A comparison of confinement and grazing systems for dairy cows:

What does the science say?

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Driving Excellence & Innovation

RESEARCH TEAM

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EXECUTIVE SUMMARY

Within Northern Ireland, milk production systems have traditionally involved cows grazing during the summer months. However, in recent years the adoption of fully housed systems (**total confinement**) or systems involving part-time housing during the summer (**partial confinement**) have become increasingly common. In addition, there is growing interest in '**zero grazing**' systems in which herbage is harvested daily throughout the summer period and offered to housed cows.

While there may be many valid reasons for the increasing adoption of confinement type systems, the relative merits of confinement versus pasture based systems are frequently debated, often in the absence of scientific evidence. To address this issue, AgriSearch commissioned a review of scientific studies examining these different systems. While the full review will be available shortly on the AgriSearch website, key findings of the review are summarised in this booklet.

EFFECT OF SYSTEM ON MILK YIELD, MILK COMPOSITION AND BODY CONDITION SCORE

- Four studies compared cows in t**otal confinement systems offered concentrates** (average, 9.9 kg/cow/day) with **grazing cows receiving no concentrate**. Across these studies confined cows had higher dry matter intakes (+ 4.2 kg day), higher milk yields (+ 7.6 kg/day), and higher fat + protein yields (+ 0.46 kg/day), and a higher body condition score (2.9 vs 2.5), than the grazing cows. However, milk composition was unaffected.
- Ten studies compared cows in **total confinement systems offered concentrates** (average, 12.3 kg/cow/day) with **grazing cows offered lower levels of concentrates** (average, 7.5 kg/cow/day). On average, across these studies confined cows had higher dry matter intakes (+ 2.3 kg/day), milk yields (+ 4.0 kg/day), fat + protein yields (+ 0.29 kg/day) and a higher condition score (2.8 vs. 2.6), than grazing cows. Milk protein content did not differ between systems, although milk fat content tended to be higher for confined cows (3.75 vs. 3.54%).
- A recent study at AFBI-Hillsborough compared cows in **total confinement and grazing systems offered the same concentrate level** (8.0 kg/cow/day). Daily milk yield was unaffected by treatment, although milk fat content was reduced with the grazing system (3.80 vs. 4.27%), resulting in a reduction in daily fat + protein yield (1.94 vs. 2.11 kg/cow). Grazing cows also completed the study with a lower body condition score than the confined cows (2.4 vs. 2.6).
- In general, across the studies comparing total confinement and grazing systems, confined cows had higher milk yields and body condition scores than grazing cows. In addition, milk fat content was normally higher within confinement systems due to silages normally having higher fibre levels than grazed grass.
- **Partial confinement systems** typically involve day-time grazing and night-time housing during summer months and are aimed at combining the benefits of confinement and pasture grazing systems. Across seven relevant studies, cow performance did not differ between partial and total confinement systems.
- Only two studies were identified in which the performance of **zero-grazed** and pasture-based cows were compared, with both studies undertaken in Switzerland. These studies found no differences in milk yield, milk composition, milk solids yield, or cow condition score. The use of zero-grazing, and its effects on herbage utilisation efficiency and land requirements, has not been examined under UK conditions, and consequently this is an area where future research is required.
- **Effects of system on the type of fat in milk**. Milk 'fat' is made up of approximately 400 different types of fat, and consumers are increasingly interested in the fat profile of the dairy products they consume. The 'less healthy' fats are generally referred to as 'saturated fats', and, results from 16 experiments clearly demonstrated that these are found in higher levels in the milk of cows in confinement systems. In contrast, the 'more healthy' fats, which are generally referred to as 'unsaturated fats', are found in higher levels in the milk of grazing cows, including a particular fat called CLA (conjugated linoleic acid) which has been linked to a number of potential health benefits in humans.

EFFECT ON ANIMAL HEALTH AND WELFARE

- **Lameness**. Ten studies showed increased levels of lameness/poorer foot health in cows with limited or no access to pasture. The increased levels of lameness observed in confined cows are likely due to the concussive effects of concrete flooring on hooves, or increased contact between hooves and slurry.
- **Mastitis**. A number of studies found higher somatic cell counts and higher levels of clinical mastitis in confined cows compared to those within grazing systems. This may reflect a greater general pathogen load and reduced hind-limb cleanliness within housed environments.
- **Other health problems**. Cows within confinement systems are at increased risk of uterine disease (metritis and endometritis), becoming a downer cow, and of certain infectious diseases (e.g. salmonellosis). In contrast, cows in grazing systems are at increased risk of nematode gut parasites and liver fluke.
- **Mortality risk (death and euthanasia)**. A number of studies found that cow mortality levels are greater within confinement than within grazing systems.
- Six studies examined if cows had a **preference for pasture over indoor housing** when given a choice. The results from five out of the six studies were consistent, with cows on average spending 62% of their time at pasture, and 38% of their time indoors, indicating a slight overall preference to spend time at grass.

  However, there were important differences according to the time of day. During the daytime cows either had a preference to be indoors (where fresh silage/concentrate was available), or else spent similar amounts of time indoors and outdoors. However, at night cows preferred to spend time at pasture, most likely because it offered a more comfortable resting place than in housed cubicles.

EFFECT ON FERTILITY

- Few studies have compared the fertility of cows in confined and grazing systems. However, the evidence available suggests that cows in grazing systems have improved ovarian activity following calving and improved heat expression, while having decreased incidences of early pregnancy loss, uterine disease and difficult calvings. However, there was no consistent evidence of either improved pregnancy rates or shorter calving intervals within grazing systems.

ENVIRONMENTAL IMPACT

- The two main environmental challenges arising from dairy farming in Northern Ireland relate to emissions of greenhouse gases (GHG) and nutrient enrichment of watercourses.
- The impact of system (confinement vs. grazing) on **GHG emissions** was inconsistent, two studies finding no effect of system on emissions, three finding higher emissions with confinement systems, and one finding higher emissions with a grazing system. If efficiently managed, the carbon footprint of contrasting milk production systems can be very similar.
- Many rivers and lakes in Northern Ireland contain high levels of **phosphorus** (and therefore are eutrophic). Two studies found confinement systems to have a higher eutrophication potential (i.e. potential for higher phosphorus losses to watercourses) than grazing systems, while a third study found these systems to have similar eutrophication potential. Irrespective of system, all famers must take precautions to minimise phosphorus losses to the environment.

ECONOMIC SUSTAINABILITY

- No UK or European studies comparing the economic performance of confinement and grazing systems were identified. However, results from a long term North American study demonstrated that grazing farms were more profitable (per hundred litres of milk, per cow, and per hectare) than confinement farms. In addition, confinement farms were more exposed to financial risk, with this reflected in a greater variability in annual profits.

SUMMARY OF THE BENEFITS OF CONFINEMENT AND GRAZING SYSTEMS IDENTIFIED IN THIS REVIEW

- **Benefits of confinement systems**
  - Increased intakes, milk yields and yields of milk solids, although little effect on milk composition
  - Improved energy balance leading to improved body condition scores
  - Cows are not exposed to adverse weather
- **Benefits of grazing systems**
  - Increased concentrations of healthier milk fats
  - In general, improved health (reduced incidences of lameness and mastitis)
  - In general, lower mortality (on-farm death and euthanasia)
  - Indications of improved cow welfare, with increased behavioural freedom and an overall preference for pasture when cows are free to choose between it and housing
  - Lower levels of calving difficulties and uterine disease, improved ovarian activity and heat expression after calving, and reduced early pregnancy loss rates
  - Indications that environmental impacts can be lower, largely driven by less reliance on external inputs (concentrates and fertiliser)
  - Based on data from the United States, improved economic sustainability due to lower production costs and less financial risk

BACKGROUND

Milk production systems within Northern Ireland have traditionally involved cows grazing during the summer months. However, in recent years the adoption of fully housed systems (**Total Confinement**) or systems involving part-time housing during the summer (**Partial Confinement**) have become increasingly common. In addition, there is growing interest in '**Zero Grazing**' systems in which herbage is harvested daily throughout the summer period and fed to housed cows.

Reasons that are often given for the increased adoption of confinement, partial confinement and zero grazing systems include;

- The desire to increase milk yields per cow, and the associated difficulties in meeting the nutrient requirements of these high yielding cows within grazing systems. Housed systems allow a more consistent ration to be offered every day.
- It is possible to adopt higher concentrate feed levels with housed cows than with twice daily in-parlour feeding. Higher concentrate feed levels can help meet the nutrient requirements of higher yielding cows, and allow total milk output to be increased without the need to access additional land.
- Expanding herd sizes mean that the grazing platform (i.e. the fields the cows can easily access from the milking parlour) is no longer adequate. Poor grazing infrastructure on many farms adds to this problem.
- On farms with fragmented land blocks, walking cows to and from grazing areas has become increasingly difficult and dangerous due to increasing volumes of traffic.
- Difficult weather conditions during a number of recent summers have resulted in poor grass growth, poor efficiency of herbage utilisation resulting in lower grass quality, and badly damaged swards.
- An increasing number of farmers are installing Automatic Milking Systems (robotic milking) and these are more suited to confinement systems.

