg	13.00	26.00
Calf conc. @ £6.50/50 kg	12.35	6.89
Mortality	3.00	3.50
Housing and equipment	5.00	4.00
Veterinary	2.00	2.00
Miscellaneous	1.00	1.00
Total	£36.35	£43.39

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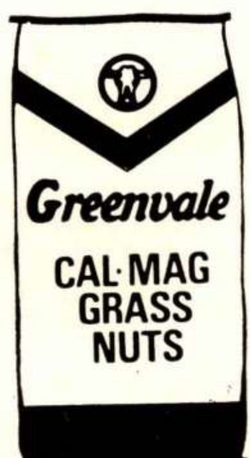

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Factors Affecting Milk Yield per Cow

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Milk yield per cow is of critical importance in defining farm income on a well stocked dairy farm. Optimum dairy farm management however requires both high stocking rate and high milk yield per cow. These dual objectives can be obtained at the same time and they are not antagonistic to each other. It is easier to increase stocking rate on dairy farms than to increase milk yield per cow. The discussion on increasing milk yield per cow in Ireland has been mainly in terms of animal breeding and feeding. While these factors are important, they are only two of the many herd management details which determine milk yield per cow within herds.

The factors affecting cow milk yield are best presented within the three categories shown in Table 1. The first factor, potential of the cow, is mainly influenced by breeding, size and age at first calving. Effects of breeding both from the male and female side will not be discussed in this paper. Size and age at first calving are important determinants in influencing both first lactation yields and possibly have major influences on the life time performance of the animal.

The management of the dairy cow during the lactation and dry periods will be discussed under the influence of feeding, time of calving and lactation number. However, two other factors are important, namely, disease control during the season and good milking management.

The rate of culling and degree of mortality in herds have a big impact on output from dairy herds. Culling is influenced by the number of herd replacements available in the herd, the disease state of the herd and the fertility of the herd. These three factors determine the rate at which culling takes place in the herd in any one year.

Table 1

Factors affecting milk yield per cow

Factor	Affected by
Potential of the cow	Breeding Size and age at 1st calving
Management during lactation and dry period	Feeding Time of calving Lactation number Disease control Milking management
Culling and mortality	No. of herd replacements Disease Fertility

Trends in milk yields and stocking rate on Irish dairy farms

In recent times it appeared that milk yield per cow was increasing. However, the more recent statistics indicate that the national yield per cow is still less than 600 gallons. This has been confirmed in a recent survey (Table 2) on a national basis. The average yield per cow was 579 gallons. There was however a higher milk yield in the Munster area, the traditional dairying area of the country, but even in that province average milk yield per cow was only 623 gallons. A further disconcerting feature emerging from this survey is the low average stocking rate of approximately two forage acres per livestock unit. It is against this background that I propose to deal with some aspects which influence milk yield per cow.

Table 2

Some aspects of milk production in 1976 : average values on 764 farms

	Munster	Leinster	Connacht	All
Herd size	26	22	9	20
Yield (gal/cow)	623	558	482	579
Forage ac/l.u.	2.01	1.73	2.34	2.03
Feed ac/l.u.	2.23	1.94	2.48	2.23
Conc. cwt/cow)	3.8	3.3	2.1	3.6

Weight at first calving

There is little information available on the optimum weight to calve down two year old heifers and its effect on subsequent lactations. An experiment is presently in progress at the Agricultural Institute Field Station, Ballyragget, Co. Kilkenny, where two year old Friesian spring calving heifers were divided into four treatment groups to compare the effect of weight at first calving on lactation performance. Two groups had a target weight of 1,000 lbs weight before calving and were stocked at 0.95 and 0.75 acres/animal after calving. The other two groups had a target weight of 1,150 lbs before calving and were also stocked at 0.95 and 0.75 acres per cow after calving. These stocking rates provide grazing and silage requirements. The heifers were fed grass silage *ad libitum* and 12 lbs concentrates/head/day after calving until transferred to grass in mid-March. The groups are rotationallly grazed on pasture and 75% of each farmlet is conserved for winter feed.

The average performance in the first two lactations is presented in Table 3.

Since this is a long term study caution must be observed in drawing conclusions at this stage. The heavier animals in the first lactation had an increased milk production of approximately 100 gallons per heifer. The first lactations in 1976 coincided with a very dry summer. This resulted in the animals being in poor body weight at the end of the first lactation. The pre-calving weights of all groups in 1977, start off the second lactation, were only at the same level as at the beginning of the first lactation.

Table 3
Bodyweight at first calving and lactation performance

1976	Calving weight			
	9 cwt		10 cwt	
Acres/cow	0.95	0.75	0.95	0.75
Yield (gal)	607	487	717	627
Pre calving wt. (kg)	448	452	528	508
Wt. end of lactation (kg)	435	416	467	454
1977				
Yield (gal)	645	545	642	519
Pre calving wt (kg)	468	452	508	508
Wt end of lactation (kg)	547	489	560	571
Body score end of lactation	2.89	2.26	2.74	2.97

3 year olds yield for 1st lactation = 640 gal.

This had a large influence on milk yields in the second lactation and, in some treatments, it depressed lactation yields in the second year from those obtained in the first lactations. Those treatment groups with poor lactations in 1977 tended to compensate in body weight and resulted in very good body weight conditions at the end of the 1977 lactation year. This increase in bodyweight could have a major influence in the lactations (third) at the beginning of 1978. The only conclusions one can draw from this experiment at this early stage are: (1) the heavier the heifer at first calving, the higher the milk yield; (2) if animals are not given an opportunity to increase body condition between the first and second calvings milk yield can be depressed in the second lactation and (3) animals tend to gain extra weight during the second lactation at the expense of milk production.

Table 4
Feed for the 800 gal cow

Feed	Lb DM/year	% of total feed	Relative cost
Grass	5700	68	100
Silage	2700	29	200
Concentrates	840	9	800

Feed requirements for a dairy cow on an annual basis

The major components of the diet of an 800 gallon spring calving dairy cow on a 12 month basis are outlined in Table 4. These figures indicate the relative importance of the components of a dairy cow's diet. It is worth noting that the cost of energy as expressed in digestible dry matter is in the following ratios of 800, 200 and 100 for concentrates, silage and grass respectively.

Pre-calving feeding

Body reserves built up during the dry period can be utilised to support milk production in early lactation. During the last eight weeks preceeding parturition, a liveweight gain of 1.5 lbs per day is desirable. An outline of how these levels of gain can be attained with various levels of feeds is illustrated in Table 5. These figures are only a guideline and show how the type and quantity of roughage fed, influence the level of concentrate feeding required with poor quality feeds. These figures are based on cows weighing 10 cwts and a silage with a dry matter of 20%.

Table 5

Pre calving feeding for 1.5 lb liveweight gain/day : general guideline

Type of roughage	Lb of roughage	Lb of concentrates
Good straw	14	11.4
Poor straw	10	14.2
Good hay	25	0.0
Poor hay	19	7.5
Good silage	93	0.0
Poor silage	95	4.0

Post-calving feeding

The effects of feeding level and milk yield are illustrated in Table 6.

Table 6

Feeding level and milk yield

Concentrates (lb/cow)	Silage D.M. intake as % of body wt	Wt changes (lb/day)		
		−1.1	−2.2	1.1
		Yield gal/cow		
12	1.6	4.3	4.9	3.0
16	1.4	4.7	5.4	3.5
20	1.2	5.1	5.8	3.9
24	1.0	5.6	6.3	4.4

The figures show that increasing the concentrate level results in a depression of silage intake by the dairy cow. This table also shows the degree to which body condition or bodyweight loss can influence the milk production obtained per cow at various feeding levels. Thus, as concentrate feeding levels increase, there is a reduction in silage intake, an increase in milk production and a decrease in bodyweight loss by the cow.

Silage quality and milk yield

Silage quality is influenced by the quality of the material ensiled, and the efficiency of preservation. Voluntary intakes of silage conserved from poor quality material or which are poorly preserved are very low and large inputs of concentrates are required to supplement low intakes. Table 7 illustrates the level of concentrates required for varying milk production levels depending on silage quality. The additional concentrates required with poor quality silage in order to achieve the same level of milk production as with good silage is about 8 lb per cow per day. Over a winter period this can amount to £33 per cow.

Table 7

Silage quality and milk yield

Milk yield gal/day	Silage quality (D.M.D.) 70	65	60
	lb of concentrates		
3	5	9	13
4	12	16	20
5	20	24	28

A guideline to the possible levels of concentrates to be fed after calving to spring calving cows in 1978 is shown in Table 8. The figures show that as the level of feeding increases the response to extra concentrates decreases when measured over the full lactation. With a possible price of 50p per gallon for milk in 1978 and the concentrates costing £120 per ton, the economic level of concentrate feeding with good silage should be between 15 - 16 lb per cow per day.

Table 8

Response to concentrate on lactation basis

Level of feeding (lb/cow)	Response lb/gallon	Cost of Conc. (£/tonne) 100	120	130
		Cost of conc./extra gal.		
8	6.4	29.1p	34.9	37.8
12	7.8	35.5	42.5	46.1
16	9.3	42.2	50.4	54.9

Effect of wilting on silage quality

Table 9 shows that wilting resulted in increased silage dry matter intakes and reduced body weight losses. However, there was very little effect on milk yield per cow in this experiment.

Table 9

The effects of wilting on silage intake and animal performance

	Direct cut	24 hour wilt	48 hour wilt
Silage D.M. (%)	17.7	24.4	30.8
Silage D.M. intake (lb/day/ 100 lb B.W.)	1.35	1.97	2.18
Total D.M. intake (lb/day/ 100 lb B.W.)	2.27	2.87	3.09
Body weight changes (lb/day)	−0.90	−0.09	0.12
Yield (lb/day)	40.7	40.7	41.2

Concentrate level = 11 lb of 15% C.P. dairy ration

Concentrate feeding on grass

There is very little limited information in the influence of concentrate feeding on pasture in early spring. This type of experimentation is difficult because the conditions vary as grass growth improves with the advancing season and the need for supplementation generally decreases. The Moorepark recommendations have been to feed the same quantity of concentrates for the first two weeks after turnout as were fed during the indoor period. The level of feeding should then be reduced by half for the next ten days and phased out completely, with the exception of a small quantity of meals to carry calcined magnesite until the end of May.

An experiment was carried out in 1977 when concentrates were fed from March 21st to May 25th as follows:

(i) no supplementation;
(ii) 10 lbs molasses per head per day;
(iii) 7 lbs barley per head per day.

The cows were stocked at 0.7 acres per cow for a 63 day feeding period. The mean calving date of this herd was January 20th. Difficulty was experienced in getting the cows to eat their respective quantity of feeds and in the molasses group some barley was introduced to entice them to take their ration. Over the total period the quantities of feed consumed were approximately half of their allotted allowance. However, the quantities consumed did not influence either milk yield or body weight during the experimental period.

A similar type experiment was carried out from July 29th to November 25th, 1976 when cows were stocked at 0.8 acre per cow. This experiment consisted of three treatment groups:

(i) control with no feed;
(ii) 10 lbs molasses/head/day;
(iii) 7.5 lbs barley +2 lbs of soyabean per head per day.

The objective was to determine the effects of supplementary feeding in the latter part of lactation. The animals on trial were milking over 2½ gallons when introduced to their feed. The supplemented groups increased milk production over the control groups but there was no difference between the two types of supplementation. The control group produced less milk and had a shorter lactation length. However, one could not economically justify this supplementation at the end of the lactation. Further studies on this subject are proposed.

The influence of stocking rate on dairy merit

It was stated earlier that high stocking rate and high milk yield per cow were not incompatable. The results from an experiment which has been carried out for three years at the Curtin's farm at Moorepark demonstrating stocking rate and dairy merit are shown in Table 10.

Table 10

Stocking rate and dairy merit

	Dairy merit			
	High		Low	
S.R. (ac/cow)	1.0	0.8	1.0	0.8
Yield (gal/cow)	964	844	749	650
Yield indoors (gal)	153	144	96	76
Yield on grass (gal)	810	700	653	574
% yield Jan-May	54	54	52	53
Calving date	6/2/77	9/2/77	20/2/77	23/2/77
Lact. length (days)	274	271	251	243

Concentrates	High merit	8.5 cwt
	Low merit	6.5 cwt

This experiment involves four groups of animals, two highly selected groups and two groups whose yields are close to the national average. Within each selection, cows are stocked at either one acre per cow or 0.8 acres per cow. The results show that at one cow per acre with an input of over 8 cwts concentrates it is possible to achieve close to 1,000 gallons per cow and per acre. Increasing stocking rate from 1 to 0.8 has depressed milk production in both the high and low merit cows. This has been a feature of stocking rate work in recent years which may well be associated with the dry summers experienced in 1976 and 1977. These depressions would justify increasing stocking rates to high levels at the present time. The proportion of yield produced indoors reflects the overall lactation yields in the high merit cows. A useful guide to early calving is the percentage of milk produced between calving and the end of May which has been approximately 54% in this experiment. This result emphasises the value of early calving, good quality winter feed with supplementation, and very good grassland management in the early part of the season. One further point illustrated by the result is the need for a long lactation in order to obtain high milk yields.

The influence of early calving is further endorsed by the data presented in Table 11. These data are taken from some of the Moorepark herds and illustrate that late calving decreases milk yield per cow and lactation length. When the January and April yields are compared there is a drop of 38 gallons per month for each months delay in calving date. The data from An Foras Taluntais survey of 700 farms in 1976 indicate the effect of early calving on milk yield as shown in Table 12.

Table 11

Date of calving and yield

Month of calving	Yield (lb/cow)	Lact. length (days)
January	7248	280
February	6289	255
March	6388	240
April	5744	216

Difference between January-April = 38 gal/month

Table 12

Average lactation yields of early and late calving cows (An Foras Taluntais survey data on 700 farms)

Province	Munster	Leinster	Connaught	All
Early calvers	660	571	541	629
Late calvers	595	546	470	559

Lactation yields generally increase from the first to the sixth lactation and decline with advancing lactation numbers. These figures are confirmed by the data shown in Table 13.

Table 13

Lactation number and yield (An Foras Taluntais, Moorepark)

Lact. No.	No. of animals	Yield (gal/cow)
1	196	529
2	153	589
3	133	684
4	82	691
5	111	726
6	89	751
7	54	716
8	31	668
9	29	515

Control of culling in dairy herds

Data from eight herds in Moorepark were used to establish average values for culling and mortality and to indicate those factors requiring particular attention in order to eliminate mortality and involuntary culling. The data are based on a period covering six years from 1969 to 1975. Of the results for culling only those cows culled for 'low milk production' or 'late calving' may be classified as 'voluntary culling', i.e. 2.8 in the total culling rate of 19.8. High losses of animals due to involuntary culling will consistently reduce the possibility of improving herd milk yields by reducing the number of cows that can be culled on low yield. The major cause of involuntary culling is infertility. This factor accounted for 39.3% of all culled cows or 7.8% of all cows. The factors that contribute to infertility have been shown to be mainly due to repeat breeders. In addition, up to 10% of cows culled for infertility may in fact be in calf. Furthermore, the late calvers may not have been offered for service for more than one or two services, and this will contribute to the number culled as being infertile within a compact calving season. The culling rates indicated in Table 14 are similar to those obtained by K. J. O'Farrell (An Foras Taluntais, Moorepark) in a recent survey of dairy farms in the Fermoy area.

Table 14

Causes of culling (1969-75) (An Foras Taluntais, Moorepark)

Factor	% of all cows culled	Culled annually (%)
Infertility	39.3	7.8
T.B.	13.8	2.7
Low yield	13.1	2.6
Abortion	12.8	2.5
Mastitis	5.5	1.1
Accidents	2.2	0.4
Late calving	1.1	0.2
Calving difficulties	0.8	0.2
Other reasons	6.1	1.2
Not recorded	5.4	1.1
Total	100.00	19.8

The key factor for early compact calving is good heat detection. An outline of the number of observations required for good heat detection is shown in Table 15. Studies at Moorepark have shown that the average duration of heat is quite short. Over 33% of heats are less than 6 hours in duration, and cows can come on heat for short periods several times a day. Thus, the importance of frequent heat observations during the day cannot be over-emphasised.

Table 15

Number of observations on heat detection

No. of observations	Times	Detection rate %
3	8 a.m. 2 p.m. 6 p.m.	75
5	7 a.m. 10 a.m. 3 p.m. 6 p.m. 10 p.m.	90

Number of replacement heifers

The high incidence of involuntary culling has allowed very low culling rates of low milk producers in Irish dairy herds. Between 18 and 20% of cows are culled annually and mostly for reasons other than yield. The recent figures for replacement heifers from the Central Statistic's Office indicate that the number of in-calf heifers being reared is considerably less than 20% of the national herd. This may have major implications with the eradication of brucellosis in the future because present culling rates on an involuntary basis will not allow for replacement of those animals being culled for brucellosis. If the two problems of eliminating low yielders by the introduction of additional replacement heifers and the eradication of brucellosis are introduced to farms, then increased numbers of heifers must be reared. The question then arises: where do these come from?

Table 16 presents two possible replacement policies. The first example is a 100 cow herd in which the cows are put in calf to dairy sires and the heifers at the 20% replacement rate are put in calf to beef type bulls, such as the Angus for easy calving. After allowing for mortality and animals not going in calf there is a maximum of 31 calves available as replacement heifers. But these heifer calves could have been born between January and July, thus making compact calving for heifers impossible if the maximum number of animals are selected.

In the second example both the heifers (if they are bred from high-yielding cows and nominated sires they should be good genetic material) and dairy cows are bred to dairy sires. The number of possible heifer replacements is increased to 39 heifers from 100 animals. The table clearly outlines the type of strategies which must be considered if we are to increase the culling for low yielders, eradication of brucellosis and T.B., and expand the national herd.

Summary

In this paper a number of factors that affect milk yield per cow have been considered. Increased milk yields per cow will be obtained by breed-

Table 16

The number of heifer replacements per 100 cows

No. of cows	(1) 100			(2) 100
	20 heifers	—	80 cows	
Type of bull	beef	—	dairy	dairy
No. of calves			40 heifers 40 bulls	50 heifers 50 bulls
Mortality 12%			35 heifers	44 heifers
Not in calf 12%			31 heifers	39 heifers

ing which is long term in nature. Increasing the weight at first calving has a large influence on initial milk yields and may have effects on the total life-time performance of the animal. The important management factors to increase milk yields per cow depend on better feeding, early calving, developing a mature herd, good disease control and efficient milking management. Finally, to allow milk yields to increase, both culling and mortality must be improved in all herds. The factor of high infertility alone which accounts for between 7 to 10% of all cows in the country being culled annually will demand greater attention from dairy farmers in the future. It is only by selecting more replacement heifers and heifers of high quality that higher milk yield per cow can be achieved.

Managing and Motivating the Dairy Worker

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I. Introduction

Agriculturalists are often complacent about man management because of a feeling that agricultural workers are more satisfied than their industrial counterparts. However, there is growing evidence that this is probably not true and it is the deferential position of agricultural workers which prevents the full expression of their dissatisfaction in agriculture. The gap in life styles between employer and employee is all too often ignored in agriculture but it is likely in the future to be a cause of friction and unrest.

The general objective of this paper is to discuss man management in agricultural activities in order to achieve more effective worker performance. The basic theme is that men have needs, some common to all, some more specific, and that successful management and motivation is concerned with identifying these needs and providing the right mix of rewards to enable the worker to fulfill these needs inside and outside his work situation.

II. Definitions

A. *Job Satisfaction.* A feeling of positive effect: produced by satisfaction of important needs; in conjunction with a feeling that these needs could not have been better or more easily satisfied in a comparable job; such perceptions being with respect to the job as a whole, i.e. satisfaction results from need fulfilment.

B. *Job Enrichment.* Adding additional elements to the job to make it more demanding and rewarding; filling higher needs and arousing human needs.

C. *Motivation.* The instigation and direction of behaviour aimed at satisfying a need. Motivation is the drive or urge to behave in a certain way; the driving force to act in a particular manner in order to achieve certain ends or objectives. One may regard motivated behaviour as extending between two poles.

In order to understand motivated behaviour one has to consider:

a) Which goals and outcomes are sought by an individual (i.e. what needs is one seeking to satisfy).
b) What are the factors influencing this choice for the individual.
c) What determines the behaviour a person will be motivated to adopt in order to reach the goals and outcomes thought desirable.

D. *Intrinsic Work Factors.* Factors associated with the nature of work itself, e.g. feelings of achievement, responsibility, recognition.

E. *Extrinsic Work Factors.* Factors associated with the environment in which the job operates, e.g. pay and working conditions.

III. **The needs of man**

In order to effectively manage and motivate the worker one needs to consider the motivation and needs of individual members of staff. There is no easy blue print to managing staff. Attention needs to be paid to individual differences and not to assume all employees want and react to the same thing, since behaviour is related to the fulfilment of needs.

Maslow, A. H. put forward a theory of the hierarchy of human needs. He advanced the concept of five basic categories of human needs being of varying degrees of potency. He asserts as a general principle that the satisfaction of each group of needs is a prerequisite to the experience of the next group of needs in the hierarchy, hence ungratified needs motivate.