REASON FOR THIS PROJECT

There appear to be many good reasons why local farmers are increasingly adopting these more intensive systems, and indeed confinement and partial confinement systems are operated very effectively on many local farms. However, these systems are not without their challenges. From a cost point of view, a lower reliance on grazed grass results in higher feed costs, while machinery and fuel costs will also be higher with confinement systems, and labour inputs will increase. From a cow performance point of view, the response to additional concentrates offered may be poor, levels of performance may be lower than expected, while some farmers claim increased cow health and fertility problems. In addition, there is a perception amongst consumers that cow welfare is poorer within confinement systems, while the environmental impact of these systems is often questioned. Nevertheless, much of the information on the relative merits of these different systems is based on anecdotal evidence or 'hear-say'.

Because of these uncertainties, AgriSearch commissioned a review of studies comparing confinement, partial confinement and zero grazing systems, with full time grazing systems. This short booklet seeks to summarise the key findings from this review, while the full review will be available shortly on the AgriSearch website. However, it is important to stress that the purpose of this booklet is not to advocate one system or the other. Rather, the intention is to highlight the current knowledge within the scientific literature so that producers are best placed to make informed decisions that suit their particular circumstances.

SOURCES OF INFORMATION

The information presented in this review was obtained from 196 articles that have been published in the 'Scientific Literature'. These articles described experiments which have been undertaken throughout the world, including the US, Europe, New Zealand and Australia. Approximately 10% of the articles describe work undertaken within the United Kingdom.

The following topics have been examined in this booklet:

- Effect of system on milk yield, milk composition and body condition score
- Animal health and welfare
- Fertility
- Environmental impacts
- Economics

EFFECT OF SYSTEM ON MILK YIELD, MILK COMPOSITION AND BODY CONDITION SCORE

Are milk yields higher in confinement systems? This question has been addressed in many of the studies which have compared these different systems of milk production. The results of these studies are presented in the following sections.

Confinement vs full time grazing

The average performance from studies where confinement has been compared with full time grazing are summarised in Table 1.

Table 1. Summary of cow performance in studies comparing Confinement and Full-time Grazing.

	Full-Time Grazing	Total Confinement
Studies where grazing cows were offered no concentrates		
Concentrate intake (kg/cow/day)	0	9.9
Total dry matter intake (kg/cow/day)	16.8	21.0
Milk yield (kg/cow/day)	21.8	29.4
Milk fat (%)	4.12	3.87
Milk protein (%)	3.24	3.30
Milk fat + protein yield (kg/cow/day)	1.56	2.02
Mean body condition score	2.5	2.9
Studies where grazing cows were offered less concentrate than confined cows		
Concentrate intake (kg/cow/day)	7.5	12.3
Total dry matter intake (kg/cow/day)	19.5	21.8
Milk yield (kg/cow/day)	27.1	31.1
Milk fat (%)	3.54	3.75
Milk protein (%)	3.11	3.13
Milk fat + protein yield (kg/cow/day)	1.85	2.14

Four studies (shaded in gray in Table 1) were identified in which cows on a confinement diet (average concentrate intake of 9.9 kg/cow/day) were compared with grazing cows receiving no concentrate. On average, across these studies confined cows had higher dry matter intakes (4.2 kg/day greater), higher milk yields (7.6 kg/day greater), and higher fat + protein yields (0.46 kg/day greater) than the grazing cows. However, milk fat and protein content was similar for both systems. Average body condition score for the confined cows was higher than for the grazing cows (2.9 vs 2.5) in the two studies in which condition score was presented.

The results highlighted in the red shaded section of Table 1 are for studies in which confined cows were offered higher levels of concentrates than grazing cows. Across the 10 studies examined, confined cows were offered 12.3 kg concentrate/cow/day, and grazing cows 7.5 kg/cow/day. Confined cows had higher total dry matter intakes (2.3 kg/day greater), and produced 4 kg more milk, and 0.29 kg more fat + protein per day than grazing cows. While milk protein content did not differ, milk fat content was greater for confined than grazing cows in a number of studies (3.75 vs. 3.54%). Confined cows also had a higher average body condition score than the grazing cows (2.8 vs. 2.6).

Only three studies were identified in which the same level of concentrates was offered to both confined and grazing cows. However, these studies involved few cows and did not provide reliable data and are not discussed further in this booklet. Nevertheless, a recent study at AFBI-Hillsborough (22 cows per treatment) compared confinement and grazing systems at a common concentrate level (8.0 kg/cow/day). The results of this study (see Table 2) clearly demonstrate that daily milk yield was unaffected by treatment, although milk fat content was reduced with the grazing system, resulting in a reduction in fat + protein yield. In addition, the grazing cows completed the study with a lower body condition score than the confined cows.

Table 2. Comparison of cow performance within confinement and grazing systems in which cows on both treatments were offered the same amount of concentrate.

	Full-Time Grazing	Total Confinement
Concentrate intake (kg/cow/day)	8.0	8.0
Milk yield (kg/cow/day)	26.8	27.1
Milk fat (%)	3.80	4.27
Milk protein (%)	3.47	3.49
Milk fat + protein yield (kg/cow/day)	1.94	2.11
Final body condition score	2.4	2.6

Summary: In general, across the studies comparing confinement and full-time grazing, confined cows had higher milk yields than grazing cows, especially when grazing cows were offered no concentrates or lower levels of concentrates. These responses are likely due to the higher concentrate levels with the confinement treatments. However, in some studies milk yields did not differ between the confinement and grazing treatments, or were actually higher with the grazing cows. In these studies forage quality is likely to have been a key driver of performance. For example, if the silage offered to confined cows is of poor quality, grazing cows may well produce more milk. Alternatively, tight grazing of poor quality pasture (as occurred in some studies) or adverse weather conditions are likely to reduce performance within grazing systems. The results from the study conducted at AFBI-Hillsborough (Table 2) clearly demonstrates that when a comparison is made at an equal concentrate level, similar levels of performance can be obtained with a confinement and full-time grazing system.

Milk fat content is normally higher within confinement systems due to silages normally having higher fibre levels than grazed grass. However milk protein levels did not differ between systems.

While cows on confinement systems are normally heavier than grazing cows, this is often due to 'gut fill' effects, i.e. grazed grass passes through the gut more quickly than silage based diets, resulting in cows being lighter. Thus, body condition score provides a better measure of the effect of system on the energy status of the cow. In most studies confined cows had a higher body condition score than grazing cows, suggesting that the confined cows had an improved energy balance. This may be due to grazing cows mobilising body tissue for milk, or the confined cows laying down body tissue, but in general suggests confined cows had an improved energy balance.

CONFINEMENT VS PART-TIME GRAZING

Systems involving 'part-time grazing' during the summer months are becoming increasingly common in Northern Ireland, with these systems normally involving day-time grazing and night-time housing. Similar systems were identified in seven studies, with the average results from these studies presented in Table 3.

Table 3. Summary of cow performance in studies comparing part-time grazing with total confinement.

	Part-Time Grazing	Total Confinement
Concentrate intake (kg/cow/day)	9.5	11.5
Total dry matter intake (kg/cow/day)	20.9	21.4
Milk yield (kg/cow/day)	31.5	31.1
Milk fat (%)	3.77	3.76
Milk protein (%)	3.08	3.04
Milk fat + protein yield (kg/cow/day)	2.01	2.06
Mean body condition score	2.88	2.94

The results in Table 3 clearly demonstrate that across the seven studies cow performance did not differ between part-time grazing and total confinement systems. However, when the results from individual studies are examined, confined cows performed better in some studies, while cows with access to grazing part-time performed better in others. These inconsistent findings are again likely to reflect differences in the quality of the forages offered to confined cows and those grazing part-time in the different studies.

ZERO GRAZING VS FULL-TIME GRAZING

The popularity of zero grazing systems has grown in Northern Ireland during the last few years, with this move prompted to some extent by a number of very wet summers. Zero grazing allows fresh grass to be included in the diet of the cow, even if the herd is not able to access a grazing platform. However, only two studies were identified in which the performance of zero-grazed and pasture-based cows were compared, with both studies undertaken in Switzerland. Table 4 below summarises the average results of these two studies.

Table 4. Summary of cow performance from two studies comparing zero-grazed and pasture-based systems.