Biological needs (the most basic needs). These may be collectively described as the need to survive : the need for fresh air for food, drink, warmth, sex, etc. They are provided for through the medium of economic rewards in more advanced societies. Such basic needs must be satisfied before a person is motivationally aware of the next group of needs —

Safety and security needs. In the work situation, these needs are manifest in a preoccupation with redundancy, the maintenance of pay differentials, the provision of pensions and, particularly in agriculture, security of tenure in farm cottages. Once they are satisfied attention is turned to —

The need for affection. This social need derives from the pleasure of associating with others, of belonging to a group and conforming to its rules and conventions. The implications for management will concern the leadership processes of the working group. Following the satisfaction of such needs attention turns to —

The need for esteem. Maslow distinguishes two classes of needs within this category—firstly the need for achievement, for independence and for a sense of personal worth, all of which may be described as the need for self-esteem. Secondly there is the desire for the *esteem of others;* the need to earn a reputation, to experience recognition and appreciation in one's achievements. Providing satisfaction of these psychological needs is a most important part of motivational policy in any business. The drive to fulfill these needs may mean that people reject their working groups and would rather work alone than as a member of a group. If fulfilled, the person will then become aware and finally require fulfilment of his —

Self-actualisation needs. This is the highest level of human needs in the hierarchy and in a job sense is reached by only the fortunate few. It is the need of a man to become everything of which he is capable. The provision of a work environment is which each individual may aspire to his full potential is the challenge it gives to Management.

The general pattern of needs is consistent person to person but these needs are in turn modified by such factors as personality, age and upbringing.

There are many other theories of human behaviour. Hertzberg, Mausner and Syndermann (1959) put forward the view that the factors producing dissatisfaction in the job were concerned with non fulfilment of extrinsic factors (e.g. pay and working conditions) and satisfaction only arose when intrinsic factors were present (e.g. achievement and recognition). Basically the dissatisfiers correspond with Maslow's lower needs, the satisfiers with Maslow's higher needs.

The strength of an individuals preference for any factor in his work is possibly dependent on the extent to which he believes it will help him to obtain other outcomes which he feels are desirable. It also shows that people may seek one goal in order to fulfill other needs and goals *outside* their work.

IV. **Work behaviour**

The objective of effective man management is to promote favourable work behaviour. One can assume that the behaviour of all workers is directed by a fairly rigid set of drives, modified by such factors as early upbringing, personality, age, experience, family commitments, family pressures, the drive to develop an individual role, and the role forced on a person by group membership and management actions. In all these processes there may be a conflict between group and management expectations and the individual's personality resources and assets.

Theories of work behaviour (or motivation theories) need to consider both the objectives sought and the behaviour used to reach the objectives. If one accepts the basic concepts of utility theory then theories such as those of Vroom (1964) and Lawler (1973) help explain behaviour. These effectively state that man chooses that behaviour from a number of plans of behaviour, which he expects will provide the best outcome as he sees it in terms of meeting the needs he had. This enables one to consider that —

A) Individuals place different values on various outcomes.
B) People have expectations about the possibility that a certain effort will lead to a certain behaviour.
C) People have expectations about the possibility that this behaviour will lead to certain outcomes.

If one considers the determinant of the effort a person puts into a job, it is the perceived value to the person individually of the likely outcome of that effort. Thus each individual has a distinct set of values which he places on any likely outcome. These values will be determined by many factors including his own personality, upbringing, family and group pressures and the needs he has to fulfill. Effort in order to maximise performance will only occur if the perceived value of the outcome had the highest value to the person.

Expectancy theory states that both extrinsic and intrinsic factors can satisfy, and also motivate, but some people may be more strongly motivated by extrinsic factors and some by intrinsic factors. Secondly, satisfaction is not to be equated with motivation but rather that satisfaction will be associated with motivation only to the extent that it is the result of valued rewards that are believed by the employee to be contingent upon the performance to be motivated. A person might be satisfied with his pay for example, but pay would motivate him to perform well only if good performance was expected to result in increased pay. Actions will be associated with varying degrees of profitability of outcomes. These outcomes will have value for an individual when they satisfy needs he has, and the value will vary with the need strength. In any situation a person will act so as to maximise the expected value of outcomes.

V. **Rewards**

Man has needs and society and management should provide rewards which meet these needs, i.e. if one is hungry then food is a good reward.

The outcome of rewards offered by management are complicated by the fact that it is the perceived value of that reward which is important (see Fig. 1).

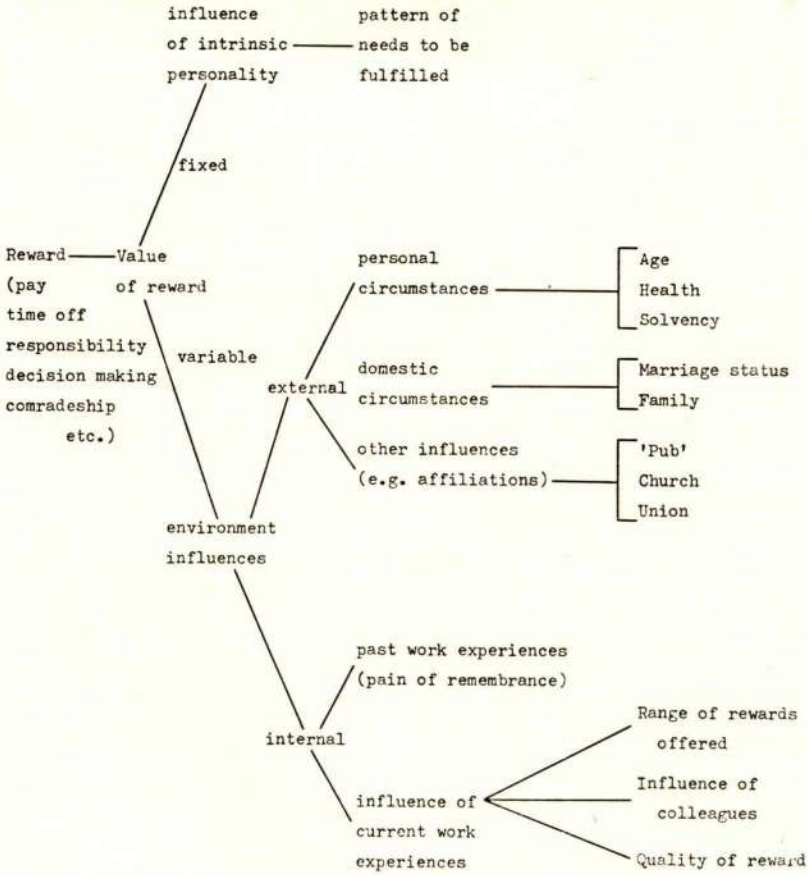

Fig. 1—The derivation of the perceived value of rewards offered.

There is always a danger of management using its perception of the value of the rewards which are not necessarily the same as that perceived by the worker. When one considers the link between rewards and the effort one can classify rewards as follows:

A) Rewards not valued (e.g. for the individual worker this may be affiliation).
B) Rewards valued but not dependant on effort (e.g. time off).
C) Rewards valued and dependant on effort (e.g. recognition).

The value of rewards and the rewards sought change over time. Generally the greater the value of a set of rewards and the higher the probability that receiving each of these rewards depends upon effort the greater effort will be put into any situation.

VI. **The interface between man and cows**

The first sections of this paper have outlined some of the components of the way in which the worker (or farmer) behaves. When one considers the dairy section there is another important aspect, i.e. the relationship between man and cows. Analysis of observations made on cow and cowmen behaviour show that personality traits of cowmen are correlated with herd yield and that all factors being equal the confident introvert personality type (behaviour) tended to develop a better relationship with cows and that this good relationship between man and cows significantly increased the milk yield of cows.

Analysis

Some forty commercial Friesian herds operating as one man units have been studied and the personality of the cowman analysed. The herds with 50 - 80 cows; autumn calving and feeding 1,400 - 1 600 kgs per cow/year of concentrate feed, were isolated and for the twenty herds in the category the following emerges.

Personality of Cowman (results 1975/6).

Confidence

	Extrovert	Introvert
Confidence	*Mean yield = 4,629 litres No. of herds = 6	Mean yield = 5,191 litres No. of herds = 8
Lack of Confidence	Mean yield = 4,527 litres No. of herds = 1	Mean yield = 4,537 litres No. of herds = 5

Lack of Confidence

*Mean yield=average annual milk yield per cow.

Statistical analysis

Mean yield of Confident Introvert cowman vs. mean yield of rest.

$t=2.92$ ($p<0.05$)

A. **The general symptoms of a good relationship between man and cow**

a) Cows come more easily to the collecting yard.
b) Cows come more easily into the parlour.
c) Cows are less restless and dung less in the parlour.
d) The cowman pats and touches the cows.
e) The cows do not move away when approached by the cowman.
f) The cows come to the cowman when out in the field (short flight distance).

B. **The behaviour to adopt**

It is now possible to draw up a generalised check list of the desirable factors to look for when selecting a new cowman.

However, these are difficult traits to assess and there are really very many other factors to consider and which may have important results. Also many farmers do the milking themselves or have a herdsman who seems to be very satisfactory even if he does not totally match up to the generalised specification. The more satisfactiry solution is to modify the farmer and cowman's behaviour so that he achieves a better relationship with his cows. This can be done by ensuring that certain activities which cows dislike are avoided and certain activities which they like are developed. This should have a beneficial effect on milk yield.

Cows can be made to like their cowman by receiving favourable stimuli when they are with him. If they associate the cowman and the parlour with pleasant sensations they will come in willingly, want to be with the cowman and be under less stress whilst there.

The following is a part of the behaviour modification programme:

When rounding up the cows for milking:

DO's	DO NOT's
—Walk up to the cow quietly, —Call to let them know your are rounding them up, —Walk confidently up to the cows and stroke them.	—Hit cows with sticks or other objects, make them run, —Crowd them through gateways, shout unduly at them.

Herding cows into milking parlour:

—Allow cows to enter parlour unhurriedly and in their own order (if they hang back — find out why). —Approach those cows hanging back with gentle talk and walk them into the parlour with a confident manner.	—Confuse or upset cows by trying to rush.

Preparing cows for milking:

—Let cow know where you are by talking to her then stroking her with your hand moving towards the udder,

—ALWAYS stick to the routine the cow is used to,

—Make special effort to reassure nervous cow or heifer,

—Ensure your behaviour is consistent, a given reaction of cow should always elicit the consistant reaction by you.

—Make sudden, unexpected movements, handle udder unexpectedly, or roughly.

Leaving the parlour after milking:

—Let the cows walk out at their own speed and in their own order,

—Encourage first cow to move by a gentle pat if necessary.

—Hurry cows out of parlour.

—Make cows reluctant to come in next time, due to fear of cowman.

Calving:

The cow is particularly sensitive to new stimuli at this time. Make sure your actions to her are favourable and pleasant, as she will remember if they are not!

DO's

—Talk to cow in gentle tone,

—Make steady quiet movements round cow,

—Be confident and in control,

—This is an opportunity to create a relationship of trust between man and cow—make a fuss of her, rub her udder, scratch her face, rump, etc.

DO NOT's

—Be impatient,

—Flap.

First few milkings:

During this time the cow is under stress and sensitive to new stimuli, the routine is changing and she misses her calf. You must be a substitute for the calf. You must encourage her to eat as much as possible and to let her milk down freely.

—Get the cow to think that milking is a pleasant experience,

—Make sure you touch the cow gently and speak kindly to her,

—Handle udder carefully,

—Talk to her.

—Cause cow pain or stress,

—Make cow frightened, or "dread" milking,

—If cow knocks unit off, calm her down before trying to put unit on again.

In conclusion it can be said that sensation of pleasure are reinforced by reward feeding, patting, and tone of voice on approaching cow. Unpleasant feelings are minimised by elimination of unfavourable treatment, especially in the parlour and at calving.

A sound relationship is based on communication and confidence. Thus the competent cowman on top of his job talks to his cows when they are under stress, as during milking. He uses a pleasant voice but at times he displays the necessary dominance, since cows can sense worry in the cowman when he is dealing with them.

VII. **Conclusion—the man management process**

A. Check the formal structure of the farm, i.e. organisation diagnosis and appraisal.
Check chain of commands, communication processes, etc. This overcomes the problem of instruction being given by more than one person.

B. Consider the problems of the interface between animal and man on the dairy farm.

C. Look at the jobs on the farm and modify if necessary using the following criteria which includes positive consideration of human characteristics and needs.
   a) optimum variety of tasks and skills;
   b) some control over methods, pace and sequence;
   c) a meaningful and compatible pattern of tasks making a recognisable contribution;
   d) optimum length of work cycle;
   e) feedback on performance, as far as possible through the work itself;
   f) opportunity for learning and development;
   g) opportunity for contact and collaboration with others.

D. Consider and rate each job on the following criteria:

Skill variety	—	The degree to which skill variety is necessary in a job.
Task identity	—	How far the job is a complete entity.
Task significance	—	The impact of the job on the lives of others.
Autonomy	—	The degree to which the job provides the worker with independence, freedom, and decision making.
Feedback	—	How much effective feedback occurs.
Knowledge	—	Degree to which knowledge is acquired related and used.

E. Attempt to put yourself in the place of the person being managed, examine the following points:

a) Communications:
   i worker must have knowledge of aims of the business;
   ii worker must have information to do job well;
   iii worker must pass on information to supervisors;
   iv worker must feel action is taken on information given.

b) Personal Relationship:
   i teamwork;
   ii close relationship with supervisors;
   iii help and co-operation with colleagues;
   iv worker must feel he can influence his workplace activities, methods and standards.

c) Control:
   i worker must feel he can control his work and methods;
   ii workers must have influence over others whose job affects his work;
   iii group consultation on job methods;
   iv checking of work standards.

d) Leadership:
   i worker must have confidence in top management/immediate superior;
   ii management must try to understand work problems;
   iii management must value and invite opinions on all aspects of the work;
   iv workers efforts must be appreciated;
   v a consistent action and reaction is important.

e) Decision making:
   i decisions should be made on all levels — worker must have opportunity to take decisions;
   ii management must be aware of work problems when it makes decisions;
   iii workers' ideas must influence decisions made.

f) Work targets:
   i workers must be involved in setting targets;
   ii targets must be clearly defined;
   iii targets must be acceptable;
   iv a sense of achievement must be got from the job.

g) Performance standards:
   i ensure job cannot be improved by using new methods;,
   ii avoid waste;
   iii ensure correct training given;
   iv ensure jobs as whole well organised (e.g. all daily jobs not just milking).

   But at all times consider the worker as an individual with individual needs and aspirations.

F. Consider needs of worker's wife and family.

G. The fundamental long term problem is that agricultural workers are finding it increasingly difficult to identify with the goals and objectives of the organisations which employ them. Until the worker is able to modify the goals and objectives of the organisation he will have no incentive to put his best into the job.

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Gabriele Lüttmann, Amsterdam Strasse 2, Düsseldorf.

At home with Kerrygold.

Gabriele Lüttmann has commuting down to a fine art. She lives in Düsseldorf and works in Cologne. And where Gabriele goes, her bicycle goes too - in the boot of the car.

"I'm really a country person," she said. "And I like to spend as much time as I can in the open".

She likes Kerrygold butter and cheese because they have a country fresh taste.

"I know they're Irish and Ireland is still one country that's unspoilt".

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And we're very pleased that people like Gabriele feel at home with Kerrygold.

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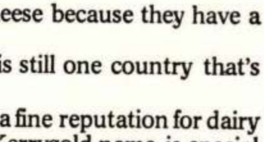

Irish International

SEVENTH RICHARDS - ORPHEN MEMORIAL LECTURE

The Influence of Management on the Control of Brucellosis

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Introduction

Mr. Chairman, I wish to express my thanks to the trustees for inviting me to give this Seventh Edward Richards - Orpen Memorial lecture.

A National Brucellosis Eradication scheme was begun in Ireland in 1966. The position in 1977 is that six counties have been declared free and eight counties are undergoing compulsory blood testing in the clearance area. The remaining 12 counties can avail of the Voluntary Brucellosis Pre-Intensive scheme which was designed to prepare the way for compulsory measures. Northern Ireland also has a Brucellosis Eradication programme which was commenced in 1964 and is nearing completion.

Ireland is an island and there are strict controls on the import of livestock. Therefore the problem is one from within the country. The northern half of the island is almost free of Brucellosis, but has a population of susceptible animals while the southern half has a high prevalence of the disease. In order to improve this situation immediate steps must be taken to reduce the disease prevalence in the southern counties thereby removing the source of further infections in the cleared areas.

The pressure of eradication must be maintained and even accelerated to achieve a successful conclusion[1]. All herdowners must be informed about the reasons for following the eradication programme[2]. Most of all we must strive for an understanding of the disease.

History of the disease

Brucellosis is a disease of animals and man. It is caused by highly contagious Brucella organisms. Formerly, the disease in the bovine was called 'contagious abortion'. This name accurately described the principle symptoms and acted as an immediate warning of the nature of the disease. As far back as 1807 "The Complete Farmer", a journal of the time, described the contagious nature of the abortion and the isolation procedures which should be undertaken. However, the cause of the disease was not identified until 1887 when a British doctor, named Bruce, and his wife isolated an organism from goats milk which was being supplied to the British forces stationed on the island of Malta. Large numbers of the troops contracted "Malta Fever", later to become known as Brucellosis. Bruce stopped the supply of goat's milk and the incidence of new infections dropped dramatically.

In 1897 Bang and Stribolt isolated an organism from aborting cows which was able to reproduce the disease in healthy stock. The causal organism of "contagious abortion" was identified. It was not until 1918 that an American bacteriologist Alice Evans suggested that the organisms described by Bruce and Bang were very similar. This was subsequently proven to be the case and the group of organisms was called Brucella in honour of Bruce who first identified them[(3)].

Several types are now recognised the first being *Brucella melitensis* which caused "Malta Fever" in man. *Brucella abortus* causes contageous abortion in cattle, *Brucella ovis* in sheep, *Brucella suis* in pigs and *Brucella canis* is found in dogs. In Ireland today only *Brucella abortus* is identified, causing abortion in cattle and providing the sole source of human infection.

The disease

Brucellosis in the bovine exhibits one principle symptom, i.e. abortion. The first abortion can occur once cows reach exactly five months pregnant. A majority of the abortions are seen around the seventh month. A cow will usually abort only once and then become a "carrier". Some cows may abort a second and occasionally even a third time.

In the bovine, infection is usually picked up through the mouth. Occasionally infection may occur through cuts on the skin or by splashes into the eye. This can be called "direct infection". If a positive animal calves or aborts unnoticed and unrestricted, pasture, feed and drink may be contaminated by the infected discharges of that animal. Cattle subsequently feeding or drinking the contaminated material could become infected. This can be called "indirect infection". A third pathway of infection is through "latency" where a calf is infected at birth or soon after and carries the infection through to adult life.

Brucella abortus organisms thrive and multiply in the pregnant animal. They only survive for limited periods on pasture, in sheds, etc. The pregnant infected animal therefore can be regarded as virtually the source of infection. All the discharges, foetus and placenta passed at an infected calving or abortion contain millions of brucella organisms. Over 90% of the total infection is passed at the actual calving or abortion. Therefore such animals must be placed under restriction to prevent further spread of the disease.

Brucella organisms are easily killed by heat, drying and the common disinfectants. They survive longer in the cold and could overwinter if frozen. This is unlikely to happen under Irish conditions. The organisms will usually die out within two months in sheds or growing pasture and within three months on land in winter.

The source of the disease and the time of spread is known. Therefore it should be possible to initiate management procedures to bring about its control.

Control of Brucellosis

The key to controlling the disease is to "break the cycle" of infection which occurs from year to year. The basic aim it to restrict the positive cow and her infected discharges at calving or abortion and secondly to maximise within-herd resistance to the disease. This can be achieved by using simple management procedures based on the following principles.

The management procedures come under five principle headings:

(1) Identification
(2) Separation
(3) Calving facilities
(4) Vaccination
(5) Disinfection

(1) *Identification*

There are two main tests for identification of brucellosis positive cows in Ireland. The first, which is used in the Eradication area, is the Blood Test. All blood samples are tested at the National Brucellosis Laboratory, Dept. of Agriculture, 'Thorndale', Dublin 9. The positive cows are ear-punched and sent for immediate slaughter while the remainder of the herd is put under movement restriction or 'locked up' and re-tested until clear.

The second test which is used in the Pre-Intensive scheme area is the Milk Ring Test. This is carried out on bulk (churn) milk samples at the creamery and on the individual cows in positive herds. Under this scheme, where cows are likely to be kept for a period, positive cows should be marked with an easily identifiable coloured ear tag, neck band or code number. This will indicate the brucellosis status of the cows to anybody herding the animals.

(2) *Separation*

The principle method of spread of brucellosis is by direct contact between negative animals and the infected products passed at an infected calving or abortion. It is recommended therefore that once the positive cows are identified plans should be made to separate the positive and negative cows. Ideally, this should be done as soon as pregnant animals reach four and a half months gestation. This will eliminate the possibility of direct contact between positive and negative animals should an abortion occur unnoticed. If separation is not possible at this time then the cows must be carefully herded. A separation may be possible once the cows go dry. Positive and negative cows should never be run together at the same silage face.