	Zero-Grazed	Pasture-based systems
Concentrate intake (kg/cow/day)	6.5	6.6
Total dry matter intake (kg/cow/day)	23.3	21.7
Milk yield (kg/cow/day)	40.0	39.5
Milk fat (%)	3.68	3.80
Milk protein (%)	3.08	3.17
Milk fat + protein yield (kg/cow/day)	2.68	2.73
Mean body condition score	2.80	2.80

The results presented in Table 4 provide no evidence of differences in milk yields, milk composition, milk solids yield, or cow body condition between zero-grazed and pasture-based cows. However, the use of zero-grazing, and its effects on herbage utilisation efficiency and land requirements has not been examined under UK conditions, and consequently this is an area where future research is required.

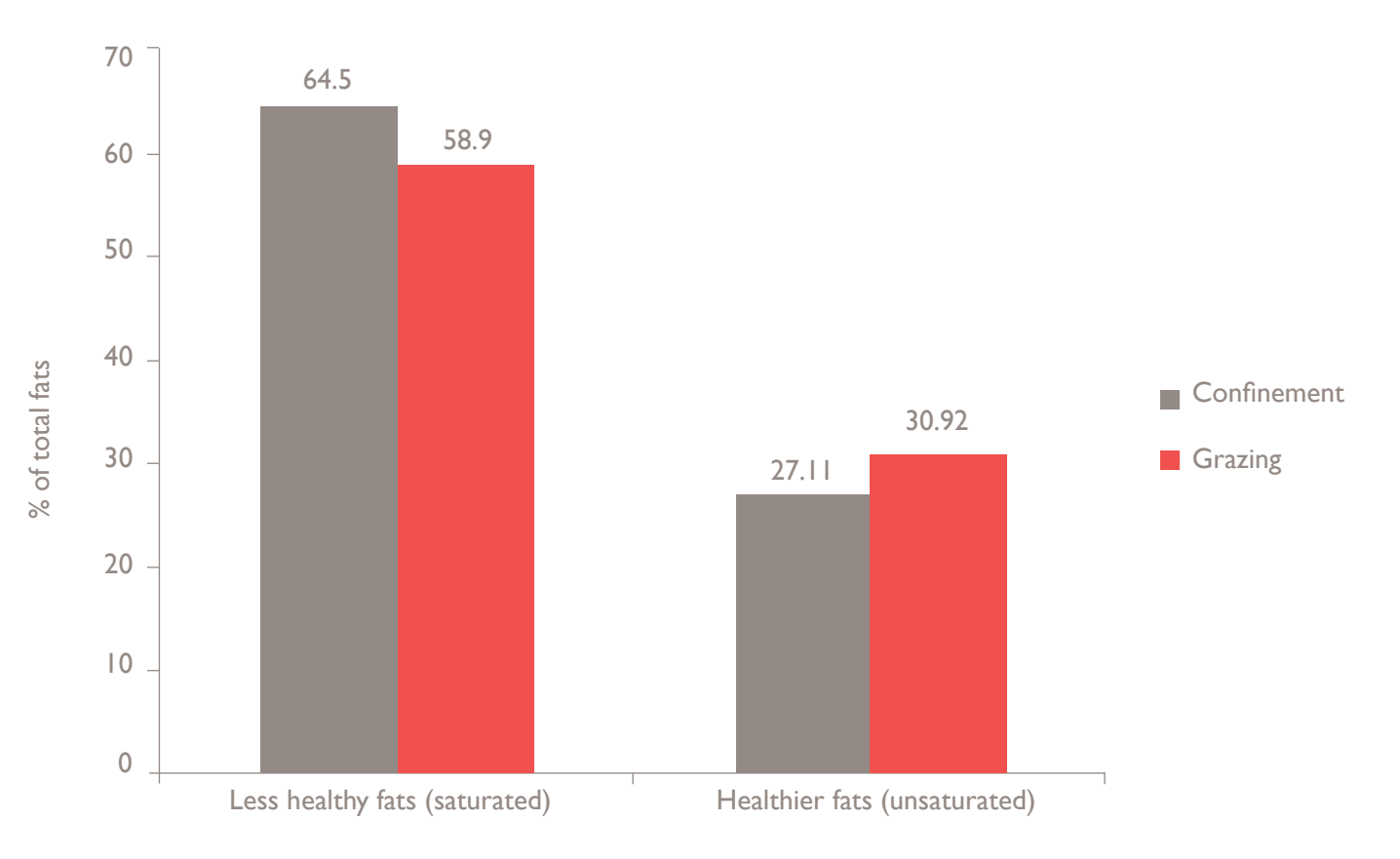
EFFECTS OF SYSTEM ON THE TYPE OF FAT IN MILK

While the previous section compared the effects of confinement and grazing systems on the 'fat' content of milk, it should not be forgotten that milk 'fat' is actually made up of approximately 400 different types of fat. This is important as consumers are increasingly aware of the 'healthiness' of the food that they eat, and milk, like most other foods, contains both 'more healthy' and 'less healthy' types of fat.

The 'less healthy' fats are generally referred to as 'saturated fats', and Figure 1 clearly demonstrates that these are found in higher levels in the milk of cows in confinement systems. In contrast, the 'more healthy' fats, which are generally referred to as 'unsaturated fats', are found in higher levels in the milk of grazing cows. One of these 'healthy fats' which is of particular interest is called CLA (conjugated linoleic acid). CLA has been linked to a number of health benefits in humans, and levels are normally approximately twice as high in milk produced from cows within grazing systems.

The type of fats in the milk produced by your herd might not seem to be important to you as most milk purchasers currently reward (or penalise) farmers according to the total fat content of the milk produced. However, recent developments in analytical techniques now mean that it is possible for purchasers to determine the types of fat in the milk that you produce on your farm at very low cost, thus introducing the possibility of making payments on this basis! In the future, milk produced by cows within grazing systems could therefore qualify for a premium based on its healthier profile of milk fats.

Figure 1. Effects of confinement and grazing systems on the levels of 'less healthy' and 'healthier' fats in milk (average results from 16 experiments)



EFFECTS OF SYSTEM ON VITAMIN D LEVELS IN MILK

While vitamin D is essential for bone health, many people within the UK have inadequate vitamin D intakes. Although milk is a good source of vitamin D, the process by which vitamin D is produced by cows (and humans) requires exposure of skin to sunshine. For this reason, vitamin D levels have traditionally been lower during the winter months than during the summer months. However, the move to confinement systems means that cows may have little exposure to sunlight, and there is increasing interest in the impact of this on the vitamin D content of milk, and on the cows own health. There is little information available on the subject at present.

ANIMAL HEALTH AND WELFARE

There is anecdotal evidence that cow health is poorer within confinement systems, compared to grazing systems. In addition, animal welfare is an increasingly important issue for consumers, who often hold the opinion that 'outdoors is best'. Thus the objective of this part of the review is to examine what the science says in relation to the health and welfare implications of confining dairy cows.

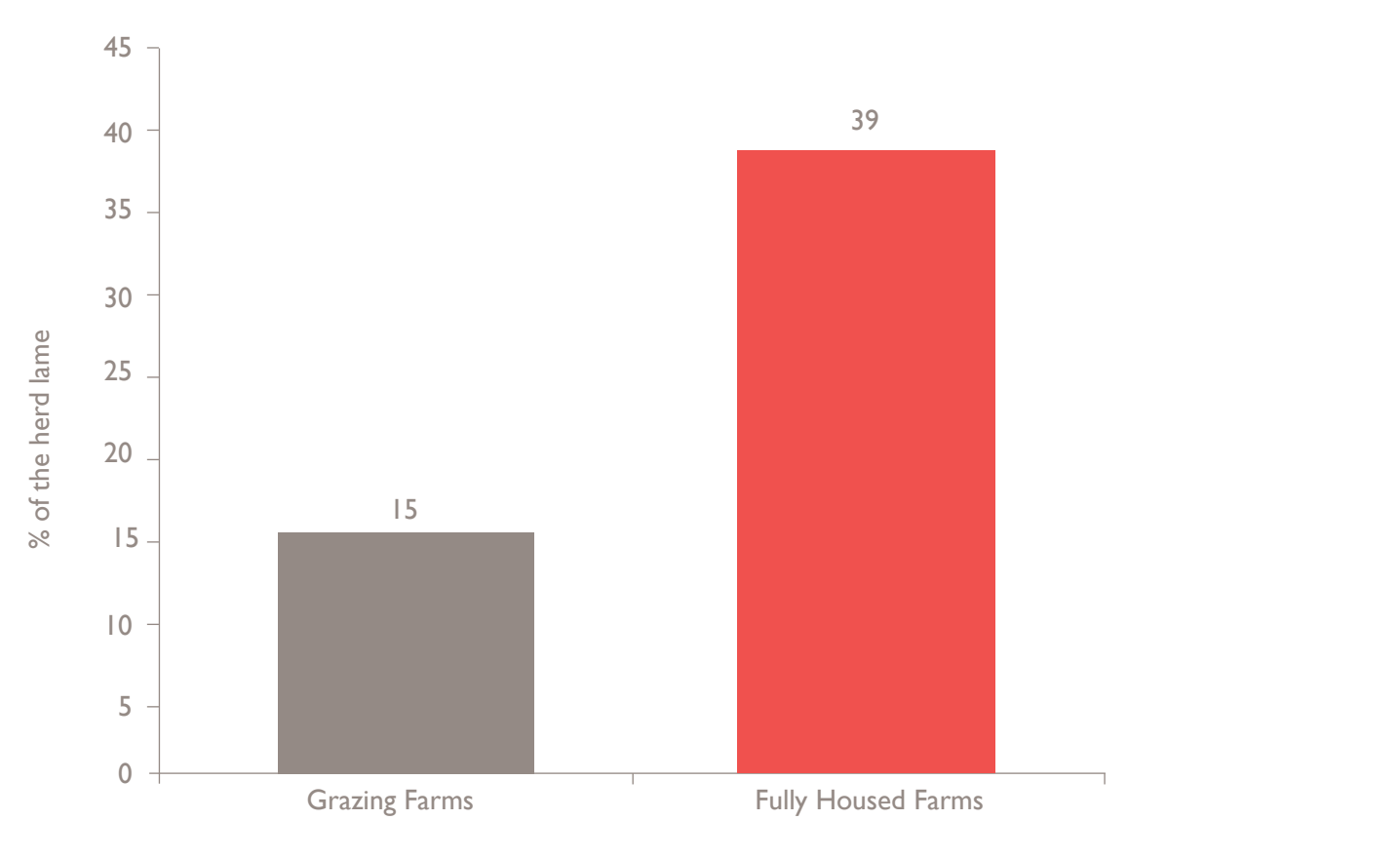
Lameness

The impacts of lameness are well known, and may include a reduction in time spent feeding, lower milk yields and loss of body condition, poorer fertility and increased culling rates. Each case of lameness has been estimated to cost £323. In addition, lameness can cause significant pain, and as such, is a serious welfare issue.

Eleven studies that investigated the impact of restricting access to pasture on foot health and lameness were identified. Ten of these studies showed increased lameness, or a reduction in foot health, when pasture access was either limited or completely absent. These studies clearly demonstrated that removing or reducing access to pasture was a risk factor for both infectious (e.g. digital dermatitis) and non-infectious (e.g. sole ulcer) causes of lameness.

The size of the effect on levels of lameness can be substantial. For example, in one study, lameness levels were recorded on 37 dairy farms in Great Britain that either adopted fully housed or grazing approaches[1]. This research found that lameness levels more than doubled on the farms operating fully housed systems compared to those that grazed cows (Figure 2). This effect was observed despite the fact that lameness was recorded during the winter when all the cows were housed.

Figure 2. Levels of lameness on 37 dairy farms across Great Britain that either adopted grazing (29 farms) or fully housed (8 farms) approaches



It was suggested that the increased levels of lameness observed in cows on the fully housed farms were due to the concussive effects of concrete flooring on hooves, or increased contact between hooves and slurry in housed systems. Therefore it appears that confinement per se, rather than the increased milk yield typically associated with confined systems, is likely to be a key factor leading to increased lameness in these systems.

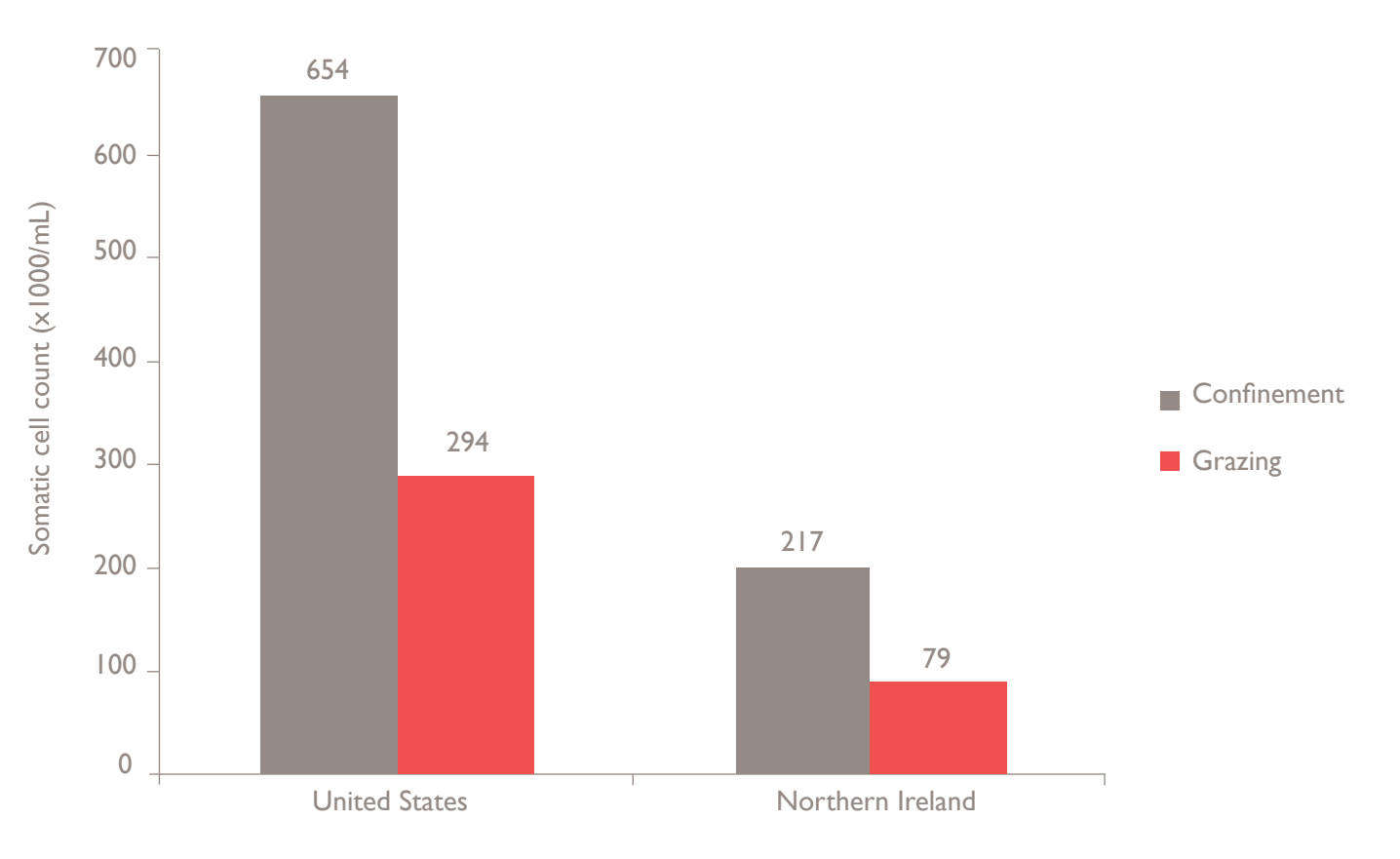
These findings suggest that a more proactive approach to lameness management should be adopted in confined systems, and that particular attention should be paid to the quality and cleanliness of standing and lying areas. The latest DARD advice on managing lameness is available online (http://www.dardni.gov.uk/index/farming/livestock/dairy-farming/lameness-or-mobility-improvement.htm).

MASTITIS

Each case of mastitis has been estimated to cost dairy farmers £250-£300. Consequently mastitis can have a significant impact on economic returns of a dairy farm.

Somatic cell count is normally considered to be a good indicator of udder health, and is often directly associated with mastitis incidence. Figure 3 summarises the results from two studies[2,3] which compared somatic cell counts in confined and grazing systems. Although the differences in SCC cannot be completely attributed to the effect of system (due to differences in concentrate levels and milk output between systems), it is likely to be a significant contributing factor.

Figure 3. Somatic cell counts from two studies comparing confined and grazing systems



In addition, a number of studies have indicated an increased risk of clinical mastitis when access to pasture is reduced. This was clearly demonstrated in a large scale study undertaken within the United States (Table 5). In this study confined cows had an increased risk of having mastitis, a greater number of cases of mastitis per cow, and an increased risk of being culled due to mastitis, than cows that were grazing. Other studies have shown that giving cows access to pasture for even part of the day can reduce the incidence of mastitis. For example, a study[4] involving 274 Dutch dairy herds indicated that cows given access to pasture at night had a lower incidence of clinical e-coli mastitis compared to those housed full time.