In the spring calving herds a farmer chooses a date on which to commence serving his cows. He can then put a reminder on his calendar of the separation date, four and a half months later. In a herd where cows have been calving all the year round a farmer can choose two dates for commencement of service, one for his 'spring' herd and one for his 'autumn' herd. He will then be in a position to know the dates on which his cows will reach four and a half months pregnant.

Under the Eradication Scheme positive cows should be totally isolated because the remainder of the herd are highly susceptible (non-vaccinated) cows. Under the Pre-Intensive scheme, vaccination with the killed 45/20 adjuvant vaccine (K45/20A) is widely practised, earnestly encouraged and is mandatory for replacement heifers. With these animals separation can be effective with as little as an electric fence. However, the best separation possible should be used on each farm. Positive cows could be grazed on separate land or on the paddock behind the grazing rotation. Separate wintering arrangements must be made to avoid putting positive and negative cows together at the silage face.

Herding. The times at which Brucella abortions may occur have been pointed out. There are definite signs to be seen pre-abortion. The principle signs are: (1) sudden springing of the udder, (2) slime at the vulva or on the hind quarters, (3) dropped pin bones (raised tailhead), (4) unusual uneasiness. Pregnant animals showing any of these signs should be isolated until they either abort or settle down. The important point in herding pregnant animals is to inspect the hind quarters. This should be done twice a day.

(3) *Calving facility*

The first requirement in a brucellosis positive herd is that a separate calving facility be provided for positive and negative animals. These facilities should be sited carefully away from the main farm road and with safe drainage, preferably into a separate soak pit. It is also essential that there should be no contact between positive and negative units either directly or via the drainage.

A calving facility can be any of the following:

- (a) Individual calving box
- (b) Tie up shed
- (c) Calving shed
- (d) Loose house
- (e) Small field or paddock

(a) The individual calving box is ideal. All of the discharges passed at the calving or abortion will be restricted and the box can be easily cleaned and disinfected. Even where individual boxes are available a certain number should be allotted to the positive cows and only positive cows should be calved in them. These would be the boxes next to the drainage outlet.

Many buildings have become redundant due to changes in management, i.e. self feed layout. These buildings could be converted into calving boxes to reduce the overall cost, provided they are suitably sited and drained.

(b) The tie up shed or cow byre is a very good system for confining the pregnant and calving cow. The positive cows should be tied together, next to the drainage outlet and by expected calving date. The negative cows can be tied in the shed with an empty standing between the two groups. The negative cows should also be tied according to expected calving date. This will avoid the possibility of cows in mid or early pregnancy becoming infected and having an abortion.

(c) A calving shed which is divided by gates into boxes can be used for one or other group. Sheeting the gates with galvanised iron or hardboard would be a useful addition.

(d) A small field or paddock could be used for either group. This paddock should not be grazed for three months following the last calving.

Any of the above facilities or any combination of them may be used successfully.

Note: The best facility should always be used for the negative cows in case one is incubating the disease and has not been identified as infected. This will help to minimise or eliminate further spread of infection.

(4) *Vaccination*

In the case of brucellosis only a dead vaccine has been used in Ireland since 1968. This is called the killed strain 45/20 adjuvant vaccine (K45/20A). The aim of any vaccination programme is to prevent infection taking place. Therefore the vaccine should be given before animals are exposed to infection. Vaccination of heifers against brucellosis should be carried out when they reach 12 months of age. A primary (essential) course of vaccination comprises two inoculations given 6 to 12 weeks apart. This should be completed before the heifers are served. In infected herds, with abortions occurring each year, booster vaccination should be given annually. In herds without infection booster vaccination can be given every 18 months or two years. This vaccination should be given when cows are non-pregnant so as to try and prevent infection taking place.

It is now widely accepted that some of the cells in the immune system of the animal which are sensitised by vaccination can live for 10 years or more. Therefore the protective effect of brucellosis vaccination can be expected to reduce, slowly, over a number of years.

(5) *Disinfection*

Brucella organisms are quite easily killed by disinfection. Disinfectants should be made up according to the manufacturer's specification and renewed regularly. The Department of Agriculture publishes a list of approved disinfectants for various diseases, including brucellosis, and gives the dilution rates at which they should be used.

A foot dip (basin, bucket, small trough, etc.) should be placed outside each calving facility. Boots should be dipped going in and coming out of each area. All the bedding from the calving facilities should be sprayed with disinfectant (sprayer, sprinkling can, etc.) before removal and stacked separately. Calving boxes, especially those used for the negative cows, should be cleaned out and disinfected between calvings.

When an abortion or calving occurs amongst a group of animals, the cows should be removed immediately and the area thoroughly disinfected. If this occurs while grazing, the herd should be moved on to the next paddock.

Note: Once steps have been taken to control the disease within the herd extra attention should be paid to the farm fencing to ensure that it remains stockproof.

Brucellosis control programme at Moorepark

A brucellosis control programme, based on the principles already discussed, was introduced to the six dairy herds of the Moorepark centre and field stations in the autumn of 1974. All six farms were accepted into the Pre-Intensive Scheme. The overall brucellosis prevalence was 20.9%, varying between herds from 12.8% to 28.9% positive. Herd size ranged from 130 to 250 cows. The total number of cows tested in 1974 was 990.

(1) *Identification*

Routine blood and milk samples were collected simultaneously from each individual cow once the whole herd had calved down. The milk ring test was repeated six weeks later while all the cows were still in lactation. The blood test was repeated when the cows were in mid pregnancy. All the positive cows were marked with a white tag in the left ear.

(2) *Separation*

Due to other on-going experiments it was not possible to separate cows from the middle of the fourth month of gestation. However, a reminder was put on the calendar to commence careful herding of the cows from this time onwards. In general the positive cows were separated once they went dry or as they came off experiment. In Herd E and a small group in Herd A, there was no separation of the positive cows. They remained in their experimental groups for grazing and on silage, but were removed for calving.

The positive cows returned to the milking herd seven days after they passed the afterbirth, provided there was no obvious discharge from the vagina. Until this time the positive cows were milked last.

(3) *Calving facilities*

The calving facilities were arranged to keep the best facilities on each farm for the negative cows.

In Herd A, two four-pen calving sheds were used for calving the negative cows. The positive cows were tied in individual feeding stalls and calved in a pen at the end of the row. The late calving positive cows were calved in the lower of the two calving sheds.

In Herd B the negative cows were calved in a loose house divided into two pens while the positives were calved in two small paddocks.

In Herd C the negative cows were calved in six individual calving sheds while the positive cows were calved in an old cow byre.

In Herd D the negative cows were calved in a large shed divided into six boxes, two at each side opening into two in the centre. The positive cows were calved in a small paddock where an L-shaped galvanised windbreak was provided.

In Herd E the negative cows were calved in a four pen calving shed while the positives were calved in a loose house.

In Herd F in 1974 the autumn calving cows calved in a paddock mixed together before the management programme began. Subsequently positive and negative cows were calved in individual boxes.

(4) *Vaccination*

All cows were booster vaccinated annually in the spring until the positive cows had been removed from the herd. Biennially vaccination will be continued in these herds. The replacement heifers were vaccinated as yearlings before being served. They were blood tested subsequently when 2 - 3 months pregnant. The 'latent carrier' would appear to give a positive result at this stage. Such heifers were then placed under restriction.

(5) *Disinfection*

The disinfectant used in 1974 was "Chloros" while "Jeyes Fluid" has been used since then in all the herds. Any of the other approved disinfectants could also be used. Garden sprayers were used in 1974, 1975 for spraying disinfectant onto bedding, cow's hind quarters, etc., but were somewhat fragile and tended to corrode. Sprinkling cans are now used.

The results from the six individual farms are given in Table 1. Certain changes in farm size and animal numbers occurred which are explained in the following way. Herd A received the majority of both spring and autumn calving cows from Herd F in winter 1974 and spring 1975. Some positive cows were also brought in to facilitate the clearance of brucellosis from other herds, i.e. Herd C, Herd D, Herd E and Herd F. All movements of animals was carried out under permit from the Department of Agriculture.

Herd C was reduced in size due to reduction in farm acreage. Herd D was transferred to a new farm in Spring 1977 following the sale of all known positive cows. Herd E was reduced in size due to reseeding of half the farm. Herd F was made up of 92 heifers which calved as two-year-olds in 1976 and the number was increased to 138 following the introduction of 50 three-year-old heifers in 1977.

The important features to note in the results are the very small number of new positive cows which were identified each year indicating that the spread of the disease had been brought under control in each herd. Gradual elimination of positive cows from the various herds have left four herds free in summer 1977. The three positive cows in Herd D were sold off. Extra replacements have been reared and it is hoped to milk out the positive cows in the remaining two herds in 1978 and not put them back in calf. The new positive cows in 1976 and 1977 are almost entirely second calvers.

The other feature of the results is the high number of positive replacement heifers which were introduced up to 1976. This problem has been overcome by the blood test which is carried out on the heifers at 2 - 3 months pregnant as previously described. The three new heifers in Herd D in 1977 had been exposed subsequent to testing.

The difficulties experienced at the beginning of the control procedures were: (1) the abortion at the end of five months gestation, (2) the occasional very quick premature calving between 8 - 9 months gestation and (3) heifers drinking from contaminated water supplies (river and stream). These problems were dealt with by putting a reminder for herding on the calendar, careful and regular observation of heavily pregnant cows and by providing piped drinking water for the paddocks concerned.

Table 1

Herd	Year	Positive cows (%)	New positive cows	Positive heifers	Total cows
	1974	72 (29)	—	—	250
A	1975	53 (24)	2	0	217
	1976	55 (23)	2	4	237
	1977	58 (27)	3	0	219
	1974	45 (27)	—	—	164
B	1975	30 (19)	1	2	157
	1976	33 (25)	3	8	132
	1977	26 (24)	3	0	110
	1974	17 (13)	—	—	132
C	1975	4 (6)	0	0	72
	1976	1 (1)	1	0	72
	1977	0 (—)	0	0	72
	1974	29 (19)	—	—	150
D	1975	26 (17)	2	6	150
	1976	32 (24)	6	6	132
	1977	3 (3)	0	3	112
	1974	23 (18)	—	—	130
E	1975	15 (12)	1	0	127
	1976	12 (10)	0	0	118
	1977	0 (—)	0	0	75
	1974	21 (13)	—	—	164
F	1975	14 (12)	1	3	115
	1976	0 (—)	0	0	92
	1977	0 (—)	0	0	138

The overall culling rate was approximately 20% and was non selective for brucellosis positive cows.

Milk Ring Test

In order to monitor the Milk Ring Test (MRT) results, simultaneous blood samples were collected from all cows. A comparison of the Milk Ring Test results with the Blood Serum Agglutination test (SAT) results are shown in Tables 2 and 3. Of the 146 cows which were positive to the MRT as interpreted under the Brucellosis Pre-Intensive Scheme, 96% had a simultaneous SAT positive result (Table 2). Much of the difference between these two figures is bridged by looking at the results in Table 4 which show that any cow giving a reading of 2+ (50% agglutination) or greater on the neat milk has more than an 88% chance of being SAT positive.

These results show that the MRT as interpreted under the Brucellosis Pre-Intensive Scheme is identifying positive animals with very few exceptions, i.e. where there is a false positive result. They also show a proportion of suspect reactions which indicate that these cows should, at least, be resampled while still in mid lactation. The disease is dynamic not static. New cows may have become infected and it can take some time for these animals to give a positive result. Again, there is the need for resampling. As approximately 90% of cows become infected in the udder[5, 6, 7] it would appear appropriate that a blood test be carried out, following disposal of the MRT positive cows, to finalise accreditation of the herd.

All tests were carried out using antigens to E.E.C./W.H.O. standards[8] supplied by the Brucellosis Laboratory, Department of Agriculture, 'Thorndale', Dublin 9.

Table 2

Cows with M.R.D.T. positive tests which were also S.A.T. positive through three lactations

	Total cows	Total tests	Cows (%) S.A.T., +	Tests (%) S.A.T., +
M.R.D.T., +	116	231	140 (96)	219 (95)

Table 3

Cows with S.A.T., positive tests which were also M.R.D.T., positive through three lactations

	Total cows	Total tests	M.R.D.T., + cows (%)	M.R.D.T., + tests (%)
S.A.T. +	252	447	140 (56)	219 (49)

Table 4

Relationship between simultaneous M.R.T., M.R.D.T., and S.A.T., titres over three lactations

	M.RT., 4+ (%)	Neg., M.R.D.T., (%)	M.R.T., 3+ (%)	Neg., M.R.D.T., (%)	M.R.T., 2+ (%)	Neg., M.R.D.T., (%)
Total tests	256	54 (21)	93	68 (74)	43	42 (98)
S.A.T., +	248 (97)	51 (20)	85 (91)	62 (67)	38 (88)	37 (86)

The 'latent carrier' heifers appeared to be identified by a blood test, as described earlier, carried out after vaccination and service but before they reached five months gestation, i.e. at 2 - 3 months pregnant. The figures for 1976 -'77 (Table 5) show that the four positive heifers represent approximately 1% and come from positive herds rather than just from positive dams. Once these heifers are identified they must be removed and placed under restriction. The remaining heifers should still be herded carefully in case of subsequent exposure. It is the early unnoticed abortion amongst a group of heifers which can lead to a high number of infected replacement animals.

Table 5

The number (%) of 'latent carriers' in a given population of heifers over two years

	Total heifers	No. (%) positive	Positive dam	Negative dam
1976	126	1 (0.8)	0	1
1977	236	3 (1.3)	1	2

Discussion

The results obtained over three years in Moorepark using basic management techniques in the control of Brucellosis suggest that such procedures will give a satisfactory outcome for the extra amount of thought and effort required to operate them. Control is not 100 per cent but it so radically slows down the spread of the disease that by selling off the known positive animals the source of spread within the herd is eliminated. Thus your problem is reduced to a minimum at which stage eradication is very possible.

The approach to be adopted is very straightforward. The extent of the problem must be discovered by testing the herd and the within herd resistance must be maximised by vaccination. Then, the farmer can decide, with the help of his Veterinary and Agricultural advisers, how he can handle the separation and calving of positive and negative cows on his farm. All a herdowner can do is to use the facilities which are already available on the farm. He should plan and organise for any necessary improvements and herd the pregnant animals carefully at the appropriate times.

A knowledge of the disease pattern, which is very consistent, gives the farmer the opportunity to intervene at the appropriate time and 'break the cycle' of the infection, thereby bringing Brucellosis under control. Once he can control the disease he can plan a culling and replacement programme to eliminate the disease as quickly as is economically possible. Three years should be the maximum timescale for any herd.

The Pre-Intensive Brucellosis Scheme has been in operation since 1973 based on the Milk Ring Testing (MRT) of bulk milk at the creamery and the individual cows in positive herds. The aim of this Pre-Intensive or Pre-Eradication Scheme is to reduce the pool of infection in advance of the compulsory blood test and slaughter policy. It has not suceeded in its aim despite the supportive intervention of the major Co-Operatives. Therefore we find ourselves in the position that most of the 12 counties in the non-eradication area still have too high a prevalence of the disease.

One half of the country has very little brucellosis and the other half has a high prevalence. It is unrealistic to expect that further progress can be made in the Eradication areas while the remainder of the country has such high infection levels. We must concentrate and accelerate our efforts in the southern counties in order to reduce the source of spread of the disease. What I would suggest, keeping in mind the ability to control the disease and the time necessary for the economic removal and replacement of positive animals, is a three year Compulsory Pre-Intensive Scheme, to be followed immediately by compulsory blood test and slaughter.

During the three year period dairy herds would continue to be MRT tested along the lines I have suggested and the beef herds could be tested by an accurate, rapid and cheap screening blood test. All positive animals would be punched and their identity cards collected. Bonuses, as now, would be paid on slaughter of these animals. A clear blood test would be the accredtiation test for all herds.

This would mean that as many positive animals as possible would be identified quickly and their access to the open market restricted. It would give time for the rearing of extra replacements to maintain stock numbers and positive cows could be milked out and culled at the end of lactation. The use of the brucellosis vaccine (K45/20A) would continue and should be greatly encouraged over this period to boost within herd resistance.

Brucellosis is dynamic not static. We must keep the pressure on to reduce the disease prevalence. This point is emphasised by Hugh-Jones in his recent "Evaluation of Brucellosis Eradication in England and Wales"[(9)]. He also emphasised the need for the constant review of eradication policy. We have a very good series of tests available which can be strategically applied to the problems of the individual herd. All we need is the will to do the job and the confidence that we will be successful.

Acknowledgments

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The Brucellosis programme was drawn up in consultation with Professor Brendan Cunningham, Department of Veterinary Pathology, University College Dublin, Veterinary College, Dublin 4.

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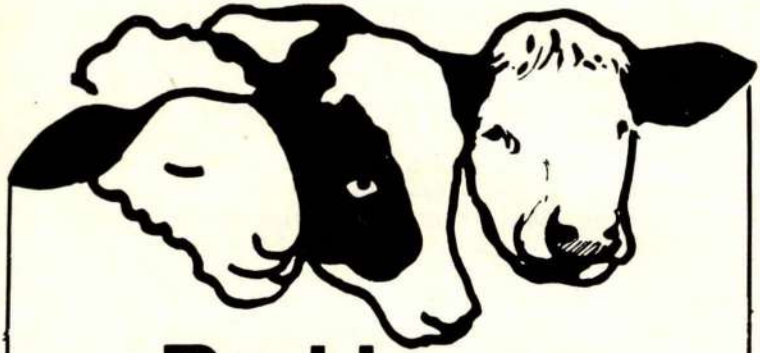

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SWARD PROCESSES UNDER GRAZING

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A grazed perennial ryegrass (S24) sward was analysed in detail during 13 months from 1st February 1977 until late Marsh 1978. In the analyses, emphasis is being placed on the identification and quantification of the factors affecting daily grass growth rate during the rest period. The factors considered are (a) climate, (b) physiological and (c) management. The climatically determined growth rates were calculated using relationships obtained from published work. Both temperature and radiation markedly depressed growth rate before May and after September. Drought depressed growth rates during July and August. The climatically determined rates were compared with observed growth rates. The results show that the calculated growth rate overestimates growth rate in the May-June period by a factor of about two and underestimates growth rates at the end of the season (September-October) by a factor of about two. This discrepancy between calculated and observed growth rates is attributed to the effect of flowering which is averaged over the season in the calculated data. The results indicate that the growth rate of a reproductive sward is three to four times as great as the growth rate of a vegetative sward. The difference in growth rate between reproductive and vegetative swards was largely due to the difference in leaf net assimilation rate. The difference in leaf net assimilation rate was only partly accounted for by differences in solar radiation receipt.

GRASS PRODUCTION AND EARLY FAT LAMB PERFORMANCE ON SOD SEEDED OLD PASTURES AT BELCLARE

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The climate in the west of Ireland is favourable for the production of early grass but this potential is difficult to exploit where old permanent pastures predominate. If early growing grasses are established in old pastures by the "stitching-in" technique, they could considerably improve the potential for early grass growth.

RVP Italian ryegrass was successfully stitched into old pastures in 1974. Pastures were grazed bare, sprayed with gramoxone at 700 ccs/ hectare and RVP sown with a Bettinson 3 D, (17.8 cm spacing) at 19 kg seed/ha in mid-July or early September. A sowing was also made after a silage cut in early September, without using gramoxone.

Establishment of Italian ryegrass was satisfactory on each site, though somewhat better on grazed and sprayed sites than after silage. Spraying pastures in early September reduced autumn growth by about 600 kg D.M./ha.

Yields were measured in 1975 and 1976 in a simulated three cut silage system on plots receiving 0, 50 or 100 kg N/ha for each cut. Total yields were highest on stitched in plots, the difference being about 900 to 1,500 kg/ha or 12 to 15 per cent. The benefit of Italian ryegrass was most noticeable in spring and in pasture recovery after cutting, especially during dry periods.

Old and stitched-in pastures were grazed with an early lambing ewe flock from late February through April and stocked at 7.5, 12.5 or 17.5 ewes plus lambs per hectare. The extra grass on stitched-in paddocks was reflected in improved liveweight gain in lambs, at all stocking rates in 1975 and at the low and high stocking rates in 1976.

The response to stitching-in Italian ryegrass looks promising, but the management of Italian in an old pasture in relation to dates of silage cuts needs attention.

THE DIGESTIBLE AND METABOLISABLE ENERGY OF GRASS JUICE FOR GROWING PIGS

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The mechanical pulping and squeezing of high moisture forage crops produces a protein rich juice and an ensilable high dry matter crop residue. The juice contains 6-10% dry matter of which 30-35% is crude protein having 6.5% lysine. For grass crops harvested at four week intervals throughout the season the juice extract contains approximately 30% of the total dry matter production and 45% of the crude protein.

A digestibility trial was conducted to establish the digestible energy (DE) and metabolisable energy (ME) of grass juice for growing pigs. The grass juice was prepared from a late autumn cut of a tetraploid ryegrass. The juice, concentrated to 11% DM (4.2% CP, 2.6% ash) and preserved with HCl and Sodium Metabisulphite, was used to replace 30% of the organic matter in a barley-soyabean ration fed in the preliminary period. Five pigs of initial weight 37-39 kg were used in metabolism crates.