Table 5. Results from a large scale study conducted in the United States that compared levels of mastitis in confined and grazing systems.

Mastitis measure	Confined Cows	Grazing Cows
% cows with at least one case of clinical mastitis	51	31
Number of cases of clinical mastitis per cow	1.1	0.6
% of cows with mastitis that were culled or died	9.7	1.6

These effects may reflect a greater general pathogen load and reduced hind-limb cleanliness within housed environments. However, an increased mastitis risk within confinement systems has not been observed in all studies, and it is likely that the risk of udder infection in cows grazing wet trampled paddocks would be greater than in cows confined within a modern cow house with well bedded cubicles and clean flooring. In addition, the risk of summer mastitis, associated with flies, is likely to be a greater problem within grazing systems. Nevertheless, the evidence suggests that fully confined systems are a particular risk, and consequently farmers operating these systems should be especially proactive in seeking to minimise the risk of mastitis. Information on the best approaches to managing mastitis is available on the DairyCo website (http://www.dairyco.org.uk/technical-information/animal-health-welfare/mastitis/).

OTHER HEALTH PROBLEMS

A number of studies have examined the effect of confinement compared to grazing on other health problems. While most health problems tend to increase within confinement systems, others occur more frequently within grazing systems. Some of these are summarised below.

Increased risk in confinement systems

- Uterine disease (metritis and endometritis)
- Downer cows
- Infectious diseases (e.g. salmonellosis)

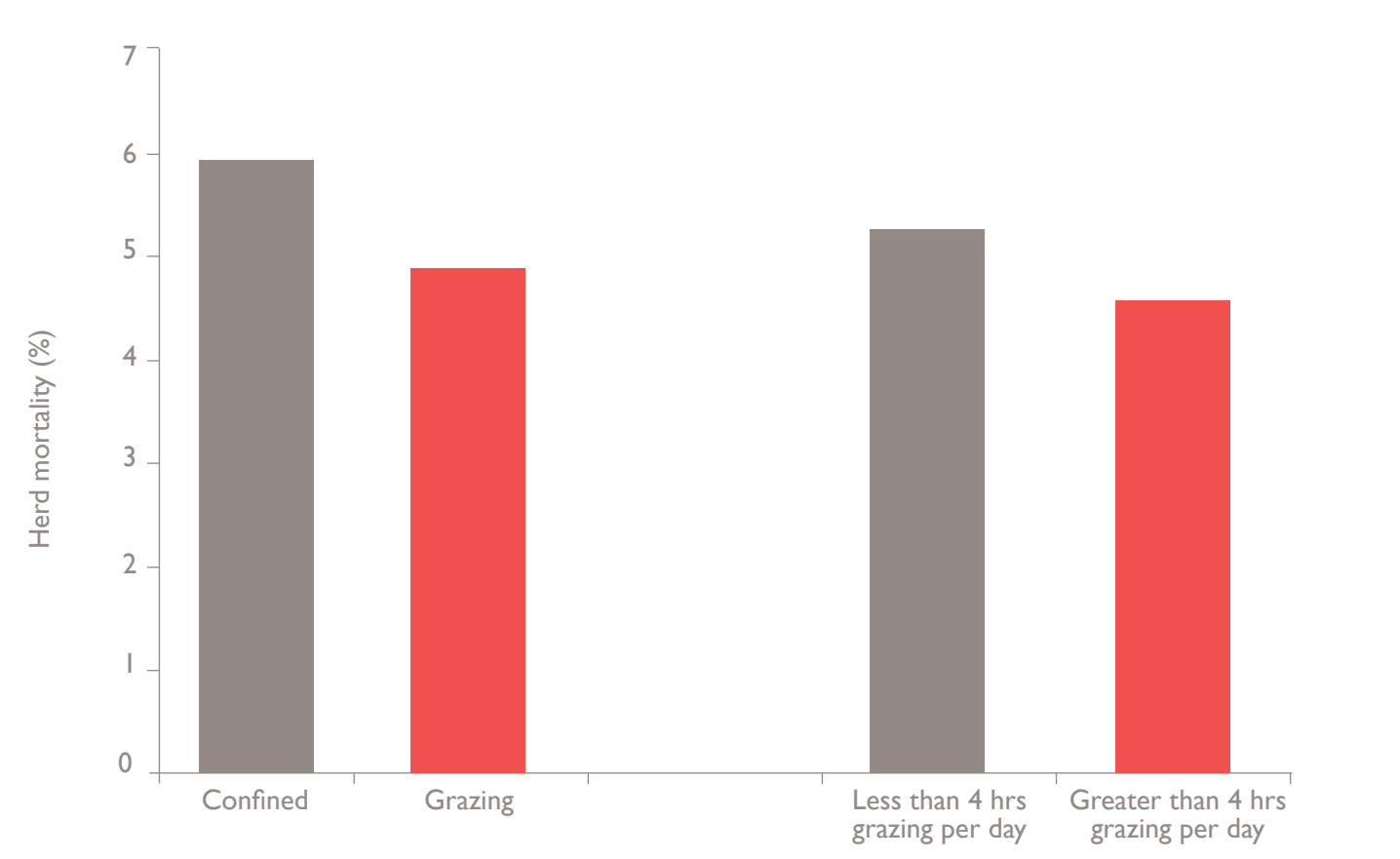
Increased risk in grazing systems

- Nematode gut parasites
- Liver fluke

Mortality risk (death and euthanasia)

There is evidence that cow mortality levels are greater within confinement systems. For example, this was clearly demonstrated in a recent Danish study[5] involving 391 dairy herds, 131 of which grazed during the summer, while 260 were completely confined. The results are presented in Figure 4, and demonstrate that mortality levels were lower in grazing herds, compared to confined herds. In addition, within those herds where grazing was adopted the mortality level decreased as daily grazing time increased.

Figure 4. Results of a Danish study comparing mortality levels (death and euthanasia) in confined and grazing herds, and the impact of time spent on pasture in grazing herds on mortality levels



Similar trends have been observed in a number of other studies. For example, a study[6] in Sweden found a 3.6 times greater chance of being in a high mortality herd if cows only had access to an exercise pen during the summer, compared to pasture. Similarly, a study[7] involving almost 7000 herds in Denmark found that the mortality risk was 22% lower in herds which grazed during the summer compared to confined herds.

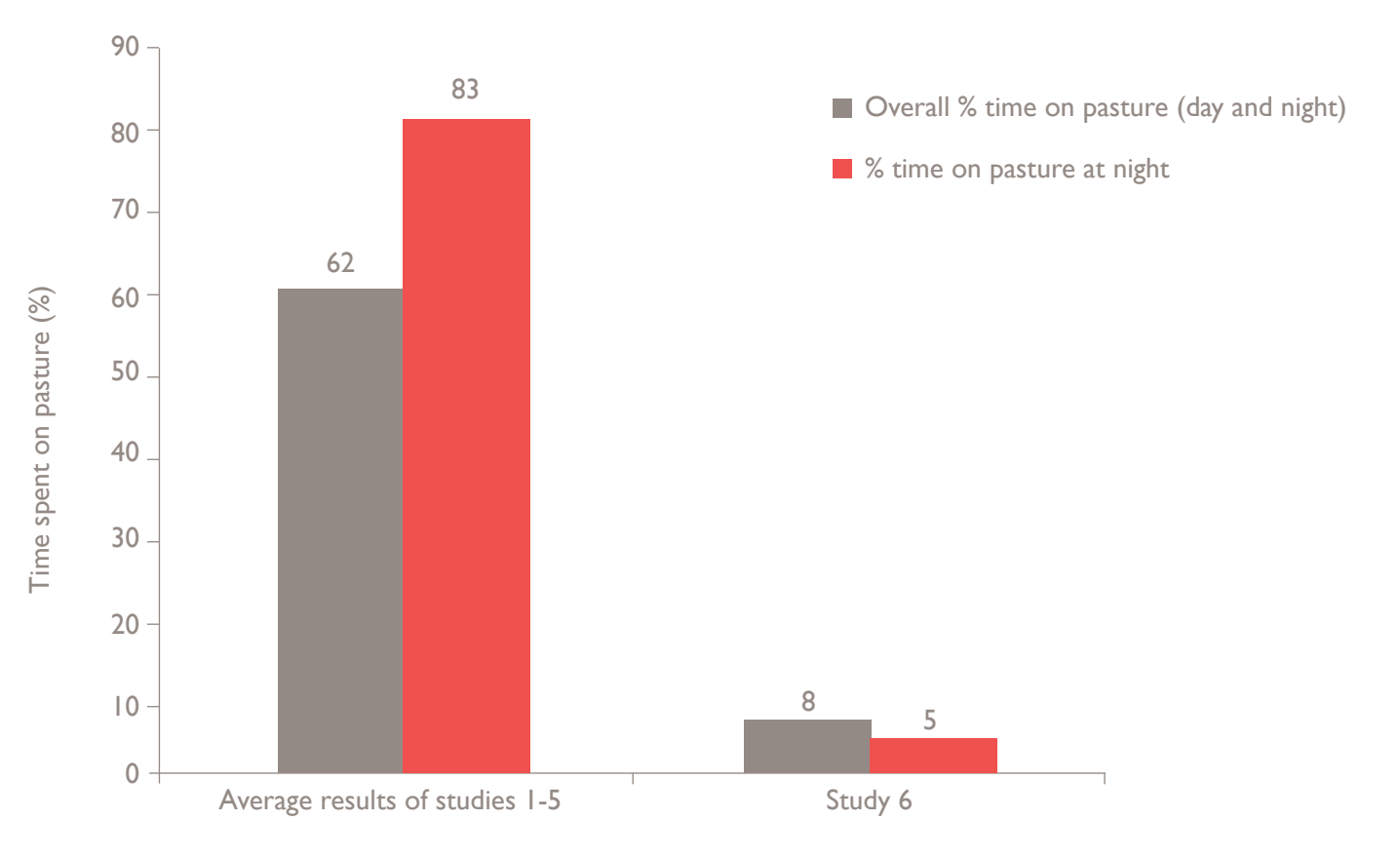
Some evidence of possible reasons for higher mortality levels in confined herds was provided by a Danish survey of 39 dairy herds. In this study, an animal health score was developed and used to define "loser" cows on the basis of an examination of body condition score, lameness, hock lesions, other skin lesions, vaginal discharge, condition of hair coat and general condition[8, 9]. These 'loser cows' produced less milk, received more veterinary treatments and had higher culling and mortality rates than non-loser cows. A higher proportion of loser cows were found in confined herds, and cows were almost twice as likely to become a loser cow if they were in a confined herd compared to a grazing herd.