The basal diet had dry matter digestibility (DMD) and organic matter digestibility (OMD) values of 82.1 and 89.5% respectively. The digestibility of grass juice dry matter and organic matter (calculated by difference) was 69.9 and 90.9% respectively. The determined DE and ME values for grass juice on a dry matter basis were 9.89 MJ/kg and 8.17 MJ/kg. The corresponding values on an ash-free basis were 12.68 MJ/kg and 10.51 MJ/kg.

SILAGE EFFLUENT AS A SOURCE OF NUTRIENTS FOR THE GROWING PIG

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In preliminary studies effluent was readily consumed by the pig without toxic effects. In two subsequent experiments littermate pairs of pigs were individually-fed either a meal plus water control diet or an effluent containing diet in which silage effluent formed 150 g/kg of dry matter fed. All pigs were fed to a scale based on metabolic body weight.

In the first experiment, freshly collected effluent from two sources was offered over a liveweight range of 64 to 85 kg. The daily gains were 719, 715 and 753 ± 16.8 g and feed : gain ratios were 3.07, 3.10 and 2.94 ± 0.075 g for the control and two effluent treatments respectively. In the second experiment effluent was stored for 3.5, 14, 28, 56, 112 or 240 days before being given to pigs. Initial and final liveweights were 33 and 83 kg respectively. Littermate pairs of pigs were allocated to a stored effluent treatment and a contemporary control treatment as the stored effluents were not available for testing simultaneously. The use of contemporary control treatments permitted adjustment of means for differences in time. The overall mean daily gains on the effluent and control diets were 646 and 655 ± 7.5 *g respectively. For the same comparison the mean feed : gain ratios (DM basis) were 2.69 and 2.64 ±0.03 *g and subcutaneous fat contents of the rump back joint were 271 and 279 ± 5.6 *g/kg respectively. None of these differences were significant. Pig performance did not deteriorate with increasing period of effluent storage.

An experiment is currently in progress in which the performance of pigs given an all-meal or effluent containing diet is being compared in both individual and group-penning situations. Results to date indicate that performance on the diet containing silage effluent is as good as on the all-meal diet in both cases.

The experimental work to date has shown that effluent can replace 150 g/kg of the dry matter of the finisher diet of bacon pigs resulting in a substantial saving in feed costs.

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* Standard error of difference

LABORATORY STUDIES ON GRASS SILAGE

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About 25% of farm silages in this country are poorly preserved with pH values of 4.7 or greater. In an attempt to explain this result the effects of nitrogen fertiliser, wilting, grass genera and ensilage technique on silage fermentation were examined in laboratory silos.

In three experiments, application of N seven weeks before cutting had little effect on silage quality. Wilting was unreliable.

Grass genus had a very significant effect. It was possible to rank grasses for silage making as follows: ryegrass, good; old permanent pasture, timothy, tall fescue, bent grass, red fescue, moderate; yorkshire fog and cocksfoot, poor.

Speed of filling had a large effect and slow filling, accompanied by heating may account for much poor silage.

Results for 800 silages relating grass, water soluble carbohydrate (WSC) and silage pH are tabulated and suggest that a WSC level of 14% of DM (3% in juice) is required.

Physical chemistry calculations show that pH in silage is largely the result of interaction of lactic acid and ammonia.

ANALYSES OF SILAGE SAMPLES — RESULTS 1970-77

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A study was made of 3,877 samples of silage received at Dunsinea from Agricultural Advisers between 1970 and 1977.

Results of chemical analyses are given in Table 1.

Table 1

Chemical composition of silages: means ± standard deviations

Year	No of. samples analysed	pH	Dry matter (%)	Crude protein (%)	*In vitro* dry matter digestibility %
1970-74	1520	4.3±0.63	21.3±4.5	12.7±2.4	63.1±6.3
1975	632	4.3±0.59	23.8±5.4	13.1±2.5	65.3±6.2
1976	1016	4.5±0.61	20.8±4.9	12.8±2.2	61.8±7.0
1977	709	4.5±0.51	24.2±5.6	14.1±5.1	67.8±6.0

In 1977 the percentage of silages with values for pH of 4.2 or less, 4.3 to 4.5 and above 4.5 were 29, 40 and 31 respectively.

The percentage of samples using an additive is shown in Table 2.

Table 2

Use of additive (%)

Additive	1970-74	1975	1976	1977
None	61	70	75	55
Formic acid	22	14	14	32
Molasses	11	6	5	8
Other	6	10	6	5

The percentage of silage conserved in each month in 1977 was May, 22; June, 42; July, 17; August, 13; September, 5 and October, 1. Also in 1977, there was an increase in May silage compared to 1976.

Between 1970 and 1976 there was little improvement in silage quality. While in 1977 dry matter and crude protein content increased as did *in vitro* dry matter digestibility, preservation was poor. There was a trend towards earlier cutting and an increased use of additives in 1977.

FEED FACTORS AFFECTING INTAKE AND BEEF PRODUCTION BY SILAGE FED CATTLE

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While it has for long been recognised that digestibility is the major factor determining intake and animal production potential of dried forages, this relationship has been less well defined for silages. The apparent inconsistency in the relationship for silages has to some extent been attributed to the nature of the ensiling fermentation and to a depressing effect of extensive fermentation on silage intake. Consequently it has often been considered desirable to increase the dry matter content of herbage by wilting before ensiling in order to restrict the fermentation and raise the feeding value of the silage.

Analyses of the results of Grange feeding trials in which 40 different but well preserved silages were fed show a clear relationship between dry matter digestibility (DMD) and production by 400-500 kg beef cattle. DMD values of 61%, 66%, 69% and 74% have been associated with daily liveweight gains of 250 g, 470 g, 670 g and 860 g respectively. Daily carcase gain has been 560 g on several of the silages in the 74% DMD class. It must be noted that production on 74% DMD silage is close to that expected on similar cattle over an entire grazing season. This suggests that proper ensiling may have little or no effect on the production potential of herbage.

The results of several trials comparing forages differing in dry matter content have shown no beef production advantage in favour of higher dry matter forage.

An attempt was therefore made to quantify the effects of dry matter content and of ensiling *per se* on the intake and production potential of herbage. During summer 1977 two groups of 10 cattle were fed either fresh grass or grass wilted for 24 hours. The trial was continued for 15 weeks. In the middle of each week fresh and wilted grass, representative of the herbage fed in that week, was ensiled. The silages were fed in sequence after four months storage to two groups of 10 cattle. Similar animals (initial liveweight 435 kg) were used for grass and silage parts of the experiment. The mean daily dry matter intakes of unwilted and wilted grass and silage were 1.98, 1.90, 1.86 and 1.89% of mean liveweight. The corresponding daily carcase gains were 420 g, 430 g, 430 g and 370 g.

These results indicate that a well preserved silage can support the same level of beef production as the grass from which it is derived and that dry matter content *per se* does not raise the beef production potential of forage.

EFFECTS OF CARBOHYDRATE AND NITROGEN SUPPLEMENTATION ON THE INTAKE AND UTILIZATION OF SILAGE BY SHEEP

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The efficiency with which nitrogen (N) in silage is utilized may be restricted by degradation of herbage protein to non-protein nitrogen (NPN) during ensilage. In addition, fermentation of soluble carbohydrate during ensilage may limit the energy available for ruminal microbial protein synthesis.

The effect upon animal performance of feeding grass silage alone or supplemented with protein (casein, 17.1g/kg fresh silage), NPN (urea, 4.56g/kg) or soluble carbohydrate (sucrose 20.6g/kg) was studied using 12 store wether lambs in a triple 4 x 4 Latin Square experiment. Parameters measured included voluntary intake, rumen fermentation and blood metabolites. Eight of the sheep were kept in metabolism cages for digestibility and balance studies. Each period lasted 21 days with excreta being collected over the final 10 days.

The silage used was of good quality as indicated by its composition and the performance of animals when receiving silage alone. The effects of supplementary casein and urea were similar; DM intake was depressed by 12-13% and the animals lost weight, whilst levels of rumen NH_3 and serum urea, intake and urinary excretion of N were raised. Supplementary sucrose did not significantly affect intake or liveweight gain but reduced rumen pH and raised blood glucose levels. Dry matter digestibility, blood pH and N retention were not significantly affected by treatment.

THE EFFECTS OF CEREAL PROCESSING AND OF ZINC SUPPLEMENTATION ON THE PERFORMANCE OF LAMBS

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A factorial design experiment was carried out with 42 early weaned lambs fed barley based concentrate ration in which the barley was fed either whole or loose, ground and loose or ground and pelleted after mixing with other ingredients. In addition, with each main plot treatment the effect of a high level of zinc supplementation (400 ppm) was compared with a low level (34 ppm) in relation to the protective effect of zinc against copper toxicity.

Live-weight gain was similar for the three barley treatments at approximately 320 g/day, but the food conversion ratio was significantly better on the whole barley treatment. This treatment resulted in a higher ratio of acetic to propionic acid in rumen fluid of the lambs accompanied by a higher pH. There was no appreciable effect of barley treatment on the melting point or fatty acid composition of subcutaneous or perinephric fat of the lambs.

Copper toxicity did not occur on any treatments but the storage of copper in liver was considerably reduced by the high zinc supplementation. Copper storage in liver was higher on the pelleted than on the unpelleted diets. The high zinc supplementation improved food intake and live-weight gain of the lambs. It did not affect the pH or volatile fatty acids in the rumen fluid or the melting point and fatty acid composition of the carcass fat.

REPLACEMENT OF CONCENTRATES WITH ROOTS IN THE DIET OF EARLY WEANED LAMBS

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In a system of accelerated lamb production, i.e. three lamb crops in two years, the lambs are weaned at 5-6 wks. of age and subsequently reared on a concentrate diet. To reduce feed costs, two experiments have been carried out to determine the extent that concentrates can be replaced with pulped roots in the diet of such lambs. The lambs were introduced to concentrates as a creep feed at three weeks of age, weaned onto concentrates at 5-6 weeks and after a transitional period of 7-10 days were allocated to diets in which concentrates were replaced by varying proportions of roots. The roots were supplemented with soya bean meal to provide 16% crude protein in the dietary dry matter (DM), similar to the concentrate diet, with minerals plus vitamins added. The lambs were slaughtered at 38 kg liveweight.

In Trial 1, the proportion of concentrates fed in the diet from weaning until slaughter was 100, 75, 50 and 25% of the total DM intake. Intake of concentrates in the mixed diets was either restricted or reduced gradually, with roots fed to appetite. The roots fed consisted of a high DM fodder beet variety Monorosa (19% DM).