COW PREFERENCE

One approach to determining the optimum system in terms of animal welfare is to ask the cows what they want. Do cows prefer spending time on pasture or indoors? This review identified six studies which examined if cows had a preference for pasture over indoor housing. In general, the approach taken within these studies was to place cows in a situation where they had access to both a cow house and to pasture, and to monitor where they spent their time. In most studies cows could access a silage/concentrate diet while indoors. In five out of the six studies, during the daytime cows either had a preference to be indoors, or else spent similar amounts of time indoors and outdoors. However, at night, cows preferred to spend time at pasture (Figure 5). These findings may reflect the fact that fresh silage/concentrate was available within the house during the day, and/or the relative comfort of sleeping on grass rather than indoor cubicles at night. Thus the overall result of these five studies was that on average cows spent 62% of their time at pasture, and 38% of their time indoors, indicating a slight overall preference to spend time at grass.

However, the results of study six[10] were in complete contrast to the outcomes of the other five studies in that cows spent over 90% of their time indoors, and less than 10% of their time on pasture, when given a choice. The preference for housing in this study may have been due to the fact that the cows had not been given access to pasture during the rearing period, and as such had limited previous experience of pasture, and/or the fact that cows had to walk relatively long distances to access the pasture.

Figure 5. Summary of studies investigating whether cows prefer to spend their time in a house or at pasture



Each of these studies involved mid or late lactation cows. To date no studies have investigated the preferences of early lactation animals. It is possible that the high metabolic demands on these animals could influence their preference substantially.

TAKE HOME MESSAGES

There is evidence that total confinement is a risk factor for reduced health, welfare and longevity of dairy cows. The effects of total confinement systems on these parameters are not always linked to milk yield effects, but simply reflect the fact that the animal is housed rather than at pasture. Housing, by its nature, may be associated with a reduction in comfort and an increase in pathogen load relative to pasture, and this could account for some of the effects seen.

It is important to consider these potential effects if moving to total confinement systems. We are in an era where animal welfare quality assurance schemes are becoming more prevalent, and where longevity should be a key performance goal. However, while the risks are clearly evident from the literature, the research also shows that some farmers can achieve very good cow health status within confined systems, and this will have consequent positive effects on cow welfare.

It is clear that farmers who adopt confinement systems must place significant emphasis on the comfort and cleanliness of housing, and must adopt a proactive approach to animal health management. The Cafre dairy unit provides a useful case study for a modern innovative facility designed with a focus on cow health, welfare and production (full information available at http://www.dardni.gov.uk/CafreDairyUnit), with additional information on buildings and cubicle design also available (http://www.dardni.gov.uk/index/farming/livestock/dairy-farming/dairy-buildings-equipment.htm). Further technical information can be accessed by logging on via DARD online services (http://www.dardni.gov.uk/index/online-services.htm) and selecting Cafre technical notes.

FERTILITY

Achieving high levels of fertility performance is perhaps the greatest challenge for dairy farmers at present, and yet it is fundamental to the survival and profitability of any dairy enterprise. Increasing intensification in milk production, in both confinement and grazing systems, has contributed directly to the current global decline in dairy cow fertility. A review of studies comparing the fertility of dairy cows in confinement and grazing systems has been published recently[11]. The main findings of that review are summarised in Table 6 below.

Table 6. Summary of the main effects of confinement and pasture-based production systems on fertility performance of dairy cows.

Fertility Parameter	Performance within grazing systems (compared to confined systems)
Ovarian activity following calving	**Improved;** earlier onset of cycling, and lower incidence of delayed ovulation with grazing systems
Oestrus (heat) expression*	**Improved;** a higher frequency of standing to be mounted, mounting other cows, and other secondary behavioural signs of heat with grazing systems. Results in higher oestrus detection rates
Early pregnancy loss rates	**Decreased;** 5% with grazing system, compared to 11% with confinement system (between day 32-86 post-insemination)[1]
Pregnancy rates	**Increased** in some, but not all studies
Calving Interval	Shorter in some, but not all studies
Uterine disease*	**Decreased** incidence of metritis (infection of the uterus at 3-9 days post calving) This condition itself results in reduced fertility; an increased interval from calving to first service, increased days open (by 20 days), decreased likelihood of pregnancy, and an increased risk of culling.
Calving difficulty	**Decreased** incidence of difficult calvings in grazing systems. Difficult calvings have a negative effect on subsequent performance, health and fertility.

**Articles on heat detection aids and dealing with the effects of uterine disease are available from AgriSearch.*

Overall, the studies undertaken to date demonstrate that fertility is generally better for cows within grazing systems than for those within confinement systems. However, only a limited number of studies have examined this issue and there is a need for further large-scale studies in this area.

ENVIRONMENTAL IMPACT

While farmers have played an important role in maintaining the countryside and the environment over many generations, the intensification of farming systems during the last few decades has created a number of environmental challenges. Within the dairy sector in Northern Ireland, the two main environmental challenges relate to emissions of greenhouse gases (GHG) and nutrient enrichment of watercourses. While the global demand for dairy products is growing, legislation increasingly requires that each litre of milk is produced with a smaller 'environmental footprint'. Thus this section seeks to identify if there is evidence that confinement and grazing systems have different environmental impacts.