In Trial 2, the proportion of concentrates fed was 100, 50, 25 or 5% of total intake. In this case a low DM root, yellow globe mangel (10% DM) was used.

Daily liveweight gains in Trial 1 were 284, 263, 278 and 262 g/day on the diets containing 100 to 25% concentrates, respectively. Replacing concentrates with a high proportion of roots (75%) increased days on trial (90 to 96 days) increased daily DM intake/lamb (937 to 990 g) and total DM intake (86 v 98 kg/lamb) and resulted in an increase in feed conversion ratio from 3.33 to 3.80 kg DM/kg lamb gain.

In Trial 2, daily liveweight gains were 272, 273, 265 and 260 g/day for diets containing 100 to 5% concentrates respectively. As in Trial 1, replacing concentrates with a high proportion of roots supplemented with protein and minerals (95%) resulted in a longer fattening period (89 v 97 days), a higher daily DM intake (876 v 985 g/lamb/day) and total intake (78 v 96 kg/lamb) and an increased feed conversion ratio (3.31 v 3.82 kg DM/kg lwt. gain). There were no differences between diets in carcass weight, killing out % or gut contents in either trial.

The results indicate that pulped roots, supplemented with protein, minerals and vitamins, can substantially replace concentrates in the diet of early weaned lambs at approximately half of the cost, resulting in only slight reduction in lamb growth rates but with an increase in feed conversion rate due to the higher DM intakes of roots. Lambs were able to consume large amounts of roots even of a low DM content at a relatively young age. Assuming that the soya bean meal supplement used was equivalent to the concentrate diet in energy value, then 1 kg concentrate DM was equivalent to 1.2 kg root DM in terms of feed conversion efficiency to liveweight gain.

THE RELATIVE EFFICIENCY OF FOOD UTILIZATION BY FRIESIAN BULLS AND STEERS

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A combined nutritional balance and comparative slaughter trial using 20 animals compared Friesian male (E) and castrate male (C) cattle when pair fed at two planes of nutrition (M and H) over the liveweight (LW) range 130-400 kg. Animals were placed on nutritional balance on four occasions during the period. Liveweight gains for each treatment were (kg/day): EH 1.10, EM 0.91, CH 0.93, CM 0.79. There were no significant differences between the digestive efficiency of bulls and steers.

Preliminary results for the carcass data showed that the bulls produced slightly more lean meat and less fat than the steers. Chemical analysis of the edible portion of the carcass showed that bulls deposited more protein and significanlty less fat. Daily carcass protein gain was significantly higher for the bulls but daily carcass energy gain was not significantly different.

	Bulls	Steers
FCR (kg DM per kg liveweight gain)	5.37	6.43
ME requirement (per kg LW gain)	59 MJ	72 MJ
ME requirement (per kg carcass meat deposition	124 MJ	159 MJ

THE GENETIC IMPROVEMENT OF LOWLAND SHEEP

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The lowland ewe population in this country consists of purebred ewes of lowland breeds (mainly the Galway breed) and ewes derived from the hill breeds (Blackface Mountain and Cheviot). Since hill breeds contribute to the lowland population, their role must be examined when considering the genetic improvement of this population. It is well established that biological efficiency and economic efficiency are both strongly influenced by variations in the number of lambs reared per ewe. That this aspect of our lowland sheep population needs to be improved is clear when our ewe flock performance is compared with that of the United Kingdom and N. Ireland. The following results emerge when the performance of lowland spring lambing flocks is examined :

No. of lambs reared per ewe to the ram		
U.K.	—	1.43
N. Ireland	—	1.35
Ireland	—	1.20

Our level of output per ewe is 20% below that in the U.K. From the results of ewe breed comparisons in Ireland and the U.K., it can be concluded that most of the difference between the two countries is due to the genetic limitations of our main lowland breed—the Galway.

A long term selection experiment for increased litter size has been underway in a Galway flock since 1964 and to-date a response of 15% has been achieved. However, while this shows that within breed selection can increase litter size, the rate of improvement, when viewed against the required improvement in the national flock, is such that this approach is not likely to generate appreciable change in the national Galway flock before the end of the present century. Consequently, immediate improvement of the Galway breed must be pursued through crossing to introduce genes for increased prolificacy. Results under research and commercial conditions have shown that $\frac{3}{4}$ Galway x $\frac{1}{4}$ Finn ewes give an increase of 0.3 to 0.4 in litter size compared with the Galway. In addition, gross margin per ewe has increased by up to 40%.

It is concluded that, since the hill breeds are more prolific than Galways (under lowland conditions), crossbred ewes from hill breed mothers should form as large a portion as possible of the lowland population. The remainder of the lowland flock should be improved Galway types like the $\frac{3}{4}$ Galway x $\frac{1}{4}$ Finn. If this objective was attained and improved ram strains were used as sires of the crossbred ewes, then lambs reared per ewe could be rapidly increased to 1.45 for our lowland sheep industry.

SUPEROVULATION AND EGG TRANSFER IN THE EWE

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During the autumn of 1977, 46 adult ewes were treated with a horse anterior pituitary extract (HAP) in association with intravaginal progestagen to induce multiple ovulation. The ewes were bred by artificial insemination at a predetermined time after the end of HAP treatment. Prostaglandins ($PGF_{2}\alpha$ and E_2) were added to the diluted semen used in the insemination of 17 sheep. Laparotomies, performed for the purpose of egg recovery, showed that all of the inseminated ewes had ovulated, shedding a total of 362 eggs of which 246 were recovered. Addition of prostaglandins to semen resulted in a significantly higher percentage of fertilized eggs.

A total of 43 fertilized eggs which had been stored in the ligated rabbit oviduct were transferred at rates of one to four per animal to the uterine horns of 18 adult recipient ewes using local anaesthesia and a laparotomy crad'e for rapid egg transfer; 12 ewes became pregnant with a total of 25 foetuses.

FACTORS AFFECTING OESTROUS BEHAVIOUR IN BEEF CATTLE

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Difficulty in detecting oestrus is a limiting factor in the use of artificial insemination in beef cattle. Oestrus behaviour was induced in ovariectomised (OVX) beef heifers using oestradiol cyclopentylpropionate (ECP) and the time from ECP injection to onset of oestrus behaviour and the duration of oestrous behaviour was recorded.

ECP administration at various times in relation to the removal of a progesterone releasing intravaginal device (PRID) showed that administering ECP 24 hours before PRID removal significantly increases the time from ECP injection to onset of oestrous behaviour. An injection of progesterone at the onset of oestrous behaviour significantly shortened its duration in OVX heifers given ECP but did not shorten the duration of oestrus following PRID removal in intact heifers. In the intact heifers, the interval from the end of oestrus to ovulation was longer in those that received progesterone at the onset of oestrus than in those that did not.

Subjecting the OVX heifers to stress before ECP injection did not affect either the time from ECP injection to the onset of oestrus behaviour or the duration of oestrus behaviour.

HALOTHANE SENSITIVITY AND MEAT QUALITY IN IRISH PIGS

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The improvement of the pig as an efficient meat producing animal has been associated with two closely related problems, namely, an increase in the susceptibility to stress which may cause sudden death during handling and transport for example, and an increasing incidence of pale, soft and exudative (PSE) meat which is an undesirable raw material for manufacturing processes.

In recent years Dutch research workers have found that stress susceptible pigs show an adverse reaction to the anaesthetic gas halothane. As a result of this, a specific test has been developed whereby pigs which react positively to halothane are considered to be susceptible to stress and likely to produce PSE meat.

A total of 464 young pigs entering one of the two national testing stations have been subjected to the 'halothane test' between October 1976 and February 1978, comprising 350 Landrace, 66 Large White and 48 Irish Welsh. The average weight at testing was 24.5 kg. A total of 19 pigs reacted positively to the test, 16 (4.6%) of the Landrace and 3 (6.3%) of the Irish Welsh. No reactors were found in the Large White breed.

Meat quality data in the form of pH_1 readings were analysed for 549 pigs (castrates, females and culled boars) from the two national test stations for the period May 1976 to January 1977. The mean pH_1 values were 6.14 ± .02 (258 pigs), 6.31 ± .02 (284 pigs) and 6.12 ± .12 (7 pigs) in the Landrace, Large White and Irish Welsh breeds respectively. The pH_1 in eight slaughtered reactor pigs was 5.88.

While the incidence of reactors was relatively low in Ireland, it was concluded that in order to prevent an increase in the incidence of halothane sensitivity and the undesirable effects associated with this condition, all young boars of the Landrace and Irish Welsh breeds submitted for performance testing should be routinely tested with halothane, and that reactors should be culled.

EFFECT OF TEMPERATURE AND HUMIDITY ON SOWS AND LITTERS

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Two experiments were carried out in controlled environment rooms at Moorepark. The first experiment involved 16 sows at each of two temperatures 27°C and 16°C from day 110 of pregnancy to weaning at 31 days old. Sow feed intake was significantly higher ($P<0.01$) and lactation weight loss lower ($P<0.05$) at 16° C. The newborn pigs at 16°C had lower rectal temperatures at 12 hrs ($P<0.01$) and 36 hrs of age ($P<0.05$), and were heavier at weaning ($P<0.05$). Sow respiration rate and rectal temperature were higher at 27°C both before farrowing ($P<0.01$, $P<0.10$ respectively) and after farrowing ($P<0.01$ and $P<0.05$).

In the second experiment two levels of humidity 75-80% and 67-70% RH were compared at 27°C with 24 sows on each treatment. None of the parameters measured including sow feed intake, sow weight loss, sow respiration rate and rectal temperature, was significantly affected by treatment.

INHIBITORY SUBSTANCES IN MILK

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The presence of antibiotics in milk is an inevitable consequence of the treatment of dairy cows with these drugs. The persistence of antibiotic residues depends upon the antibiotic itself, the complete formulation of the product, the route of administration to the animal and is further subject to wide individual variations within the animal itself.

There is intense competition in the veterinary antibiotic market with at least 40 separate organisations marketing their own brand of product. There are at least 70 different formulations of intramammary tubes on the market with a further 86 or more injectable preparations of antibiotics. Each one of these products require to be tested to determine effective withholding times for milk.

The market requirement for milk is that it should be free from antibiotics, i.e. there is a zero tolerance set for the presence of antibiotics in milk. Reputable scientists recognise that this is a scientific impossibility and merely means that no antibiotic must be detected in milk irrespective of what test is used. The tests used to detect antibiotics in milk are generally non-specific in nature and are referred to as tests for inhibitors. The TTC and Inter tests have been widely accepted both here and in the U.K. for a number of years. However, a newer more sensitive test known as the DELVO P test is now gaining broad acceptance in Ireland and is creating problems for the pharmaceutical industry, the milk producer and the consumer. Attempts to clarify some of the issues involved were discussed.