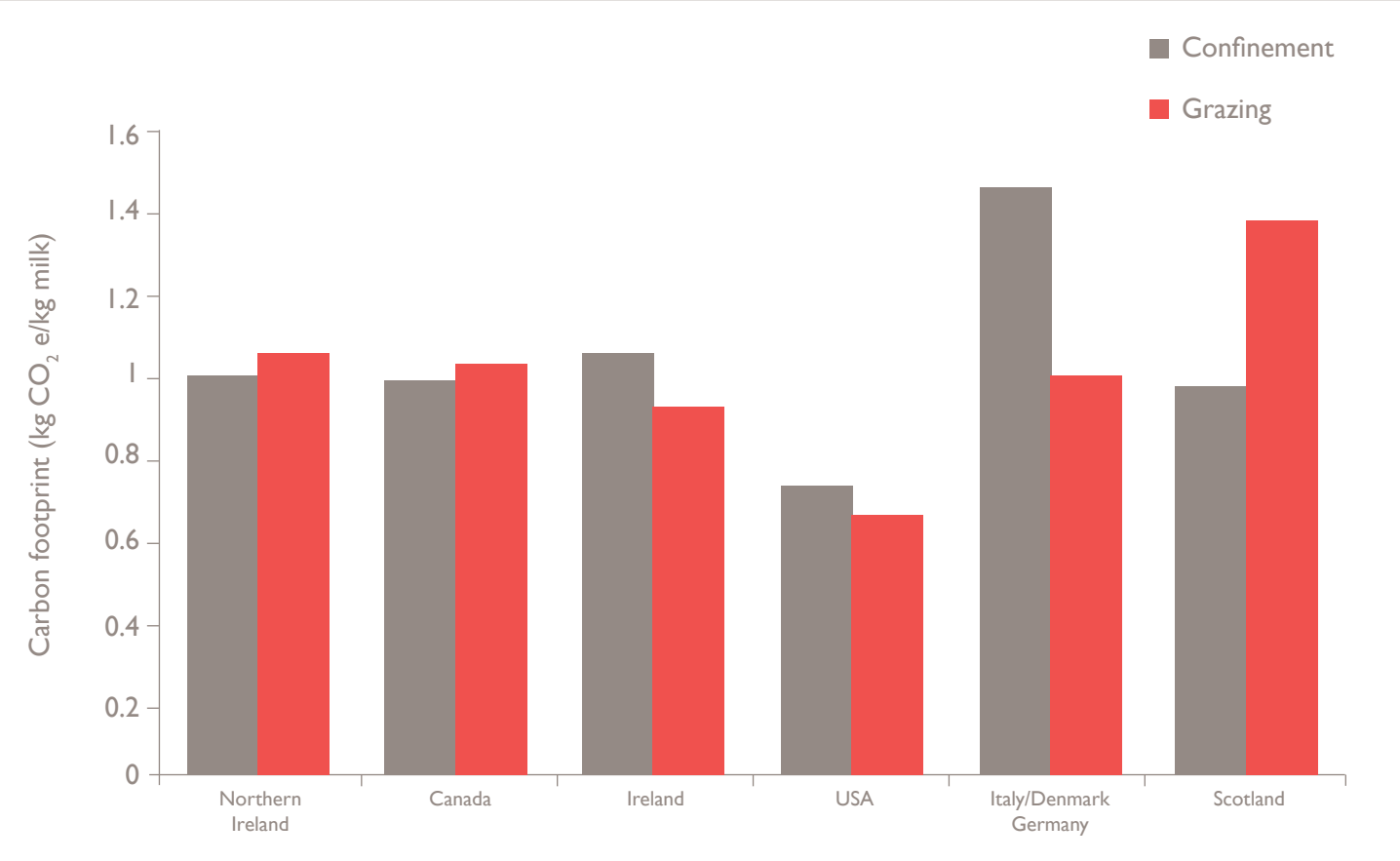
Greenhouse gas (GHG) emissions

There is now overwhelming scientific evidence that emissions of greenhouse gases (carbon dioxide, methane and nitrous oxide) have been responsible for increasing the temperature of the earth's atmosphere over the last one hundred years. This 'global warming' is now having an effect on climate patterns. Within Northern Ireland approximately 26% of total GHG emissions are from agriculture, compared to only 9% within the UK as a whole. This difference simply reflects the importance of agriculture to the NI economy. While it is easy to view emissions of GHG's as someone else's problem, there are important reasons why dairy farmers in Northern Ireland should become informed about the issues surrounding agricultural GHG emissions:

- As a result of global agreements, governments are setting targets to reduce GHG emissions, and agriculture is falling under the spotlight.
- Supermarkets and consumers are increasingly interested in the 'carbon footprint' of food products, including milk. Production systems associated with lower GHG emissions may be viewed more favourably.
- GHG emissions cost you money in terms of a loss of both feed energy (in the form of methane) and nitrogen from your farm.
- Global warming is already being attributed to changes in the global climate. While there are considerable uncertainties about the effects at a local level, climate changes associated with GHG emissions could make farming within Northern Ireland more difficult.

In the case of a dairy farm, GHG emissions are determined using a validated GHG calculator and are normally presented as 'emissions per kilogram of milk produced', and this is usually referred to as the 'carbon footprint' of the milk produced. In order to account for the different potential global warming effects of carbon dioxide, methane and nitrous oxide, total emissions from all sources are expressed as 'carbon dioxide equivalents' (CO_2-e).

Figure 6. Summary of results from studies comparing the carbon footprint (kg of carbon dioxide equivalent (CO_2-e) per litre of milk) of confinement and grazing systems.



Two studies (Northern Ireland and Canada) found similar carbon footprints for confinement and grazing systems. Three studies (Ireland, USA, Italy/Denmark/Germany) found that emissions were greater for confinement systems. In contrast, the Scottish study found a greater carbon footprint for the grazing system. The variable results from these studies highlight that it is not a simple case of one system being superior to another. Rather, if efficiently managed, the carbon footprint of contrasting milk production systems can be very similar.

The method used in these studies accounts for both 'on-farm' and 'off-farm' emissions. Off-farm emissions are those which arise outside of the farm (often in a different country, or even different continent), and these tend to be higher for confinement systems. Examples of these off-farm GHG emissions are those associated with the production of concentrate feeds and inorganic fertiliser. It therefore follows that a reduction in imported concentrate inputs, together with increased used of on-farm resources will typically translate to improved environmental performance. It may also be possible to substitute particular concentrate ingredients for ones with a lower environmental impact. For example, in the Irish study the researchers modelled the effects of substituting Brazilian soybean meal with rape meal or soybean meal from the USA. This was found to reduce environmental impacts, although the ranking between the confined and grazing system did not change. Similarly, in the Scottish study inclusion of by-product feeds sourced from the brewing/distilling industry was crucial in minimising emissions associated with purchased feeds.

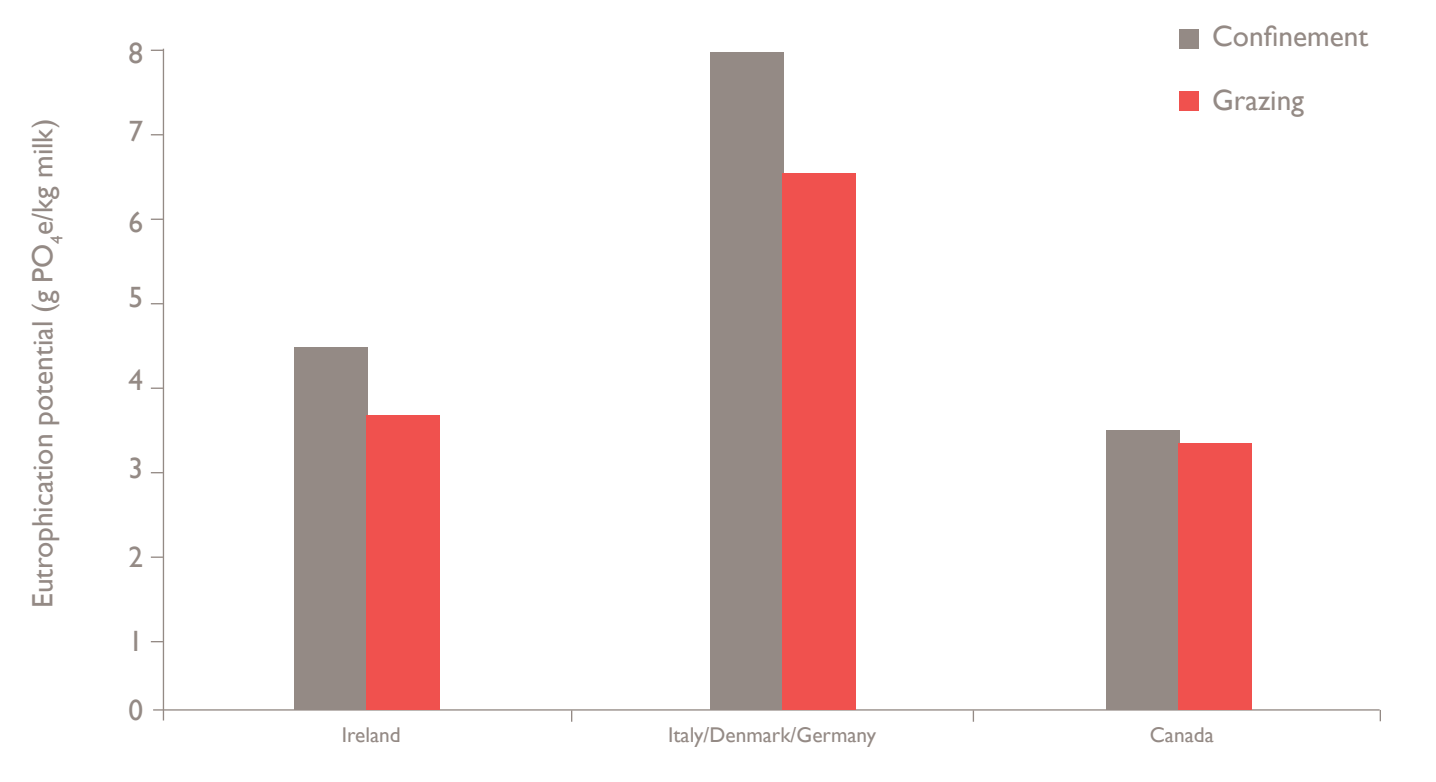
Further information on GHG reduction strategies is available on the DARD website (http://www.dardni.gov.uk/index/farming/climate-change-farming.htm). In addition, AFBI have produced the BovIS Dairy Greenhouse Gas calculator which is available to Northern Ireland dairy farmers. By inputting your own farm information, you will be able to determine the carbon footprint of your farm. The calculator can be accessed through DARD online services (https://www2.dardni.gov.uk/gatewayweb/internet/).

PHOSPHORUS LOSSES

Many of the rivers and lakes in Northern Ireland contain high levels of phosphorus. This is a problem because it encourages the growth of algae and water plants which can be toxic to both animals and humans. The growth of these plants also reduces the level of oxygen in the water, causing a reduction in fish and other animals. This process, termed eutrophication, can destroy fisheries and reduce the recreational value of waterways, while removal of algae increases water treatment costs. Nitrates (a form of nitrogen) of agricultural origin (e.g. fertiliser and manure) also lead to eutrophication when they leach and run-off into waterways. Within Northern Ireland, phosphorus loss is more of a problem than loss of nitrates to waterways.

Approximately 60% of phosphorus entering our waterways is of agricultural origin. The whole of Northern Ireland has been declared a Nitrate Vulnerable Zone (NVZ) because of the high phosphorus levels in our waters. As farmers face pressure to reduce phosphorus losses it is useful to examine if confinement and grazing systems differ in this regard. The figure below summaries the results from three studies which compared the eutrophication potential (expressed as g phosphate equivalent per kilogram of milk produced) of confinement and grazing systems.

Figure 7. Summary of studies comparing the eutrophication potential (g of phosphate equivalent per litre of milk) of confinement and grazing systems.



Two of the studies (Ireland, Italy/Denmark/Germany) found a higher eutrophication potential (i.e. potential for higher phosphorus losses to watercourses) for confinement systems, while a third study found similar values for each system. It therefore appears that confinement systems are more likely to have a higher eutrophication potential value than grazing systems. This is the result of higher off-farm nitrate and phosphorus losses following the application of inorganic fertiliser used for the production of concentrate feed ingredients. In both confinement and grazing systems nitrate and phosphorus loss following the application of inorganic fertiliser and manure for forage production is a significant on-farm contributor to the eutrophication potential.

Options for reducing phosphorus losses to waterways

1. Feed less concentrates. One tonne of dairy cow meal can contain over 6.0 kg of phosphorus. However, cows do not utilise phosphorus very efficiently, and up to 70% of phosphorus consumed by cows can end up in manures. Concentrate feed is expensive and should be fed in an efficient and targeted way.
2. Feed a lower phosphorus concentrate.
3. Purchase less phosphorus fertiliser and use fertiliser in a targeted way.
4. Careful management of manures and fertilisers. Follow the regulations set out within the Nitrates Action Programme for Northern Ireland. These are designed to minimise the risk of nutrients from manures and fertilisers entering water courses.
5. Improved slurry spreading techniques. Phosphorus losses are reduced when slurry is spread using a trailing shoe system.

Further details on managing phosphorus balance are provided in a booklet produced previously by AgriSearch (Booklet 18, available to download at http://www.agrisearch.org/publications/farmer-booklets)

ECONOMIC SUSTAINABILITY

If dairy production systems are to be sustainable in the long term, they must be profitable. While no UK or European studies comparing the economic performance of confinement and grazing systems were identified, a number of North American studies have compared these systems. The results from one of these studies[12], which compared the economic performance of confinement and grazing farms (62 dairy farms with less than 200 cows) in Maryland and Pennsylvania (USA) over a 15 year period (1995 to 2009), are summarised in Table 8. There are clearly limitations to this study in terms of its applicability to Northern Ireland, nevertheless, it does serve to highlight a number of general themes.

Table 8. Economic performance of confinement and grazing farms in the US over a 15 year period.

Economic Measure	Confinement	Grazing	% difference compared to Confinement
Total Income (milk, livestock and crop sales)			
Per hundred litres of milk:	£29.59	£31.73	7
Per cow:	£2502	£2009	-20
Per hectare:	£2214	£1635	-26
Total Expenses (feed, fertiliser, fuel, rent, labour, veterinary, etc)			
Per hundred litres of milk:	£26.15	£25.05	-4
Per cow:	£2206	£1603	-27
Per hectare:	£1926	£1270	-34
Profitability			
Per hundred litres of milk:	£3.44	£6.68	94
Per cow:	£296	£406	37
Per hectare:	£288	£365	27
Financial risk (expressed as the profit attained in 3 out of every 4 years)	£16644	£23238	40

While confinement farms generated a greater income due to higher milk sales, they also incurred greater expenses, including, feed, labour and veterinary costs. In addition, grazing farms had higher value cattle sales (high value heifers and young stock) as a result of increased longevity and lower replacement rates, in contrast to more lower value cull cows being sold off confinement farms. Therefore, overall, the grazing farms were more profitable per hundred litres of milk, per cow, and per hectare. In addition, confinement farms were more exposed to financial risk, with this reflected in a greater variability in annual profits. The level of financial risk associated with a system is an increasingly important consideration when operating within a globalised market (and following EU milk quota deregulation in 2015) where volatility is likely to increase.

Looking beyond the results of the above study, it appears that in general terms, the financial performance of grazing systems is at least equal to that of confinement systems. Trade-offs exist within each system that result in similar overall competitiveness. Confinement systems generate high milk production and sales, yet incur high expenses, whereas, while grazing systems may have lower milk production and sales, they also incur lower costs. Furthermore, as grazing systems are less reliant on external inputs (e.g. concentrate feed), and are consequently less exposed to volatility in the costs of inputs, they may have lower financial risk, with less variation in annual income.

In the future, there may also be financial gains associated with premium payments from processors (e.g. Friesland Campina in the Netherlands) for milk from grazing cows, with benefits for animal welfare and milk with a healthier composition. There is also a marketing opportunity for milk produced from grazing cows given that consumers have a positive image associated with this type of production.

SUMMARY OF KEY BENEFITS OF CONFINEMENT AND GRAZING SYSTEMS

Benefits of confinement systems

- Increased intakes, milk yields and yields of milk solids, although little effect on milk composition
- Improved energy balance leading to improved body condition scores
- Cows are not exposed to adverse weather

Benefits of grazing systems

- Increased concentrations of healthier milk fats
- In general, improved health (reduced incidences of lameness and mastitis)
- In general, lower mortality (on-farm death and euthanasia)
- Indications of improved cow welfare, with increased behavioural freedom and an overall preference for pasture when cows are free to choose between it and housing
- Lower levels of calving difficulties and uterine disease, improved ovarian activity and heat expression after calving, and reduced early pregnancy loss rates
- Indications that environmental impacts can be lower, largely driven by less reliance on external inputs (concentrate feed and fertiliser)
- Based on data from the United States, improved economic sustainability due to lower production costs and less financial risk

CONCLUSIONS

While milk production systems on the majority or Northern Ireland farms still incorporate grazing during the summer months (either full-time or part-time), there is a trend towards systems in which grazing is of less importance, or plays only a minor part. This review has clearly demonstrated that both confinement and grazing systems have their own distinct advantages and disadvantages, although there are still areas where the scientific evidence remains ambiguous. While a key outcome of this review has been to demonstrate that there are considerable benefits from incorporating grazing within milk production systems, evidence from local farms suggests that when well managed, both systems can be efficient, sustainable and profitable. Nevertheless, within any 'system', and at any given level of performance, those farms which achieve higher levels of 'milk from forage' tend to be more profitable than those with lower levels of milk from forage.

Ultimately the choice of system that a farmer adopts is more than a 'scientific question', and will be influenced by personal choices, preferences, individual farm circumstances, by the cost of inputs relative to the value of outputs (both of which are increasingly determined by global issues), and by government policy and legislation. With regards the latter, environmental constraints are likely to become increasingly stringent, especially in relation to climate change and water quality. In addition, consumer choice and perception is becoming increasingly important. For example, in a recent UK study 95% of consumers questioned did not think it acceptable to keep cows permanently housed indoors. This in itself may present a marketing opportunity for NI milk based on a clean, green, welfare-friendly image, and may offer scope for processors to offer a premium for milk produced by cows which have access to grazing.

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